INFECTION PREVENTION AND CONTROL SPECIFICATIONS FOR NEW HEALTHCARE BUILDINGS

Revised 2024

TABLE OF CHANGE

Date of Issuance	Description of Change
6 August 2019	• Published as a *one-year-in-use* consultation document.
27 October 2022	• Added WHO's recommended ventilation requirements in Section 1.4.4. • Added wastewater management for isolation rooms in Section 1.7. • Added detailed specifications and planning model for operating theatre in Chapter 3.
16 May 2024	• Minor editorial and content changes. • Added Appendix 13-1: Design Parameters for Hospital Facilities
30 Sept 2024	• Minor editorial and content changes.

FOREWORD

It is with pleasure that the National Infection Prevention and Control (NIPC) Committee presents this document to aid in the design of new healthcare buildings. Infection Prevention and Control (IPC) experts must be integral in the many steps of design but often their role is not clear or adequately defined and as a result the expectations and responsibilities can be underutilised.

This document is designed to be read by those commissioned to build or perform major renovations in a healthcare building in Singapore. It is also a reference for IPC experts involved in the process. We hope to standardise the advice provided after taking reference from best evidence. However, this document is not designed to replace domain clinical experts with experience in a specific field, moreover it is the IPC component we wish to complement such clinician input.

I would like to acknowledge, A/Prof Ling Moi Lin and the team that helped draft this document under the auspices of the NIPC.

Professor Dale Fisher
Chairperson
NIPC

ACKNOWLEDGEMENTS

The Revised Infection Prevention and Control Specifications for New Healthcare Buildings has been endorsed by the National Infection Prevention and Control Committee (NIPC). The composition of the NIPC is provided in Table 0.1 below.

Table 0.1: Composition of NIPC

S/N	Name	Role	Designation
1	Adj Asst Prof Kalisvar Marimuthu	Chairperson	Senior Consultant, Department of Infectious Diseases, TTSH & National Centre for Infectious Diseases (NCID)
2	Prof Dale Fisher	Advisor	Senior Consultant, Division of Infectious Diseases, University Medicine Cluster, National University Hospital (NUH)
3	A/Prof Ling Moi Lin	Member	Director, Infection Prevention and Epidemiology, Singapore General Hospital (SGH)
4	Adj Asst Prof Surinder Pada	Member	Director and Senior Consultant, Infectious Diseases, Ng Teng Fong General Hospital (NTFGH)
5	Dr Louisa Sun	Member	Consultant, Division of Infectious Diseases, Alexandra Health (AH)
6	Dr Tan Si Huei	Member	Consultant, Laboratory Medicine, Changi General Hospital (CGH)
7	A/Prof Thoon Koh Cheng	Member	Senior Consultant, Infectious Disease Service and Infection Control Committee Chair, KK Women's and Children's Hospital (KKH)
8	Dr Ray Lin	Member	Clinical Lead, Infection Prevention and Control Office, WH
9	Ms Poh Bee Fong	Member	Deputy Director of Nursing and Infection Control Lead Nurse, TTSH
10	Adj A/Prof Brenda Ang	Member *(Former)*	Clinical Director, Department of Infection Prevention and Control, Tan Tock Seng Hospital (TTSH)
11	Ms Sharon Wong	Member *(Former)*	Senior Nurse Clinician, Infection Prevention and Control, Sengkang General Hospital (SKH)

The MOH would like to acknowledge A/Prof Ling Moi Lin (Director, Infection Prevention and Epidemiology, Singapore General Hospital) for leading the group of experts in the writing of the guidelines. The members of the expert workgroup who contributed in their individual capacity to the drafting of the *Revised Infection Prevention and Control Specifications for New Healthcare Buildings* are listed in Table 0.2 below.

Table 0.2: Experts who contributed to the drafting of the guidelines (in alphabetical order)

S/N	Name	Designation
1	Adj A/Prof Brenda Ang	Clinical Director, Department of Infection Prevention and Control, Tan Tock Seng Hospital
2	Ms Lee Lai Chee	Assistant Director, Nursing and Infection Prevention Lead, Infection Prevention & Epidemiology, Singapore General Hospital
3	Dr Yvonne Lim	Senior Deputy Director, Healthcare Infrastructure Projects Division, MOH Holdings Pte Ltd
4	A/Prof Ling Moi Lin	Senior Consultant, Director of Infection Prevention & Epidemiology, SGH
5	Adj Asst Prof Surinder Pada	Director and Senior Consultant, Infectious Diseases, NTFGH
6	Ms Cathrine Teo	Senior Nurse Clinician, Infection Prevention, National University Hospital
7	Ms Yong Seow Kin	Director, Facilities Development, SingHealth

CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

The World Health Organization (WHO) defined “health” as “a state of physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 1946). Healthcare facilities should provide a therapeutic environment in which the overall design of the building contributes to the process of healing and reduces the risk of healthcare-associated infections rather than simply being a place where treatment takes place. It is important that healthcare buildings are designed in consultation with healthcare professionals’ inputs. The initial planning and design of new hospitals, or major hospital refurbishments, should maximise the available space for current inpatient accommodation and support services’ needs. Healthcare building designs also need to accommodate for future changes in layout, function and patient volume. Plans showing potential future reconfigurations should be included in the design and briefing process. The design should facilitate good infection prevention and control (IPC) practices and have quality finishes and fittings that enable thorough cleaning and maintenance to take place.

The healthcare environment is a potential reservoir for infectious organisms. To minimise the transmission of healthcare associated infections (HAIs), it is imperative that IPC measures are “designed-in” at the very outset of the planning and design stages of a healthcare facility and that input continues beyond the final building stage. Hence, a multidisciplinary team comprising designers, architects, engineers, facilities managers and planners is essential. The collaborative partnership among IPC teams, environmental services and workplace safety teams, healthcare staff and users help to ensure IPC needs are anticipated, planned for and met in the facility. For new builds or major refurbishments, the project team should include, or seek input from, a person with practical experience in the IPC aspects of hospital design.

The participation of an IPC team in all phases of building planning, construction and renovation is essential. The IPC team needs to develop a basic working knowledge of the building system for effective communication with the design team. Appropriate safeguards must be put in place to minimise the risk of transmission of infection during the construction period, in particular, the prevention of Aspergillus and Legionella transmission, in accordance with the national guidelines (refer to the MOH ‘National IPC Guidelines for Acute Healthcare Facilities’).

There are 7 phases in the building process and a post-project evaluation phase:

1. **Design brief** – This includes “blue sky” (“wish list”) considerations, master planning, and predesign efforts. The IPC input is usually in the area of highlighting general IPC requirements as well as assisting in giving justification for business case of project.

2. **Concept design**

3. **Schematic design** – This involves drawing a rough outline of the project, including preliminary room layout, structure, and scope. At this stage, the IPC team highlights specific IPC requirements to ensure patient and staff safety. The IPC team needs to assess whether the facility is designed to support the prevention and control of infection.

4. **Detailed Design** – This includes adding details to the design, such as fixtures, furniture location, and decor. IPC team’s input on the selection of finishes will help to ensure good environmental hygiene and cleaning practice in the healthcare facility.

5. **Tender preparation documents for construction**– This requires converting all aspects of the design into a template from which contractors can estimate costs, identify issues and plan construction activities. At this point, organizations will discuss contract conditions - the rights and duties of all participants, including the owner, the architect and the contractor. The IPC team is usually called upon at this stage to sign off detailed design documents. This is the final opportunity to ensure that specifications are met during the planning. The final documentation should include evidence that advice was sought from the IPC team at all relevant stages of the project.

6. **Construction** – This is the phase in which the building or facility is actually built. The IPC team’s role at this phase is to ensure a safe environment for existing patients in the other parts of the healthcare facility through auditing and monitoring of the construction works. It is important that an appropriate risk assessment is carried at an early stage prior to any building works, including assessment of disturbance/alterations to the water system, building fabric, and ventilation systems.

7. **Testing and commissioning** – Before taking ownership of a building, project, or renovation, an organization must make sure that all specifications are met and that

all systems, components, equipment, and so forth are fully operational. Commissioning encompasses these activities.

8. **Post-project evaluation** – The purpose of the post-project evaluation is to appraise the project design, management and implementation. The evaluation typically takes place 12 months' post-handover and is a learning process for future projects. The project is evaluated in terms of its original objectives. There are three stages:

    i. Project appraisal;
    ii. Monitoring and evaluation of project; and
    iii. Review of project operations.

Performance indicators may be used if these can be measured retrospectively. Measurable objectives may include:

a) Activity data;
b) Patient satisfaction surveys etc; and
c) Compliance with *Legionella* risk assessments.

The intention of this document is to support the planning, design and development of new acute and community hospital projects in Singapore. The specific requirements of the MOH's policies, licensing requirements, clinical services and guidelines for acute and community hospitals shall take precedence over the recommendations in these guidelines. These guidelines do not grant exemption from adherence to the relevant Acts, Codes and Regulations.

PART I. DESIGN AND PLANNING PROCESS

CHAPTER 1 INFECTION PREVENTION AND CONTROL CORE ASPECTS

Design of a new healthcare facility will need to take into consideration planning for

a) Inpatient accommodation units;
b) Outpatient accommodation units;
c) Intensive care units (ICUs);
d) Special Areas such as operating theatres, sterilisation units
e) Pandemics and Outbreak response

Core foundational infection prevention and control (IPC) issues to consider include:

f) Space;
g) Workflows and Flows (of patients, staff, food, materials and waste)
h) Hand hygiene facilities;
i) Ancillary areas;
j) Engineering services;
k) Toilets and changing facilities;
l) Lifts;
m) Wastewater and sanitation;
n) Finishes and curtains;

With respect to location, the general principle is that no sewage (including open-to-sky landscape areas) and water pipes should run above and across all procedure rooms (including operating theatres/suites), clean utility/storage rooms and sterile supplies unit.

1.1 Space

This should take into account various furniture and equipment related to each bed area and the necessary accessibility, as well as accessibility of staff to clinical handwash basins. The principle should be to maintain sufficient space for activities to take place and to avoid cross-contamination between adjacent bed spaces. Distance between beds or chairs should be at least 2 m from edge to edge for new facilities. Modes of transmission of infection should also be taken into account when bed space and size of facility is discussed. The exact space needed will vary according to number and activity of staff, type of patient, and environmental factors such as ventilation and humidity.

Floor/bed space is influenced by the type of healthcare facility and the type of patient care. In general, there are four distinct patient groups:

a) Acute care patients;

b) Patients who require longer term hospitalisation or rehabilitation
c) Mental health or learning disability in-patients;
   Ambulatory care patients – these include diagnostic services, day surgery, minor injuries and attendance at primary care facilities and walk-in centres.

The volume and type of care and the degree of intervention, diagnostic equipment, and movement of staff around the patient dictate the bed space needed.

The primary aim of IPC is to prevent the spread of infection between patients, visitors and staff by control or containment of potentially pathogenic organisms. Many of these organisms can be controlled by basic IPC practices such as hand hygiene and environmental hygiene. Only a small proportion of patients requiring isolation need to use specially ventilated isolation facilities.

The key to effective isolation on general wards is the provision of sufficient en-suite single-bed rooms for patients with known risk of spreading infections to other patients in open ward areas. Single rooms reduce the risk of cross-transmission for n for all diseases, including on-airborne diseases. A risk assessment should be used to inform decisions regarding which patients to nurse in single-bed rooms. Multi-bedded rooms can also be used to cohort infectious patients if they have an en-suite water closet (WC) and shower, and preferably, a door to the main ward area. Refer to Chapter 3 for detailed IPC specifications on isolation facilities.

1.2 Hand hygiene facilities

Well-designed hand-hygiene facilities at convenient locations can help to improve compliance with guideline recommended hand-hygiene practices. Hand hygiene facilities refer to the following 2 types of wash basins:

a) Clinical handwash basins;
b) General handwash basins.

Hand-hygiene facilities should be readily available in all clinical areas. There should be sufficient numbers and appropriate sizes of clinical handwash basins to facilitate staff's adherence to hand-hygiene protocols. All clinical handwash basins in the hospital setting should be accessible and should not be situated within patient zone. If possible, it is recommended to be sited or located outside patient cubicle. It is recommended that patient bed, medical equipment and clean supply should not be situated within 2m of the basin. Inconveniently located or insufficient clinical handwash basins are two of the main reasons that healthcare staff do not comply with hand-hygiene protocols.

It is recommended that a minimum of one clinical handwash basin in each single-bed room is required. It should be located outside the bed screen or curtain and convenient to staff access. En-suite single-bed rooms should have a general handwash basin for personal hygiene in the en-suite facility in addition to the clinical handwash basin in the patient's bedroom. There should be one clinical and one general handwash basins in multi-bedded rooms. In primary care and out-patient settings, where clinical procedures or examination of patients/clients is undertaken, a clinical handwash basin should be close to where the procedure is carried out. Ideally, there should be a clinical handwash basin and general handwash basin for every room or cubicle of 4-6 patients.

A general handwash basin should be at least 400 mm deep × 500 mm wide for ambulant / semi-ambulant use and 500 mm deep × 600 mm wide for wheelchair/ seated use. Wheelchair-accessible handwash basins should have a size and profile that maximises access and reduces obstructions. They should be designed with a shallow depth, tapering from the rim to a depth not exceeding 250 mm at the outlet, which in turn should be positioned as near the supporting wall as possible; preferably project 500 mm in order to provide adequate leg room underneath the basin. Wash basins for Persons with Disabilities must also comply with BCA's Code on Accessibility in the Built Environment 2019.

The general handwash basin is for use by patients and their visitors. All toilet facilities should have a general handwash basin. Taps should not be aligned to run directly into the drain aperture. All general handwash basins should be sealed to a waterproof splash-back.

Basin taps used in clinical areas, food-preparation and laboratory areas are required to be operated without physical contact.

The clinical handwash basin should be large and deep enough to prevent splashing to areas where direct patient care is provided, particularly those surfaces where sterile procedures are performed and medications are prepared. The basin should contain most splashes to enable the correct hand-wash technique to be performed without excessive splashing of the user. The area of the basin should not be less than 144 square inches (365.76 square millimeters), with a minimum 9-inch (22.86mm) width or length. It should be wall-mounted using concealed brackets and fixings. They should also be well-fitted and sealed to a waterproof splash-back to allow effective cleaning of all surfaces and to prevent water leaks onto or into cabinetry and wall spaces. They should not have a plug or a recess capable of taking a plug. Clinical handwash basins should not have overflows, as these are difficult to clean and become contaminated. Taps should not be aligned to run directly into the drain aperture, as contamination from the waste outlet could occur via splashing. The water pressure at the fixture should be regulated. Policies should be in place to ensure that clinical

handwash basins are not used for other purposes such as emptying of liquids from patient care processes, or rinsing of reusable equipment. Design of sinks should not permit storage beneath the sink basin.

Clinical handwash basins should be installed in all clinical areas. Typical requirements are:

a) Integral back outlet;
b) Washing under running water (therefore no plug);
c) Wall-mounted single-lever-action (with single self-draining spout);
d) TMV3-approved thermostatic mixing valve (either fitted directly to tap or integral within it); and
e) Connection to concealed services.

Provide the following at handwash basin – liquid soap, paper towels dispenser. Alcohol-based / antimicrobial hand rub (ABHR) should be provided at point of care.

The use of reusable towels should not be permitted. Hot air dryers should also not be used as they generate aerosols and have the potential for depositing pathogenic bacteria onto the hands and body of users.

Taps discharging directly into a drain hole can cause splashing, which could disperse contaminated droplets. Swan-neck tap outlets are not recommended, as they do not empty well after use. As tap aerators and constant flow regulators may become colonised with bacteria after use, biofilm can build up and have been associated with outbreaks e.g. *Elizabethkingea meningoseptica.* Tap aerators / constant flow regulators and use of sensor taps have been associated with non-fermentative Gram-negative bacteria outbreaks e.g. *Pseudomonas aeruginosa*. This is related to a comparatively low flow rate coupled with a lack of thermal control and the presence of synthetic rubber materials that may facilitate the survival of bacteria and encourage biofilm growth in sensor taps. Protocols should be in place to keep these clean and safe for use. It is recommended that aerators / constant flow regulators are not installed in high-risk areas e.g. ICUs, haematology wards, etc. In existing healthcare facilities, it is also recommended that aerators/ constant flow regulators be removed from high-risk areas.

Sensor taps are not recommended unless it is clear that they are not associated with spread of infections.

Clear signage should be placed to remind healthcare professionals that clinical handwash basins are for handwash only (no brushing teeth / spitting etc.) and bodily fluids must not be discarded into clinical handwash basins.

Contaminated fluids such as patients' wash-water should not be emptied down clinical handwash basins. Disposal facilities should be provided in areas where dirty wastewater is disposed (for example, dirty utility rooms and cleaners' rooms/areas for cleaning equipment).

1.3 Ancillary areas

The ancillary areas include:

a) Dirty utility room;
b) Clean utility room;
c) Clean linen store;
d) Treatment room;
e) Decontamination room;
f) Disposal room;
g) Cleaner's room; and
h) Storage area.

Clean and dirty areas should be kept physically separate, and the workflow patterns of each area should be clearly defined. The design and finish of ancillary areas should facilitate good cleaning. These areas should have facilities for hand hygiene and sufficient storage for supplies and equipment.

1.3.1 Dirty utility room

Dirty utility rooms should contain:

a) Sluice with a cover for disposing of body fluids and patients' wash-water, where macerators are not in use;
b) Separate sink for cleaning equipment; and
c) Clinical handwash basin.

The facilities in a dirty utility room should allow for

a) Cleaning items of equipment;
b) Retrieving urine samples for testing;
c) The disposal of `body fluids including water contaminated with body fluids;
d) The decontamination of commodes;
e) Temporarily holding items requiring reprocessing;
f) Clinical handwash basin for washing of hands after activity in the dirty utility room.

Space and facilities for the holding, reprocessing, or disposing of bedpans, urinals and vomit bowls are required.

Clean bedpans and linen-bag carriers can also be stored in this area. Masks, aprons, and gloves should be provided for ease of access to personal protective equipment (PPE) as well as dispensers containing disinfectant wipes to clean equipment.

Where commodes are to be used, there should be sufficient space allowed for their decontamination and storage.

A clinical handwash basin is necessary plus a slop-hopper for disposal of body fluids and a separate sink for decontaminating equipment.

There needs to be a clear demarcation between section storing clean/unused equipment and section temporarily housing soiled/dirty equipment in the room. Touch-free sensor-operated doors are preferred to minimize environmental surface contamination by dirty hands or equipment.

1.3.2 Clean utility room

A clean utility room is required where medications and clean and sterile supplies are stored. Clinical handwash facilities are required. The room should have temperature and relative humidity monitoring devices to allow for constant temperature and relative humidity monitoring and prompt response by facilities department when the reading is beyond the desirable range. The room should be located adjacent to the treatment area. There should be enough storage area for sterile supplies, equipment, and other clean supplies. Supplies should be kept off the floor with sufficient space under the lowest shelf to permit cleaning the floor underneath. It is important that sufficient worktop area that is away from the sink is provided to enable aseptic preparation to be carried out (e.g. preparation of intravenous infusion).

Storage facilities should be of materials that are easily and quickly cleaned while protecting clean stores and equipment from dust and contamination.

1.3.3 Clean linen storage

Clinical areas should have designated areas for the storage of clean linen to maintain the cleanliness of the linen and allow easy access to staff. Storage should be on slatted shelving or racking and be off the floor, with sufficient space under the lowest shelf to permit cleaning of the floor underneath.

1.3.4 Treatment room

A treatment room may be required for in-patient examination or investigations. In primary care settings, it will require different design features according to its planned use, for example immunisation or wound dressing. A clinical handwash basin should be provided.

From the outset, it should be said that carpets are not allowed in any patient care or treatment areas and then need not be mentioned again. Carpets should not be used as this area has a high probability of body fluid contamination. Space should be available to allow for the storage of equipment and sterile supplies. If sterile supplies are stored in this room, the temperature and relative humidity of the room should be monitored to comply with standards viz. RH<60% and temperature ranging from 21 to 24˚C.

1.3.5 Equipment decontamination room

Local decontamination (i.e. the decontamination of reusable medical devices undertaken at the point of use) is associated with large items of equipment that are not amenable to steam sterilization such as infant incubators in neonatal intensive care units. It is preferable to have a designated equipment decontamination room that facilitates a defined dirty-to-clean flow throughout the decontamination process and have sufficient work surfaces and sinks to allow effective reprocessing. In the planning of design and ventilation specification of the room, consideration must be taken on emerging decontamination technologies such as hydrogen peroxide vaporization or UV-C irradiation.

1.3.6 Disposal room

The disposal room is for temporary storage of supplies and equipment that have to be removed for cleaning; reprocessing or disposal (for example, used linen, items to be returned to the sterile services department (SSD), waste bags and sharps bins). The size of disposal rooms should be considered at the design stage, taking into account the predicted levels and types of waste to be generated and the planned operational policies relating to frequency of waste and linen collection. The room should be provided with hand hygiene facilities. This area should be secured and not accessible to the public.

1.3.7 Cleaners' room

This room is used to deliver day-to-day cleaning services for a defined area. Cleaning materials and equipment in daily use should be stored in this room. The room should be provided with a sink and slop-hopper or janitorial unit as well as a handwash basin. There should be unrestricted access to the sink and slop-hopper/janitorial unit. Space should be provided for mops, buckets, a vacuum cleaner, scrubbing/polishing machine (for hard floors).

1.3.8 Storage

Storage areas need to be appropriate for the operational requirements of each clinical area. Cleaning equipment, laundry and clinical waste need to be stored in separate purpose-built areas to prevent cross-contamination.

1.4 Engineering Services

1.4.1 Pipework siting and access

Pipework should be contained in a smooth-surfaced box that is easy to clean; pipework sited along a wall can become a dust trap and be impossible to adequately clean. Pipes and cables running through walls above suspended ceilings should be sealed as far as is practicable.

1.4.2 Heating and general ventilation grilles

Ventilation grilles need to be accessed easily for inclusion in cleaning programmes by cleaning and facilities management staff.

1.4.3 Ventilation ductwork

Ventilation ductwork should be installed in such a way that it can be accessed for cleaning. Extract ductwork accumulates large amounts of dust, particularly where heat reclamation systems are used.

1.4.4 Ventilation

COVID-19 pandemic highlighted the importance of adequate ventilation in all parts of the hospital to help prevent the transmission of acute respiratory tract infections amongst patients as well as staff who work in the buildings. The World Health Organization (WHO) has issued guidance on this viz.:

a. Ventilation rate minimum requirements of 160 L/s/person or 12 ACH where aerosol generating procedures are performed; and 60 L/s/person or 6 ACH for other areas;
b. Airflow direction should be from clean to less clean area.

1.4.5 Specialised ventilation

Specialised ventilation is required for the following areas (refer to ASHRAE Standard 170-2021 Ventilation of Health Care Facilities):

a) Operating departments;
b) Airborne infection isolation rooms;
c) Bronchoscopy and sputum induction rooms where a risk assessment has indicated a Tuberculosis (TB) risk;
d) Accommodation for highly immunocompromised patients;
e) Cardiac catheterisation/interventional rooms;
f) Radiology units;

g) Microbiology containment laboratories; and

h) Mortuaries.

1.5 Toilets and changing facilities

Water Closets (WCs), bathrooms and showers should be designed to be easily cleaned and maintained. General handwash basins should be provided in or adjacent to WCs. Showers are generally more practical than baths in connection with clinical procedures and are easier to keep clean. Any fixture with a shower such as a seat should be readily amenable to cleaning. To minimise the possibility of bacterial colonisation of showerheads, they should be regularly cleaned and descaled.

Bidets may present infection risks, depending on design and patient group. The appliance should be rimless with an over-rim water supply and should be easy to dismantle for regular cleaning. If present, baths should be easy to clean. Recirculating spa pools or Jacuzzi baths are not recommended.

In wet rooms, high quality water-resistant cladding should be used on the walls to prevent mould development.

Staff changing facilities, sanitary facilities, showers, and sufficient locker space should be provided for staff to change out of their uniforms on-site. General handwash basins and shower facilities for staff should be available and easily accessible in case of substantial blood or body-fluid contamination. There needs to be sufficient storage space for clean scrub suits and footwear.

1.6 Lifts

There should be designated lifts for delivery of clean supplies and return of used (dirty) supplies/services (e.g. waste, used linen). Items from or returning to the CSSD should have clear designated paths away from public areas.

1.7 Waste, wastewater, and sanitation

Ensure that waste is stored safely on-site. Waste storage areas at ward and unit level should be secure and located away from public areas. Storage areas should be sufficient in size to allow packaged waste to be segregated and so as to avoid waste of different classifications being stored together in the same area.(Refer to Waste Management Chapter in the '*National IPC Guidelines for Acute Healthcare Facilities'*).

Waste discharged from isolation rooms for emerging pathogens will need to be treated before final discharge to public sewer system. Where general wards are converted to isolation

wards during a pandemic, consideration will need to be made regarding a possible need for waste treatment before discharge.

Storage for used linen should be in a clearly designated area separate from waste. This should minimise any risks of used linen being accidentally taken for disposal, or of waste being taken to the laundry. The waste and used linen storage areas should be designed to be cleaned easily and efficiently. The holding area should be large enough to hold a wheeled bin to reduce handling of waste by porters. The area should be provided with hand hygiene facilities.

A designated secure area is also necessary to hold receptacles from the whole healthcare facility while awaiting collection by licensed waste collectors and should be provided with good access routes within the healthcare facility, away from public areas. The waste storage area should also be washable and animal (pest)-proof.

Wastewater is generated from a huge number of tasks carried out in healthcare buildings, which range from cleaning, handwashing, specialist laundries, surgical operations, and areas such as renal dialysis units. Most of this wastewater contains pathogenic microorganisms and must be disposed of via a safely contained internal drainage system into the external wastewater sewerage system. Plans should be made for possible treatment of wastewater from isolation facilities in the event of pandemic or where there is management of an infectious disease pathogen of significant national concern before discharge into the sewage system.

When considering installation of bedpan macerators, it should be established that internal drains and the external sewerage system can cope with the resultant slurry. Where reusable supports are used with maceratable bedpans, there should be adequate facilities for their cleaning and disinfection between uses.

1.8 Finishes and curtains

Walls and floors should have a smooth finish that are easily cleaned and can withstand repetitive cleaning with hospital-approved disinfectant e.g. sodium hypochlorite and will dry quickly. The design should discourage accumulation of dust and moisture. Floors or walls penetrated by pipes, ducts and conduits should be sealed to stop entry of pests.

Carpets should be avoided in all clinical areas. There is always a risk of spillage of urine, faeces, vomitus, or any other body fluid. Furthermore, contamination and colonisation by fungus, bacterial spores etc. are inevitable when cleaning is difficult. Soiled carpeting provides an ideal setting for the proliferation and persistence of hospital pathogens especially Gram-negative bacteria and fungi. Vacuuming and shampooing or wet cleaning of carpets can

disperse microorganisms to the air. Moreover, not all modern carpet brands suitable for public facilities can tolerate the activity of a variety of liquid disinfectant used in cleaning at healthcare setting.

Soft furnishings (for example, seating) used within all patient areas should also be easy to clean and compatible with detergents and disinfectants. They should be covered in a material that is impermeable, preferably seam-free or heat-sealed.

Privacy curtains can be contaminated with microorganisms, which can then be transmitted to staff hands. Curtains should have fittings that make them quick and convenient to replace. Where applicable, reusable curtains should be able to withstand decontamination in healthcare laundering processes. There should be a policy in place on the changing of privacy curtains, both for routine changing or when the curtains become soiled and after the discharge of a patient with a known/or suspected infectious disease requiring terminal cleaning (e.g. multi-drug resistant organisms).

Where electrochromic glass is used, provisions should be made to ensure that the glass remains opaque in the event of power interruption.

Window blinds should be readily amenable to cleaning. Double-glazed room vision panels with integral blinds that are easy to clean are recommended.

Impervious dividers, screens that can be manoeuvred on wheels or retractable fixed screens between bed spaces can be of benefit in certain clinical areas. This is a reasonable alternative to walls. The use of these dividers requires consideration at the planning stage; as extra space is required either for their use between beds or for storage. The dividers/screen should be easily cleaned and withstand the effect of repetitive cleaning with disinfectants.

All ceilings in restricted areas in OTs and CSSD must be of monolithic construction to form a barrier between interstitial space; of non-fibre shedding and monolithic material.

1.9 Inpatient accommodation

In Singapore public hospitals, the layout of inpatient accommodation is determined by the selected ward class. When designing a new health care building, consideration should be given to the anticipated number of patients who require inpatient accommodation beyond this ward class system i.e. patients who are suspected or have potentially infectious diseases or are especially vulnerable. Isolation and intensive care wards are regarded as classless. Transplant and oncology wards likewise are potentially classless allowing for more single rooms or smaller cohorts of patients in shared rooms.

Inpatient accommodation in hospitals should be designed in a way that addresses a

number of requirements, including:

a) Maximising patient comfort and dignity;
b) Ensuring ease of delivery of medical care;
c) Making appropriate provision for family members, and other visitors;
d) Minimising the risk of infection;
e) Minimising the risk of other adverse events, such as falls or medication errors;
f) Sustainable design and energy efficiency;
g) Ward/unit fixtures and fittings - Fixtures and fittings should be easily cleaned and disinfected and designed to minimise the risk of transmission of infection, in line with appropriate international guidance documents;
h) Communicable disease surge capacity - Hospital ward/units that may have an increased patient load during periods of increased communicable disease activity should have sufficient infection prevention and control infrastructure to deal with such activity;
i) Ventilation – design of ventilation for patient area should take into consideration such that zoning is provided to minimise cross infections between patient rooms.

1.9.1 Single patient room design

The overall proportion is based on risk assessment of the predicted patient population and future use of space, in consultation with the local IPC team. This includes isolation rooms for patients under airborne, droplet or contact precautions.

All single patient rooms:

a) Should have an en-suite facility i.e. a toilet, handwash basin and shower for patient use.
b) Should have a clinical handwash sink, in close proximity to the entrance to the room (in addition to a sink for patient use, included as part of the en-suite facilities). The en-suite facilities should be for the sole use of the patient occupying the room.
c) Should have a floor area of at least 25 m^2 (not including en-suite sanitary facilities).
d) In critical care areas (e.g. intensive care units) should have a minimum floor area of 26 m^2 (not including “en-suite” sanitary facilities, if such facilities are present). In critical care areas and emergency departments, a proportion of single patient “rooms” may be constructed using moveable see-through walls. This facilitates conversion to partially open cubicles, or cohorting of multiple patients, to allow for changes in requirements for close patient monitoring or urgent interventions.
e) Should be designed in a way that maximises visibility of patients by healthcare staff, while allowing for patient privacy. Single patient rooms should be visible from

the nursing/staff base and provided with communication links to the nursing/staff base. Consideration should be given to the use of technology to assist monitoring patients with confusion, frailty or other conditions putting them at risk of injury.

f) Should have adequate seating space for family and other visitors that does not interfere with clinical care of the patient. In paediatric settings, this should include facilities to allow a parent or carer to sleep in the room overnight.

1.9.2 Inpatient accommodation for new hospital builds or major renovations

1.9.2.1 *Single room for airborne infection isolation rooms (Negative pressure, Class N isolation room; Negative pressure anteroom with Class P isolation room for immunosuppressed patients)*

The minimum proportion of airborne isolation rooms (Class N) for newly built:

a) Acute general hospitals should be one per 150-200 acute inpatient beds;
b) Emergency departments should each have at least one airborne infection isolation room (Class N). The required number will depend on the size of the ED and the workload, which will be different from hospital to hospital. Ideally, hospitals should plan accordingly based on their historical numbers and rates of patients with respiratory infections going to the ED
c) Sub-acute hospitals (i.e. community hospitals) should be one per 200 beds. (See Chapter 2)

1.9.2.2 *Airborne infection isolation room design*

Airborne infection isolation rooms should be based on a “negative pressure” design and include a dedicated anteroom.

1.9.3 Multiple-patient room design

Multiple-bedded rooms should include shower and toilet facilities and be designed in a way that allows for future reconfiguration. There should be a minimum clearance of 2000 mm between the side edges of beds, and another 1200 mm clearance beyond the curtain available at the foot end of each bed, to allow for easy movement of equipment and beds.

1.9.4 Ward/unit layout

Wards/units that include inpatient accommodation should be designed in line with ‘*Technical Reference for Facility Design Guidelines for Acute General Hospitals: Singapore Standards Council*’ (TR 42:2015, published by SPRING Singapore), including adequate space for ancillary services and storage.

1.9.5 Refurbishment of existing inpatient accommodation units in acute healthcare facilities

Refurbishment of existing acute hospitals should follow the planning and governance recommendations outlined in Chapter 1, including involvement of the IPC team in all stages of project design and implementation.

1.9.6 Hospital development plans

Existing acute hospitals should produce a development control plan for maximising the number of single-patient rooms to cater for isolation needs.

1.10 Outpatient Centres

In the examination room, a clinical or general handwashing sink should be provided where patient care is provided. In the medication preparation room, a clinical handwash basin or alcohol-based handrub station shall be provided next to stationary medication dispensing units. Where pantry or refreshment is provided, it should have the following;

a) One general handwashing basin located in or directly accessible to the refreshment area;
b) A food preparation sink when meals are prepared in the refreshment area.

As part of pandemic preparedness, I don't think it's just for pandemic preparedness – it would be good for handling someone with a potentially very infectious disease e g measles an isolation room (Class S isolation room) should be identified for the review of the suspect patient (Refer to chapter 2). Appropriate PPE, disinfectant wipes and posters should be made available outside this room.

1.11 ICUs

The ICUs shall be located so that medical emergency resuscitation teams can respond promptly to emergency calls with minimum travel time. In ICUs with open-plan areas, at least one general handwash basin shall be provided for every bed. This should be away from patient's head. Each patient room shall have direct access to enclosed toilet or human waste disposal room, where a bedpan washer or macerator is installed for easy and direct access by ICU staff.

At least one AIIR (Class N isolation room) shall be provided in the ICU; complying with the requirements stated in Chapter 2 section 2.1.

The ceiling finishes should be monolithic, without crevices, impermeable and able to withstand hospital grade disinfectant. A secondary ceiling such as a dropped ceiling/false ceiling should not be installed in the ICUs as it is a reservoir for dust and mould.

Ventilation and temperature requirements will be as in Table 1.1 below.

Table 1.1: Design parameters for non AIIR ICU rooms

Area	Pressure	Minimum air changes of outdoor air per hour	Minimum total air change per hour	Relative humidity (%)	Temperature (^{0}C)
ICU room	Positive or neutral (in relation to outside of patient's room)	2	10	40-60	21-24

It is important that Individual hospitals allocate and determine the ventilation pressures (positive or neutral) of the non AIIR ICU rooms based on the anticipated patient case mix of their hospital. The general (international) recommendation for non AIIR ICU rooms is positive pressured or neutral is based on the principle of keeping the room as "clean as possible" in the interests of wound care, minor procedures etc.

When a patient has major immune suppression, positive pressure within patient's room (with a negative pressure anteroom) is preferred. This is adequate even when the immunocompromised patient requires airborne infection isolation. It is not recommended to alter or alternate the designated ICU ventilation pressure status of the rooms to suit new incoming patients to the ICU rooms as this could lead to errors. NIPC also recommends the construction of anterooms (whenever possible) for non AIIR ICU rooms to mitigate the unintended impact of ICU room pressurisation.

1.12 Pandemic planning

Should a pandemic infectious outbreak occur, the facility should be capable of isolation by zones if lock down needs to be activated. Doors at the entrances should be able to be closed to restrict access when necessary. (Refer to Pandemic Planning for Healthcare Infrastructure document)

1.13 References

Alharbi SA et al. (2016). Assessment of the bacterial contamination of hand air dryer in washrooms. Saudi Journal of Biological Sciences, 23, 268–271

Building and Construction Authority (2019). Code on Accessibility in the Built Environment 2019.

Carter CD, Barr BA. (1997). Infection control issues in construction and renovation. Infect Control Hosp Epidemiol; 18:587–96.

Guidelines for design and construction of hospitals. (2022). The Facility Guidelines Institute.

Health Building Note 00-01: Designing health and community care buildings (2021).

Health Building Note 00-09: Infection control in the built environment (2021).

Planning, Design, and Construction of Health Care Facilities, 4th Edition, 2019. Joint Commission.

Infection Prevention and Control Building Guidelines for Acute Hospitals in Ireland. Strategy for the control of Antimicrobial Resistance in Ireland (SARI), 2008

Ministry of Health, Singapore. (2017). National Infection Prevention and Control Guidelines for Acute Healthcare Facilities.

Moore G et al. (2015). Biofilm formation in an experimental water distribution system: the contamination of non-touch sensor taps and the implication for healthcare, Biofouling, 31:9-10, 677-687, DOI: 10.1080/08927014.2015.1089986

Morey PR. (1997). Building-related illness with a focus on fungal issues. In: Hansen W, ed. A guide to managing indoor air quality in health care organizations. Oakbrook Terrace, IL: Joint Commission on Accreditation of Healthcare Organizations Publications, 15–25.

Rhame FS. (2008). The Inanimate Environment, *In* Hospital Infections, 4th Edition, edited by Bennet JV and Brachman PS. Lippincott-Raven Publishers, Philadephia.

Redway, K & Fawdar, S. (2008). A comparative study of three different hand drying methods: paper towel, warm air dryer, jet air dryer. European Tissue Symposium (ETS). pp. 2–34.

Roadmap to improve and ensure good indoor ventilation in the context of COVID-19. WHO, 2021.

Streifel AJ, Stevens PP, Rhame FS. (1987). In-hospital source of airborne *Penicillium* species spores. J Clin Microbiol;25:1–4.

Walker JT et al. (2014). Investigation of healthcare-acquired infections associated with *Pseudomonas aeruginosa* biofilms in taps in neonatal units in Northern Ireland. J Hosp Infect.; 86:16–23.

PART II. SPECIAL AREAS

CHAPTER 2 ISOLATION ROOMS

This chapter provides guidelines on the design of isolation rooms for housing patients known or suspected of infectious diseases. Design of isolation rooms in the form of protective environment (PE) isolation rooms for housing immunocompromised patients are also included here.

2.1 Classifications of Isolation Rooms

The following illustrates the different types of isolation rooms.

Isolation room type	Patient type	Features
Class S (standard pressure)	• Patient known or suspected to have infections requiring contact or droplet precautions	• Staff handwash basin • Self – closing door • Ensuite bathroom
Class N (negative pressure)/ Airborne Infection Isolation (AII) Units	• Patient known or suspected to have infections requiring Airborne Infection Isolation precautions (e.g. chicken pox, measles, infectious pulmonary and laryngeal tuberculosis)	• Staff handwash basin • Self – closing door • Ensuite bathroom • Anteroom • Continuous monitoring of pressure with alarm system
Class P (positive pressure) / Protective Environment (PE) Room/ Protective Isolation Units	• Immuno-compromised patients (e.g. oncology), that requires protection from all potential airborne infectious organisms	• Staff handwash basin • Self – closing door • Ensuite bathroom • Anteroom • Continuous monitoring of pressure with alarm system
Combination AII/PE Room	• Immunocompromised patients who are diagnosed with infectious diseases	• Staff handwash basin • Self – closing door • Ensuite bathroom • Anteroom • Continuous monitoring of pressure with alarm system

2.2 General Requirements for Isolation Rooms

a) Visibility and location – The design of isolation rooms should allow staff to have direct line of sight of their patients in case of an emergency, and patients are able to see staff from their room to reduce the psychological issues arising from isolation.

b) If there is a mix of AII Rooms and PE Rooms in the same vicinity, the entrance of the rooms should be prominently marked and preferably color-coded to prevent accidental mix-up.

c) The provision of sufficient space in isolation units, particularly for each bed space, is an important consideration. A risk-based approach should be taken to ensure that the environment is appropriate for carrying out clinical activities and undertaking manual handling operations while maintaining a good standard of infection control (e.g. dialysis, physiotherapy, and sputum induction).

d) Isolation rooms should be well-sealed (including walls, floors, ceilings, windows, service penetrations, etc.) to minimize infiltration of outside air or cross-contamination due to room leakage. Removable ceiling tiles are not to be used for isolation rooms.

e) Finishes for isolation rooms including floor, wall and ceiling should be monolithic, continuous, without crevices and well-sealed. Materials used should be able to withstand regular cleaning with hospital grade cleaning detergent and disinfectant.

f) Access to isolation rooms should be via automatic doors activated by non-contact sensors to avoid contamination. Overhead sensors should be avoided to prevent accidental opening.

g) There shall be ensuite bathroom directly accessible from the patient room.

h) Class N and P Isolation Rooms should ideally be fitted with anteroom large enough for a patient bed. The doors of the anterooms should be interlocked such that only one door can be opened at any one time. Manual bypass features can be built in to allow simultaneous opening when the room is not occupied by patients for servicing and maintenance purpose.

i) The anterooms should provide facilities for handwashing, gown-up/gown-down and storage of clean and soiled materials.

j) Where possible, intercommunication system should be made available to facilitate direct communication between patients and nursing support or visitors outside the rooms.

2.3 Ventilation Requirements

a) Ventilation design shall meet ANSI/ASHRAE/ASHE Standard 170-2021 Ventilation for Healthcare Facilities or equivalent.

b) Airflow shall be designed such that it flows from clean to less clean areas.

c) The ventilation system for AII and PE Rooms shall have robust backup and redundancy to ensure that the pressure regime can be maintained at all time

including during power interruptions, routine servicing/repair and/or equipment failure.

d) The space ventilation and pressure regime for AII and PE Rooms shall be monitored continuously. There shall be a differential pressure indicator outside the isolation rooms to alert nursing staff and/or service personnel of any out-of-specification condition.

e) Switching of pressure regime from positive to negative or vice versa for isolation rooms is not permitted.

2.4 Operation and Maintenance Requirements

a) ACMV equipment for isolation rooms such as fan coil units (FCUs) and fans should ideally be located outside patient rooms so that service personnel do not need to access the patient room for repair and maintenance when the room is occupied.

b) When designing isolation rooms, appropriate provision can be made to allow effective decontamination, e.g. when gaseous decontamination is used, leakproof dampers can be incorporated in the ACMV system to allow the room to be sealed quickly for decontamination. If ultraviolet germicidal irradiation (UVGI) is to be used, there should not be blind corners and crevices and finishes used should be able to withstand regular UV irradiation.

c) Bag-in-bag-out (BIBO) filters should be used where possible to prevent the maintenance personnel from being exposed to infectious agent during replacement. Decontamination ports and leak-proof isolation dampers should be available for isolating and decontaminating the exhaust ducting and filter unit casing.

d) Room tightness and ventilation systems of the isolations room must be properly tested and commissioned before being put to use.

e) Proper maintenance of the ventilation system including routine testing to verify correct operation must be carried out to ensure that the isolation room environmental specifications are within specifications.

f) When AII Rooms are not to be occupied by infectious patients for a long period of time, the ventilation may be turned down, e.g. number of air changes reduced, but the system should remain on, and pressure regime shall be maintained at all times.

g) Before the AII Rooms are to be occupied by infectious patients again, the ventilation systems must be recommissioned to their original operating conditions with proper testing to verify that the required specifications have been met before being approved for use.

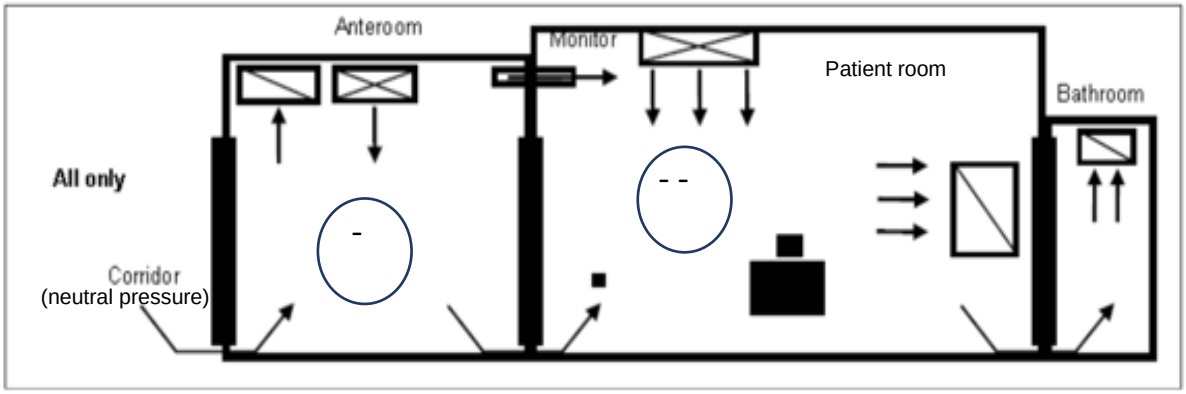
2.5 Airborne infection isolation rooms (AIIRs) or Class N isolation rooms

AIIRs are a single patient room equipped with specialized ventilatory systems needed for patients requiring airborne precautions. Airborne Infection Isolation Precautions prevent transmission of infectious agents that remain infectious over long distances when suspended in the air (e.g., rubeola virus [measles], varicella virus [chickenpox], and *M. tuberculosis*.

An AIIR shall have the following features:

a) The room shall have negative pressure relative to the surrounding area of > -2.5 Pa (0.01″ water gauge) at all time.
b) The differential pressure shall be monitored continuously with visual and audio alarm indication should there be out of specification conditions.
c) The room shall have 12 air changes per hour (ACH) for new construction and renovation. Where possible anteroom with minimum 10 ACH should be included in the design.
d) For existing facilities where infrastructure limits deployment of new AHUs, min 6 ACH may be used for the room. Standalone HEPA filtration units may be used to reduce virus/bacteria load if needed.
e) Air should flow from the entrance, across the caregiver/provider and then towards the head of the patient before being exhausted through the exhaust grilles above or behind the patient's bedhead. Air shall be HEPA filtered and exhausted directly to the outside
f) Recirculation of room air is to be avoided. When the recirculation of air from AII rooms is unavoidable, HEPA filtration is required before return.
g) Where exhaust from multiple AII rooms is combined before being exhausted through a remote exhaust fan and HEPA filter unit, exhaust ducts for each room should be fitted with non-return dampers to prevent backflow and cross contaminations between rooms.
h) An anteroom should be included in the design of AIIR.

The following diagram shows the pressure regime for AII rooms.



Tables 2.1 and 2.2 provide ventilation requirements for negative pressure rooms.

2.6 Protective environment (PE) Room or Class P Isolation Rooms

PE Rooms are rooms of positive pressure with respect to the surrounding environment and are used when caring for immunocompromised patients (e.g., solid-organ transplant patients, allogeneic neutropenic patients or oncology patients who are undergoing very intensive chemotherapy).

PE Rooms should be designed and constructed to minimize fungal spore counts in the air and reduce the risk of invasive environmental fungal infections for the occupants.

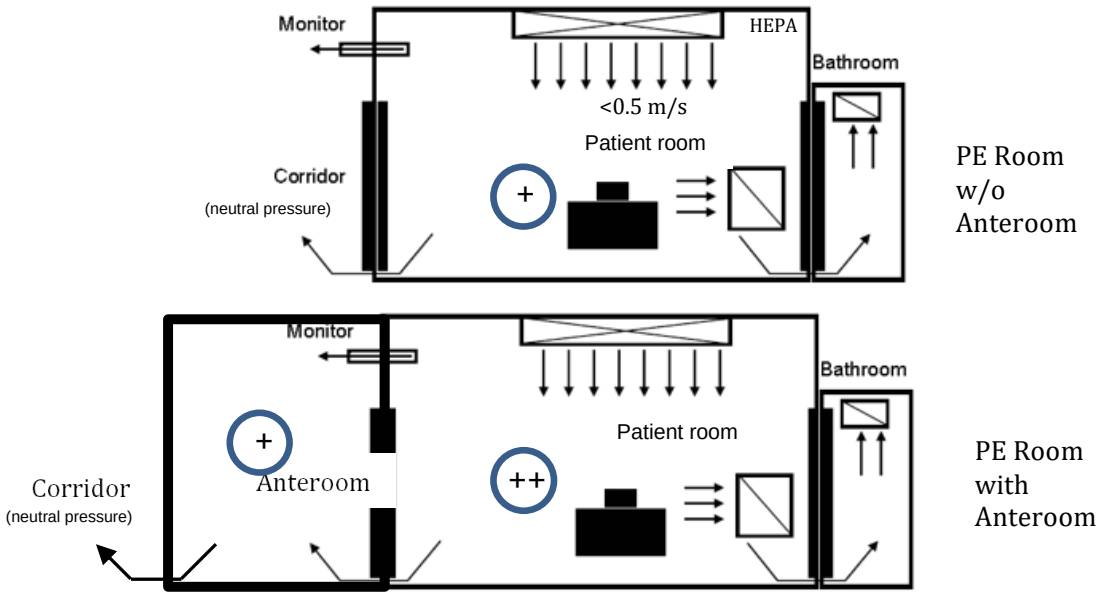
Tables 2.1 and 2.2 contain a summary of the specifications needed for such rooms.

Required air quality for PE Rooms is provided through a combination of environmental controls which include:

a) HEPA filtration of incoming air with filters capable of removing 0.3um diameter particles for incoming supply air;
b) Airflow from the patient bed towards the room entrance hence supply air diffusers shall be above the patient bed and return/exhaust grilles shall be located near the patient room door. Diffuser design shall limit air velocity at the patient bed to reduce patient discomfort;
c) Positive room air pressure relative to the corridor with a pressure differential of > +2.5 Pa [0.01” water gauge];
d) Continuous monitoring and documentation of results of air flow patterns with visual and audio indication to alert of out-of-specification conditions;
e) Well-sealed rooms (including sealed walls, floors, ceilings, windows, electrical outlets) to air ingress from the outside;
f) An anteroom to ensure proper seal of the room;

g) Ventilation to provide >12 air changes per hour;
h) Room air permitted to be recirculated but must be through HEPA filters;
i) Strategies to minimize dust and mould:
    i. Scrubbable surfaces rather than upholstery and carpet;
    ii. Routine cleaning of crevices and sprinkler heads;
    iii. Monolithic and smooth ceilings free of fissures, open joints, and crevices;
    iv. Walls sealed above and below the ceiling.
j) No dried and fresh flowers and potted plants in the rooms.

The following diagram shows the pressure regime for PE rooms.



2.7 Combination AII/PE Rooms

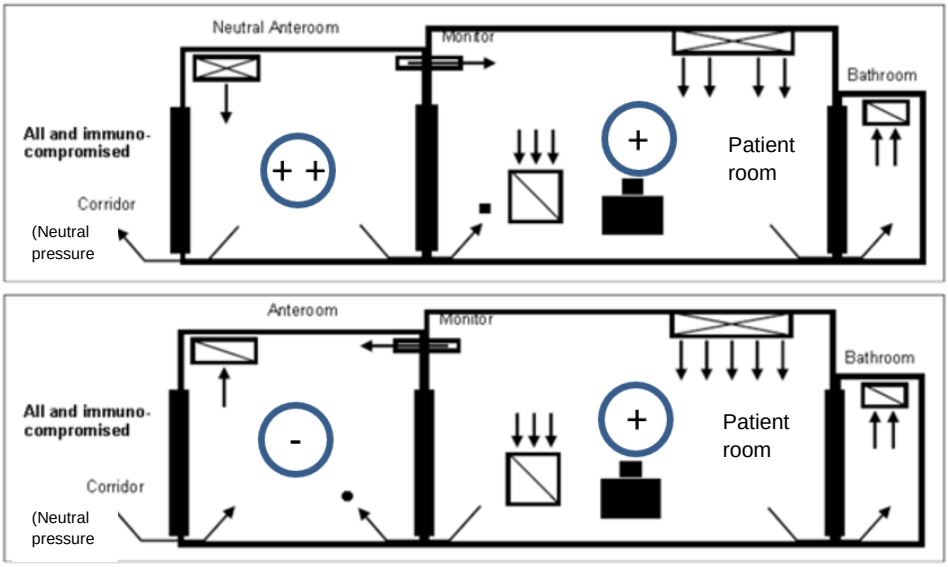
For patients who require both a protective environment and Airborne Infection Isolation such as immunocompromised patients who have acquired infectious diseases, the following two options of pressure regimes may be used, the choice of which should be based on proper risk assessment.

a) Option 1 uses an anteroom of higher pressure to the corridor and the patient room to provide an air barrier to prevent infectious agents in the patient room from migrating to the surrounding areas. The patient room pressure remains positive to the outside environment to minimize risk of external contaminants from entering but is negative relative to the higher pressure in the anteroom so that infectious agents do not escape to the corridor.

b) Option 2 utilises a negative pressure anteroom with respect to the patient room and the corridor to prevent infectious agent from migrating to the surrounding. For such AII/PE Room design, clean supply and PPE shall not be stored in the negative pressure anteroom to minimize risk of contamination. Donning of PPEs shall be done before entering the anteroom and doffing and handwashing should be done in the anteroom.

c) Re-circulation of patient room air shall be avoided for both options.

The following diagram shows the two options of pressure regime for AII/PE Rooms.



a) AII/PE Room with positive pressure anteroom

b) AII/PE Room with negative pressure anteroom

Table 2.1: Summary of ventilation requirements for positive pressure and negative pressure isolation rooms

	Positive pressure	Negative pressure
Minimal pressure differentials	> +2.5 Pa (0.01″ water gauge)	> -2.5 Pa (0.01″ water gauge)
Air changes per hour (ACH)	>12	>12 (for renovation or new construction)
Room airflow direction	Out to the adjacent area	Into the room
Clean-to-dirty airflow in room	Away from the patient (high-risk patient, immunosuppressed patient)	Towards the patient (airborne disease patient)
Ideal pressure differential	> + 8 Pa	> - 2.5 Pa

Table 2.2: Design Parameters for Isolation Rooms

Function of Space	Pressure Relationship to Adjacent Areas	Min Outdoor ACH	Min Total ACH	All Room Air Exhausted Directly to Outdoors	Air Recirculated by means of Room Units	Design RH %	Design Temp °C
AII Ante Room	Negative (--)	NR	10	Yes	No	NR	NR
AII Room	Negative (-)	2	12	Yes	No	Max 60	21-24
Combination AII/PE Ante Room	Negative (-)	NR	10	Yes	No	NR	NR
Combination AII/PE Room	Positive	2	12	Yes	No	Max 60	21-24
PE Ante Room	Positive (+)	NR	10	NR	No	NR	NR
PE Room	Positive (++)	2	12	NR	No	Max 60	21-24

2.8 References

American Institute of Architects. (2006). Guidelines for Design and Construction of Hospital and Health Care Facilities. In: American Institute of Architects. Washington, DC: American Institute of Architects Press.

ANSI/ASHRAE/ASHE Standard 170-2021 Ventilation of Health Care Facilities

ASHRAE (2015) ASHRAE Handbook – HVAC Applications Chapter 8 Healthcare Facilities.

ASHRAE (2020) ASHRAE Position Document on Infectious Aerosols

(Australia) Victorian Advisory Committee on Infection Control 2007 Guidelines for the classification and design of isolation rooms in health care facilities

CDC Guidelines for Environmental Infection Control in Health-Care Facilities, June 2003 (Updated Jul 2019)

Estates & facilities. Health Building Note 00-09: Infection control in the built environment. August 2021

Sehulster LM, Chinn RYW, Arduino MJ, Carpenter J, Donlan R, Ashford D, Besser R, Fields B, McNeil MM, Whitney C, Wong S, Juranek D, Cleveland J. (2004). Guidelines for environmental infection control in health-care facilities. Recommendations from CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC). Chicago IL; American Society for Healthcare Engineering/American Hospital Association.

Siegel JD, Rhinehart E, Jackson M, Chiarello L, and the Healthcare Infection Control Practices Advisory Committee. (2007). Guideline for Isolation Precautions:

Preventing Transmission of Infectious Agents in Healthcare Settings. http://www.cdc.gov/ncidod/dhqp/pdf/isolation2007.pdf

Singapore Standards Council. (2015) TR42 Technical Reference Facilities Guidelines for Acute General Hospitals

World Health Organization (2021) Roadmap to improve and ensure good indoor ventilation in the context of COVID-19

CHAPTER 3 OPERATING THEATRES

3.1 General Principles and Layout

3.1.1 Access

There are typically three zones identified within the Operating Unit. These help to guide logistic support within the OT as well as to ensure optimisation of patient outcomes. These include:

a) Unrestricted areas

Staff and visitors may wear their own civilian attire or perioperative attire, for example change rooms, entries, and public areas.

b) Semi-restricted areas

Staff and selected visitors usually wear perioperative attire, in some cases this could be a uniform, or hospital issued scrub suits that are self-laundered and include holding areas, recovery and other support spaces where handover of patients may occur.

c) Restricted areas

Only accessible by approved staff wearing perioperative attire, usually hospital-issued and hospital laundered scrub suits. These areas require the strictest sterile environments and include the operating and procedure rooms. A common practice in many institutions is to use a ‘red line,’ to demarcate this area or other prominent signage that provide visual cues to staff working within the Operating Unit to reinforce restricted access areas. In modern hospitals, these are also augmented by electronic access control systems.

3.1.2 Immediate Use Sterilization Immediate use (‘flash’) sterilizers

In the past, while flash sterilisers were designed for one-off sterilization of reusable medical device (RMD) (e.g. an instrument which has been inadvertently left out of a set or dropped) and were generally located in an Operating Unit, use of such technology is no longer recommended. Rather systems within the Sterilizing Services Unit (SSU) / Central Sterile Supply Department (CSSD) should be in place to ensure urgent items can be processed in a timely way to provide the necessary support so that clinical care is not compromised.

3.1.3 Planning models

3.1.3.1 *Number of Rooms*

The number of operating and procedure rooms is important and should take into account the service plan of the Operating unit as well as the:

a) case mix and complexity of the surgical and procedural caseload
b) surgical and technology trends that may influence future patterns of activity;
c) anticipated volume of procedures including some assumptions regarding the anticipated number of cancellations;
d) operating hours, such as the length of time a room operates per day e.g. eight to 10 hours;
e) management of emergencies; and
f) length of changeover time between procedures.

3.1.3.2 *Size of Rooms*

The size of rooms is an important consideration since with advances in surgical techniques and the use of new equipment and technology larger operating rooms may be needed in order to accommodate such bulky equipment e.g. robotics for surgery.

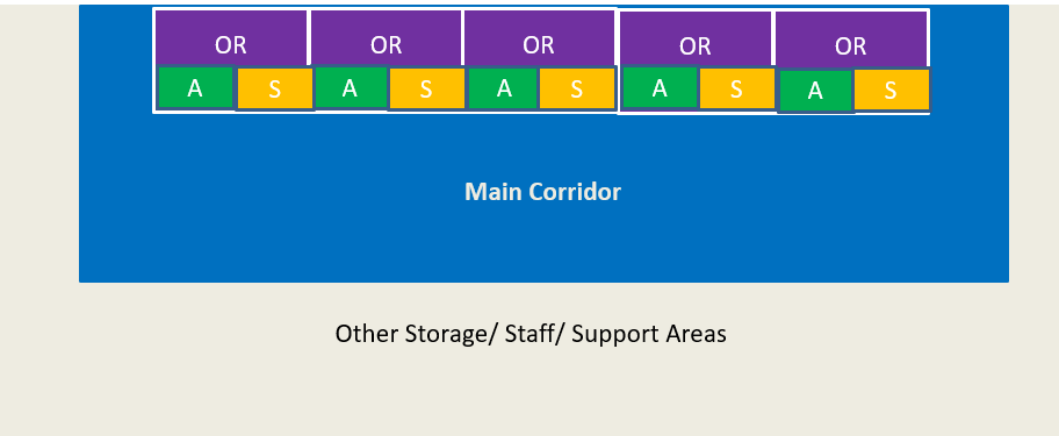
3.1.3.3 *Design of Operating Unit*

The design of the operating unit is also important and there are a number of configurations that could be considered. These include:

a) Single corridor design:

A single corridor is an option where goods, clean and used and all pre and post-operative patients traverse the one corridor. There is ongoing debate as to the suitability of this approach and indeed many institutions have moved away from this model. It does however, work well when the main circulation corridor is sufficiently wide to permit separation of the passage of patients on beds, goods, and waste. It can also provide an opportunity for natural light within operating rooms. A major disadvantage of this planning model is that a patient awaiting surgery may be exposed to post-operative patients.

Figure 3.1: Schematic of single corridor layout



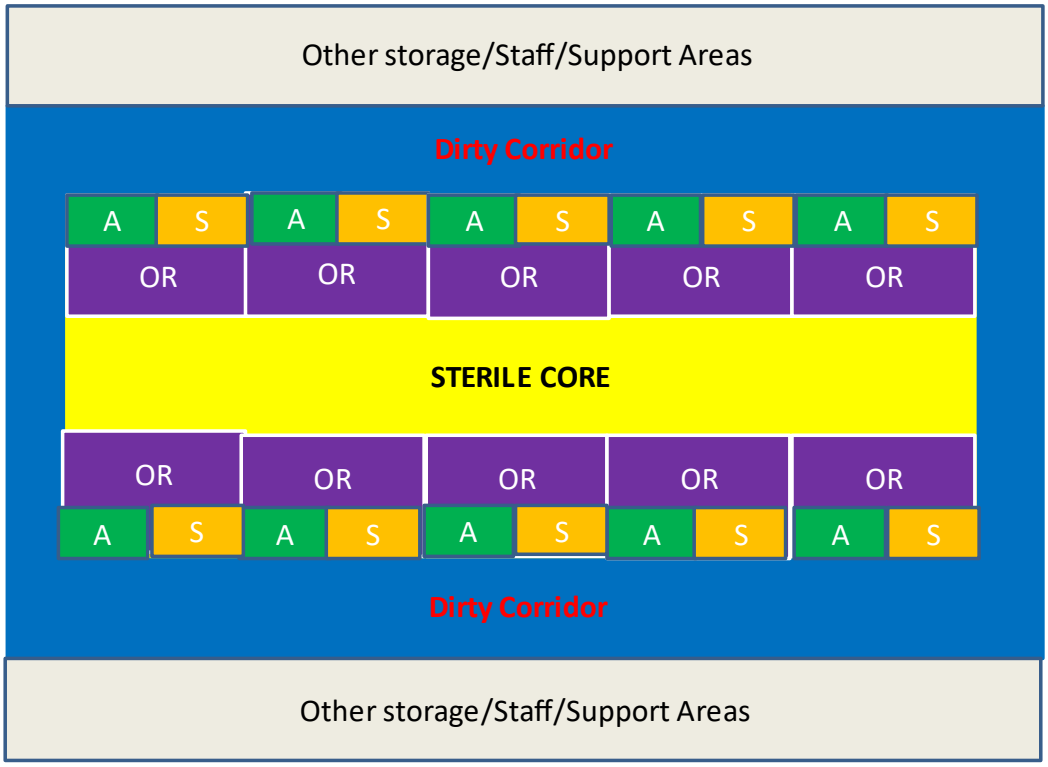
S: Scrub Room
A: Anaesthetic Room
OR: Operating room

b) Racetrack Design:

This model aims to separate dirty from clean traffic by controlling the use of each corridor. Sterile stock and RMD storage are usually centralised in a sterile 'core' which prevents duplication of supplies and staff. While a central sterile core is a good option for operational efficiency, the use of this approach on a large number of operating rooms means that travel distances to recovery become significant. Where the design abuts two banks of OTs, staff may use this as a short cut. As a large number of items may end up being stored in the sterile core, meticulous attention must be paid to particle and microbiological counts on a regular basis. Additionally, if large numbers of OTs are served by one clean core, should repair or maintenance work need to be done on the clean core, this would impact all OTs in that bank. Finally, recovery as well as other supportive areas should be located so it is easily accessible from each operating room, which may be difficult to incorporate into this design.

Ideally, in large units, a sterile core option can be used but for a smaller number of OTs in order to mitigate some of the issues highlighted. This can be via a "cluster" design as discussed below.

Figure 3.2: Schematic of double corridor "Racetrack" layout



S: Scrub Room
A: Anaesthetic Room
OR: Operating room

c) Clusters or Pods:

Clusters or Pods of two to four operating rooms with a shared sterile stock store is a model often considered during the planning stages. Clusters of rooms are often grouped around surgical specialities. The operating costs of providing dedicated staff and stock duplication in this arrangement of Operating Rooms, however, need to be considered. This model can add to the corridor space and circulation space and staff may prefer the extra space to be allocated to stock storage.

d) Dedicated Operating Rooms with Fixed Equipment:

This model dedicates particular operating rooms to specific types of surgery using fixed equipment for specialities such as urology with a dedicated table and drainage, and ophthalmology with ceiling-mounted microscopes. This may be beneficial in larger units where work volumes justify this specialisation. In smaller units the benefits of flexible use of operating rooms usually outweighs the benefits of specialisation. However, fixed equipment can preclude the multifunctional use of the room and if a piece of equipment needs servicing or repair, the room cannot be used. Fixed radiology equipment is large and difficult to clean and may not be required for all cases.

Table 3.1: Summary of advantages and disadvantages of specific OT configurations

Configuration	Requirements	Advantages	Disadvantages
Single corridor design	Single corridor must be wide enough to allow segregation of clean and dirty pathways	• May be able to design OT with natural light • Other supporting areas can be located close by, e.g. dirty utility across the corridor	• Patient awaiting surgery may be exposed to post-operative patients. • Risk of contamination to clean supplies if segregation is not strictly adhered to.
Dual corridor or racetrack design	Separate dirty and clean corridor, the clean corridor forming a "sterile core".	Supplies can be maintained in the sterile core, reducing duplication of staff and supplies	• The sterile core becomes a large "storeroom" • High particle counts may be experienced with large number of items stored in these areas • Maintenance and design of higher pressures than OT have cost implications • Sterile core could be used as a "short cut between OTs, if design involves back-to-back OTs. • Large number of OTs affected if maintenance work needs to be carried out in sterile core • Due to design, long distances to traverse for recovery, dirty utility etc.
Clusters of ORs	Cluster of 4 ORS around a sterile store	• Surgical Specialty ORS may be clustered in a group. • Amenities can be designed close by. • If maintenance needs to be carried out on clean core, less impact on the number of ORs affected	• Can add to the corridor space and circulation space: less storage available • Some duplication of staff and stores, cost impact needs to be taken into account
Dedicated specialty ORs	Fixed equipment for specialties	Beneficial in larger units with high number of specialty cases	• High cost • Maintenance of equipment even when not in use and difficulty in cleaning.

3.2 Operating Room Module

3.2.1 Usual Components of Operating Room Module

a) Anaesthetic room

The Anaesthetic room may be used for administration of local and spinal anaesthetics, patient monitoring or patient preparation prior to the procedure. General anaesthetics and sedations are typically administered in the operating room. Therefore, Anaesthetic induction rooms are optional and may be replaced with preparation bays or holding bays, depending on the operational policy of the facility.

b) Operating room

Where the actual procedure takes place

c) Scrub bay +/- exit bay

Should be provided and be positively pressured.

d) Clean up room/ soiled workroom or holding room

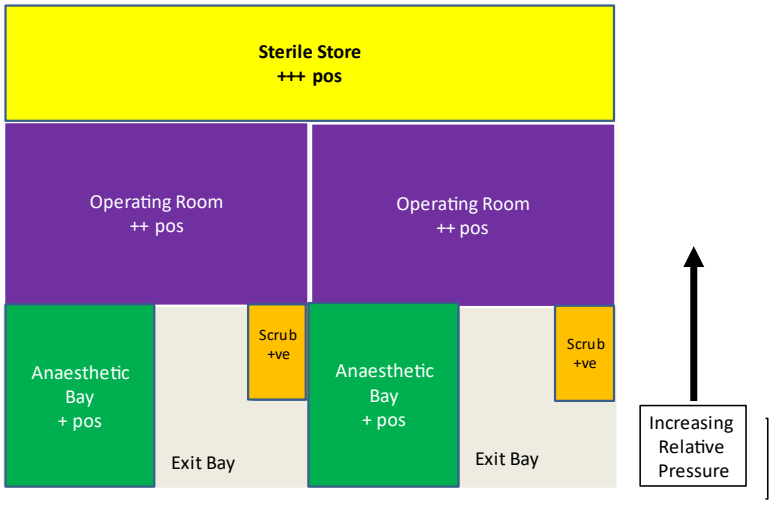
A clean up room may be included in the general layout of the operating room module as shown in Figure 3 below or may exist outside the “module” where it can be shared by multiple OTs. The purpose of this room is for used equipment to be transferred and cleaned up when carts/trolleys are stripped of sharps, waste and instrument trays. Staff will collect covered trolleys and transfer RMD to the SSU/CCSD for reprocessing. Where a surgical waste management system is in use, and this will be specialty dependent, these units will usually be docked within the clean-up room. It is likely that one of these kinds of units will serve six to eight operating rooms.

The soiled workroom shall contain a flushing-rim or equivalent flushing-rim fixture, a general hand-wash basin, a work counter, and space for waste receptacles and soiled linen receptacles.

e) Others

This module will also include a sterile store for holding consumables, RMD and trolleys with stock assembled but unopened for the next number of cases. In the case of hybrid rooms, a control room will also form part of the module.

Figure 3.3: Possible Layout of OT Modules



3.2.2 Direction of Airflow

Pressure differentials must be maintained to ascertain that air flows from the cleanest to the dirtiest area within the suite. Figure 3 shown some examples of how this can be achieved by increasing relative pressures from “clean” to “dirty” areas such that air flows down the gradient. This ensures minimal contamination by airborne bacterial contaminants. Understanding the “hierarchy of cleanliness” may also aid in helping the design of OTs as well as the pressure differentials required for the various spaces, where the sterile store or preparation area needing to be the cleanest to the clean-up room, the least sterile. In the example above (see Figure 3.3), the sterile store or preparation area is the most positive pressured, followed by the OT, anaesthetic room, scrub and exit being positively pressures and clean up room being negatively pressured. Table 4 also illustrates some of the pressure values that could be considered.

This can be further facilitated by transfer grilles or suitably dimensioned door undercuts that enable air to pass in either direction between rooms of equal class and pressure. Pressure relief dampeners and pressure stabilisers that operate in one direction only allow excess air to be directed to the area desired and assist in maintaining room pressure differentials.

3.2.3 Functional Areas

The functional areas that will need to be planned for include:

a) Admissions/ Reception and Holding area

These areas are for receiving and admission of patients to the Unit, with general overseeing of day-to-day operations, control of entry and exit from the Unit and completion of general administrative tasks including: - Reception and Waiting areas - Interview room - Staff Station and write up bay - Bays for handwashing, linen - Clean and dirty utilities - Holding bays for holding and management of patients prior to their operation or procedure.

b) Support Areas

These will generally comprise:

i. Bays for linen and mobile equipment
ii. Blood store – Refrigerated blood bank storage should meet the standards required by the Health Sciences Authority (HSA).
iii. Cleaners’ room/s – Dedicated housekeeping facilities shall be provided exclusively for the surgical suite. It shall be directly accessible from the suite and shall contain a service sink / floor receptor and provisions for storage of supplies and housekeeping equipment.

iv. Pathology area for frozen sections – This may be part of the general laboratory if immediate results are obtainable without unnecessary delay in the completion of surgery. Alternatively, a room may be designed for this procedure.

v. Organ storage - Where applicable, appropriate provisions should be made for refrigeration storage facilities for harvested organs and pathological specimen storage prior to transfer to pathology section/department.

vi. Where formaldehyde is used, adequate ventilation of at least 10 ACH must be provided to prevent build-up, with room designed to be at negative pressure to adjacent areas.

vii. Storerooms and storage areas for:

- Anaesthetic supplies;
- Drugs;
- Equipment, including mobile items, table accessories, loan equipment;
- Perfusion equipment and supplies (if cardiac surgery is undertaken);
- Sterile stock and non-sterile stock.

viii. Recovery Areas where patients are assisted through the process of recovering from the effects of anaesthetic including: - Patient bed bays, open and enclosed for Isolation - Bays for blanket warmer, linen, handwashing - Clean and Dirty Utilities - Store for consumable items and equipment.

c) Administrative and Staff Amenities

These will generally comprise:

i. Change Rooms with showers, toilets and lockers and additional separate toilets for large units;

ii. Staff Room;

iii. Meeting rooms; and

iv. Offices and administrative space for clinical staff.

These areas shall be arranged to encourage a one-way traffic pattern so that personnel entering from outside the surgical suite can change and move directly into the surgical suite. Support areas for staff to store personal items in order to discourage these from being brought into the OT should be provided.

3.2.4 Specific Infection Prevention Considerations

a) Air handling (airflow management, air filtration, pressure gradients and humidity) as described in the sections below.
b) Hand hygiene, both surgical scrub and in other clinical areas throughout the Unit. While a 'rub-scrub' may replace a traditional water scrub, the scrub sink design is likely to remain the same, with additional dispensers added.
c) Design of selected spaces such as operating rooms to identify zones such as the sterile field, within the room. This sterile field includes 'the area immediately surrounding the draped patient, the sterile surgical personnel and the sterile draped instrument tables and equipment.
d) Storage space's moisture Relative Humidity and temperature should be controlled and should be free from cross traffic.
e) Surfaces and finishes to promote easy cleaning. This can be challenging where there is significant wall and ceiling mounted equipment.
f) Selecting equipment that is easy to clean. Personal computers are increasingly being used in the operating room and all components, including keyboards, should be easy to clean.
g) Ceilings – All ceilings in restricted areas (such as OTs) must be of monolithic construction to form a barrier between interstitial space and the OT. Cracks, fissures, and crevices are not permitted and that all finishes must be cleanable, scrubbable, and withstand cleaning compounds typically used in OTs. All ceiling penetrations should be gasketed or sealed. Detailing of ceiling mounted equipment must ensure that cabling is enclosed and cannot easily collect dust.
h) Cleaning and waste management. The location of clean-up rooms close to operating rooms will provide an easily accessible area to store cleaning equipment and dispose of used RMD, used consumables and fluids.

3.2.5 Ventilation

Ventilation supplied to the OT must be able to:

a) Control the temperature and humidity;
b) Dilute and remove waste anaesthetic gases;
c) Dilute airborne bacterial contamination;
d) Control air movement such that air flows from the cleanest area to the least clean area within the suite;
e) Manage exhaust from equipment capable of being a source of airborne pathogens such as heater cooler devices.

3.3 Conventional Operating Theatre

Ventilation considerations in the ORs are important considerations in design. The supply diffuser arrays should be concentrated over the patient and surgical team to assist in establishing a sterile field. The coverage of the supply diffuser array should also include a safety margin that extends at least 305 mm beyond the footprint of surgical table on each side.

3.3.1 Temperature and humidity control

a) Supply flow rates to achieve the required room conditions are calculated conventionally, taking account of all heat and moisture gains and losses, and of maximum permissible temperature differences between the room and supply air.
b) Temperature should be kept constant wherever possible, between 18^{0}C and 25 ^{0}C. For Burns OT, temperature of up to 35 ^{0}C is allowed to prevent the development of hypothermia.
c) Humidity should be kept between 30% and 60% saturation. In the unlikely event of flammable anaesthetic gases being used, a minimum of 50% humidity must be maintained within the operating room. The set point for the humidity control would, therefore, be set at 55% ±5%.

3.3.2 Removal and dilution of waste anesthetic gases

Waste anaesthetic gas must be contained and removed by a suitable gas scavenging system. Some leakage from the anaesthetic equipment and the patient's breathing circuit should be anticipated particularly during connection and disconnection of the circuit. The air movement scheme should ensure that this leakage is diluted and removed from the theatre suite.

3.3.3 Air Changes per Hour (ACH)

The number of ACH within various areas of the suite must also allow for rapid dilution and removal of bacterial contaminants and should range from the highest number of ACH to the lowest number of ACH from clean to dirty areas respectively within the suite. If air is recirculated, at least 20% of the total ACH should be fresh air.

3.3.4 Recirculation

Air extracted may be recirculated after HEPA filtration.. Particle counts shall be within the ISO 14644-1:2015: Class 5 requirement (see Table 3.2 below) for conventional OT if testing interval is within 6 months. Subsequent shows testing parameters and relevant timeframe of tests is shown in Table 3.3 below.

Table 3.2: New ISO 14644-1: 2015 Class Requirements

Maximum concentration limits (particles/m^3 of air) for particles equal to and larger than the considered sizes below:						
ISO classification Number (N)	**0.1 μm**	**0.2 μm**	**0.3 μm**	**0.5 μm**	**1.0 μm**	**5.0 μm**
ISO 1	10	*	*	*	*	#
ISO 2	100	24	10	*	*	#
ISO 3	1 000	237	102	35	*	#
ISO 4	10 000	2 370	1 020	352	83	#
ISO 5	100 000	23 700	10 200	3 520	832	*,#,+
ISO 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO 7				352 000	83 200	2 930
ISO 8				3 520 000	832 000	29 300
ISO 9				35 200 000	8 320 000	293 000

Table 3.3: Tests to demonstrate Continuing compliance ISO 14644-2

Schedule of Tests to Demonstrate Continuing Compliance			
Test Parameter	Class	Maximum Time Interval	Test Procedure
Particle Count Test	<= ISO 5	6 Months	ISO 14644-1 Annex A
	> ISO 5	12 Months	
Air Pressure Difference	All Classes	12 Months	ISO 14644-1 Annex B5
Airflow	All Classes	12 Months	ISO 14644-1 Annex B4

Particles may gain ingress into the OT:

a) Directly through the air supply;
    i. Particles entering with the air supply can controlled by the selection of suitable filter grades.
b) Through shedding from the room occupants; Particles shed directly by the room occupants can be controlled by:
    i. Restricting access to essential persons only;
    ii. The choice of the occupants' clothing;
    iii. The room's ACH rate.

c) As a result of work activities; and can be prevented by
   i. Enclosing, semi-enclosing, or otherwise, the work-based source;
   ii. The room ACH rate.

d) From adjacent spaces: and can be prevented by
   i. Differential pressure;
   ii. Clean air-flow paths.

A summary of the ventilation and other specifications from guidelines for the areas in the operating unit and OR are presented in Table 3.4 below, where after deliberating on these various guidelines, a consensus recommendation for institutions to consider has been made. Do note that these guidelines (ASHRAE and AIA) offer "minimum" standards, newly constructed facilities should allow for a higher margin of safety.

Table 3.4: Operating unit specifications from guidelines and consensus recommendation

Description	ASHRAE	HTM 03-01	iHFG	Consensus Recommendation	
Lay up / preparation room					
Pressure	NR	35	+++	35	
ACH	NR	>25	NR	>25	
Relative humidity	NR	35-60	NR	35-60	
Temperature	NR	18-25	NR	18-25	
Operating room					
Pressure Pa	Positive (2.5)	25	Positive (2.5–10)	25	
ACH	20	25	20	25	
Relative humidity %	20-60	35-60	20-60	35-60	
Temperature ^{0}C	20-24	18-25	18-22	18-25	
Airbourne particle count	NR	ISO 14644	NR	⩾0.5um	⩾5.0um
				⩽3 520	⩽29
Total bacterial count test[1] (CFU/m^3)	NR	<35	NR	<35	

[1] The level of airborne bacteria introduced by the supply air should be checked by closing all doors and leaving the operating room empty with the ventilation system running for 15 minutes. An active air sampler set to take at least

Sound levels[2] NR	NR	40	NR	40
Anaesthetic Bay				
Pressure	NR	15	+	15
ACH	NR	15	NR	15
Relative Humidity	NR	35-60	NR	35-60
Temperature	NR	18-25	NR	18-25
Scrub room				
Pressure	NR	5	Negative	14
ACH	NR		NR	
Relative humidity %	NR	35-60	NR	35-60
Temperature	NR		NR	18-25
Soiled workroom / holding room				
Pressure	Negative	-5	Negative	-5
ACH	10	>20	NR	>20
Relative humidity	NR	NR	NR	NR
Temperature	NR	NR	NR	NR

NR: No Recommendation

3.4 Ultra Clean Ventilated (UCV) Operating Theatre

A recent meta-analysis showed no benefit for laminar airflow compared with conventional ventilation of the operating room in reducing the risk of surgical site infections (SSIs) in total hip and knee arthroplasties, and abdominal surgery. This corroborated earlier studies that used data from the German National Nosocomial Infections Surveillance System or "KISS," where the univariate analyses revealed higher SSI rates in departments with laminar airflow ventilation (as compared with conventional OT ventilation) with the multivariate analyses confirming the tendency toward a higher SSI risk in laminar airflow ventilated OTs.

The WHO Guidelines on Prevention of Surgical Site Infection (2016) had recommended that laminar airflow ventilation systems in the context of the operating theatre

a 1 m3 sample and mounted in the centre of the room approximately 1 m above floor level should then be activated remotely. Aerobic cultures on nonselective media should be performed.

[2] Criteria for internal noise from mechanical and electrical services. The noise rating (NR) should take into account noise in the octave band range from 63 Hz to 4 kHz.

should not be used to reduce the risk of SSIs for patients undergoing total arthroplasty surgery (conditional recommendation, low to very low quality of evidence). As such, we do not recommend the installation of UCV theatres at the present time.

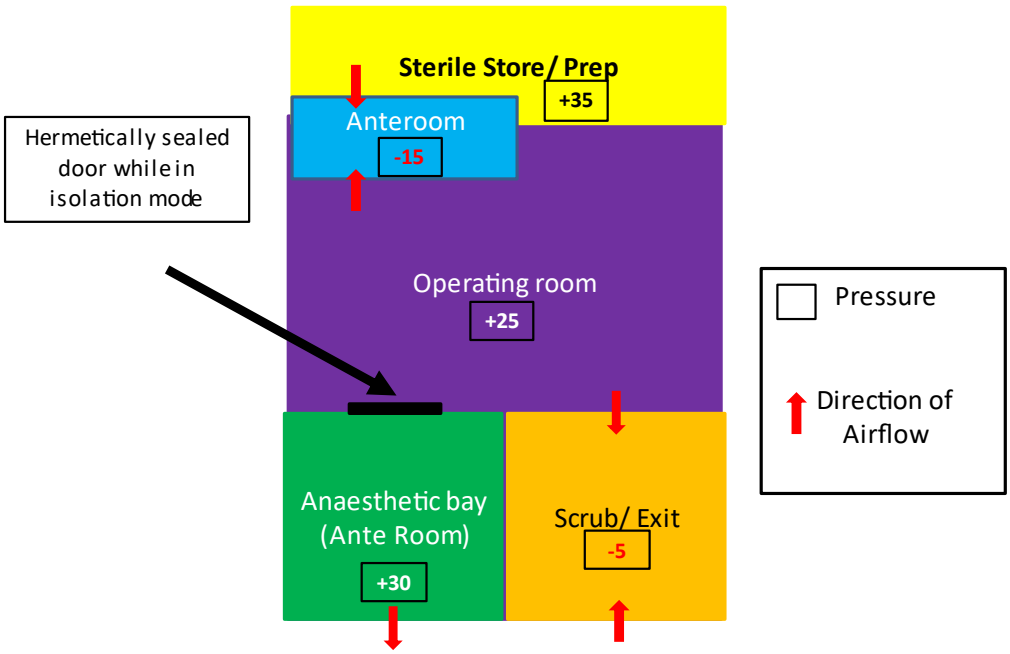
3.5 Isolation OT

The COVID-19 pandemic has highlighted the need to safely manage patients with infections (airborne, droplet and contact). The approach that should be undertaken should be a holistic one that takes into account safe transfer of the patient to the OT from other areas of the hospital, routes within the suite to the designated OT used, PPE use and stepped-up cleaning measures as necessary, as well as scheduling cases at the ned of the list where practical to allow for the thorough cleaning of the OT as well as possible deployment of adjuvant cleaning methods. The emphasis in this section, however, will discuss mainly the airflow and pressure aspects of such an OT.

The use of negative pressure environments within an operating theatre is not an option as the air handling system needed to prevent surgical site infections is positive. The American Institute of Architects (AIA) and the American Society for Healthcare Engineering (ASHE) recommend that air flow should be designed to create positive pressure in the operating room relative to areas outside the OT to prevent the entry of common pathogens (e.g., *Staphylococcus aureus*) that could contaminate an open wound. These basic requirements are the standard for all patients receiving care in the OT. Therefore, it may be necessary to adjust air-pressures in the rooms surrounding the OT, including the set-up of an anteroom as required to obtain direction of airflow that prevents egress into the clean and dirty corridors. Consideration of how these rooms may be used may also have to be adjusted. An example is provided below.

Creating a negative pressure anteroom to the OT can help control the movement of contaminated air and is a fairly simple modification which can either be temporarily or permanently constructed. This anteroom need not be large but should be able to manoeuvre a bed into the OT and also hold a small air handling unit if it is built into an existing OT. Locating the anteroom near a return air duct simplifies the routing of the air handling duct work. These rooms can be designed in a hallway with self-closing doors which can allow personnel to walk through the area. If an anteroom is deployed, then other doors to the OT should be sealed to airflow.

Figure 3.4: Example of Isolation OT design



Some institutions may choose to design an isolation OT that can be "flipped" to isolation mode so that under normal circumstances, to increase efficiency, these theatres can be used for other cases as well. However, "flipping" whenever possible should be kept to a minimum, if unavoidable. Occasional testing of the system and the use of a smoke test to document directional flow is a useful technique to check that the airflow is as it should be. Care must also be taken to ensure that a process to check the pressures in the isolation OR is done before the patient arrives. Alternatively, a portable negative pressure anteroom may be installed, when required.

Another consideration for such OTs in terms of ventilation is the use of a Bag In/Bag Out (BIBO) filter system which serves as a safe, simple, reliable method for removing contaminated particulate filters and/or gas absorbers used for air purification in hazardous environments. These systems protect maintenance personnel from coming in direct contact with the interior of the housing and hazardous contaminants during filter change-out.

3.6 Commissioning reports for Conventional OT

If in-house staff do not possess the necessary qualification to undertake the process, an accredited and qualified Authorised Person (3rd party) appointed by the client should carry out the validation of theatre ventilation systems.

The report should conclude with a clear statement as to whether the ventilation system achieved or did not achieve the required standard. A copy of the report should be lodged with the following groups:

a) The end user department;
b) Infection prevention and control; and
c) Facilities management.

3.6.1 Maintenance following commissioning

All OT systems will be continuously monitored with regular recorded readings of room pressure differentials, temperature, and humidity. Conventional OTs shall be retested every 2 years, or earlier if problems arise. The schedule of maintenance and filter change frequency is dependent on air quality and the type of filter purchased as well as the primary and secondary filters used.

3.7 Devices that generate airflows

There is now a sizeable amount of evidence that highlights the risks associated with devices that generate airflows in the operating room. There is usually no contingency plan that takes the use of these devices into account when initially designing operating room air management systems.

Heater-cooler systems used in cardiothoracic surgery is one such example. Outbreaks of *Mycobacterium chimaera*, thought to be due to disruption of vertical airflows in ultraclean OTs by the horizontal airflow generated by these units contaminated by these pathogens is thought to be a potential mechanism for transmission to surgical sites. Positioning heater–cooler units away from the surgical field, and removal of the exhaust air by a secondary housing which reliably channels the air to the operating room exhaust should be considered if direct exhaust of air.

3.8 PACU

A post-anaesthesia care unit (PACU), sometimes referred to as post-anaesthesia recovery (PAR), is normally attached to OT suites, designed to provide care for patients recovering from anaesthesia, whether general, regional, or local. The recommendation is for a minimum of 6 ACH total for recovery rooms with a minimum of 2 ACH outdoor air. The temperature in the room must be 21-24°C, with relative humidity ranging from 40-60%. The PACU must be positively pressurized in relation to the corridor. Care must be taken to ensure air velocities in the occupied zone, especially around the patients, does not exceed 0.25 m/s to avoid complaints of drafts. Return or exhaust air inlets must be located in the sidewall near the floor, similar to the placement of OR returns. A centralised induction area is not recommended due to increased risk of potential infectious pathogenic airborne exposure.

3.9 References

Achermann Y, Rossle M, Hoffmann M, Deggim V, Kuster S, Zimmermann DR, et al. (2013).

Australasian Health Facility Guidelines Part B - Health Facility Briefing and Planning 0520 – Operating Unit, Revision 6.0, 5 July 2018

Benedetta A., Bassim Z., Bischoff, P., Kubilay, NZ., Jonge S. et al. (2016). New WHO recommendations on intraoperative and postoperative measures for surgical site infection prevention: an evidence-based global perspective. Lancet Infect Dis; 16: e288–303.

Bischoff, P. Zeynep NK., Allegranzi, B., Egger, M., Gastmeier. P. (2017). Effect of laminar airflow ventilation on surgical site infections: a systematic review and meta-analysis. The Lancet Infectious Diseases. Published online February 16, 2017 http://dx.doi.org/10.1016/S1473-3099(17)30059-2.

Centers for Disease Control and Prevention (US Centres for Disease Control and Prevention). (2008). Guideline for the prevention of Surgical Site infection.

Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee (HICPAC). (2003). Guidelines for Environmental Infection Control in Health-Care Facilities.

Cowles C E, Feldman J, Kaplan M B. Recommendations for OR Ventilation during the SARS COV-2 Pandemic – Staying Positive. Anaesthetic Patient Safety Foundation Newsletter 36(1), Feb 2021.

DIN 1946-4 Ventilation and air conditioning - Part 4: VAC systems in buildings and rooms used in the health care sector, December 2008. EN/ISO 14644-1: 2015

Gastmeier P, Breier AC, Brandt C. (2012). Influence of laminar airflow on prosthetic joint infections: a systemic review. J Hosp Infect; 81:73-78.

Guidelines for Design and Construction of Hospital. The American Institute of Architects, 2022 Edition.

Health Technical Memorandum 03-01: Specialised ventilation for healthcare premises. Part A - Design and installation, 2007.

Health Technical memorandum 08-01: Acoustics, 2013.

Health Technical Memorandum 03-01: Specialised ventilation for healthcare buildings, 2021.

International Health Facility Guidelines, Part B, D, E– Health Facility Briefing & Design 235 Operating Unit Version 5.1 May 2017

Kohler P, Kuster SP, Bloemberg G, Schulthess B, Frank M, Tanner FC, et al. (2015). Healthcare- associated prosthetic heart valve, aortic vascular graft, and

disseminated *Mycobacterium chimaera* infections subsequent to open heart surgery. Eur Heart J; 36:2745–53.

Lidwell OM, Lowbury EJL, Whyte W, et al. (1982). Effect of ultraclean air in operating rooms on deep sepsis in the joint after total hip or knee replacement: a randomised study. BMJ;285:10-14.

Nagpal A, Wentink JE, Berbari EF, Aronhalt KC, Wright AJ, Krageschmidt DA, et al. (2014). A cluster of *Mycobacterium wolinskyi* surgical site infections at an academic medical center. Infect Control Hosp Epidemiol.;35:1169–75.

Ninomura P, Bartley J. (2001). New Ventilation Guidelines for Health-Care Facilities. ASHRAE Journal ;29-33.

Pada S., Perl T. M. (2015). Operating room myths: what is the evidence for common practices. Curr Opin Infect Dis, 28:369–374.

Prosthetic valve endocarditis and bloodstream infection due to *Mycobacterium chimaera*. J Clin Microbiol.; 51:1769–73.

Sax H, Bloemberg G, Hasse B, Sommerstein R, Kohler P, Achermann Y, et al. (2015). Prolonged outbreak of *Mycobacterium chimaera* infection after open-chest heart surgery. Clin Infect Dis.; 61:67–75.

Sommerstein R, Rüegg C, Kohler P, Bloemberg G, Kuster S P, Sax H. (2016). Transmission of *Mycobacterium chimaera* from Heater–Cooler Units during Cardiac Surgery despite an Ultraclean Air Ventilation System. Emerging Infectious Diseases; 22(6):1008-1013

Ventilation of Health Care Facilities ANSI/ASHRAE/ASHE Standard 170-2021.

CHAPTER 4 CENTRAL SUPPLY AND STERILISATION DEPARTMENT

The goals of safe reprocessing of medical equipment/devices include preventing transmission of microorganisms to personnel and patients, minimizing damage to medical equipment/devices from foreign material (e.g., blood, body fluids, saline and medications) or inappropriate handling.

Processing potentially infected equipment also presents a hazard to medical staff. The procedures for cleaning and disinfecting these materials should therefore include protective measures for those who handle them.

4.1 Why centralize?

Centralizing the activities of receipt, cleaning, assembly, sterilization, storage and distribution of sterilized materials from a central department aims to ensure safe sterilization under controlled conditions with adequate managerial and technical supervision at an optimum cost. This provides an efficient, economic, continuous, and quality supply of sterilized material to various areas of the hospital so as to deliver safe patient care. Having a defined area with allocated staff to do sterilisation and reprocessing reduces this burden of work from nursing personnel, enabling them to devote more time to direct patient care.

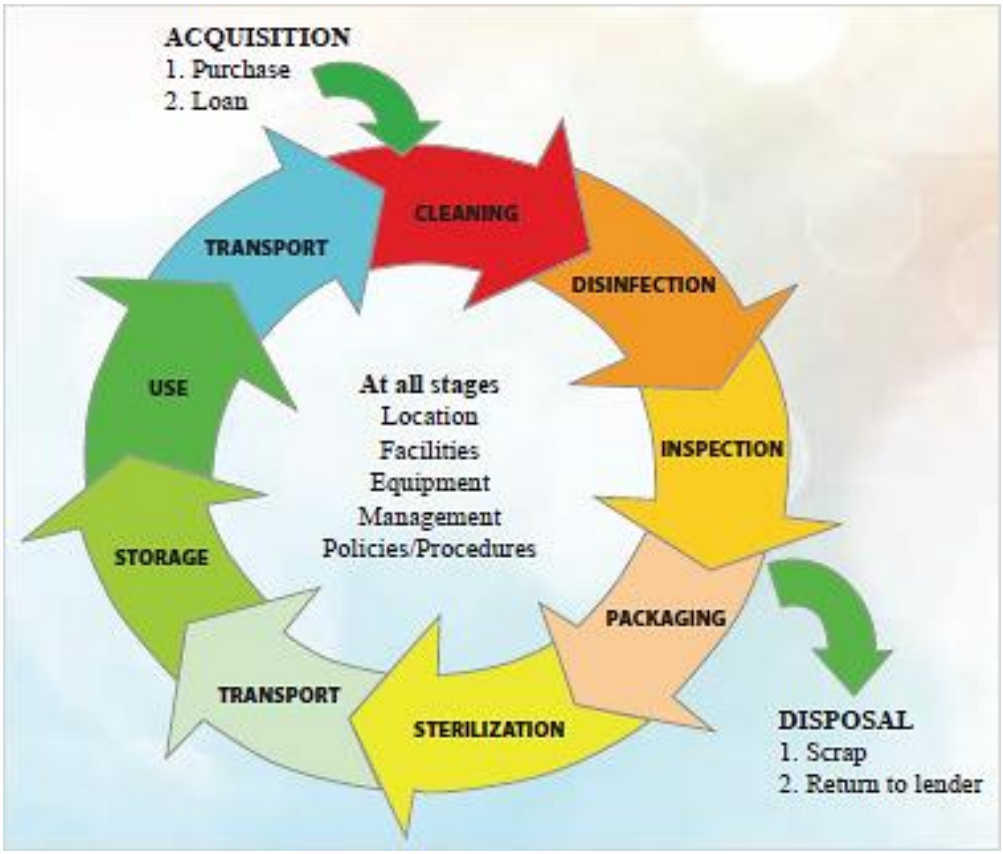
Larger healthcare institutions should have a centralized area for reprocessing medical equipment / devices. In smaller settings, such as clinics or offices in the community, centralized sterilization may be done in a dedicated segregated area where reprocessing of equipment / devices takes place away from clients/patients/residents and clean areas.

In some larger hospitals, there may be several separate sterilization departments, i.e. Theatre Sterile Supply Unit (TSSU), decentralised sterilisation units, relatively small units located close to where the instruments may be used. This reduces time and distance to move sterilised instruments or equipment to where they are to be used.

Reprocessing performed outside the medical device reprocessing centre must be kept to a minimum and must be approved by the reprocessing committee or those accountable for safe reprocessing practices and must conform to the requirements for reprocessing space.

In designing or planning the layout of a CSSD, one needs to understand the steps in the process of decontamination leading to packing of cleaned instruments and their distribution (see Figure 4.1).

Figure 4.1: The Decontamination Life Cycle



Source: HBN 13, Sterile Services Department, Department of Health, UK

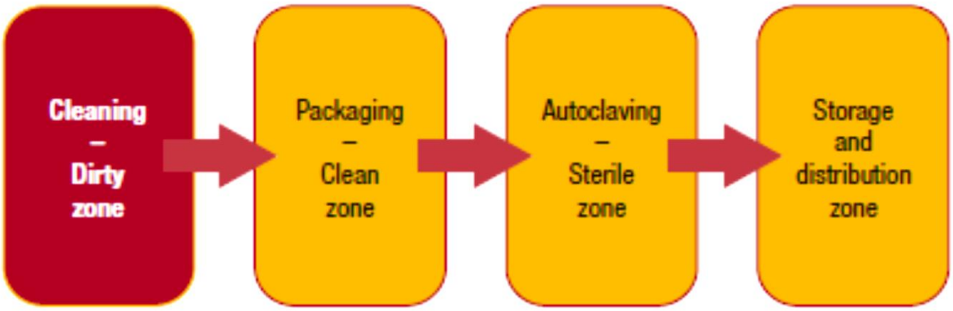
The lay out follows the above workflows, and keeping with the following designing principles:

a) There is no back tracking of sterile goods;
b) One-way movement from receiving counter to issue counter;
c) Sterile area should be prior to sterile storage and issue;
d) The receiving counter must be away from the issue counter.

While there have been significant changes to the equipment being reprocessed/ sterilized now compared to a few decades ago, the steps in workflow have remained largely similar (see Figure 4.2 below). The layout of any CSSD still follows a basic pattern for optimum flow of instruments/equipment.

The location of the CSSD needs to be carefully evaluated to avoid no wet areas / sanitary pipes running above the ceiling at any part of the CSSD, including the decontamination area.

Figure 4.2: Optimum Flow of Instruments/Equipment



Source: Sterilization Guidelines, International Committee of the Red Cross

4.2 Functional areas

These are segregated into 3 zones:

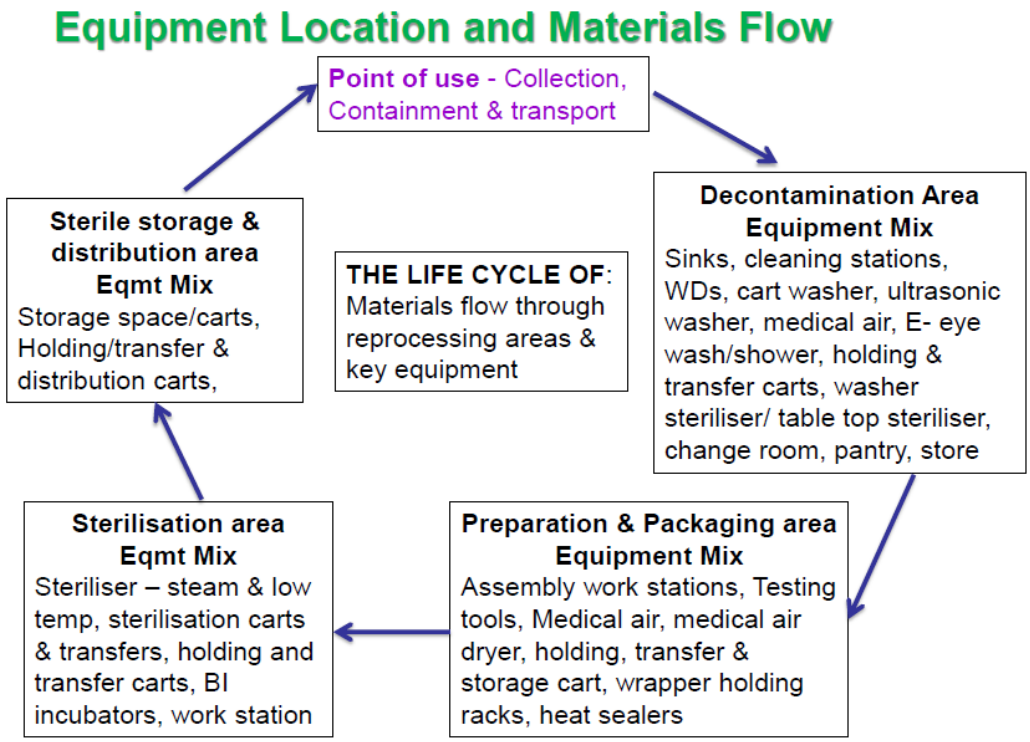
a) Dirty zone
   i. Disassembly (if required);
   ii. Receiving area;
   iii. Cleaning, rinsing (decontamination area);
   iv. Trolley washing area;
   v. Drying / aeration.

b) Clean zone
   i. Inspection area;
   ii. Assembly and packing area;
   iii. Sterilising and cooling.

c) Sterile zone
   i. Sterile store.

See Figure 4.3 below for the flow of materials through the zone**.**

Figure 4.3: Equipment Location and Materials Flow



4.2.1 Dirty Zone

Decontamination work areas should be physically separated from clean and other work areas by walls or partitions to control traffic flow and to contain contaminants generated during the stages of cleaning. Walls at Decontamination area – should be homogeneous with no grouts – to prevent growth of moulds, water pooling. Walls or partitions should be cleaned regularly and be constructed of materials that can withstand cleaning and disinfection.

Decontamination sinks should:

a) Be designed and arranged to facilitate soaking, washing and rinsing of equipment / devices with minimal movement or delay between steps;
b) Be adjacent to waterproof counter tops and a backsplash;
c) Not have an overflow;
d) Be at a height that allows workers to use them without bending or straining;
e) Be large enough to accommodate trays or baskets of instruments;
f) Be deep enough to allow complete immersion of larger devices and instruments so that aerosols are not generated during cleaning;
g) Be equipped with water ports for the flushing of instruments with lumens, if appropriate.

Hand hygiene facilities should be readily accessible and located in all personnel support areas and at all entrances and exits of the decontamination area. Hand hygiene facilities should include:

a) General handwashing basins, soap dispensers and paper towels; and / or
b) Alcohol-based hand rub (ABHR).

4.2.2 Clean zone

This consists of:

a) Inspection, Packaging, and Assembly Area; and
b) Sterilization and cooling Area.

The choice of method for reprocessing and sterilization / disinfection will determine the equipment to be used and in turn impact the space requirements and layout of the clean zone.

4.2.3 Sterile zone

The sterile storage area should be located adjacent to the sterilisation area, preferably in a separate, enclosed, limited-access area. Requirements for this sterile storage area include:

a) Containers used for storage of sterilised devices should be moisture-resistant and easily cleaned. Corrugated boxes are not suitable for use as a container as they shed lint, and potentially may harbour pests or parasites;
b) Devices are stored in a well-ventilated, clean, dry, dust-free area (closed shelves preferably), not at floor level, and at least one meter away from debris, drains, moisture, and vermin to prevent contamination;
c) Sterile items are stored at least 20-25 cm above the floor, at least 45 cm below the ceiling or sprinkler heads, and at least 5 cm from outside walls.
d) Supplies and materials used for reprocessing should not be stored in sterile storage area.

4.3 Environmental Conditions

The recommendations for temperature and humidity are:

a) Room temperature of all decontamination work areas should be between 18-20 °C and between 20-23 ^{0}C for clean areas;
b) Relative humidity should be maintained between 40-60% and be monitored daily;
c) An independent humidity monitor that is calibrated regularly should be used in each sterile storage area;

d) If humidity increases such that sterile packages become damp or wet (e.g., > 70%), the integrity of the package may be compromised.

4.4 Air quality

Wherever chemical disinfection/sterilization is performed, air quality shall be monitored when using products that produce toxic vapours and mists.

The air quality of the CSSD should be compliant with ANSI/ASHRAE/ASHE Standard 170-2013, HTM 03-01 and SS 553. Clean areas and sterile storage areas should be air-conditioned with HEPA filtration. Filtered air should be discharged directly to the outside. The packing area should have localised high-level extraction for heat removal. Sterilisation and cooling areas should have an exhaust installed over the opening faces of the steriliser(s) for extraction of steam and heat. The sterile store should have ventilation, humidity and temperature control. Recommended pressure requirements between areas are as follows:

a) Sterile: ++ve pressure to adjacent areas;
b) Clean: +ve pressure to adjacent areas;
c) Dirty: -ve pressure to adjacent areas.

See Table 4.1 below for further details.

Local exhaust ventilation systems should be available to adequately protect staff from toxic vapour. Excessive humidity may compromise sterile wrappings.

Table 4.1: Design parameters (Example from ANSI/ASHRAE/ASHE standard 170-2008)

Location	Pressure relationship to adjacent areas	Minimum outdoor ACH	Minimum total ACH	All room air exhausted directly to outdoors	Air re-circulated by means of room units	Relative humidity (%)	Temperature (^{0}C)
Cleaning room	Negative	2	6	Yes	No	No require-ment	22-26
Clean workroom	Positive	2	4	No require-ment	No	Maximum 60	22-26
Sterile storage	Positive	2	4	No require-ment	No requireme nt	Maximum 60	22-26
Steriliser equipment room	Negative	No require-ment	10	Yes	No	No require-ment	No require-ment

Note: There should be a minimal pressure difference of 2.5 Pa to the adjacent area. See proposed pressure readings in Appendix 4-1.

4.5 Water quality

Water used in the processing area should be tested and be free of contaminants. Water quality can be a significant factor in the success of decontamination procedures. In addition to issues of mineral content (hardness or softness), piped water supplies can also introduce pathogens and unwanted chemicals to decontamination processes. Manufacturers of medical equipment/devices, decontamination equipment and detergents should be consulted regarding water quality requirements.

To minimise wet packs, instrument staining and chamber scale/rouge, steam quality is critical. Water source for steam should be from purified water (either distilled or reverse osmosis treated water). For optimal steam penetration, steam should be dry and consist of 97% vapor and 3% liquid.

Water should appear colourless, clean and without sediment. Limiting values of water contaminants:

a) pH: 6.5 to 8;
b) Evaporation residue: ≤15 mg/L;
c) Conductivity: ≤ 50 µs/cm;
d) Hardness: ≤ 0.1 mmol/L.

4.6 Protection of Staff

It is important to ensure the following:

a) Hand hygiene facilities are located at all entrances and exits of reprocessing areas. Faucets should be supplied with foot-, wrist- or knee-operated handles.
b) An eyewash fountain is installed for washing of eyes when in contact with a biological or chemical agent.
c) Personal protective equipment must be available and appropriately stored in a location easily accessible to staff.
d) Eating/drinking, storage of food, smoking, and application of cosmetics or lip balm and handling contact lenses in the reprocessing area are not permitted.
e) There is no storage of personal effects, including food and drink, in the reprocessing area.

4.7 References

APSIC guidelines for disinfection and sterilisation of instruments in health care facilities (2017).

Provincial Infectious Diseases Advisory Committee (PIDAC). (2013). Public Health Ontario. Best Practices for Cleaning, Disinfection and Sterilization in All Health Care Settings, 3rd Edition.

UK Health Technical Memorandum 03-01 (2021). Specialised Ventilation for Healthcare Buildings.

UK Health Building Note 13 (2021). Planning and design of sterile services departments.

Centre of Disease Control (CDC, USA) (2003). Guideline for Environmental Infection Control in a Health Facility.

Appendix 4-1: Proposed Design Pressure for Commissioning

Dirty Zone	Clean Zone	Sterile Zone
-5 Pa (-2.5 Pa)*	+10 Pa (+5 Pa)*	+5 Pa (+2.5 Pa)*

** min. pressure difference to adjacent areas*

Note: As pressure difference is relative to the Pascal readings of adjacent rooms, the guidelines focus on the principle i.e. whether the room is positive or relative to adjacent area. Users should decide on degree of positivity or negativity e.g. minimum is 2.5 difference but 5 could be preferred. Do note that there is a limit as too big a pressure difference will mean that it would be difficult to open the doors.

CHAPTER 5 ENDOSCOPY UNIT

The aim of an endoscopy facility is to provide high quality diagnostic and therapeutic endoscopy services. Endoscopy units may be sited in acute hospitals or be stand-alone facilities.

5.1 Types of Procedures

Endoscopy units are used mainly for gastrointestinal procedures including gastroscopy, Endoscopic retrograde cholangiopancreatography (ERCP) and colonoscopy. In some centres, they may also be used for urological procedures such as cystoscopy and respiratory procedures such as bronchoscopy.

5.2 Location

Endoscopy units may be sited in acute hospitals or be stand-alone facilities as most endoscopies are carried out on a day-stay basis. Having dedicated endoscopy units allows for greater convenience for patients and less disruption to other hospital services and more efficient use of resources by scheduling groups of similar procedures together.

In the acute hospital setting, where possible, the endoscopy unit should be sited close to the emergency room, intensive care facility, acute wards, and the operating room, in order to facilitate safe endoscopy. It is recommended that reprocessing of endoscopes is centralised and performed by trained and competent staff. Of note, there should be no sewage (including open-to-sky landscape areas) and water pipes running above and across all procedure rooms (including operating theatres/suites), clean utility/storage rooms.

Endoscopy units whether in-hospital or stand alone should be located in a space where they do not open into a public waiting room or a high-traffic public corridor. Access to endoscopy units' rooms should be restricted to patients or staff working in the endoscopy unit.

If a unit needs more than 200–500 X-ray screenings a year, then it would be advisable to have its own X-ray machine with appropriate storage facilities.

5.3 Size

The size of the unit has to take into considerations the procedures being done. Certain procedures will require radiology support and lead lining. Endoscopic procedure rooms will vary in size, with more complex procedures, such as endoscopic retrograde cholangiopancreatography (ERCP), requiring greater space for more specialized equipment and possibly additional staff. Other factors to consider would be requirement for anaesthetic support and necessary machines.

The endoscopy unit may need to factor a requirement for bronchoscopy or change in type of procedures as well as an increase in workload caused by the introduction of new referral guidelines, increase in screening programs or change in population patient profile.

Each area within the endoscopy unit should have a designated flow for the safe physical movement of dirty endoscopes that does not cross-contaminate clean endoscopes coming out of the cleaning process and their storage. Table 5.1 presents the design parameters for the endoscopy unit.

Table 5.1: Design Parameters for Endoscopy

Area	Pressure relationship to adjacent rooms	Minimum air changes of outdoor air per hour	Minimum total air change per hour	Relative humidity (%)	Temperature (^{0}C)
Reprocessing area	Negative	2	10	No requirement	No requirement
Gastrointestinal endoscopy procedure room	No requirement	2	6	40-60	21-24
Bronchoscopy * suite	Negative	2	12	40-60	21-24

Note: There should be a minimal pressure difference of 2.5 Pa to the adjacent area.

** The suite should be air-sealed (pertains to closed doors and surface joints) to minimize infiltration for optimal ventilation control and the exhaust air should not be recirculated unless the exhaust air is first processed through a HEPA filter.*

5.4 Layout

5.4.1 Functional organization

The key zones for functional areas are:

a) Public areas;
b) Consult / preparation areas;
c) Procedural areas;
d) Reprocessing areas;
e) Clinical support areas;
f) Administration, staff welfare, training, educational and research areas.

The patient's journey through the endoscopy unit can be separated into the following areas:

a) Entrance / exit;
b) Reception and waiting;
c) Preparation for the procedure;
d) Procedure;
e) Recovery and discharge.

5.4.2 Entrance / Exit

If the endoscopy unit is in a hospital, then ideally, there should be separate entrances for inpatients and outpatients. Inpatient entrances should be wide enough to allow for passage of patients in beds or trolleys. Outpatient entrances should be accessible for disabled or wheelchair patients. Entrances and exits should be clearly signposted.

5.4.3 Reception and waiting area

The reception area accommodates the initial processing and admission of all scheduled and unscheduled patients. It should be spacious enough to avoid a sense of overcrowding and provide an open, friendly facility. Patients' escorts and staff must be able to talk and exchange information with ease while ensuring safety measures management and patient confidentiality.

The reception desk should be adjacent to the general administrative office and close to the main waiting area. The administrative office should be large enough to accommodate administrative staff, as well as storage of the necessary health records. There should be adequate telephone, fax, and internet facilities for communication, booking and audit activities.

Staff will be managing the assessment and preparation of patients prior to their procedure. The staff base should thus be sited for easy access to patient records and nursing assessment forms as well as to oversee the patient changing rooms and sub-wait areas.

The waiting area should be able to accommodate sufficient distancing between seats and should factor in the need for wheelchair-bound patients and trolley-bound patients.

5.4.4 Preparation for procedure

Changing rooms are required where a patient can undress in privacy and put on theatre clothing. Intake rooms (or cubicles) are needed for patients to give their medical history, allow baseline observations to be carried out and enable confidential discussions with the staff; for example, taking informed consent.

Patient preparation rooms should be adjacent to the main waiting area and be provided with toilet facilities. There should be easy access from the patient preparation rooms to the endoscopy rooms. The number of patient preparation rooms will depend on the throughput of

the endoscopy rooms. Generally, one patient preparation room for each endoscopy room will be adequate, with an additional one containing a trolley for non-ambulatory patients.

Pressure on the number of patient preparation rooms resulting from fast throughput of patients will be relieved by the inclusion of a sub-wait area. The width of the entrance and corridors should be broad enough to allow for the transportation of beds, stretchers and wheelchairs and allow for beds to turn around in corridors. Two separate entrance/exit doors should be provided to allow for the entry of clean instruments and for the removal of used endoscopes at the end of the procedure.

With respect to space requirements, the following are specifications for the area:

a) Patient Bays: a minimum clear floor area of 9 m^2 shall be provided for each patient in a lounge chair or stretcher;
b) Cubicles: each station shall have a minimum clear floor area of 9 m^2;
c) Single-bed rooms: a minimum clean floor area of 9 m^2 shall be provided in each room.

With respect to space requirements on clearance:

a) Patient Bays: a minimum clearance of 2 m shall be provided between the sides of patient beds/stretchers; 1.2 m between the sides of patient beds/stretchers and adjacent walls or partitions; and 900 mm between the foot of the bed and the cubicle curtain;
b) Patient Bays: an aisle with a minimum clearance of 2.4 m independent of the foot clearance between patient stations or other fixed objects shall be provided;
c) Cubicles and Single-bed rooms: a minimum clearance of 2 m shall be provided between the sides and foot of lounge chairs/stretchers and adjacent walks or partitions.

Handwash stations should be evenly distributed for use. The patient's toilet should be separate from public use and be directly accessible by patients.

5.4.5 Procedure

The room should be laid out into two main areas, the endoscopes area, and the assistant area. Each procedure room shall have a minimum clear floor area of 15 m^2. Room arrangement shall permit a minimum clearance of 2 m at each side, head, and foot of the stretcher/table.

The endoscopes area should include clinical hand-wash facilities and a small office workstation where the endoscopes may sit to dictate, write or enter endoscopy findings or post-procedure instructions.

The assistant area should include a work surface with inset sink, and units for the storage of endoscope accessories, small quantities of clean and sterile supplies and drugs, including the temporary storage of controlled drugs. There should be direct access from the assistant area to the endoscope cleaning room to facilitate the reprocessing of endoscopic equipment.

The endoscopy procedure room should be purpose-designed to accommodate, but not limited to the following:

a) Endoscopy stack and video monitor(s);
b) Endoscope cabinet with clean endoscopes and accessory equipment such as endoscopy biopsy forceps, snares, injectors to allow for endoscopes to hang without coiling, preventing damage to either end of the scope, and properly ventilated with temperature and humidity controls, preferably a pass-through type, located between decontamination/sterilizing areas and operating/procedure room;
c) Monitoring equipment to allow continuous monitoring of patient condition during procedures;
d) Anaesthetic equipment and medication to provide procedural sedation;
e) Diathermy and/ or argon plasma coagulation equipment;
f) Imaging equipment, such as image intensifier or C-Arm X-Ray screening unit, depending on procedures to be performed; imaging equipment should be portable or installed in room.

There should be considerations for the special requirements of imaging and laser equipment, if required.

The procedure room for endoscopy will require direct access to the clinical scrub-up area, clean-up, and decontamination area for rapid processing of endoscopes and their storage.

The width and height of the doorways to operating/procedure should ensure that transportation of equipment is not impeded, and the patient trolley/bed movement is not hampered, with a minimum clear opening of 1.5 m. The doors should be automatic and fitted with wave sensors.

All scrub-up/ gowning rooms should be located with direct access to the procedure rooms. To avoid contamination, the door(s) between adjacent procedure room and scrub-up

room should have a non-contact mechanism for operation. The scrub-up/ gowning room should be sized to accommodate several staff scrubbing, gowning and moving simultaneously without any risk of contamination from each other or surrounding fixtures. The fixtures in the scrub-up/ gowning room should meet the following requirements:

a) The chemical and stain resistant stainless-steel trough and fixtures should be wall mounted for hand and arm washing;
b) Efficient drainage in the trough should be provided to avoid spills onto the floor during the scrub-up procedures;
c) The rim of the scrub trough should not have an internal lip as dirty water may drain from the elbows into the sink. Debris may also be potentially trapped under rims with internal lips which cause risk of infection. The wall surface behind the trough should be a single waterproof surface;
d) Provide hands-free activation taps for washing.

5.5.5.1 *Bronchoscopy suite*

The reports documenting healthcare-acquired tuberculosis had highlighted the importance of appropriate placement of patients with potential airborne disease in rooms with engineered control ventilation to prevent the spread of the disease to other patients[6, 7 and 8]. Bronchoscopy is one of the diagnostic procedures indicated for identifying active pulmonary tuberculosis[8]. As such, a room designated for bronchoscopy should be engineered according to the requirement required for patients with AII (airborne infection isolation) disease[6]. The room should have negative pressure difference in relation to adjacent areas and be supplied with air at 12 air exchanges per hour[6]. Refer to Table 5.1 for further details. On-going digital display monitor of the pressure differential readings and personal protective equipment cabinet should be installed outside the procedure room. This is to allow staff to check that the pressurization of the room is functioning well and to put on respirator before entering the room. Air flow to other rooms is recommended to be negative (6 ACH) for odour control as well as to contain leakage of anaesthetic gases.

5.4.6 Others

There should be sufficient space for equipment to monitor patients e.g. pulse oximeter, sphygmomanometer, and ECG machines. All rooms should have facilities for piped oxygen and suction and adequate electrical socket outlets for ancillary equipment. Consideration should be given to providing appropriate services on ceiling-mounted pendants and to locating CCTV camera links to the seminar room.

A reliable and adequate source for oxygen is required. Sources may include in-wall or free-standing oxygen. In some units, carbon dioxide may be used for insufflation of the

gastrointestinal lumen, but this is not a requirement. A suction source for the equipment and patient must be present either in-wall or portable. An uninterruptible source of power supplied either by a generator or battery source is required.

The purpose of a secondary power source is to finish the current procedure in the event the primary power source malfunctions. There should be adequate space in the intervention room, especially for fluoroscopic or other portable devices or carts. Planning for general anaesthesia should focus on providing adequate space for anaesthesia staff and equipment at the head of the bed and for storage of anaesthesia equipment.

If an image intensifier is to be used, space must be allowed to manoeuvre and position the equipment. There should be adequate space to store lead aprons worn by staff.

Puncture resistant containers for biohazardous materials and sharps should be located so that sharps are not passed over the patient. If special therapeutic procedures are planned, specific room features may be required, such as leaded walls when flat table fluoroscopy is utilized.

5.5 Recommendation for Storage of Supplies

Sterile supply items such as intravenous (IV) solutions should be protected from splash contamination during environmental cleaning (10 to 25 cm off the floor), damage from compression (stacking only ridged containers), and water damage (no storage under sinks).

5.6 Endoscope cleaning, reprocessing room, and storage

Endoscope and instrument processing is a multi-step procedure involving:

- Decontamination / intake of dirty scopes/ instruments as soon as the procedure is complete.
- Sterilisation of scopes/instruments in the reprocessing room, with an autoclave to sterilize accessory instruments (if it is not feasible to send the accessories and instruments to a centralized sterile supplies department for reprocessing).
- Packaging and storage of clean scopes, for reuse in the procedure room(s).

An endoscope cleaning room and storage area should have a ‘dirty’ or ‘contaminated’ area where used equipment can be manually cleaned and tested and a separate ‘clean’ area where equipment can be disinfected and stored. These areas should be in a space that are separated from procedural areas. The layout should ensure a “one way” workflow that separates contaminated workspaces from clean work spaces. In addition, these areas may be separated by ‘pass through’ automatic endoscope reprocessor (AER). If a separate room

is used for manual cleaning of endoscopes, ensure a directional airflow that maintains negative pressure within that room relative to adjoining spaces.

Depending on local policy, endoscope accessories may be sterilized, and suction bottles may be automatically emptied, washed, and disinfected; alternatively, these items may be sent to the Sterile Services Department (SSD) for reprocessing. The 'dirty' area should be equipped with at least one double sink unit and a double drainer, a work surface and low-level cupboards for the storage of a working supply of consumables (such as enzymatic detergent). A handwashing facility should also be provided.

A space should be provided for leak testing to be performed after pre-cleaning and prior to reprocessing. Sinks should be supplied with washing hoses to allow adequate rinsing.

The 'clean' area of the endoscope cleaning room should contain the AER, the number of which will be dictated by the number and throughput of rooms. The area should include storage areas for the decontamination solutions and appropriate personal protective equipment. This area should have negative pressure ventilation and fulfil the local health and safety ventilation requirements required for the specific decontamination solutions in use and adequate clinical and handwashing facilities. The clean area should be adjacent to the storage area for flexible endoscopes and reusable accessories. If purpose-designed drying cabinets are going to be used, adequate space should be allotted.

The endoscope cleaning room 'dirty' area and 'clean' storage area should have separate direct access from the rooms, preventing cross-over of 'dirty' and 'clean' endoscopes. Clean and dirty utility rooms are ideally placed with easy access from both the preparation and recovery areas. The dirty utility area should be fitted with a sluice sink, a sink unit with drainer, a hand-washing facility, a work surface, cupboards and shelves. There should be a minimum gap of 1m between the decontamination and work areas, and of 2 m between sinks and work areas. The design of the work areas should consider the workflow of reprocessing to ensure minimal criss-crossing between staff and safe distancing between staff.

Storage for clean scopes should be located in a clean room, within a HEPA filtered cabinet with control of humidity and temperature and features to allow safe placement of scopes. Space and utility connections should be made available for AERs, sonic cleansers and sterilisers.

Space should be allocated for the following cleaning and disinfection equipment to be installed:

a) Decontamination and reprocessing sinks - Sinks for soaking and rinsing, sufficiently sized to prevent tight coiling of the endoscope which may damage the fibre-optic cables in the instrument;
b) Ultrasonic cleaner for accessory equipment used in procedures;
c) Automated endoscope cleaning/ disinfecting machines;
d) Compressed air to aid drying of endoscopic equipment after cleaning;
e) Handwash basin that is separated from decontamination and reprocessing sinks;
f) Safety eyewash facility either self-contained or plumbed;
g) Designated space to ensure readily access to information essential for reprocessing[5] (e.g., Instruction for Users for the reprocessing of endoscopic equipment, and Safety Data Sheets for chemical used to reprocess endoscopes).

Note: Eyewash facility should not be installed in a location that requires flushing of the eyes in the decontamination sink.

5.7 Recovery areas

Various arrangements for patient recovery may be in place in different institutions. When the number of procedures is small to moderate, all the patients may be in a single location post-procedure. For endoscopy units with greater volumes of patients and procedures, having a design that allows for a two-stage recovery may be more efficient.

Units with a two-stage process: where the first allows for close monitoring immediately post-procedure and the second, a less intensively supervised area which allows patients to wait for their escorts and receive refreshment.

With respect to space requirement, a minimum clear floor area of (9 square meters) shall be provided for each bay or cubicle.

Each patient care station shall have the following minimum clearance:

a) A minimum clearance of 2 m between patient stretchers or beds;
b) A minimum clearance of 1.2 m between patient stretchers or beds and adjacent walls or other fixed elements at the stretcher/bed's sides;
c) A minimum clearance of 900 mm from the foot of the stretcher or bed to a closed cubicle curtain.

In the absence of an isolation room, MDRO patients at recovery area may be managed through observation of good hand hygiene practices and use of gown and gloves.

Patient's toilet should be separate from public use and be directly accessible by patients.

5.8 Radiation protection

The systems and processes that are put in place for radiation protection and provision of storage for radioactive sources and waste under clinical support areas shall be in accordance with the Radiation Protection Act (Cap.262) and its Regulations. Plans and specifications of the areas that require radiation protection will require assessment by radiation Protection and Nuclear Science Department (RPNSD), National Environment Agency of Singapore.

5.9 Conclusion

With the increasing numbers and types of endoscopy procedures done, the roles of endoscopy units have expanded over the years causing strains on endoscopic facilities, design and unit management. Trying to do more procedures in limited space and infrastructure, may lead to hasty processes and potential mistakes and constitute a major threat to infection prevention and patient safety.

It is thus vital that any healthcare facility planning an endoscopy unit take into consideration all the aspects of present workload, as well as the potential expansion of services in estimating the area and layout before designing the unit.

5.10 References

1. Ministry of Health, Singapore. (2023). National Infection Prevention and Control Guidelines For Endoscopy Centres.
2. Guidelines for safety in the gastrointestinal endoscopy unit. (2014). Gastrointestinal Endoscopy; Volume 79, No. 3.
3. Guidelines for designing a digestive disease endoscopy unit: Report of the World Endoscopy Organization Digestive Endoscopy 2013; 25: 365–375
4. The Facility Guidelines Institute (2022). Guidelines for design and construction of hospitals,St. Louis, MO.
5. NIOSH Control Guidance Sheet 406. Endoscopy Suite Architectural Design.
6. Healthcare Infection Control Practices Advisory Committee (2017). Essential elements of a reprocessing program for flexible endoscopes – recommendations of the Healthcare Infection Control Practices Advisory Committee. https://www.cdc.giv/hicpac/recommendations/flexible-endoscope-reprocessing.html. Accessed on 30 Aug 2021.
7. Centers for Disease Control and Prevention (2003). Guidelines for environmental infection control in health-care facilities. https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf. Accessed on 31 Aug 2021.

8. Cookson ST, Jarvis WR. Prevention of nosocomial transmission of Mycobacterium tuberculosis. Infect Dis Clin North Am 1997;11:367-409.
9. Center for Disease Control (1994). Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care facilities. MMWR 1994;43(No. RR-13):1-132. https://www.cdc.gov/mmwr/PDF/rr/rr4313.pdf. Accessed on 31 Aug 2021.

CHAPTER 6 PHARMACEUTICAL CLEANROOM

A cleanroom environment is required for the Pharmacy Laboratory preparing sterile products for patient's use. A cleanroom is defined in ISO standard 14644 (Cleanrooms and associated controlled environments, 1999) as "*a room in which the concentration of airborne particles is controlled, and which is constructed and used in a manner to minimise the introduction, generation, and retention of particles inside the room, in which other relevant parameters, e.g. temperature, humidity, and pressure, are controlled as necessary*."

6.1 General Principles

a) Sterile product manufacture should be carried out in a clean area the entry to which should be through airlocks for personnel and/or for equipment and materials.
b) The various operations of component preparation, product preparation and filling should be carried out in separate areas within the clean area and can be divided into 2 categories; those where the product is terminally sterilised, and those which are conducted aseptically at some or all stages.
c) Each manufacturing operation requires an appropriate environmental cleanliness level to minimise the risks of particulate or microbial contamination of the product or materials being handled.
d) Four grades of room cleanliness can be distinguished as set out in Table 6.1 below.
e) ACMV system for aseptic and/or cytotoxic drug compounding shall be designed to achieve clean room environment of appropriate class of cleanliness, complete with anteroom and appropriate pressure requirements in compliance with USP 797 or EU-GMP Standard.
f) The clean room used for compounding medications and/or TPN shall be in accordance with the minimum cleanliness standards in ISO Class 7.
g) Anterooms shall meet ISO Class 8 standards and ante areas opening into a less positive pressure preparation area shall meet ISO Class 7 standards. The room can be used for gowning, handwashing and emergency rinse purposes.
h) Surfaces of ceilings, walls, floors, fixtures, carts, shelving, counters, and cabinets in the cleanroom should be smooth, impervious, free from cracks and crevices, non-shedding and resistant to sanitizing agents.
i) The cleanroom should not contain sinks or floor drains.
j) There should be an anteroom next to but separated from the cleanroom.
k) There should be designated areas for the receipt, unpacking and storage of hazardous drugs.

l) A sink for emergency access to water should be made available for removal of hazardous substances from eyes and skin in the event of an accidental exposure. Sinks for handwashing should be located at least 1m away from the Segregated Compounding Area.

m) Availability of eye wash station is also recommended as per OSHA.

Table 6.1: Grades of room cleanliness

Grade	Area used for purposes of:	Maximum number of particles per m^3					
		At rest			In operation		
		ISO class	0.5 um	5.0 um	ISO class	0.5 um	5.0 um
A	High risk operations (laminar flow required[2])	4	3 52	20	4	3 520	20
B	Aseptic preparation and filling, background environment for grade A zone	5	3 520	29	7	352 000	2 930
C	Clean areas, less critical stages in manufacture of sterile products	7	352 000	2 930	8	3 520 000	29 300
D		8	3 520 000	29 300		Not defined	Not defined

6.2 Terminally sterilised products

Preparation of components and most products should be done in at least a grade D environment in order to give low risk of microbial and particulate contamination, suitable for filtration and sterilisation. Where the product is at a high or unusual risk of microbial contamination, then preparation should be carried out in a grade C environment.

Filling of products for terminal sterilisation should be carried out in at least a grade C environment. Where the product is at unusual risk of contamination from the environment, for example because the filling operation is slow or the containers are wide-necked or are necessarily exposed for more than a few seconds before sealing, the filling should be done in a grade A zone with at least a grade C background. Preparation and filling of ointments,

[2] e.g. filling zone, stopper bowls, open ampoules and vials, making aseptic connections. Laminar air flow systems should provide a homogeneous air speed in a range of 0.36 – 0.54 m/s.

creams, suspensions, and emulsions should generally be carried out in a grade C environment before terminal sterilisation.

6.3 Aseptic preparation

Components after washing should be handled in at least a grade D environment. Handling of sterile starting materials and components, unless subjected to sterilisation or filtration through a micro-organism-retaining filter later in the process, should be done in a grade A environment with grade B background.

Preparation of solutions which are to be sterile filtered during the process should be done in a grade C environment; if not filtered, the preparation of materials and products should be done in a grade A environment with a grade B background.

Handling and filling of aseptically prepared products should be done in a grade A environment with a grade B background. Prior to the completion of stoppering, transfer of partially closed containers, as used in freeze drying should be done either in a grade A environment with grade B background or in sealed transfer trays in a grade B environment. Preparation and filling of sterile ointments, creams, suspensions, and emulsions should be done in a grade A environment, with a grade B background, when the product is exposed and is not subsequently filtered.

6.4 Environmental specifications

All exposed surfaces should be smooth, impervious, and unbroken in order to minimize the shedding or accumulation of particles or micro-organisms. All recesses and a minimum of projecting ledges, shelves, cupboards, and equipment should be cleaned. Doors should be designed to avoid recesses which are hard to clean; false ceilings should be sealed to prevent contamination from the space above them and pipes and ducts and be installed so that they do not create recesses, unsealed openings and surfaces which are difficult to clean. Sinks and drains should be prohibited in grade A/B areas used for aseptic manufacture. In other areas air breaks should be fitted between the machine or sink and the drains. Floor drains in lower grade clean rooms should be fitted with traps or water seals to prevent backflow.

Changing rooms should be designed as airlocks and used to provide physical separation of the different stages of changing and so minimize microbial and particulate contamination of protective clothing. The final stage of the changing room should, in the at-rest state, be the same grade as the area into which it leads. Handwashing facilities should be provided only in the first stage of the changing rooms. Both airlock doors should not be opened simultaneously. An interlocking system or a visual and/or audible warning system should be operated to prevent the opening of more than one door at a time.

A filtered air supply should maintain a positive pressure and an air flow relative to surrounding areas of a lower grade under all operational conditions and should flush the area effectively. Adjacent rooms of different grades should have a pressure differential of 10 - 15 Pa. Particular attention should be paid to the protection of the zone of greatest risk, that is, the immediate environment to which a product and cleaned components which contact the product are exposed.

It should be demonstrated that air-flow patterns do not present a contamination risk, e.g. care should be taken to ensure that air flows do not distribute particles from a particle generating person, operation, or machine to a zone of higher product risk.

A warning system should be provided to indicate failure in the air supply. Indicators of pressure differences should be fitted between areas where these differences are important. These pressure differences should be recorded regularly or otherwise documented.

6.5 Hazardous Drug Cleanroom

All parenteral cytotoxic/hazardous drug admixtures must be prepared in minimum Class II Type B Biological Safety Cabinet (BSC) that adhere to ISO Class 5 environment:

a) BSC used for HD compounding must be located away from doors, corridors, and air conditioning vents, inside a restricted access negative pressure ISO Class 7 cleanroom.
b) Negative pressure must be maintained between the pharmacy cleanroom and the anteroom to provide inward airflow to the cleanroom to contain any airborne drug (HD) particulate. Pressure indicator should be installed that can readily monitor the cleanroom pressure.
c) Appropriate personal protective equipment (PPE) e.g. chemotherapy gowns must be donned by all personnel prior to entering the cleanroom.
d) Staff must be trained to safely clean the cleanroom, the anteroom and the BSC to minimize HD exposure to themselves and the environment.
e) An emergency alert system should be installed to provide visual and audio alarms when spillage of hazardous substance occurs. Such system can include manual push buttons within the cleanroom at strategic locations, beacon lights and audio alarms etc. outside the cleanroom to alert other personnel for support.

Refer to the following table for engineering control recommendations.

Summary of USP <797> Engineering Control Requirements for Hazardous Drug Sterile Product Preparation and Storage Areas

	Cleanliness classification	HVAC (Heating Ventilation and Air Conditioning)					
		Temperature and humidity	Min Total Air Changes per Hour (ACPH)	Relative pressurization to adjacent area	Pressure monitoring device installed and monitored	Area exhaust ventilation	HEPA filtered supply air
HD Cleanroom (Buffer room)	ISO Class 7 [1,12] (under dynamic conditions)	20° or cooler[1] 25-50% relative humidity*[13] *appropriate controls present	≥ 30 ACPH[1]	**Negative[1]** (not less than 0.01-inch water column negative pressure to adjacent positive pressure ISO Class 7 or better ante-areas[1]	Required[1]	Required[1]	Required[1,12]
Anteroom (adjacent to HD cleanroom)	ISO Class 7 [1,12] (under dynamic conditions)		≥ 12 ACPH[14]	**Positive[1]**	Required[1] (between anteroom and the general environment		Required[1]
HD Storage Area(s) (may include HD Clinical Trials area and HD receiving area if HDs are stored in area)			≥ 12 ACPH[1]	Negative* *preferred[1]		Required[1]	

6.6 References

BC Cancer Agency for Pharmacy Practice Standards for Hazardous Drugs Feb 2014: Hazardous Drugs Cleanroom Standards accessed on 2/7/2021 at www.bccancer.bc.ca

EN/ISO 14644-1:2015

EudraLex. (2008). The Rules Governing Medicinal Products in the European Union, EU Guidelines to Good Manufacturing Practice Medicinal Products for Human and Veterinary Use, Brussels, Volume 4.

Ministry of Health, Singapore. (2016). Guidelines for the Conduct of Sterile Pharmaceutical Services in Healthcare Institutions.

Office of Regulatory Affairs. (2004). Guidance for Industry Sterile Drug Products Produced by Aseptic Processing — Current Good Manufacturing Practice U.S. Department of Health and Human Services. Food and Drug Administration Center for Drug Evaluation and Research (CDER) and Center for Biologics Evaluation and Research (CBER).

CHAPTER 7 EMERGENCY DEPARTMENT

The Emergency Department is generally the point of entry to a hospital for undiagnosed patients, some of whom may be carriers of dangerous infectious diseases like tuberculosis or imported emerging infections.

7.1 General principles

Air circulation in emergency room waiting areas is exhausted or may be returned if a HEPA filter is used on all return air recirculating in the space or to other spaces as a means of protecting patients and staff from infectious patients.

The layout should take into consideration safe triaging of patients (at the point of entry) to result in prompt isolation of patients with suspect infectious diseases of concern viz. varicella zoster, TB, MERs-CoV, etc. There are many examples of outbreaks amplifying an EMD waiting room, through lack of triage, early suspicion and pre-emptive isolation. As the infectious status of the patient is usually unknown at the Emergency Medicine, the design should take into consideration the need to ensure a high level of infection prevention practices to prevent cross infection; including clearly defined clean and dirty workflows; and separation of patient care areas from staff areas and contaminated spaces. The department should be planned in an on-stage and off-stage design approach where the corridor and routes are separated physically to minimise cross-contamination between the different flows. This would enable necessary precautions to be implemented, such as isolation of pathways for infectious patients and negative pressure regimes.

Dedicated isolation rooms/areas should be provided for patients with a known or suspected infectious disease of concern and are awaiting transfer to other relevant care facilities within or outside the hospital. AIIR facilities are recommended for patients with suspected infectious diseases with airborne transmission. The isolation rooms will need to have direct access to an enclosed toilet or human waste disposal room, where a bedpan washer or macerator is installed for easy and direct access by the emergency medicine staff. The room size should be of similar size to an acute treatment room to allow for the treatment and resuscitation of critically ill isolated patients if required. The rooms should be positioned adjacent to the triage area where patients are received to allow for the immediate isolation once the diagnosis or suspicion of airborne transmission is made.

Decontamination rooms are designed for patients who have been exposed to chemical spills or some type of radiation exposure. Some facilities designate space outside the facility for decontamination and others create a decontamination room inside the facility. All air in

decontamination rooms is exhausted to the outdoors and surfaces and materials in the room are designed to get wet or be exposed to higher levels of moisture.

A pandemic disease outbreak involves multiple victims of a contagious disease. This situation requires basic preparations as well as isolation protocols, waste isolation, and separate ventilation. Patient journeys both within and outside of the emergency department (example: OT and ICU) should be mapped to determine likelihood of cross contamination and to ensure practical measures such as segregating the different routes are in place to control people's movement within the department.

In the planning for a pandemic outbreak, assess the ventilation systems of an existing facility to ensure that the systems are zoned to isolate flow from one area of the building to another. Areas at high risk should be designed with the flexibility to segregate large numbers of patients and staff from the rest of the facility. Because a pandemic outbreak has the potential to quarantine a large number of staff, a cohorting plan must also include preparations for converting existing spaces on the clean side of the quarantine area into storage spaces for isolation controls (such as protective clothing) and also creating a holding area on the contaminated side for temporary storage of contaminated materials until they can be properly disposed.

7.2 Hand hygiene facilities

Handwashing stations should be readily available at all treatment areas and patient areas as well as:

a) Resuscitation rooms;
b) Point of care testing areas;
c) Dirty utility rooms; and
d) Staff areas.

Alcohol-based hand rubs should be made available and accessible to increase the staff to routinely use them in the course of patient care – mounted on walls, trolleys, entrances and in all clinical areas.

7.3 Isolation room / Ward

Emergency Departments should be capable of cohorting patients who present with suspected infectious diseases in a dedicated separate isolation area. This is recommended for the management of suspected cases of infectious disease of concern, especially those transmitted by airborne route as well as other emerging pathogen of interest (e.g. Ebola, MERs-COV, etc. Please refer to chapter 2 on specifications for isolation rooms. Intuitive

wayfinding and signage should be clearly implemented to indicate the locations of the cohort areas and the appropriate level of PPE requirement.

This unit should be located in close proximity to the isolation OT. There should be a designated lift and dedicated route to transfer high risk patients from the isolation resuscitation room to the isolation OT, ICU isolation and isolation ward.

7.4 Waiting rooms for patients

Consideration is to be given with respect to spatial relationships for patients waiting at triage, entrances, reception, and clinical areas. Sub-waiting areas may be planned to relieve congestion. Electronic display system may help towards allowing patients to be in other areas while waiting, and then moving in to be seen by the clinical team when ready.

Where the triage and waiting area is indoor, then the room should be at negative pressure with 12 ACH (ASHRAE 170, 2021).

Stations with surgical masks and alcohol-based hand rub agent located strategically at these rooms will help towards use of appropriate PPE by patients who need them.

Emergency Department waiting rooms should implement social distancing during pandemic disease outbreak. It is unlikely that all emergency departments will be able to expand their waiting rooms sufficiently. Alternative options may be necessary such as utilising additional space outside of the emergency department.

7.5 Clean and dirty utility rooms

The size of the clean utility room for storage of medications or consumables should be adequately sized according to needs – centralised or decentralised model may be used. Where sterile items and medication are stored, there should be controlled ventilation and relative humidity (<60% RH).

The dirty utility room should be negatively pressured with a minimum of 12 m^2 with a handwashing sink. In a larger Emergency Department, 2 or more dirty utility rooms may be required to minimise travel distance for disposal by staff.

7.6 References

Common infection control practices in the emergency department: A literature review. Carter EJ, Pouch SM and Larson EL.

COVID-19: Guidance for maintaining services within health and care settings Infection prevention and control recommendations Version 1.2 C NHS

Emergency Department Design Guidelines. Australian College for Emergency Medicine, 2014

Infection control in the emergency department. Fusco FM and Puro V. Jun 12, 2012. Reorganising the emergency department to manage the COVID-19 outbreak Quah et al. International Journal of Emergency Medicine (2020)

The Facility Guidelines Institute. (2022). Guidelines for design and construction of hospitals. St. Louis, MO.

CHAPTER 8 SPUTUM INDUCTION ROOMS

Sputum induction is used to obtain sputum for diagnostic purposes when patients are unable to spontaneously expectorate a specimen. Sterile water or hypertonic saline is used to irritate the airway, increase secretions, promote coughing, and produce a specimen. The Center for Disease Control (CDC) and the Occupational Safety and Health Administration (OSHA) both classify sputum induction as a high-risk procedure when performed on a suspected or known infectious TB patient.

8.1 General Principles

Sputum induction rooms should have the following considerations.

a) Have negative pressure relative to adjacent areas of -2.5 Pa (exhaust airflow rate greater than supply airflow rate by 50 CFM or 10% of the supply, whichever is greater).
b) Exhaust air change rate of at least 12 ACH for new or renovated isolation and procedure rooms.
c) For existing isolation and procedure rooms built before 1994, 6 ACHs are acceptable if this airflow rate cannot be increased to 12 ACH by adjusting or modifying the ventilation system or by using auxiliary means (e.g., recirculation of air through fixed HEPA filtration units or portable air cleaners).
d) Supply and exhaust grilles should be positioned on opposite sides of the room to promote good air mixing. The exhaust grille should be positioned near the patient.
e) Air from the room should be exhausted directly outdoors, away from ventilation intakes, operable windows, and people.
f) The general ventilation system should be designed and balanced so that air flows from less contaminated (cleaner) to more contaminated (less clean) areas (into the room).
g) Recirculation of air is not recommended.
h) The temperature should be maintained at 20-23ºC.

8.2 Air Exhausted Outdoors from Sputum Induction Booths, Hoods, and Rooms

Air should be discharged a minimum of 7.6m from operable doors and windows or air intakes. If this is not possible, the air removed from the room should be HEPA-filtered prior to being exhausted.

8.3 Maintenance of Rooms with HEPA Filters

The maintenance includes inspecting and replacing pre-filters and final HEPA filters. Many of these devices are equipped with filter gauges that indicate when filters are dirty and need replacement. Pre-filters (used to prolong the life of HEPA filters) need to be changed more often than final HEPA filters. Filters should be changed and disposed of in accordance with hospital policy.

Staff dealing with such filters should wear respirators and treat the discarded filters as medical waste. Recommendations on scheduled maintenance may vary with each manufacturer.

A staff person or facility engineer should be assigned to monitor the maintenance of the room. This person should be trained in the basic principles of the unit's operation, including recommended periodic checks.

8.4 Location of Sputum Induction Rooms

Sputum induction rooms and local exhaust devices should be placed near patient care areas, where staff can monitor and assist patients as needed. The room should be located away from waiting rooms and other areas where patients or visitors are likely to enter and risk exposure.

Choose a room where room exhaust can easily be routed outdoors. Air should be discharged away from other outdoor air intakes or openings into the building (such as operable windows and doors, and outdoor air intakes into building ventilation systems).

Local sputum induction tents, booths, or hoods can be used in any patient care room. There is no need to place these devices in a negative pressure room since all air from the procedure is HEPA-filtered or exhausted directly outdoors.

8.5 Signage

It is essential to place a warning sign on the door of any room being used for sputum induction. Signage should:

a) Warn patients and family members not to enter the room;
b) Remind clinic staff that a respirator is required for entrance when the room is, or has recently been, occupied by a suspected or known infectious TB patient; and
c) Indicate when the room was last occupied by a suspected or known infectious TB patient and at what time the room will be safe to enter without a respirator.

8.6 Clearance Time between Patients in Sputum Induction Rooms

Adequate time must elapse between patients to allow for the removal of at least 99% of airborne contaminants by the exhaust system. Staff entering before sufficient time has elapsed must wear a respirator. The time required can be calculated by using Table 8.1 below.

Table 8.1: Air changes per hour (ACH) and time in minutes required for removal of airborne contaminants

Air changes per hour (ACH)	Minutes required for a removal efficiency of:		
	90%	99%	99.90%
1	138	276	414
2	69	138	207
3	46	92	138
4	35	69	104
5	28	55	83
6	23	46	69
7	20	39	59
8	17	35	52
9	15	31	46
10	14	28	41
11	13	25	38
12	12	23	35
13	11	21	32
14	10	20	30
15	9	18	28
16	9	17	26
17	8	16	24
18	8	15	23

Air changes per hour (ACH)	Minutes required for a removal efficiency of:		
	90%	**99%**	**99.90%**
19	7	15	22
20	7	14	21
25	6	11	17
30	5	9	14
35	4	8	12
40	3	7	10
45	3	6	9
50	3	6	8

8.7 Verifying Negative Pressure in Rooms

A pressure gauge should be installed at the entrance of the anteroom (if available) and induction room. It should display a reading visible to staff of the pressure between these rooms and the corridors. This will enable confirmation of negative pressure whenever the sputum induction room is used for any procedures.

8.8 References

Centers for Disease Control and Prevention. (2005). Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Settings, MMWR 2005;54(No. RR-17)

Francis J. (1999). Curry National Tuberculosis Center, Institutional Consultation Services. Conducting Sputum Induction Safely.

Ventilation of Health Care Facilities ANSI/ASHRAE/ASHE Standard 170-2017.

CHAPTER 9 INTERVENTIONAL IMAGING

These refer to vascular and non-vascular imaging. In some facilities, there may be a combination of interventional radiology and interventional cardiology.

The majority of angiography vascular imaging is now undertaken using Magnetic Resonance Imaging (MRI), particularly with the introduction of new technologies and the increased use of contrast media in MRI. However, some work, for example femoral and renal angiograms (which have been replaced largely by MRI), is still undertaken in X-ray fluoroscopy facilities. Patients contra-indicated will still be imaged conventionally. Some patients may undergo X-ray angiography post-MRI, prior to interventional procedures.

Examples of angiography examinations are as follows:

a) venography;
b) fistulogram.

Examples of vascular interventional work:

a) balloon catheter angioplasty;
b) stent placement;
c) IVC filter insertion;
d) Cardiac pacemaker insertion.

9.1 General Principles

Accommodation in support of vascular and nonvascular interventional procedures should be as follows:

a) an examination room containing the multi-angular X-ray projection fluoroscopy equipment for vascular and non-vascular procedures;
b) a control area housing the computer workstations associated with the imaging equipment;
c) a small area outside the examination room for storage of the lead-lined aprons and other radiation protection equipment;
d) sub-waiting areas for both out-patients and, where appropriate, in-patients;
e) changing cubicles for patients;
f) combined anaesthetic induction recovery area, depending on the use of anaesthetics and local policies;
g) a machine room, depending on equipment type and manufacturer;
h) storage space for catheters, and sterile packs;

i) a day case recovery ward for out-patient appointments;
j) a porters' base to assist with the transfer of patients to and from the wards;
k) a counselling room;
l) a main reception area for patients;
m) a dirty utility/disposal area;
n) a clean utility;
o) a laser printing facility;
p) toilets for use by the patients and accompanying relatives/carers;
q) scrub-up facilities.

9.2 Pre-procedure and recovery patient care areas

Recovery / Anaesthesia combined areas should be provided on the approximate ratio of two bays per procedure or examination room for those patients requiring recovery or inducement of anaesthesia. The suite may also be used for the administration of sedatives or other pre-medication prior to a procedure.

9.3 Space requirements

The procedure room should be large enough to accommodate required equipment and clearances in accordance with manufacturer's technical specifications.

Adequate clearance should be made available at recovery patient care areas. Each cubicle should have a minimum clearance of 2 m between sides of beds. Each cubicle should have a minimum clearance of 90 cm between walls or partitions and sides of beds.

9.4 Air-conditioning, Mechanical Ventilation (ACMV)

The procedure room is positively pressured in relation to adjacent areas with controlled ventilation and humidity as shown in Table 9.1 below.

Table 9.1 ACMV requirements for Interventional radiology procedure room

Area	Pressure relationship to adjacent area(s)	Minimum air changes of outdoor air per hour	Minimum total air change per hour	Relative humidity (%)	Temperature (^{0}C)
Interventional radiology procedure room	Positive	3	15	Maximum 60	21-24

Note: There should be a minimal pressure difference of 2.5 Pa to the adjacent area.

9.5 Handwashing stations

These should be provided especially at locations of patient contact and where radiopharmaceutical materials are handled, prepared, or disposed of.

CHAPTER 10 RENAL DIALYSIS UNIT IN ACUTE CARE FACILITY

Renal Dialysis is performed on patients who are diagnosed with reduced kidney function/failure. This is performed as haemodialysis or peritoneal dialysis. Haemodialysis is a treatment for end stage renal failure using a haemodialysis machine to filter substances from the blood. Haemodialysis may be undertaken as an inpatient or outpatient.

10.1 General principles for Functional Design

The following functional areas should be included in a Renal Dialysis Unit:

a) Public areas
b) Triage/Screening area
c) Patient consult / treatment areas
d) Clinical support areas
    i. Patient segregation area for infectious Hepatitis B surface antigen positive and Hepatitis C virus with a separate individual patient treatment area (preferably single rooms).
    ii. Optional - Dialyser Reprocessing Room (for dialyser wash and solution preparation)
    iii. Clean and Dirty Utility Room(s)
    iv. Large storage for dialysis fluids, equipment, sterile stock, and consumables
    v. Water Treatment Plant Room
e) Administration, staff welfare, training, educational and research areas

The Unit should be accessible:

a) For patients who may arrive walking, using mobility equipment or on trolleys;
b) For delivery of large amounts of fluids (dialysate) on palettes on a regular basis;
c) By having separation of walking and trolley / ambulance patient arrivals;
d) For the delivery of food, clean linen, drugs, consumables, disposable items, and collection of waste and soiled linen.

10.2 Finishes

Selection of finishes including fabrics, floors, walls and ceilings should address the following:

a) Durability and replacement considerations;
b) Fire safety;

c) Infection control issues such as surface cleaning.

All surfaces should be easy to clean and be free from grooves and creases which can harbour bacteria. The floor should be easily cleaned and of impervious finish with skirting due to high risk of spillage of body fluids and other contaminants. It should have sufficient slip resistance to prevent it becoming slippery when wet. Vinyl flooring is generally preferred in all treatment areas Skirting should be coved to prevent dirt congregating in corners. Washable paint should be used for all walls and ceilings. The toilets and bathrooms must be covered by slip resistant floor tiles and ceramic smooth walls.

10.3 Patient Consult / Treatment Areas

Ideally where possible, acute care facility should have separate dialysis units for inpatient and outpatients to maintain clear segregation and for ease of management. However, a dialysis centre catering to both inpatients and walk-in patients, design should allow for clear segregation of inpatients from walk-in patients during pandemic period, both physically and in terms of ventilation to prevent cross infection.

Provision for triaging of walk-in patients at the entrance / waiting area should also be considered where possible.

Patient treatment areas include dialysis treatment chairs/bay, training areas and Procedures Room. These will require easy access to patient toilets. In a large area, there will be more than one station.

Treatment chairs in the form of reclining chairs are provided for ambulant patients. For bed bound inpatients that are more severely ill, bed bays are to be provided. A minimum 2.0 metre bed separation is recommended for bed and equipment movement and also for reducing cross infection. Width of aisles should be wide enough for turning of beds. It is good to provide one or two single rooms within the dialysis unit for patients who need to be separated from others.

Space for reclining chairs should be approx. 9 square metre and for trolleys/bed should be 12 square meters. This is to ensure sufficient space to ensure appropriate space for machine accommodation, service, and curtain track placement. This will also ensure sufficient space for emergency situations.

At each station, there needs to be space for hand hygiene facilities comprising of hand hygiene sink with wall-mounted soap dispenser & towel dispenser, plus clinical and non-clinical waste bin & sharps container. Alcohol hand rub dispenser should be available at various points of care.

10.4 Clinical Support Areas

Clinical support areas for the Renal Dialysis Unit including Dialyser Reprocessing Room (if on site) and Dialysate Preparation Room (if onsite), Utility and Storeroom should be located in a staff-only zone with ready access to treatment areas. Storeroom(s) and bays will be required for linen, general consumables, sterile stock, mobile equipment, and bulk storage for dialysis fluids.

10.5 Dirty Utility

A dirty utility room should contain a sluice, pan sanitiser, handwashing station, work counter, storage cabinets and storage of contaminated waste bins. Sharps disposal containers and dirty linen skips can also be kept there.

Note: Dirty Utility & Dialyser Reprocessing Area (if onsite) should have negative pressure (exhaust) with min 10 air change per hour and the area should be designed to achieve one way workflow where the dirty instruments / equipment enters the dirty area, cleaned, and stored before dispatched out, all carried out in a well separated manner to prevent cross contamination.

10.6 Air-conditioning, Mechanical Ventilation (ACMV)

The Unit should be air-conditioned to maintain a comfortable temperature for patients as well as provide adequate ventilation. The relative humidity should be ≤60% to prevent mould development. The dialyzer reprocessing room should be designed with negative pressure in relationship to adjacent areas. The ACMV system in the Renal Dialysis Unit must be serviced regularly, and filters cleaned periodically.

10.7 Water treatment service & water quality

The Renal Dialysis Unit is required to treat water used in the haemodialysis process to remove any contaminants. Water treatment involves filtration, water softening, removal of water contaminants and Reverse Osmosis. Reverse Osmosis (RO) is the process of producing purified water and leaving residual dissolved solids and organic particles.

Regular microbiologic sampling of dialysis fluids is recommended because gram-negative bacteria can proliferate rapidly in the water and dialysate in haemodialysis systems. High levels of these organism place patients at risk of pyrogenic reactions or healthcare-associated infections (HAI).

Refer to National IPC Guidelines for Outpatient Dialysis Centres 2020: Chapter 7, Water quality for details on type of tests, frequency, and parameters.

The design and installation of water pre-treatment services should consider:

a) Water feed quality and pressure; Booster pumps may be required to ensure a minimum water speed of at least 10 m/s and a minimum water pressure to limit tubing contamination by bacteria and moulds.
b) There shall not be any joint connection for RO line to all the dialysis stations exception a short “T” off connection with mini valve or tap point for the hose from the dialysis machine. This is to avoid stagnation and contamination along the RO pipeline.
c) The dialysis discharge from the machine shall feed directly into funnel located next patients’ station and discharge to drain off pipe minimum size is 50 diameter UPVC.
d) Preferably a single floor trap to serve 2 -3 drain off pipe for 2-3 stations and a removable strainer installed in floor trap’ s opening.
e) Daily check and wash down of the strainer are essential to prevent fluid wastes or moulds.
f) Main RO line should not have any dead legs and flow should be continuous to avoid bacteria growth due to stagnation.
g) Feed water temperature control – high feed water temperatures may require a heat exchanger to cool it. If the feed water is cold, it can be heated by mixing hot and cold water with a thermostatic mixing valve.
h) Back flow prevention – all water pre-treatment systems may require a reduced pressure zone device or a break tank with an air gap to prevent backflow.
i) Multi-media depth filter to remove particulates of 10μ or larger as particulates can clog the carbon and softener tanks and destroy the Reverse Osmosis (RO) pump and the membrane.

The Plant Room for water treatment should be sited next to the Renal Dialysis Unit. This favours short tubing and easy access for monitoring and servicing the water treatment systems.

To prevent condensation and the subsequent growth of mould, drainage systems, covers and screens for fluids from haemodialysis machines must be well ventilated.

10.8 Hand hygiene

Handwashing basins should be located at entrances to facilitate staff, patient and visitors’ handwashing. It is recommended that handwashing facilities are provided as follows:

a) One at each entrance/exit of the Unit
b) One in Training, Treatment and Procedures Room(s)
c) One per four open treatment bays

d) One in each enclosed treatment bay / room
e) In non-clinical support rooms such as Clean Utility, Clean-Up, Dirty Utility
f) One adjacent to Staff Station(s).

The basin should be located as near to the station as possible without causing risk of splashing and cross-infection.

10.9 Standard precautions

Standard precautions should be practiced for all patients as their infectious status may not be known initially. Infectious patients and patients with reduced immunity may also be sharing the same treatment space at different times of the day. Re-using of dialyser is not recommended for Hepatitis B, C, D or HIV infected patients. An eye bath for staff or patients affected by blood or chemical spills subject to OSH guidelines.

10.10 Cleaning

The unit requires a high standard of cleanliness to guard against infection; thorough cleaning of the unit and 'terminal' cleaning of isolation rooms. All surfaces should be easy to clean and be absent from seams and creases which may harbour bacteria. Vinyl that is easily cleaned should be installed in all treatment areas with coved skirting to prevent dirt/dust collection. All walls and ceilings should be painted with washable paints. The air conditioning system must be serviced, and filters cleaned regularly. Damp mopping is preferable to prevent the production of air borne particles.

10.11 References

Australasian College for Emergency Medicine. (2014). Emergency Department Design Guidelines, revised 2014 Oct.

Australasian Health Facility Guidelines. Part B Health Facility Briefing and Planning 2022: 0620 Renal Dialysis Unit

Centre for Disease Control and Prevention (CDC). (2003). Guidelines for Environmental Infection Control in Health-Care Facilities

Centre for Disease Control and Prevention. (2007). Guidelines for Isolation Precautions: Preventing Transmission of Infectious Agents in Healthcare Settings

Department of Health (UK). (2013) *'Renal Care; Health Building Note 07-01: Satellite Dialysis Unit'* 2013.

Ministry of Health, Singapore (2020. National Infection Prevention Control Guidelines for Outpatient Dialysis Centres

Ministry of Health, Singapore. (2017). National Infection Prevention and Control Guidelines for Acute Healthcare Facilities.

National Institute for Health and Care Excellence (NICE). (2011). Infection Prevention and Control of Healthcare-associated Infections.

National Institute for Health and Clinical Excellence. (2002). Health Technical Memorandum 56 – 'Partitions'. Good practice guidelines for renal dialysis/transplantation units. Prevention of healthcare-associated infection in primary and community care.

New Zealand Nephrology Services. (2005) New Zealand Dialysis Standards and Audit

Singapore Standards Council, TR42:2015 - Technical Reference for Facility Design Guidelines for Acute General Hospitals

Victorian Advisory Committee on Infection Control. (2007). Guidelines for the classification and design of Isolation Rooms in healthcare facilities

World Healthcare Organisation (WHO). (2009). World Alliance for Patient Safety, Guidelines on Hand Hygiene in Health Care.

CHAPTER 11 TRANSPLANT FACILITIES

Transplant patients are immunosuppressed and generally fall into two categories: contagious and non-contagious. When the patient is non-contagious, positive pressure is maintained between the patient room and the corridor; exam and treatment rooms should be controlled in the same manner. When the patient is contagious, isolation rooms within the unit may be designated and provided with an anteroom. When an anteroom is provided, the pressure relationship from the anteroom should be more positive with respect to the patient room and corridor.

11.1 Protective environment

Protective environment (PE) room (Positive pressure (Class P) isolation rooms) (Refer to Chapter 2 for details) are designed for bone marrow transplant, oncology, haematology, and for any condition that leaves a patient severely immunocompromised. A PE room seeks to protect the patient from all potential airborne infectious organisms, some of which may be benign to other patients with normal immune systems.

PE rooms are designed to minimize fungal spore counts in air by maintaining:

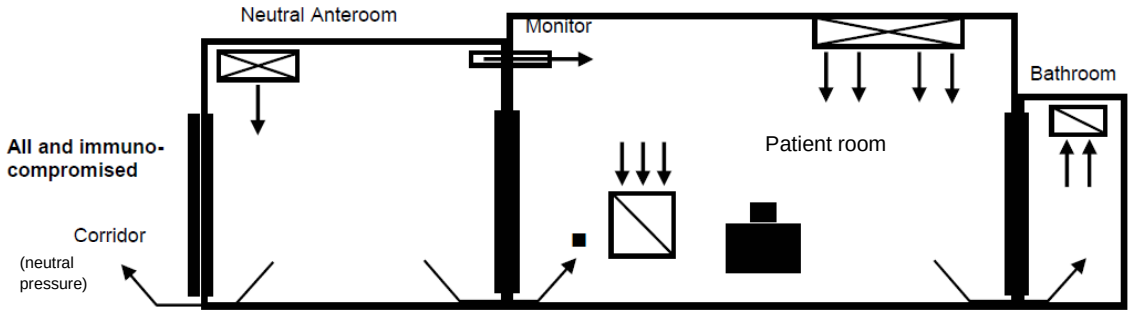
a) filtration of incoming air by using central or point-of-use HEPA filters;
b) directed room air flow [i.e., from supply on one side of the room, across the patient, and out through the exhaust on the opposite side of the room];
c) positive room air pressure of 2.5 Pa [0.01" water gauge] relative to the corridor;
d) well-sealed rooms; and
e) >12 ACH.

An anteroom is required for combined AII/PE rooms, where a patient who is immunocompromised and has a suspected or known respiratory disease, such as tuberculosis, is housed. The anteroom helps maintain the pressurization and the air pattern to protect the patient. Seal Class P isolation rooms to reduce air leakage area and/or increase differential air volume to maintain a differential pressure of 0.01 in. of water [2.5 Pa].

Air flow rates must be adjusted accordingly to ensure sufficient ACH, and these rates vary depending on certain factors (e.g., room air leakage area). For example, to provide >12 ACH in a typical patient room with 0.5 sq. ft. air leakage, the air flow rate will be minimally 125 cubic feet/min (cfm). Higher air flow rates may be needed. A general ventilation diagram for a positive-pressure room is given in Figure 11.1 below. Directed room air flow in Class P isolation rooms is not laminar.

Class P isolation rooms require continuous monitoring of pressurization with alarms. A differential pressure indicator must be visible from outside the room. Positive-pressure status of the patient room must be validated, and the controls tested so that room pressure cannot become negative relative to the environment.

Figure 11.1: Positive-pressure room control for protection from airborne environmental microbes (Class P isolation room)



11.2 References

ASHRAE, 2013. HVAC Design Manual for Hospitals and Clinics. Second Edition.

U.S. Department of Health and Human Services Centers for Disease Control and Prevention (CDC). 2003. Guidelines for Environmental Infection Control in Health-Care Facilities. Recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee (HICPAC).

CHAPTER 12 BURNS CENTRE

When designing a Burns unit, it is important to understand that these particular patients are extremely susceptible to infection. The skin is one's most important protection feature, and with these patients, many layers of the skin are gone, exposing the inner layers. The risk of infection increases as the percent of burn injury increases or in the presence of complication by other injury. Bacterial infection is one of the most common causes of complication in the burns patient, so it is vital to design to prevent this from happening.

12.1 General principles

It is considered optimal for an adult or paediatric Burns Centre to be co- located with a corresponding adult or paediatric major Trauma Centre.

Special points to note include:

a) A Burns Centre provides care for patients with the most severe injuries and for those requiring the highest level of critical care. It will have a physically separate ward specifically for the care of adult burn patients or children, never both. Single bedded humidity and thermally controlled cubicles may be designed to care for the burn injured patients. A protective environment (PE) isolation room (positive pressure (Class P) isolation room) with HEPA-filtered (MERV 17) air achieving an air velocity at the bed level of less than 0.25 m/s. Use low-sidewall returns near the door of the room and maintain the room under positive pressurization at all times.
b) A negatively pressurized anteroom for each patient's room would help prevent the possibility of aerosol dispersal created during dressing changes in the patient's room. It reduces airborne contaminant concentration by containment and dilution of the migrating air and to protect the adjacent corridor from excess airflow into or out of the patient's room.
c) Airborne transmission has been implicated in a varicella outbreak in a Burns unit although it is not a common mode of transmission among Burns patients. Provision should be made for a properly engineered AII (airborne infection isolation) room for Burns patients with suspected or confirmed airborne transmissible infections. The design of AII room with depressurized anteroom, the design appropriate for immunocompromised patient with airborne infectious disease, is recommended.
d) 24-hour immediate access to a temperature controlled operating theatre within close proximity (approximately <25 metres) of the critical care service for burns patients is recommended.

e) Patients with major burns will require massive dressing changes and hence, the dressing room should be adequately sized for this (ideally, as large as an operating theatre) to be done safely without causing risk of spread of aerosols created during the procedure.

f) A dedicated intensive care within the Burns Centre with full intensivist support is recommended. As part of continuing care of the Burns patients, an intensive (rehabilitation) ward is necessary within the centre.

g) Provision should be made for close proximity to rehabilitation services to encourage early rehabilitation for the Burns patients.

h) In reporting healthcare-acquired infections in Burns patients, inanimate environment had been reported as one of the major reservoirs. The design of the patient room, treatment or procedure room and the selection of furnishing materials should take into consideration the ease of cleaning and disinfection.

12.2 References

1. Weber JM, Sheridan RL, Pasternack MS, et al. Nosocomial infections in paediatric patients with burns. *American Journal of Infection Control* 1997;25:195-201.
2. Mayhall CG. The epidemiology of burn wound infections: then and now. *Clinical Infectious Diseases* 2003;37:543-550.
3. British burn association. (2001). National Burn Care Review Committee Report. Standards and Strategy for Burn Care.
4. British Burn Association and the Hospital Infection Society. (1991). Principles of Design of Burns Units: Report of a Working Group of the British Burn Association and the Hospital Infection Society. J Hosp Infect: 19, 63-66
5. NHS England. (2014). Specialised burn care. Principles for service development and effective network working. London Health Programs. December 2011.
6. Centers for Disease Control and Prevention (2003). Guidelines for environmental infection control in health-care facilities. https://www.cdc.gov/infectioncontrol/pdf/guidelines/environmental-guidelines-P.pdf. Accessed on 31 Aug 2021.
7. Zanetti G, Blanc DS, Federli I, et al. Importation of *Acinetobacter baumannii* into a burn unit: a recurrent outbreak of infection associated with widespread environmental contamination. *Infection Control & Hospital Epidemiology* 2007;28:723-725.
8. Simor AE, Lee M, Vearncombe M, et al. An outbreak due to multiresistant *Acinetobacter baumannii* in a burn unit: risk factors for acquisition and management. *Infection Control & Hospital Epidemiology* 2002;23:261-267

PART III. INFECTION CONTROL RISK ASSESSMENT AND PLANNING DURING CONSTRUCTION PHASE

CHAPTER 13 INFECTION CONTROL RISK ASSESSMENT

An infection control risk assessment (ICRA) during construction phase prevents infectious hazards through a set of prevention measures to mitigate contamination during actual construction or renovation.

13.1 Principle

a) It is a multidisciplinary, organized process that helps plan construction work with potential health risks in mind ahead of time. The ICRA should be incorporated into all construction and renovation projects in healthcare setting. Please refer to the MOH 'National IPC Guidelines for Acute Healthcare Facilities' on steps on how to use the ICRA in assessing risk.
b) The ICRA shall be conducted by a panel with expertise in infection prevention and control, epidemiology, direct patient care, risk management, facility design, construction, ventilation, and safety. The panel shall provide documentation of the risk assessment together with updated infection prevention risk mitigation recommendation (ICRMR) throughout all phases of the construction project including commissioning.
c) Every ICRA will be different depending on the scope of work being done and the patient population that is affected. The ICRA is intended to be a living document, so its scope may change throughout a project and as construction moves through the different project phases.
d) The owner shall ensure that ICRA-generated design recommendations and construction-related ICRMR are incorporated into project requirements.
e) The owner shall also provide monitoring of the effectiveness of the applied ICRMR during the course of the project.

13.2 ICRA: Construction documents

a) ICRA construction documents comprise two major components: i) the scope of work in relation to the extensiveness of the project in generating dust, and, ii) the type of patients that may be affected by the project, in relation to the vulnerability of the patients affected by the project.
b) The scope of work is categorized to four risk categories (Type A to D) as shown in Table 13.1. The construction risk can be based on how much dust may be generated and dispersed, project duration, type of demolition, removal of building components and assemblies, and/or whether the project will involve major-scale

demolition and renovation projects. The risk may also increase if mould is present or there are other known water-damaged areas.

Table 13.1: Risk categories of construction activities

TYPE A	**Inspection and Non-Invasive Activities** Includes, but is not limited to: • removal of ceiling tiles for visual inspection limited to one tile per 50 square feet • painting (but not sanding) • wall covering, electrical trim work, minor plumbing, and activities which do not generate dust or require cutting of walls or access to ceilings other than for visual inspection
TYPE B	**Small scale, short duration activities which create minimal dust** Includes, but is not limited to: • installation of telephone and computer cabling • access to chase spaces • cutting of walls or ceiling where dust migration can be controlled
TYPE C	**Work that generates a moderate to high level of dust or requires demolition of any fixed building components or assemblies.** Includes, but is not limited to: • sanding of walls for painting or wall covering • removal of floorcoverings, ceiling tiles, and casework • new wall construction • minor duct work or electrical work above ceilings • major cabling activities • any activity which cannot be completed within a single work-shift
TYPE D	**Major demolition and construction projects** Includes, but is not limited to: • activities which require consecutive work shifts • requires heavy demolition or removal of a complete cabling system • new construction

Appendix 13-1: Design Parameters for Hospital Facilities

Area	Pressure relationship	Minimum outdoor ACH	Minimum Total ACH	All room air exhausted directly to outdoors	Minimum Filter Efficiencies	Relative Humidity (%)	Space Design Temp (°C)	Remarks
Critical and Intensive Care	Positive or neutral	2	10	NR	MERV 14	40 - 60	21 - 24	For non-AII rooms
Emergency Department (high risk patients zone, such as fever zone)	Negative	2	12	Yes	MERV 14	Max. 60	21 - 24	• 100% outdoor air system • Exhaust HEPA filtration • Maintain directional airflow from clean to less clean areas.
Emergency Department (waiting area)	Negative	2	12	Yes	MERV 14	Max. 65	21 - 24	• 100% outdoor air, or recirculation air with HEPA filters at return air side and minimum 12 total ACH. • Maintain directional airflow from clean to less clean areas.
General Ward (AC)	NR	2	6	NR	MERV 14	Max. 60	21 - 24	

Area	Pressure relationship	Minimum outdoor ACH	Minimum Total ACH	All room air exhausted directly to outdoors	Minimum Filter Efficiencies	Relative Humidity (%)	Space Design Temp (°C)	Remarks
General Ward (NV)	NV/MV/MMV							• Ensure windows and/or doors are opened at all times to achieve good NV, unless outdoor air quality is poor, or the weather condition does not allow. • Turn on fans to improve indoor air movement to minimise air stagnation with windows and doors opened.
Airborne Infection Isolation (AII) room	Negative (min. -2.5 Pa)	2	12	Yes	MERV 14	Max. 60	22- 24	• 100% outdoor air system • Exhaust HEPA filtration • Maintain directional airflow from clean to less clean areas.
Protective Isolation Room	Positive (min. +2.5 Pa, ideal +8 Pa)	2	12	NR	MERV 14/ HEPA	Max. 60	21 -24	• Maintain directional airflow from clean to less clean areas.
Clean Utility Room	Positive	2	NR	NR	MERV 14	NR	NR	
Dirty Utility Room	Negative	2	10	Yes	MERV 8	NR	NR	
Consultation Room	NR	2	6	NR	MERV 14	Max. 60	21 - 24	

Area	Pressure relationship	Minimum outdoor ACH	Minimum Total ACH	All room air exhausted directly to outdoors	Minimum Filter Efficiencies	Relative Humidity (%)	Space Design Temp (°C)	Remarks
Gastrointestinal Endoscopy Procedure Room	NR	2	6	NR	MERV 14/ HEPA	40 - 60	21 - 23	
Bronchoscopy, Sputum Induction and Pentamidine Administration	Negative	2	12	Yes	MERV 14/ HEPA	40 - 60	21 - 23	• 100% outdoor air system • Exhaust HEPA filtration • Maintain directional airflow from clean to less clean areas.
Endoscopy Reprocessing Rooms	Negative	2	10	Yes	MERV 14	NR	NR	• 100% outdoor air system • Maintain directional airflow from clean to less clean areas.
Procedure Room	Positive	3	15	NR	MERV 14	40 -60	21 - 24	
Treatment Room	NR	2	6	NR	MERV 14	40 -60	21 - 24	
Imaging Room	NR	2	6	NR	MERV 14	Max. 60	22 - 26	
Interventional Imaging Procedure Room	Positive	3	15	NR	MERV 14	Max. 60	21 - 24	

Area	Pressure relationship	Minimum outdoor ACH	Minimum Total ACH	All room air exhausted directly to outdoors	Minimum Filter Efficiencies	Relative Humidity (%)	Space Design Temp (°C)	Remarks
CSSD Clean Assembly/ Workroom	Positive (+10 Pa)	2	4	NR	MERV 14/ HEPA	Max. 60	20 - 23	
Sterile Storage Room (clean/sterile medical/surgical supplies)	Positive (+5 Pa)	2	4	NR	MERV 14/ HEPA	Max. 60	24	
Soiled Workroom/ decontamination Room	Negative (-5 Pa)	2	6	Yes	MERV 14	NR		• 100% outdoor air system • Maintain directional airflow from clean to less clean areas.
Autopsy Room	Negative	2	12	Yes	MERV 14	NR	20 - 24	• 100% outdoor air system • Exhaust HEPA filtration • Maintain directional airflow from clean to less clean areas.
Non-refrigerated Body Holding Room	Negative	NR	10	Yes	MERV 14	NR	21 - 24	• 100% outdoor air system • Exhaust HEPA filtration • Maintain directional airflow from clean to less clean areas.

Area	Pressure relationship	Minimum outdoor ACH	Minimum Total ACH	All room air exhausted directly to outdoors	Minimum Filter Efficiencies	Relative Humidity (%)	Space Design Temp (°C)	Remarks
Staff Change and Rest Areas	NR	Refer to SS 553, Table 1	NR	NR	MERV 14	Max. 65	23 - 25	
Meeting Rooms	NR	Refer to SS 553, Table 1	NR	NR	MERV 14	Max. 65	23 - 25	
Auditoriums, large rooms pax >150	NR	Refer to SS 553, Table 1	NR	NR	MERV 14	Max. 65	23 - 25	
Staff/public toilets	Negative	NR	20	Yes	MERV 8	NR	NR	• General/public toilets and multi-bed toilets/ensuites have been classified as 'Public Toilets' as per the Code of Practice on Environmental Health. • For ensuite toilet in class A room, minimum ACH is 10.

Remark: (1) ACH – Air changes per hour. (2) NR – No requirement. (3) MERV – Minimum Efficiency Reporting Values.

CHAPTER 14 INFECTION RISK MITIGATION DURING CONSTRUCTION

This chapter highlights measures to be taken during construction or renovation to prevent transmission of diseases.

14.1 Internal construction or renovation activities

14.1.1 Barrier placement

a) Barriers range from flexible prefabricated containment to containment build on-site. The selection of the type of barriers will base on the Class of Infection Control Precautions, the specifics of the job and worksite. In general, use sealed, airtight barriers.
b) Prefabricated containments are suitable for use on small projects such as inspection above suspended ceilings, small plumbing repairs, ventilation damper adjustment and cable pulling.
c) To use the portable prefabricated containment / barrier:
    i. Ensure that the barrier has the height to reach the ceiling for above ceiling work, and can pass through the doors, tight corners, and under any low-hanging obstructions located on the way to the work site.
    ii. The size must be adequate to enclose the workers, ladder, equipment, and supplies necessary to do the work, and still allow room for the workers to complete the work and clean themselves and the inside of the barrier at the completion of the work.
    iii. When work is completed, ensure prefabricated containment is cleaned thoroughly, covered and stored to prevent dust from accumulating on the barrier. When work requires moving the barrier from site to site, for e.g., cable pulling, the barriers must be cleaned each time before unsealing and moving.
d) If plastic sheets are used for containment, an access to the work zone must be created: the seams between the plastic sheets on long runs should overlap by at least 1 meter for entry and exit of authorized personnel. The containment must be tight to the ceiling, walls and floors.
e) For larger projects encompassing whole rooms, activities that require consecutive shifts, or within congested environment, building the containment on-site using solid materials is the best option. Examples include removal of floor coverings, new

wall construction, and major cabling activities. To build an on-site solid wall containment:

i. use solid materials, e.g., drywall and rigid plastic panels;
ii. prior to constructing a solid wall containment, a temporary plastic sheets containment is to be erected if necessary to contain the dust and other contaminants generated during construction of the solid wall containment;
iii. Containment walls should be smooth and seamless, extending all the way up to the sofit, and all penetrations for services such as piping and ducting, etc. should be properly sealed to prevent dust migration;
iv. if anteroom is required (as in Class IV Infection Control Precautions), it should be large enough to permit workers to don and remove any protective clothing and working shoes, and to place a HEPA-filtered vacuum for removing dust from clothing;
v. traditional doors with control door access (e.g., digital lock) can be framed into the containment wall or anteroom wall for the access to the worksite.

f) Use heavy-duty and durable tapes (e.g., polyethylene tapes designed for construction containment) where necessary for sealing of all joints, seams, gaps, holes, opening or penetrations, especially for critical clinical areas like transplant or haematology or oncology wards.. Taping should be attached to the barriers in a continuous fashion to prevent any gaps.
g) Use signage to direct pedestrian traffic away from construction area.

14.1.2 Air filtering

Determine if construction area uses fresh/outside or recirculated air; consider adding filters or sealing return vents as needed with filter material or plastic. Adequate and proper ventilation should be provided at the work site.

For construction sites adjacent to areas with immune-compromised patients, demolishing work should be carried out in a way that minimizes dust generation, e.g., using fine water spray. Deploy mobile Hepa-filter units where necessary to reduce dust concentration on site and exhaust from the site should be Hepa-filtered before being discharged to the surrounding.

14.1.3 Noise and vibration

Assess the impact of noise and vibration, and explore the strategies (e.g., relocating patients, scheduling the work to low-activity times when feasible).

14.1.4 Ventilation

a) Monitor ventilation to ensure exhaust maintains negative airflow in construction zone.
b) Verify that adjacent areas have sealed penetrations and intact ceilings.
c) Verify that facility systems can continue to provide proper air exchange rates and pressure relationship in crucial areas near construction activity, and that air is not being recirculated from construction area into other patient care areas
d) Ensure that testing of air pressure is done throughout the project.
e) Specify temperature and humidity limits affecting ventilation that could lead to limiting use of the work area.

14.1.5 Debris removal

a) If possible, use a chute with HEPA-filtered negative air machines for debris removal over use of elevators; however, the chute opening should be sealed when not in use.
b) Remove debris at lease daily in carts with tightly and completely fitted covers.
c) Clean cart exteriors before transportation out from the construction area.
d) Transport debris during lowest activity period, and use the route agreed on as part of the traffic flow planning.

14.1.6 Monitoring of airflow and potential airborne contamination

a) Install monitoring device (e.g., vanemeter) in solid barriers to facilitate continuous monitoring of pressure relationships.
b) Identify visual monitoring indictors (e.g., dusty floors, footprints, visible dust on other environment surfaces, opened doors, incomplete hoardings, and wet ceiling tiles). Educate staff of the implications of such observations and to contact designated personnel for prompt corrective actions.
c) Do not perform air sampling routinely.
d) For renovation involving protective environment and OTs etc., consider fumigation at suitable stage(s) of the project for hard-to-reach areas such as ceiling plenums, etc. to discourage mould growth, especially if signs of mould have been detected.

14.1.7 System balancing after completion of construction

a) Ensure that the ventilation systems are balanced to design specifications.
b) Visually examine the filters for plugging or leakage. Preventive maintenance or cleaning of ductwork, vents, or induction units should have been agreed on during the planning phase.

14.1.8 Water issues

a) Flush water lines thoroughly in newly renovated and adjacent areas.
b) If interruption of water supply is anticipated, consider the following:
    i. schedule interruptions for low-activity times when feasible;
    ii. plan and arrange for volume of potable water for drinking and food preparation;
    iii. plan and arrange for supplies for patient care and cleaning;
    iv. provide disposable towelettes or waterless alternatives for handwashing for patients and personnel.

14.1.9 Contractor clean-up

Contractors should complete removal of containment barriers / hoardings and clean and disinfect according to specific agreement. The partitions should be wiped down with disinfected before removal.

14.1.10 Facility clean-up

Ensure that healthcare facility staff performs routine cleaning before returning area to service. Repeat environmental surface cleaning and disinfection if punch-list items are still being addressed.

14.2 External construction, major construction/renovation projects: additional precautions

14.2.1 Filter changes

a) Increase the frequency of changing the prefilters.
b) When admission is necessary, locate high-risk patients in areas as remote from the construction areas as possible.

14.2.2 Environment cleaning

Increase the frequency of cleaning the areas adjacent to construction zone.

14.2.3 Air handler changes

Consider closing down dampers temporarily in areas adjacent to construction zone.

14.2.4 Power disruptions

a) Develop protocols to address power interruption (e.g., purge air out of the duct for a specified time; perform immediate cleaning before putting the area back into service).

b) Ensure long-range follow-up (regular maintenance and duct cleaning; surveillance of airborne infectious agents or healthcare-associated infections with airborne pathogens).

14.2.5 Verification of air handler status

Ensure that the facility's systems can provide the proper air exchange rates and pressure relationships in crucial areas near construction activity, and air is not being circulated from the construction zone into other areas of the healthcare facility.

14.2.6 Cleaning of air handler

Facility engineers should advise about the special maintenance and cleaning of the ventilation system likely to be affected by construction. After completion of construction, it must be ensured that the ventilations systems are balanced to design specifications and that scheduled maintenance is maintained.

14.2.7 Final cleaning

Thoroughly clean the new areas before installing furnishings, privacy curtains, and clean supplies, and permitting patient admission.

14.3 External excavation precautions

External excavation ideally is conducted during off-hours so that air handlers can be adjusted; the goal is to protect the intake as much as possible. Working during off-hours reduces traffic and opening of doors, which reduce the volume of unfiltered air that flows into the building during excavation activity. Small projects require similar planning and vary by degree, but preparation still requires early communication with facility management.

14.4 Monitoring

Based on the scope of the project, a walk-through of the area at least weekly may be necessary to ensure that all specifications in the ICRA are being followed throughout the project, and to monitor the effectiveness of the infection prevention and control measures. Daily inspections should be made particularly at the start of a project. The monitoring shall be done by infection prevention and control team, in the presence of the designated individuals who can correct the situation or issue stop-work-order when necessary. Use an inspection worksheet or checklist and document inspections and observation, and corrective actions, if any (See Table 14.1 below). The contractors shall be informed of the essential monitoring measures and elements.

The essential elements of monitoring should include the following:

a) Dust containment barriers are appropriate and dust-tight;
b) The frequency in wetting excavated soil or demolished building, truck, and equipment path is adequate (for demolition, excavation and construction);
c) Doors, windows, and other ports of entry located near the project are sealed or barred from use;
d) Construction workers observe good hygiene practices;
e) Debris is bagged and secured tightly before transporting out from the construction or renovation area;
f) Waste is kept to a minimum at the construction or renovation area;
g) Materials delivered and stored outside for later installation are properly protected from dust.

Table 14.1: Example of an Infection Prevention & Control Worksite Inspection Checklist

Location and type of work:					**Project Manager:**				
Project start date:					**Contractor in-charge:**				
Check Applicable	Infection Control Measures		Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA
	Outside the worksite	Are containment barriers airtight?							
		Are all gaps, holes, opening sealed adequately?							
		Are adjacent areas kept clean?							
		Are traffic pathways kept clean?							
		Are unused doors kept closed or appropriately sealed?							
		Is signage to restrict and direct traffic around the area available?							

Location and type of work:					**Project Manager:**				
Project start date:					**Contractor in-charge:**				
Check Applicable	Infection Control Measures		Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA
		Is HEPA filter unit working properly as evidenced by the anemometer display?							
		Are walk-off mats provided at the point of exit from the worksite clean?							
	Within the worksite	Is air supply, existing ductwork sealed or capped off?							
		Are windows closed when hacking is process?							
		Is the worksite being regularly cleaned?							
		Are ceiling tiles replaced at the end of the shift if removed for access?							
		Are the debris transportation carts tightly and completely covered and wiped down before being leaving the worksite?							
		Is designated route used for debris removal?							
		Is designated lift (i.e., lift no. _____) used for debris removal?							

Location and type of work:				**Project Manager:**				
Project start date:				**Contractor in-charge:**				
Check Applicable	Infection Control Measures	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA	Y/N/NA
Signature by IPC & Contractor in-charge								

Source: Adapted with permission, A/Prof Ling M.L., Singapore General Hospital

14.5 Air sampling

Routine air (microbiologic) sampling is not recommended due the following reasons:

a) There is a lack of standards for interpreting air quality control testing results; no standards exist for safe levels of *Aspergillus* in the hospital environment;
b) Microbial sampling provides delayed results.

However, air sampling is justifiable when:

a) the patient areas that are adjacent to a major internal construction or renovation cannot be closed during the project;
b) as an integral part of an epidemiologic investigation;
c) commissioning of special areas such as pharmacy clean room and OT.

If air sampling is to be performed, it is critical to determine actions regarding results of sampling before undertaking the process. To determine the relative threshold, compare fungal spore counts from outdoor air to those counts obtained from indoor air. Elevated level from indoors might suggest amplification from a contaminated reservoir.

Before air sampling is performed, a real-time quantitative analysis using particles counters is useful to assess the function of a filter and the presence of water leaks. These devices provide rank order analysis to assess if the area with highest filtration has the lowest particle counts. In addition, the confirmation of ventilation parameters for specified rooms (air pressure differentials, room air exchange per hour, relative humidity) is essential before the microbiology sampling takes place.

14.6 References

Association for Professionals in Infection Control and Epidemiology (2015). Infection Prevention Manual for Construction & Renovation, Association for Professionals in Infection Control and Epidemiology, Inc., Washington.

Johnson L. (2019), in APIC Text of Infection Control and Epidemiology, 3rd edition, Association for Professionals in Infection Control and Epidemiology, Inc., Washington, Chapter 106 – Construction and Renovation.

CHAPTER 15 COMMISSIONING PHASE

Commissioning is a process whereby a facility which is completed or near completion is tested to verify that it functions according to design specifications and objectives.

15.1 General principles

Sufficient time should be provided for testing and commissioning and any rectification of identified problems. Technical commissioning of the building, services and equipment should include any areas that require inspection and testing to demonstrate compliance with design requirements, specifications, and IPC standards (refer to Appendix 15-1 for requirements). Examples of these are operating theatres, special ventilated isolation rooms, pharmacy clean rooms and sterile service departments.

A commissioning team is needed upon should be formed at early stage of the project to work with the project team to formulate commissioning strategy and develop the commissioning masterplan. Those involved may comprise senior managers, specialist teams including the IPC and users, as the tasks involved may be complex. External technical specialist may be required to supplement in-house expertise and resources.

IPC team should ensure that they are fully consulted and engaged. By understanding the commissioning process, they can contribute their expertise especially in those areas whereby requirements to modify services may have an impact on other aspects of IPC.

The IPC team should be involved in processes for:

a) analysis of commissioning data;
b) phased or staged occupation;
c) proper storage to protect patient care equipment and supplies from dust exposure
d) subsequent cleaning/disinfection of any furniture or equipment; dismantle barriers/temporary partitions after cleaning the work area in a manner to avoid dispersing dust;
e) approval of engineering commissioning data for operating theatres;
f) approval of engineering commissioning data for special ventilated isolation room;
g) commissioning tests (water testing, microbiological air-sampling for operating theatres);
h) onsite visits and testing;
i) transfer of facilities;
j) staff orientation and training;

k) post-handover period;
l) decommissioning of redundant facilities;
m) period of handover to operational management.

After hand-over the hospital should ensure the area complies with hospital cleanliness and standards for occupation. The hospital should be thoroughly cleaned and decontaminated including all surfaces, walls, ceilings, windows, high-risk area ventilation systems, service cavities and ceiling spaces using detergent and appropriate disinfectant.

Environmental air sampling testing is required prior to commissioning of operating theatres and clean rooms which include microbiological sampling, air flow testing and assessing pressure differentials.

If areas such as operating rooms, pharmacy clean rooms and high-risk area where severely compromised patients will be accommodated have been involved or affected by the construction process, air sampling may be required prior to operational use. Allow enough time, at least 48 hours, for culturing and sampling results prior to occupation. Once all these tasks have been completed, re-certify HEPA filters and laminar / clean flow systems where installed.

If the water supply has been disrupted during construction/renovation, then the taps should be flushed, and water sampling performed. The results should comply with acceptable local standards.

It is the responsibility of the multi-disciplinary planning committee to ensure the area is fit for use prior to handover and before patient occupation. Table 15.1 below is a sample completion checklist (non-exhaustive) that can be used as a guide.

Table 15.1: Example of checklist for commissioning

Date of project review:			
Infection Prevention & Control Measures Met?	**Yes**	**No**	**N/A**
The area has been thoroughly cleaned. This includes all horizontal and vertical surfaces to ensure all dust and debris has been removed.			
The area has been vacuumed with a HEPA filter vacuum.			
The area has been wet mopped with detergent / disinfectant.			
When commissioning a new or refurbished operating theatre or pharmacy clean room: air sampling and particle counts have been performed and results are within acceptable limits.			
Air conditioning is working correctly and within recommended parameters as per engineering and building services and / or the Contractor.			
HEPA filters and laminar/clean flow systems (where installed) have been certified or recertified.			
If the water supply has been disrupted: maintenance/contractor has flushed water through all taps and water sampling is done and results are within acceptable levels			
Sinks and plumbing fixtures are suitable for the task and properly located as per relevant standards.			
Pressure differential measurements are correct and meet requirement.			
Air intake and exhaust outlets are located and working properly.			
Coved corners on flooring.			
Absence of features that are difficult to clean.			

15.2 References

Department of Health, Estates & Facilities (2021). Health Building Note 00-09: Infection control in the built environment.

NHS Estates (2002). Infection Control in the Built Environment: Design & Planning.

Infection Control Risk Assessment (ICRA): Matrix of Precautions for Construction and Renovation. Joint Commission Resources

Appendix 15-1: Design requirements

S/N	Area	Pressure relationship to adjacent area(s)	Minimum air changes of outdoor air per hour	Minimum total air change per hour	Relative humidity (%)	Temperature (^{0}C)
1	ICU	Positive or neutral in relation to outside of patient's room	2	10	30-60	21-24
2	CSSD					
	Cleaning room	Negative	2	6	No requirement	22-26
	Clean workroom	Positive	2	4	No requirement	22-26
	Sterile storage	Positive	2	4	< 60	22-26
	Steriliser equipment room	Negative	No requirement	10	No requirement	No requirement
3	Isolation Room					
	Class S isolation rooms	Equal	No requirement	No requirement	No requirement	No requirement
	Class N isolation rooms	Negative	No requirement	12	Maximum 60	21-24
	Class P isolation rooms	Positive	No requirement	12	Maximum 60	21-24
4	Interventional radiology procedure room	Positive	3	15	Maximum 60	21-24
5	Sterile storage	Positive	2	4	Maximum 60	22-26
6	Steriliser equipment room	Negative	No requirement	10	No requirement	No requirement
7	Endoscopy					
	Reprocessing area	Negative	2	10	No requirement	No requirement
	Gastrointestinal endoscopy procedure room	No requirement	2	6	40-60	21-24

S/N	Area	Pressure relationship to adjacent area(s)	Minimum air changes of outdoor air per hour	Minimum total air change per hour	Relative humidity (%)	Temperature (^{0}C)
	Bronchoscopy procedure room	Negative	2	12	40-60	21-24

---- End of Document ----