



## APPLICATION NOTE

# Air Systems for Patient Isolation Rooms

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**Patient Isolation Rooms are used in hospitals for patients with infectious diseases such as TB and SARS. There are no NZ specifications or standards for such Patient Isolation Rooms. It is therefore up to the hospital to specify requirements for such rooms based on international “best practice.” This paper lists and describes recommended performance requirements for Isolation Rooms, which may be specified prior to design and construction or modification of such rooms. Reasons and literature references are presented for each performance requirement.**

This paper deals primarily with air systems for negative pressure isolation rooms for infectious patients. Positive pressure isolation rooms for immuno-compromised patients have different requirements. In general each patient room will have an ensuite bathroom which is also at negative pressure.

### Relevant Literature

1. Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-Care Facilities, 1994 by U.S. Department of Health and Human Services – Centers for Disease Control and Prevention (CDC) (Available on-line at <http://www.cdc.gov/mmwr/preview/mmwrhtml/00035909.htm>)

This reference provides recommendations on general ventilation, the TB isolation rooms in particular and a supplement, which discusses the purpose and types of air systems used. The use of such engineering controls is considered as one of 13 measures to reduce the risk for transmission of M. tuberculosis.

2. Preventing Transmission of Tuberculosis in Health Care Facilities: An Engineering Approach, D.T. Hitchings, P.E., C.I.H. Member ASHRAE. (Available on-line at [http://www.safelab.com/TECH\\_PAPERS/TBPAPER/TBPaper.htm#TBPAPER](http://www.safelab.com/TECH_PAPERS/TBPAPER/TBPaper.htm#TBPAPER))

This paper elaborates on the CDC Guidelines above and provides detailed examples of Isolation Room designs.

3. Guideline for Isolation Precautions in Hospitals, 1997 by U.S. Department of Health and Human Services – Centers for Disease Control and Prevention (CDC) (Available on-line at <http://www.cdc.gov/ncidod/hip/isolat/isolat.htm>)

This guideline is more general in nature. It provides the more fundamental air system requirements and refers to the Guidelines above for applications involving TB.

4. Draft Guideline for Environmental Infection Control in Healthcare Facilities, 200, CDC, Healthcare Infection Control Advisory Committee (HICPAC)
5. Tuberculosis Isolation Room Design using CDC Guidelines, Kenneth E. Gill, HPAC Heating/Piping/AirConditioning, Sept 1997.

This paper is a case study of the conversion of medical observation cells to respiratory isolation cells in a Texas jail.

6. AS/NZS 2243.3:2002 Australian/New Zealand Standard, Safety in Laboratories Part 3: Microbiological aspects and containment facilities

This standard, while not strictly applicable to TB Patient Rooms, does include a set of requirements for Physical Containment Level 3 (PC3) laboratories where there is a risk of serious infection.

7. Health and Safety Issues in New Zealand Mortuaries, OHS, 1998

Safety requirements for mortuaries, including air system controls, are listed. The high-risk mortuary requirements are relevant to TB isolation rooms.

8. Room Pressure for Critical Environments, Brian Wiseman, ASHRAE Journal, Feb 2003, pp34-39

An investigation of differential pressure required for proper airflow direction through doors.

9. Guidelines for the Classification and design of Isolation Rooms in Health care Facilities, Standing Committee on Infection Control, A Public Health and Development Publication, State of Victoria, July 1999.

Covers four categories of patient isolation rooms including negative pressure rooms. Provides summary of microbial transmission methods and guidance in the appropriate type of isolation room for a particular patient.

10. AS 1668.2-2002, The use of ventilation and airconditioning in buildings Part 2: Ventilation design for indoor air contaminant control.

Section 6.5 includes a few notes on Infectious Isolation Rooms but falls well short of a detailed specification.

## **Performance Requirements**

### **1. Dilution and Removal**

***The air change rate shall be not less than 12 ACH.***

The purpose is to reduce the concentration of contaminants in the air by removing contaminated air and replacing it with contamination-free air.

The amount of contamination-free air is an air-change rate expressed in ACH (air changes per hour.)

CDC Guidelines<sup>(1)</sup> require 6 ACH minimum and recommend 12+ ACH. Higher air change rates are considered preferable.

In the case study presented by Gill<sup>(5)</sup> the air change rate was 15 ACH.

The requirement for high-risk mortuaries<sup>(7)</sup> is at least 12 ACH.

The Victorian Guidelines<sup>(9)</sup> recommend at least 12 ACH or 145 L/s per patient of 100% fresh air whereas AS 1668.2<sup>(10)</sup> requires the greater of 10 ACH, 10 L/s per person and 2 L/s per square metre.

## 2. Airflow Patterns

**Air shall generally flow from the supply to the Health Care Worker to the patient (or other infectious source) to the exhaust.**

The objectives are to avoid short-circuiting of fresh air from supply to exhaust, to avoid stagnation of air and consequent build-up of contaminant concentration, and to avoid the Health Care Worker being positioned between the infectious source and the exhaust.

This is a recommendation in CDC Guidelines<sup>(1)</sup>, which describe some supply/exhaust configurations.

D.T. Hitchings, in his paper<sup>(2)</sup>, describes practical systems for good room air distribution in more detail and recommends relatively low velocity, non-aspirating type diffusers.

The Victorian Guidelines<sup>(9)</sup> recommend exhaust from low-level ducts approx 150mm above floor level.

## 3. Room Pressurisation

**Room pressurisation shall be at least –12.5 Pa for Infectious Isolation Rooms. Provision shall be made for daily monitoring of the pressurisation.**

**(Optional) An audible alarm to indicate loss of room pressure control shall be provided.**

(Note: Pressurisation should be positive for Protective Isolation rooms. Refer Hitchings paper<sup>(2)</sup>)

Air flows from areas of higher pressure to areas of lower pressure. Thus negative pressurisation of isolation rooms is desired so that air flows into the room from adjacent rooms and not from the potentially contaminated isolation room into adjacent rooms.

The pressure of the ensuite bathroom/toilet should be more negative than the main patient room for odour control. This is the pressurisation described by Hitchings<sup>(2)</sup> and was achieved by extracting air from the bathroom.

CDC Guidelines<sup>(1,3)</sup> specify negative, monitored pressure, but do not specify well what the pressure should be. A minimum of -0.25 Pa is stated as the requirement for control of airflow direction. However such low pressures are very difficult to monitor conveniently. In fact CDC require monthly smoke checks of these low pressure differentials.) Furthermore, Brian Wiseman, has conducted tests on room pressurisation and airflow direction and challenges the effectiveness of -0.25 Pa pressurisation.<sup>(8)</sup> He recommends minimum pressurisation of -2.5 Pa and prefers -12.5 Pa.

In the case study presented by Gill<sup>(5)</sup> the pressurisation was -12.5 Pa. Magnehelic pressure gauges were used to indicate pressurisation. Also pressure switches and alarms were added at the nurses station with a 30 sec time-out to allow for door opening and access to the room without setting off the alarm.

The Victorian Guidelines<sup>(9)</sup> recommend -30 Pa pressurisation with an airlock at –15 Pa. Display of room differential pressures is recommended in a prominent position outside the room as well as an audible alarm to warn of fan failure.

For Physical Containment level 3 microbiology laboratories<sup>(6)</sup>, the requirement is -50 Pa with an airlock at -25 Pa. A magnehelic type differential pressure gauge and an audible alarm is also recommended for monitoring of pressurisation.

#### 4. Treatment of Exhaust Air

***Either:* Exhaust Air shall be recirculated or discharged via HEPA filters.**

***Or:* Exhaust Air shall be exhausted directly to outside via negatively pressurised ducting, away from air-intake vents, persons and animals or recirculated or discharged via HEPA filters.**

**Provision shall be made for monitoring (pressure differential), testing (integrity) and safe change of HEPA filters. Provision shall be made to automatically or manually adjust airflow to compensate for HEPA filter loading.**

The purpose of HEPA filtration is to remove contaminants from the air. HEPA filters remove at least 99.97% of all particles greater than 0.3 µm in diameter. CDC Guidelines<sup>(1)</sup> state that M. tuberculosis droplet nuclei probably range from 1µm to 5 µm in diameter, therefore HEPA filters can be expected to remove all infectious droplet nuclei from contaminated air.

CDC Guidelines<sup>(1)</sup> and the Victorian Guidelines<sup>(9)</sup> allow for air to be exhausted directly to outside via negative pressure ducting, away from air intakes, people or animals without HEPA filtration. However, there are good reasons for using HEPA filtration for all exhaust air from isolation rooms:

1. It is difficult to guarantee that exhaust air will not be re-entrained or come in contact with people or animals.
2. It may be desirable to recirculate air for energy saving reasons if the area is air-conditioned.

In the case study presented by Gill<sup>(5)</sup> the exhaust air handler was fitted with pre-filters, HEPA filters and an ultraviolet germicidal irradiation lamp (UVGI) section downstream of the HEPA filters.

For Physical Containment level 3 microbiology laboratories<sup>(6)</sup>, an exhaust filter is specified which shall be a HEPA filter.

CDC Guidelines<sup>(1)</sup> stress the importance of proper installation and meticulous maintenance of HEPA filtration systems. A HEPA filter integrity test which checks for leaks through or around the installed HEPA filter is recommended after installation of a HEPA filter and 6-monthly thereafter. Also a manometer or other pressure sensing device installed to indicate filter loading is recommended. Filter maintenance should only be carried out by qualified persons wearing appropriate respiratory protection.

Hitchings<sup>(2)</sup> recommends use of “bag-in, bag-out” housings for HEPA filters to minimise the risk of exposure of maintenance personnel to potentially infectious materials. This is certainly the preferred method when HEPA filters are located in the ducting. However, they are not required when the HEPA filter is mounted at the room exhaust – i.e. a terminally mounted HEPA filter. Hitchings also draws attention to compensation for HEPA filter loading. He recommends an automatic active volume control system. In practice, a manually adjustable system may be sufficient and will certainly be less expensive.

## 5. Anterooms

**(Optional) Normal entrance to the isolation room shall be via an airlock. Doors shall open outwards, be self-closing and shall contain glass panels so occupants of the airlock can be seen. With both doors closed, the airlock shall be at negative pressure to the corridor and positive pressure to the isolation room.**

An airlock is not required by CDC Guidelines<sup>(1)</sup> but the Guidelines explain that an anteroom may increase the effectiveness of the isolation room by minimising the potential escape of droplet nuclei into the corridor when the door is opened.

The Victorian Guidelines<sup>(9)</sup> require an airlock.

In his paper on Room Pressure for Critical Environments<sup>(8)</sup> Brian Wiseman recommends that anterooms (airlocks) be used whenever possible and further recommends that doors to negative pressure rooms open outwards to avoid momentarily pressurising the room as the door opens.

For Physical Containment level 3 microbiology laboratories<sup>(6)</sup>, an airlock is mandatory as it is for cleanrooms (Refer AS 1386.1-1989, Cleanrooms and clean workstations, Part 1: Principles of clean space control.)

On the basis of airflow testing, Total Air care can confirm that with a door open, the airflow becomes essentially un-controlled.

However, in some cases, it may not be possible to fit an airlock. This was the case in Gill's case study<sup>(5)</sup>.

## 6. Other Requirements

**Windows shall be sealed shut.**

If windows are opened, pressurisation will be lost and contaminated air may flow out the open window.

CDC Guidelines<sup>(1)</sup> recommend that openings including windows and electrical and plumbing entries shall be sealed as much as possible.

The Victorian Guidelines<sup>(9)</sup> recommend that all room leaks be minimised.

Windows in a PC3 laboratory must be closed and sealed<sup>(6)</sup>.

**(Optional) Water supplied to isolation rooms shall be fitted with back flow prevention.**

This is to prevent cross-contamination via the water supply.

Back flow prevention is required for a PC3 laboratory<sup>(6)</sup>.

**(Optional) Label the area as being a negative pressure isolation room**

As recommended by the Victorian Guidelines.<sup>(9)</sup>