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REVIEW ARTICLE

# Planning and Designing an Isolation Facility in Hospitals: Need of the Hour

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## ABSTRACT

Emerging infectious diseases represent an ongoing threat to the health and livelihoods of people globally. Over the past decade, numerous infectious diseases have shown up in the United States including SARS in 2003, H1N1 or 'swine flu' in 2009, and now, the Ebola virus.

Isolation of a patient is essentially an escalation of the core healthcare process. Best practice demands that isolation rooms be provided where care for the underlying medical condition is optimal. As uncontroversial as infection control may seem, the infrastructure required (such as washbasins and isolation rooms) is often lacking in hospitals. And if isolation rooms are available, proper maintenance of pressure gradients is an issue. In normal circumstances no purpose is served by routine cleaning of ventilation ducts. During replacement, dust is shed from old filters. All extract grilles and some types of supply grilles accumulate dust. These represent an infection risk. The dust reflects the air-borne flora at the time of deposition with organism death taking place at a rate determined by microbial, environmental and other factors.

It is vital that regular monitoring and maintenance of the ventilation system is in place. The physical design of a hospital is an essential component of its infection control measures to minimize the risk of transmission of any infectious disease. Today, with a more progressive outlook, it is the fundamental requirement to adopt a holistic view of the design and management of hospitals. This document will not only help in making strategy for planning or renovating an isolation room and also helps in cleaning or maintenance of ventilation.


**Keywords:** Infection control, Isolation room design, Ventilation system.

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## INTRODUCTION

Infection control is emerging as a biggest challenge to health services around the world. All hospitals knowingly or unknowingly admit patients with communicable diseases. In recent years, emerging infectious diseases represent an ongoing threat to the health and livelihoods of people everywhere. Over the last few decades, there have been several emerging infectious diseases (EIDs) that have taken the global community by surprise and drawn new attention to EIDs, including HIV, SARS, H1N1, and Ebola.

For over a century, it has been recommended that patients with infectious diseases should be placed in segregated facilities to prevent the spread of infection.[1]

The effectiveness of a hospital's isolation precautions is dependent upon an amalgam of interactions between the appropriate:

- Physical environment, i.e. isolation room
- Healthcare policies;
- Healthcare staff behavior.

Isolation of a patient is essentially an escalation of the core healthcare process. As our understanding of the transmission of infection has improved, isolation practices have developed and moved away from early empirical approaches to become more evidence-based and targeted. Best practice demands that isolation rooms be provided where care for the underlying medical condition is optimal.

As uncontroversial as infection control may seem, the infrastructure required (such as washbasins and isolation rooms) is often lacking in hospitals. And if isolation rooms are available, proper maintenance of pressure gradients is an issue.

## FUNCTIONS

- To separate patients who are likely to be infectious to other persons.
- To provide an environment that will allow reduction of the concentration of airborne particles through various engineering methods.

- To prevent escape of airborne particles from such rooms into the corridor and other areas of the facility using directional airflow.
- To protect patients who are immunocompromised from potential harmful pathogens.

## Types of Isolation Rooms

There are two types of isolation rooms: (1) airborne infection isolation (AII) rooms and (2) protective environment (PE) rooms.

- Airborne infection isolation (AII)/Negative pressure isolation refers to the isolation of patients infected with organisms spread via airborne droplet nuclei <5 µm in diameter. These include patients suffering form measles, chickenpox and tuberculosis.
- Protective environment (PE)/Positive pressure isolation is a specialized area for patients who have undergone allogeneic hematopoietic stem cell transplant (HSCT).

## Planning Premises of Isolation Rooms

*Location*: The isolation rooms should be located at one end of medical and surgical wards/critical care units/pediatric care units/newborn intensive care units/emergency service areas/also other areas, such as dialysis. Isolation wards for infectious cases to be kept out of routine circulation. The location of the proposed isolation room, such as those near elevator banks or doorways should be avoided if possible.

- *Number of beds for isolation beds*: About 2.5% of the beds of a large hospital in a special unit would probably be adequate except during periods of unusually high demand.[2]
- *Space*: An isolation room has to provide uncluttered space around the bed for equipment and the increased number of personnel involved in emergency care. A room area of about 22 $m^2$ is adequate within an isolation unit.[2]
- Adequate number of wash hand basins should be provided within the patient care areas and nursing stations with a view to facilitate hand washing practice.
- Separate arrangements for garbage and infectious waste removal from wards and departments in the form of separate staircases and lifts.
- One to two standard isolation rooms per ward unit should be planned throughout the hospital with wash hand basin in room, shower, toilet and wash hand basin in bathroom. Door with self closing device and a normal window AC to be provisioned for these rooms.
- Gasketing should be provided at the sides and top of the door, and at ceiling and wall penetrations, such as those around medical and electrical outlets.

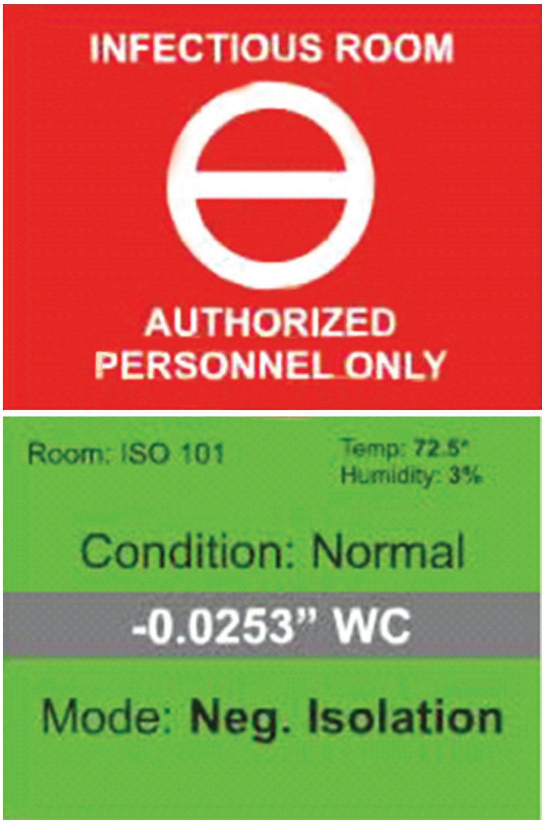
## Bed Management System[3]

- Bed centers should be at least 3.6 m apart.
- Minimum possible number of beds[2-4] should be kept in a cohort as to prevent chances of cross-infection.
- Design, accessibility and space in patient areas all contribute to ease of cleaning and maintenance.
- Spacing must take account of access to equipment around the bed and access for staff to hand-wash facilities.
- Provision of permanent screens between bed spaces should be there as an aid to prevent frequent traffic and thus the potential for microorganism transfer.

## General Planning Considerations

The design, materials and construction of the interior surfaces of an isolation room plays a critical role in the performance of the room in containing infections.

- Continuous impervious surfaces such as welded vinyl, epoxy coatings or similar durable surfaces.
- Welded vinyl floors coved up the walls, and wall finishes that are durable and easy to clean; for example, welded vinyl isolation rooms with smooth finishes, free of fissures or open joints and crevices that retain or permit passage of dirt particles. The use of carpet is discouraged because it is difficult to clean.[4]
- Minimisation of horizontal surfaces.
- Guard rails to protect the walls from damage by beds and mobile equipment.
- Epoxy-coated or stainless steel joinery that is easier to clean than uncoated timber.
- Windows designed to avoid pelmets and dust collection areas.
- Washable curtains.
- Wall-hung toilet pan and basin with non-hand operated taps.
- *Window setting*: Isolated patients can distinguish day and night by looking through the window panes at the isolation room. This is particularly important to the elderly as it relieves symptoms of disorientation.
- *Signs and labels*: All isolation room ductwork systems should be labelled with appropriate warning signs.[8] Appropriate signage should be prominently placed outside the door of isolation rooms. The bedside and other charts should also be labelled once isolation has been ordered for a patient.




- *Doors*: Sliding doors are not recommended but if space is an issue, sliding doors should only used as a last resort due to difficulties with maintenance and maintaining a seal. The pressure differential should force swing doors into the seal; that is, doors should open out of a NPR or open into a PPR) An alternative arrangement can be to have both doors swing into the anteroom. If doors have an interlocks mechanism fitted, an emergency breakout system must be provided.

- Communication system.
- A nurse call system with the capacity for direct communication between the nurse and patient should be available in each room.

## CLASS N—NEGATIVE PRESSURE ISOLATION ROOM

Air in an open class N room, for example, should flow from corridors INTO the isolation room to prevent the spread of airborne contaminants from the isolation room to other areas. The purpose of this design is to eliminate the spread of infectious contaminants and pathogens into the surrounding environment via the airborne route. Other patient treatment areas that can also be benefitted from in-room negative pressure isolation with HEPA-CARE systems include:

- Bronchoscopy suites
- Endotracheal intubation and extubation
- Open suctioning of airways
- Invasive vascular procedures
- Er Triage and treatment rooms
- Waiting areas
- Morgue/autopsy.

Figure 1 shows HVAC air flow arrangement for class N rooms.[12] An anteroom designed to provide an 'air-lock' (no mix of air) between the infectious patient and the common space is placed adjacent to the patient room. The air would flow from the anteroom to the isolation room. Pressure control is maintained by modulating the main supply and exhaust dampers based on a signal from a pressure transducer located inside the isolation room.

## Ventilation

Recirculation of exhausted air is discouraged, from class N rooms. The exhaust air should be directed to outside, away from air-intakes and populated areas. However, where recirculation may be deemed acceptable, HEPA filters (99.97% @ 0.3 μm DOP) capable of removing airborne contaminants on the supply side must be incorporated. The supply air should be located such that clean air is

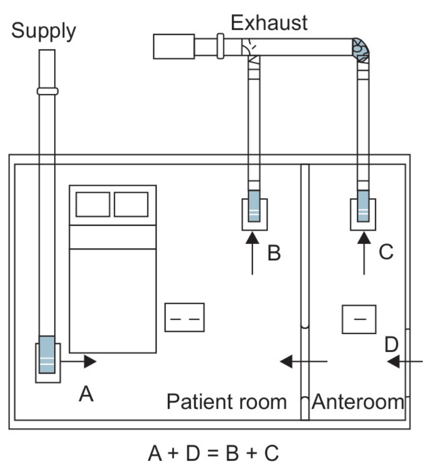



**Fig. 1:** Negative pressure isolation room (adapted from HVAC design for healthcare facilities by CED engineering)[12]

first passed over the staff/other occupants and then to the patient. Air distribution should reduce the staff's exposure to potential airborne droplet nuclei from infectious patients, accounting for the positions of the staff and the patient, and the procedures undertaken in the isolation room. Insider patient room, the supply air should be from the ceiling diffuser located at the perimeter near to the entry and the exhaust air should be drawn at lower levels approximately 6" above the floor in the room. Exhaust air ducts should be independent of the building's common exhaust air system to reduce the risk of contamination from back draught. The exhaust fan should be located at a point in the duct system that will ensure the duct is under negative pressure throughout its run within the building. The makeup air intakes should be located so that no contaminated air from nearby exhaust stacks or any sources of air contaminants is drawn into the makeup air system. Ensure supply air ducts are independent of the building's common supply air system. If sharing of supply ducts with other isolation rooms is unavoidable, provide the ducts with terminal HEPA filters (or other failsafe back draught prevention system). A high efficiency bag filter may be installed as a pre-filter to protect the HEPA filter.

### Emergency Rooms and Reception Areas

The likelihood of airborne contaminants leaving these rooms is reduced by keeping these rooms under negative pressure, relative to surrounding areas. Air is exhausted from these rooms either directly to the outside or through high efficiency particulate air (HEPA) filters.

## CLASS P—POSITIVE PRESSURE ISOLATION ROOMS

Class p—positive pressure isolation rooms are set at positive pressure relative to ambient pressure, meaning that air flow must be from the 'cleaner' area toward the adjoining space (through doors or other openings). This is achieved by the HVAC system providing more air into the 'cleaner' space than is mechanically removed from that same space.[6]

In the Figure 2, an airlock or anteroom is provided adjacent to the patient room. For a positive pressure room, air would flow from the isolation room to the anteroom and then to the corridor. Pressure control is maintained by modulating the main supply and exhaust dampers based on a signal from a pressure transducer located inside the isolation room.

### Ventilation

Class P rooms can be either 100% fresh air or can use recirculated air usually a 60/40 mix of outdoor air/recirculated air. The supply air should be located such that clean air is first flows across the patient bed and exits from the opposite side of the room. Air distribution should reduce the patient's exposure to potential airborne droplet nuclei from occupants. Positive pressure rooms may share common supply air systems (Table 1).

## ANTEROOMS[4]

If space and budget permit, an anteroom should be provided between the negative/positive pressure isolation room and the corridor (Fig. 3). It is always recommended for both positive and negative isolation rooms for three main reasons:

1. To provide a barrier against loss of pressurization, and against entry/exit of contaminated air into/out of the isolation room when the door to the airlock is opened.

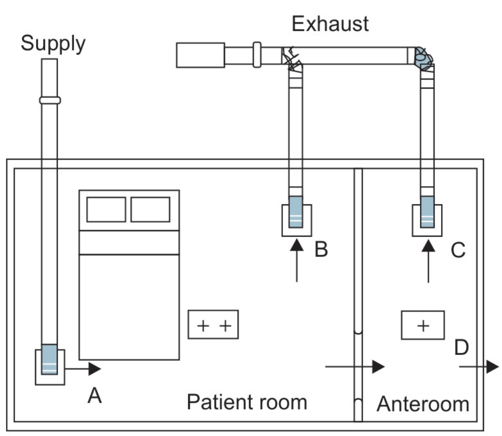



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**Fig. 2:** Positive pressure isolation rooms (adapted from HVAC design for healthcare facilities by CED engineering)[12]

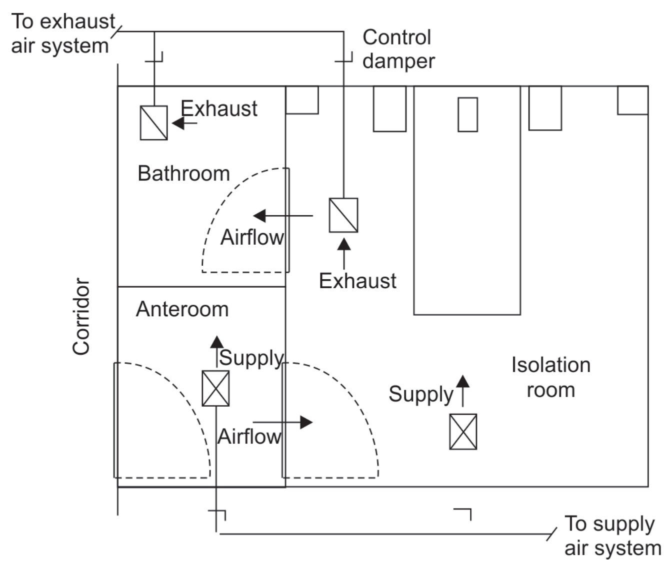


**Fig. 3:** Anteroom: outside and inside view (isolation room design by Thailand engineering company)[13]

**Table 1:** Isolation room checklist[5]

| *Features* | *S (Standard)* | *N (Negative)* | *P (Positive)* |
|---|---|---|---|
| Non-hand operated<br>Hand basin in room and anteroom | Yes | Yes | Yes |
| Ensuite (shower toilet and hand wash basin) | Yes | Yes | Yes |
| Pan sanitizer (near room) | Optional | Optional | Optional |
| Door or room with door closer | Yes | Yes | Yes |
| Anteroom | | Yes | |
| Sealed room, door grilled for controlled air flow | | Yes | Yes |
| 12 ACHR or 145 liters per patient | | Yes | Yes |
| 100% outside air ventilation | | Yes | |
| Local differential<br>Pressure monitoring | | Yes | Yes |
| Independent supply air[4] | | Yes | |
| HEPA filters on supply air | | | Yes |
| Low level exhaust 150 mm above floor | | Yes | Yes |
| Independent exhaust discharging vertically 10 m/s according to AS 1668.2<br>Type A exhaust[4] | | Yes | |
| Exhaust dust under negative pressure within building with duplex fans | | Yes | Optional |
| HEPA filters on exhaust for retrofit[3] | | Optional | |

2. To provide a controlled environment in which protective garments can be donned without contamination before entry into the isolation room.
3. To provide a controlled environment in which equipment and supplies can be transferred from the isolation room without contaminating the surrounding areas.

### Other Requirements of Anteroom

- Provision of a sink, cabinets and work counter
- Provision of a view window in the door to the isolation room
- Alignment of door to corridor with door to isolation room
- Maximum of two isolation rooms per anteroom.

## SPECIFIC DESIGN CONSIDERATIONS[6,7]

Environment control is very important in isolation facility. This is achieved by:

*Maintaining air changes*: A monitoring system should be provided to signal any malfunction of the supply/exhaust air system. A separation of 25 feet is recommended between exhaust from isolation rooms and other ventilation system intakes or occupied areas.[11]

1. Pressure gradient

| *Room type* | *Room* | *Ensuite* | *Anteroom* |
|---|---|---|---|
| Class N | –ve 30 Pa | –ve 30 Pa | –ve 15 Pa |
| Class P | +ve 30 Pa | +ve 30 Pa | +ve 15 Pa |
| Class P room with negative pressure anteroom | +ve 15 Pa | +ve 30 Pa | +ve 15 Pa |

2. Planned and unplanned leaks—rooms are well-sealed for better maintenance of pressure gradients that will also eventually reduce load on the air handling plant. Ensure air tightness by
   - Properly constructing windows, doors, and intake and exhaust ports
   - Maintain plasterboard ceilings that are smooth and free of fissures, open joints and crevices
   - Sealing all penetrations on the walls above and below the ceiling
   - Monitoring for leakage and making any necessary repairs.
3. Proper room pressurization can be checked using a smoke stick or smoldering match at doors held open approximately 1/4 inch to visually see which direction air is moving. Care must be taken when checking this to make sure that the door is not moving during the test since a door swinging can move more air than the design ventilation differential in the room. An alarm system (visual/audible) should be installed to warn of pressurisation failure.
4. *Thermal comfort*: Isolation rooms have relatively high air exchange rates in relation to other patient rooms. This implies high ventilation air supply and exhaust rates as well. Potentially uncomfortable air velocities (draughts) within the patient room can result, and therefore special attention must be given to thermal comfort, particularly for the patient, as a design issue.
5. *Air distribution (Fig. 4)*[12]
   - Air distribution systems should be designed to provide a high effective ventilation rate. The design and balance of the ventilation system should ensure that air flows from less contaminated to more contaminated areas. Air in an open

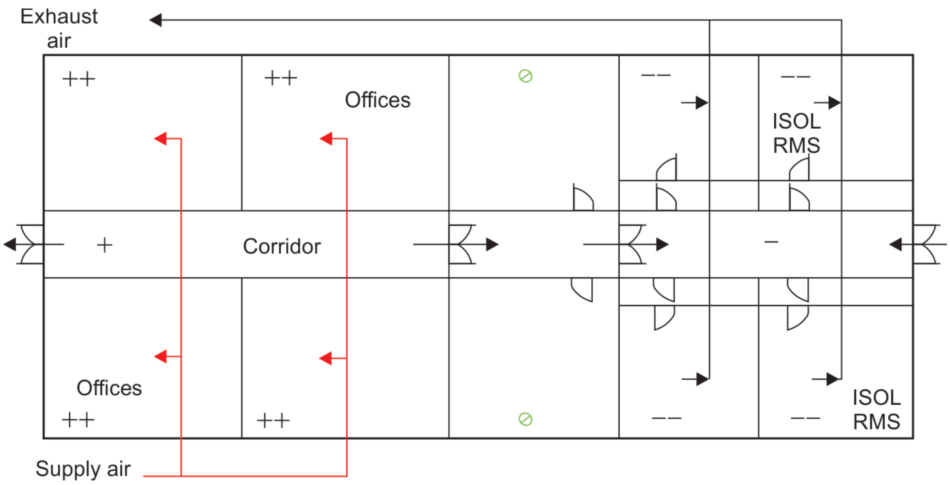


**Fig. 4:** Air distribution pattern (adapted from HVAC design for healthcare facilities by CED engineering)[12]

class N room, for example, should flow from corridors into the isolation room to prevent the spread of airborne contaminants from the isolation room to other areas. Within the room, the air should follow similar principles:

- In a class N room, the air should pass over first the staff then the patient
- In a class P room, the air should pass over first the patient then the staff
- Air distribution should reduce the staff's exposure to potential airborne droplet nuclei from infectious patients, accounting for the positions of the staff and the patient, and the procedures undertaken in the isolation room.

## Renovating or Converting a Room (Appendix-2)

When an isolation room is being incorporated into an existing facility, it is rarely possible to create the ideal room. Physical and financial factors often constrain the construction. It is critical to create a room that is fit for its purpose; therefore, the design intent should be adhered to as closely as possible.

When converting existing accommodation into class N rooms, the easiest and least expensive option is to adapt existing single rooms with ensuite facilities. The following requirements should be met in any conversion:

- Furnishing and fittings:
- Clinical hand wash basin with non-touch, fixed temperature mixer tap
- Wall-mounted soap dispensers
- Disinfectant hand rub dispensers
- Disposable towel holders
- Glove dispensers
- Storage for clean personal protective equipment
- Clean waste bins
- Observation window in corridor wall with integral privacy blinds
- Investigate the use of a pressure stabilizer above the bedroom door
- Compliant exhaust system
- Compliant air supply (see below)
- Sliding transfer grille in room door
- Sealed, monolithic ceiling with sealed access panels
- Windows to the exterior to be locked shut and sealed
- Provision of two-way intercommunication system between the patient's room and the nurses' station.

## Fire Strategy

- The isolation suite is intended to be built as a single fire compartment (Fig. 5).[9] The positive pressure in the lobby will detect smoke originating in the corridor from entering the room. Smoke from a fire in the room will be contained within the suite and extracted via the en-suite extract. Because of this the ventilation system serving the isolation facility should be kept running in the event of a fire.
- Ductwork thickness should be such that ducts can be considered an extension of the isolation suite. Fire dampers, where the ducts penetrate walls and floors will not then be required.
- A motorized smoke/fire damper should be fitted at the discharge of the supply air handling unit (AHU). The damper should close in the event of an AHU or intake fire under the control of a smoke detector mounted in the AHU.

## CONCLUSION

The physical design of a hospital is an essential component of its infection control measures to minimize the risk of transmission of any infectious disease. Today, with a more progressive outlook, it is the fundamental requirement to adopt a holistic view of the design and management of hospitals.

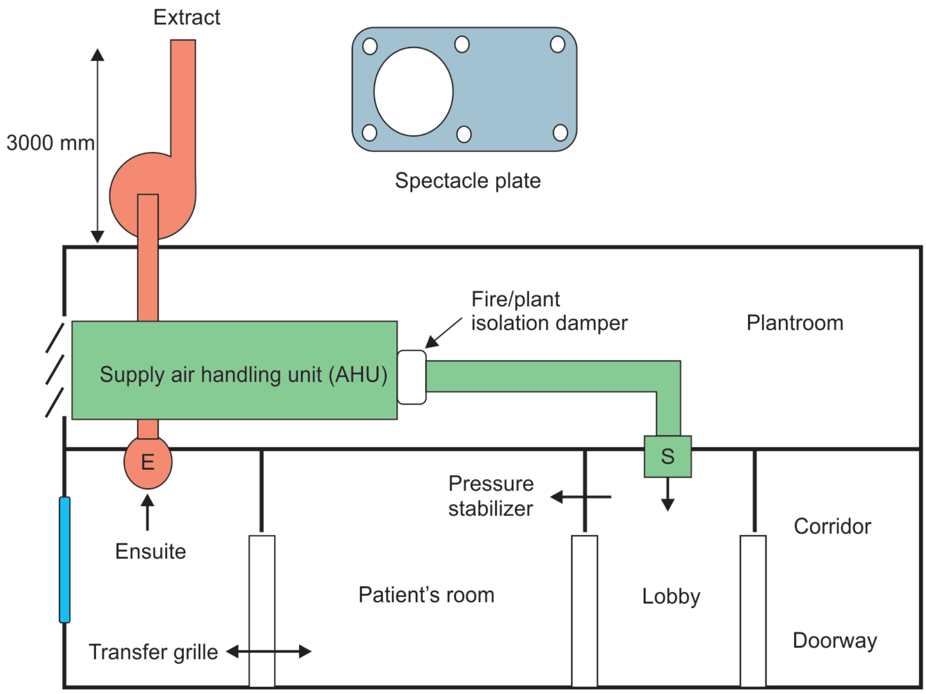


**Fig. 5:** Fire control (NHS estates health building note)[9]

With the challenges of new and emerging infectious diseases as well as higher public expectations and awareness of healthcare related issues, much consideration has to be given to these in the planning phase of building hospitals. For existing institutions and hospital buildings, renovation and upgrading plans must incorporate the necessary changes. Among the various methods for infection control two important environment factors are isolation and ventilation. Infected patients or those highly susceptible to infection need to be isolated in private rooms with proper ventilation systems in order to stop spread and reduce the possibility of developing a new infection. The more stringent guidelines stress the importance of utilizing an engineering team that has experience in designing the mechanical systems for AII rooms. Collaboration between the mechanical engineer and architect early in the design process is essential in avoiding issues that may arise relating to the placement of supply and exhaust locations and maintaining the standard pressure differential.

## Appendix I

Newly built single isolation room with anteroom (NHS estates health building note) (Fig. 6).[9]

### Minimum Requirements

1. Clinical hand washbasin with non-touch, fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to en-suite door.
4. Supply air.
5. Pressure stabiliser.
6. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
7. Double door for personnel and bed access.
8. Disposable apron dispenser.
9. En-suite WC to be non-touch flush and wash basin to have single tap with flow and temperature control.
10. Ceiling to be sealed solid construction, external window to be sealed.

## Appendix II

Upgrading three existing single rooms to provide two single rooms with anteroom in common (NHS estates health building note) (Fig. 7).[9]

Minimum requirements to upgrade existing facilities.

1. Add clinical hand-wash basin with non-touch fixed temperature mixer tap.
2. Provide suitable extract fan.
3. Install transfer grille to ensuite door.
4. Observation window in corridor wall with integral privacy blinds to allow for staff observation and patient views out.
5. Ensuite WC to be non-touch flush and wash basin to have single tap with flow and temperature control.

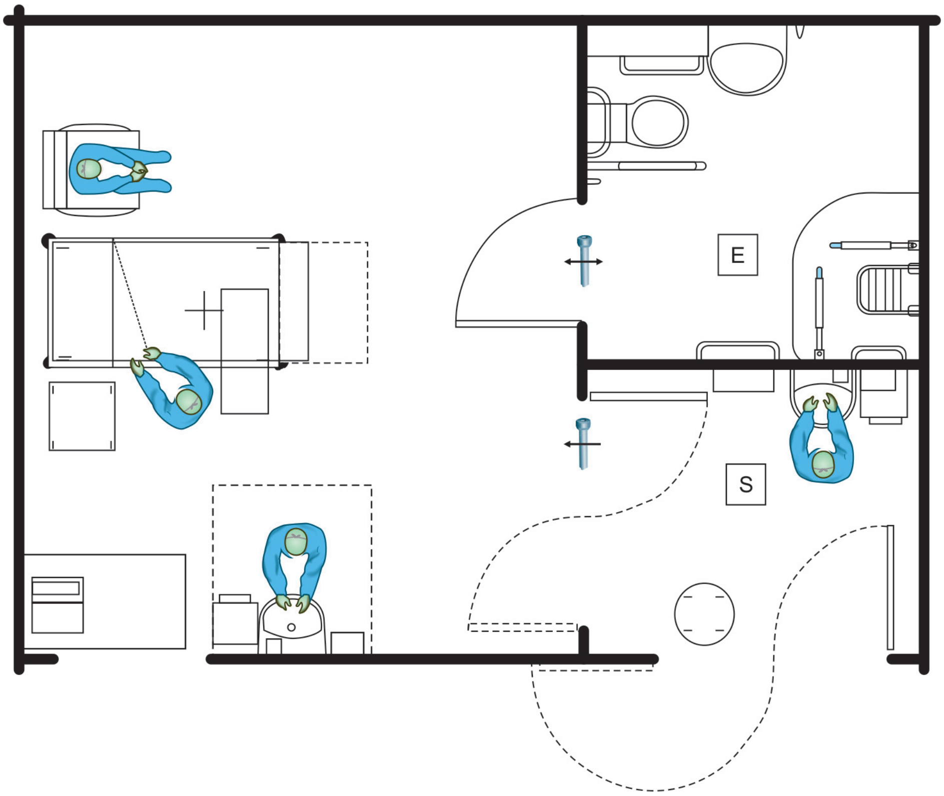


**Fig. 6:** Newly built single isolation room with anteroom (adapted from NHS estates health building note)[9]

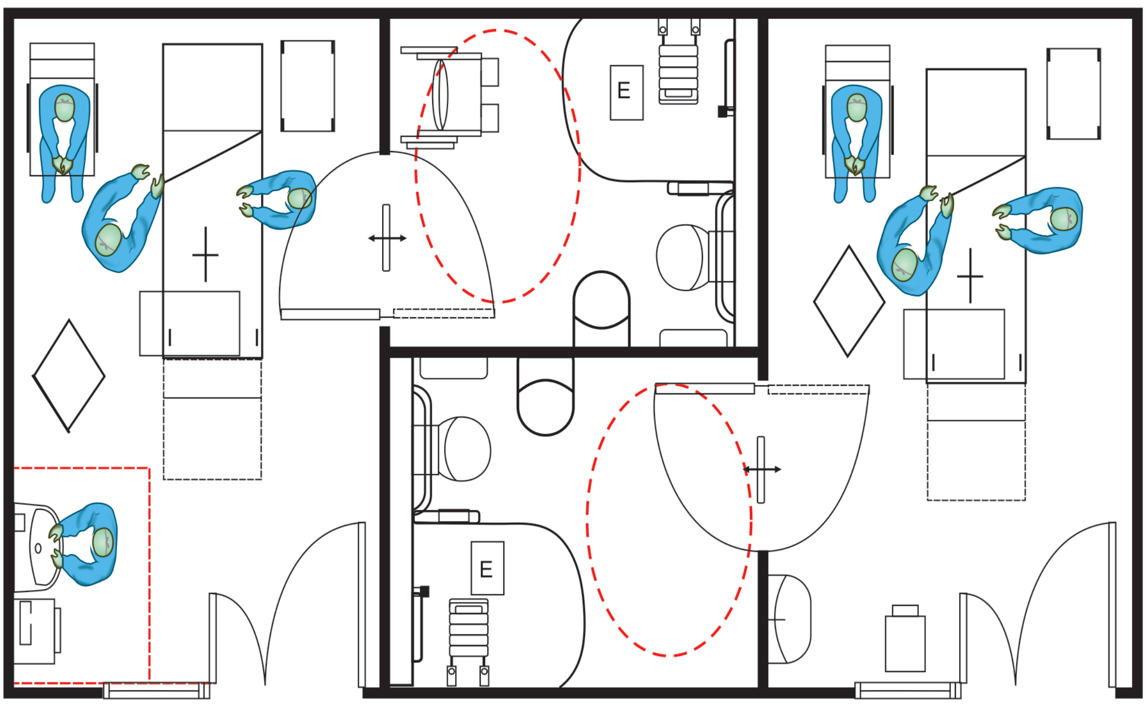


**Fig. 7:** Upgrading existing rooms into isolation room with anteroom (adapted from NHS estates health building note)[9] instead of existing bedrooms

## REFERENCES

1. Recommendations for Isolation Precautions in Hospitals (Part II), CDC, Hospital Infection Control Practices Advisory Committee (HICPAC). Available at: http://www.cdc.gov/ncidod/hip/ISOLAT/isopart 2.htm.
2. Putsep E. Modern Hospital: International planning practices. Lloyd- Luke Ltd., London 1979.
3. Campbell HCB. Isolation rooms (including Mechanically Ventilated Rooms): Best Practice Standards for Capital Planning: Northern Ireland 2004.
4. Moon K. Design of hospital isolation room; Business briefing; Hospital engineering and facility management 2004;24(1996).
5. Guidelines for Isolation Precautions in Hospitals: Hospital Infection Control Advisory Committee Julia S. Garner, RN, MN; the Hospital Infection Control Practices Advisory Committee Publication date: 01/01/1996.

6. Rydock JP, Lindqvist C. Best practice in design and testing of isolation rooms in nordic hospitals, Nordic innovation centre, September, 2004.
7. Isolation Rooms (including Mechanically Ventilated Rooms): Best Practice Standards for Capital Planning. Belfast; Department of Health, Social Services and Public Safety, Regional Advisory Committee on Communicable Disease Control; 2003.
8. Chowdhury PK, Bajaj S. HVAC Design Criteria for Isolation Rooms. HVAC J 2002 Jul-Sep.
9. Scottish Health Planning Note 04. In-patient Accommodation: Options for Choice Supplement 1: Isolation Facilities in Acute Settings.
10. Guidelines for the classification and design of isolation rooms in health care facilities Victorian Advisory Committee on Infection Control, 2007.
11. American Institute of Architects, Academy of Architecture for Health. Guidelines for design and construction of hospital and healthcare facilities. 1996-97. American Institute of Architects, Press Washington 1996; 102-105.
12. Bhatia A. HVAC design for healthcare facilities course no: M06-011 credit; 6 PDH. CED engineering.
13. Supote T. Isolation room design. Air conditioning engineering association of Thialand, Article 17 sets:56-66.