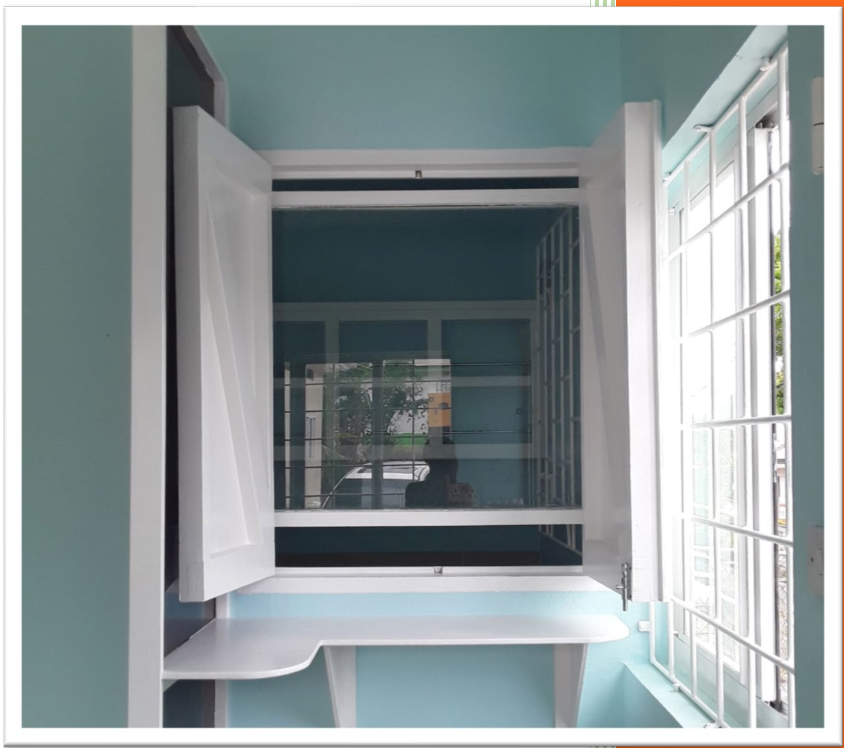
Smart Hospital Project

Retrofit Measures for COVID-19



Pan American Health Organization

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We would like to acknowledge and thank those who have contributed to the development of this technical guidance document expanding on the current work of the PAHO Smart Healthcare Facilities project. This document is specifically aimed at incorporating safety measures in the retrofit of healthcare facilities in consideration of COVID-19.

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Cover photo depicts a sneeze guard at the pharmacy of a health centre in Saint Lucia.

Table of Contents

COVID-19

RETROFIT MEASURES

Improving safety and saving lives!

COVID-19 VIRUS TRANSMISSION

The transmission of SARS-CoV-2 or COVID-19 virus is yet to be fully elucidated to date. What is known so far is the following for the purpose of risk assessment:

- **Droplets**: The main transmission is via droplets that are produced when coughing and sneezing and are absorbed by the opposite person via the mucous membranes of the nose, mouth and possibly the eye. Contact transmission is also theoretically possible, but there is no scientific proof so far.

- **Aerosols** (droplet nuclei, smaller than 5 micrometres): In a study of experimentally generated aerosols enriched with SARS-CoV-2 viruses, viruses were detectable for up to three hours. However, this was an artificial mechanical aerosol production, which is fundamentally different from coughing/sneezing patients with COVID-19 in the population. More research is currently being done on this.

- **Contact transmission**: Transmission through contaminated surfaces cannot be ruled out, especially in the immediate vicinity of the infected person, since reproducible SARS-CoV-2 viruses can be detected in the environment under certain circumstances. In COVID-19 patients, PCR-positive stool samples were also occasionally identified. For infection via stool, however, viruses must be capable to replicate. This has been shown in one study, but even then, the detection was rarely successful.

1. INFECTION CONTROL RETROFIT MEASURES

PAHO's Smart Hospitals Project started in 2009 and has been implemented across nine countries in the Caribbean Region. The onset of the COVID-19 pandemic has introduced new lessons to be incorporated as part of Smart Retrofits.

This document is intended to describe simple natural and mechanical ventilation measures which can be implemented as an extension of the PAHO Smart Retrofits with the aim of reducing the risk of transmission of viruses like COVID-19.

1.1 Handwashing Stations

One of the most effective ways to avoid contracting COVID-19 is to wash hands often and properly.
Smart retrofits recommend the installation of handwashing stations following these minimum standards:

1:10 ratio for handwash sinks to number of beds in hospitals and in-patient facilities
1:30 ratio for handwash sinks to number of patients in health facilities (no in-patients)
Handwash stations within 5 metres of toilets
Handwash sinks should be user friendly and easy to use by staff and visitors to the facility

Image 1 - PAHO/WHO Handwash protocol

1.2 Hand Sanitizer

Install hand sanitizer pumps in places where handwashing sinks may not be practical due to space restrictions or the difficulty of installing plumbing lines.

Hand sanitizer must be alcohol-based with at least 60% alcohol to be effective against COVID-19.

1.3 Screens or sneeze guards

Install screens between staff and visitors in areas such as pharmacy and reception to limit the transmission of droplets between people.

Existing spaces can be retrofitted to install a light timber frame with acrylic plastic such as Plexiglass. Plexiglass, also known as annealed glass, is stronger than standard glass. Polycarbonate plastic and shatterproof glass can also be used but is a more expensive option to acrylic. It is recommended to use a material that will not shatter and cause injury in an earthquake or if accidentally broken. Acrylic is suitable as it is affordable, structurally safe during an earthquake and is readily available in most countries.

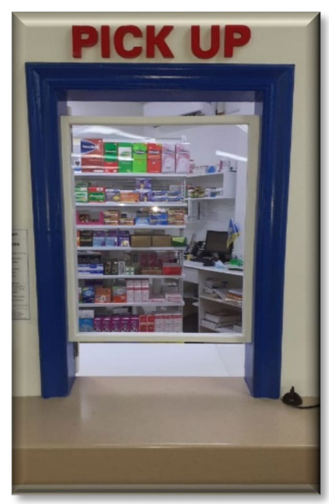
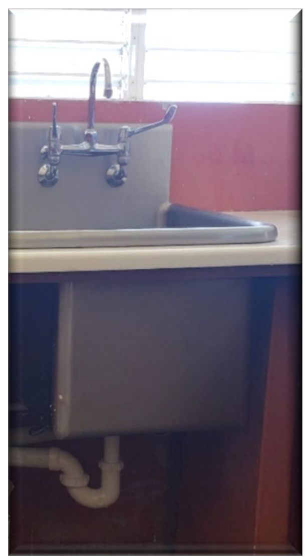


Image 2 - Pharmacy window with acrylic screen and one-way reflective tint

1.4 Types of Faucets

Table 1: Types of faucets

Standard hand-operated faucet	Push faucets
	
Touching handles unsuitable for infection control. Consider using faucets that do not require hand touching to operate.	Push lever operated with elbows and had automatic lock-off to limit water flow. Push lever can be broken easily if users do not know how to operate.

Foot pedal faucet	Long lever handles
	
Suitable for healthcare facilities for both staff and visitors use.	Handles can be operated with elbows. Suitable in areas for staff use only.

Smart Greening Tip: Use aerators in the faucets to reduce the volume of water being used for hand washing.

2. Patient Flow

One of the critical measures to limit the spread of COVID-19 is to control the movement of people and implement social distancing of 6 feet (1.83 metres) or an average of two arm's length between people. Patient flow also includes the movement of resources and internal systems.

Some simple guidelines which can be incorporated in healthcare facilities include the following:

- Establish dual direction flow where staff, patients and visitors only move in one direction along walkways and corridors. Dual direction flow reduces the space available between people moving in opposite directions.
- Reduce the number of patients in waiting rooms to permit social distancing spacing. Establish waiting areas in open spaces with full natural ventilation where possible.
- Set up temporary plastic screens as barriers between patients or services to limit virus transmission where there is inadequate physical space available.

2.1 Establishing an Isolation Room

Isolation rooms should be set up at healthcare facilities to treat confirmed patients of COVID-19. Simple, comprehensive guidance on setting up an isolation ward can be found in "*COVID-19 Outbreak Guidelines for Setting up isolation ward/ facility.*" Some of the key measures from this document are listed below:

Post signages on the door indicating that the space is an isolation area.

Remove all non-essential furniture and ensure that the remaining furniture is easy to clean and does not conceal or retain dirt or moisture within or around it.

If sufficient single rooms are not available to house patients, beds should have a spatial separation of at least 1 meter (3 feet) from one another.

- To create a 10-bed facility, a minimum space of 2000 sq. feet area segregated from other patientcare areas is required.
- Preferably, the isolation ward should have a separate entry/exit and should not be co-located with post-surgical wards/dialysis unit/SNCU/labour room etc.
- It should be in a segregated area which is not frequented by outsiders.
- The access to isolation ward should be through dedicated lift/guarded stairs.
- Stock the Personal Protective Equipment (PPE) supply and linen outside the isolation room or area (e.g. in the change room). Setup a trolley outside the door to hold PPE.
- Place appropriate waste bags in a bin. If possible, use a touch-free bin. Ensure that used (i.e. dirty) bins remain inside the isolation rooms.
- Keep the patient's personal belongings to a minimum. Keep water pitchers and cups, tissue wipes, and all items necessary for attending to personal hygiene within the patient's reach.
- Non-critical patient-care equipment (e.g. stethoscope, thermometer, blood pressure cuff, and sphygmomanometer) should be dedicated for the patient, if possible. Any patient-care equipment that is required for use by other patients should be thoroughly cleaned and disinfected before use.
- Place an appropriate container with a lid outside the door for equipment that requires disinfection or sterilization.
- Ensure that appropriate hand washing facilities and hand-hygiene supplies are available. Stock the sink area with suitable supplies for hand washing, and with alcohol-based hand rub, near the point of care and the room door.

3. Ventilation Considerations

3.1 Natural Ventilation

Natural ventilation reduces the risk of droplet transmission and infection. Natural ventilation is defined as the exchange of air by natural airflow through a building. Natural ventilation is advantageous over mechanical systems such as fans, vents, ducting and air conditioning systems because it does not require maintenance such as extensive cleaning. Natural ventilation should be used at facilities where there are prevailing cross-winds and the building is oriented to permit the flow of cross-winds. In the Caribbean, natural winds flow from East to West direction due to tradewinds.

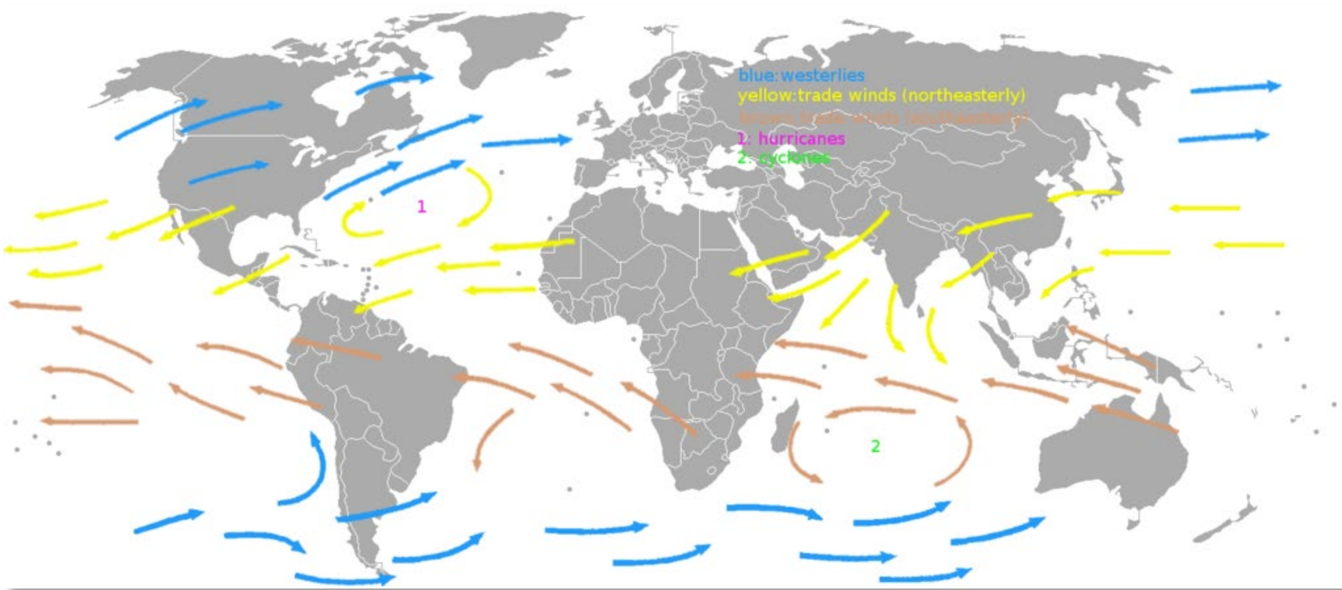


Image 3 - Prevailing winds on Earth

At facilities where there is insufficient movement of air through natural ventilation, a combination of natural and mechanical systems can be used. Windows and doors should be opened for fresh air intake for 30-minute intervals at least twice per day if the mechanical system does not have a fresh air intake installed. The WHO publication on *Natural Ventilation for Infection Control in Health-Care Settings* provides a detailed guide on the volume of airflow and how to set up a natural ventilation system.

Smart Greening Tip: Use of natural ventilation reduces cost of energy and carbon footprint.

3.2 Ventilation for Isolation Rooms and Operating Theatres

This section provides guidance on the installation and considerations for air conditioning systems for isolation rooms and operating theatres in healthcare facilities. It references technical specifications and standards from the American Society of Heating, Refrigerating and Air-Conditioning Engineers American (ASHRAE) and the Society of Health Care Engineering (ASHE), specifically the ASHRAE/ASHE Standard 170 -Ventilation of Healthcare Facilities and ASHRAE Handbook 2019 - Heating Ventilation Air Conditioning (HVAC) Applications Chapter 9 - Healthcare Facilities.

3.2.1 Introduction

In typical office and commercial establishments, air conditioning systems are maintained for user comfort. Temperature, humidity and air changes are the key factors that are considered in the design process. In Healthcare facilities, in addition to providing patient and staff comfort, the HVAC system is required to improve indoor air quality and mitigate against airborne transmission of diseases. This entails filtration systems, exhaust systems and the maintenance of pressure gradients in different areas on the hospital.

ASHRAE Standard 170 "Ventilation of Healthcare Facilities" sets the minimum standard for ventilation, air changes, temperature, humidity, filtration and design requirement for healthcare facilities and specialist areas in the hospital environment. The requirements for ventilation and filtration are to dilute and reduce contamination in the form of odour, airborne microorganisms and viruses, and hazardous chemical and radioactive substances. Ventilation effectiveness is particularly important to maintain appropriate indoor air quality in the hospital environment. In recent times we have seen the effects of COVID-19 and the mode of spread via airborne transmission.

Currently, studies on the spread of COVID-19 via air conditioning systems are still inconclusive. ASHRAE has set up a pandemic task force to look at the data available, however, in the interim they have been advising members to consider bringing more outside air into the spaces, upgrade filters on the air conditioning systems and direct the flow of clean air to areas of the building with less clean air. This entails maintaining pressure relationships in the building so that air flows from clean areas i.e. (clean rooms, sterile areas etc.) to the less clean areas and not vice versa.

The following are existing guidelines for the air conditioning and ventilation of areas for patients with airborne infections:

- The air conditioning system should be designed for a minimum air change of 12 air change per hour. This impacts the size and rating of the air conditioning equipment to deal with the added latent heat load due to the additional fresh air intake into the system.
- The direction of flow away from the breathing zone is desired to reduce the possibility of cross-infection.
- The exhausted air should not be returned but discharged to the atmosphere at a suitable height where it can be diluted and treated by the sun's UV rays. In some cases, the discharged air is required to be filtered by HEPA filters before discharge to the atmosphere.

3.2.2 Ventilation Requirements for Operating Theatres

This article deals specifically with HVAC systems in operating theatres and isolation rooms. The focus is intended to highlight the guidelines for dealing with airborne infections in hospital areas. ASHRAE Standard 170 applies to new buildings, additions to existing buildings and alterations to existing buildings.

Operating room categories

ASHRAE Standard 170 has categorised surgeries under three classifications because the ventilation requirements differ for each category.

1. **Class A Surgery-**Provides Minor Surgical procedures performed under topical, local or regional anaesthetics without preoperative sedation. Excluded are intravenous oral and epidural procedures.
2. **Class B Surgery-** Provides minor or major surgical procedures performed in conjunction with oral parenteral or intravenous sedation or performed with the patient under analgesic or dissociative drugs.
3. **Class C Surgery** – Provides major surgical procedures that require general or regional block anaesthesia and /or support of vital bodily function.

Design parameters for operating rooms

Table 7.1 of ASHRAE Standard 170 gives the minimum design parameters for operating rooms based on the classifications above.

Class B and Class C Operating Rooms

Pressure Relationship to Adjacent Areas	Minimum outdoor air Changes per hour	Minimum Total Air Change per hour	All Room Air Exhausted directly to outdoors	Air Recirculated by Means of Room Units	Relative Humidity %	Design Temperature °F / °C
Positive	4	20	Not Required	No	30-60	68-75 / 20-24

Class A Operating Procedure Rooms

Pressure Relationship to Adjacent Areas	Minimum outdoor air Changes per hour	Minimum Total Air Change per hour	All Room Air Exhausted directly to outdoors	Air Recirculated by means of Room Units	Relative Humidity %	Design Temperature °F/°C
Positive	3	15	Not Required	No	30-60	70-75 / 21-24

3.2.3 Filtration requirements for operating rooms

Air conditioner filters are rated by a number depending on the filtration efficiency. The minimum efficiency reporting value (MERV) rating is a standard that rates the filtration effectiveness of the filter. MERV Rating numbers are from 1 to 20. The higher the MERV rating equates to the finer filtration, meaning that finer particles and contaminants cannot pass through the filter e.g. MERV 13 to 16 will filter 0.3 to 1.0 Micron Particle size, Filters above MERV 16 will filter under 0.3 microns particle size. High-efficiency filters, also known as HEPA filters, have a MERV rating from 17 to 20 and will filter at least 99.97 percent of air pollutants.

ASHRAE Table 6-1 specifies the filtration requirements for Operating Rooms as follows:

Space designation	Filter Bank 1 MERV rating	Filter Bank 2 MERV rating
Class B and Class C Surgery, Inpatient and ambulatory diagnostic and therapeutic radiology, inpatient delivery and recovery spaces.	7	14
Class A Surgery, Laboratories and associated semi-restricted spaces.	13	Not required

Note: (1) *Filters above MERV 12 should be installed with a differential pressure monitoring device which will indicate when the filter needs replacement.*
(2) The supply diffusers for Class B and C surgeries shall be designed and Installed to allow internal cleaning.

SPECIFIC DESIGN CRITERIA FOR OPERATING ROOMS

1. Air conditioning systems serving operating rooms require careful design to avoid concentrations of airborne microorganisms. The largest concentration of bacteria in the operating room comes from the surgical team because of the activities during Surgery. During the operations, the surgical team around the table creates a concentration of contamination around the table.
2. Studies on operating room air distribution schemes carried out by Memarzadeh and Manning (2002) and observations of installations in cleanrooms and other commercial applications indicate that delivering air from the ceiling with a downward draft to several exhaust return openings located at low level on opposite walls is most effective and is the current code requirement for minimizing contamination of the surgical field. This also applies to spaces that are used for the treatment of infectious diseases most recently COVID-19.
3. Laminar supply ceiling diffusers above the surgical area allows the air to wash down over the patient and away to the corners is most applicable. Air supply velocities are kept low to avoid turbulence above the surgical table is the best option for operating room contamination control.

Image 4: *Typical HVAC system room arrangement for an Operating Room taken from ASHRAE Handbook 2019 HVAC Applications - Chapter 9 Healthcare Facilities*

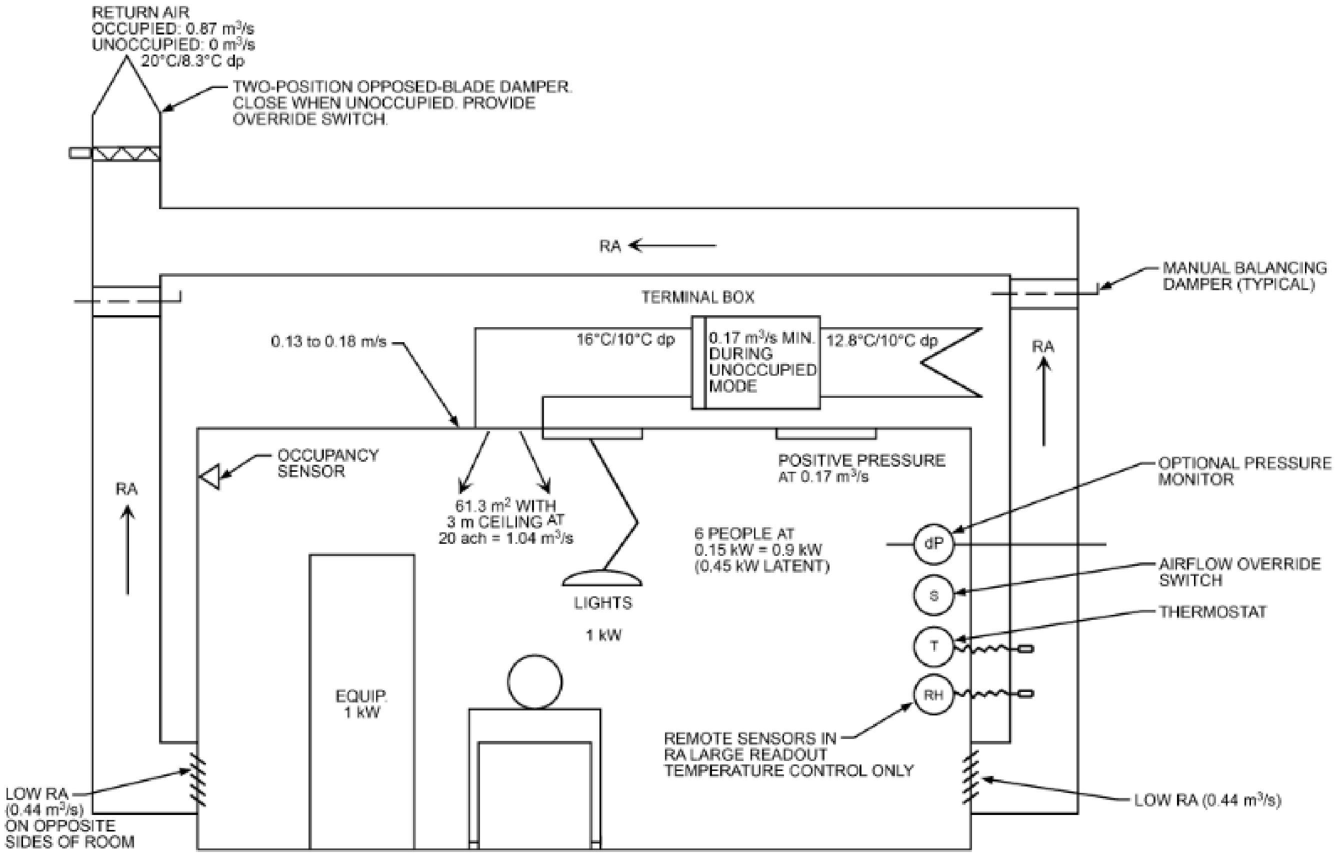


Fig. 2 Operating Room Layout
(ASHRAE 2013)

3.4 Ventilation Requirements for Isolation Rooms

ISOLATION ROOM CATEGORIES

ASHRAE Standard 170 categorises Isolation Rooms into two categories.

1. **Airborne Infection Isolation Rooms (AII)**: The isolation of Patients infected with organisms spread by airborne droplet nuclei less than 5 µm. AII rooms are designed to provide airborne infection isolation. Airborne infections include COVID-19. AII rooms are designed to be maintained at a negative pressure relative to all surrounding spaces.

2. **Protective Environment Rooms** (PE) is designed to protect the high-risk immunocompromised patient from human and environmental airborne pathogens. Immunocompromised patients are patients whose immune systems are deficient due to immunologic disorders, e.g. HIV. PE rooms are designed to be maintained at a positive pressure relative to all surrounding spaces.

DESIGN PARAMETERS FOR ISOLATION ROOMS

Table 7.1 of ASHRAE Standard 170 gives the minimum design parameters for Isolation rooms based on the given classification:

AII ROOMS

Pressure Relationship to Adjacent Areas	Minimum Outdoor Air Changes per Hour	Minimum Total Air Change per Hour	All Room Air Exhausted Directly to Outdoors	Air Recirculated by Means of Room Units	Relative Humidity %	Design Temperature $^{o}F/^{o}C$
Negative	2	12	Yes	No	Max 60	70-75/21-24

AII ANTEROOM

Pressure Relationship to Adjacent Areas	Minimum Outdoor Air Changes per Hour	Minimum Total Air Change per Hour	All Room Air Exhausted Directly to Outdoors	Air Recirculated by Means of Room Units	Relative Humidity %	Design Temperature $^{o}F/^{o}C$
Not required	Not required	10	Yes	No	Not required	Not required

PROTECTIVE ENVIRONMENT ROOMS (PE)

Pressure Relationship to Adjacent Areas	Minimum Outdoor Air Changes per Hour	Minimum Total Air Change per Hour	All Room Air Exhausted Directly to Outdoors	Air Recirculated by Means of Room Units	Relative Humidity %	Design Temperature °F/°C
Positive	2	12	Not required	No	Max 60	70-75/21-24

FILTRATION REQUIREMENTS FOR ISOLATION ROOMS

ASHRAE Table 6-1 specifies the filtration requirements for isolation rooms as follows:

Space designation	**Filter Bank 1 MERV rating**	**Filter Bank 2 MERV rating**
Airborne Infection Isolation Rooms AII	7	14
Protective Environment Rooms PE	7	17(HEPA)

Filters above MERV 12 should be installed with a differential pressure monitoring device which will indicate when the filter needs replacement.

3.4.1 Specific Design Criteria for Isolation Rooms

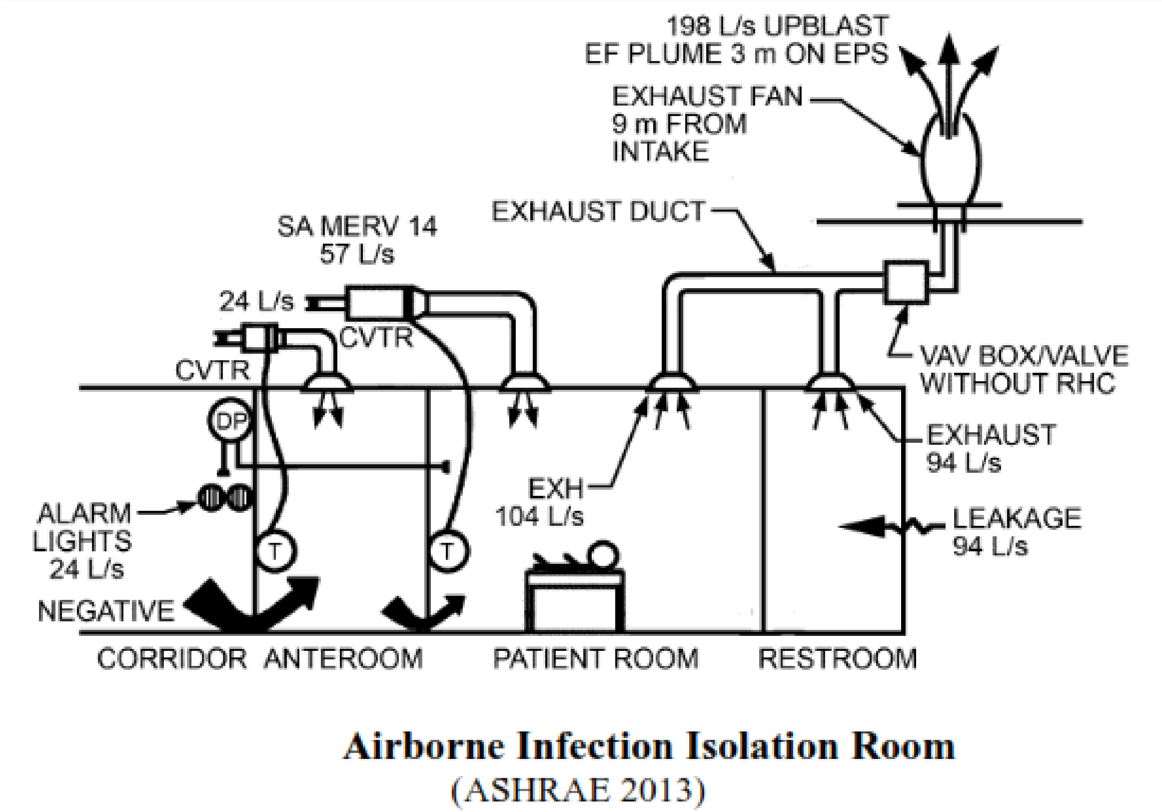
AII ROOMS

Ventilation for *all* rooms should meet the following criteria when an infectious patient occupies the room:

1. *AII* rooms shall have a permanently installed device to monitor the differential pressure between the isolation room and the adjoining spaces which will alert personnel when the negative pressure in the room is compromised. The alarm should be visual and audible.
2. All the air from the *aII* room, the associated aII anteroom and the associated toilet in the isolation room should be exhausted directly to the outside without mixing with any other air from non *aII* areas. In cases where the air cannot be exhausted directly to the outdoors, it should pass through a HEPA filter before mixing with other exhaust air.
3. The supply air diffuser to the *aII* room should be located at the foot of the patients' bed and the exhaust diffuser should be located directly above the patient.
4. For isolation rooms, the exhaust is taken above the patients head so that the infectious microorganisms are exhausted out of the room once they are released from the patient mouth and are not gathered on the floor which will happen if the draft is downwards.
5. In operating theatres, the exhaust is taken at a low level 18" above the floor is to remove pathogens away from the breathing zone of the operating team who will be occupying the space during the operation.
6. The room envelope should be sealed to limit leakage of air into the envelope.

7. The *aII* anteroom and *aII* toilet shall be at a negative pressure relative to the *aII* space where the patient is located, and the entire space shall be maintained at a negative pressure relative to all non *aII* spaces.
8. The differential pressure between the *aII* room and the adjacent non-*aII* spaces shall be a minimum 0.01iwg (2.5 Pa).

Image 5: *Typical HVAC system room arrangement for aII room taken from ASHRAE Handbook 2019 HVAC Applications - Chapter 9 Healthcare Facilities*

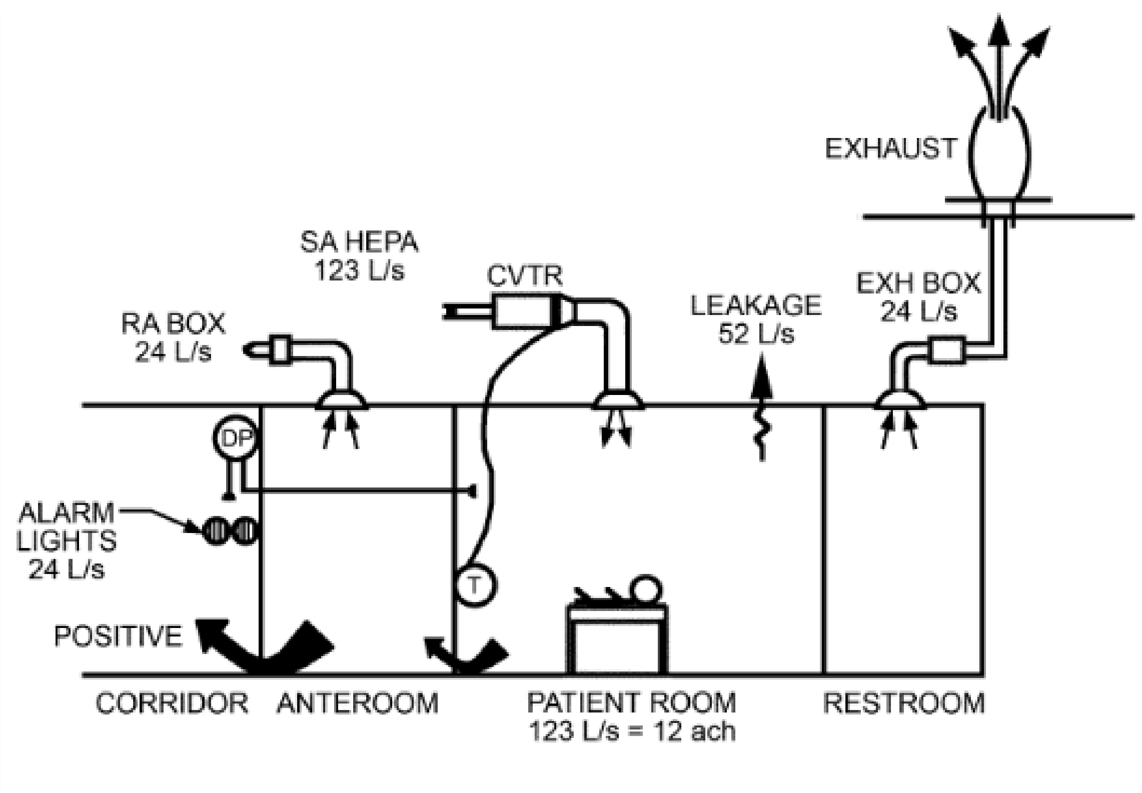


Airborne Infection Isolation Room
(ASHRAE 2013)

PROTECTIVE ENVIRONMENT ROOMS

1. The room envelope shall be sealed to limit leakage of airflow at 0.01 iwg[1] (2.5Pa[2]) differential pressure across the envelope.
2. Each protective environment (PE) room shall have a permanently installed device to monitor the differential pressure between the room and the adjoining spaces which will alert personnel when the positive pressure in the room is compromised. The alarm should be visual and audible.
3. Air distribution pattern within the room shall conform to the following:
    a. Supply air diffusers shall be located above the patient bed diffusers design shall limit the air velocity at the patient's bed to reduce patient discomfort.
    b. Return/exhaust diffusers of grilles shall be located near the patient room door.
4. The differential pressure between the PE room and the adjacent non-PE spaces shall be a minimum +0.01iwg (+ 2.5 Pa).
5. Constant volume airflow is required for consistent ventilation for the protected area.

Image 6: *Typical HVAC system room arrangement for a PE room taken from ASHRAE Handbook 2019 HVAC Applications - Chapter 9 Healthcare Facilities*



Protective Environment Room Arrangement
(ASHRAE 2013)

[1] iwg – inches of water gauge. Unit to measure pressure differentials
[2] Pa – Pascal. SI unit for pressure equivalent to newton per square metre

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