



FRANCIS J. CURRY
NATIONAL
TUBERCULOSIS
CENTER

Tuberculosis Infection Control

A PRACTICAL MANUAL FOR PREVENTING TB



CLINICS

SPUTUM INDUCTION

AIRBORNE INFECTION
ISOLATION ROOMS

EMERGENCY DEPARTMENTS

HOMELESS SHELTERS



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Abbreviations

Organizations

AIA	American Institute of Architects
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
Cal/OSHA	California Division of Occupational Safety and Health (California OSHA)
CDC	Centers for Disease Control and Prevention (a Federal agency)
CMC	California Mechanical Code
CNTC	Francis J. Curry National Tuberculosis Center
FDA	US Food and Drug Administration (a Federal agency)
MMWR	Morbidity and Mortality Weekly Report
NIOSH	National Institute for Occupational Safety and Health (a Federal agency)
OSHA	Occupational Safety and Health Administration (a Federal agency)
OSHPD	Office of Statewide Health Planning and Development (a California agency)

Terms

ACH	Air changes per hour	LTBI	Latent tuberculosis infection
AFB	Acid-fast bacilli	M. tb	<i>Mycobacterium tuberculosis</i>
AIDS	Acquired immunodeficiency syndrome	MDR	Multidrug-resistant
AIIR	Airborne infection isolation room	NAAT	Nucleic acid amplification test
BAMT	Blood assay for <i>Mycobacterium tuberculosis</i>	NTM	Nontuberculous mycobacteria
BCG	Bacille Calmette-Guérin (vaccine)	PIN	Policy intent notice
CFM	Cubic feet per minute	PPD	Purified protein derivative
DOT	Directly observed therapy	QFT-G	QuantiFERON®-TB Gold blood test
FPM	Feet per minute	RIPT	Respiratory isolation of pulmonary tuberculosis
HCW	Healthcare worker	RTMCC	Regional Training and Medical Consultation Center
HEPA	High efficiency particulate air	TB	Tuberculosis
HIV	Human immunodeficiency virus	TST	Tuberculin skin test
HVAC	Heating, ventilating, and air conditioning	UV	Ultraviolet
ICP	Infection control plan	UVGI	Ultraviolet germicidal irradiation
IGRA	Interferon gamma release assay	VAV	Variable air volume
INH	Isoniazid	" W.G.	Inches of water gauge
LEV	Local exhaust ventilation	XDR	Extensively drug-resistant

Tuberculosis Infection Control Overview

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ENVIRONMENTAL CONTROLS	15

Preface

About the Francis J. Curry National Tuberculosis Center

One of four regional tuberculosis training and medical consultation centers (RTMCC) funded by the Centers for Disease Control and Prevention (CDC), the Francis J. Curry National Tuberculosis Center (CNTC) is a joint project of the San Francisco Department of Public Health and the University of California, San Francisco. CNTC creates, enhances, and disseminates state-of-the-art resources and models of excellence to control and eliminate tuberculosis (TB) nationally and internationally. Committed to the belief that everyone deserves the highest quality of care in a manner consistent with his or her culture, values, and language, CNTC 1) develops and delivers versatile, culturally appropriate trainings and educational products, 2) provides technical assistance, and 3) provides medical consultation.

Purpose of the Tuberculosis Infection Control Manual

The Tuberculosis Infection Control Manual is designed to provide information about TB infection control to clinics, homeless shelters, hospitals, and other interested parties. The goal of this manual is to provide consistent and up-to-date information about the guidelines and regulations pertaining to TB infection control, methods of reducing the risk of TB infection, and facility-specific guidelines for reducing the risk and dealing with potential TB exposure.

Before the publication of this manual, information about the potential risk of TB infection in various facilities, ways to reduce the risk of infection, and engineering details were provided in multiple CNTC products. Each product provided specific information for its topic with no single document covering all of these aspects. The following five products have been combined and updated to form this manual:

- Tuberculosis Exposure Control Plan: Template for the Clinic Setting
- Conducting Sputum Induction Safely
- Isolation Rooms: Design, Assessment and Upgrade
- A Guideline for Establishing Effective Practices: Identifying Persons with Infectious TB in the Emergency Department
- TB in Homeless Shelters: Reducing the Risk through Ventilation, Filters, and UV

The “Tuberculosis Infection Control Plan Template for Jails” (published 2001) is currently available from CNTC (product number WPT-09C) and is not included in this manual. Much of the content for the original products was researched and compiled by the Institutional Consultation Services (ICS), a component of CNTC that is no longer active. ICS staff had expertise and practical experience in infection control, occupational health, and mechanical engineering, and provided telephone and on-site consultations to TB control staff of

high-risk institutions, including health-care facilities, and shelters. While the ICS no longer exists, their work is an integral part of this document.

This manual was developed in an effort to compile all of the information into one cohesive document, making it easier to:

- Understand how TB is spread
- Understand how ventilation, filters, and UVGI can help reduce the spread of TB
- Evaluate and improve ventilation
- Use filters and UVGI to reduce the risk that TB will spread

In addition, this manual provides facility-specific procedures for TB infection control, making it easier to:

- Understand the special needs and requirements of each facility type
- Sustain TB control measures to ensure their effectiveness
- Make informed decisions regarding planning, funding, and selection of ventilation equipment, filters, and UVGI
- Learn the essential elements of a safe sputum induction program
- Learn the design and regulatory requirements for airborne infection isolation rooms (AIIRs)

Who Should Use This Manual

The primary audience for this manual includes:

- Directors and facility managers of the following health-care facilities:
 - Community and public health clinics
 - Hospital emergency departments, and
 - Homeless shelters
- TB/infection control program managers in public health departments

Secondary audiences for this document are:

- Public health nurses and community health nurses
- Staff of homeless shelter funding sources, such as governmental agencies and community-based organizations
- Homeless shelter designers, such as architects and engineers
- Others who work in or may provide services to health-care facilities or shelters:
 - Medical staff, such as on-site clinic and TB screening staff
 - Environmental health inspectors and occupational health inspectors
 - Engineering staff
 - Building inspectors
 - Advocates and educators
 - Caseworkers
- Other interested parties

How This Manual Is Organized

This manual is divided into the following sections:

- **Acknowledgements:** Lists the people, facilities and organizations who helped make this manual possible
- **Abbreviations:** Lists the abbreviations used in the manual
- **Part I:** Contains general information about the manual, TB disease, and regulations, including:
 - Background about the manual and how to use it
 - The intended audience
 - Descriptions of TB and transmission of *M. tuberculosis*
 - Information about how to reduce the risk of spreading the disease
 - Engineering details for the implementation of systems
 - Review of the current CDC guidelines
 - Description of other applicable guidelines and regulations
- **Part II:** Contains more specific information about TB infection control in various settings:
 - Clinics, especially TB clinics where the following are found:
 - Sputum Induction booths/rooms
 - AIRs
 - Hospital emergency departments
 - Homeless shelters
- **Appendices:** This section contains forms and worksheets that help in the assessment of risk; provides a tracking mechanism for training and triage criteria, among other items; and provides formulas to calculate conversion rates and room clearance times. Also included are a description of air change, and “Cover Your Cough” and room clearance signs.
- **Glossary:** Provides definitions of the terms used in the manual
- **Resources:** This section contains a list of the guidelines, educational materials, services, and web sites mentioned in this document. Additional resources are also supplied.
- **References:** This section contains a list of the documents referenced in the manual.

How to Use This Manual

1. Review the table of contents to get an overview of the manual contents. Note the titles of the appendices for future reference.
2. Read the introduction. This section contains information on how TB is spread and drug resistance.
3. Read “Guidelines and Regulations.” This section contains information from the CDC, AIA, OSHA, and Cal/OSHA.
4. Read the “Environmental Controls” section to understand how filters, UVGI, and ventilation should be implemented..
5. For detailed information, read the section that corresponds to your needs or setting:
 - Clinics (page 49)
 - Sputum Induction (page 73)
 - AIRs (page 87)
 - Hospital Emergency Departments (page 113)
 - Homeless Shelters (page 131)
6. As you read this manual, refer to the Glossary for definitions of terms used in the document, and Resources and References to see which works were referenced in a passage, and to learn about resources from which you can obtain additional materials.

About the Use of “TB” and “*Mycobacterium tuberculosis*” in this Document

In this document, the terms “TB” and “*Mycobacterium tuberculosis*”/“*M. tuberculosis*”/“*M. tb*,” (the germ that causes TB) are used in different ways. It is technically correct to use “TB” only in reference to the disease (i.e., TB disease). Likewise, it is correct to use *M. tuberculosis* with the words exposure, infection, disease, and transmission (for example, “*M. tuberculosis* exposure,” “*M. tuberculosis* infection,” “*M. tuberculosis* disease,” and “*M. tuberculosis* transmission”). To reflect common usage, this document uses “TB” with these words, instead of *M. tuberculosis* (for example, “TB exposure,” “TB infection,” “TB disease,” and “TB transmission”). *M. tuberculosis* is used in this document only to describe particles that a person with TB disease of the lungs or larynx expels from the lungs.

Introduction

How Tuberculosis (TB) Is Spread

TB is caused by bacteria (a type of germ) called *Mycobacterium tuberculosis* (*M. tuberculosis*). A person who has TB disease in his or her lungs or larynx (throat) can release tiny particles called droplet nuclei into the air by coughing, sneezing, singing, shouting, talking, or breathing.

These particles are invisible to the naked eye and are approximately 1 to 5 microns in size. (A micron is approximately one-hundredth the width of a human hair.) Droplet nuclei can remain airborne in room air for a long period of time, until they are removed by natural or mechanical ventilation.

In order for TB to spread, there must be a source patient who has infectious TB disease and a susceptible host (a person to inhale droplet nuclei containing *M. tuberculosis*). Anyone who shares air with a person with infectious TB disease of the lungs or larynx is at risk, although TB is not usually spread by brief contact. TB is spread when another person inhales one or more of these particles and becomes infected with TB.

The Difference Between TB Infection and TB Disease

Latent TB Infection (LTBI)

Latent TB infection (LTBI) does not cause a person to feel sick, and there are no symptoms.

Tuberculin skin tests (TSTs) or interferon gamma release assay (IGRA) blood tests are used to diagnose LTBI. A positive result means that TB infection is present.

Treatment for LTBI is effective in preventing persons with LTBI from developing TB disease.

Nine in ten people with a normal immune system with LTBI will never develop TB disease. However, one in ten of those infected will develop TB disease at some time in their lives, though the risk is lower if they receive preventive therapy. About half of these will develop TB disease within the first 2 years after they become infected.

There is no way to determine which people with LTBI will later get sick with TB disease. The following persons are at high risk for progressing from LTBI to TB disease:

- Persons infected with HIV and other diseases, such as diabetes and renal conditions that require dialysis, that weaken the immune system
- Persons infected with *M. tuberculosis* within the previous 2 years
- Infants and children <4 years old
- Persons who receive medical treatments, such as certain cancer treatments or prolonged steroid use, that weaken the immune system
- Persons with a history of untreated or inadequately treated TB disease

TB Disease

Most TB disease occurs in the lungs, but about 15% occurs in other parts of the body (e.g., bone, eye, and brain). General symptoms of pulmonary TB include:

- Cough
- Fever
- Night sweats
- Fatigue
- Unexplained weight loss
- Hemoptysis (bloody sputum)

Without treatment, a person with TB disease will get sicker. A person with untreated pulmonary TB disease of the lungs or larynx will also become more contagious. Untreated TB can become a life-threatening disease; however, with effective and complete treatment, TB can be cured.

A person with a cough lasting 3 or more weeks along with any other symptoms of TB disease (fever, night sweats, fatigue, unexplained weight loss, hemoptysis [bloody sputum]) should be evaluated by a healthcare provider as soon as possible. If TB disease is diagnosed or suspected, treatment will be prescribed.

When TB is Infectious

With rare exceptions, TB is infectious only when it occurs in the lungs or larynx. TB that occurs elsewhere in the body is usually not infectious, unless the person also has TB in the lungs or larynx at the same time.

In general, a person with suspected or confirmed TB disease of the lungs or larynx should be considered infectious until the person has:

- 1.** Had three negative acid-fast bacilli (AFB) sputum smear results obtained 8-24 hours apart, with at least one being an early morning specimen (an AFB sputum smear is a type of medical test used in the diagnosis of TB); and
- 2.** Shown to have clinical improvement as a result of antituberculosis treatment (for a minimum of 2 weeks) that is based on susceptibility results,
- 3.** Been determined to be noninfectious by a physician knowledgeable and experienced in managing TB disease.

A person who has met all three of the above conditions must continue to take TB medications as prescribed and continue to receive medical care for TB.

Drug-resistant TB

Drug-resistant TB is a growing global problem and is more difficult and expensive to treat and cure. Like “regular” drug-susceptible TB, drug-resistant TB is airborne and is just as contagious. In addition, there is often a delay in recognizing drug-resistant TB that can lead to prolonged exposure, making it easier for TB to spread.

Drug resistance is divided into two types: primary resistance and secondary (or acquired) resistance. Primary resistance occurs when a person gets infected with TB that is already resistant. We would know this because they were never treated for TB before. Secondary resistance occurs during treatment for tuberculosis, because the doctor prescribes inadequate treatment, patients with TB stop their treatment prematurely, or take their medicine sporadically.

Preventing drug-resistance is very important. When medications are not taken as prescribed or the treatment regimen is inadequate (such as therapy with a single drug), drug-resistant organisms emerge and take over. Therefore, patient adherence to a prescribed course of therapy and treatment with multiple drugs are essential factors in preventing the emergence of drug resistance.

Multidrug-resistant TB (MDR TB)

MDR TB is tuberculosis disease caused by *M. tuberculosis* that is resistant to the two most effective and important TB drugs, Isoniazid (INH) and Rifampin (RIF). MDR TB became a major concern in the US in the early 1990s when outbreaks occurred in seven hospitals in New York, New Jersey, and Florida. These outbreaks involved immunocompromised, HIV-infected patients and inmates in a state correctional system. Inadequate infection control practices and prolonged infectiousness contributed to significant transmission in these facilities and resulted in TB infection, TB disease, and death among a significant number of patients and staff.

CDC has published recommendations for prevention of MDR TB and for the treatment and management of MDR TB cases and their contacts. Consultation with medical and nursing experts who are knowledgeable and experienced in MDR TB case/contact management is essential.

Extensively Drug-resistant TB (XDR TB)

XDR TB, or extensively drug-resistant TB, is now being recognized as a serious and growing problem. In many developing countries, this form of TB is untreatable. The CDC first published a report in March 2006 entitled, “Emergence of *M. tuberculosis* with extensive resistance to second-line drugs, worldwide, 2000-2004.” The findings in the report indicated that XDR TB has worldwide distribution, including within the US, and has worse treatment outcomes than MDR TB. The report concluded that new TB drugs and better tests for detection are urgently needed.

XDR TB is a severe form of MDR TB where resistance extends beyond Isoniazid and Rifampin and includes resistance to the 2 most important drugs used in treating MDR TB. These cases are often resistant to up to 9 drugs when diagnosed.

Consultation with medical and nursing experts who are knowledgeable and experienced in MDR TB case/contact management is essential.

Guidelines & Regulations

Multiple TB outbreaks occurred in healthcare facilities in the late 1980s and early 1990s. In response, guidelines and regulations were developed and implemented to help ensure safe TB control practices. Investigations of these outbreaks found lapses in administrative, environmental, and respiratory protection control measures.

Highlights from TB-related guidelines and regulations are included below. While guidelines are not requirements nor are they binding by law, regulations are required by law and often refer to and rely on guidelines. Refer to your state and local regulations for requirements that are binding by law.

Centers for Disease Control and Prevention (CDC) Guidelines

The most comprehensive TB control guideline for healthcare facilities published to date is the CDC document, “Guidelines for Preventing the Transmission of *M. tuberculosis* in Health-Care Settings 2005.” The CDC guidelines include a supplement called “Environmental Controls,” which contains recommendations for AIIRs. Much of this Infection Control Manual is based on the CDC Guidelines.

Environmental control recommendations for the design of TB patient rooms include exhausting air to create negative pressure (see page 26 “What is Negative Pressure?”). For AIIR exhaust, the preferred practice is to directly exhaust to the outdoors. If recirculation is unavoidable, then HEPA filters are recommended.

A minimum ventilation rate of 12 air changes per hour (ACH) is recommended for AIIRs that are being renovated or newly constructed, and where HEPA filter units are used to supplement the central ventilation system.

For existing AIIRs, the CDC Guidelines are less restrictive. Increasing the AIIR air change rate to 12 ACH is recommended where feasible, but a minimum of 6 ACH is acceptable.

The CDC Guidelines also include recommendations for testing and monitoring AIIRs. The recommendations address testing methods and frequency of testing.

American Institute of Architects (AIA)

The AIA has published a revision of its guideline titled “Guidelines for Design and Construction of Health Care Facilities.” These guidelines apply to the design and construction of new health care facilities and major renovations in existing facilities.

Recommendations of the 2006 AIA guidelines include the following: 12 ACH in AIIRs, negative pressure, and daily confirmation of negative pressure when a room is used for isolation.

These guidelines also recommend that air from AIIRs be either exhausted outdoors or HEPA-filtered before recirculation.

A separation of 25 feet is recommended between exhaust from AIIRs and other ventilation system intakes or occupied areas.

ASHRAE

The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), Inc. published a handbook in a series of four volumes, one of which is revised each year to ensure that no volume is older than 4 years. The 2004 Handbook covered “HVAC Systems and Equipment,” and the 2003 Handbook addressed “HVAC Applications.”

Occupational Safety and Health Administration (OSHA)

On October 17, 1997, OSHA published a proposed standard for occupational exposure to *M. tuberculosis*. In May 2003, OSHA announced the termination of rulemaking for a TB standard. Effective December 31, 2003, OSHA revoked 29 CFR 1910.139 which had regulated the use of respirators to protect against exposures, and placed this use of respirators under the general standard, 29 CFR 134.

The compliance directive issued in 1996 remains in place: CPL 2.106 – Enforcement Procedures and Scheduling Occupational Exposure to Tuberculosis. OSHA will enforce the most current CDC TB Guidelines.

California Division of Occupational Safety and Health (Cal/OSHA)

Interim Tuberculosis Control Enforcement Guidelines

Cal/OSHA has published and enforces Interim Tuberculosis Control Enforcement Guidelines. These were published in 1992 and have been updated periodically. The most recent update was in March 1997.

In 2004, Cal/OSHA took the equivalent action to OSHA, in repealing Title 8 California Code of Regulations, Section 5147, that had applied to the use of respirators against tuberculosis, and placed this use under Section 5144.

Cal/OSHA is working on an aerosol transmissible disease standard, which would include tuberculosis. If that standard is adopted, the Enforcement Guidelines will be revised to reflect that standard. The Cal/OSHA website should be monitored for further information and updates: www.dir.ca.gov.

Environmental controls mandated for AIIRs include negative pressure and an air change rate of 12 ACH, which can be achieved by a combination of building ventilation and HEPA filtration. The agency also mandates that ventilation systems be tested at least annually and that records of each test be kept for at least 5 years.

Office of Statewide Health Planning and Development (OSHPD)

The California Mechanical Code (CMC)

The CMC regulates the construction of new and renovated AIIRs in California hospitals. The current version is the 2001 CMC and consists of the 1997 Uniform Building Code (UBC) combined with amendments specific to California. The CMC is enforced by OSHPD.

The California amendments include detailed requirements for the mechanical design of many hospital spaces, including AIIRs. Requirements for AIIRs include negative pressure and a minimum ventilation rate of 10 ACH. OSHPD also mandates that each new and renovated AIIR be equipped with an anteroom and a permanent room pressure monitor.

In response to the resurgence of TB, and recognizing the expense of constructing a new CMC-compliant AIIR, OSHPD provides a less expensive option for the isolation of TB patients in existing AIIRs or patient rooms. These requirements were published as Policy Intent Notice (PIN) Number 4 in 1996. PIN Number 4 allows the use of portable HEPA filter units to create negative pressure and increase the effective ventilation rate in TB AIIRs. The requirements for such rooms include negative pressure, a minimum ventilation air change rate of 12 ACH to match Cal/OSHA requirements, and provision of a permanent room pressure monitor.

TABLE 1.

Comparison of Regulations and Guidelines At-A-Glance

An At-A-Glance table comparing selected environmental controls for AIIRS of five prominent Federal and California regulations and guidelines follows:

	REGULATIONS		GUIDELINES		
	OSHPD ¹	CAL/OSHA ²	CDC ³	ASHRAE ⁴	AIA ⁵
Room designation	Negative-pressure isolation room	Atmospheric isolation	Airborne infection isolation room	Airborne infection isolation room	Airborne infection isolation room
Applies to	New & renovated	All	All	New & renovated	New & renovated
Total air changes per hour (ACH)	≥10	≥12	Prefer ≥12, minimum >6 for facilities existing pre-1994; >12 for post 1994 new & renovated	>12	≥12 May be reduced if room unoccupied
In-room HEPA recirculation allowed?	Only for remodel under (PIN) 4, dated 2/16/96	Yes	Yes, if used to achieve 12 ACH in existing pre-1994 facilities	No	No
Total ACH can include HEPA recirculation?	No	Yes	Yes, if used to achieve 12 ACH in existing pre-1994 facilities	No	No
HEPA-filtered recirculation to other areas?	No	Yes	Only if unavoidable Single pass recommended	No	No Exhaust to outside, if not possible recirculate to air handling unit exclusively serving AIIR
Minimum outside air change rate (OSA ACH)	2	Section 5142 requires employers to maintain the minimum amount of outside air required by the building code at the time the system was permitted.	See table 2 of CDC guidelines	2	2
Minimum exhaust air excess airflow (offset)	75 CFM	Not addressed	See page 64 of CDC guidelines	Not addressed	Not addressed
Minimum room pressure differential	0.001" W.G.	Not addressed	≥0.01" W.G.	≥0.01" W.G.	≥0.01" W.G.

1 2001 California Mechanical Code. Title 24, Part 4, Chapter 4: Ventilation Air Supply.

2 California Division of Occupational Safety and Health (Cal/OSHA). Interim Tuberculosis Control Enforcement Guidelines, revised March 1, 1997. Policy and Procedure C-47.

3 Centers for Disease Control and Prevention. Guidelines for preventing the transmission of Mycobacterium tuberculosis in health-care settings, 2005. MMWR 2005; 54 (No.RR-17),

4 American Society of Heating, Refrigerating and Air Conditioning Engineers. Chapter 7: Healthcare Facilities. In: 2003 HVAC Applications handbook. Atlanta: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 2003.

5 American Institute of Architects, 2006 Guidelines for Design and Construction of Hospitals and Health Care Facilities published by the American Institute of Architects Academy of Architecture for Health, with assistance from the Department of Health and Human Services (DHHS).

	REGULATIONS		GUIDELINES		
	OSHPD ¹	CAL/OSHA ²	CDC ³	ASHRAE ⁴	AIA ⁵
Minimum air velocity under door	100 FPM	Not addressed	Not addressed	Not addressed	Not addressed
Air distribution	Supply high, exhaust low, specific arrangement	Not addressed	See figure 3 on page 63 of CDC Guidelines	From clean (ceiling) to less clean (floor) areas	From clean to less clean areas
Upper-air or in-duct UVGI allowed?	Not addressed	Yes, but not in lieu of ventilation	Yes, but not in lieu of ventilation	Not addressed	Yes, but not in lieu of ventilation
Variable air volume ventilation allowed	No	Not addressed	Yes, must maintain negative pressure at all times, minimum set point must be adequate to maintain the recommended mechanical and outdoor ACH and a negative pressure >0.01" W.G. compared with adjacent areas	Not addressed	Yes, but maintain minimum code ACH and pressurization
Anteroom required?	Yes	No	No	"May be desirable"	Noted as general option, required for PE isolation rooms for airborne infection isolation
Minimum anteroom ACH	10	Not addressed	Mechanical 10 ACH See Table 2 of CDC guidelines	10	10
Minimum anteroom outside air change rate (OSA ACH)	2	Section 5142 requires employers to maintain the minimum amount of outside air required by the building code at the time the system was permitted	Defers to ANSI/ASHRAE Std 62.1-2004	2	Defers to ASHRAE & 100% exhaust to outside
Anteroom pressurization?	Positive to isolation room, neutral to corridor	Not addressed	Positive or negative See table 2 of CDC guidelines	Not addressed	Positive or negative See table 2.1-1 of AIA guidelines
Monitoring of negative pressure	Continuous, alarmed	Test annually	Check daily while being used for isolation	Not addressed	Not addressed

Environmental Controls

In this manual, the term “environmental controls” refers to the use of engineering technologies to help prevent the spread and reduce the concentration of infectious droplet nuclei in the air.

Due to funding and other restrictions, public health clinics, community health clinics, and homeless shelters frequently make use of locations that were not originally designed for use as clinics or shelters. As a result, if a location has an existing ventilation system, it may not have sufficient safeguards to prevent the spread of TB, or it may not be operational. Some settings have no ventilation system at all.

Additional risks faced by clinics, shelters, and hospital emergency departments, are deficiencies in AIIR environmental controls. When deficiencies occur, suspected or known TB patients may be placed in AIIRs that have inadequate environmental controls, such as low air change rates or positive pressure, placing others at risk of exposure.

This section outlines the environmental controls for designing, implementing, and maintaining an effective ventilation system at both a facility level and at an AIIR level. See part 2 for more specific information on different settings.

Using Ventilation to Reduce the Risk of Spreading TB

What is Ventilation?

Ventilation is the movement of air in a building and replacement of inside air with air from the outside. Two general types of ventilation are the subjects of this manual:

- Natural ventilation, which relies on open doors and windows to bring in air from the outside. Fans may also assist in this process and distribute the air
- Mechanical ventilation, which usually refers to the use of mechanical air-moving equipment that circulates air in a building and may also involve heating and/or cooling. Mechanical ventilation systems may or may not bring in air from the outside

How Ventilation Helps Reduce the Risk

Ventilation can reduce the risk of infection through dilution and removal.

When clean or fresh air enters a room, by either natural or mechanical ventilation, it dilutes the concentration of airborne particles, such as droplet nuclei, in room air. This is similar to opening doors and windows to dilute objectionable odors. Dilution reduces the likelihood that a person in the room will breathe air that may contain infectious droplet nuclei.

This removal effect occurs when potentially contaminated room air is either:

- Exhausted outdoors to a safe place (i.e., away from persons), or
- Filtered or irradiated to trap or inactivate droplet nuclei containing *M. tuberculosis*.

In any ventilated space, air is constantly entering (being supplied) and leaving (being exhausted). When air is introduced into a space, it will mix to a certain extent with the air already in the room. This will dilute any airborne pollutants to create an air mixture.

The more effective the mixing of air, the better the dilution of infectious particles.

Natural Ventilation and Fans

Note: *This information may not apply to certain settings, such as hospitals or AIRs. Natural ventilation should be implemented only when in compliance with your facility's regulations.*

In buildings without operational central forced-air heating and/or air conditioning systems, natural ventilation and fans should be used whenever possible to provide fresh outdoor air to all occupied rooms in the building. However, this may not be practical in extremely cold climates.

This section explains how fresh air and fans can be used to improve ventilation in a building. It includes information on:

- What to check and how to improve ventilation
- How to use exhaust and freestanding fans more effectively
- Advantages and disadvantages of natural ventilation.

A case study about how one homeless shelter director improved ventilation in her building is located at the end of this section.

About Natural Ventilation

Natural ventilation refers to fresh dilution air that enters and leaves a building through openings such as windows, doors, and skylights. All rooms where people congregate, such as waiting rooms or shelter dormitories (and that are not served by a central ventilation system) should have an operable window, door, or skylight that is kept open as often as possible.

Using Propeller Fans

Propeller fans can be an inexpensive way to increase the effectiveness of natural ventilation.

Types of Propeller Fans

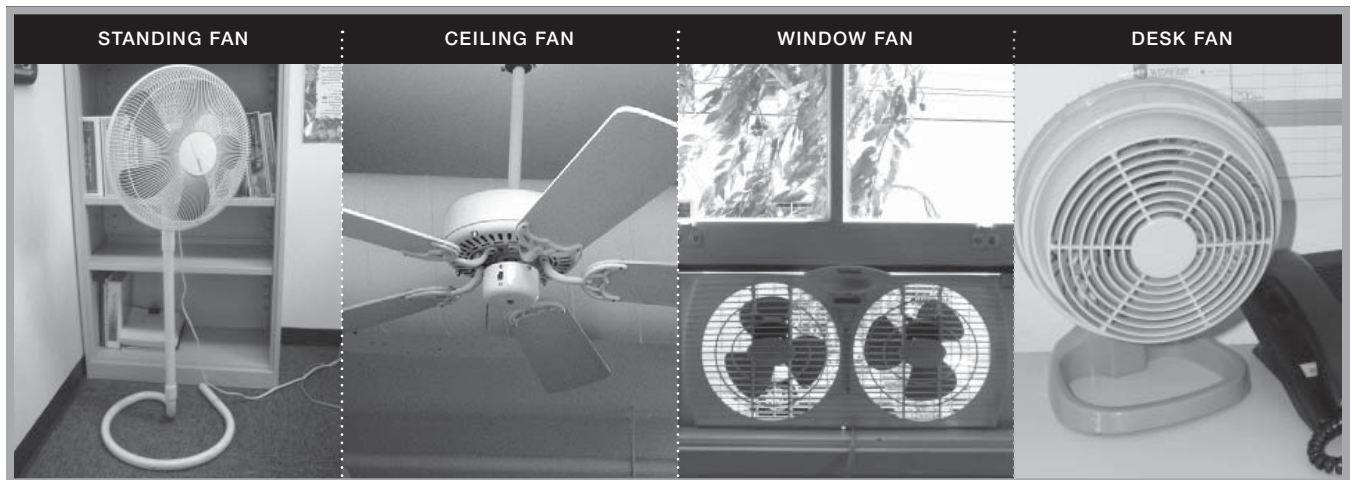
Ceiling fans are propeller fans that are suspended from the ceiling. They circulate air throughout a room but do not move it in any particular direction.

Propeller fans that move air in a particular direction include:

- Small fans that sit on a desk or other surface
- Fans that stand on the floor
- Fans mounted in a window opening

FIGURE 1.

Propeller Fans



Air Mixing and Removal

A propeller fan helps mix air in a room. This dilutes any infectious particles by spreading them throughout the room. The amount of particles near the source is reduced, but the amount in other parts of the room may increase.

If this dilution effect is combined with a way to replace room air with fresh air, such as an open window or door, the result will be fewer particles overall in the room.

A room with an open window and a fan will have less TB-transmission risk than an enclosed room with no fan, an enclosed room with a fan, or a room with an open window but no fan.

Using Directional Airflow to Reduce the Risk of Spreading TB

What is Directional Airflow?

Ventilation can also help reduce the local concentration of infectious particles in a room. This is done by matching the location of people in a room to the airflow. Simply stated, locate the people you are trying to protect from TB exposure near an air supply. Locate people who may be infectious near a place where air is exhausted from the space.

How Directional Airflow Helps Reduce the Risk

In the homeless shelter setting, this principle can help protect staff from an unidentified TB patient. For example, use of directional airflow can help reduce the chance that TB will spread from a client to a staff member doing intake interviews. If the air direction is known, the staff member should sit near the fresh air source, and the clients should sit near the exhaust location.

In a room in which large numbers of people may congregate, such as a dormitory or a waiting room, anyone could be a source of TB, and TB could spread to others in the room. Therefore, the direction of air movement is less critical. It is more important to achieve good air mixing in all locations so that particles are more quickly diluted and removed.

Directional Airflow and Staff Location

If placed in or near a wall opening, propeller fans can also be used to encourage air movement into and out of a room.

For example, fans installed in the windows on the back wall of a building exhaust air to the outside. If doors and windows in the front of the building are kept open, the overall effect should be to draw in fresh air through the front of the building and exhaust air through the rear.

With this arrangement, the risk that TB will be spread is greater near the back of the building. If this building is used as a homeless shelter, place the staff near the front of the building, and place people who are coughing or have other symptoms of airborne infectious diseases, including TB, near the exhaust fans.

Using Exhaust Fans

Clinics or shelters that do not have a central heating and/or air conditioning system often do have exhaust fans serving certain areas. Two common examples are bathroom exhaust fans and range hoods used over kitchen stoves. These fans increase ventilation by directly exhausting room air outdoors.

There is a wide variety of exhaust fan systems. A system can be as simple as a propeller fan installed in the wall, or it could include a ceiling grille, with a fan and a duct, leading to discharge on an outside wall or on the roof.

Over time, dust and lint accumulate on exhaust fans. The fans and ducts become clogged and less air is exhausted. For this reason, these systems should be cleaned regularly.

Locate the people you are trying to protect from TB exposure near an air supply.

Air Supply and Exhaust Locations

A ventilation system introduces and removes air by means of air outlets. In health-care applications, outlets are usually mounted on a ceiling or on a wall.

- Ceiling supply outlets are called *diffusers*. Wall supply outlets are called grilles or registers. Exhaust (or return) outlets are also called *grilles* or *registers*, regardless of whether they are mounted on the ceiling or the wall
- The neck of the outlet is the point at which the outlet connects to the air duct. The neck size is selected to match the airflow quantity
- The pattern or style of an outlet is the physical configuration of its face as seen from the room. For example, outlets can have a louvered pattern or a perforated metal pattern

Air provided to a room is always *supply* air. Air removed from a room, however, is either *return* or *exhaust* air, depending on the path it takes after it leaves the room.

- **Return air** is returned to the unit for recirculation
- **Exhaust air** is discharged outdoors

The effectiveness of any given ventilation rate in clearing a space of air contaminants depends on how well the air is mixed. In turn, air mixing depends largely on how and where air enters and leaves the space. The most common causes of poor air mixing are stagnation and short-circuiting. Both should be avoided because they reduce the benefits of ventilation.

Stagnation occurs when part of the room does not benefit from the fresh supply air. It also occurs in a room that does not have any ventilation. People in a stagnant location would probably feel that the air is stuffy. Infectious particles in a stagnant area are not diluted or removed quickly.

Short-circuiting occurs when clean air is removed before it has mixed well with room air, such as when the exhaust is located right next to the supply of incoming air. A room must not only have a satisfactory amount of clean air supplied to it, but this air must also mix with the air already in the room.

Proper selection and location of the supply and exhaust outlets will help avoid stagnation and short-circuiting.

Checking Natural Ventilation and Fans

People can usually feel the presence or absence of air movement in a space. A ventilated space has a slight draft. In the absence of ventilation, air will feel stuffy and stale and odors will linger. Use the following checklist to assess natural ventilation in your facility:

- Check that all occupied rooms have a source of natural ventilation
- Check that windows and doors are easy to open and to keep open
- Check air mixing and determine directional air movement in all parts of occupied rooms. An inexpensive way to visualize air movement is to use incense sticks:

1. Hold two incense sticks together and light them. (CNTC recommends that two sticks be used side-by-side)
 2. As soon as the incense starts to burn, blow out the flame. Now the incense should produce a continuous stream of smoke.
 3. Observe the direction of the smoke.
 4. Observe how quickly the smoke dissipates. This is a subjective test that may require some practice. It does not give a definite result but is useful for comparing rooms to each other. For example, it may take 5 seconds for smoke to dissipate in one room but 10 seconds in another.
 5. Repeat smoke tests for different common conditions at your facility. For example, if doors are kept open during the day but closed at night, the tests should be done under both conditions.
- Check that all room fans are working and clean
 - Check that exhaust fans are working and clean. To check exhaust fans that have a grille, hold a tissue or a piece of paper against the grille. If the fan is working, the tissue or paper should be pulled against the grille.

Recommendations for Natural Ventilation and Fans

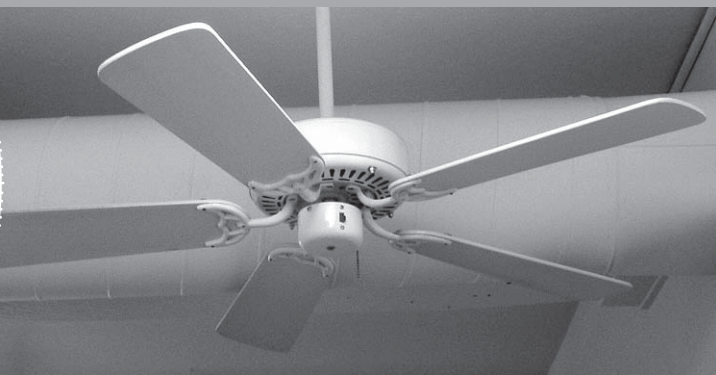
- Provide fresh outside air to all occupied rooms. Use natural ventilation and fans to provide this air where there is no central ventilation system
- Keep doors, windows, and skylights open as often as possible
- Check that doors, windows, and skylights are easy to open
- Add fans to increase air mixing and directional airflow
- Keep fans running as much as possible when the space is occupied
- Place fans so that air movement can be felt in all occupied parts of the room
- Room fans should be placed in locations where they will add to natural ventilation currents. For example, if a building experiences natural air currents from east to west, fans should be placed so that air is blown out the west windows
- Place fans so that air flows from clean to less clean areas. Place staff near fresh air sources
- In shelters, provide extra blankets to clients who complain of drafts so that ventilation can be used when the space is occupied
- If ventilation and fans cause objectionable noise or drafts and cannot be used when the space is occupied, consider increasing ventilation at times when the space is unoccupied. For example, many shelters are closed during part of the day, providing an opportunity to open windows and doors while running fans at high speed to “air out” dormitories
- Natural ventilation can be unpredictable and may not be practical in cold climates. If this is the case, you should consider adding a central ventilation system. See “Central Ventilation Systems” on page 24. If this is not feasible, consider the use of HEPA filter units or upper-air UVGI to provide clean air on a room-by-room basis. See “Upper-Air UVGI and HEPA Filter Units” on page 38

Routine Upkeep for Natural Ventilation and Fans

- Clean exhaust fan outlets and fans about once a month with a HEPA-filtered vacuum cleaner. Use a damp cloth or vacuum cleaner to remove dust and lint from fans, grilles, and ducts. Clean ducts behind grilles as far back as the vacuum cleaner can reach. This should not be done when patients are in the room
- Check natural ventilation at least once a year or whenever disruption/alteration is suspected
- Keep records of all routine upkeep activities and dates

Advantages and Disadvantages of Natural Ventilation and Fans

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none">• Natural ventilation can be implemented immediately by opening doors, windows, and skylights• Bringing fresh air into a space not only reduces the risk of TB transmission, but also improves overall indoor air quality. Unwanted indoor pollutants and odors are reduced• Freestanding fans are relatively inexpensive to buy and operate• Freestanding fans can be moved wherever needed	<ul style="list-style-type: none">• Natural ventilation can be uncontrollable and unpredictable depending on wind conditions and other factors. For example, people may close windows and doors, or the wind direction outside may change• Air that is introduced directly from the outdoors, without the benefit of filters or ductwork, may bring in unwanted elements, such as traffic exhaust and noise, rain, dust, odors, pollen, and insects• Keeping windows and doors open may adversely affect security, comfort, and privacy. This is especially true at night and in the winter



Natural Ventilation & Fans

Lynn is the director of Welcome Home, a homeless shelter that serves approximately 100 people each night.

The building is a converted warehouse with a high ceiling. It is divided into men's and women's dormitories, each with a shower and toilet room, and a small office area.

Lynn is concerned about the spread of TB because of the high incidence of TB among the urban homeless population. Her facility does not screen clients for TB, and because it operates on a first-come, first-served basis, it generally houses a different group of clients each night, thereby possibly increasing the risk. While her facility has not had a TB outbreak, Lynn knows it could happen any time.

There is no central forced-air ventilation system. Each shower and toilet room has an exhaust fan.

Check Ventilation

Lynn wanted to improve ventilation in her building. Her first step was to check the existing ventilation.

Using incense, she noted that air mixing seemed satisfactory near doors and open windows as smoke seemed to disperse quickly. In the corners, away from doors and open windows, however, air movement seemed slow.

To match nighttime conditions, Lynn closed the doors and windows and repeated the tests. Air movement was slow throughout the facility.

During both sets of tests, Lynn noticed that most air moved upward and from the front of the building toward the back.

Lynn looked at the two exhaust fans. Both had a considerable buildup of lint and dust. She turned them on and held a piece of paper against each grille. In the men's room the paper was pulled against the grille. But in the women's room there was no pulling effect, and Lynn noticed that she could not hear the fan running.

Based on these simple checks, Lynn now had a good idea of the ventilation in her building:

- Air moved from the front of the building to the back
- During the day, when doors and windows were kept open, air movement was good except in the corners of the rooms
- At night, when doors and most windows were closed, air movement was slow
- Both exhaust fans needed cleaning
- The fan in the women's room was not operating.

How could Lynn improve the situation with her limited budget? She got out the vacuum cleaner and thoroughly cleaned the two exhaust grilles. She noticed an immediate improvement in airflow at the grille in the men's room, but the fan in the women's room still was not working.

Improvements

Near the corners on the back wall were two blocked-up windows. It occurred to Lynn that if she were to install a fan in each of these windows, it should produce an air current throughout the building, regardless of whether the doors and windows were open.

She measured the windows and bought a through-the-wall fan at her local hardware store for each window. Staff from an affiliated job-training program installed the fans in the windows as part of a training exercise. Lynn made sure that the window fans exhausted air out the back of the building.

While they were at her building, Lynn asked the crew to look at the exhaust fan in the women's room. They found the problem, a broken electrical wire, and repaired it.

The Results

Lynn did some final incense tests that night, with the fans on and the doors closed. Air movement was greatly improved throughout the facility. However, some clients complained about a slight draft and were provided with extra blankets.

She repeated the tests the next morning with the windows and doors open and was pleased to see that airflow was now satisfactory, even in the corners.

Feeling very proud of herself, Lynn wrote and posted a one-page policy summarizing her environmental control efforts:

- Keep doors and windows open during the day
- Keep all fans (toilet exhaust and through-the-wall fans) on at all times
- Clean fans on the first of every month.

The next month, Lynn was happy to share her experience, and her policy, with her peers at a meeting of the local homeless shelter directors' organization. The members agreed that, while TB transmission at Welcome Home could still occur, the risk had been reduced. Furthermore, the increased fresh air had improved the indoor environment for her staff and clients.

What else could be done to prevent the transmission of TB in homeless shelters?

Central Ventilation Systems

Facilities that do not already have a central ventilation system can improve air circulation and reduce TB transmission risk by adding one. Facilities that have existing central ventilation systems should make any necessary improvements to make sure the systems have adequate components in place and meet the applicable regulatory requirements. In all cases, environmental controls must be in place and followed to prevent the spread of contaminants.

This section describes a central ventilation system and methods to assess and improve a system. It should be useful to those responsible for an existing facility served by a mechanical system and to those considering the design of a central ventilation system for a new or an existing building. It includes information about:

- Configuration and components of a central ventilation system
- Checking a ventilation system
- Recommendations for existing systems
- Recommended routine upkeep
- Advantages and disadvantages of a central ventilation system.

A case study about how one homeless shelter director made immediate low-cost improvements to ventilation in his shelter is located at the end of this section on page 36.

Note: *Staff members who have little or no previous knowledge of mechanical systems can make many of the improvements described here. For example, replacing lint filters with pleated filters and cleaning outside air intakes are easy to do. Other improvements, such as the installation of in-duct UVGI, will require the services of an outside contractor.*

About Central Ventilation Systems

Central ventilation systems, also called forced-air systems, are mechanical systems that circulate air in a building. By providing fresh dilution air, a mechanical system can help prevent the spread of TB.

However, the same system can inadvertently spread particles containing *M. tuberculosis* beyond the room occupied by the TB patient because it recirculates air throughout a building. Ventilation systems have been responsible for TB transmission among people who were never in the same room but shared air through a ventilation system.

Using a Mechanical System to Improve TB Control

There are three general ways in which a central ventilation system can help interrupt the path of TB transmission:

- It can introduce fresh outside air to replace room air
- It can use filters to remove infectious particles from recirculated air
- It can use UVGI lamps to disinfect recirculated air.

These features can be incorporated into the design of a new system or can be added to an existing system.

Configurations

Forced-air systems come in many different configurations. A ventilation unit can be located in an attic, a basement, or a closet, or it can be suspended from the ceiling in the room itself. The basic components of the system are usually the same and may include some or all of the following:

- Filters to clean air before recirculation
- A fan to move the air through the unit
- A furnace for heating
- An air conditioning section for cooling

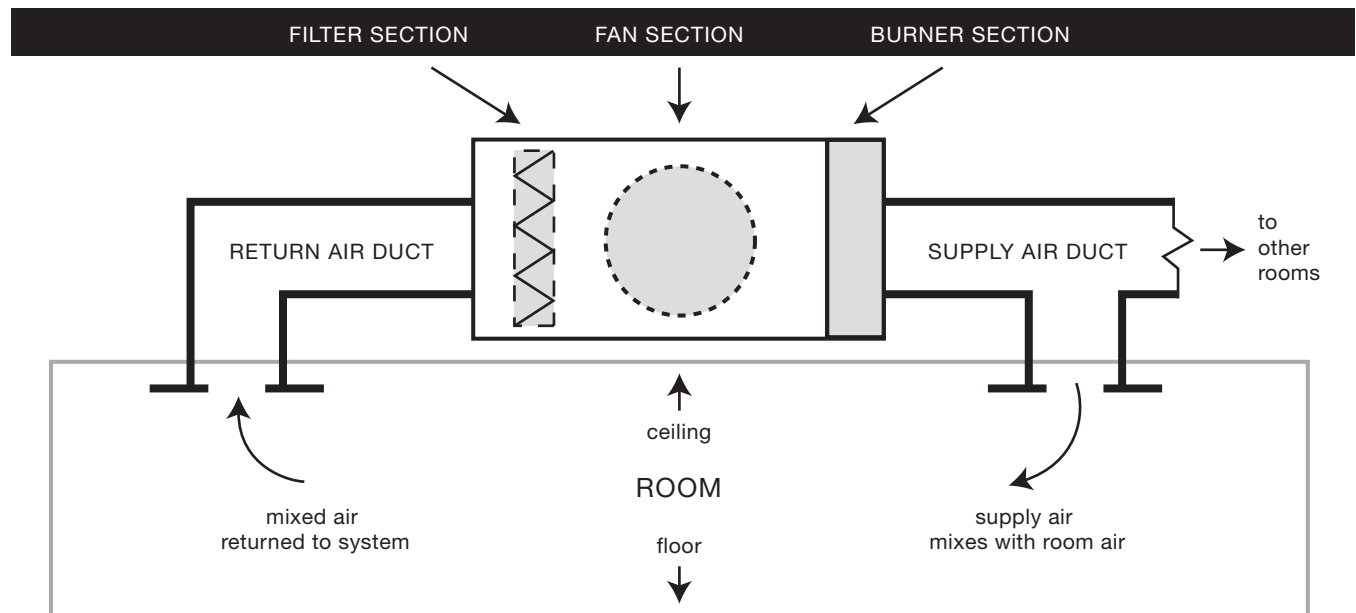
These components can be installed in a single unit or can be housed in separate sections.

A system may also include other parts, such as:

- A thermostat and controls to turn the fan on and off and to control the temperature
- Ductwork, diffusers, and/or grilles to distribute and collect air

FIGURE 2.

Recirculating Central Ventilation Unit



Recirculating Systems

Some buildings have a mechanical system that recirculates all air returned to the system—that is, 100% recirculation (See Figure 2).

In a 100% recirculating system, air is supplied to a room to provide ventilation and/or heating or air conditioning. This air mixes with room air and then is drawn back (returned) to the unit, where it is filtered and/or heated or cooled before being sent back to the room.

Even in a building with a recirculating air system, some rooms will exhaust rather than return air. Typically, bathrooms, shower rooms, institutional kitchens, and similar spaces will have a separate fan to exhaust air directly outdoors. See “Using Exhaust Fans” on page 18 for more information.

Negative pressure is created by exhausting more air from a room than is supplied to the room so infectious particles are contained within a room by a continuous air current being pulled into the room under the door.

Using Negative Pressure to Reduce the Risk of Spreading TB

What is Negative Pressure?

Negative pressure is created by exhausting more air from a room than is supplied to the room so infectious particles are contained within a room by a continuous air current being pulled into the room under the door. Therefore, when the negative pressure room is used as designed, airborne particles generated in the room cannot escape to the corridor.

Negative pressure is created by setting (or balancing) a ventilation system so that more air is mechanically exhausted from a room than is mechanically supplied. This creates a ventilation imbalance, called an offset. The room makes up the offset by continually drawing in air from outside the room. Probably the most common examples of negative pressure are residential bathrooms. Often a bathroom will have an exhaust fan but no supply.

How Negative Pressure Helps Reduce the Risk

A negative pressure room must be as air-tight as possible to prevent air from being pulled in through cracks and other gaps. This is called *sealing* a room. In a sealed room, the direction from which the make-up air enters the room and the speed with which it moves can be controlled. The smaller the make-up air opening, the faster the make-up air will move.

Ideally, the room should be well sealed except for a small (typically half-inch high) gap under the door. This should create a strong current under the door into the room.

Whenever the door is open, air movement at the doorway is uncertain. Although more air is being drawn into the room than is leaving because of the offset, the large door opening results in a free exchange of air occurring at the door. Air is coming into the room, but air is also leaving.

If the room has leaks, such as those around windows or around lights, control of the offset is lost. If the leaks allow in a greater amount of air than the negative pressure offset, this excess air will flow out of the room under the door. This can cause a room to operate under positive pressure even though the mechanical system is designed to create negative pressure.

In conclusion, the greater the offset and the tighter the room is sealed, the better.

Components: Air Filters

Filters are used to clean air. They remove particles from air that is passed through them. The cleaned air is then distributed. Many different levels of filters are available.

If a suitable filter is used, many particles containing *M. tuberculosis* will be removed and the risk of spreading TB by recirculation will be reduced.

Ventilation systems may have just one filter or they may have two or more. More than one filter is referred to as a *filter bank*.

What Type of Filter Should Be Used?

The most suitable type of filter for many recirculating air systems is a pleated filter. Pleated filters are so called because the filter inside the filter frame is folded into pleats. Lint filters are commonly flat.

The graph in Figure 3 compares the efficiency of three different types of filters:

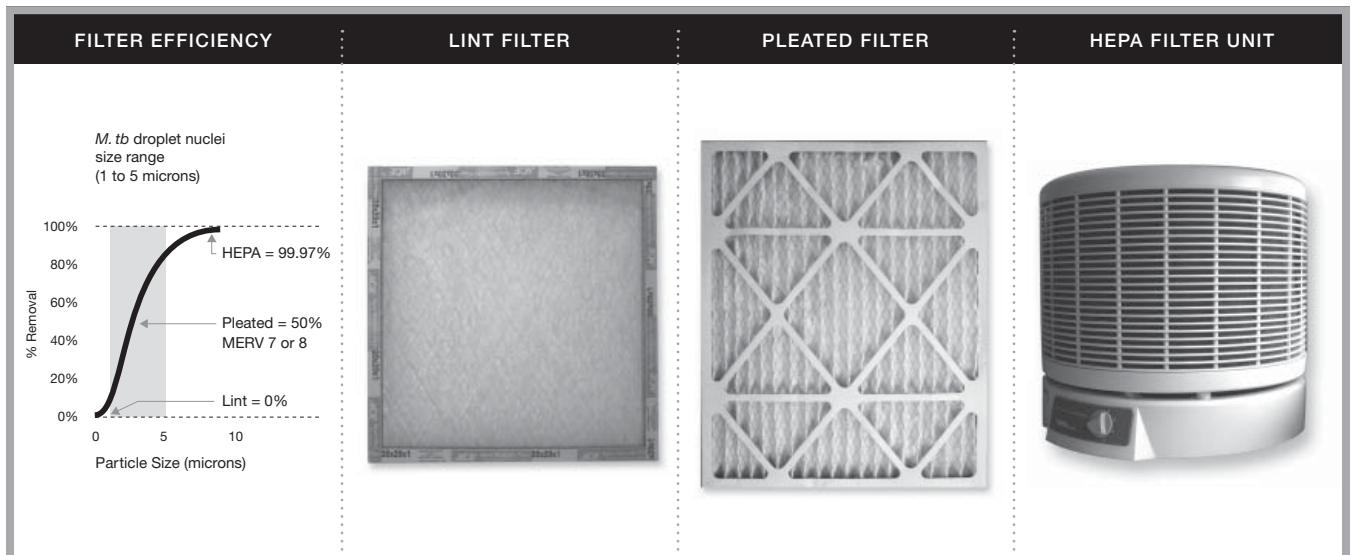
- High-efficiency particulate air (HEPA) filter
- Pleated ASHRAE 25% efficient filter (MERV 7 or 8)
- Lint filter

The shaded area in the figure represents the size range of TB droplet nuclei (1-5 μm). Each of the three filters will remove an amount of particles equivalent to the area under the line corresponding to that filter. The ASHRAE Minimum Efficiency Reporting Value, or MERV, rates the filtering efficiency of an air filter. The higher the MERV rating, the more efficient a filter is.

- A HEPA filter will remove all particles in the size range of TB bacteria droplet nuclei. (However, a HEPA filter is a specialized device that will not fit in most central ventilation systems.)
- A common lint filter will remove no particles in the size range of TB droplet nuclei size
- Pleated filters (MERV 7 or 8) can remove approximately half of all particles in the size range of TB droplet nuclei, though the efficiency varies with the MERV rating

FIGURE 3.

Air Filtration



Pleated filters are readily available from hardware stores in sizes that fit most ventilation systems.

Pleated filters are slightly more expensive than lint filters. They also cause more of an obstruction, which will reduce airflow slightly.

How Often Should Filters Be Changed?

In the absence of a filter gauge, there should be a set schedule to change the filters. In addition, filters should be checked visually every month and replaced as needed when they are evenly coated with dust.

It is important to replace filters frequently. Pleated filters will load up with lint and dust more quickly than lint filters. The amount of time it takes for a filter bank to load up depends on:

- How many particles there are in the air (the dustier room air is, the quicker the filter will load up), and
- How often the ventilation system is operated (the more frequently the ventilation system is used, the quicker the filters will become dirty).

Fan energy is used to push or pull air through filters. This is because filters cause an obstruction in the air's path. Over time, as dust accumulates, the obstruction increases. Consequently, the amount of air that the fan can move through the filter decreases.

Less airflow means less air supply to dilute objectionable air particles and less return air to remove such particles.

Pressure Drop and Filter Gauge

The relative amount of obstruction caused by filters is called the pressure drop. It is measured in inches of water gauge (" W.G.).

A filter gauge installed across a filter bank shows the pressure drop across the filter in " W.G. This is the most effective way to track filter loading and to determine when it is time to change the filter.

A filter gauge assembly consists of:

- The gauge
- Two sensors installed inside the duct, one on each side of the filter
- Copper or rubber air tubing

Tubing connects each sensor to the gauge. The gauge reads the pressure difference between the front (upstream) and the back (downstream) of the filter.

The observed pressure drop when new filters are installed is called the *clean pressure drop*. For pleated filters, this is usually about 0.25" W.G. As the filter loads up, the pressure drop will increase. The filter is usually replaced when the pressure drop increases by roughly 0.20" W.G. to 0.45" W.G. This is called the *changeout pressure drop*.

Many filter banks do not include a filter gauge, and many smaller ventilation systems are not constructed to accommodate one. For example, residential-type recirculating heating systems do not have an obvious location for a filter gauge.

As a rule of thumb, you should install a filter gauge if you have a filter bank, as opposed to just a single filter. If you have a filter bank that does not include a filter gauge, a facilities engineer or mechanical contractor should install one.

Components: Outside Air

For TB control, the best type of system is one without recirculation—that is, a 100% outside air (single-pass or once-through) arrangement. In this case, all supply air is fresh outside air, which is filtered and then heated or cooled before it is supplied. All potentially contaminated room air is exhausted directly outside the building.

However, once-through systems are uncommon because it is expensive to continuously heat or cool air from outside to a comfortable room temperature. For example, if it is 40 degrees Fahrenheit (°F) outdoors and 70°F indoors, recirculating 70°F air is cheaper than heating outdoor air from 40° to 70°F.

Most commercial ventilation systems, such as those that serve office buildings, are a compromise between 100% recirculation and 100% outside air. They recirculate most, but not all, of the air returned by the system. The portion of outside air is usually somewhere between 10 and 30% of the total quantity of supply air.

Outside Air Intake

The outside air intake is where fresh air enters the ventilation system on the roof or an outside wall. It can be a duct opening or part of the unit, and it usually includes an adjustable damper. A damper is a device that can be opened to increase the amount of outside air drawn into the unit.

Existing 100% recirculating air systems should be modified to include an outside air intake. A facilities engineer or a mechanical contractor should do this work.

As air is drawn in, dirt and debris, such as pigeon feathers, accumulate around the opening. For this reason, intakes are usually easy to find. A wire mesh screen is often used to trap dirt and debris.

Outside air intakes should be kept fully opened and clean to allow in as much fresh outside air as possible.

Components: In-Duct UVGI

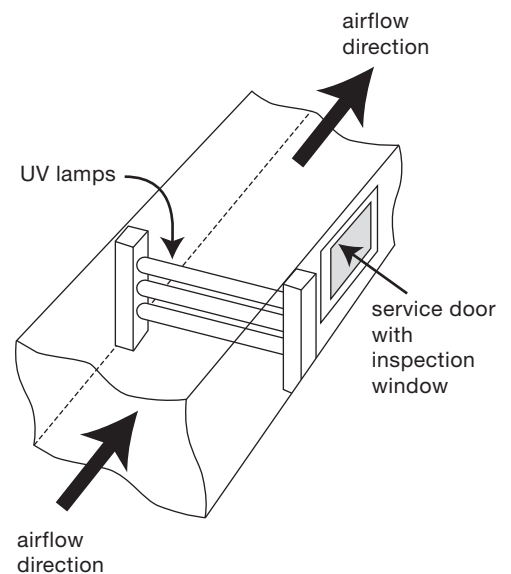
In a recirculating air system, pleated filters remove about half of all TB particles. The remaining TB particles are recirculated. This is why 100% outside air systems are ideal for high-risk settings. However, 100% outside air systems are expensive to install and operate. To provide increased protection, UVGI lamps can be installed in a recirculating system in conjunction with pleated filters to further clean the air.

An appropriately designed, installed, and maintained in-duct UVGI system should effectively disinfect most recirculated air and, therefore, significantly reduce the risk of TB exposure. For TB control purposes, such a system would be almost equivalent to a 100% outside air system.

In-duct UVGI is a useful option for a recirculating air system that serves areas at high risk for TB transmission as well as areas with lower risk.

FIGURE 4.

In-duct UVGI



Installation and Monitoring

A UVGI installation should be designed and installed by an experienced professional, such as a UVGI lamp manufacturer representative, a mechanical engineer, or a mechanical or an electrical contractor.

The expertise and equipment required to install, monitor, and maintain the lamps may be difficult and expensive to acquire.

Lamps are installed in a row at right angles to the airflow direction. The number and spacing of the lamps should be selected to ensure that all air is exposed to the radiation. Detailed calculations and measurements based on airflow and duct size will be required.

The UV intensities used inside a duct can be, and should be, greater than for upper-air UVGI because the lamps are mounted inside the ductwork, thereby reducing the risk of UV exposure to staff and others. The required intensity of the lamps will depend on air speed in the duct.

A duct access door, with a glass viewing window, should be provided so that the lamps can be cleaned, checked, and replaced. (UVGI does not penetrate glass.) The duct access door should be electrically linked to the lamps' power supply so the lamps are switched off when the access door is opened. This will protect maintenance staff from accidental exposure to UVGI. A warning sign alerting staff of the danger to the skin and eyes from direct exposure to the bulbs should be posted on, or adjacent to, the viewing window.

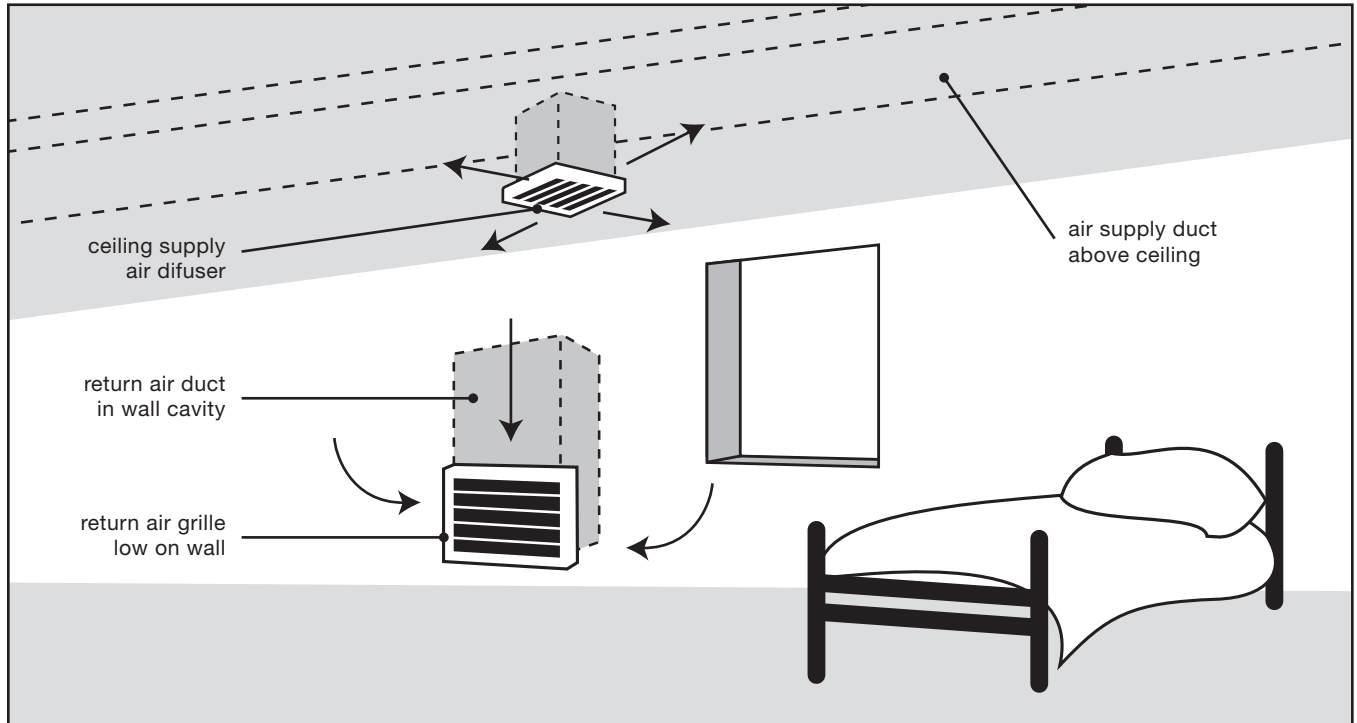
Monitoring and maintenance are crucial, because the intensity of lamps fades over time. See "Routine Upkeep of Existing Central Ventilation Systems" on page 3.

Advantages and Disadvantages of In-Duct UVGI

ADVANTAGES	DISADVANTAGES
<p>in-duct UVGI lamps, unlike HEPA filters, do not cause a significant obstruction to airflow in the system. Therefore, they can remove most infectious particles from air but do not significantly reduce the amount of airflow.</p> <p>In-duct UVGI is usually less expensive to install and operate than a 100% outside air system.</p>	<p>UVGI lamps are a more specialized type of equipment than almost all other components of a mechanical system and require specialized expertise to install and maintain.</p>

FIGURE 5.

Examples of Diffusers and Grilles



Components: Diffuser and Grille Locations

Supply air provides the heating or cooling effect. It also reduces the concentration of infectious particles in a room. Generally, air is supplied by an individual diffuser in every room but returned through just one grille.

For example, a mechanical system may provide heating to two separate dormitories in a homeless shelter. Each dormitory may have three small diffusers in the ceiling to ensure that the heated air reaches everyone in both rooms. A single large grille in the hallway may return air to the heating unit. In this building, the general direction of air will be from the diffusers, throughout the dormitories, and into the hallway to be returned to the unit.

Components: Thermostats

Room thermostats are electrical devices that control ventilation systems. They are usually mounted on a wall near a return air grille.

Many different types of thermostats are available, ranging from the very simple to programmable units with many functions. Most designs include three basic components:

- A switch that allows the thermostat to control the unit
- A thermometer that measures and displays room temperature, and
- An adjustable set point that allows the user to input the desired room temperature.

More expensive thermostats allow the user to program the fan, furnace, and air conditioning individually and to have different set points for weekdays and weekends.

The simplest type of thermostat is a two-position switch that operates in response to room temperature. The two positions are OFF and AUTO. When set to OFF, the unit will not run no matter how cold or hot the room becomes. When set to AUTO, the thermostat will turn on the fan and furnace when the room temperature, as measured by the thermostat, drops below the heating set point or rises above the cooling set point. This type of control is not recommended for TB control because the system does not operate continuously.

Checking a Ventilation System

To improve TB control and general indoor air quality, make regular checks of all ventilation systems serving the facility. An N-95 mask should be worn in the area where AIR air is exhausted. Choose a staff person to be the in-house monitor for the ventilation system.

A useful tool is a list of basic information for all units in the building. The list should include information such as ventilation unit location, rooms served by the unit, the thermostat location, and the number and size of filters. See “Summary of Ventilation Units Worksheet” on page 152 for a sample checklist.

If engineering drawings are unavailable, it probably will be necessary to crawl around the attic to see where all the ducts lead in order to find the ventilation units and identify the areas they serve. For this task you will need a rough floor plan of the facility so you can draw the ductwork as well as a tape measure to measure the filter size. Ducts exhausting air from AIRs should be labeled.

Performing Checks at Ventilation Unit or Furnace

Check that:

- Unit is operating
- Unit has filters
- Filters are the pleated type
- Filters are clean

The filter bank should be located at the return grille (remove grille to check and replace the filters), in the return ductwork, or at the unit.

Check whether an outside air intake is provided at the ventilation units. If so, check that the damper is set to the fully open position and that the intake grille and ductwork are clean. If there is an outside air intake, it will be on the roof or an outside wall.

Performing Checks in Rooms

- Check that each ventilation unit is working by turning on the fan at the thermostat and observing airflow at all supply and return outlets. Hold a tissue against each outlet to check airflow
 - If the outlet is supply, the tissue will be blown away from the outlet
 - If the outlet is exhaust or return, the tissue will be drawn toward the outlet
 - If the tissue does not move, the outlet is not working. The cause should be investigated
- Check that the thermostat has a FAN ON or similar setting that allows continuous operation of the fan

- Check that a central ventilation unit serves all occupied rooms
- Check air mixing and determine directional air movement in all parts of occupied rooms. An inexpensive and reliable way to perform these tests is to use incense sticks to visualize air movement as described under “Checking Natural Ventilation and Fans,” on page 19
- Check that all outlets are clean
- Check the return and exhaust air ductwork for dust and lint buildup. Return and exhaust air often include dust and lint that become deposited and accumulate on grilles and ductwork upstream of (before) the filter bank
- Check that all exhaust fans in bathrooms and shower rooms are working

Recommendations for Existing Central Ventilation Systems

- Use pleated filters
- Provide outside air intakes
- Set outside air intakes to the fully open position
- Use thermostats that allow continuous fan operation
- Run ventilation systems continuously whenever the building is occupied
- Install, if one doesn't already exist, a pressure gauge for ventilation units that have more than one filter
- Provide natural ventilation to occupied rooms not served by ventilation systems and to all occupied spaces at times when ventilation systems are broken or otherwise not operating
- Consider the use of in-duct UVGI as a supplement to filtration and outside air dilution

Routine Upkeep of Existing Central Ventilation Systems

- Check filters every month and replace when required. Make sure filters are installed correctly in the filter track, not jammed into position. When a new set of filters is installed, write the replacement date on the cardboard frame of the filter. Tracking the average life of the filters will help in planning maintenance
- Clean diffusers, grilles, and in-duct UVGI lamps every month
- Clean return air ductwork with a vacuum cleaner every year. Remove grille and clean as far back as the vacuum cleaner hose can reach
- Check ventilation units and thermostats every year. Make sure that thermostats start units and that units are running
- If you have in-duct UVGI:
 - Check that lamps are operating
 - Clean lamps every month
 - Replace lamps at least once a year or as recommended by the manufacturer. Dispose of used lamps as the manufacturer recommends
 - Keep records of all routine upkeep activities and dates

An appropriately designed, installed, and maintained in-duct UVGI system should effectively disinfect most recirculated air and, therefore, significantly reduce the risk of TB exposure from recirculated air.

Recommendations for the Design of New Central Ventilation Systems

Architects, engineers, and others designing mechanical systems for new or renovated facilities should consider the following recommendations:

Ventilation Rate

Provide a ventilation rate of at least 12 ACH in rooms frequented by patients or clients. Dilution ventilation is the most effective environmental control against TB transmission. Generally, the incremental cost of increasing ventilation capacity in a new ventilation system installation is not significant compared with the total cost of the installation's design and construction. 12 ACH is the minimum rate recommended by ASHRAE for waiting rooms in health facilities. Given the rates of TB among the homeless, a shelter has comparable risk to a hospital waiting room.

Once-Through System or Economizer Capability

Consider using a single-pass or once-through ventilation system. This type of system exhausts to the outside all air returned to the system, rather than recirculating a portion of the air. If it is decided that operation of this type of system would be too expensive, then consider providing a system that is capable of once-through operation—one that will automatically vary the amount of return air to be recirculated depending on the temperature outdoors. If it is temperate outdoors (about 65°F), no air will be recirculated. Rather, outdoor air will be continuously brought in to provide what is often referred to as free cooling, or the economizer cycle.

Minimum Outside Air Quantity

If a recirculating system is used, a fixed minimum proportion of the supply air should be fresh outside air. This value is usually called the *minimum outside air set point*. The CDC recommends a minimum outside air supply rate of 25 cubic feet per minute (CFM) per person for homeless shelters. ASHRAE recommends a minimum outside air change rate of 25 CFM per person in patient rooms, 15 CFM during medical procedures, and 12 ACH for waiting rooms in health facilities. The higher of the two airflow rates generated by means of these criteria should be used as the minimum outside air set point.

Air Distribution

- Provide supply and return air in each room, rather than collecting air from several rooms at a single location. This will reduce the possibility of air currents carrying infectious particles to other areas
- Design the ventilation system for good air mixing. Adequate air supply and air mixing will greatly reduce the risk of TB transmission by diluting and removing infectious particles. Diffuser characteristics, such as size and air diffusion pattern, should be selected to suit the room in which diffusers are installed and the individual diffuser location within the room
- If the system will include ceiling diffusers, you can enhance air mixing by using the louvered face type, rather than the perforated face type
- If sidewall air supply grilles are used, the diffusers should be the double deflection type, with two sets of air deflection blades. The front set of blades is vertical; the second set behind these is horizontal. The louvers should be adjusted to provide even airflow patterns in each room
- Return registers should be located in the same room and as far away as possible from supply diffusers so that supply air can fully mix with room air

In-Duct UVGI

In-duct (or return-duct) UVGI may be used in a ventilation system to disinfect air removed from a group setting before recirculation.

Advantages and Disadvantages of Central Ventilation Systems

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none">• Can be effective 24 hours a day, year-round• Controllable, adjustable, and predictable• Helps prevent transmission of airborne infectious diseases, including TB• Helps control temperature, odor, and indoor air pollutants	<ul style="list-style-type: none">• Expensive to plan, install, operate, and repair• May be drafty and/or noisy• Maintenance required



Central Ventilation System

Dan has been running an inner-city homeless shelter called You're Welcome for the last 4 years. The shelter is in the converted basement of a church. When he started working there, Dan noticed that it felt stuffy most of the time.

The shelter screens clients for TB symptoms at intake and regularly tests staff for TB infection. After several negative annual TSTs, Dan just converted his test to positive. This meant that he had acquired TB infection sometime over the last year. He thought that he had probably become infected at work.

This prompted Dan to implement some environmental control measures, something he had been thinking about since his first day on the job. He decided to start by taking a look at the ventilation system.

Dan made the following assessments and improvements in a few hours, without having to call in the service company, and equipped only with incense sticks, a screwdriver, and a tape measure.

- The existing forced-air heating system consisted of a furnace in a janitor's closet, a single return grille on the wall outside the closet, six ceiling supply grilles, and a thermostat
- The return grille and duct were extremely dusty. Dan removed the grille and cleaned out the dust with a vacuum cleaner
- He opened the filter section. The filter was a flat lint-type. It was also extremely dusty and was incorrectly installed in the filter track. Dan measured the lint filter (25" x 14" x 1") and discarded it. He bought three replacement pleated filters from a nearby hardware store. They cost about \$5 each. He wrote the date on one of the filters and placed it in the furnace
- The thermostat had an adjustable temperature setting and three fan settings: OFF, AUTO, and FAN ON. It was set to AUTO so the fan would come on only when the temperature dropped below 68°F. Dan set the controls to FAN ON, and the fan in the unit came on immediately. The improvement in ventilation was obvious
- The furnace had no outside air intake and there was no obvious way to connect one because the unit was not close to an outside wall. To let in natural ventilation, Dan decided to keep at least two windows open whenever the building was occupied
- Dan used some incense sticks to evaluate air movement. He was happy to see that air movement was brisk throughout the shelter. He also confirmed airflow at each diffuser and at the grille

What steps should Dan take to ensure that routine maintenance is done for the Central Ventilation System?

Using UVGI to Reduce the Risk of Spreading TB

What is UVGI?

Ultraviolet germicidal irradiation (UVGI) uses a type of radiation that has been shown to kill or inactivate *M. tuberculosis* in air. UVGI may be used to supplement ventilation as an environmental control measure. Because UVGI can have negative short-term health effects on the skin and eyes, a safety plan should be implemented when it is used. UVGI has two applications: in-duct UVGI and upper-air UVGI.

- In-duct UVGI is the installation of UV lamps in a return or exhaust air duct to kill any *M. tuberculosis* that may be in the airstream. This is useful as a supplemental environmental control in recirculating air systems, but is not recommended as an alternative to direct exhaust or HEPA filtration for AIIR exhaust. See “Components: In-Duct UVGI” on page 29 for a detailed discussion
- Upper-air UVGI refers to the use of UV lamps directly in a room. Lamps are mounted high on walls or suspended from the ceiling. Radiation is directed into the upper portion of the room, where the air is disinfected. The ventilation system mixes this air with the air in the lower part of the room, resulting in dilution of potentially contaminated air
- Upper-air UVGI is a useful environmental control for crowded congregate settings, where susceptible people may have prolonged exposure to an unidentified infectious TB patient. Examples are homeless shelters, emergency department waiting rooms, and prison day rooms. See “Upper-Air UVGI” on page 38 for detailed discussion of upper-air UVGI

An AIIR has a different type of transmission risk than a congregate setting. In an AIIR, the infectious source (patient) and the individual at risk (HCW) are known. Consequently, the HCW wears respiratory protection. The HCW is at greatest risk in close proximity to the patient. In general, this “near field” area contains the greatest concentration of infectious particles in the air. Although upper-air UVGI will help dilute the overall room concentration of *M. tuberculosis*, it will have little beneficial effect on this near field infection risk.

If used in an AIIR, UVGI will lower the concentration of infectious particles. However, given that staff in the AIIR wear respirators and the room air is exhausted or HEPA-filtered, the added benefit of upper-air UVGI in an AIIR will probably not be significant.

Effectiveness of UVGI

UVGI’s effectiveness increases with:

- **Intensity of the radiation**—depends on the wattage, condition, and age of the lamp (the intensity of a lamp fades over time and also, to a lesser extent, as dust accumulates on the lamp)
- **Length of exposure time**—depends on how quickly air containing infectious particles moves past the lamp
- **Proximity of infectious particles to the UVGI lamp**—depends on the placement and number of lamps used

UVGI’s effectiveness decreases with:

- **Relative humidity**—UVGI is not recommended for rooms in which the relative humidity of the air is greater than 70%

Hazards of UVGI

Although UVGI can cause temporary harm to the eyes and skin, newer fixture designs and compliance with guidelines on the use of UVGI should make it possible to use this control measure safely and effectively.

Precautions should be taken to alert and protect the people using the room(s) in which the UVGI is used. Facility staff should also receive appropriate education.

Upper-Air UVGI and HEPA Filter Units

Previous sections described how to improve natural ventilation in a building without a central ventilation system and how to improve and design a central ventilation system.

In addition to ventilation, upper-air UVGI lamps and HEPA filter units can be used on a room-by-room basis to help reduce the risk of TB transmission in a facility.

This section provides an introduction to upper-air UVGI and HEPA filters. The UVGI material is written to help individuals working with a contracted installer to achieve a better installation. The HEPA filter unit information is provided to help individuals select and use HEPA filter units.

Upper-Air UVGI

Upper-air UVGI is a specialized technology that can only be used in certain rooms. It uses UVGI lamps and room air currents to help stop the spread of TB. It is a unique infection control measure because the air is disinfected in the upper part of the room. It can be added on a room-by-room basis without affecting the existing building ventilation system. Upper-air UVGI should be considered to supplement the ventilation system in high-risk public areas, including emergency department (ED) waiting rooms and homeless shelters.

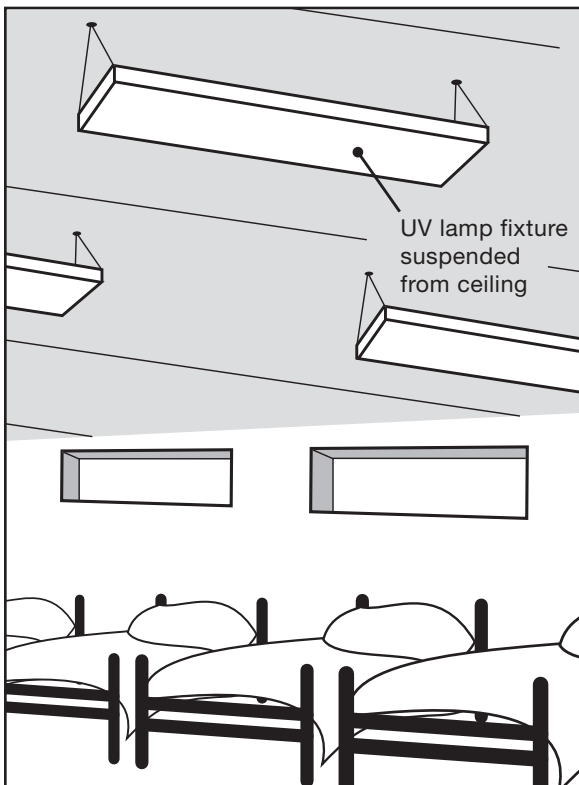
This section provides an overview of upper-air UVGI. Use this section to determine whether it can be used in your facility, and if appropriate, for advice on finding an installer and working with the installer to plan and install the fixtures so they are safe and effective.

You can also find information about evaluating an existing UVGI installation and helping to keep staff and patients protected from the hazards of overexposure to UV radiation.

It may take an hour or more for TB particles to be removed by ventilation even in a room with a comfortable ventilation rate. Adding even more ventilation will help reduce the amount of time required to remove these particles. However, it may also be expensive to install and operate and may cause objectionable noise and drafts. In this case, using upper-air UVGI to supplement ventilation should be considered.

FIGURE 6.

Upper-air UVGI in a dormitory



- Upper-air UVGI lamps are mounted high on walls or hung from the ceiling
- Metal baffles on the fixtures are needed to ensure that the radiation is directed only outward and upward, away from where people are in the room below
- Upper-room air is irradiated and disinfected. Cleaned air mixes with the air in the lower part of the room and dilutes infectious particles

The clinical effectiveness of upper-air UVGI as a means to reduce the risk of TB transmission is uncertain and can't be measured. It varies depending on many factors, including the age of the lamps, placement of the lamps, room configuration, and room airflow patterns.

Care must be taken in the design, installation, and maintenance of UVGI because of safety concerns, because effectiveness can vary, and because every installation is unique.

Ensuring Safe Radiation Levels

Radiation can reach the lower occupied part of the room through reflection from the ceilings and walls and perhaps directly from the fixtures.

The actual radiation levels of an upper-air UVGI installation are difficult to predict. For a given fixture, final radiation levels will vary for every room and for different parts of the same room. Factors that affect each installation include:

- Type of lamps used
- Effectiveness of the fixture baffles at preventing radiation from reaching occupied areas
- Locations of the fixtures
- Reflectivity of the walls and ceilings.

The only way to tell if an installation is safe is to measure radiation levels in the occupied part of the room.

Measurements should be made at numerous locations and elevations where people may be exposed for long time periods. For example, in a dormitory room, readings should be taken at the heads of beds as well as the center and corners of the room.

Recommended Exposure Limit

The National Institute for Occupational Safety and Health (NIOSH) has published a recommended exposure limit (REL) for ultraviolet energy at the UVGI wavelength, approximately 254 nanometers. The REL depends on the intensity of the radiation and the exposure time. For an exposure time of 8 hours, the REL is 0.2 microwatt per square centimeter. *If the exposure time is longer or shorter than 8 hours, the REL is proportionally lower or higher.*

The measured UVGI intensity should be no more than the NIOSH REL at any location.

UVGI Radiometer

Radiation levels are measured with a device called a radiometer. The radiometer should be calibrated specifically to measure UVGI radiation.

Radiation levels at the lamps should be much greater than radiation levels in the occupied room. Because of the difference in radiation levels, two separate meters may be required, one to verify that the radiation levels at the lamps are high, and another to verify that radiation levels in the occupied room are low.

Determining If Upper-Air UVGI Is Suitable for a Particular Room

A room must meet the following criteria if upper-air UVGI is to be used:

- Upper-air UVGI is not recommended in rooms with ceilings less than 8 feet high. The lamps must be installed at a height of about 7 feet, sufficiently high so that people cannot look into the lamps or bump into them
- In homeless shelters using UVGI, bunk beds should not be used in dormitory rooms unless they have very high ceilings. A client who is sitting on the top bunk of a bunk bed may be exposed to radiation in the upper, radiated, part of the room
- Room fans or a ventilation system are recommended to help mix the disinfected air in the upper-air with the potentially contaminated air below. The fans or ventilation system should operate continuously when the building is occupied.

Preparing for an Upper-Air UVGI Installation

Find a suitable consultant and contractor. A poorly installed upper-air UVGI system could result in:

- Harmful radiation levels in the occupied space, and
- Ineffective radiation levels in the upper-air bacterial kill zone.

Specialized expertise and equipment are required to establish effective upper-air UVGI. Only a qualified contractor, working closely with a lamp manufacturer's representative, should attempt the design, installation, and testing of an upper-air UVGI system.

1. Start by contacting a number of UVGI lamp manufacturers. Ask each for the names and addresses of some local experienced consultants and contractors.
2. The next step is to contact the suggested consultant companies or individuals. Interview them about their experiences with previous installations.
3. Ask the consultant to arrange a visit to a successful installation. This will provide an opportunity to see an existing installation and to talk with another person about his or her experience with upper-air UVGI.
4. Talk to the contractor about the possibility of arranging a service contract for system monitoring and replacement of the lamps after the installation.

Planning an Installation

Before installing UVGI fixtures, address the following items:

- Locate UVGI fixtures so that radiation in the upper-air is uniform, continuous, and complete
- In the installation contract, include measurements of radiation levels after installation
- Take these measurements before the job is accepted and payment is made. Submit a written report to the owner
 - Until readings have been taken in the occupied zone to ensure that radiation levels are below the NIOSH REL, the installation is not complete, and the lamps should not be used. Readings should be taken in a number of locations corresponding to where people will be exposed
 - Take radiometer readings at each lamp to ensure that the radiation intensity meets the manufacturer's specifications

- Non-reflective paint may need to be added to ceilings and walls. Some ceiling paints can reflect too much radiation down to the occupied room below. If meter readings indicate excessive radiation in the occupied area, the ceiling may need to be painted with non-reflective paint. This should be included in the budget for the planned installation. Paint containing titanium dioxide is recommended for reducing reflection from surfaces
- Post warning signs, in all appropriate languages, on the UVGI fixtures and on the walls. The signs should carry the following or a similar message:

CAUTION

Ultraviolet Energy

Turn off lamps before entering the upper part of the room.
(The upper part of the room is the space above the UVGI fixtures.)

- Staff, patients, or shelter clients may have concerns regarding health hazards from UVGI. To address these concerns, provide education on the purpose, benefits, and risks associated with upper-air UVGI. (OSHA requires staff training.) Also, consider posting an information sheet on the wall of the room
- The on/off switch for the lamps should be accessible to appropriate staff members but not located where patients or clients may turn off the fixtures

Checking Upper-Air UVGI

- Check radiation levels in parts of the room where people are likely to be exposed using a radiometer. Radiation levels should be below the NIOSH REL
- If radiation levels are too high in any location, turn off the lamp or lamps causing the high radiation levels. To correct the problem, it may be necessary to add non-reflective paint to the ceiling and/or wall and/or to relocate or replace the fixtures
- Check that lamps are not burned out or broken. If lamps are working, they emit a visible violet blue glow that can be seen from below
- Turn off lamps and check that lamps and fixtures are free of dust and lint
- Check that the radiation level at each fixture meets the lamp manufacturer's recommendation. Protective clothing or special equipment may be required to take these readings without overexposing the skin or eyes to the radiation. Bulbs should be replaced if the radiation levels are below the manufacturer's recommended minimum levels

Routine Upkeep

- Designate a staff member to be the in-house monitor for UVGI fixtures. This person should be trained in the basic principles of UVGI operation and safety and should be responsible for cleaning, maintaining, and replacing the lamps. This may include regular maintenance by the engineering department, but a record should be kept of this work
- Check and clean lamps and fixtures every 3 months. Turn off the lamps before they are cleaned; clean with a cloth dampened with water or alcohol

- Replace lamps once a year or as recommended by the manufacturer. The violet blue glow emitted by a lamp is not an indicator of the lamp's effectiveness. Take radiometer readings at each new lamp to ensure that radiation levels meet the manufacturer's recommendations. Dispose of used lamps as recommended by the lamp manufacturer
- Keep a record of all maintenance and monitoring, including radiometer readings and dates. This will help determine the average life of the lamps. Lamps should be purchased close to your planned replacement time, as prolonged storage may result in a loss of radiation intensity

Advantages and Disadvantages of UVGI Systems

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> • Inexpensive to buy and operate compared to a central ventilation system • Can be implemented room by room • Limited impact on structure and mechanical systems • Do not cause noise or drafts 	<ul style="list-style-type: none"> • Potentially hazardous to staff and people who use the rooms in which they are located • Effectiveness uncertain • Requires specialized expertise to install and monitor • Each installation is site-specific • Only addresses TB; does not remove dust and other particles • Hard to tell if working • Not as effective in humid rooms • Glow from lamps may bother individuals who are trying to sleep • Staff, patients, or shelter clients may have unwarranted fear of radiation

High Efficiency Particulate Air (HEPA) filter units

HEPA filter units are readily available machines that can be used anywhere to provide clean air. Use this section to get an overview of HEPA filter units and to learn how to use them effectively, to determine what type and size of unit is suitable for your facility, and to help plan routine upkeep of HEPA filter units.

HEPA filter units allow anyone to improve air quality in any room almost immediately. No detailed engineering knowledge is required to install or maintain HEPA units. These units are especially useful in settings that may have inadequate or no ventilation and limited funds for upgrades.

High efficiency filters, such as HEPA filters, remove essentially all particles in the size range of droplet nuclei from the air that passes through them. These filters are used in self-contained units to provide a source of clean air. A HEPA filter unit will provide cleaned air to dilute infectious particles and will also remove airborne particles.

HEPA filter units are available in a variety of sizes and configurations, but all consist primarily of:

- A HEPA filter to remove small particles from the air
- A prefilter to remove coarser particles and thereby prolong the life of the HEPA filter
- A fan to circulate air past the HEPA filter and into the room
- Controls, such as an on/off switch and fan speed control

HEPA filter units allow anyone to improve air quality in any room almost immediately.

The most common types of units are portable, freestanding devices. Ceiling-mounted and wall-mounted units are also available. Portable units have the advantage of greater flexibility and ease of installation and service. Permanent units are less vulnerable to tampering and theft, less likely to be in the way, and can't be easily moved to a location where they will be less effective.

The size of HEPA filter units is based on the amount of air they deliver, usually expressed in CFM. Most units include a switch that can be used to vary the airflow.

Small, Portable HEPA filter units

Small, portable units deliver 150 to 250 CFM. Most units include a three-position fan speed switch but no other controls. Small units are useful for offices, on-site clinic rooms, and other smaller areas.

Small units are light enough to be easily carried around and placed on a desktop or other surface. These units are readily available from hardware stores and similar retail outlets.

Some small units may use high efficiency filters that do not meet the precise requirements for HEPA filters. (A HEPA filter must remove 99.97% of particles equal to or greater than 0.3 micron in diameter.) However, TB droplet nuclei are significantly larger than particles used to test HEPA filters, so "near-HEPA" filters will remove the majority of particles in the size range of TB droplet nuclei.

Large HEPA filter units

Larger units can deliver from 300 to 1,000 CFM and can be used in rooms in which groups of people may spend time, such as TV lounges or waiting rooms.

These units usually have wheels so they can be moved from room to room. Controls include a fan speed switch and often a warning light to indicate when filter replacement is recommended.

Options may include a lockable cover for the controls to prevent tampering and an internal UVGI lamp. Because the HEPA filter removes all infectious particles in the TB droplet nuclei size range, the UVGI offers no added benefit.

Larger units are available from specialized medical equipment suppliers.

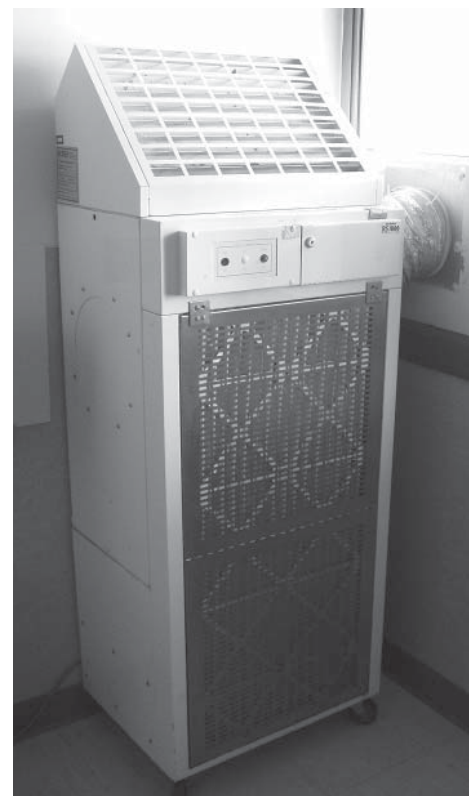
FIGURE 7A.

Small HEPA filter unit



FIGURE 7B.

Large HEPA filter unit



Recommendations for HEPA Filter Unit Selection

- **HEPA Filter Operation**

- Provide portable HEPA filter units for all unventilated rooms frequented by patients or shelter clients unless the rooms have an operable window or door that is usually kept open
- Place small units off the floor and next to staff so that the purified air generated by the filter units is delivered close to the faces of the people that they are used to protect. Consider the HEPA filter unit primarily as a source of clean air and secondly as a removal device for contaminated air
- Place units evenly throughout crowded rooms so that air movement can be felt in all parts of the room
- Select each unit based on the airflow it produces when it is running at or near the low-speed setting. HEPA filter units can be noisy when running at the higher speed settings. For this reason, people tend to operate them at low or medium speeds in small rooms during interviews. However, at lower speeds, the dilution effect is reduced because the units do not provide as much purified air
- Operate HEPA filter units continuously while rooms are occupied by patients or shelter clients and for approximately 1 hour after they leave

- **HEPA Filter Unit Selection**

- Select HEPA filter units to provide an air change rate of at least 6 ACH. See “What Does Air Change Mean?” in Appendix K on page 156 for a more detailed description of room air change rates. ASHRAE recommends the minimum air change rate of 12 ACH for waiting rooms and 6 ACH for exam rooms in health facilities. Given the rate of TB among the homeless, a group room is comparable to a hospital waiting room, and an interview room is comparable to an exam room
- Make unit selection based on the HEPA filter unit’s published airflow at low speed. For example, if the manufacturer’s data rate a unit’s three speeds as 100, 150, and 200 CFM, select the unit based on 100 CFM
- Units may deliver less than the manufacturers’ listed airflow, and output may decrease as the filters load up. To compensate for this, add a safety factor of 25% to the required airflow. The additional cost of buying a unit with more capacity is usually not significant compared to the cost of the unit

The “HEPA Filter Selection” table below lists recommended airflow and minimum HEPA filter unit sizes for some sample room volumes.

TABLE 2.

HEPA Filter Selection Table

Use this table to select a HEPA filter unit based on measured room volume. The recommended safety factor is included.

ROOM VOLUME	AIRFLOW REQUIRED FOR 6 ACH	LISTED MINIMUM AIRFLOW
800 ft ³	80 CFM	100 CFM
1,000 ft ³	100 CFM	130 CFM
1,500 ft ³	150 CFM	190 CFM
2,000 ft ³	200 CFM	250 CFM
4,000 ft ³	400 CFM	500 CFM
8,000 ft ³	800 CFM	1,000 CFM

- Room volume (first column) is room length times width times ceiling height. For example, a room that is 8 feet wide by 8 feet long with a 10-foot-high ceiling will have a volume of 640 cubic feet. A tape measure is required to measure room dimensions
- Six (6) ACH (second column) is the minimum recommended air change rate
 - The required airflow in CFM to achieve this air change rate is calculated as follows:
(Room volume x 6 ACH) / 60 minutes per hour = airflow in CFM
- The listed minimum airflow (third column) is the minimum rated airflow of a HEPA filter unit. The recommended 25% safety factor is included. Most HEPA filters include a switch that adjusts the airflow from a fixed minimum (low setting) to a fixed maximum (high setting). Because of the increased noise, people tend to use the units at the low setting. Therefore, the low setting should be the basis for unit selection
 - Example: Assume an 800-cubic-foot room volume. A unit that lists airflows as 100/150/200 CFM would be preferable to a unit that lists airflows of 50/100/150 CFM because it will provide the recommended airflow at the low (quieter) setting

Routine Upkeep of HEPA Filters

- Designate a staff person to be the in-house monitor of the HEPA filter units. This person should be aware of the basic principles of HEPA filter unit operation, including effective placement and maintenance. This person should also implement a written schedule for changing the prefilters and HEPA filters
- Maintenance consists of replacing the prefilter and the HEPA filter at regular intervals. The manufacturer's data should explain how this is done. In general, replace the prefilters every 6 months, and replace the HEPA filters every 1 or 2 years. Actual replacement time will depend mainly on how often the units are used and how dusty the room air is

Advantages and Disadvantages of HEPA Filter Units

ADVANTAGES	DISADVANTAGES
<ul style="list-style-type: none"> • Can be implemented almost immediately • Can be implemented room by room • Relatively inexpensive to plan, install, and maintain • Have adjustable airflow rate • Can be portable • Remove other indoor air pollutants, such as dust and allergens • Do not require costly equipment to evaluate 	<ul style="list-style-type: none"> • Unpredictable because, if controls are accessible, patients, shelter clients, or staff members may turn them down or off; also, they may move or unplug the units • Can be drafty and noisy • Do not bring in outside air • Do not filter out odors

HEPA Filter Unit

Catherine is a case manager in an inner-city homeless shelter. As part of her work she interviews about six new clients every week. Her office has no ventilation and no window to the outdoors. Because clients have not been medically screened and because of the lack of ventilation, she is concerned about TB transmission. The clinic manager has set aside \$150 to buy a HEPA filter unit for the office once Catherine can tell her what size of unit she would like.

Catherine wants a unit that will provide an air change rate of at least 6 ACH. She gets out a tape measure and a calculator so she can estimate a suitable HEPA filter unit airflow based on the room's volume.

She measures the room. It is 8 feet wide by 10 feet long. The ceiling is 9 1/2 feet high. She then calculates the room volume:

$$\begin{aligned} \text{Room volume} &= \text{width} \times \text{length} \times \text{height} \\ &= 8 \times 10 \times 9.5 \\ &= 760 \text{ cubic feet} \end{aligned}$$

$$\begin{aligned} \text{Airflow required for 6 ACH} &= \text{room volume} \times 6 \text{ ACH} \\ &= 760 \times 6 \\ &= 4,560 \text{ cubic feet per hour} \\ &= \frac{4,560}{60 \text{ cubic feet per minute (CFM)}} \\ &= 76 \text{ CFM} \end{aligned}$$

The actual airflow may be less than advertised. To compensate, Catherine adds a 25% safety factor to get a required airflow of 95 CFM.

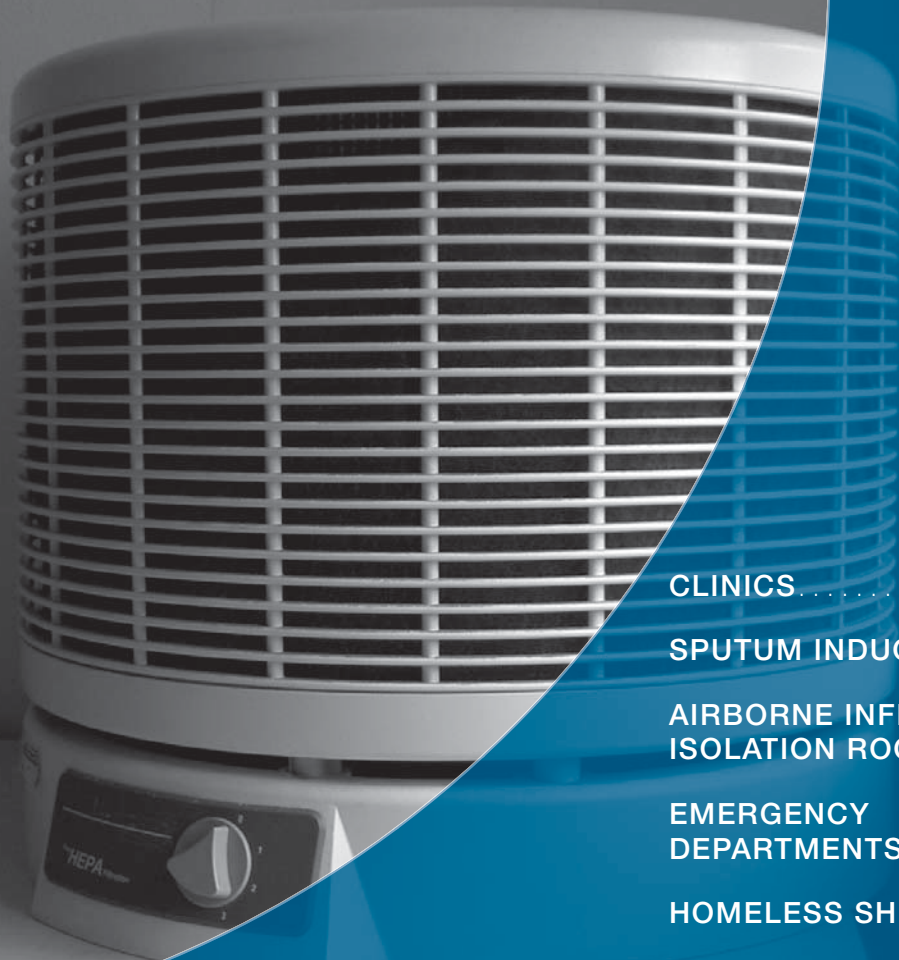
$$76 \text{ CFM} \times 1.25 = \mathbf{95 \text{ CFM}}$$

Most units have an adjustable speed setting. They become noisier at the higher speeds. Catherine plans on running the unit at low speeds during interviews, so she decides to select a HEPA filter unit with a low-speed setting of at least 95 CFM.

Should Catherine aim to achieve 6 ACH or a higher rate? Why?

2

Infection Control in Specific Settings and Procedures



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Clinics



CLINICS

Patients who are at high risk for TB often receive care at public health and community clinics prior to diagnosis and treatment. Clinic funding does not generally allow for facility renovation or installation of special ventilation. Furthermore, clinic staffing does not always include experienced infection control, occupational health, or mechanical engineering personnel, which often places clinic staff and other patients at increased risk of exposure to TB.

To help reduce the risk of exposure to TB, clinics should have a TB infection control plan (ICP) in place that is part of the overall infection control program. This section of the manual describes the problems faced by clinics, how to develop and maintain an effective TB ICP, and how to reduce the risk of TB exposure for clinic staff.

TB Infection Control Plans (ICP)

Employers who fall within the scope of federal or state OSHA TB compliance requirements must establish and comply with an effective written TB ICP. The TB ICP must contain information about how that facility:

- Defines employees who are at risk of occupational TB exposure
- Identifies suspected or confirmed TB cases
- Isolates or controls exposures when a suspected or confirmed infectious TB patient is identified
- Minimizes employee exposure to TB
- Alerts employees to hazards
- Screens employees for TB
- Conducts follow-up of employees exposed to TB
- Protects employees during high-risk procedures
- Uses environmental controls to reduce the likelihood of TB exposure
- Maintains environmental controls
- Uses respirators (a written respiratory protection program is also required)
- Provides employees with TB training

All of the above information must be specific to the facility and available to any employee who requests it. The effectiveness of the ICP should be evaluated annually and following any occupationally-acquired employee TB infection.

Meeting Regulatory Requirements

Efforts have been made to ensure that this TB ICP section of the manual includes applicable recommendations from the CDC and meets existing standards set by regulatory agencies such as OSHA and Cal/OSHA. Although this manual addresses the most important issues in clinic TB control efforts, it may not address every issue of interest to all regulatory agencies.

Because regulations vary from county to county and from state to state, each facility should review its local and state regulations before finalizing its TB ICP. Each facility must also ensure that the final ICP accurately reflects current practices and the environmental controls of its clinic building.

Facility Risk Assessment

Assessing your facility's risk for *M. tuberculosis* transmission is the first step in developing an ICP. The CDC and OSHA recognize that this risk is not equal in all facilities. The risk level will vary depending on the population served, the type of building, the procedures performed, community/facility prevalence, and other factors. Clinics may be located in buildings converted from business offices and grocery stores, or in new structures built specifically for the delivery of healthcare services. The TB risk level of the population treated and the community itself will vary. Some clinics perform high-risk procedures, such as sputum induction and bronchoscopy, and some do not. All these factors affect the likelihood of *M. tuberculosis* transmission in a facility, and therefore, the level of TB control intervention required. The frequency of screening HCWs for TB, use of respirators, and facility use of environmental controls such as AIIRs, will influence the risk level of the facility.

Determining the Facility's Risk

Assessing the risk level of your facility will help determine the level of TB control needed in the following areas:

- Employee TB screening
- Environmental controls
- Respiratory protection

Guidance on performing a complete risk assessment can be found on pages 9-10 and the revised version of Appendix B: TB Risk Assessment Worksheet, of the CDC Guidelines. The CDC notes that a medium-risk category is warranted if drug-resistant TB has occurred in the community or facility, or if there is a relatively high prevalence of HIV infection among patients or HCWs. The CDC Guidelines also recommend that facilities be classified as medium-risk if cough-inducing procedures (e.g., sputum induction, bronchoscopy, and administration of aerosolized medications) are performed on patients who may have TB disease. Read the entire TB ICP and review the available options. If it is determined that a facility is medium-risk, select options that provide the greatest protection to staff and patients. Low-risk facilities are free to select these more protective options, if desired.

Please consult Appendix B (revised version) of the CDC guidelines to determine the risk level for your facility. Use the worksheet on page 53 of this manual to identify who is responsible for the various controls in the TB ICP.

Low-risk facilities are free to select these more protective options, if desired.

TABLE 3.

Excerpt from CDC guidelines Appendix C:

Risk classifications for health-care settings that serve communities with high incidence of tuberculosis (TB) and recommended frequency of screening for *Mycobacterium tuberculosis* infection among health-care workers (HCWs)*

Setting	Risk classification [†]		Potential ongoing transmission [§]
	Low risk	Medium risk	
Inpatient <200 beds	<3 TB patients/year	≥3 TB patients/year	Evidence of ongoing <i>M. tuberculosis</i> transmission, regardless of setting
Inpatient ≥200 beds	<6 TB patients/year	≥6 TB patients/year	
Outpatient; and nontraditional facility-based	<3 TB patients/year	≥3 TB patients/year	
TB treatment facilities	Settings in which <ul style="list-style-type: none"> persons who will be treated have been demonstrated to have latent TB infection (LTBI) and not TB disease a system is in place to promptly detect and triage persons who have signs or symptoms of TB disease to a setting in which persons with TB disease are treated no cough-inducing or aerosol-generating procedures are performed 	Settings in which <ul style="list-style-type: none"> persons with TB disease are encountered criteria for low risk is not otherwise met 	
Laboratories	Laboratories in which clinical specimens that might contain <i>M. tuberculosis</i> are not manipulated	Laboratories in which clinical specimens that might contain <i>M. tuberculosis</i> are manipulated	
Recommendations for Screening Frequency			
Baseline two-step TST or one BAMT [¶]	Yes, for all HCWs upon hire	Yes, for all HCWs upon hire	Yes, for all HCWs upon hire
Serial TST or BAMT screening of HCWs	No**	Every 12 months ^{††}	As needed in the investigation of potential ongoing transmission ^{§§}
TST or BAMT for HCWs upon unprotected exposure to <i>M. tuberculosis</i>	Perform a contact investigation (i.e., administer one TST as soon as possible at the time of exposure, and, if the TST result is negative, place another TST 8–10 weeks after the end of exposure to <i>M. tuberculosis</i>) ^{¶¶}		

* Health-care workers (HCWs) refers to all paid and unpaid persons working in health-care settings who have the potential for exposure to *M. tuberculosis* through air space shared with persons with TB disease.

[†] Settings that serve communities with a high incidence of TB disease or that treat populations at high risk (e.g., those with human immunodeficiency virus infection or other immunocompromising conditions) or that treat patients with drug-resistant TB disease might need to be classified as medium risk, even if they meet the low-risk criteria.

[§] A classification of potential ongoing transmission should be applied to a specific group of HCWs or to a specific area of the health-care setting in which evidence of ongoing transmission is apparent, if such a group or area can be identified. Otherwise, a classification of potential ongoing transmission should be applied to the entire setting. This classification should be temporary and warrants immediate investigation and corrective steps after a determination has been made that ongoing transmission has ceased. The setting should be reclassified as medium risk, and the recommended timeframe for this medium risk classification is at least 1 year.

[¶] All HCWs should have a baseline two-step tuberculin skin test (TST) or one blood assay for *M. tuberculosis* (BAMT) result at each new health-care setting, even if the setting is determined to be low risk. In certain settings, a choice might be made to not perform baseline TB screening or serial TB screening for HCWs who 1) will never be in contact with or have shared air space with patients who have TB disease (e.g., telephone operators who work in a separate building from patients) or 2) will never be in contact with clinical specimens that might contain *M. tuberculosis*. Establishment of a reliable baseline result can be beneficial if subsequent screening is needed after an unexpected exposure to *M. tuberculosis*.

** HCWs whose duties do not include contact with patients or TB specimens do not need to be included in the serial TB screening program.

^{††} The frequency of testing for infection with *M. tuberculosis* will be determined by the risk assessment for the setting.

^{§§} During an investigation of potential ongoing transmission of *M. tuberculosis*, testing for *M. tuberculosis* infection should be performed every 8–10 weeks until lapses in infection controls have been corrected and no further evidence of ongoing transmission is apparent.

^{¶¶} Procedures for contact investigations should not be confused with two-step TST, which is used for newly hired HCWs.

Responsibility

Use the following worksheet to identify who is responsible for the various controls in the TB ICP. In the first column, insert the appropriate name, position or committee responsible for that control.

POSITION / COMMITTEE RESPONSIBLE	RESPONSIBILITY
	Ensure full compliance with the provisions of this TB ICP
	Perform risk assessment annually; review and revise TB ICP as needed
	Review and approve facility risk assessment and TB ICP
	Educate and document facility-wide TB education
	Monitor compliance with TB ICP and report compliance issues for resolution
	Develop and implement TB screening program for employees, physicians, and volunteers
	Monitor and maintain environmental controls
All Employees	Comply with all elements of the TB ICP, including attending education sessions, obtaining required screening, using respirators when indicated, using safe work practices, and reporting all TB exposures
	Administer and maintain the Respiratory Protection Program

Note: Delete the last row if your classification is low-risk, all patients with TB disease are immediately transferred to another location, and you elect to not use respirators.

Employee Categories at Risk

All employees working in the clinic who share air with patients who may have infectious TB are considered to be at risk for TB exposure. Review the following list of at risk employee categories and determine which categories apply to your facility:

- Counselors and interviewers
- Engineering and building maintenance staff
- Housekeeping personnel who work in the clinic
- Laboratory staff
- Medical records or clerical staff, if work area is within clinic or is ventilated by clinic ventilation system
- Nurses and medical assistants
- Patient-care personnel who provide directly observed therapy (DOT) or visit patients in their homes
- Physicians
- Radiology staff
- Registration staff
- Security guards who spend time in clinic
- Volunteers who will spend more than 6-8 hours in the setting cumulatively working with persons who may have TB

Registry and Contract Personnel

- Clinic management should ensure that registry and contract personnel in any of the above categories have received TB education, TB screening, and respirator fit testing (if needed) from their employer
- Clinic supervisors will provide these employees with any clinic-specific TB control information necessary for them to safely perform their work
- Registry or other employer, and the employee, should be notified in writing of all exposures

Administrative Controls

This TB ICP is based on a hierarchy of three levels of controls: administrative controls, environmental controls, and respiratory protection. Administrative controls, the first level of the hierarchy, are intended to reduce the risk or exposure to persons with infectious TB.

Administrative controls include:

- Assigning responsibility for the TB ICP
- Conducting a TB risk assessment of the setting
- Implementing work practice controls
- Training, educating, and counseling employees about TB
- Screening employees for TB infection and disease
- Developing and implementing TB control policies and procedures to ensure prompt identification, isolation, evaluation, and treatment of persons likely to have TB

Work Practice Controls

Definition of a Suspected Infectious TB Patient

An individual will be suspected of having infectious TB (unless the individual's condition has been medically determined to result from a cause other than TB) if it is determined that the individual:

- Is known, or with reasonable diligence should be known, to have TB infection and has signs and symptoms of pulmonary or laryngeal TB, or
- Has a positive acid-fast bacilli (AFB) sputum smear, or
- Has a persistent cough lasting 3 or more weeks and one or more symptoms of TB disease (e.g., fever, night sweats, fatigue, unexplained weight loss, bloody sputum [hemoptysis]), or
- Has been started on antituberculosis medications for clinical suspicion of active pulmonary or laryngeal TB, but has completed less than 2 weeks of treatment or has not demonstrated clinical response.

Your clinic may serve persons with additional symptoms or risk factors including HIV infection, homelessness, alcoholism or drug abuse, poor nutrition, or medical conditions that increase the risk of progression from LTBI to TB disease. A definition that is applicable to your clinic should be included in your TB ICP.

Early Identification

Efforts to identify suspected or confirmed infectious TB patients will begin as soon as the patient enters the clinic. All clinic personnel are encouraged to identify patients who are coughing. Registration personnel are encouraged to ask simple questions such as, "How long have you had that cough?" or "Do you have any symptoms other than your cough?" Patients with coughs lasting more than 3 weeks, or who have other signs and symptoms of TB will be immediately referred to triage personnel.

Triage personnel can use a written questionnaire to assist in the early identification of persons with suspected or known infectious TB. Rapid identification of these patients will enable staff to mask or isolate them as necessary. See page 146 and page 155 for tools that you can use for this identification process.

The TB ICP will document the risk level and/or practice at your facility. Choose one of the following paragraphs for this documentation:

- This clinic has been assessed as a **low-risk facility** for *M. tuberculosis* transmission. Patients will not be screened for TB unless they have signs or symptoms of TB.
- This clinic has been assessed as a **medium-risk facility** for *M. tuberculosis* transmission. Any patient with symptoms of TB or known HIV infection will be screened for TB.

If the risk level of the clinic is ever determined to be **potential ongoing transmission** of *M. tuberculosis*, all patients presenting to the clinic for service will be screened for TB symptoms and risk factors. This is a temporary risk classification that requires immediate investigation and corrective steps. After determination is made that ongoing transmission has ceased, the clinic will be reclassified as medium-risk and maintain that classification (medium-risk) for 1 year.

Patient Respiratory Protection

Individuals with suspected or known infectious TB should wear a surgical mask when not in an AIIR or a local exhaust ventilation (LEV) enclosure. The purpose of the mask is to block aerosols produced by coughing, talking, and breathing. Patients will be monitored to ensure compliance, and masks will be changed when damp.

Isolating Persons with Suspected Infectious TB

Masked patients will be escorted to a private waiting area, exam room, or other room to prevent transmission and avoid embarrassment and concern. The TB ICP should identify which rooms have been designated for isolation of persons with suspected or known infectious TB.

The following are examples of paragraphs you can include:

- Room(s) _____ has/have been designated for isolation of persons with suspected or known infectious TB. This room is under negative pressure; exhausts directly outside, away from air intake vents, operable windows, and doors; and has at least _____ ACH. The room door will be closed when occupied by a person with suspected or known infectious TB. A sign will be placed to alert staff to use proper precautions. The sign will read: "STOP, CHECK WITH NURSE BEFORE ENTERING, WEAR RESPIRATOR TO PROTECT YOUR LUNGS." A sign will be placed on the door to indicate when the room will be safe for use after the patient leaves

Note: *Twelve (12) ACH is the minimum ventilation rate recommended by the CDC for new or renovated AIIRs, and where portable HEPA filtration units are used. CDC allows 6 ACH for existing AIIRs, but recommends that this be increased to 12 ACH "where feasible." In general, 12 ACH is usually feasible. It should be noted that, even for existing rooms, 6 ACH may not satisfy local requirements. See Appendix G on page 150 for a worksheet to calculate room clearance time. See Appendix L on page 157 for sample room signs*

- Room(s) _____ has/have been designated for segregation of persons with suspected or known infectious TB. These rooms have been selected because they are located away from immunocompromised patients and young children. Since these rooms do not meet the CDC criteria for AIIRs, patients will be masked and supervised for compliance with masking. The room door will be closed when occupied by a person with suspected or known infectious TB. A sign will be placed on the door that reads: "PATIENT UNDER RESPIRATORY PRECAUTIONS." A small portable HEPA filter will run in the room when it is occupied by a person with suspected or known infectious TB. The HEPA unit will run for _____ minutes after the patient leaves. A sign will be placed on the door to indicate when the room will be safe for use after the patient leaves

In addition, the TB ICP should identify where warning signs are stored. This location should be close to the AIIR and accessible to all employees.

Fast Tracking

A person with suspected or known infectious TB in need of a medical test or procedure will be accompanied to other departments and will not wait in occupied waiting rooms. Communicating with the receiving department prior to the patient's arrival will minimize delays.

For example, a suspected infectious TB patient who needs a chest x-ray will be masked and escorted to the radiology department. The escort is provided to ensure that the patient does not remove the mask or get lost. The receiving department will be notified prior

to patient arrival. Staff will be ready to perform the x-ray immediately to avoid possible exposure of other patients and staff.

Whenever possible, tests such as electrocardiograms and specimen collection for laboratory analysis will be performed where the isolated or segregated patient is located, further reducing the risk of transmission to other patients and staff.

Delay of High-Risk Procedures

High-risk (cough-inducing) procedures, which are not immediately required for diagnosis or treatment, will be delayed until the person with suspected or confirmed infectious TB is no longer contagious.

Covering Coughs

Tissue dispensers are placed within reach of patients throughout the facility. Signs are placed in all waiting areas to remind patients to “Cover Your Cough” (see Appendix L on page 157 for sample signs).

Nursing and registration staff have been trained, and are encouraged, to provide tissues and remind patients to cover coughs.

Transfer of Suspected or Confirmed Infectious TB Patients

If your facility needs to transfer suspected or confirmed infectious TB patients, include a section in the TB ICP on how to handle those patients. For example:

This facility does not have an AIIR. All patients with suspected or known infectious TB are transferred to _____, a facility with AIIR(s).

While awaiting transfer, persons with suspected or known infectious TB will wear surgical masks and will remain isolated in room _____, which has been designated for this purpose.

Employee Education

TB prevention training for employees is provided as mandated by OSHA and recommended by the CDC. Training is offered to employees upon employment during regular work hours and annually thereafter.

The employee signs a training record sheet at the end of the session to acknowledge understanding of information described in the learning objectives. See Appendix I “TB Infection Control Training Record” on page 154 for a sample sign-off sheet.

The following topics are included in employee TB education:

- Where to get a copy of the TB ICP if desired
- Groups at risk for occupational TB, especially immunocompromised workers
- Modes of *M. tuberculosis* transmission
- Symptoms of TB
- TB screening and treatment for LTBI
- MDR TB
- Procedure for isolating persons with suspected or known infectious TB

Whenever possible, tests such as electrocardiograms and specimen collection for laboratory analysis will be performed where the isolated or segregated patient is located, further reducing the risk of transmission to other patients and staff.

- Employer and employee responsibilities under the TB ICP
- Use and limitations of methods that will prevent TB transmission, including administrative and work-practice controls, environmental controls, and respiratory protection
- Reuse and disposal of respirators

The educational session includes an opportunity for interactive questions and answers with the instructor.

Employees Required to Attend TB Prevention Education

Identify the persons who work in increased-risk environments and are required to attend TB prevention education. If you choose to educate all employees, specify that in the TB ICP.

All employees listed on page 54 who may work with persons with suspected or confirmed TB should be included in the TB education and training.

Employees Who Are Not Required to Attend TB Prevention Education

Identify the individuals who are not mandated to attend TB education, as they are not at increased risk for *M. tuberculosis* transmission:

- Outdoor security guards
- Equipment repair personnel who primarily work off-site
- Clerical staff who work off-site or in a separately ventilated clinic area

If you choose to educate all employees, the identification of these employees will not be needed. If some of these categories do not exist in your facility, do not include them in your TB ICP.

Educational Record Maintenance

Educational records will include the class topic, name and qualifications of the instructor, employee name, position, department, and date and time of educational program. To document that the employee attended the training session, the employee must sign the training record sheet. Records will be maintained for 3 years.

Pre-placement and Periodic Employee Screening

All employees, physicians, and volunteers who have potential for exposure to *M. tuberculosis* will be screened for TB at hire, and at least annually thereafter by TST or IGRA, if indicated by the settings' TB IC policies or TB risk classification, and complete a TB symptom review questionnaire. For a sample HCW screening questionnaire, please see Appendix E on page 147. Contract employees and students must provide proof of TB screening that meets this facility's requirements prior to assignment. The clinic's policies will specify which method of TB testing will be used in the setting (TST or IGRA). Follow the content provided here that is specific for the selected testing method. Either method is acceptable for diagnosing LTBI. However, the IGRA method requires different equipment, laboratory, and courier service to ensure prompt and proper processing of the blood specimens.

TB Symptom Screen

All employees, physicians, and volunteers will be screened at hire and at least annually for TB symptoms such as:

- Cough lasting more than 3 weeks
- Fever
- Night sweats
- Fatigue
- Unexplained weight loss
- Hemoptysis (bloody sputum).

TB symptom screen will be repeated annually by all employees regardless of their TST status.

Symptomatic Employees

Any employee, physician, or volunteer with a persistent cough, especially in the presence of other signs or symptoms of TB, will be evaluated promptly for TB. The individual will not return to work until the following criteria are met:

- TB disease is ruled out based on physical exam, chest x-ray, and bacteriology (if indicated); or
- TB disease is diagnosed and treated, and the individual is determined to be non-infectious as defined below:
 - Had three negative AFB sputum smears obtained 8-24 hours apart, with at least one being an early morning specimen; and
 - Responded to antituberculosis treatment that will probably be effective, based on susceptibility results; and
 - Had been determined to be noninfectious by a physician knowledgeable and experienced in managing TB disease.

Interferon Gamma Release Assay (IGRA)

IGRA is the term used to refer to the blood test that detects infection with *M. tuberculosis*. A more general term for these tests is Blood Assay for Mycobacterium Tuberculosis (BAMT). In this manual we will use IGRA to refer to all blood tests currently used to diagnose TB infection in Europe and the United States. QuantiFERON®-TB Gold (QFT-G) is the IGRA that was approved by the FDA in 2005 and is currently recommended by CDC as a diagnostic test for TB infection. QFT-G measures the T-cell immune responses to two *M. tuberculosis* proteins that are not present in any BCG vaccine strain nor in the majority of nontuberculous mycobacteria (NTM). Therefore, QFT-G is a more accurate test when compared to the TB skin test because it is much less likely to be falsely positive in individuals who have received BCG vaccinations or are infected with most other environmental mycobacteria.

The results of IGRAs are automated and reported by laboratory technology. Unlike the TST, IGRAs do not involve reading or interpretation by health staff. This means results are more consistent and less prone to errors made in placing and reading a skin test. A positive QFT-G result occurs when interferon gamma concentrations reach a designated threshold. A positive result suggests that *M. tuberculosis* infection is likely; a negative result suggests that TB infection is not likely; an indeterminate result suggests that the QFT-G result cannot be interpreted. For a person with an indeterminate IGRA result, healthcare

IGRAs are a new test and it is still unclear how to use prior TST information when interpreting the new IGRA result, expert advice may be needed in some situations.

providers should consult a physician who is knowledgeable and experienced in managing TB disease.

When using IGRAs in healthcare workers (HCWs) or other workers who need annual testing, only a single step test is needed at baseline, unlike the two-step testing used in skin testing. If the test changes from a negative to a positive result within a 2-year period, the person is considered a “converter” or newly infected. IGRAs are a new test and it is still unclear how to use prior TST information when interpreting the new IGRA result and expert advice may be needed in some situations. In addition to a positive or a negative result, the test may be reported as “indeterminate.” An indeterminate result means that the test cannot be used to determine infection because of a lack of appropriate responses to the controls in the test. In these situations, the IGRA can be repeated or a TST can be used to avoid getting another indeterminate result. As with the TST, QFT-G results and their interpretation should be considered in conjunction with other epidemiological, historical, physical, and diagnostic findings.

More immunoassays are being developed that should be useful in the diagnosis of TB infection. Future test methods using FDA-approved products, in combination with CDC issued recommendations, may provide additional diagnostic options. CDC will periodically publish guidelines as alternate methods become available.

Testing Health-care Workers for TB

All employees, physicians, and volunteers who have unknown or undocumented previous TST or IGRA results will have a TST or IGRA administered and read prior to starting employment.

Mantoux Tuberculin Skin Test (TST)

Identify the name(s) and job title(s) of the practitioner who will place the TST and who will read the TST result after 48-72 hours. Employees may not read their own TST results.

Two-Step Skin Testing

Two-step testing is used to detect individuals with TB infection acquired in the remote past who may now have diminished skin test reactivity. This procedure reduces the likelihood that a boosted reaction will later be interpreted as new infection in employees who are periodically tested.

- Two-step testing is performed on all new employees who do not have written documentation of a negative TST result in the preceding 12 months and have an initial negative TST result at the time of employment
- The second TST is placed 1-3 weeks after the initial test result is read. Employees who have a negative reaction to the first test and a negative TB symptom screen may start work before the second test is placed. Any employee with a persistent cough (more than 3 weeks), especially in the presence of other signs or symptoms compatible with TB, should be excluded from the workplace and promptly evaluated for TB
- Asymptomatic employees with a positive (boosted) reaction to the second TST are considered previously infected. The employee will be given a baseline chest x-ray and referred for consideration of treatment for TB infection

Past Positive TST

Employees, physicians, and volunteers who have written documentation of a previous positive TST result are required to have a baseline chest x-ray at hire or provide written documentation of a normal chest x-ray taken no more than 12 months prior to hire. The chest x-ray will be repeated only if the employee develops signs or symptoms of TB or when the attending physician decides a repeat chest x-ray is needed.

Screening is conducted, at least annually, via a TB symptom review questionnaire. The symptom review form will be completed whenever a TST would be required of an employee with a negative TST result. If the symptom screen reveals signs or symptoms of TB, the employee will be excluded from the workplace. A new chest x-ray and physical assessment is then required.

BCG Vaccination

A history of previous vaccination with Bacille Calmette-Guerin (BCG) is not a contraindication for having TSTs. Criteria for placing and interpreting TST results are unchanged.

TABLE 4.

Definition of a Positive TST Result for HCWs

TST results are always recorded in millimeters (mm) of induration measured across arm, not simply as positive or negative. Erythema (redness) without induration should not be measured. A TST result with no induration is recorded as 0 mm.

5 mm or greater is considered positive in:	10 mm or greater is considered positive in:	15 mm or greater is considered positive in:
<ul style="list-style-type: none"> • Persons with HIV infection • Recent contacts of a person with TB • Organ transplant recipients • Persons with other immunosuppressing conditions (e.g., receiving >15 mg/day of prednisone for >1 month) • Persons with fibrotic changes on chest x-rays consistent with previous TB disease 	<ul style="list-style-type: none"> • Persons with medical conditions (e.g., diabetes, chronic renal failure, silicosis, etc.) that increase the risk of progression to TB disease • Persons who use intravenous drugs • Foreign-born persons from areas where TB is common who have immigrated to the US within the past 5 years • All employees of healthcare, correctional, homeless shelter, long term care, hospice, AIDS residential care (where TB patients receive care), and mycobacteriology laboratory settings 	<ul style="list-style-type: none"> • All persons with no known risk factors (in some states, including California, 10 mm is the cutoff for all persons without risk factors) • HCWs with no known risk factors who work in facilities where the risk of TB exposure is very low

TST Conversion

A TST conversion is defined as an increase of at least 10 mm in the size of induration from less than 10 mm to 10 mm or greater within a 2-year period.

Note: *the CDC states, "For HCWs who are at low risk (e.g., those from low incidence settings), a baseline result of >15mm of induration (instead of >10mm) might possibly be the cut point."*

Frequency and Timing

All clinic employees who work in areas where air may be shared with persons with suspected or known infectious TB must be screened for TB at least annually.

Include one of the following frequency options based on your facility risk assessment:

- This clinic has been assessed using a risk assessment tool and is classified as a **low-risk facility**. No additional TB screening is necessary unless unprotected exposure to an infectious TB patient occurs
- This clinic has been assessed using a risk assessment tool and is classified as a **medium-risk facility**. Employees will be screened for TB annually, on the anniversary of their hire dates, and following any unprotected exposure to an infectious TB patient.

If the clinic has been assessed as having evidence of **potential ongoing *M. tuberculosis* transmission**, employees will be screened for TB every 8-10 weeks until lapses in infection control have been corrected and there is no evidence of ongoing transmission. The clinic will then be reclassified as medium-risk and maintain that classification (medium-risk) for 1 year.

More Frequent TB Screening for Increased Risk Employee Categories

If your facility overall is categorized as low-risk, but some employees are at increased risk for TB exposure, you may selectively increase the frequency of their TB screening. Identify the employee and physician categories that are designated at increased risk for TB exposure and screen them for TB annually.

Volunteers will not be placed in high-risk areas or participate in high-risk procedures.

Evaluation of TST or IGRA Conversion

Any employee, physician, or volunteer with a TST or IGRA conversion or newly positive TST or IGRA result will have a chest x-ray within 1 week. Identify by name the clinic physician who will evaluate the chest x-ray. Alternately, the employee's private physician can evaluate the x-ray if preferred by the employee. Symptomatic employees will be excluded from work until cleared by a qualified physician with expertise in TB diagnosis and treatment.

Employee with Suspected Infectious TB

If the symptom-screen, history, physical examination, or chest x-ray is consistent with TB disease, the worker will be excluded from the workplace until:

- A qualified physician rules out TB disease based on physical exam, chest x-ray, and bacteriology; or
- TB disease is diagnosed, treated, and the individual is determined to be non-infectious as defined above under 'Symptomatic Employees'

TB Screening Record Maintenance

All employees, physicians, and volunteers will receive a copy of their TST results and interpretations. The following statement is included on the test result sheet, "HIV infection and other medical conditions may cause a TST result to be negative even when TB infection is present." The facility's copy of the TST form is maintained in the employee's confi-

dential health file. Records will be maintained for the duration of employment plus 30 years. Identify the person by position or title who will maintain an aggregate log of TSTs.

All employee TST conversions and confirmed TB cases will be recorded on the OSHA 300 Log unless substantiated as community-acquired.

Facility TST or IGRA Conversion Rates

Identify how the TST or IGRA conversion rates are determined for your facility. Use one of the following paragraphs:

- The facility TST or IGRA conversion rate is calculated every 12 months to assess the level of occupational risk. The calculation is as follows:

$$\frac{\text{Total number of staff (except new hires) with newly positive TST or IGRA results/year}}{\text{Total number of staff (except new hires) who had TSTs applied and read/year or IGRAs completed/year}} \times 100 = \text{Conversion Rate}$$

- Facility TST or IGRA conversion rates are not calculated because a small number of employees receive TSTs or IGRAs. An epidemiological investigation will be conducted following any employee TST or IGRA conversion.

Determine and identify the appropriate committee or group (Infection Control Committee, Administration, Safety Committee, TB control staff) who will interpret the TST or IGRA conversion data. The committee will identify factors that could have contributed to transmission and infection, and recommend implementation of appropriate preventive measures.

Compliance with TB Screening

Compliance with the TB screening program and post-exposure follow-up is mandatory for all employees, physicians, and volunteers. Identify the appropriate department or individual (department manager, employee health, human resources) who will notify the staff when screening is due. Employees will have 30 days to complete the screening process. Failure to comply will result in disciplinary action up to, and including, removal from the work schedule.

Employee Exposure and Follow-up

Clinic employees may be inadvertently exposed to TB during the course of their work.

Exposure Definition

An employee is considered exposed when the employee has contact for more than a few hours in a confined space, without the benefit of all appropriate exposure control measures, with a patient who has a positive AFB smear result or positive culture result for *M. tuberculosis* or is strongly suspicious for being contagious, and who has not met all three criteria (listed on page 8) to indicate that the patient is noncontagious.

Suspected or confirmed infectious TB cases that trigger contact investigations must be reported promptly to the local Public Health Department.

Factors that affect the significance of contact include:

- Duration of contact (at least a few hours)
- Proximity of contact
- Use of control measures that are functioning appropriately at the time of exposure (e.g., employee wore a properly fitted N-95 respirator, TB patient was masked, and/or sputum induction was conducted in a well-functioning LEV device)

Contact Investigation

Specify the name or position of the individual responsible for conducting a contact investigation. This person is responsible for the contact investigation, potentially in collaboration with the local Health Department, following any known occupational TB exposure. The contact investigation will begin when employee exposure to a suspected infectious TB case has been identified and results of sputum culture or NAAT for *M. tuberculosis* are pending. The contact investigation will include interviews with the work area supervisor and the patient with suspected infectious TB (index case), if possible. A thorough review of the patient's chart will determine if the patient was transported to the clinic, had laboratory work done, visited radiology, or was interviewed by screening or counseling personnel. A brief memo identifying the patient by initials and date and time of visit will be posted in employee-only areas of all departments where an exposure could have occurred in order to alert those who wish to self-identify. If the index case is an employee, the memo will identify work areas and meetings that may have provided opportunities for exposure without revealing the employee's initials or identity. Suspected or confirmed infectious TB cases that trigger contact investigations must be reported promptly to the local Public Health Department.

Screening Following Exposure

Specify the name or position of the individual responsible for screening employees following occupational exposure to TB. This person is responsible for tuberculin skin testing or providing IGRA and TB symptom screening of employees following occupational TB exposure. A post-exposure baseline TST (for employees with negative TST results) and TB symptom screen will be administered to exposed personnel within 1 week of suspected TB exposure (i.e., positive AFB sputum smear report and clinical findings consistent with pulmonary TB or positive NAAT for *M. tuberculosis*). Employees who have had a negative TST result within the last 3 months may use that test and a new TB symptom screen form as a baseline. Baseline status of employees with past positive TST results will be established by completion of a TB symptom screening form.

If the post-exposure baseline TST result is negative, a second test will be performed 8-10 weeks after the date of the last known exposure.

Follow-up and Tracking

Specify the position title or name of the person who will be immediately notified of all new TST conversions and will track required follow-up care (i.e., chest x-ray, initial follow-up medical evaluation, confirmation of report to local Public Health Department).

Employee with TB Disease

If the symptom screen, history, physical examination, or chest x-ray are indicative of TB disease, the employee will be excluded from the workplace until:

- TB disease is ruled out based on physical exam, chest x-ray, and bacteriology; or
- TB disease is diagnosed, treated, and the individual is determined to have non-infectious TB as defined under “Symptomatic Employees” on page 59

Employee TB Exposure Follow-Up

Use this worksheet to track the person or job position responsible for intervention.

POSITION / POSITION RESPONSIBLE	INTERVENTION
	Identifies employees occupationally exposed to TB by interviewing patient, area supervisor, and reviewing patient's chart.
	Writes notification letter and ensures all identified employees are aware of exposure. Places notice on employee bulletin board in all departments in which exposure may have occurred so that employees can self-identify.
	Interviews identified employees to confirm exposure.
	Organizes and tracks screening and TST or IGRA results.
	Places, reads, and interprets TST or IGRA results. Completes TST or IGRA form.
	Evaluates TB symptom screening forms.
	Ensures employee with TST or IGRA conversion or TB symptoms is referred for further evaluation.
	Performs medical history, physical exam, medical management and follow-up, and other related tests, if indicated.
	Records occupational TB infections/TST or IGRA conversions and TB disease on OSHA 300 Log and completes required paperwork.
	Ensures that employees with suspected or known infectious TB do not return to the workplace until their TB is non-infectious.
	Notifies Public Health Department of suspected and confirmed TB cases as required.
	Notifies Public Health Department of TST or IGRA conversions if required.

Environmental Controls in the Clinic Setting

Environmental controls, the second level of the TB control hierarchy, can reduce the risk of TB infection by decreasing the concentration of *M. tuberculosis* droplet nuclei and exhausting them from a space. For more information about environmental controls, see “Environmental Controls” on page 15.

Facility Ventilation System Description

Describe the facility’s ventilation system. Examples of ventilation system descriptions include:

- This clinic uses a single-pass air system (air is not recirculated, 100% of supply air comes directly from outdoors, and all air from these areas is exhausted) in the following areas where infectious TB patients receive care:
_____.
- This clinic uses 25% efficient filters in the ventilation system.
- The fan setting on thermostats is maintained in the “on” position whenever the clinic is occupied for continuous air movement and filtration.
- Portable HEPA filter units are used in the following rooms/areas:
Note rooms here: _____.
- Permanently-mounted HEPA filter units are located in the following rooms/areas:
Note rooms here: _____.
- AIIR(s) are available for isolating persons with suspected or known infectious TB.
- Ultraviolet germicidal irradiation (UVGI) is used in the following areas as an adjunct to ventilation and filtration:
Insert areas where UVGI is used here: _____.

Add any additional items that may be in place at your facility.

Environmental Controls for High-Risk Procedures

High-risk procedures include cough-induction which may and may aerosolize *M. tuberculosis*. Special precautions must be used to prevent occupational exposure when these procedures are performed on a person with suspected or known infectious TB.

Use one of the following statements:

- No high-risk procedures are performed on persons with suspected or known infectious TB at this clinic.
- Special precautions are used to prevent/minimize occupational exposure when high-risk procedures are performed on persons with suspected or known infectious TB.

Use all or part of the following table if high-risk procedures on persons with suspected or known infectious TB are performed at your facility. Do not include the table if high-risk procedures are not performed at your facility.

TABLE 5.

Ventilation Precautions for High-Risk Procedures

For persons with suspected or known infectious TB

HIGH-RISK PROCEDURES	SPECIAL VENTILATION PRECAUTIONS USED
<ul style="list-style-type: none"> • Sputum induction or sputum collection • Aerosol breathing treatments • Pentamidine treatment (on any patient) 	<p>Local exhaust ventilation booth or tent</p> <p>Local exhaust ventilation hood</p> <p>AllR with 6*-12 air changes per hour (ACH) exhausted directly outdoors away from operable windows, doors, and air intake vents (using HEPA filtration if possible, where human traffic may exist)</p> <p>Performed outdoors only (sputum collection only)</p>
<ul style="list-style-type: none"> • Bronchoscopy • Airway suctioning 	<p>AllR with 6*-12 ACH exhausted directly outdoors away from operable windows, doors, and air intake vents (using HEPA filtration if possible, where human traffic may exist)</p>
<ul style="list-style-type: none"> • Processing specimens for mycobacteriology studies 	<p>Class I or Class II biological safety cabinet (BSC) in a room with All environmental controls</p>

*6 ACH for existing, pre-1994 facilities

Employees who assist with high-risk procedures in any settings will wear NIOSH-approved N-95 or more protective respirators. Respirators are not required when local exhaust ventilation enclosures are used.

TABLE 6.

Environmental Controls for Low-Risk Clinics

AREA	RECOMMENDATION	COMMENTS
General Ventilation System	<ul style="list-style-type: none"> Ventilation systems should have minimum 25% efficient filters (MERV 7 or 8) Provide at least 15 CFM of outside air per occupant or 2 air changes per hour (ACH) of outside air, whichever is greater 	25% efficient filters (MERV 7 or 8) remove about 50% of infectious particles in the size range of <i>M. tuberculosis</i> droplet nuclei.
General Waiting Rooms	<ul style="list-style-type: none"> Ten (10) ACH with 2 ACH of outdoor air is recommended for this area Use high efficiency particulate air (HEPA) filter units to increase effective ACH if needed Ultraviolet germicidal irradiation (UVGI) may also be used in this area to supplement ventilation systems Air should flow from clean areas toward less clean areas 	Patients have not yet been screened or diagnosed. Increasing the ACH will dilute infectious particles. Airflow from staff areas (clean areas) toward areas that may be occupied by TB patients (less clean areas) will help to protect clinic staff.
General Exam Rooms	<ul style="list-style-type: none"> Recirculated air should be filtered with minimum 25% efficient filters (MERV 7 or 8) At least 6 ACH are recommended Room should be at neutral or negative pressure relative to adjacent spaces 	
Airborne infection Isolation/Exam Room	<ul style="list-style-type: none"> Probably not needed for low-risk facilities. The occasional person with suspected or known infectious TB can be masked and segregated in a closed room with a small HEPA filter unit, or directed outdoors and referred to a facility with an AIIR 	
Sputum Induction	<ul style="list-style-type: none"> Fully enclosed sputum induction booth with local exhaust ventilation (LEV) is preferred Partially enclosed LEV is the second-best option If LEV is unavailable, any room used for sputum induction should meet all recommendations for an AIIR, including negative pressure, at least 12 ACH, and air exhausted directly outside or HEPA-filtered. Negative pressure should be checked daily when in use 	<p>CDC Guidelines recommend a medium-risk category for facilities performing sputum induction on suspected or confirmed TB patients.</p> <p>Air intake flow should be designed to come in from both sides (in front of patient and health-care worker) and out to the back of patient so that exposure is minimized for the healthcare worker. Negative pressure (direction of flow) should be monitored constantly</p>

TABLE 7.

Environmental Controls for Medium Risk Clinics and Clinics with Potential Ongoing Transmission

AREA	RECOMMENDATION	COMMENTS
General Ventilation System	<ul style="list-style-type: none"> Ventilation systems should have minimum 25% efficient filters (MERV 7 or 8) Provide at least 15 CFM of outside air per occupant or 2 air changes per hour (ACH) of outside air, whichever is greater 	25% efficient filters (MERV 7 or 8) remove about 50% of infectious particles in the size range of the TB droplet nuclei.
General Waiting Rooms	<ul style="list-style-type: none"> Ten (10) ACH recommended with 2 ACH of outdoor air Use high efficiency particulate air (HEPA) filter units to increase the effective ACH if needed Ultraviolet germicidal irradiation (UVGI) may also be used in this area to supplement ventilation systems Air should flow from clean areas toward less clean areas 	Patients have not yet been diagnosed or screened. Increasing ACH dilutes any infectious particles in the air. Airflow from staff areas (clean areas) toward areas that may be occupied by TB patients (less clean areas) will help to protect clinic staff.
Medium-Risk Waiting Areas such as those in Radiology or Pulmonary Clinics	<ul style="list-style-type: none"> Air from this room should be exhausted or HEPA-filtered before recirculation Ten (10) ACH with 2 ACH of outdoor air is recommended for this area Air should flow from clean toward less clean areas Use portable HEPA filter units to increase effective air change rates if needed UVGI may also be used in this area to supplement ventilation systems 	CDC Guidelines recommend that ambulatory care areas where patients at high risk for TB are treated be ventilated in the same manner as similar in-patient areas.
General Exam Rooms or Interview Rooms	<ul style="list-style-type: none"> Six (6) ACH with 2 ACH of outside air is recommended Room should be at neutral or negative pressure relative to adjacent spaces Use portable HEPA filter units to increase the effective ACH if needed 	
Airborne infection Isolation/Exam Room	<ul style="list-style-type: none"> Recommended for medium-risk clinics At least 12 ACH with 2 ACH of outdoor air recommended Air should be properly discharged outdoors or HEPA-filtered before recirculation Room should be under negative pressure Negative pressure should be monitored at least monthly, and daily when room is in use 	Twelve (12) ACH is the minimum ventilation rate recommended by the CDC for new or renovated AIIRs. The CDC allows 6 ACH for existing pre-1994 AIIRs, but recommends that this be increased to 12 ACH "where feasible." In CNTC experience, 12 ACH is usually feasible. It should be noted that 6 ACH may not satisfy local requirements.
Sputum Induction	<ul style="list-style-type: none"> Fully enclosed sputum induction booth with LEV is preferred. Partially enclosed LEV is the second-best option If LEV is unavailable, any room used as a sputum induction room should meet the requirements for AIIRs, including negative pressure, at least 12 ACH, and air exhausted directly outside or HEPA-filtered. Negative pressure should be checked daily when in use 	CDC Guidelines recommend a medium-risk category for facilities performing sputum induction on suspected or confirmed infectious TB patients. CDC Guidelines recommend that LEV devices are located in an AIIR.

Maintenance, Monitoring, and Communication

Specify the individual or department responsible for the maintenance, monitoring, and communication of the environmental controls. The following list shows examples of the type of controls to track:

.....
Mechanical equipment is inspected by _____
and maintained at least yearly, and as needed.
.....

Filters are inspected quarterly and changed if necessary
by _____.
.....

Supply and return air registers are cleaned every 6 months and as needed
by _____.
.....

The negative pressure of airborne infection isolation rooms (AIIRs) and sputum induction
rooms is checked daily (when in use) by _____.
.....

UVGI bulbs are dusted monthly and changed according to manufacturer's recommen-
dations by _____.
.....

UVGI warning signage stating, "Caution, High Intensity Ultraviolet Energy, Protect Eyes
and Skin" is posted by _____.
.....

Engineering and infection control personnel work as a team in efforts to control TB.
Maintenance and monitoring results are promptly communicated to clinic management/
infection control staff by _____.
.....

Results of air balance reports and negative pressure checks in AIIRs are copied to clinic
management/infection control staff by _____.
.....

Shutdowns for maintenance of the ventilation system are coordinated with clinic
management/infection control staff by _____.
.....

Records of maintenance and monitoring are maintained for 5 years
by _____
and are located _____.
.....

Respiratory Protection

The third level of the TB control hierarchy is the use of personal respiratory protection equipment. Respirators are used by HCWs in certain situations in which the risk for exposure to *M. tuberculosis* may not be controlled by administrative or environmental measures alone.

If your clinic is a **low-risk facility**, include the following paragraph in the TB ICP:

This clinic has been designated as a low-risk ambulatory care setting. We have opted to utilize administrative and environmental controls to prevent high-risk exposure situations that require the use of respirators. For example, until they can be transferred to a facility for appropriate evaluation and care, persons with suspected or known infectious TB will be given surgical masks, educated on the importance of keeping the mask in place and changing it when damp, and observed for compliance with this request. This risk designation will be reassessed annually and after any occupational TB exposure.

If your clinic is a **medium-risk facility** include the following paragraphs:

This clinic has been designated as a medium-risk ambulatory care setting. Employees provide care to TB patients and may perform high-risk procedures such as sputum induction. OSHA mandates respirator use for facilities unable to prevent certain high-risk situations via administrative or environmental controls. A respiratory protection program utilizing N-95 respirators has been developed and instituted to enhance staff safety.

Clinic employees are required to wear NIOSH-certified N-95 respirators, which have been approved for protection against TB, when:

- In the presence of a suspected or confirmed infectious TB patient who is unable or unwilling to wear a mask
- Entering a room, including an AIIR, which has been occupied by an unmasked person with suspected or confirmed infectious TB, prior to the time required for 99% of the airborne contaminants to be removed from the room
- Transporting or accompanying a person with suspected or known infectious TB in an enclosed vehicle, even if that patient is wearing a surgical mask
- In the presence of high-risk procedures (e.g., sputum induction)

[All of the following are OSHA-mandated and should remain in your TB ICP]

We have selected the following [Insert brand(s) of respirators used here. A selection of sizes must be offered] N-95 respirators for use in this clinic: _____.

Respiratory Protection Program

If your facility uses respirators, you must have a Respiratory Protection Program that includes a written Respiratory Protection Plan (RPP).

Specify where the written RPP is located. The RPP should include instructions related to:

- Selecting and issuing respirators
- Respiratory protection for bearded employees or individuals unable to use a respirator
- Employee training (including which employees are required to use respirators)
- Conducting respirator fit tests
- Conducting respirator fit checks
- Inspecting respirators
- Cleaning, sanitizing, and maintaining respirators
- Storing and disposing of respirators
- Respirator limitations
- Medical surveillance

Note: Additional information and assistance with writing an RPP can be found on the following Web sites:

http://www.dir.ca.gov/dosh/dosh_publications/respiratory.pdf

<http://www.osha.gov/SLTC/etools/respiratory/oshfiles/writtenprogram1.html>

TB Infection Control Plan (ICP) Evaluation

The TB ICP should be reviewed at least annually. Specify the name of the individual or committee who will perform the review. The review will include a reassessment of the clinic's risk level (please consult Appendix B [revised version], of the CDC guidelines), including an analysis of any employee TB exposures, employee TST or IGRA conversions, or evidence of person-to-person transmission. Factors that may have contributed to TB exposures or transmission will be reviewed. Interventions to prevent recurrence will be implemented. The TB ICP will be amended to reflect these policy and/or procedure changes.

Any cluster of employee TST or IGRA conversions will prompt an immediate review and assessment of the TB infection control program.

Any cluster of employee TST or IGRA conversions will prompt an immediate review and assessment of the TB infection control program.

Sputum Induction



SPUTUM INDUCTION

This section of the manual provides practice-based guidance on conducting sputum induction safely. It addresses the following issues:

- **Safe sputum induction for a person with suspected or known infectious TB**
- **Administrative controls, including signage and a sample sputum induction procedure**

For a complete review and discussion of early identification of persons with suspected or known infectious TB in a variety of healthcare settings, refer to the Appendix for TB triage tools and the Resources section for a list of additional materials and suggested reading.

About Sputum Induction

Sputum induction is used to obtain sputum for diagnostic purposes when patients are unable to spontaneously expectorate a specimen. The procedure uses sterile water or hypertonic saline to irritate the airway, increase secretions, promote coughing, and produce a specimen. The CDC and OSHA both classify sputum induction as a high-risk procedure when performed on a person with suspected or known infectious TB. This procedure induces coughing, resulting in a greater likelihood that infectious droplet nuclei are expelled into room air. Because of this increased risk, it is recommended that sputum induction be performed on persons with suspected or confirmed infectious TB only if absolutely necessary to obtain/confirm a TB diagnosis. All appropriate precautions must be used whenever sputum induction is performed.

Elements that are essential for a safe sputum induction program include:

- A triage program to identify persons with suspected or known infectious TB prior to sputum induction
- A written sputum induction procedure that includes TB infection control instructions
- Employee training on safe and effective sputum induction procedures
- Appropriate signage for high-risk procedure rooms
- Environmental controls meeting OSHA requirements and CDC recommendations, which may include use of the following:
 - Local Exhaust Ventilation (LEV, see page 78 for definition)
 - Airborne infection isolation precautions
 - Supplementary UVGI
- Monitoring and maintenance programs for environmental controls
- A respiratory protection program

Effective TB control programs are based on a hierarchy of control measures. In the order of priority, the three levels of the hierarchy are: administrative controls, environmental controls, and respiratory protection for employees.

Administrative Controls for Sputum Induction

Administrative controls, the first level of the hierarchy, are designed to reduce the risk of exposure to persons with infectious TB. These controls include policies and procedures for early identification, evaluation, isolation, and treatment of patients likely to have TB. Administrative controls essential to safe sputum induction on high-risk patients include:

- Educating employees about TB and the risk of *M. tuberculosis* transmission during sputum induction
- Developing a sputum induction policy and procedure that includes patient care measures and staff safety issues, and is easily followed by staff
- Identifying persons likely to have TB prior to the sputum induction procedure
- Implementing work control practices for sputum induction
- Monitoring compliance with and evaluating sputum induction procedures on a periodic basis.

Educating Staff

A system should be developed to inform staff of new or updated policies and procedures; education should be provided as necessary. One simple way of documenting that staff have read a new policy is to post it in a staff-only area and require that staff initial the posted copy after reading it. After a 30-day posting, the document is placed in a binder that remains available to staff. The information should also be included in department-specific orientations for new employees who will be assisting in sputum induction.

Product sales representatives will often train facility staff when equipment such as a local exhaust hood or booth has been purchased from their company. After the initial training session, a brief review of important safety issues can be presented periodically at staff meetings.

Providing a Written Sputum Induction Procedure

High-risk procedures such as sputum induction must have up-to-date, understandable written procedures for staff to follow. One copy should be filed in the policy and procedure manual. A second, simplified set of instructions should be posted within view of the employee performing the sputum induction. These instructions can be placed on the door of the sputum induction room or attached to the sputum induction hood.

A written procedure should include safety measures such as identifying person with suspected or known infectious TB, using a respirator correctly, placing cautionary door signage, and verifying negative room pressure. The following are suggested topics to include in a sputum induction procedure:

Early identification of patients who have TB is especially important prior to high-risk procedures such as sputum induction.

- Patient instructions and education
- Instructions for operating sputum induction equipment
- Instructions for confirming room negative pressure or properly functioning hood or booth
- Instructions for safe use of UVGI, if applicable
- Specimen handling instructions
- Use of respirators by staff
- Use of other personal protective equipment such as gloves and face shields
- Cleaning and disinfection requirements for room/equipment
- Instructions for placing signage during procedure
- Instructions for assuring adequate removal of airborne contaminants between patients

See “Performing Sputum Induction” on page 82 for highlights of a sputum induction procedure.

Early Identification of a Suspect TB Patient

Early identification of patients who have TB is especially important prior to high-risk procedures such as sputum induction. All facilities should have written criteria and a protocol in place to rapidly identify and implement precautions for suspected infectious TB patients. In out-patient settings or emergency departments, efforts to identify infectious TB patients should begin as soon as the patient enters the facility and approaches the admission or registration desk. In both in-patient and out-patient settings, the following patient’s warrant additional screening or action:

- Patients presenting with TB symptoms (e.g., cough, fever, night sweats, fatigue, weight loss, hemoptysis)
- Patients who have risk factors for TB (e.g., HIV infection, birth in country where TB is endemic, homelessness, injection drug use, recent incarceration, recent exposure to an infectious TB case, a new positive TST, or a history of TB infection or disease).

Cal/OSHA requires that healthcare facilities develop criteria to identify individuals who are “suspect” TB cases. These criteria must include identification of the following individuals:

- Any person who is known, or with reasonable diligence should be known, by the employer to be infected with TB and has signs or symptoms of pulmonary or laryngeal TB
- Any person who has a positive AFB smear, or any other positive test result, obtained for the purpose of diagnosing pulmonary or laryngeal TB
- Any person who meets the facility’s criteria for identification based only on signs and symptoms when TST and laboratory-generated information are not available.

A person with suspected or known infectious TB waiting for a sputum induction procedure should wear a surgical mask when not in an AIIR or complete enclosure. The purpose of the mask is to block aerosols produced by coughing, talking, and breathing. A surgical mask on a cooperative patient may provide adequate short-term protection. A mask is not effective for extended periods of time, however, and should be changed if damp.

All patients having sputum induced for diagnostic purposes should first be screened for TB. If the minimum criteria for a suspected infectious TB case are met, the sputum induction procedure is considered a high-risk procedure, and must be performed using LEV or in a room that meets the ventilation requirements for TB isolation.

Two tools are included in the Appendix to assist in the early identification of persons with suspected or known infectious TB. The first is the Respiratory Isolation of Pulmonary Tuberculosis (RIPT) protocol developed by Roger Lewis, MD, PhD, Department of Emergency Medicine at Harbor-UCLA Medical Center, in Appendix J on page 155. The second tool, “Early Detection of Tuberculosis Questionnaire,” in Appendix D on page 146 is an adaptation of a questionnaire developed by OSHA. See “References” and “Resources” at the end of this document for additional articles and information on the early identification of suspected TB patients.

Implementing Safe Work Practices

The sputum induction procedure included in this guideline outlines and discusses important issues for patient and employee safety. After adapting the procedure to fit your facility, practice, and equipment, you must educate all employees who may participate in sputum induction procedures. This can involve interdepartmental meetings, educational sessions, and equipment demonstrations by product sales representatives. Periodic monitoring is essential to ensure that the sputum induction procedure is fully implemented by all staff. Periodic updating and refresher sessions will be necessary as staff or equipment change.

Environmental Controls for Sputum Induction

Environmental controls are the second level in the TB control hierarchy. They help to reduce the risk of *M. tuberculosis* transmission during sputum inductions by removing infectious particles from the air and controlling the direction of airflow. Two main types of environmental controls for sputum induction are LEV devices and rooms that have the same ventilation characteristics as AIRs. Sputum induction should not be done in facilities that do not have rooms with these characteristics. Patients should be referred to facilities that are appropriately equipped.

A comparison chart showing the advantages and disadvantages of different sputum induction environmental controls is included in “Summary of Sputum Induction Environmental Controls” on page 86.

Local Exhaust Ventilation (LEV) Devices

LEV devices provide the most efficient method of capturing infectious particles. By capturing these particles close to the point of generation, dispersion of particles to other areas of the building is prevented. If particles are not captured at the source, they become more difficult to control due to the larger space they will occupy. Removal of particles from room air requires longer periods of time, special exhaust or filtration systems, and higher operating costs than if particles are captured at the source.

Local exhaust units should be placed in an AIIR. The effective operation of these units requires that staff know how to set up, use, and maintain them. Respiratory protection for staff is recommended, at least an N-95 respirator.

There are two basic types of local exhaust devices: complete enclosures and partial enclosures.

Complete Enclosures (Booths and Tents)

A fully enclosed booth or tent is the preferred type of local exhaust device. These devices physically separate the patient from others during sputum induction. Air from booths and tents is usually HEPA-filtered and discharged back into the room, but can also be exhausted outdoors. Some booths and tents can be easily assembled, dismantled, folded, and stored. Others are more difficult to assemble and disassemble, requiring greater installation time and effort.

Booths typically have rigid walls and are less portable than tents and partial enclosures. Some units require assembly in the room, while others come already assembled and can be used immediately.

Tents have flexible walls with rigid frames. They require some minor assembly prior to use and disassembly prior to storage.

Partial Enclosures (Hoods)

Partial enclosures are hoods that do not fully enclose the patient. These devices are open on one side, where the patient sits. Air is drawn across the patient's breathing zone, then HEPA-filtered and discharged back into the room. Some units discharge exhaust air directly outdoors.

Patients must be instructed to sit as far as possible inside the hood opening when coughing. The hood should maintain an air velocity of at least 200 feet per minute (FPM) at the patient's breathing zone to capture droplet nuclei. Air currents from open windows and doors or people moving about the room, can adversely impact the effectiveness of these devices. Partial enclosures are commonly mounted on carts that can be moved to any room for sputum induction procedures.

Since partial enclosures do not physically separate the patient from others, these devices may not be as effective as fully enclosed units.

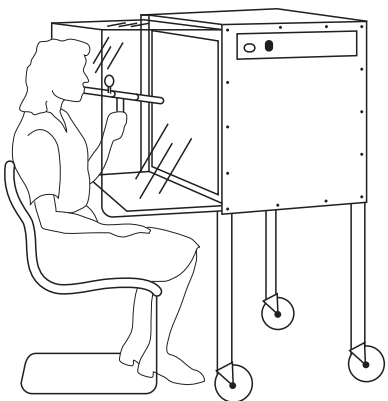
FIGURE 8A.

Complete Enclosure



FIGURE 8B.

Partial Enclosure



Sputum Induction Rooms

A room with special ventilation should be used for sputum induction to prevent infectious particles from escaping to other areas of the facility.

The CDC *Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Health-care Settings, 2005* recommend that sputum induction rooms have the following characteristics:

- Negative pressure relative to adjacent areas
- Air change rate of at least 6 mechanical ACH for existing isolation and procedure rooms. However, the CDC Guidelines also recommend, “Whenever feasible, this airflow rate should be increased to ≥ 12 mechanical ACH by adjusting or modifying the ventilation system or should be increased to >12 equivalent ACH by supplementing with air-cleaning technologies (e.g., fixed or portable room air recirculation systems or UVGI systems)
- Air change rate of at least 12 ACH for new or renovated isolation and procedure rooms
- 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
- Air from the room should be exhausted directly outdoors, away from air-intake vents, persons, and animals. Exhaust ducts should be located away from areas (e.g., side-walks or windows) that can be opened. The CDC Guidelines allow for recirculation into the general ventilation system if unavoidable and the air is HEPA-filtered before recirculation. Local codes and regulations should be checked, as even HEPA-filtered air cannot be recirculated in many localities.

Local codes and regulations should be consulted to determine specific ventilation system requirements for your area. For example, Cal/OSHA, who require 12 ACH for sputum induction rooms, will not accept an air change rate of 6 ACH for this setting.

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

Air exhausted outdoors from complete enclosures, partial enclosures, and AIRs should be discharged at a safe location in accordance with local regulations. If this is not possible, the air removed from the room should be HEPA-filtered prior to being exhausted.

Maintaining Sputum Induction Devices and Rooms with HEPA Filters

The maintenance of partial and complete enclosures 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 local requirements. Some localities may require that staff 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 sputum induction device. This person should be trained in the basic principles of the unit’s operation, including recommended periodic checks.

Adequate time must elapse between patients to allow for the removal of >99% of airborne contaminants by the exhaust system.

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.

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).

Signage

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

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

The sign's message should be clear to non-English speaking individuals and children. One suggestion is a sign that combines a stop sign symbol with the message, "Do not enter, N-95 respirator required." A second sign should state, "Room will be safe to enter without a respirator at _____." The sign should state the clearance time period needed to attain 99% clearance of airborne particles in the room. This will make it easier for staff to determine when it is safe to enter the room.

Signs can be developed in-house or purchased from a company that specializes in medical signs and labels. Professionally made signs tend to be more readily noticed, and therefore are generally more effective. Sample signs are included in Appendix L starting on page 157.

Clearance Time Between Patients in Sputum Induction Rooms or Complete Enclosures

Adequate time must elapse between patients to allow for the removal of >99% of airborne contaminants by the exhaust system. Exhaust fans serving the rooms or enclosures must always be left on during the clearance period to remove the airborne particles. Staff entering before sufficient time has elapsed must wear a respirator.

Appendix G on page 150 contains a step-by-step worksheet to help determine the time required to achieve a removal efficiency of >99% in a room or enclosure.

The relatively small size of complete enclosures makes high air changes in these devices readily achievable. The manufacturer's instructions should be consulted for recommended clearance times for complete enclosures.

Verifying Negative Pressure in Rooms, Booths, and Tents

The CDC Guidelines recommend the confirmation of negative pressure through the use of manometer measurements, smoke tubes, or other reliable indicators. Confirmation should be done daily whenever a sputum induction room is used for high-risk procedures. Negative pressure in LEV devices, such as partial or complete enclosures, should also be verified daily. This testing can be done with tissue paper or incense sticks if the other instruments are not available.

To use smoke or incense, release the smoke parallel to the door about 2 inches in front of the gap under the closed door outside the room as shown in figure 9. The smoke should be observed moving under the door into the AIIR, or into the enclosure.

To use tissue paper, hold a thin strip of tissue parallel to the door outside the room, extending across the gap under the closed door. The tissue should be drawn towards the room by the airflow under the door. Tissue is not as sensitive to air movement as smoke or incense.

FIGURE 9.

Smoke Test with Incense



Respiratory Protection for Sputum Induction

In the absence of LEV, administrative and environmental controls will reduce, but not eliminate, the risk of exposure to *M. tuberculosis* in rooms used to perform sputum induction procedures on persons with suspected or known infectious TB. The third level of the TB control hierarchy is the use of respiratory protection. HCWs present during a high-risk procedure, such as sputum induction, must wear N-95 NIOSH-approved respirators unless the patient produces the sputum while isolated in a properly functioning LEV device. Since LEV devices capture infectious particles at their source, respirators are not required.

Staff entering a room or booth after sputum induction must wear respiratory protection until >99% of airborne contaminants have been removed from the air. This time period will vary depending on the size of the area, the number of ACH, and the estimated amount of air mixing. This same time period should be used when calculating the time interval that must pass before another patient can use the enclosure or room. See “Room Clearance Time Calculation Worksheet” in Appendix G on page 150 for a form to calculate clearance times.

Performing Sputum Induction

- Sputum induction on a person with suspected or known infectious TB is considered a high-risk procedure because it can expose HCWs to droplet nuclei containing *M. tuberculosis*. LEV devices should be used to capture airborne contaminants at or near their source so they do not enter the general air circulation
- If sputum induction is performed without LEV devices, the CDC Guidelines recommend a minimum of 6 ACH in the sputum induction room. However, at least 12 ACH are preferred, recommended for new/renovated construction, and may be required by local codes. The room air should be exhausted directly outdoors at least 25 feet away from air inlets and operable windows and doors. The room should be under negative pressure, which should be monitored daily when sputum induction procedures are being performed
- Partial LEV devices should be monitored daily to confirm airflow when being used for persons with suspected or known infectious TB
- Partial LEV devices should maintain an air velocity of at least 200 feet per minute at the patient's breathing zone. This velocity should be checked monthly
- Complete LEV enclosures should be monitored daily when being used for persons with suspected or known infectious TB to assure that the device is operating correctly
- Standard precautions must be followed in all patient care activities. Gloves must be worn when hand contact with blood or other potentially infectious materials is anticipated. Masks and eye protection must be worn if the face may be splashed, sprayed, or splattered with blood or other potentially infectious material. Gowns or aprons must be worn if clothing or skin may be splashed or splattered with blood or other potentially infectious material
- A properly fitted NIOSH-approved respirator must be worn by any employee who enters a sputum induction room or other complete enclosure during a cough-inducing procedure or before 99% of the airborne particles are removed from the space
- Disposable nebulizers, corrugated tubing, and mouthpiece are preferred. Reusable items must be washed and disinfected by:
 - Pasteurization (75°C water for 30 minutes) or
 - High-level disinfection with a glutaraldehyde product following manufacturer's label instructions
- Aseptic technique must be used when placing sterile water or hypertonic saline in the nebulizer chamber. While some ultrasonic devices have a tap water reservoir, only sterile solutions should be placed in the cups or nebulizers that produce the mist inhaled by the patient.
- Disposable tubing, cups, and tissues may be disposed of in regular trash containers. Only blood-containing body fluids, which may drip or splash, must be disposed of in special biohazard containers.

Equipment

- Aerosol generator/nebulizer
- Clear plastic zip-lock bag with biohazard label
- Corrugated aerosol tubing (disposable preferred)
- Cup of water
- Disinfectant (household bleach 1:10 dilution or tuberculocidal quaternary ammonium compound)
- Gloves
- Lab slip
- Mouthpiece (disposable preferred)
- Respirator (N-95 for HCW)
- Sterile sputum collection container
- Sterile water or sterile hypertonic saline
- Surgical mask (for patient)
- Tissues

TABLE 8.

Step-by-step Guide to Performing Sputum Induction

PROCEDURE	KEY POINTS
<p>1. Explain the procedure to the patient</p>	<ul style="list-style-type: none"> • Purpose of procedure • Disinfection or disposal of equipment after patient use • When results will be available • How to use the nebulizer • How to open and expectorate into sputum container • How to place container in plastic bag • How to notify nurse if assistance is needed or when procedure is completed • Importance of staying in the room or booth until coughing has stopped • Importance of replacing surgical mask before leaving room or booth (if appropriate)
<p>2. Instruct patient in sputum induction</p>	<ul style="list-style-type: none"> • Remind patient to not begin the sputum induction procedure until staff member has left the room and closed door (where applicable) • Rinse mouth or drink water prior to beginning procedure • Inhale mist with deep breaths • Cough vigorously if spontaneous coughing does not occur. Cover mouth with tissue when coughing, unless expectorating into a jar • Continue attempts until 5-10 ml of sputum have been obtained. (Show patient how much is needed on specimen container.) Confirm quantity of sputum with your testing laboratory
<p>3. Prepare nebulizer for patient use</p>	<ul style="list-style-type: none"> • Two types of nebulizers are commonly used for sputum induction: <ul style="list-style-type: none"> • Compressor devices that create an aerosol with compressed air • Ultrasonic devices that use sound waves in a tap water reservoir to create aerosol • Test nebulizer to ensure that adequate mist is produced
<p>4. Ensure patient has all necessary equipment and understands all instructions</p>	<ul style="list-style-type: none"> • Patient should remain in booth or room after procedure begins • Turn on LEV and/or verify that air is flowing into device or room (room or device is at negative pressure)

PROCEDURE	KEY POINTS
<p>5. Patient must be observed at all times during the procedure</p>	<ul style="list-style-type: none"> • Watch carefully for signs of respiratory distress and ensure that patient does not leave the room until coughing has stopped • A view window in the door should be provided to monitor the patient
<p>6. Wear properly fitted, NIOSH-approved respirator if entering or remaining in sputum induction room</p>	<ul style="list-style-type: none"> • Infectious droplet nuclei may be dispersed into the air during the procedure • Staff standing outside properly functioning local exhaust booth or AIIR do not need to wear respirators
<p>7. Ensure that patient remains in the room/enclosure until coughing has stopped</p>	<ul style="list-style-type: none"> • Contain infectious particles in the room/enclosure
<p>8. If it is necessary for the patient to leave before coughing has stopped, ensure patient is masked</p>	<ul style="list-style-type: none"> • Prevent dispersion of infectious particles
<p>9. If sputum induction is performed on a suspected or confirmed infectious TB patient, the patient should be masked continuously when not in the LEV device or sputum induction room</p>	<ul style="list-style-type: none"> • Prevent dispersion of infectious particles
<p>10. Ensure that door is closed after patient completes the procedure and leaves the room or complete enclosure</p>	<ul style="list-style-type: none"> • Prevent contaminated air from escaping into the corridor (if room is used)
<p>11. Place a sign on the door indicating when the room will be safe to enter</p>	<ul style="list-style-type: none"> • Adequate time must be allowed for removal of at least 99% of airborne contaminants. This time period will vary, depending on the amount of air exhausted from the room, room air mixing, and the size of the room (see Appendix G on page 150)
<p>12. Prepare room for next patient</p>	<ul style="list-style-type: none"> • Wait required time for room to clear of infectious airborne particles (see #11) or wear properly-fitted, NIOSH-approved respirator when entering room • Remove and discard disposable items. If reusable components are used, soak in detergent or enzyme solution to prevent drying of secretions • Wipe counter with approved disinfectant between procedures and at the end of the day. If preferred, an imperviously-backed absorbent paper may be placed on counter and changed between patients

TABLE 9.

Summary of Sputum Induction Environmental Controls — Advantages & Disadvantages

TYPE OF CONTROL	ADVANTAGES	DISADVANTAGES
<p>Complete Enclosure</p> <p>Booth or Tent</p>	<ul style="list-style-type: none"> • Complete physical separation between patient and staff • Provides highest degree of safety for staff • Airborne particles quickly captured due to high air-change rates. Short airborne particle clearance times (vs. sputum induction room) • Can be moved to accommodate room function changes • Tents can be folded for compact storage • Tents are more portable than booths 	<ul style="list-style-type: none"> • Cost is higher than partial enclosures • Requires routine maintenance such as changing the HEPA filter and pre-filter • Tents require some assembly prior to use • Booths are not as portable as partial hoods
<p>Partial Enclosures</p> <p>Partial hood is enclosed on all sides except side where patient sits</p>	<ul style="list-style-type: none"> • Provides a high degree of safety for staff • Commercially available devices are equipped with HEPA filters (do not require special exhaust systems) • Cost is relatively low compared to complete enclosures • Portable, small enough to be used at patient's bedside, and easy to store 	<ul style="list-style-type: none"> • Does not provide complete physical separation between patient and staff • Requires more supervision of patient than complete enclosures to ensure proper placement of patient • Air velocity (minimum 200 feet per minute) at the side of patient's head must be verified monthly • Requires routine maintenance such as changing the HEPA filter and pre-filter • Noise of operating unit may be annoying to patient
<p>Sputum Induction Rooms</p> <p>Room meeting all recommendations (see "Sputum Induction Rooms" on page 79) and/or requirements for AIIRs</p>	<ul style="list-style-type: none"> • Provides complete separation between staff and patients • If an AIIR is available, sputum induction can be done in this room with no additional ventilation equipment 	<ul style="list-style-type: none"> • Separate designated room required • If an AIIR is not available, these rooms require installation of dedicated exhaust systems or HEPA filtration systems prior to recirculation of air (local codes should be checked for requirements) • Airborne particle clearance times will be high due to lower ACH rates (vs. booths and tents) • Room ventilation system must be monitored to ensure proper operation • Operation can be affected by general building ventilation systems • Most expensive option if an existing AIIR is not available

Airborne Infection Isolation Rooms



AIRBORNE INFECTION ISOLATION ROOMS (AIIRS)

A properly designed and operating AIIR can be an effective infection control measure. Infectious airborne particles are contained within the room, and the concentration of these particles inside the room is reduced.

However, a badly designed and/or incorrectly operating AIIR can place HCWs and other patients at risk for TB infection and disease. In this situation, infectious particles may not be contained in the room, and/or their concentration inside the room may not be effectively reduced. Staff members who rely on such an AIIR may have a false sense of security.

The mechanical elements that make an AIIR effective will deteriorate over time, which may make the controls ineffective. For example, fans can break and ducts can become clogged with dust and lint. People who have not been trained in environmental controls may inadvertently adjust or alter the controls. An AIIR that was successfully tested after construction may not be operating correctly a month later. Hence, periodic and ongoing assessment of AIIRs is important.

This manual provides basic information about assessing and improving the design and operation of an AIIR. It also includes options to convert an existing patient room into an AIIR and information on guidelines and regulations covering AIIR environmental controls.

TB control in high-risk settings is commonly organized in a hierarchy: administrative (or work practice) controls are the most important, followed by environmental controls, and then respiratory protection. Although this section only addresses environmental controls, all three components should be in place for an effective TB control program.

Whenever an AIIR is used, written policies and procedures should be developed and implemented to address the administrative aspects of the AIIR. They should include:

- criteria for initiating and discontinuing isolation
- who has authority for initiating and discontinuing isolation
- isolation practices
- how often and by whom the policy and procedure is evaluated
- developing and implementing a written respiratory protection program is also required.

Designing a New State-of-the-Art AIIR

This section describes the requirements and guidelines to be considered when designing a new AIIR, either during new construction or during renovation.

Planning Stage

During the planning stages of a new construction or a remodel project, users often meet with architects to discuss various design elements. This enables the users to provide input to the design team. These discussions usually concentrate on the physical layout of the space. The mechanical elements are often left to the mechanical engineer's discretion.

Infection control coordinators and other appropriate managers should be included in this process. The infection control aspects of the mechanical system should be addressed so that the people relying on the controls understand this system.

Architects and mechanical engineers may not be aware of some infection control requirements. While engineers must comply with building codes to get approval for construction and occupancy, they may not be aware of CDC recommendations, or of federal or local OSHA requirements. However, architects and engineers should be familiar and comply with the most current AIA Guidelines for Design and Construction of Hospital and Health Care Facilities and ANSI/ASHRAE Standard for Ventilation for Acceptable Indoor Air Quality.

The mechanical design elements of a new hospital AIIR should, at a minimum, meet all local code requirements, as well as OSHA requirements, CDC recommendations, AIA Guidelines, and ANSI/ASHRAE Standards.

Architectural Considerations

Architecturally, an AIIR should meet all the detailed requirements for a single-patient room, including a dedicated adjacent bathroom.

Architectural design elements should also meet local code requirements. For example, California requirements include:

- Code minimum clearance around the bed
- Code minimum room area
- Windows operable only by use of tools or keys

To increase the effectiveness of negative pressure, the architectural elements should ensure that the AIIR suite is sealed, except for a half-inch high air gap under the door. Towards this end, the ceiling should be plaster/sheet rock rather than removable ceiling tiles, and lights should be surface-mounted. 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.

The location of the proposed AIIR should also be considered: areas prone to strong drafts, such as those near elevator banks or doorways, should be avoided if possible.

AIIR doors should be equipped with self-closing devices.

The mechanical design elements of a new hospital AIIR should, at a minimum, meet all local code requirements, as well as OSHA requirements, CDC recommendations, AIA Guidelines, and ANSI/ASHRAE Standards.

Determining the Correct Ventilation Rate

When designing the heating, ventilating, and air-conditioning (HVAC) elements of a building, the amount of air supplied to each room is usually selected on the basis of comfort concerns. Unless there are governing code requirements, the engineer will provide ventilation air as required to keep the space comfortable. This air quantity is usually less than the amount required for effective dilution and removal of infectious particles.

For many spaces in healthcare facilities, such as AIIRs, infection control concerns may be more important than comfort concerns. Engineers should increase the airflow rate accordingly. A straightforward way to increase the effectiveness of ventilation is to increase the amount of air moving through a space—in other words, to increase the ventilation rate.

A room's ventilation rate can be calculated if it has mechanical ventilation. The ventilation rate is usually expressed in air changes per hour (ACH). By calculating the ACH, the room ventilation rate can be compared to published standards, codes, and recommendations. It can also be used to estimate the length of time required to remove infectious particles.

One air change occurs in a room when a volume of air equal to the volume of the room is supplied and/or exhausted. The air change rate in ACH is the volume of air circulating every hour divided by the room volume. Appendix K (page 156) describes air change rates in more detail and demonstrates how to calculate the air change rate of a room that has mechanical ventilation and/or a HEPA filter unit.

It is recommended that AIIRs have an exhaust air ventilation rate of at least 12 ACH. This recommendation is consistent with the CDC Guidelines and meets all local requirements known to CNTC.

The ACH is the airflow per hour divided by room volume (see Appendix K). For AIIRs, the exhaust airflow should be calculated, rather than supply airflow. The ACH of the dedicated bathroom or anteroom, when present, should be calculated separately from that of the AIIR itself. In other words, only include exhaust air that is exhausted in the AIIR.

Variable Air Volume (VAV) Systems

Many mechanical systems do not provide a constant airflow rate. These are called variable air volume (VAV) systems. They are designed to continually vary the amount of cooling or heating air delivered to a room in response to the amount of cooling or heating required. Supply air varies between a fixed minimum and a fixed maximum using a VAV box installed in the ductwork. VAV systems are generally not found in hospitals, but are common in buildings that may include clinics.

The volume of air supplied to an AIIR should not vary. Therefore, if an AIIR is to be included in a building served by a VAV system, the box supplying air to the AIIR should be set to deliver constant airflow. The mechanical engineer will need to address comfort control of this room separately.

Locating Supply and Exhaust Ductwork and Outlets

The supply and exhaust location should be chosen to maximize air mixing and to optimize directional airflow from the staff member towards the patient. Exhaust should be removed near the possible contamination source.

The best arrangement is to supply air at the ceiling above the foot of the bed, and to exhaust air on the wall near the floor at the head of the bed (where the patient's head is likely to be).

The supply diffuser should be the louvered blade type, rather than the perforated face type. The diffuser neck size and blow pattern should be selected so that air is directed to all parts of the room. Locate the diffuser where the airflow is not obstructed by items such as surface-mounted light fixtures or a suspended television set.

The bottom of the exhaust grille should be located approximately 6 inches above the floor. Because the grille does not direct air, its face pattern is not as important as that of the diffuser. The vertical exhaust duct should be installed in the AIIR wall. An enlarged wall cavity will be required and should be coordinated with the architect. To reduce noise, dampers should be located at a point in the duct far from the outlet. The area in front of the exhaust grille should be kept clear of obstructions, such as furniture and supply carts.

The individual air ducts providing supply and exhaust air for the AIIR suite should have control dampers to adjust the airflow quantity. These dampers are usually manually operated, but may be automatic. To ensure access, the handles for the dampers should not be above the AIIR ceiling. They should be either accessible from above the corridor ceiling, or remote, tamper-proof handles should be provided in the ceiling or wall of the AIIR.

Maintaining Negative Pressure

As described previously (on page 26), negative pressure is achieved when exhaust air exceeds supply air and the room is well sealed except for a gap under the door.

The CDC Guidelines recommend a negative pressure differential of at least 0.01 inches of water gauge (" W.G.).

In practice, an offset this small can be inadequate. Negative pressure may not be consistently maintained if there are other external factors, such as fluctuating air currents caused by elevators, doors, or windows to the outside.

Because smoke may migrate into a room during a fire, building code officials are concerned with the amount of air drawn into a room under the door from a corridor. The amount of exhaust air offset from the corridor will need to comply with local codes, which may limit the maximum allowable offset. If the AIIR is equipped with an anteroom, this issue will not be as important.

CNTC recommends that the negative pressure differential across the AIIR door be approximately 0.03" W.G. In practice, this may require that the airflow offset be adjusted to more than 100 CFM after the room is built, but before it is occupied. Engineers should allow for this possibility in their designs.

AIRR with Dedicated Bathroom

Some AIIRs have a dedicated bathroom that is part of the AIIR suite and only for use by the isolated patient. Such AIIRs are more likely to be found in hospitals than in clinics. The advantage of the bathroom is that the patient will not have to open and close the door as often to leave the suite.

To contain odors, the AIIR bathroom should be at negative pressure with respect to the AIIR, where applicable. The bathroom ventilation should comply with local requirements. For example the California Mechanical Code (CMC) mandates an air change rate of 10 ACH, negative pressure, and direct exhaust to the outdoors for bathrooms. In general, an offset of 50 CFM is sufficient between the bathroom and the AIIR.

Both the AIIR and the combined AIIR and bathroom should be at negative pressure. In other words, not only must the total exhaust for the AIIR plus bathroom exceed the total supply for AIIR plus bathroom, but the AIIR exhaust should also exceed the AIIR supply. This is illustrated in the “Case Study: Dedicated Bathroom” on page 107.

Handling AIIR Exhaust

Exhaust air removed from AIIRs is likely to contain infectious particles. Consequently, this air should be discharged directly outside the building, where the particles can be diluted by outdoor air and killed by sunlight.

While not included as a minimum recommendation by the CDC Guidelines, the optimum type of exhaust system should serve only AIIR suites, i.e., a dedicated exhaust system. Where applicable, this exhaust system should also serve the dedicated AIIR bathroom and anteroom.

Over time, dust and lint can collect at exhaust grilles and in exhaust ducts. Also, seals at duct joints break down and leak. These two effects result in diminished exhaust airflow from the AIIR. To compensate, exhaust ducts should be oversized. AIIR exhaust ducts and fan systems should be sized for the expected airflow plus an extra 50%.

Labeling

Maintenance personnel and contractors often re-route ducts to accommodate new services. To help protect these workers from potentially contaminated AIIR exhaust, the exhaust ductwork should be permanently labeled. The label should read, “Caution—AIIR Exhaust,” or similar words to that effect. The labels should be attached, at most, 20 feet apart, and at all floor and wall penetrations.

Maintenance workers may also shut down the exhaust fan without realizing this will cause a loss of negative pressure. To avoid this possibility, a permanent warning sign should be posted on the fan at the electrical disconnect and at appropriate electrical panel breakers. The sign should read, “AIIR Exhaust Fan—Contact Infection Control Coordinator Before Turning Off Fan,” or have similar wording. The sign should also include the telephone number of the infection control coordinator and the room number(s) of the AIIR(s) exhausted by the fan.

Exhaust Discharge

The exhaust fan discharge should be located and designed to minimize the possibility that this air is inhaled by people who are outdoors or inside the building. Exhaust air should be

directed away from occupied areas (i.e., walkways) or openings into the building (i.e., windows or outside air intakes).

To promote dilution, the fan discharge should be directed vertically upward at a speed of at least 2,000 FPM. The discharge location should be at least 25 feet away from public areas or openings into a building.

If a suitable discharge location is unavailable, then the exhaust can be disinfected using a HEPA filter (see page 42). In this case, a HEPA filter must be installed in the discharge duct upstream of the exhaust fan. This is not a desirable option, however, because it will be considerably more expensive to install, maintain, and operate than a simple exhaust fan assembly.

Installing a Permanent Room Pressure Monitor

After a new AIIR is constructed and before it is occupied, the mechanical contractor will adjust the airflow quantities as directed by the engineer to ensure that it operates as designed. However, mechanical systems do drift out of balance over time. It is important to regularly check that an AIIR is still operating under negative pressure; planning for this should be included in the initial mechanical design of the room. Room pressure monitors should be used as a supplement to daily visual checks when the room is in use.

The most reliable way to monitor negative pressure is to install a permanent electronic room pressure monitor as part of the construction project.

When properly selected and installed, a room pressure monitor can provide continuous qualitative and quantitative confirmation of negative pressure across a room boundary. This is in contrast to routine periodic smoke testing, which merely provides an indication of directional airflow at the moment of testing.

Continuous monitoring can provide instant notification if the pressurization fails or fluctuates during the day.

Most monitors consist of two main components: a wall-mounted panel and a sensor. The panel is usually mounted on the corridor wall just outside the AIIR suite and displays the pressure difference in units of " water gauge.

There are two common types of permanent pressure monitors: those that measure and display the actual air pressure difference between the AIIR and the reference space (direct type); and those that measure the velocity of air moving between the two spaces through a fixed opening and convert this to a pressure value (indirect). Both types require an electrical power connection at the wall panel. Either type is suitable for an AIIR, but indirect monitors generally provide a more accurate pressure reading.

Pressure differentials across room boundaries can be very small, often in the range of thousandths of an inch. For example, the CDC Guidelines recommend that negative pressure be at least ≥ 0.01 " of water gauge. Some devices that measure differential pressure are not accurate to this level. Before specifying or purchasing a room pressure monitor, make sure that the device is capable of accurately and reliably measuring a pressure difference this small.

Direct Room Pressure Monitor

To record a pressure differential directly, two readings are required: the air pressure in the room and the reference pressure in the corridor. A remote sensor to measure the room pressure is installed in the negative pressure room wall or ceiling. Another sensor measures the air pressure in the corridor. The difference in these two pressure values is the relative room pressurization, which is displayed on the panel.

If there is an anteroom between the AIIR and the corridor, the pressure differential to be measured is the one between the AIIR and the anteroom. In this case, both measurement points are remote from the corridor panel. If there is no anteroom, the reference pressure can be measured right at the panel, and only one remote reading is required.

The location of the remote sensors will affect the accuracy of the measurement. They should be installed as close as possible to the AIIR door, but away from drafts.

Tubing will need to be run from the panel to the sensor(s). For new construction, this tubing will typically be run out of sight inside wall cavities and above the ceiling. Air tubing is usually rigid plastic, but can be made of copper.

Indirect Room Pressure Monitor

The sensing component of a velocity-reading room pressure monitor consists of an air tube with an interior velocity-sensing element. The tube is installed in the wall between the AIIR and the anteroom or corridor. An electrical device measures the air velocity and direction. This signal is run back to the wall panel, where it is converted to a pressure readout.

Again, care should be taken when installing the sensor. It should be located above or next to the door, but away from the influence of drafts. To help shield the sensors, louvered cover plates are usually provided on both sides of the wall.

The signal between the sensor and the wall panel is a low voltage electrical signal instead of the air tubing used in direct pressure monitors.

Alarm(s) and Controls

In addition to providing a continuous readout of the pressure difference, the wall panel should include an audible and visual alarm to warn staff when pressurization is lost.

The alarm will sound when the measured room pressurization drifts to less than the monitor's reference pressure value. Reference pressure values are programmed into the unit by an engineer or trained staff member. It will be a value between the steady state pressure differential maintained by the room and zero (neutral pressure).

For example, in a room with a steady state pressure differential of minus 0.03" W.G., the alarm could be programmed to activate when the pressure differential falls to minus 0.001" W.G.. Minus 0.001" W.G. is the reference pressure value.

The wall panel should also allow staff to program a built-in time delay between loss of pressurization and alarm activation. The time delay will allow staff a sufficient interval to routinely enter and leave the room without setting off the alarm. A typical time delay is 45 seconds.

The audible alarm is usually a beeping sound, which will stop when negative pressure is restored or when a "mute" button on the panel is pressed.

The visual alarm usually consists of a red warning light. Most wall panels also have a green "normal" or "safe" light, which indicates that the monitor is operating and negative pres-

sure is within programmed parameters. Unlike the audible alarm, the visual alarm will not reset when the “mute” button is pressed. After negative pressure is restored, the lights will either automatically reset or the “reset” button must be pressed, depending on the brand of the monitor. In case no one was present, the latter option will indicate that negative pressure was temporarily lost.

Remote Alarm

In addition to the alarm included on the wall panel, most room pressure monitors include an extra identical signal that allows a “safe” or “alarm” signal to be sent from the wall panel to a remote location. Common locations for this remote alarm are the nurses’ station, the engineering department, and the central switchboard.

It is usually possible to connect the alarm signals from a number of AIR monitors to a remote alarm panel. In California, for example, the hospital building codes require that AIRs be equipped with an alarm that annunciates at the room *and* at a nurses’ station or other suitable location.

Other Optional Features

There are a number of room pressure monitors available with additional options. Examples of such options include: an amber “warning” light that illuminates during the time delay when negative pressure is lost; adjustment for use in positive pressure rooms; and remote control of a fan or damper to maintain and control negative pressure.

Commissioning and Staff Training

The monitor installer’s responsibilities should include verifying the operation of the sensor. A detailed checklist is included as Appendix C on page 145. The following should be completed before the room is used to isolate suspected or confirmed infectious TB patients:

- 1. Verify that the alarm works.** Hold the room door open. After the time delay, the audible and visual alarm should annunciate. The alarm should reset after the “mute” or “reset” button is pressed and/or the door is closed again.
- 2. Verify that the monitor is correctly reading the pressure.** While the door is held open, the pressure reading should be at or near 0” water gauge.
- 3. Instruct staff on monitor usage.** The floor staff that depend on the monitor for their safety should feel comfortable using it. They should receive detailed instructions on how the monitor works and how it is used.

The checklist should be completed for each AIR monitor in the facility. A copy of the completed steps in the checklist should be kept in the Policies and Procedures binder for that department.

Ongoing Monitor Checks

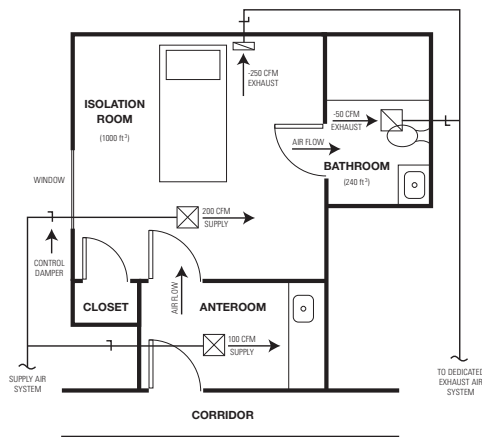
To validate the continuous pressure monitor, negative pressure should be verified monthly with smoke tube or similar testing (see page 81). Daily verification is required when the room is in use or if there are no alarms on the pressure monitor. The results should be recorded. Space for this is included in the checklist.

Most manufacturers recommend that each monitor be recalibrated annually. The recalibration procedure will depend on the monitor type and should be available from the manufacturer. CNTC recommends that the step in the new monitor checklist be completed at the same time.

To validate the continuous pressure monitor, negative pressure should be verified monthly with smoke tube or similar testing.

FIGURE 10.

AIIR with Anteroom



Providing an Anteroom

An anteroom should be provided between the AIIR and the corridor. This will help prevent infectious particles in the AIIR from escaping into the corridor.

When an AIIR door is open, negative pressure is immediately lost. If there is an anteroom that is negative to the corridor, then the overall integrity of the suite is maintained. The anteroom provides an “air lock” between the AIIR and the rest of the facility.

An anteroom should be at positive pressure with respect to the AIIR, and at either neutral or negative pressure with respect to the corridor. Because smoke may migrate from the corridor if there is a fire, some codes and regulations mandate that the anteroom be neutral to the corridor, rather than negative. However, in practice this is very difficult to accomplish. It is not easy to balance airflow to a space so that it will be positive at one door and neutral at the other. Furthermore, air pressure in the corridor will vary due to external factors such as elevators and corridor doors to the outside.

Local codes should be consulted regarding other design elements of anterooms for AIIRs. For example, California requirements include:

- Provision of a sink, cabinets, and work counter
- Provision of a view window in the door to the AIIR
- Alignment of door to corridor with door to AIIR, or provision of a second locked and gasketed entry for gurney
- Maximum of two AIIRs per anteroom.

Assessing an Existing AIIR

This section covers the steps that should be taken to evaluate the effectiveness of an existing AIIR.

Failed environmental controls in AIIRs have been identified as factors in documented hospital TB outbreaks. Regularly scheduled assessment of environmental controls will identify and may help prevent such failures.

Items that should be checked include the exhaust and supply airflow rate, negative pressure, and exhaust duct termination location.

Ventilation

To determine the ACH of a space, you will need to measure the airflow and calculate the room volume. See Appendix K on page 156.

The airflow measurements and calculations should be performed by a certified testing and balancing agency or by in-house engineering staff.

Airflow Measurement

The airflow of a room is usually measured at the individual registers and diffusers using a balometer. This is a device that consists of a hood, a velocity sensor, and a microprocessor.

The hood is placed over a register or diffuser and should completely cover the air outlet. The top of the hood should have a foam gasket that establishes a good seal between the hood and the ceiling or wall around the outlet.

The hood directs all air entering or leaving the outlet past a velocity-sensing grid. The area of the grid is fixed. Therefore, the microprocessor can calculate and display the quantity of air being exhausted or supplied by the air outlet. Balometers usually provide an airflow reading in cubic feet of air per minute (CFM).

The standard size of a balometer hood outlet is 24" X 24", although adapters are provided to adjust the hood size. This size hood can be used to measure the airflow of any outlet equal to or smaller than this (e.g., 12" X 24" or 18" X 18" diffuser). For other size outlets, such as a 36" X 6" slot diffuser, the hood size on the balometer may need to be changed.

There may not be sufficient space in front of some outlets to place the balometer. In this case, the airflow should be measured by a pitot traverse in the duct that serves the outlet.

A pitot traverse is a specialized measurement that requires access above the ceiling. Air velocity is measured at a number of sample locations inside the duct. Airflow is calculated based on these velocity readings and the area of the duct cross-section. However, pitot traverses are not as accurate as balometers.

If a dedicated exhaust fan serves the AIIR suite, it may be possible to estimate the airflow at the room by measuring the airflow at this fan. Because of duct leakage, this measurement will not be as accurate as one taken at or near the outlet. Inadequately sealed duct joints can result in extra air being sucked into the duct between the AIIR exhaust grille and the fan, which would result in an overestimate of airflow in the room. To compensate for this, an allowance of at least 10% should be made. This allowance should be increased in the case of a long duct run.

If room airflow is found to be inadequate, i.e., less than 12 ACH, it should be increased. For information on modifying existing room airflow, see "Upgrading or Converting an Existing Room" on page 101.

Air Mixing and Directional Airflow

After establishing the airflow, the next step is to evaluate how effectively this air is used in the AIIR. This assessment is not as straightforward as calculating the airflow rate because there is no clearly defined numerical standard to meet.

Smoke testing can be used to visualize the direction of room air and to estimate how well air is mixing. Consequently, ventilation problems can be identified, such as undesirable directional airflow patterns and poor mixing.

Ideally, the clean supply air will be introduced near a HCW, while exhaust air will be removed near the patient. Good air mixing is confirmed by rapid dissipation of the test smoke in all parts of the room, which demonstrates that particles generated in the room are being diluted and removed.

If air mixing is not optimal due to short-circuiting or stagnation, the diffuser and/or register should be relocated or replaced. Either of these options will require the services of a consultant mechanical engineer. In the interim, a supplemental propeller-type fan can be placed in the AIIR to encourage air mixing. Such a fan is not recommended as a long-term solution because it may create uncomfortable drafts and be turned off by the patient.

Regularly scheduled assessment of environmental controls will identify and may help prevent failures.

Exhaust Ductwork and Discharge

The engineering department staff at the facility should trace the path taken by the exhaust air duct after it leaves the AIIR. If applicable, they should also check the exhaust duct serving the bathroom and anteroom. For the record, a set of drawings should be generated (or an existing design set marked) to show the ductwork and fan.

The exhaust ductwork and fan should also be checked for optimum performance. Conditions that should be corrected include: excess air leakage at duct joints, damaged ductwork, incorrectly adjusted dampers, and fans in need of servicing.

Recirculating Air Systems

If air from an AIIR is returned to a recirculating ventilation system that does not include HEPA filtration, this room should no longer be used for isolation. Staff and patients in rooms served by this system may be exposed to *M. tuberculosis* from patients in isolation.

The risk of exposure from a recirculating mechanical system is affected by dilution of the return air with outside air and by the filter in the mechanical system. The risk is reduced as the percentage of outside air is increased and the efficiency of the filter is increased.

Filtration in hospital ventilation systems is usually better than in clinics because hospitals are typically covered by stricter building codes and have larger facilities and maintenance budgets.

Dedicated or Shared Exhaust System

The CDC Guidelines do not address the issue of dedicated exhaust air systems serving AIIRs. However, in some jurisdictions this is mandated by the building code for new or renovated rooms. Because most building codes are not retroactive, it is usually acceptable for an existing AIIR to combine the exhaust air with other exhaust systems, such as those serving bathrooms.

Duct and Fan Labeling

If the existing exhaust system is dedicated, make sure that the ductwork is labeled as recommended for a new AIIR (“Caution—AIIR Exhaust”). For a shared system, only the ductwork between the AIIR and the main exhaust trunk needs to be labeled.

The exhaust fan, whether dedicated or shared, should have a warning label as recommended for a new system (“AIIR Exhaust Fan—Contact Infection Control Coordinator Before Turning Off Fan”).

See “Handling AIIR Exhaust” on page 92, for additional information on labeling of exhaust ductwork and fans.

Verifying Negative Pressure

Negative pressure is the easiest characteristic of an AIIR to check. Several methods are available to qualitatively assess negative air pressure, including smoke tube testing and tissue testing.

If the AIIR is operating as intended, there will be an air current moving into the room under the door. The existence and direction of this current should be verified.

Smoke Tube Test

Smoke tube testing helps visualize the current near a room door. In this simple procedure, smoke is released near the air gap under an AIIR door. See “Smoke Tube Testing Method for AIIRs” on page 106 for more detailed instructions.

Commercially available smoke-generating kits produce a visible cloud, which usually consists of water and acid. The quantity of smoke typically issued from the tube is minimal and is undetectable at short distances from the tube. Because inhalation of this smoke in concentrated form can cause irritation, care should be taken not to expose workers or patients until the smoke has been diluted. The amount of smoke used should not be excessive.

There are many different types of easy-to-use smoke-generating kits available from safety supply companies. A typical design is the disposable self-contained puff bottle. Another common design is the disposable smoke tube, which attaches to a rubber bulb that acts like a bellows.

If commercial smoke-generating devices are not available, incense sticks can be used. CNTC recommends that two sticks be used side-by-side. However, incense smoke does have a strong odor, and is not as visible or controllable as commercial smoke.

Tissue Test

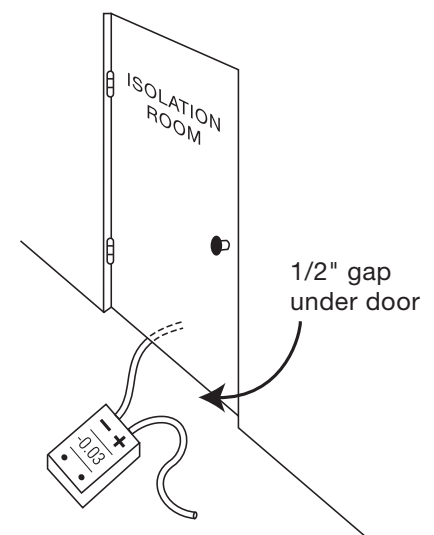
If smoke-generating devices are not available, or if the room is occupied by a patient who may be vulnerable to the irritant properties of smoke, a thin strip of tissue can be used to determine whether a room is at negative, neutral, or positive pressure. A thin strip of tissue should be held parallel to the gap between the floor and bottom of the door. The direction of the tissue's movement will indicate the direction of air movement.

Manometer

Relative room pressurization can also be verified using a handheld pressure gauge or manometer, which is similar to a direct room pressure monitor, except it is portable. A length of rubber tubing is attached to each of the two ports on the manometer. The manometer displays " W.G., the pressure difference between the two spaces at the termination of the tubes. If one of the tubes is threaded under the door into the AIIR and the other is in the hallway, the manometer will indicate the pressure difference between the two spaces. A negative symbol verifies that the room is at negative pressure.

FIGURE 11.

Manometer



Velometer

Air speed is measured by a velometer, usually in units of feet per minute (FPM). These devices can be placed near the gap under the AIIR door to measure the speed of the airstream. Velometers are available in a number of different configurations. Many only indicate air speed regardless of air direction. For instance, some velometers indicate how fast the air is moving, but not whether the air is entering or leaving the room. However, there are models available that can also be used to determine airflow direction.

Repeat Test

All of these tests to verify negative pressure should be conducted at least three times until the results are consistent.

Validate Existing Monitor

If the existing room is equipped with a permanent room pressure monitor, one of the above tests should be performed to confirm negative pressure and to validate the monitor. Also, the AIIR Pressure Monitor Checklist (Appendix C on page 145) should be completed for the monitor.

Measuring Negative Pressure

After negative pressure has been verified, it should be measured. Table 10 summarizes three ways to quantify negative pressure. The corresponding units of measurement and the measuring device for each method are also shown.

TABLE 10.

How to Quantify Negative Pressure

PARAMETER	UNITS OF MEASUREMENT	MEASURING DEVICE
pressure difference	inches of water gauge (" W.G.)	manometer
speed of air under the door	feet per minute (FPM)	velometer
exhaust air offset	cubic feet per minute (CFM)	balometer

Upgrading or Converting an Existing Room

This section covers methods of improving the ventilation characteristics of an existing room to make it more effective for AIIR.

Previous sections have outlined recommendations for a new state-of-the-art AIIR and have shown how to assess an existing room to see how it compares with these recommendations. This section describes how to correct deficiencies found during the assessment.

The methods outlined below could also be used to convert an existing patient room into an AIIR.

- **Disconnect Recirculating Air System**

The first step is to ensure that air from the room is not inadequately filtered and recirculated to other areas. The air removed from the room must either be exhausted outdoors to a safe location or HEPA-filtered. If room exhaust is currently connected to a recirculating air system that does not include a HEPA filter, it should be disconnected from this system.

- **Install HEPA Filter in Existing Return Air System**

Theoretically, another safe option for correcting a recirculating system is to replace the existing filter with a HEPA filter. However, CNTC does not recommend this. A HEPA filter is a specialized piece of equipment that should only be used in a ventilation system specifically designed to accommodate it. HEPA filters are physically larger than most filters and require larger fans to overcome increased resistance to airflow.

- **Two Upgrade/Conversion Options**

There are two basic approaches to upgrading or creating an AIIR. The preferred option is to adjust the building ventilation system to create a permanent AIIR. A temporary solution is to add a recirculating HEPA filter unit to supplement, or even replace, the building ventilation system.

Regardless of the upgrade option selected, steps must be taken to reduce unwanted air leakage from the room, i.e., the room must be sealed.

- **Negative Pressure**

As explained previously, the negative pressure value will depend on two factors: how much more air is exhausted than supplied (i.e., the offset); and how well the room is sealed. In general, when converting or upgrading a room, the negative pressure value will not be as high as that attainable for new construction because there is less control over the architectural elements.

CNTC recommends that the negative pressure value should be at least minus 0.006" W.G. for upgraded or converted AIIRs.

This is more stringent than the CDC Guidelines, which recommend ≥ 0.01 " of water gauge as a minimum negative pressure value.

Sealing the Room

A room in which exhaust exceeds supply will not necessarily be at negative pressure with respect to the corridor; it is not unusual to have such a room at positive pressure.

For example, a room could have exhaust air from the central system exceeding supply by 100 CFM. Assume this room has leaky windows and some holes in the ceiling tiles. If it is windy outdoors, 75 CFM could enter through the leaks around the windows, and another 75 CFM could enter through the ceiling. Now the air being introduced to the room exceeds exhaust by 50 CFM. Smoke testing at the door would probably indicate positive pressurization.

When upgrading an existing AIIR or converting an existing room to operate at negative pressure, it is important to make the best use of the excess exhaust by sealing the room as tightly as possible. For a given exhaust air offset, the better the room is sealed, the greater the amount of air that will flow into the room under the door and the greater the negative pressure.

The following are some examples of steps that can be taken to improve a room's airtightness:

- Apply gasketing at sides and top of room door
- Caulk around windowpanes and around window frames
- Apply gasketing at the connection of the ceiling and the walls
- Apply gasketing around electrical boxes
- Replace acoustic ceiling tiles with non-porous vinyl tiles and apply gasketing at tile connection to ceiling grid
- Replace recessed light fixtures with surface-mounted fixtures

Adjusting the Ventilation System

If the room is not currently connected to an exhaust system, it should be either connected to an existing exhaust system or a new system should be installed. Consult with the building facilities department staff, which will probably hire a mechanical engineering consultant to design this work and oversee the construction.

Connect to Existing Exhaust System or Add New One

If there is an accessible exhaust air system nearby, such as a toilet exhaust system, with sufficient capacity, it may be possible to make a new exhaust connection to the existing return register. Otherwise, a new exhaust air fan and ductwork system should be installed.

New exhaust ducts, and new or existing exhaust fans serving AIIRs, should have the same warning labels used for new AIIRs.

Rebalance Existing Mechanical System

To increase room airflow and/or create, or increase, negative pressure, the existing ventilation system needs to be adjusted to exhaust more air. The supply air quantity may also need to be increased. Airflow is varied using dampers.

Adjust Dampers

Dampers are devices that control the flow of air in ducts, similar to the way valves control the flow of fluids in pipes. Dampers, usually located above the ceiling, should only be adjusted by a facility engineer or certified air balance contractor. To increase airflow, the dampers in the ducts serving the room should be opened wider. It usually takes an air balancer two or three adjustments to obtain the desired airflow.

The exhaust airflow rate should be at least 12 ACH. For existing rooms, this recommendation is more restrictive than the CDC Guidelines, which accept an air change rate of 6 ACH. However, 6 ACH will not satisfy some local regulatory agencies, including Cal/OSHA and the Office of Statewide Health Planning and Development (OSHPD) in California. Twelve (12) ACH, which meets all local requirements known to CNTC, is readily achievable using HEPA filter units.

The supply should be approximately 100 CFM less than exhaust. Depending on how well the room is sealed, more air may need to be exhausted in order to achieve a larger pressure differential.

Most rooms do not have a dedicated ventilation system. They are connected to a fan system that serves other rooms in the building. Before and after adjusting the AIRR airflow, the air balancer should measure the airflow in some of these other spaces to make sure that the AIRR adjustments do not have an adverse effect on ventilation elsewhere.

Adding a Recirculating HEPA Filter Unit

It may not be possible or practical to connect to an existing exhaust air system, or to install a new one. It is possible to create a temporary and less expensive AIRR. This can be done using a recirculating HEPA filter unit. There are two basic ways to use these units in AIRRs. They can be used to increase only the ventilation rate of a room without affecting room pressurization. Or they can be used to simultaneously:

- Increase the ventilation rate,
- Create or increase negative pressure, and
- Replace the need for additional exhaust.

HEPA Filter Units

HEPA filter units are readily available electrical devices that consist primarily of a fan, a HEPA filter, and a prefilter. They also include controls, such as a three-speed switch, and possibly an indicator light to indicate when the filter needs to be changed.

HEPA filter units are available in a number of different physical configurations, including wall- and ceiling-mounted types. The most popular configuration is the floor-standing, portable type.

Wall- or ceiling-mounted units are less obtrusive and do not take up floor space. They are also less likely to be tampered with by staff and patients. However, floor-mounted units are more portable and are easier to service. Regulatory bodies, such as OSHPD in California, may require that a structural engineer oversee the design and construction of the support system for a wall-mounted or ceiling-mounted HEPA filter unit.

Increase Ventilation Rate

If negative pressure in the AIR is satisfactory, but the ventilation rate is low, a HEPA filter can be used to supplement the room airflow rate. The effective ventilation rate of the room is the sum of the central system airflow and the HEPA filter unit airflow.

Sizing HEPA Filter Units

The size of the unit selected should be based on the additional airflow (in CFM) required to achieve the desired ACH in your room. To determine the additional airflow:

- Measure the actual CFM exhausted from the room, and
- Calculate the CFM required to achieve the desired ACH. The HEPA filter unit should be sized to make up the difference.

Most HEPA filter units allow staff to adjust the amount of air delivered by means of a switch. Common examples of switches include those with three fixed settings and those that allow any setting between the maximum and minimum. Manufacturers' catalogs generally list a CFM delivered by the unit at each of the three speeds, or at the high and low setting.

In practice, people usually turn down the HEPA filter unit switch and operate the units at or near the low setting. This is because the units can be very noisy and/or drafty when the fan is at, or near, full speed.

CNTC recommends that HEPA filter units be selected based on the airflow at or near the low speed.

These units may deliver less than the manufacturers' listed airflow, and output of the units may decrease as the filters load up. To compensate for this, it is recommended that the unit selected have a listed capacity that is 25% more than required. The marginal cost of selecting a unit with more capacity is usually not significant, compared to the initial cost of the unit.

To summarize, it is recommended that a unit is selected that can deliver 25% more CFM than required at or near the low speed fan setting.

For example, if 150 CFM is measured, and 220 CFM is required to achieve 12 ACH, then the required additional airflow is 70 CFM. If a HEPA filter unit is used to increase airflow, then 25% should be added to 70 CFM for a total of approximately 90 CFM. Therefore, a unit with a listed capacity of at least 90 CFM at or near the low fan speed setting should be selected.

Increase Ventilation Rate and Create or Increase Negative Pressure

If a sufficient portion of the discharge from a HEPA filter unit is ducted somewhere outside of the room, then the HEPA filter unit can create negative pressure and replace the need for any extra exhaust.

A HEPA filter unit supplements ventilation as follows:

- The effective exhaust air quantity is increased by an amount equal to the airflow of the HEPA filter unit (because this air is now being removed and droplet nuclei are removed by the filter)
- The effective supply is increased by an amount equal to the returned air quantity (HEPA unit airflow minus the amount discharged outside the room)
- The effective negative pressure offset is increased by an amount equal to the HEPA unit airflow discharged outside the room.

Theoretically, the technique described above could also be used to create negative pressure in a room that had no ventilation system. However, this is not recommended because the room would then have no outside air at all, only recirculated, HEPA-filtered air. Building codes mandate that fresh outdoor air be supplied to all occupied spaces that do not have an operable window.

Monitoring the Environmental Controls

Once the AIIR upgrade has been completed, procedures to monitor the environmental controls must be implemented. This is essential to ensure that staff will be alerted if the controls fail.

The two items that need to be monitored are the airflow rates and the room pressurization.

Airflow Rate Monitoring

The airflow rates are monitored by measuring with a balometer to ensure that the rates have not deviated more than about 5% from the initial values.

Airflow rates should be measured and air change rates calculated at least once a year.

Room Pressurization Monitoring

Room pressurization should be continuously monitored to ensure that the room remains under negative pressure.

The CDC Guidelines recommend that room pressurization be confirmed daily while the room is occupied by a suspected or known infectious TB patient, and at least once a month at other times.

These tests can be done with smoke or a telltale device, such as a tissue. However, it is recommended that each AIIR be equipped with a permanent room pressure monitor.

Documentation

Records should be kept of all AIIR environmental control tests and measurements. Local regulatory agencies may require that these records be kept for a number of years. For example, Cal/OSHA requires that records be kept for a minimum of five years.

Smoke Trail (or Smoke Tube) Testing Method for Negative Pressure AIIRs

Smoke from a smoke tube can be used to observe airflow between areas or airflow patterns within an area. Smoke tube testing must be performed outside the room with the door closed.

To check the negative pressure in a room, hold the smoke tube near the bottom of the door and approximately 2 inches in front of the door, or at the face of a grille or other door opening. Generate a small amount of smoke by gently squeezing the bulb.

The smoke tube should be held parallel to the door, and the smoke should be issued slowly from the tube to ensure that the velocity of the smoke does not overpower the air velocity. The smoke will travel in the direction of airflow.

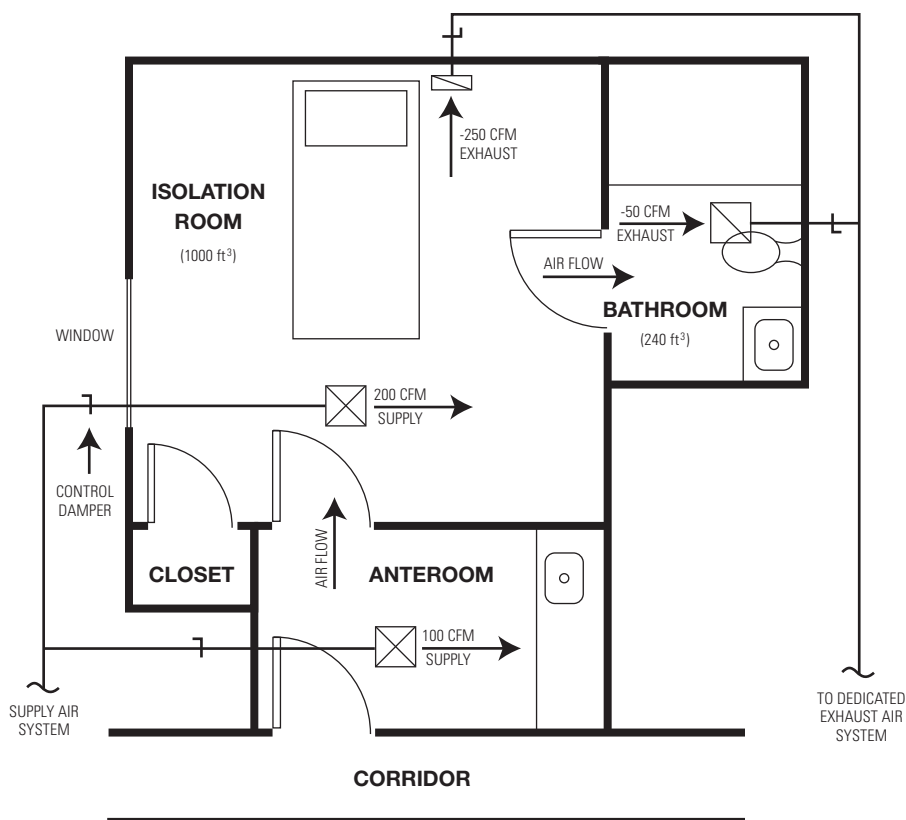
If the room is at negative pressure, the smoke will travel under the door and into the room (e.g., from higher to lower pressure). If the room is not at negative pressure, the smoke will be blown outward or will remain stationary.

If there is an anteroom, release smoke at the inner door undercut, with both anteroom doors shut.

In addition to a pedestrian entry, some AIIRs or areas are accessed through a wider wheeled-bed stretcher door. Release smoke at all door entrances to AIIRs or areas.

If room air cleaners are being used in the room, they should be running during the test.

Because the smoke is irritating if inhaled, care should be taken to prevent direct inhalation from the smoke tube. However, the quantity of smoke issued from the tube is minimal and is not detectable at short distances from the tube.



Dedicated Bathroom

Background

The setting is an AIIR with a dedicated bathroom. Supply air to the AIIR is 200 CFM.

The Options

The AIIR volume is approximately 1,000 cubic feet, so the supply air change rate is 12 ACH.

You are installing a new exhaust fan with a capacity of 300 CFM that will serve only the AIIR suite. Local codes mandate a minimum of 10 ACH in bathrooms. The bathroom volume is approximately 240 cubic feet, so a minimum of 40 CFM exhaust is required.

How should the 300 CFM of exhaust air be split up between the bathroom and the AIIR?

Should 250 CFM be exhausted in the AIIR and 50 CFM in the bathroom?

Or should 200 CFM be exhausted in the AIIR and the remaining 100 CFM in the bathroom?

The Best Option

The preferred arrangement is to exhaust 250 CFM at the AIIR and 50 CFM at the bathroom (as shown in the above diagram), rather than 200 CFM at the AIIR and 100 CFM at the bathroom.

The Reason

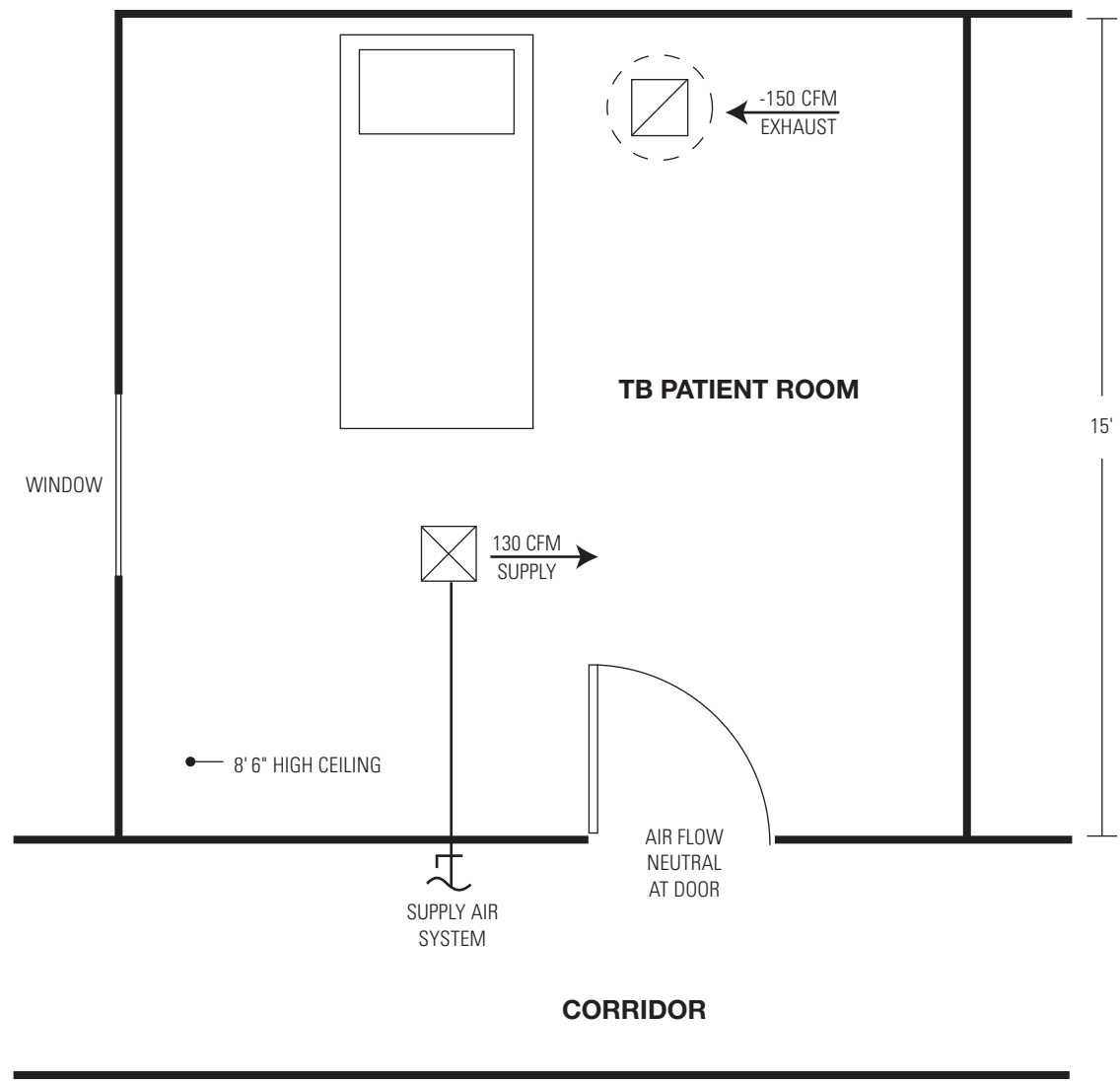
Each arrangement will result in both a 100 CFM offset across the AIIR door and an equal volume of air moving through the AIIR. But only the preferred option provides more exhaust than supply in the AIIR itself, resulting in negative pressure, and increases airflow towards the head of the bed.

Also, code officials may require that direct exhaust from the AIIR exceed direct supply air. The latter option would result in a room with supply equal to exhaust.

CASE STUDY



TB CLINIC HOURS	
Monday	1:00 - 4:30
Tuesday	9:00 - 6:30
Wednesday	Closed
Thursday	9:00 - 6:30
Friday	8:00 - 10:30
CLOSED WEEKENDS	



AIRR: Part One

Background

Routine annual tuberculin skin testing revealed that two employees in a small, single-story county clinic converted their TSTs over the last year. Both employees were clerks in the billing department; neither had patient contact.

Assessment

The clinic manager, Janet, was concerned because the billing department shares a corridor with the room used to isolate TB patients. *M. tuberculosis* transmission may have occurred due to failed environmental controls in the AIIR.

Janet tested pressurization of the AIIR with a piece of tissue. The room clearly had positive pressure with respect to the corridor. She felt airflow from the supply grille. Even after wiping off the considerable amount of dust on the exhaust grille, there was no air movement. A tissue held against the grille was not pulled toward the grille as would be expected.

The county facilities department sent out a maintenance engineer, Cynthia, to investigate further.

Cynthia remembered converting this room into an AIIR for TB patients about 2 years ago. She had sealed the room and installed a small, dedicated rooftop exhaust fan. But now she found that dust and lint had accumulated on the fan motor, causing the motor to overheat and burn out. She cleaned the fan and ductwork and replaced the motor. Exhaust was now measured and found to be 150 CFM.

Room air supply was 130 CFM, which was 20 CFM less than exhaust. However, a series of smoke tests showed that the room was now at neutral pressure rather than negative pressure. Room air leakage exceeded the 20 CFM offset.

Calculate Air Change Rate

The room was square-shaped (15 feet each side), with a ceiling height of 8.5 feet. The exhaust air change rate was calculated as follows:

$$\text{Room Volume} = 15 \times 15 \times 8.5 = \mathbf{1913 \text{ cubic feet}}$$

$$\frac{150 \text{ CFM} \times 60 \text{ minutes}}{1913 \text{ cubic feet}} = \text{approx. } \mathbf{5 \text{ ACH}}$$

Therefore, even with the exhaust fan fixed, the room was unsuitable for isolation because it was at neutral pressure with a low air change rate.

Clearly, something had to be done. See "AIIR: Part 2" for conclusion.

What steps should be taken to achieve negative pressure in the AIIR?

AIIR: Part Two

Calculate Additional Airflow

Although Janet, the clinic manager, wanted to bring the AIIR into compliance with CDC environmental control recommendations, she thought her budget was too limited to accomplish this.

Cynthia, the engineer, suggested a portable HEPA filter unit as an affordable upgrade option. A HEPA filter unit would provide additional airflow. If a portion of the discharge were ducted outside, it would also create negative pressure.

The first step was to calculate the additional airflow required:

$$\text{Airflow required for 12 ACH} = \frac{1913 \text{ cubic feet} \times 12 \text{ ACH}}{60 \text{ minutes}} = \text{approx. } \mathbf{400 \text{ CFM}}$$

$$\text{Additional airflow required} = 400 \text{ CFM} - 150 \text{ CFM} = \mathbf{250 \text{ CFM}}$$

Sizing and Installing a Portable HEPA Filter Unit

A HEPA filter unit that produced at least 250 CFM airflow was required. Cynthia contacted a mechanical equipment supplier. Two units were available: a small unit rated for 150 to 300 CFM; and a large unit rated for 250 to 750 CFM. Each unit had a variable speed switch and an optional connection that could be used to duct some of the discharge air outdoors.

Janet suggested buying the small unit to save money. If run at high speed, it would provide more than enough airflow. However, Cynthia explained that most people turn down the fan speed switch because the units can be noisy. The units may also produce less airflow than the catalog claims. She suggested adding a 25% safety factor, then buying a unit listed for this airflow at low or medium speed.

$$\text{Additional airflow} + \text{safety factor} = 250 \text{ CFM} + 25\% = \text{approx. } \mathbf{310 \text{ CFM}}$$

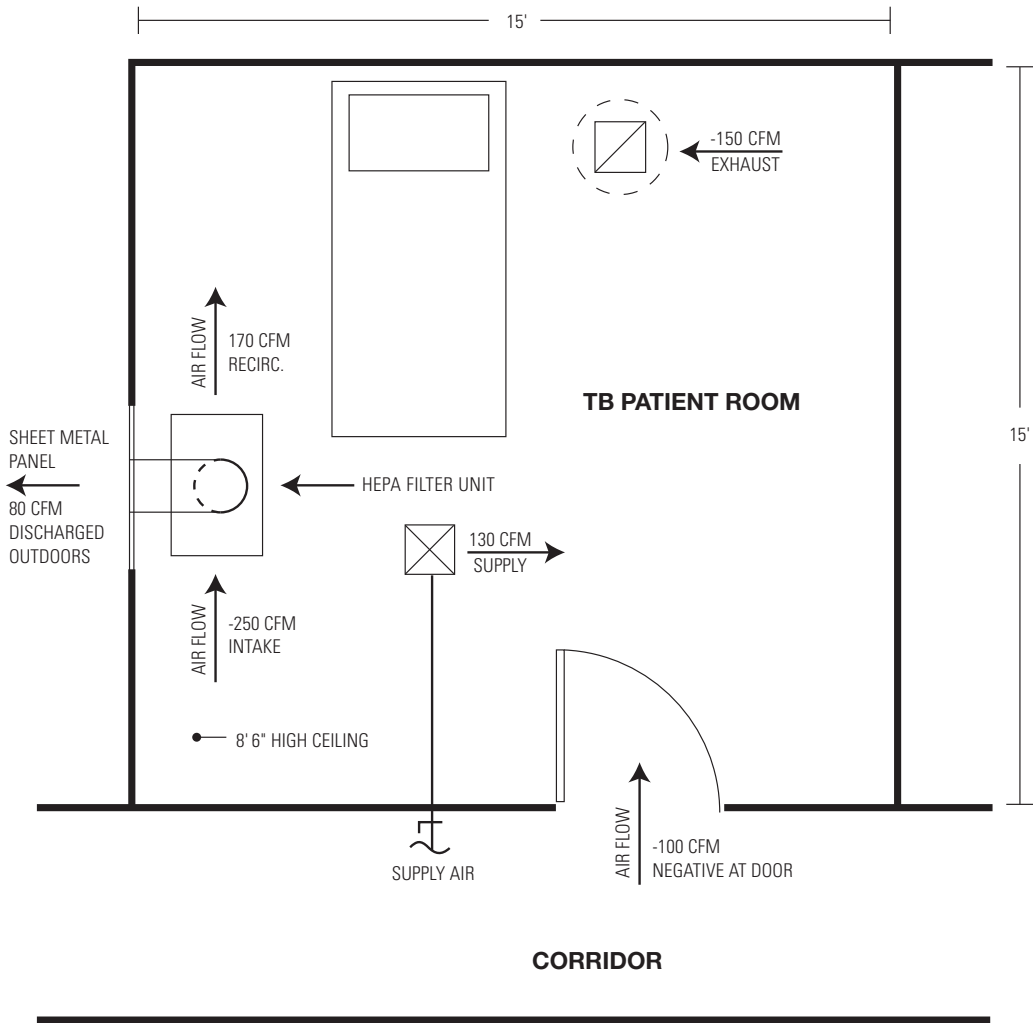
Based on this, the larger unit was selected and placed in the room. Cynthia replaced a windowpane with a sheet metal panel. She connected a flexible duct from the HEPA unit discharge to a hole in the sheet metal panel, set the unit to about 300 CFM, and diverted about a third of the discharge air to the outdoors.

The Happy Ending

The room was now clearly at negative pressure, the airflow was improved, and the noise from the HEPA filter unit was acceptable.

Cynthia's final measurements showed that the HEPA filter was returning approximately 250 CFM, with 80 CFM of this discharged outside and the remaining 170 CFM recirculating in the room.

Effective supply = 130 CFM + 170 CFM = **300 CFM**
 Effective exhaust = 150 CFM + 250 CFM = **400 CFM**
 Effective supply = 400 CFM - 300 CFM = **100 CFM**



How often should the negative pressure be verified for this AIIR?

Emergency Departments



EMERGENCY DEPARTMENTS (EDs)

TB transmission is a recognized risk to patients and HCWs in healthcare settings. The magnitude of this risk varies significantly depending on:

- **Facility type**
- **Patient population**
- **Prevalence and incidence of infectious TB in the community**
- **Occupational group and work area of the HCW**
- **Effectiveness of the facility's TB control program**

The risk of transmission is greater in areas in which care is provided to patients with TB disease before they are identified, properly isolated, and started on appropriate therapy. This care is often provided in hospital EDs.

ED Workers at Higher Risk for Exposure to TB

In addition to providing care to persons with unidentified TB disease, EDs increasingly provide care to those populations most impacted by the TB epidemic:

- Urban poor
- Immigrants
- Persons at risk for HIV infection
- Persons recently incarcerated
- Homeless persons
- Persons with inadequate access to health-care

Because they don't have health insurance and a private doctor, many patients with TB disease seek care in the EDs of urban public hospitals. They may wait for long periods under crowded conditions with inadequate room ventilation. These factors increase the risk of transmission to ED staff. A random sample of EDs nationally found that EDs with the greatest number of TB patients had the longest waiting times. Many patients with TB disease do not yet have a diagnosis when care is sought in EDs. This results in delay in initiating All precautions and other infection control measures by ED staff. Furthermore, delays in seeking medical care may result in presentation with more advanced TB disease, increasing the risk of transmission to staff in EDs.

TB transmission to HCWs and patients in EDs has been well documented. One outbreak occurred following a 4-hour exposure to a patient, known at the time of admission to the ED to have pulmonary TB. Another outbreak occurred after only 2 hours exposure to a patient with unrecognized pulmonary TB. Most transmission in EDs undoubtedly occurs without known links between an infectious source and susceptible individuals with whom air is shared.

In summary, EDs present a unique intersection of risk factors. Given these factors, the cornerstone of effective TB control programs in EDs is early identification of patients with infectious TB. After identifying these patients, implementing appropriate isolation and diagnostic procedures are the most important and effective risk reduction activities. An index of suspicion for TB appropriate to the facility, the community, and the client population is an essential component of these practices.

Determining the Likelihood of TB Transmission in the ED

The risk for TB transmission in the ED is approximated by looking at several factors:

- TB in the community
- TB in your facility
- *M. tuberculosis* TST or IGRA conversion rate in your facility

With information on these factors, you will be able to assess your ED's risk.

Obtaining Information about TB in the Community

To assess TB in the community served by your ED, you will need information such as:

- Number of TB cases in the past year in the county or counties from which you draw your ED patients
- Number of TB cases with drug resistance in the past year in the county or counties from which you draw your ED patients
- Demographic information on community TB cases:
 - Race/Ethnicity
 - Age distribution

Other, community-specific information that can be important in evaluating the community TB risk includes general health factors in the community from which your client population is drawn, such as:

- Prevalence of HIV infection
- IV drug use
- Homelessness
- Access to preventive health-care

This information can be found by contacting sources such as:

- Your local TB control program
- Your state TB control program
- Local health information groups such as the American Lung Association and/or AIDS information services

Once you have obtained general information about TB in your community, you need to obtain some facility-specific information.

Obtaining Information About Confirmed TB in the Facility

You will want to determine the number of confirmed TB cases in the past year that were:

- Admitted to your facility
- Admitted to your facility with drug-resistant TB
- Admitted to your facility and were seen in the ED

This information can be found by looking at records from:

- Admissions/medical records
- Infection control
- Laboratory

The above information is needed to help you assess your ED risk using the “Risk Assessment Worksheet,” which appears in the Appendix on page 149.

Calculating the TST Conversion Rate for the Staff

A conversion rate provides an estimate of the risk of TB transmission. This rate is a simple way of comparing the number of staff who have converted their TST result since the prior year and the TST-negative staff who did not convert over the same time period. It gives you information needed to determine the significance of the actual number of conversions.

For example, your IC practitioner might say, “We have had five staff conversions in the past year.” If the number of TST-negative staff who were tested that year was five thousand, five conversions may not represent a large percentage of staff (0.1%). But if the number of TST-negative staff who were tested that year was only twenty-five, five conversions represents a much greater percentage of the staff (20%).

It can be misleading to look only at the number of conversions. Conversions must be looked at within the context of the TST-negative staff population.

To facilitate the collection and analysis of this information, it is crucial that TB skin testing data be entered in an aggregate log by department, as well as kept in individual employee records. In order to protect medical record confidentiality requirements, the aggregate log need not give the names of the employees.

Use the “Conversion Rate Calculation Worksheet” in Appendix A on page 141 to calculate and log the aggregate conversion rate. If your facility uses IGRA testing instead of or in addition to TST, these results should be included in the conversion rate calculation as shown in Appendix A.

Next Steps

Compare the information you developed about your facility with the general ED risk classification in the revised version of Appendix B in the CDC guidelines. Use these classifications in conjunction with community-specific information to determine your ED risk.

Next, determine whether the community-specific information warrants a shift in the general ED risk classification. For example, if your facility sees few of the TB cases in your community, or has an ED population that is not representative of the community demographics for confirmed TB cases, you may want to revise your classification to a lower-risk category. Conversely, if your patient population closely matches the demographics of the TB cases in your community, or you serve a particularly high-risk population, you should consider revising your classification to a medium-risk category.

TABLE 11.

General Risk Classifications

The general risk classifications for EDs can be defined as follows:

POTENTIAL ONGOING TRANSMISSION	Should be temporarily applied to any setting (or group of HCWs) if evidence suggestive of person-to-person transmission of <i>M. tuberculosis</i> has occurred in the setting during the preceding year. Of if any of the following has occurred: <ul style="list-style-type: none">• clusters of TST or IGRA conversions• HCW with confirmed TB disease• increased rates of TST or IGRA conversions• DNA fingerprinting that shows the presence of identical strain in patients or HCWs with TB disease
MEDIUM RISK	Facilities of >200 beds with >6 TB patients Facilities of <200 beds with >3 TB patients
LOW RISK:	Facilities of >200 beds with <6 TB patients Facilities of <200 beds with <3 TB patients

Note: *These are general classifications and may be modified depending on the facility situation. For example, a facility that would fall into the low- or medium-risk categories may upgrade to a classification of potential ongoing transmission if the facility is seeing patients with multidrug-resistant (MDR) TB.*



Privacy During Triage

Mr. B, a 57-year-old Chinese man, came to the busy ED of the hospital near his home. It was crowded with people and noisy. When the triage nurse brought him over to the triage area, she sometimes had to speak loudly to be heard over the noise. Mr. B told the nurse that he had not been feeling well and that he had been having some chest discomfort, but denied having a cough or other symptoms. Since he was not currently having any discomfort, he was asked to wait in the waiting area.

After 2 hours, Mr. B was brought into the ED. When the ED doctor came in to examine him, Mr. B admitted that he had been coughing up greenish stuff for the past month, and that he had been losing weight. The doctor ordered a chest x-ray, which was abnormal and indicative of TB disease. Later sputum smears and cultures were positive for TB.

Why did Mr. B deny having a cough or other symptoms during triage? The triage area was not located in a private area where the patient could discuss his symptoms confidentially. Although the triage area was obscured from the view of others in the area, both the nurse's questions and the patient's answers could be overheard. So even though the triage nurse asked all the right questions, the patient did not answer truthfully. This resulted in delayed isolation, which caused exposure for other patients and staff.

What are some actions or methods the ED personnel could use to prevent this in the future?



EMERGENCY

CASE STUDY

TB Symptom Screening During Triage

Ms. K, a 39-year old Mexican woman, was brought to the ED after falling from a ladder at her sister's home. She complained of arm and back pain and headache. After staff had ascertained that her injuries were minor, they set her broken arm.

While preparing to discharge her, Ms. K asked if she could also have something for her very productive cough, which she had had for several months. Before discharging Ms. K, the doctor called radiology for a reading on the chest x-rays which had been taken 6 hours earlier. The x-rays were abnormal, and a further work-up revealed that Ms. K had both a positive smear and TB culture.

Although Ms. K was not admitted to the ED for a complaint related to TB symptoms, she did have TB. If TB screening were a routine part of the triage procedure at this urban ED, Ms. K would have been isolated for the entire 6 hours she was there. Instead, she exposed staff members and other patients.

What are some of the questions triage personnel should ask patients to determine their TB status?

Efforts to identify infectious patients and prevent transmission should begin as soon as the patient enters the door and approaches the admission or registration desk.

Implementing and Performing TB Triage

Generally the initial ED triage interaction focuses only on patient acuity. As a result, a stable, but infectious, TB patient may be left sitting in the waiting room for a long time.

Efforts to identify infectious patients and prevent transmission should begin as soon as the patient enters the door and approaches the admission or registration desk.

When suspect TB patients are identified early in the admitting process, these patients can be placed on a “fast-track” for further triaging and possible isolation or masking precautions. EDs that do not have a specific triage tool for this purpose tend to over-look suspect TB patients and triage for acuity only.

About Triage Levels

This manual introduces three levels of suggested triage procedures for early identification of suspect TB patients:

- **Level A:** Written TB symptom and risk factor screening of all patients presenting to the ED, regardless of the nature of the chief complaint.
- **Level B:** Written TB symptom and risk factor screening of all patients with respiratory complaints or known HIV infection presenting to the ED.
- **Level C:** Develop facility-defined criteria for determining when to suspect TB in your ED patients. No TB symptom and risk factor screening of any patient unless these facility-defined criteria are met.

Each level of triage procedure has advantages and disadvantages. These are discussed in more detail on the following page.

Determining Which Triage Level to Use

A facility can choose to use any of the three triage levels; there are no requirements that would compel any facility to choose a level above **Level C**. However, there are instances when choosing **Level A** or **Level B** is more protective of the health and safety of ED staff and patients.

We recommend that you use the “Risk Assessment Worksheet” in Appendix B (revised version) of the CDC guidelines and Appendix F on page 149 of this manual to help you decide which triage level to use.

TABLE 12.

Triage Levels—Advantages and Disadvantages

LEVEL	DEFINITION	ADVANTAGES	DISADVANTAGES
A	TB symptom and risk factor screening of all patients presenting to the ED, regardless of the nature of the chief complaint.	<ul style="list-style-type: none"> This option is likely to “catch” more infectious TB patients. Because screening must be done on all patients, those with atypical presentations of TB are more likely to be found. A high level of suspicion maintained by screening all patients will assure a constant level of readiness to deal with TB effectively. 	<ul style="list-style-type: none"> Screening must be done on all patients, and the triage nurse cannot use clinical judgment to decide whom to screen. This can be difficult for staff to accept. Increased time spent in triage. May result in over-isolation.
B	Written TB symptom and risk factor screening of all patients with respiratory complaints or known HIV infection presenting to the ED.	<ul style="list-style-type: none"> This level involves minimal behavioral changes for most triage nurses and may be easier to implement. A moderate level of suspicion maintained by screening all patients with respiratory symptoms or known HIV infection will assure some level of readiness to deal with TB effectively. 	<ul style="list-style-type: none"> This level requires the triage nurse to decide when to apply the screening. This can result in missing patients with TB, especially if they present atypically. This level may result in under-isolation.
C	<p>Develop facility-defined identifying criteria for determining when to suspect TB in your ED patients.</p> <p>No TB symptom and risk factor screening of any patient unless these facility-defined criteria are met.</p>	<ul style="list-style-type: none"> This level will save time at triage since only patients who meet the facility-defined criteria for suspect TB will be screened. 	<ul style="list-style-type: none"> This level requires the triage nurse to decide when to apply the screening. This can result in missing more patients with TB, especially if they present atypically. This level may result in under-isolation. This level of screening does not require staff to “think TB” and may result in decreased readiness to deal effectively with TB. This level creates vulnerability to occasional outbreak and decreases preparedness to deal effectively with a TB patient and the post-exposure follow-up, which should occur.

These are our recommendations, based on the risk assessment classifications:

Use **Level A** if your ED’s risk assessment is: **Potential Ongoing Transmission**

Use **Level B** if your ED’s risk assessment is: **Medium Risk**

Use **Level C** if your ED’s risk assessment is: **Low Risk**

Note: *Facilities choosing Level C screening should be aware that they may be more vulnerable to occasional outbreaks and less likely to be prepared to deal effectively with a TB patient and the post-exposure follow-up that should occur.*

Setting up the Triage Area

The triage area should be set up to provide the patient with as much privacy as possible. Patients may be reluctant to answer triage questions truthfully when others can overhear them. This can lead to a delay in identifying suspect TB patients. Even if the triage area must be located in an open area, you can create more privacy by strategically placing portable screens or cubicle walls.

Implementing the Triage Plan

The only difference between the levels of triage is the population targeted for screening. The recommended actions for patient screening are identical at all levels.

- Develop and implement a written procedure for TB-specific screening.
- Develop specific, written triage questions concerning both risk factors and symptoms of TB disease.

Note: *The infection control practitioner should look at the current ED triage forms to determine if such a TB-specific checklist is included. In our experience, many ED staff believe that a general respiratory system checklist meets this need. It does not! If the TB-specific questions are not written down, there will be little consistency between triage nurses, and important questions may not be asked.*

Many organizations have developed TB-specific triage questionnaires. A sample triage questionnaire is included in Appendix B on page 143. Others are referenced in the Resources section on page 170.

The triage criteria for Respiratory Isolation of Pulmonary Tuberculosis (RIPT) Protocol was developed at Harbor-UCLA Medical Center (Appendix J on page 155) to aid in early identification and isolation of patients at high risk for pulmonary TB in the ED.

The triage worksheet consists of a questionnaire of both risk factors and symptoms of pulmonary TB. Point values are assigned to each risk factor and symptom and patient scores are added. Patients who score 5 or more are immediately isolated and evaluated for TB.

This tool is a good example of a short, TB-specific triage checklist.

A Word About Triage Checklists and Algorithms...

The use of TB checklists and algorithms poses two main problems. First, as people with varying backgrounds, interest, and experience with TB may administer them, the tools may be used differently depending on the user. Second, there will never be complete information at the time the tools are used. Incomplete information will cause errors in the assumptions of the tools.

Nevertheless, these tools are useful to facilitate a standard and consistent collection of information. Triage tools are not foolproof, and, like all other tools, are more effective when used by an experienced practitioner.

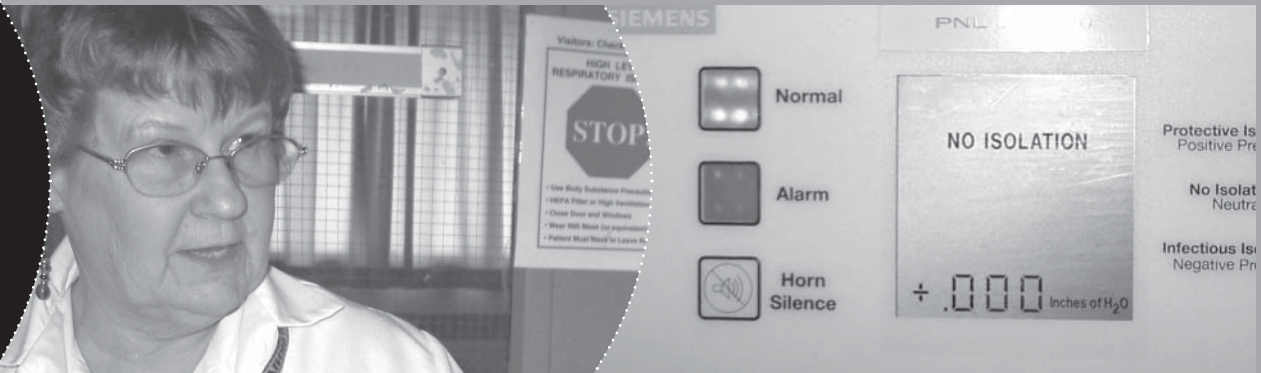


AIIR Signage

The housekeeping manager called the ED nurse manager. A housekeeper who was regularly assigned to the ED had complained about going into an exam room in the ED for routine matters, such as emptying the trash containers. After he came out of the room, he found that the nurses and doctors going into the room were wearing respirators. He was worried that he was going to get sick, and angry because he felt important information was being withheld. The ED manager tried to explain that the staff was very busy, and that they communicated informally to one another about the isolation status of the patients. But she realized that this would have to change, in order to better protect the safety of all the workers in the ED. She called the infection control nurse (ICN) and enlisted his help.

At the next staff meeting, the ED manager and the ICN presented a plan they had developed jointly. They made a double-sided sign to hang on the doors of the rooms that were sometimes used as AIIRs for suspect TB patients. The sign was a simple one which on one side read “Exam Room — No Special Precautions Required,” and on the other side read “AIIR—N-95 Respirators Required.” Since the signs would be on the doors, staff would just need to turn them to the isolation side when occupied by a suspect TB patient. The staff agreed to give the signs a try. This was a simple system of notification which benefited all staff who worked in the ED, including housekeeping, lab, and radiology.

Can you think of other ways, ED managers can inform staff about potential TB transmission in their facility?



Communication and Monitoring

A busy Northern California hospital has a pro-active infection control committee, which includes the infection control coordinator, the chief engineer, and the nurse manager of the ED. In response to the resurgence of TB, they initiated a construction project to convert the ED waiting room to 100% exhaust air, and convert one of the ED exam rooms to meet the CDC recommendations for a TB AIIR (i.e., 12 ACH with negative pressure and 100% exhaust). The project was successfully completed in 2004.

In 2006, a young engineer was surveying the ED mechanical systems for another planned renovation. During a quiet moment, she asked the triage nurse which was the TB segregation exam room. He told her it was Exam Room #9. However, when the engineer looked at the mechanical drawings for the 2004 remodel, she was surprised to find that the room that had been converted was across the hall from Exam Room #9, and was being used for pediatric exams. Subsequent airflow measurements indicated that Exam Room #9 was under positive pressure and had an air change rate of only 4 ACH.

This example indicates the importance of two things: communication and monitoring. The various disciplines involved in TB control should continually share information. If the engineering department had involved ED staff in the construction project, they would probably have known the correct segregation room. Had engineering been checking airflow annually and sharing this information with others, the mistaken room would have been discovered. Had ED staff been checking for negative pressure at Exam Room #9, they would have discovered that it was under positive pressure.

What are two ways a healthcare worker can check a room for negative pressure?

Handling Suspect TB Patients in the ED

Removing or limiting a suspect TB patient from contact with other patients and staff should be an initial action based on the TB triage results. We refer to such a process as “fast-tracking.” Airborne infection isolation is the ideal for placement of infectious patients. We refer to the use of AIIRs as “isolation.” Many EDs do not have AIIRs, and may instead use treatment/exam rooms with doors closed to separate suspect TB patients from others. This use of treatment/exam rooms is referred to as “segregation.” In the absence of isolation facilities, the ED should be prepared to implement the highest level of containment possible.

The basic concept of fast-tracking can be used in all settings, with isolation or segregation.

Taking Initial Actions

Fast-Tracking

Fast-tracking suspect TB patients requires a plan to address:

- Communication among ED staff of the need for masking, isolation, or segregation of the suspect TB patients
- Appropriate isolation or segregation of the patients
- The manner in which necessary services are provided to these patients.

Communicating the Need for Isolation or Segregation

Patients with suspected or confirmed infectious TB should be masked as soon as they are identified and then moved to isolation or segregation. A sign should be placed on the door of the room, notifying staff that the room is being used for isolation or segregation. The sign should clearly state that no one should enter the room without using an approved respirator. The door should remain closed.

Signage must be kept accessible to staff or it will not be used. A holder on the wall near the room(s) used to isolate/segregate can be a convenient place to store the signage when it is not needed.

It is also important to have approved respirators readily available near the isolation/segregation room. Some facilities have placed wall-mounted boxes of respirators outside these rooms.

The registration and financial clerks are often overlooked in the communication loop. Suspect TB patients should not be sent to the registration or financial area. To minimize contact, alternatives should be explored. Perhaps the clerk could go into the patient's room, using an approved respirator, or complete the registration over the telephone.

Isolating or Segregating Suspect TB Patients

The most appropriate room in which to place a suspect TB patient is one that complies with the environmental recommendations as listed in the CDC Guidelines for a newly constructed AIIR. To review, an AIIR is a single patient room that has a minimum air change rate of 12 ACH, negative air pressure relative to adjacent spaces, and direct exhaust to the outdoors or recirculation of air through a HEPA filter.

Patients with suspected or confirmed infectious TB should be masked as soon as they are identified and then moved to isolation or segregation.

Many facilities do not have such a dedicated AIIR available in the ED. Such facilities often segregate suspect TB patients in any available closed exam room, regardless of the ventilation characteristics of the room.

The two most important environmental characteristics of an AIIR are a high ventilation rate and negative pressure relative to the adjacent space. The direct exhaust requirement is not as crucial because ED supply air filters should remove most TB particles from recirculated air. We recommend that a specific exam room with these two ventilation characteristics be identified to segregate such patients. You can assess the ventilation of a number of rooms and use the one that is most satisfactory. Alternately, you can select the room based on other concerns, and then improve the ventilation as required. A removable sign should be placed on the room door to warn staff that a segregated patient is inside.

The room should have a high ventilation rate (minimum 12 ACH). The airflow rate in the room should be measured. The hospital engineering department may have the equipment to measure room airflow. Otherwise, your engineering department can contract with a certified air balancing firm to perform these measurements. Once you know the amount of air moving through the room, you can calculate the air change rate. If the room airflow is inadequate, it should either be increased, or supplemented with a portable High Efficiency Particulate Air (HEPA) filter unit.

The room should also be under negative pressure. Check the room's pressurization relative to the corridor using a telltale such as smoke tubes or incense sticks. (Your engineering department may have smoke tubes that you can use. Otherwise you may be able to buy them from a local safety supply company.) Hold the smoke-generating device at ground level just outside the door and observe the smoke trail. Repeat this or a similar test daily to verify negative pressure of any room used for segregation or isolation.

Negative air pressure may be achieved in a room by increasing the amount of air exhausted by the existing ventilation system so that more air is exhausted than supplied. If this cannot be accomplished, you may have to add a dedicated exhaust fan, or a stand-alone HEPA filter unit with a portion of the discharge diverted outside.

For information about AIIR criteria, see "AIIRs" on page 88. For more information about HEPA filters see page 42.

Providing Services to Suspect TB Patients

Services should be brought to the patient as much as possible, rather than bringing the patient to the service. When this is not possible, a system must be in place to assure that the patient is masked when not in isolation or segregation. It is also imperative that the staff in the department providing the service are notified that the patient is an isolation/segregation patient and should be masked. Ideally, an ED staff member should accompany the patient at all times when out of the isolation/segregation room. This is not always possible, so it is important to develop a facility-specific process for communicating the isolation status of the patient between departments. Some facilities have a computerized notification that accompanies the order for services. Other facilities place a special color wristband on patients who should be masked when out of isolation or segregation.

The ED Waiting Room—A Port of Entry

EDs can be described as places where high-risk, undiagnosed patients may come for treatment when in crisis. ED staff members are often aware of TB and the high-risk populations that frequent the ED, but their attention is usually focused on identifying and treating acute, life-threatening injuries and illnesses. Frequently the initial triage interaction is delayed and/or focuses only on patient acuity. Too often this leaves a person with infectious TB sitting in the waiting room.

Protecting Patients from Exposure

Special efforts should be made to protect patients who are at high risk for developing TB disease after infection, such as infants or persons with HIV/AIDS, from coughing patients who may have TB. When possible, coughing patients should be placed in a separate waiting area. Patients who are noted to be coughing at registration or triage could be directed to this alternate site. Surgical face masks and tissues should be provided to patients who are directed to this area.

The direction of the airflow should be checked to help determine the area you select for this alternate waiting site. The preferred location is in a separate room that is well ventilated and under negative pressure. If a separate room is unavailable, use an area in the general waiting room that is as close as possible to where air is being removed from the room. This will help to prevent the spread of infectious particles to other areas of the waiting room.

You can visualize air movement in the waiting room using smoke-generating devices. Release smoke at various locations in the room. Note the directions in which the smoke is blown by the air currents in the room. If you hold the smoke-generating device close to the ventilation system outlets, you should also be able to observe which outlets are supplying air and which are removing air.

Educating Patients

Placing signs that show a coughing individual using tissue or a surgical-type mask are non-judgmental and lend support to ED staff TB control efforts.

Signs in appropriate languages for your facility's clientele should be easily visible in your ED registration and waiting areas to encourage coughing patients to cover their coughs. The sign should have a picture of a person covering their cough and be easily understandable. Sample signs for you to copy and use are included in Appendix L, starting on page 157.

A variety of patient literature on TB should also be available in the waiting area. Pamphlets can be obtained from a number of sources including the CDC, your state TB Control Program, and the American Lung Association.

Providing Short-term Protection (Masking Tissues)

The purpose of masking a suspect or known infectious TB patient is to block aerosols produced by coughing, sneezing, talking, etc. A surgical mask placed on a cooperative patient provides adequate short-term protection for staff and other patients in the ED. Covering a cough with a tissue is also an effective TB control measure. All staff, including staff at the front reception desk, should be trained to look for patients with symptoms of TB, especially coughs. Surgical masks and/or tissues should be readily available to coughing patients at the registration desk, in the waiting room, the triage area, and the treatment room. Staff should be trained and empowered to offer coughing patients masks/tissues with a gentle reminder to cover their mouth and nose when coughing. This can be a difficult task for employees, and role-playing may be helpful during training.

Some facilities are concerned that having tissue boxes in waiting areas can be very messy, since children may pull tissue after tissue out of the box. One solution to this is to mount dispensers on the wall, above the reach of children, to assure that tissues are always available, but out of the reach of children.

Masking Considerations

Patients who are suspected or known to have infectious TB must be masked until placement in appropriate airborne infection isolation. A regular surgical mask is sufficient to block droplets from escaping into the room air. Masks must be changed if they become damp or difficult to breathe through.

Respirators should not be used on patients. Respirators increase the work of breathing which can prompt the patient to remove the respirator.

About ED Waiting Room Environmental Controls

ED waiting rooms are areas in hospitals where there is a particularly high risk of TB transmission. These areas tend to be crowded spaces where people can spend a large amount of time before they are medically screened. The ventilation system for ED waiting rooms should be designed and maintained to reduce the risk of TB transmission.

Environmental controls for ED waiting rooms include:

Ventilation

Ventilation is the most effective environmental control. Ventilation can dilute and remove infectious TB particles, as well as other airborne contaminants. The current California Building Code mandates a minimum air change rate of 10 ACH for new or renovated hospital ED waiting rooms. Many EDs were constructed before 1991 when this requirement was added to the building code. Such EDs may have ventilation rates less than 10 ACH. Facilities are not required to bring existing ED ventilation rates into compliance with the current code unless they are renovating the ED.

The first step you should take is to have the hospital engineer calculate the air change rate in the waiting room. You will need to have the actual airflow in your waiting room measured, probably using an airflow hood.

If the air change rate is less than 10 ACH, it should be increased. It may be possible to achieve this by adjusting the amount of air supplied and exhausted by the building ventilation system. Otherwise, self-contained HEPA filter units can be used to increase the effective air change rate. For more information, see page 42.

Negative Pressure

The ventilation system for an ED waiting room should be balanced to achieve negative pressure in the room with respect to adjacent spaces. The amount of air exhausted from an ED waiting room should exceed the amount supplied.

General air movement will, consequently, be towards the waiting room from adjacent areas in the hospital. This will help contain any infectious particles generated in the waiting room.

For effective negative pressurization of a room, all doors should be kept closed. However, this is usually not practical for an ED waiting room. Nevertheless, the design of the mechanical systems for EDs should endeavor to keep air moving towards the waiting room. Smoke-generating devices can be used to confirm this airflow.

If the exhaust airflow rate in your waiting room does not exceed supply, then exhaust should be increased. It may be possible to increase the exhaust airflow by adjusting (also called rebalancing) the existing mechanical exhaust air system. Alternately, a new exhaust system could be installed. This option will obviously be more expensive. You should discuss these options with your facility's engineering staff. For more information, see page 26.

Routine Assessment and Maintenance

Ventilation systems drift out of balance over time. Monitoring is required to verify the actual conditions, and maintenance is required to reset airflows to the intended values.

The airflow in waiting rooms should be measured and rebalanced at least annually. Records should be kept documenting airflow readings. These readings should be shared with the infection control committee and ED management.

Upper-air Ultraviolet Germicidal Irradiation (UVGI)

Upper-air UVGI is recommended for crowded congregate settings, such as waiting rooms, to increase the effective air change rate. Consider upper-air UVGI to supplement the ventilation system in high-risk public areas, such as ED waiting rooms.

Expertise is required for the safe and effective installation and use of upper-air UVGI lamps. Issues to address include:

- Initial and routine monitoring of radiation levels (both in the occupied area of the room and in the upper room)
- Routine maintenance
- Staff education
- Labeling and posting of warning signs

For more information, see "Upper-air UVGI" on page 38.

Homeless Shelters



HOMELESS SHELTERS

Homeless shelters present considerable variation in the types of services they provide, the people they serve, and the type of buildings in which they are housed.

- **Some shelters provide food and shelter, but no other services. Other facilities provide a range of services on-site, including case management and chemical dependency recovery services**
- **Some shelters serve a different group of clients every night on a first-come, first-served basis. Other shelters allow clients to stay for up to 6 months**
- **Buildings used as shelters vary from a converted warehouse sleeping 600 people to a self-contained trailer for 4 clients**
- **Many shelters serve only adult male clients. A smaller number serve women, families, or teenagers**

Because of these factors, the likelihood that TB will spread varies considerably from shelter to shelter.

This section describes the challenges faced by shelters and how to reduce the risk of spreading TB in these settings.

Background and Needs Overview

During 1996-1998, a mechanical engineer conducted on-site consultations at 19 California homeless shelters. These consultations included an evaluation of how ventilation, filters, and UV, when present, helped reduce the risk of TB transmission. Consultations also included conversations with shelter managers and other staff to determine their knowledge and skills regarding TB control measures.

The most common problems found with ventilation, filters, and UVGI at homeless shelters included:

- Rooms without ventilation
- Broken ventilation equipment
- Ventilation systems operating below capacity because the equipment needed cleaning or other routine upkeep
- Inadequate air filters in central ventilation systems
- Inappropriate design and installation of UVGI lamps

The following barriers to more effective use of ventilation, filters, and UVGI were encountered:

- Limited knowledge about TB and how TB is spread
- Limited knowledge of the role of ventilation, filters, and UVGI in reducing TB transmission risk
- High staff turnover rate and overworked staff
- Limited maintenance staff and budgets
- Dilapidated buildings and mechanical ventilation systems
- Limited funds to improve TB control through use of ventilation, filters, and UVGI

Following each consultation, the facility received a report recommending ways of reducing the likelihood that TB would spread in the shelter. Recommendations varied from immediate no-cost steps, such as opening windows and doors, to suggested modifications of the shelter's ventilation equipment.

Why TB is a Problem in Homeless Shelters

TB is likely to spread in shelters. If a shelter client has infectious TB, it can place shelter staff and clients at risk. Shelters are especially vulnerable because:

- The shelter environment often increases the chances that if a person with TB is present, TB will be spread.
- Homeless people are more likely to have TB than others in the general population.

In 2005, 6.1% of reported TB cases in the United States were people who were homeless at some time during the year before their TB was diagnosed.

The homeless are more likely than the general population to have TB because risk factors for TB, including the following, are more common:

- Contact with other homeless people who have TB
- Poor nutrition
- Poor access to health care
- Poor adherence to follow-up visits and prescribed treatment for TB infection
- Substance abuse, especially injection drug use and alcohol
- Limited access to HIV education and prevention measures, increasing the risk of HIV infection among the homeless.

TB disease develops more quickly among people who are infected with both TB and HIV. Because homeless persons are at higher risk for HIV infection than the general population, TB can also develop among the homeless more quickly and spread to others before it is even suspected.

For homeless people, food, shelter, and personal safety are often higher priorities than TB and HIV prevention.

In addition to increased TB among the homeless, characteristics of shelter environments often increase the chances that TB will spread. For example:

- Building ventilation is often inadequate
- Clients are crowded into close quarters, typically for 8 to 12 hours per night

Other factors contribute to the high likelihood that TB will spread in shelters. Among these, the most important is that many shelters do not screen clients for TB symptoms. Without this screening, a client with symptoms of TB will not be:

- Referred for medical care and treatment
- Separated from other clients or asked to use a face mask to lessen the chance that TB, if present, will spread

Reducing the Risk of Spreading TB in Homeless Shelters

Although the likelihood of spreading TB in shelters is high, shelter operators and others can take steps to significantly reduce this risk. There are three main ways in which shelters can reduce the chances that TB will spread:

- Administrative and work practice control measures
- Ventilation, filters, and UVGI
- Staff use of respiratory protection

In general, administrative and work practice control measures have the greatest impact on preventing TB transmission, followed by the use of ventilation, filtration, and UVGI. Use of respirators by shelter staff may be important in certain situations, such as when transporting a client suspected of having TB of the lungs or larynx, or entering a room in which such a client has been placed temporarily to separate him or her from other clients and staff.

Administrative and Work Practice Control Measures

Homeless shelter management and staff should employ the following control measures:

- Identify clients who have a cough and one or more other symptoms of TB disease of the lungs or larynx (see “When TB Is Infectious” on page 8)
- Promptly refer clients with one or more symptoms of TB disease for medical care
- Promptly report clients with suspected or confirmed TB disease to the public health department (a guest log and bed map should be maintained, these are essential if the health department conducts a contact investigation to follow-up a TB outbreak in a shelter)
- Separate clients with symptoms of TB from other clients and staff by placing them in rooms by themselves until they can be medically evaluated. (Medical evaluation should take place as soon as possible, though is sometimes not possible until the following day. Clients may also be instructed to use masks over the nose and mouth to trap droplet nuclei and be monitored to ensure that they are wearing them)
- Make tissues readily available to clients, instructing them to cover their nose and mouth with tissues when coughing and sneezing, and reinforcing this behavior with signs and verbal reminders

- Perform TB screening of shelter staff and clients, such as TB symptom screening, tuberculin skin testing or IGRA, chest x-ray, and medical follow-up, if indicated (See a sample screening questionnaire in Appendix D on page 146)
- Assign a health ‘point person’ for your agency to coordinate TB and other health-related activities. This person can order and display educational brochures and posters throughout your agency, provide instructional videos on TB, conduct or schedule client health groups, attend TB and other health workshops in the community, share health resources, serve as a health resource to other staff and residents, and contact the health department, when appropriate
- Require documentation of TB screening for new volunteers and employees
- Assist the local public health department in treating shelter clients for TB infection and disease (e.g., provide transportation assistance and follow-up for health-care appointments and provide incentives for clients to complete their full treatment, help clients cooperate with DOT provided by the public health department to ensure TB treatment is taken as ordered)
- Educate staff and clients about TB (sample curriculum and training materials are available from www.hhcla.org)
- Place each bed as far from neighboring beds as possible, with head-to-foot, instead of head-to-head, arrangement of beds

Note: *Shelters should not house clients who are being evaluated for, or known to have, TB disease of the lungs or larynx until the conditions listed in “When TB Is Infectious” (page 8) have been met. Consult with your local public health department for assistance with alternative housing.*

Using Ventilation, Filters, and UVGI

These measures will reduce the chances that others will inhale air containing *M. tuberculosis*.

- **Ventilation** can reduce the spread of TB through dilution and removal. Ventilation is either natural (employing windows, doors, skylights, and/or fans) or mechanical (air conditioning, heating, and other forced air systems). To read how ventilation can help prevent TB from spreading, see “Using Ventilation to Reduce the Risk of Spreading TB” on page 15
- **Filters** clean air by removing particles from air that is passed through them. Many different levels of filters are available and ventilation systems may have only one filter or have two or more. Using a suitable filter with your central ventilation system helps reduce further the risk of spreading TB. For more on filtration, see page 27
- **UVGI** uses a type of radiation that has been shown to kill or inactivate *M. tuberculosis* in the air. It is used in TB control either as in-duct UVGI (using UVGI lamps inside an air duct or air cleaner) or as upper-air UVGI (mounting UVGI lamps in the upper part of a room). To read how UVGI can help prevent TB from spreading and potential hazards of UVGI, see “Using UVGI to Reduce the Risk of Spreading TB” on page 37

Your shelter's current system should be evaluated for effectiveness and modifications should be made, if needed. Read the following information to help you determine any changes that may work in your situation:

Natural Ventilation

If rooms in your building are not served by a central ventilation system, read "Natural Ventilation and Fans" on page 16 to learn how to check and improve natural ventilation, how to use exhaust and freestanding fans more effectively, and to learn about the advantages and disadvantages of natural ventilation and fans as compared to other types of ventilation.

Methods that help improve natural ventilation in the shelter include:

- Providing fresh outside air to all occupied rooms in homeless shelters
- Keeping doors, windows, and skylights open as often as possible and check that they are easy to open
- Adding fans to increase air mixing and directional airflow. Place them so air movement can be felt in all occupied parts of the room, and keep them running as much as possible
- Providing extra blankets to clients who complain of drafts so that ventilation can be used when the space is occupied
- Increasing ventilation at times when the space is unoccupied if ventilation and fans cannot be used when the space is occupied because they are too noisy or cause unacceptable drafts. Many shelters are closed during part of the day, for example. This provides an opportunity to open windows and doors while running fans at high speed to "air out" dormitories.

Natural ventilation can be unpredictable and may not be practical in cold climates. If this is the case, consider adding a central ventilation system.

To see how one homeless shelter director improved the natural ventilation in her building, see "Case Study: Natural Ventilation and Fans" on page 22.

Central Ventilation

If rooms in your building have an existing central ventilation system, read "Central Ventilation" on page 24 to learn about the various parts of your central ventilation system, how they help control the spread of TB, what to check and how to make improvements, and the advantages and disadvantages of central ventilation.

If you are considering the design of a central ventilation system for a new or an existing building, read "Recommendations for the Design of New Central Ventilation Systems" on page 34.

Methods that help improve existing central ventilation systems in the shelter include:

- Using pleated filters
- Providing outside air intakes
- Setting outside air intakes to the fully open position
- Using thermostats that allow continuous fan operation
- Running ventilation systems continuously whenever the building is occupied
- Providing a pressure gauge for ventilation units that have more than one filter
- Providing natural ventilation to occupied rooms not served by ventilation systems

and to all occupied spaces at times when ventilation systems are broken or otherwise not operating

- Considering the use of in-duct UVGI as a supplement to filtration and outside air dilution.

In addition to the above methods, perform regular checks of each ventilation unit and the rooms that it serves and perform routine upkeep. See “Checking a Ventilation System” on page 32 for a description of the checks to perform, and see “Summary of Ventilation Units Worksheet” on page 152 for a sample checklist that you can use. To learn about central ventilation upkeep, see “Routine Upkeep of Existing Ventilation Systems” on page 33.

To see how one homeless shelter director used these ideas and made immediate low-cost improvements to ventilation in his shelter, read “Case Study: Central Ventilation” on page 36.

Air Filters

There are three types of filters that are used in central ventilation systems:

- High-efficiency particulate air (HEPA) filter
- Pleated ASHRAE 25% efficient filter (MERV 7 or 8)
- Lint filter

See the graph in Figure 3 on page 27 for a comparison of filter efficiency.

A pleated filter is the most suitable type of filter for many recirculating air systems, such as those in homeless shelters. Pleated filters are readily available from hardware stores in sizes that fit most ventilation systems. They are slightly more expensive than lint filters and cause more of an obstruction, which will reduce airflow slightly. To read more about filters, see “Components: Air Filters” on page 26.

HEPA filter units allow you to improve the air quality in a room almost immediately. These units are especially useful in homeless shelters that may have inadequate or no ventilation and limited funds for upgrades.

The following describes ways to use HEPA filter units in your shelter:

- Provide portable HEPA filter units for all unventilated rooms frequented by clients unless the rooms have an operable window or door that is usually kept open
- Place small units off the floor and next to staff so that the purified air they generate is delivered close to the faces of the people that they are used to protect. An ideal location is on a desk or on a file cabinet adjacent to a staff member. Consider the HEPA filter unit primarily as a source of clean air and secondly as a removal device for contaminated air
- Place units evenly throughout crowded rooms so that air movement can be felt in all parts of the room
- Operate HEPA filter units continuously while rooms are occupied by clients and for approximately 1 hour after they leave

To keep HEPA filter units operating efficiently, designate a staff person to be the in-house monitor of the units and to perform routine maintenance. This person should know the basic principles of HEPA filter unit operation and should create a written schedule for changing the filters. To read more about HEPA filter units, how to select suitable units, and their routine upkeep, see “HEPA Filter Units” on page 42.

UVGI

Only an experienced professional, such as a UVGI lamp manufacturer should design and install UVGI in your shelter. This type of installation (and the maintenance of such an installation) requires expertise and equipment that may be difficult and expensive to acquire.

In-duct UVGI is a useful option for a recirculating air system that serves areas at high risk for TB transmission and areas without risk. The UVGI lamps are installed inside an air duct. This type of UVGI is usually less expensive to operate than a 100% outside air system. To read more about this type of UVGI and advantages and disadvantages of in-duct UVGI, see “Components: In-Duct UVGI” on page 29.

Upper-air UVGI is a specialized technology that is particularly appropriate for homeless shelters but can only be used in certain rooms. UVGI lamps are mounted high on walls or hung from the ceiling (at a height of 7 feet), resulting in irradiating and disinfecting the upper-room air. UVGI lamps should not be installed in rooms with ceilings less than 8 feet tall to avoid having people look into the lamps or bump into them. In addition, bunk beds should not be used in rooms that have an upper-room UVGI installation.

When using upper-air UVGI, it is essential that the lamps and radiation levels be checked on a regular basis.

- Have an expert use a radiometer to check the radiation levels in parts of the room where people are likely to be exposed. Radiation levels should be below the NIOSH REL
- If radiation levels are too high in any location, turn off the lamp or lamps causing the high radiation levels. It may be necessary to add non-reflective paint to the ceiling and/or wall, and/or to relocate or replace the fixtures to correct the problem
- Check that lamps are not burned out or broken. If lamps are working, they emit a visible violet blue glow that can be seen from below
- Turn off lamps and check that lamps and fixtures are free of dust and lint
- Check that the radiation level at each fixture meets the lamp manufacturer’s recommendation. Protective clothing or special equipment may be required to take these readings without overexposing the skin or eyes to the radiation. Replace the bulbs if the radiation levels are below the manufacturer’s recommended minimum levels

To read more about upper-air UVGI, how to determine whether a room is suitable, about installation planning, routine upkeep, and the advantages and disadvantages of upper-air UVGI, see “Upper-Air UVGI” on page 38.

Staff Use of Respiratory Protection

A respirator is a CDC/NIOSH approved “mask” that fits over the nose and mouth of the user. In TB control, a respirator is designed to prevent the user from inhaling droplet nuclei containing *M. tuberculosis*.

The OSHA has specific requirements for staff use of respirators. Contact OSHA for additional information. <http://www.osha.gov>

Appendices

This section contains a set of worksheets, forms, and signs that are referenced throughout the manual. Use these items to assist in the assessment of risk; track training, triage criteria and other data; and calculate conversion rates and room clearance times. In addition, the appendices contain a description of air change, and sample “Cover Your Cough” and “Respirator/Room Clearance” signs.

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A. How to Calculate Conversion Rates

Do not count any baseline TST or IGRA results on new hires in either the numerator or denominator. TB transmission at your facility would only be accurately reflected in TST or IGRA results after the baseline.

Only persons who had a negative TST or IGRA result at your facility in the prior year, and have a positive TST or IGRA result this year should be counted in your numerator.

Only persons who had a negative TST or IGRA result at your facility in the prior year should be counted in your denominator.

$$\text{Annual Conversion Rate} = \frac{\text{Total number of persons (except new hires) with newly positive TST or IGRA results obtained/year}}{\text{Total number of persons (except new hires) who had TSTs applied and read/year or IGRAs completed/year}} \times 100$$

To help you judge the risk of TB transmission in your setting compared with the entire facility, you should perform the following two calculations:

1. For each year, note the total number of persons with newly positive TST or IGRA results in your facility (excluding staff in your setting, ex. ED, clinic, etc.). Divide by the number of facility employees (excluding staff in your setting) who received a TST with documented results or who completed an IGRA test.

For example, if seven employees had a positive TST result and you tested a total of 350 employees (in areas other than in your setting), the calculation would be $7/350$, or .02, or 2% conversion rate.

2. For each year, note the number of employees in your setting with newly positive TST or IGRA results. Divide by the total number of employees in your setting who received a TST with documented results or who completed an IGRA test.

For example, if 50 employees were tested and two employees had a positive TST result, the calculation would be $2/50$, or .04, or 4% conversion rate.

These above examples tell you that the conversion rate is higher for employees in your setting than for employees who work elsewhere in your facility. You should compare the conversion rate of the staff in your setting and the rest of the facility from one year to the next to identify any changing trends.

Please see the sample worksheet on the next page which uses the Emergency Department as an example.

Note: Since there is no national, standardized, comparable database against which to evaluate the data for your facility, you must establish your own facility criteria for periodic comparison.

SAMPLE CONVERSION RATE CALCULATION WORKSHEET FOR EDs

ALL INFORMATION ON THIS WORKSHEET IS FOR THE YEAR: _____

1. Facility Conversion Rate for Staff Not in ED

- a. Total number of persons (excluding ED staff and new hires) with newly positive TST or IGRA results obtained/year: a. _____
- b. Total number of persons (excluding ED staff and new hires) who had TSTs applied and read/year or who had IGRA tests completed/year: b. _____
- c. $A \div B =$ c. _____
- d. $C \times 100 =$ d. _____ %
-

2. ED Conversion Rate

- a. Total number of persons in the ED (excluding new hires) with newly positive TST or IGRA results obtained/year: a. _____
- b. Total number of persons in the ED (excluding new hires) who had TSTs applied and read/year or who had IGRA tests completed/year: b. _____
- c. $A \div B =$ c. _____
- d. $C \times 100 =$ d. _____ %
-

The overall conversion rate for staff not working in the ED is _____%. (1d)

The overall conversion rate for ED staff is _____%. (2d)

B. ED TB Triage Evaluation Worksheet

Evaluation is not only a good way to ascertain that your efforts at establishing appropriate triage and fast-tracking procedures have been well implemented, but should also be considered as a good way to begin looking at the practices which are currently being used. This can give you an ED-specific baseline to use as a later comparison.

The easiest and most comprehensive evaluation method we have found is a retrospective review of patient charts. We recommend that you select a random sample of the medical records of patients with confirmed TB who were admitted to your hospital through the ED within the past year. You can quickly develop a sense of what is happening in your ED by using the ED TB Triage Evaluation Worksheet, found on the following page.

Using the ED TB Triage Evaluation Worksheet

SECTION 1 asks for general information about the patient with confirmed TB whose chart is being reviewed.

- **Medical record number:** This is a more private identifier than patient name
- **Patient race/gender/age:** This is optional information, but may allow you to compare your confirmed TB cases with your county's confirmed TB cases
- **Discharge diagnosis in the ED:** This may give you a quick idea of whether TB was a suspected diagnosis after being seen in the ED

SECTION 2 asks for documentation of the time of four specific events:

- **Time of entry:** When did the patient arrive in the ED?
- **Time of triage check-in:** What time was the patient seen by the triage nurse? How long was the interval between arrival and triage?
- **Time of ED admission:** When was the patient placed in an emergency bed? How long was the interval between arrival and admission?
- **Time isolation was initiated:** When was the patient placed in isolation/segregation? How long was the interval between arrival and isolation/segregation?

While all of these times should be documented in the ED record, it often is not done. Sometimes the ED records have no spaces that ask for this information, sometimes the spaces are there but are left blank.

The information in **Section 2** gives you an idea of the effectiveness of early identification efforts.

SECTION 3 asks about documentation of risk factors associated with TB disease. It asks if each risk factor is documented positively, negatively, or not at all. For example, a notation such as:

“Patient’s roommate was diagnosed with TB two months ago”

would be considered positive documentation for recent TB exposure. A notation such as:

“Patient denies recent exposure to anyone with TB”

would be considered negative documentation for recent TB exposure.

A thorough history should contain the basic information asked for in this section. Sometimes, especially when the ED physicians do not admit patients to the hospital, a thorough history is deferred to the admitting physician and is done on the floor after admission. A practice of deferring the history can often contribute to delay in identification and isolation of a patient with TB.

ED TB TRIAGE EVALUATION WORKSHEET

SECTION 1

Medical Record Number	
Patient Age	
Patient Race/Ethnicity	
Patient Gender	<input type="checkbox"/> M <input type="checkbox"/> F
Discharge Diagnosis in ED	

SECTION 2

EVENT	TIME	TIME ELAPSED SINCE ARRIVAL	NOT DOCUMENTED
Time of arrival in ED		0 hours, 0 minutes	<input type="checkbox"/>
Time of triage check-in			<input type="checkbox"/>
Time of ED admission			<input type="checkbox"/>
Time isolation initialed			<input type="checkbox"/>

SECTION 3

HISTORY OF	DOCUMENTED AS YES	DOCUMENTED AS NO	NOT DOCUMENTED
Cough lasting more than 3 weeks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Fever	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Night sweats	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Unexplained weight loss	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hemoptysis (blood in sputum)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Positive TST or IGRA result	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
TB disease	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HIV risk factors	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
HIV infection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other chronic illness (specify: _____)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Homelessness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Immigration from an area of high TB incidence	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Recent TB exposure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

C. Airborne Infection Isolation Room Pressure Monitor Checklist

AIRBORNE INFECTION ISOLATION ROOM PRESSURE MONITOR CHECKLIST

ROOM NAME AND NUMBER _____

MONITOR MANUFACTURER AND MODEL NUMBER _____

This form should be completed annually and updated monthly for each room pressure monitor. Negative pressure should be verified monthly* to validate the monitor. A copy of the completed form should be kept in the Policies and Procedures binder for the department.

MONITOR SETTINGS	
Normal pressure reading (monitor reading with door closed)	_____ " water gauge
Alarm will sound if pressure differential drops to	_____ " water gauge
Time delay	_____ seconds
Remote alarm location(s)	_____

ANNUAL MONITOR CHECKS		
TASK	DATE COMPLETED	SIGNED OFF BY
Monitor calibrated in accordance with manufacturer's requirements		
Confirmed negative pressure using smoke tube testing (this test should be repeated monthly* and signed below to confirm)		
Verified alarm operation (by holding door open or blocking off exhaust grille)		
Alarm sounded after _____ seconds		
Pressure reading at alarm _____ " water gauge		
Monitor use and functions demonstrated to all floor staff		

MONTHLY* NEGATIVE PRESSURE CHECK		
Initials _____ Month/Year_____	Initials _____ Month/Year_____	Initials _____ Month/Year_____
Initials _____ Month/Year_____	Initials _____ Month/Year_____	Initials _____ Month/Year_____
Initials _____ Month/Year_____	Initials _____ Month/Year_____	Initials _____ Month/Year_____
Initials _____ Month/Year_____	Initials _____ Month/Year_____	Initials _____ Month/Year_____

*Daily when in use for suspected or known pulmonary or laryngeal TB

D. Early Detection of TB Questionnaire

EARLY DETECTION OF TUBERCULOSIS QUESTIONNAIRE

This questionnaire will help identify patients who meet this facility's definition of "suspected infectious TB" so that appropriate precautions can be taken. An individual with two or more symptoms of TB, in addition to a prolonged cough, will be considered a suspected infectious TB patient unless the physician has ruled out this diagnosis.

HISTORY/SYMPTOMS	Yes	No	Don't Know
1. Do you have a cough that has lasted longer than 3 weeks?			
2. Have you lost your appetite?			
3. Have you lost weight without dieting?			
4. Have you had fever, chills, or night sweats?			
5. Have you coughed up blood?			
6. Have you been feeling very tired?			
7. Have you ever had a positive tuberculin skin test (TST) result or interferon gamma release assay (IGRA) result?			
8. Have you ever had an abnormal chest x-ray?			
9. Have you recently had the mucous you coughed up tested for TB?			
10. Have you ever been told you had TB?			
11. Have you ever taken medicine for TB?			
12. Have you ever lived with or had close contact with someone who had TB?			

EVALUATOR'S COMMENTS

EXPOSURE CONTROL METHODS IMPLEMENTED

<input type="checkbox"/> Surgical mask on patient Date: _____ Time: _____	<input type="checkbox"/> Given tissues and instructions Date: _____ Time: _____
<input type="checkbox"/> Segregated in room Date: _____ Time: _____	<input type="checkbox"/> Placed in AIIR _____ Date: _____ Time: _____
<input type="checkbox"/> Sign placed on door Date: _____ Time: _____	<input type="checkbox"/> No action required Date: _____ Time: _____

Evaluator's signature _____ Date _____

E. TB Screening Questionnaire for Healthcare Workers

_____ Date Form Complete ____ / ____ / ____
Last Name First Name Middle Initial Mo Dy Yr
Date of Birth ____ / ____ / ____ Social Security Number ____ - ____ - ____
Department _____ Job Title _____ Work Phone _____

.....

1. Please check the general category that best describes your current job title
[Develop facility-specific categories from the examples below]

- Admitting Clerk Housekeeper Maintenance Worker
 Physician RN Respiratory Therapist

2. Check one general category that best describes where you will spend most of the work day
[Develop facility-specific categories from the examples below]

- Admitting/Registration Emergency Room Radiology
 Laboratory Pharmacy Many Locations

3. Were you born in the U.S.A.?

- Yes No

a. If no, what is your country of birth? _____

b. What year did you move to the U.S.A.? 19____ 20____ Don't know

4. Have you traveled or lived outside the U.S.A. in the last 2 years?

- Yes No

a. If yes, where? _____

5. Have you ever had a TB skin test? (Bubble under skin, not four-prong test)

- Yes No Don't know

a. If yes, when was your latest test? ____ / ____ / ____

b. What was the test result?

- Positive Negative Don't know

c. Do you have a copy of this result in writing?

- Yes No Don't know

d. If the test result was positive, what medication(s) did you take?

- Isoniazid None Other _____ Don't know

6. Have you ever had an IGRA blood test?

- Yes No Don't know
- a. If yes, when was your latest test? ____ / ____ / ____
- b. What was the test result?
 Positive Negative Indeterminate Don't know
- c. Do you have a copy of this result in writing?
 Yes No Don't know
- d. If the test result was positive, what medication(s) did you take?
 Isoniazid None Other _____ Don't know

7. Have you ever received BCG vaccine?

- Yes No Don't know

8. Have you ever been treated for TB disease?

- Yes No Don't know
- a. If yes:
1. In what year did you start treatment? 19 ____ 20 ____ Don't know
2. What medication did you take? _____
3. How long did you take this medication? _____

9. Have you ever had a chest x-ray?

- Yes No Don't know
- a. If yes, when was your last chest x-ray? _____

10. Has a health practitioner ever told you that your immune system isn't working right or can't fight infection?

- Yes No Don't know

11. Do you work, volunteer, or live in another facility that provides medical or social services?

- Yes No
- a. If yes, where? _____

12. Have you ever had any of the following symptoms for more than 3 weeks at a time? (Please check all that apply)

- Persistent coughing Excessive fatigue Excessive sweating at night
 Hoarseness Coughing up blood Persistent fever
 Excessive weight loss

Date TST Applied	Initials	Site (RA/LA)	Product Name	Lot #	Expiration Date	Dose (TU)	Date Read	Initials	Induration (mm)
__ / __ / __	_____	_____	_____	_____	__ / __ / __	_____	__ / __	_____	_____
__ / __ / __	_____	_____	_____	_____	__ / __ / __	_____	__ / __	_____	_____

F. Risk Assessment Worksheet for the ED

Please consult the revised version of Appendix B of the CDC guidelines for more detailed risk assessment tools for a variety of settings

RISK ASSESSMENT WORKSHEET

ALL INFORMATION ON THIS WORKSHEET IS FOR THE YEAR: _____

1. Total Number of Confirmed TB Cases in County: _____

2. Total Number of Drug-Resistant TB Cases in County: _____

3. Race/Ethnicity of Confirmed TB Cases in County:

You can compare this pattern to your own ED patients and decide if your patients are similar to or different from the profile of the cases of TB in your county.

Race/Ethnicity				
Number of Confirmed TB Cases				

4. Age Distribution of TB Cases in County:

You can compare this pattern to your own ED patients and decide if your patients are similar to or different from the profile of the cases of TB in your county.

Age Range				
Number of Confirmed TB Cases				

5. Other County-Specific Information: _____

6. Number of Confirmed TB Cases Admitted to the Facility: _____

7. Divide the answer to number 6 by the answer to number 1. Multiply the result by 100.

$$\frac{\text{Total Number of Confirmed TB Cases Admitted to the Facility (Line 6)}}{\text{Total Number of Confirmed TB Cases in County (Line 1)}} \times 100 = \%$$

This gives you an idea of the percentage of the TB cases in your county that were admitted to your facility. Since your facility may draw significant numbers of patients from more than one county, this may be a crude estimate.

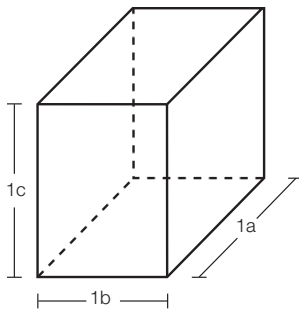
8. How many of the confirmed TB cases admitted to your facility were seen in the ED? _____

G. Room Clearance Time Calculation Worksheet

CONVERSION RATE CALCULATION WORKSHEET

Room or Booth # _____

1. Calculate Room Volume



1a. Room Length 1a. _____ ft

1b. Room Width 1b. _____ ft

1c. Room Height 1c. _____ ft

1d. $1a \times 1b \times 1c = \text{volume}$ 1d. _____ ft³

2. Calculate Air Changes Per Hour (ACH)

2a. Measured exhaust airflow rate 2a. _____ CFM

2b. = $2a \times 60 \text{ minutes}$ 2b. _____ ft³ per hr

2c. = $2b \div 1d$ 2c. _____ ACH

3. Calculate Room Clearance Time

3a. Find the Uncorrected Clearance Time 3a. _____ min.

Using Table 1 of the CDC Guidelines (see next page), follow the first column down until the ACH value on line 2c is found. A removal efficiency of >99% is preferred; for 99% efficiency follow this row horizontally to the second column, ideally the value in the third column (99.9% removal efficiency) should be used. Record this value (the number of minutes).

This is the amount of time that should elapse before staff or other patients enter a sputum induction area (booth, hood, or room) after sputum has been induced on a person with suspected or known infectious TB and the patient has left. Table 2 of the CDC Guidelines should be consulted to ensure that your calculated ACH is appropriate for the type of setting you are working in.

TABLE 1. FROM THE CDC GUIDELINES

Air changes per hour (ACH) and time required for removal efficiencies of 99% and 99.9% of airborne contaminants*

ACH	99%	99.9%
MINUTES REQUIRED FOR REMOVAL EFFICIENCY†		
2	138	207
4	69	104
6	46	69
12	23	35
15	18	28
20	14	21
50	6	8
400	<1	1

* This table can be used to estimate the time necessary to clear the air of airborne *Mycobacterium tuberculosis* after the source patient leaves the area or when aerosol-producing procedures are complete.

† Time in minutes to reduce the airborne concentration by 99% or 99.9%.

H. Summary of Ventilation Units Worksheet

The following form should be completed to create a handy summary of information on the ventilation units in a building. A sample of the completed form is also included.

SUMMARY OF VENTILATION UNITS			
UNIT LOCATION	ROOMS SERVED BY UNIT	THERMOSTAT LOCATION	FILTERS (NUMBER) & SIZE

Samples:

SUMMARY OF VENTILATION UNITS

UNIT LOCATION	ROOMS SERVED BY UNIT	THERMOSTAT LOCATION	FILTERS (NUMBER) & SIZE
Attic above men's dorm	Women's and men's dorm	Large men's dorm	(1) 15" x 27" x 2"

Filter is behind return grille in large men's dorm.
 Spare filters are stored in janitor's closet.
 Access to unit is through ceiling hatch in men's dorm.

Janitor's closet in kitchen	Kitchen, meeting room, dining room, women's bathroom	Dining room	(1) 24 $\frac{1}{2}$ " x 19 $\frac{1}{2}$ " x 2"
-----------------------------	--	-------------	--

Filter is at unit; undo four screws to change.
 Spare filters are stored in janitor's closet.

Roof above director's office	Offices, women's dorm, small men's dorm, men's bathroom	Women's room	(1) 24 $\frac{1}{2}$ " x 19 $\frac{1}{2}$ " x 2"
------------------------------	---	--------------	--

Filter is near unit on roof; ladder to get to roof is in shed.
 Spare filters are stored in janitor's closet.

I. TB Infection Control Training Record

TUBERCULOSIS (TB) INFECTION CONTROL TRAINING RECORD

Training Date _____ Instructor _____

	Employee Initials
1. I know where the tuberculosis (TB) infection control plan (ICP) is kept and how to obtain a copy.	[]
2. I know how TB is spread from person-to-person.	[]
3. I know the signs and symptoms of TB.	[]
4. I know the difference between TB infection and TB disease.	[]
5. I am aware that health-care workers (HCWs) are at risk for TB infection and TB disease.	[]
6. I know that diseases and drugs that affect the immune system increase the risk of TB infection progressing to TB disease.	[]
7. I am responsible for following work practices discussed in this class and in the TB ICP.	[]
8. I understand the purpose of testing for <i>M. tuberculosis</i> infection and TB symptom screening.	[]
9. I know what to do if I see a coughing patient who has other signs and symptoms of TB.	[]
10. I know that treatment for TB infection can reduce the risk of progressing to TB disease.	[]
11. I know when employees must wear respirators for protection against TB transmission.	[]
12. I know which environmental controls (ventilation, filters, ultraviolet lamps, AIRRs) are in place at this facility.	[]
13. I know where to find safety and protective equipment (respirators, gloves), how to use these devices, and how to dispose of them after use.	[]
14. I know what multidrug-resistant (MDR) TB is.	[]
15. I have had an opportunity to have my questions answered about the above topics.	[]

Employee Name (Please PRINT)

Employee Department

Signature

Date

J. Triage Criteria for Respiratory Isolation

ADAPTED FROM HARBOR-UCLA TRIAGE CRITERIA RESPIRATORY ISOLATION OF PULMONARY TUBERCULOSIS (RIPT)

Chief Complaint _____ Date _____

CHECK ALL APPLICABLE RISK FACTORS, SYMPTOMS, OR COMPLAINTS

RISK FACTORS:

- (2) HIV Infection
- (1) Male Homosexual
- (1) Foreign-Born
- (2) Homeless or in Shelter
- (1) Intravenous Drug User
- (4) History of TB Now or at Any Time In the Past (even if on meds)
- (2) Incarcerated Within Last 2 Years
- (2) Newly TST or IGRA results Positive (within 2 years) or History of Recent TB Exposure

SYMPTOMS/COMPLAINTS:

- (3) Cough (any duration)
- (2) Fever or Chills or Night Sweats
- (2) Weight Loss >10 Pounds
- (5) Hemoptysis (blood in sputum)

Total Points _____

RIPT FOR 5 OR MORE POINTS

Add up points. Respiratory Isolation scale scores of 5 or more points indicate a need for immediate mask and respiratory isolation. For patients meeting criteria, please order a posterior-anterior (PA) and lateral chest x-ray and have an emergency medicine senior resident or emergency medicine attending physician record their reading of the chest x-ray and their decision regarding the need for continued isolation below. This form should be attached to the nursing notes for the patient and, when the chart is broken down, returned to the envelope by the clerk's desk. All patients with scores of 5 or more must be entered in the RIPT logbook.

Name _____
LAST
FIRST
MI

Assigned RIPT Number _____

CHEST X-RAY RESULT

(To Be Recorded By Physician Reading Film, Check All That Apply):

- | | |
|---|---|
| <input type="checkbox"/> Upper Lobe Infiltrate(s) | <input type="checkbox"/> Infiltrate Not in Upper Lobe(s) |
| <input type="checkbox"/> Diffuse Infiltrate or Interstitial Pattern | <input type="checkbox"/> Pleural Effusion |
| <input type="checkbox"/> Mediastinal Lymphadenopathy | <input type="checkbox"/> Mass or Coin Lesion (not cavitory) |
| <input type="checkbox"/> Other Findings (hyperinflation, rib fractures, etc.) | <input type="checkbox"/> Cavitory Lesion |
| <input type="checkbox"/> Normal | |

K. What Does Air Change Mean?

One **air change** occurs in a room when a quantity of air equal to the volume of the room is supplied and/or exhausted.

Air change rates are units of ventilation that compare the amount of air moving through a space to the volume of the space. Air change rates are calculated to determine how well a space is ventilated compared to published standards, codes, or recommendations.

Air changes per hour (ACH) is the most common unit used. This is the volume of air (usually expressed in cubic feet) exhausted or supplied every hour divided by the room volume (also usually expressed in cubic feet).

Airflow is usually measured in cubic feet per minute (CFM). This is multiplied by 60 minutes to determine the volume of air delivered per hour (in cubic feet).

To calculate room volume (in cubic feet), multiply room height (in feet) by the room area (in square feet). Room area is the room width (in feet) times the room length (in feet).

$$\text{Air Changes per Hour (ACH)} = \frac{\text{airflow per hour}}{\text{room volume}} = \frac{\text{CFM} \times 60 \text{ minutes}}{\text{cubic feet}}$$

A room may have two airflow values, one for supply and another for exhaust. (The airflow difference between these two values is called the offset.) To calculate the air change rate, use the greater of the two airflow values. For AIIRs, the exhaust should be greater than the supply.

Example of Air Change per Hour Calculation

An AIIR is 200 square feet in area and has a ceiling height of 9 feet. Airflow measurements indicate a supply airflow of 360 CFM and an exhaust airflow of 480 CFM. Does this room comply with the CDC recommendation that AIIRs have a minimum airflow rate of 12 ACH for new construction?

$$\text{Air change rate: } \frac{480 \text{ CFM} \times 60}{200 \text{ ft}^2 \times 9 \text{ ft}} = 16 \text{ ACH}$$

$$\text{Exhaust air offset: } 480 \text{ CFM} - 360 \text{ CFM} = 120 \text{ CFM}$$

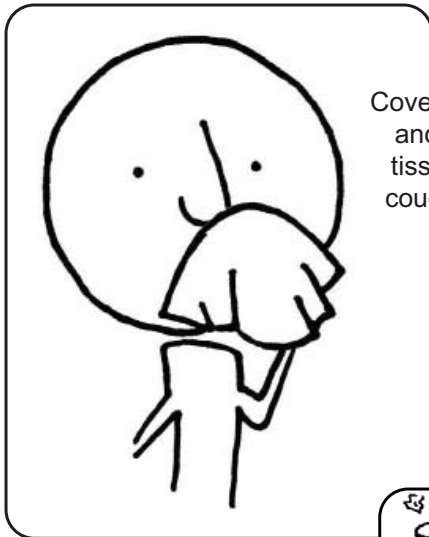
As you can see, this room exceeds the CDC minimum requirement. The offset of 120 CFM is made up by air from outside the room.

L. Sample Signs

COVER YOUR COUGH: ENGLISH.....	158
COVER YOUR COUGH: ENGLISH.....	159
COVER YOUR COUGH: CHINESE.....	160
COVER YOUR COUGH: TAGALOG.....	161
COVER YOUR COUGH: RUSSIAN.....	162
COVER YOUR COUGH: VIETNAMESE.....	163
COVER YOUR COUGH: SPANISH.....	164
COVER YOUR COUGH: ENGLISH.....	165
RESPIRATORY PROTECTION REQUIRED.....	166
ROOM CLEARANCE.....	167

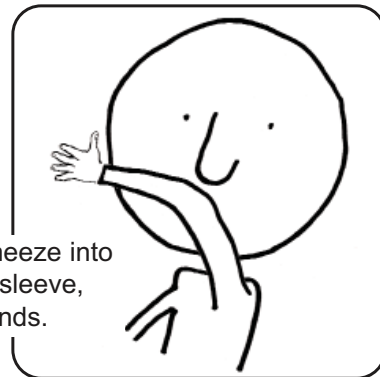
Stop the spread of germs that make you and others sick!

Cover your Cough

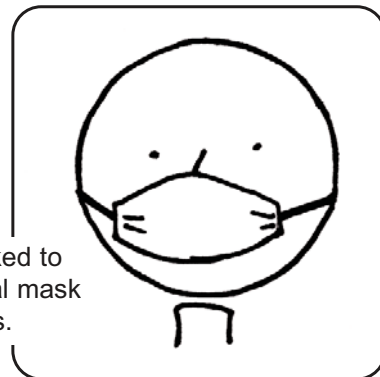


Cover your mouth and nose with a tissue when you cough or sneeze

or cough or sneeze into your upper sleeve, not your hands.



Put your used tissue in the waste basket.



You may be asked to put on a surgical mask to protect others.

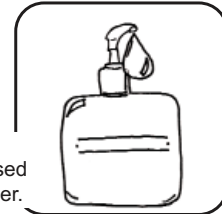
Clean your Hands

after coughing or sneezing.



Wash hands with soap and warm water for 20 seconds

or clean with alcohol-based hand cleaner.



Minnesota Department of Health
717 SE Delaware Street
Minneapolis, MN 55414
612-676-5414 or 1-877-676-5414
www.health.state.mn.us





P L E A S E

**COVER YOUR MOUTH
WHEN YOU COUGH**



**咳嗽時，請
蓋住您的口**

Kapag
umuboo,
paki-takpoan
ang inyong
bibig





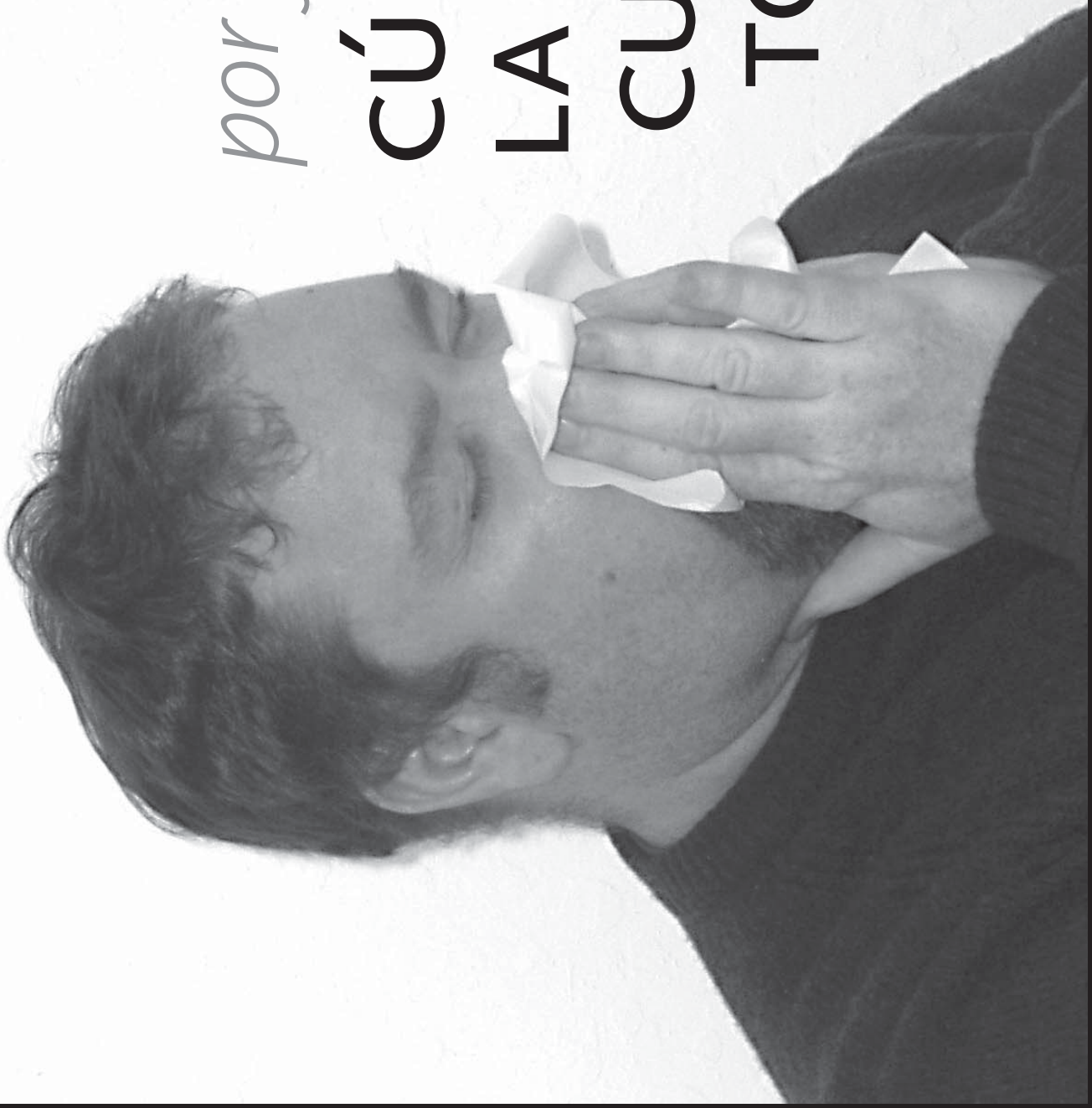
**При кашле,
пожалуйста,
прикрывайте рот.**

Khi ho
xin che
miệng
lại



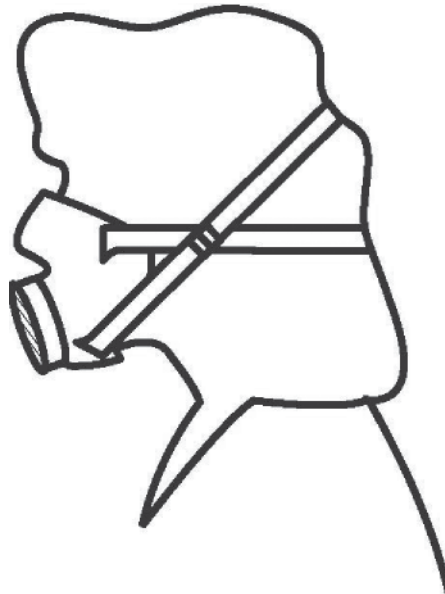
por favor...

**CÚBRASE
LA BOCA
CUANDO
TOSA.**



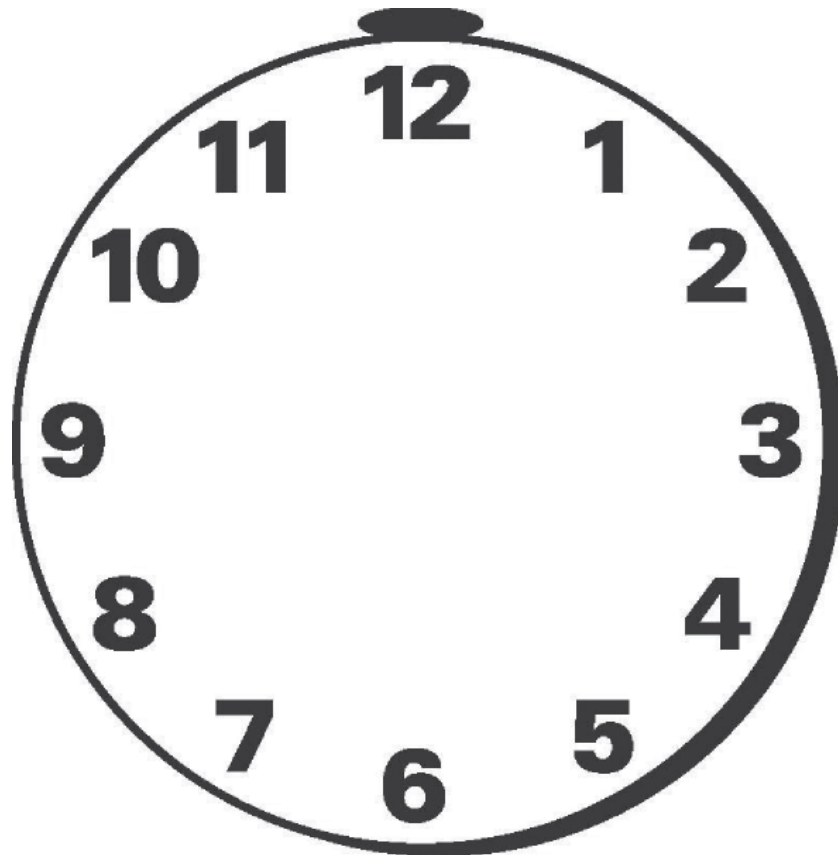


Please cover
your cough



**WEAR RESPIRATOR TO
PROTECT YOUR LUNGS**

**N-95 RESPIRATOR
MUST BE WORN
WHEN ENTERING
THIS ROOM UNTIL...**



**Set clock for ____ hour and ____ minutes
clearance time between patients**

Glossary

The following terms are defined or used in this manual. Terms are listed in alphabetical order, followed by their definition.

ACH: Air changes per hour. This is a measurement commonly used to express the ventilation rate of a space. ACH is the number of times an amount of air equal to the volume of the space is exhausted or supplied every hour.

BAMT: Blood assay test for *Mycobacterium tuberculosis*. This is a general term which refers to recently developed in vitro (*iv*) diagnostic tests that assess for the presence of infection with *M. tuberculosis*, the term includes but is not limited to IGRA's. QuantiFERON®-TB Gold is the IGRA that was approved by the FDA in 2005 and is approved by the CDC as a diagnostic test for TB infection.

Boosted Reaction: A positive reaction to a tuberculin skin test due to a boosted immune response from a skin test given up to a year earlier. Occurs in people who were infected a long time ago and whose ability to react to tuberculin has lessened.

CFM: Cubic feet per minute. This is a measurement commonly used to express an airflow quantity. Airflow hoods usually provide readouts in CFM.

Diffuser: Mechanical device, installed on a ceiling, that supplies air to a room.

Droplet nuclei: Microscopic particles (1-5 microns in size) that can become airborne when a person coughs, sneezes, shouts, sings, breathes, or talks. Droplet nuclei produced by a person who has TB disease of the lungs or larynx in an infectious state can remain airborne for a long time and can spread TB to others.

Exhaust air: Air that is removed from a building by a fan system, as opposed to air that is removed from a space and then recirculated or returned.

Fit Check: Should be conducted each time a respirator is put on to determine if it is properly sealed to the face.

Fit Test: Evaluation of how a respirator fits conducted by trained personnel. Includes the use of scented solution and the determination of whether the employee can detect the odor. Should be conducted prior to the use of a respirator and annually thereafter.

Grille: Mechanical device that usually removes exhaust or return air from a room. Grilles are usually on the ceiling but can be on the wall or floor. If a grille is on a ceiling or floor or low on a wall, it is usually for exhaust or return air. However, if a grille is high on a wall, it can be exhaust, return, or supply.

HEPA filter: High-Efficiency Particulate Air filter. This is a filter that is capable of removing 99.97% of particles 0.3 micron in diameter or greater. HEPA filters remove all particles in the size range of TB droplet nuclei.

HEPA filter unit: Self-contained device consisting mainly of a HEPA filter, a prefilter, and a fan. These units can be used to provide clean air to supplement a building ventilation system.

HIV: Human Immunodeficiency Virus. This is the virus that causes AIDS.

IGRA: Interferon gamma release assay. This is a type of blood test that detects cell-mediated immune response to this cytokine. In the U.S., QuantiFERON®-TB Gold is a currently available IGRA.

Index Patient: The first case who comes to attention as an indicator of a potential public health problem.

In-duct UVGI: The installation of ultraviolet germicidal irradiation (UVGI) lamps in a return or exhaust air duct to kill any *M. tuberculosis* that may be in the air stream.

MDR TB: Multidrug-resistant TB. TB that is resistant to Isoniazid and Rifampin. More difficult to treat than drug-susceptible TB.

Mycobacterium tuberculosis (M. tuberculosis): The germ that causes TB.

Nosocomial: Infections which are a result of treatment in a hospital or hospital-like setting, but secondary to the patient's original condition.

OSHA 300 log: Used by employers to record all work-related injuries and illnesses.

PPD: Purified Protein Derivative. It is the substance used in the Mantoux TB skin test, which is the accepted standard method of TB skin testing. Commonly, TB skin tests are referred to as TSTs.

Recirculation: Ventilation system in which supply air includes air that has been previously removed from an interior space.

Return air: Air that is removed from a space by a mechanical system, but not all of it is discharged directly outdoors. This air is usually returned to the mechanical system, where a portion of it is exhausted. The remainder is diluted with some outdoor air, filtered, conditioned (or heated), and then distributed.

Short-circuiting: Occurs when clean air is removed before it has mixed well with room air, such as when the exhaust is located right next to the supply of incoming air.

Stagnation: Occurs when part of the room does not benefit from the fresh supply air or in a room that does not have any ventilation.

Supply air: Air that is introduced into a space by a mechanical system.

TB control measures: Steps taken to reduce the risk of TB transmission. TB control measures are divided into a hierarchy: (1) administrative (work practice) controls, (2) environmental controls, and (3) respiratory protection controls.

TST: Tuberculin Skin Test. Refers to administration of the Mantoux TB skin test and replaces the term 'PPD.'

Upper-air UVGI: Refers to the use of UV lamps directly in the upper part of a room.

UVGI: Ultraviolet Germicidal Irradiation. The use of ultraviolet radiation to kill or inactivate microorganisms.

UVGI lamps: Lamps that kill or inactivate microorganisms by emitting ultraviolet germicidal irradiation, predominantly at a wavelength of 254 nanometers. UVGI lamps are used in ceiling or wall fixtures for upper-air UVGI and inside air ducts or air cleaners for in-duct UVGI.

Ventilation: Movement of air in a building and replacement of air with air from outside.

Ventilation rate: Quantity of air that is removed from or supplied to a room. It is usually expressed in air changes per hour (ACH).

XDR TB: Extensively Drug-resistant TB. MDR TB that is also resistant to fluoroquinolones and at least one of three injectable drugs (i.e., amikacin, kanamycin, or capreomycin).

Resources

This section contains a list of resources that provide more information about the topics covered in this manual.

Web Sites

- American Society for Healthcare Engineering of the American Hospital Association: <http://www.ashe.org>
- California Tuberculosis Controllers Association: <http://www.ctca.org>
- Centers for Disease Control and Prevention (CDC): <http://www.cdc.gov/tb>
- CDC Slide Set—Guidelines for Preventing the Transmission of *M. tuberculosis* in Health-Care Settings, 2005: <http://www.cdc.gov/tb/pubs/slidesets/InfectionGuidelines/default.htm>
- CDC Revised Version of Appendix B: Tuberculosis (TB) risk assessment worksheet: http://www.cdc.gov/tb/pubs/mmwr/Maj_guide/AppendixB_092706.pdf
- Francis J. Curry National Tuberculosis Center: <http://www.nationaltbcenter.edu>
- Heartland National Tuberculosis Center: <http://www.heartlandntbc.org>
- National Institute for Occupational Safety and Health (NIOSH): <http://www.cdc.gov/niosh/>
- National Tuberculosis Controllers Association: <http://www.ntca-tb.org>
- New Jersey Medical School Global Tuberculosis Institute: <http://www.umdnj.edu/globaltb/home.htm>
- Occupational Health and Safety Administration: <http://www.osha.gov>
- Southeastern National Tuberculosis Center: <http://sntc.medicine.ufl.edu>
- World Health Organization—WHO Tuberculosis Site: <http://www.who.int/tb/en>

Sources for Triage Checklists and Algorithms

El-Solh A, Mylotte J, Sherif S, et al. Validity of a decision tree for predicting active pulmonary tuberculosis. *Am. J Respir Crit Care Med.* May 1997;155(5):1711-1716.

Molitor L, Rowe JA. Triage decisions: A 25-year-old woman with productive cough. *J Emerg Nurs.* June 1995; 21(4):362-363.

Pegues CF, Johnson DC, Pegues DA, et al. Implementation and evaluation of an algorithm for isolation of patients with suspected pulmonary tuberculosis. *Infect Control Hosp Epidemiol.* July 1996;17(7): 412-418.

References

- 2001 Triennial Edition of the California Code of Regulations, Title 24: California Mechanical Code. Apr 2004; Title 24, Part 4.
- American Association for Respiratory Care. Clinical Practice Guideline. Respiratory Care. 1996;41(7):647-653.
- The American Institute of Architects and the Facilities Guidelines Institute. Guidelines for Design and Construction of Hospital and Healthcare Facilities, 2001. Washington, DC: American Institute of Architects Press, 2001.
- American National Standards Institute and American Society of Heating, Refrigerating, and Air-conditioning Engineers, Inc. Standard 62-2004, Ventilation for Acceptable Indoor Air Quality. 2004.
- American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Handbook 2004: HVAC Systems and Equipment. Chapter 24: Air Cleaners for Particulate Contaminants. 2004:25.
- American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. Handbook 2003: HVAC Applications. Chapter 7: Healthcare Facilities. 2003:8.
- Asimos AW, Kaufman JS, Lee CH, et al. Tuberculosis exposure risk in emergency medicine residents. *Acad Emerg Med*. Oct 1999;6(10):1044-1049.
- Association for Professionals in Infection Control and Epidemiology, Inc. (APIC). St. Louis, Missouri: Mosby Year Book, Inc;1996.
- Bock NN, McGowan JE Jr., Ahn J, et al. Clinical predictors of tuberculosis as a guide for a respiratory isolation policy. *Am J Respir Crit Care Med*. Nov 1996;154(5):1468-1472.
- Cal/OSHA. California Division of Occupational Safety and Health Policy and Procedures Manual: Blood-borne Pathogens Standards. California Code of Regulations, Title 8, Section 5193. Dec 1991.
- Cal/OSHA. California Division of Occupational Safety and Health Policy and Procedures Manual: Interim Tuberculosis Control Enforcement Guidelines. Issued Dec 1992, revised April 1997:P&P C-47.
- Campos Communications. *Community Clinic Fact Book*, 1992 Edition. San Francisco, CA, Mar 1994.
- Centers for Disease Control and Prevention. Guidelines for preventing the transmission of *Mycobacterium tuberculosis* in health-care settings, 2005. MMWR2005; 54 (No.RR-17), URL: <http://www.cdc.gov/mmwr/pdf/rr/rr5417.pdf>
Errata URL : <http://www.cdc.gov/tb/pubs/mmwr/Errata09-25-06.pdf>
- Cohen R, Muzaffar S, Capellan J, et al. The validity of classic symptoms and chest radiographic configuration in predicting pulmonary tuberculosis. *Chest*. 1996;109:420-423.
- Francis J. Curry National Tuberculosis Center. Tuberculosis Infection Control Plan Template for Jails. 2002. http://www.nationaltbcenter.edu/products/product_details.cfm?productID=WPT-09
- Griffith DE, Hardeman JL, Zhang Y, et al. Tuberculosis outbreak among healthcare workers in a community hospital. *Am J Respir Crit Care Med*. Aug 1995;152(2):808-811.
- Haley CE, McDonald RC, Rossi L, et al. Tuberculosis epidemic among hospital personnel. *Infect Control Hosp Epidemiol*. May 1989;10(5):204-210.
- El-Solh A, Mylotte J, Sherif S, et al. Validity of a decision tree for predicting active pulmonary tuberculosis. *Am J Respir Crit Care Med*. 1997; 155(5):1711-1716.
- Mathur P, Sacks L, Auten G, et al. Delayed diagnosis of pulmonary tuberculosis in city hospitals. *Arch Intern Med*. 1994;154(3):306-310.
- Moran GJ, Fuchs MA, Jarvis WR, et al. Tuberculosis infection control practices in United States emergency departments. *Ann Emerg Med*. Sept 1995; 26(3):283-289.
- Moran GJ, McCabe F, Morgan MT, et al. Delayed recognition and infection control for tuberculosis patients in the emergency department. *Ann Emerg Med*. Sept 1995; 26(3):290-295.
- OSHA. Health Enforcement Procedures and Scheduling for Occupational Exposure to Tuberculosis. CPL 2.106, Feb 1996.
- Sokolove PE, Lee BS, Krawczyk JA, et al. Implementation of an emergency department triage procedure for the detection and isolation of patients with active pulmonary tuberculosis. *Ann Emerg Med*. Apr 2000; 35(4):327-336.
- Sokolove PE, Mackey D, Wiles J, et al. Exposure of emergency department personnel to tuberculosis: PPD testing during an epidemic in the community. *Ann Emerg Med*. Sept 1994; 24(3):418-421.



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