USACHPPM

Readiness thru Health

Guidelines on the Design and Operation of HVAC Systems in Disease Isolation Areas

TG 252

November 2000

U.S. Army Center for Health Promotion and Preventive Medicine
5158 Blackhawk Road
Aberdeen Proving Ground, MD 21010-5403

Guidelines on the Design and Operation of HVAC Systems in Disease Isolation Areas:

NOTE: Use of registered trademarks and references provided by private corporations are meant for informational purposes only. The U.S. Army does not imply endorsement of any particular company.

Chapter 1. Introduction

Section 1-1. Purpose.

1-1.1. This technical guide (TG) provides recommended guidance to individuals responsible for the design and maintenance of areas used to house and treat disease isolation patients. These individuals include architects, design engineers, hospital facility managers, hospital safety managers, industrial hygienists, and hospital maintenance staff.

1-1.2. The guide outlines recommended practice for the construction and regular maintenance of Heating, Ventilation, and Air-Conditioning (HVAC) systems installed in disease isolation areas to include bedrooms, treatment rooms, operating rooms, autopsy rooms, and waiting areas. The information provided is pertinent to new and existing areas.

1-1.3. This guide also provides information on alternate engineering controls that may be used to supplement existing HVAC designs.

1-1.4. This document is meant to incorporate guidelines provided by nationally recognized agencies and military design offices into a central document for new and existing facilities. It is intended to be used as a supplement to design criteria published by the DoD and other national agencies and organizations. It is not meant to supercede design information provided by these governing agencies or organizations.

Section 1-2. References. Appendix A lists the publications pertaining to this technical guide.

Section 1-3. Abbreviations. Appendix B lists the various abbreviations used in this technical guide.

Section 1-4. Technical Assistance. Any questions or comments regarding this information may be addressed to the Industrial Hygiene Field Services Program, ATTN: MCHB-TS-OFS, 5158 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5403. Our office may be reached at DSN 584-3118 or 410-436-3118, or via e-mail: chppm-ihfsp@apg.amedd.army.mil. Appendix C contains a USACHPPM request form, which may be used to inquire about additional information or mission services.

Chapter 2. Background

Section 2-1. Definition of Disease Isolation. A disease isolation room is an area where infectious patients, requiring segregation from the remainder of the patient population, may be housed or treated. The emphasis of isolation room design is protecting the health care worker from nosocomial transmission of diseases. Patients in these isolation rooms might suffer from chicken pox, measles, severe influenza, and tuberculosis (TB).

Section 2-2. Relationship Between Disease and Tuberculosis Isolation Rooms. The proper design and maintenance of disease isolation rooms is an effective strategy for protecting workers from exposure to infectious diseases. This guide specifically targets exposure from mycobacterium tuberculosis. Recent changes to new military construction criteria require that all disease isolation rooms be designed to hold TB patients. Any discrepancies in this technical guide concerning TB and general isolation rooms in existing facilities will be appropriately noted.

Section 2-3. Information on the Rise in Tuberculosis Cases.

2-3.1. TB kills more youth and adults than any other infectious disease in the world today.[1] Every second, someone in the world is infected by the airborne spread of TB bacilli. It is estimated that in 1998, one-third of the world's population was infected with the TB bacillus.[2]

2-3.2. Within the United States, tuberculosis had been reduced to extinction by the mid-1980s. A conference was held in 1985, to plan the final eradication of TB in the United States.[3] However, between the years of 1985 to 1992, there was a 20 percent increase in the number of TB cases in the United States.[4] This rapid increase has been contributed to various factors: neglect in fighting the disease, the increase in the number of AIDS cases, drug-resistant bacteria strains, poverty, homelessness, drug abuse, and increased international travel.[5]

2-3.3. The concerns of possible exposure to infectious diseases are greater in facilities, such as health care and correctional occupancies. A survey of 763 U.S. hospitals in 1992 concluded that 88% had admitted TB patients. According to the survey, 70% of the hospitals had isolation rooms that met criteria set forth by the Center for Disease Control (CDC). Where isolation rooms were present, 45% of the facilities kept doors open some

---

[1] World Health Organization. Tuberculosis. Fact Sheet No. 104, February 1998, http://www.who.int.

[2] World Health Organization. Tuberculosis.

[3] Mayo Clinic. Tuberculosis – On the Rebound?. Newsletter, June 1997, http://www.mayohealth.org.

[4] American Industrial Hygiene Association. White Paper on Occupational M. Tuberculosis. 22 March 1995, http://www.aiha.org/papers/tb2.html.

[5] Mayo Clinic. Tuberculosis – On the Rebound?.

or most of the time with patients in these rooms, and only 47% of the facilities routinely checked for negative air pressure. TB had been transmitted to workers at 13% of the 763 hospitals surveyed.[6]

2-3.4. In 1998, it was estimated that worldwide, more people would die of TB than in any other year, resulting in 2 to 3 million casualties.[7] Recent outbreaks have been occurring in Eastern Europe and Southeast Asia. Some less-industrialized countries have 50% of their populations infected with the TB bacillus. However, in the United States, the rate of new cases has leveled off.[8] Despite the stunted growth of TB in the United States, the alarming rate of worldwide cases cannot be ignored, especially with servicemen stationed overseas.

Section 2-4. OSHA Proposed TB Standard. In November 1997, Occupational Safety and Health Administration (OSHA) published a proposed rule to control TB exposure, based in principle on guidelines provided by the CDC and other government organizations, including the U.S. Army. The standards proposed by OSHA would be enforceable nationwide, once finalized, unlike the published CDC guidelines. OSHA estimates that as many as 13 million Americans are currently infected with the TB bacteria, with about 5 million of those exposures occurring at work.[9]

Section 2-5. Guidance from the Office of the Surgeon General. In May 1998, the OTSG published a memorandum establishing Army Medical Department policy for the design and construction of inpatient TB isolation rooms.[10] The criteria described in this memorandum will be detailed within this document.

Section 2-6. Purpose. This technical guide was developed to consolidate the information concerning isolation room design provided by OSHA, CDC, USACE, and other nationally recognized organizations, such as ASHRAE, into an easily referenced medium. This document provides information on HVAC systems in inpatient bedrooms and treatment areas.

Section 2-7. Definitions.

2-7.1. Volumetric Flow Rate (Q). The volumetric flow rate is a measurement of the volume of air into an area per unit of time. For the purposes of this document, Q is

---

[6] American Industrial Hygiene Association. White Paper on Occupational M. Tuberculosis.

[7] World Health Organization. Tuberculosis.

[8] Mayo Clinic. Tuberculosis – On the Rebound?.

[9] Safetyadvantage. OSHA News. December, 1998, http://www.safetyadvantage.com.

[10] Office of the Surgeon General. Policy Memorandum – Design and Construction of Inpatient TB Isolation Rooms in Army Medical Treatment Facilities. 1 May 1998.

expressed in cubic feet per minute (cfm). The symbol Qe refers to the volumetric flow rate of exhaust air. The symbol Qs refers to the volumetric flow rate of supply air.

2-7.2. Pressurization in a room is categorized as either "positive," when Qs > Qe, or negative, when Qs < Qe. Neutral pressure occurs when Qs = Qe. The percentage of pressurization can be calculated using the following formulas:

When Qs > Qe: % Positive Pressure = ((Qs-Qe)/Qs) * 100.
When Qs < Qe: % Negative Pressure = ((Qe-Qs)/Qe) * 100.

2-7.3. Negative pressure is achieved by balancing the exhaust airflow by 10% or 50 cfm greater than the supply airflow. This should establish a pressure difference of at least 0.001 inches of water.[11]

2-7.4. Air exchanges in each room shall be measured with the following equation:

$$\#\text{ of ACH} = \frac{\text{Qe,s (Cubic Feet / Minute) * 60 (Minutes / hour)}}{\text{Volume of Room (Cubic Feet)}}$$

The number of air exchanges in a room under positive pressure (Qs > Qe) is determined by using Qs in the above equation. The number of air exchanges in a room under negative pressure (Qs < Qe) is determined by using Qe in the above equation.

[11] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities. 1994. MMWR 1994,43(No. RR-13), p. 77, http://www.cdc.gov.

Chapter 3. HVAC Design Guidelines for New Disease Isolation Bedrooms

Section 3-1. General.

3-1.1. These requirements apply to new facilities and to existing facilities scheduled for major renovations. During major projects, care should be taken to ensure isolation rooms and suites are designed in accordance with the most current guidance from military handbooks and other nationally recognized standards. Examples of major renovation may include, but are not limited to: HVAC system upgrades, architectural upgrades which may detail the redesign of current inpatient areas, and major life safety upgrades which may adversely impact the construction of the facility.

3-1.2. All new disease isolation bedrooms will have the capacity to house TB inpatients. The HVAC design requirements are the same for both "general" disease and TB isolation rooms.

3-1.3. Supply, return, and exhaust ventilating systems serving isolation rooms shall be arranged for either delayed automatic or manual connection to the equipment branch of the emergency power system.[12]

Section 3-2. Pressurization.

3-2.1. If equipped with an anteroom, between the corridor and isolation bedroom, the bedroom shall be under negative pressure, with respect to the anteroom. The anteroom shall be under negative pressure, with respect to the corridor. The anteroom shall be provided a minimum 10% negative pressure.

3-2.2. The disease isolation bedroom shall be under negative pressure. The bedroom shall be provided a minimum 20% negative pressure. [13]

3-2.3. The bathroom shall be under negative pressure, with respect to the isolation bedroom. The bathroom shall be provided 100% negative pressure, thus no supply registers shall be located within the bathroom. (Note: This simply means that smoke from a tube held at the base of the door between the bathroom and the isolation bedroom will flow into the bathroom. It does not imply that there must be a greater **quantity** of air (cfm) exhausted from the bathroom than from the isolation bedroom). If desired, a louvered door may be installed to the bathroom, in accordance with National Fire Protection Association (NFPA) criteria, to provide supply air from the bedroom.

---

[12] National Fire Protection Association. National Electric Code (NFPA 70). 1999, Quincy, MA, http://www.nfpa.org.

[13] Defense Medical Facilities Office. MIL-HBDK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria. 1996 (New Version Under Revision), Falls Church, VA.

3-2.4. The door from the corridor to the anteroom (if provided) or isolation room shall be permitted to have a clearance no greater than 1" from the finished floor, to allow for air pressurization. This is in accordance with the Life Safety Code and Joint Commission on the Accreditation of Healthcare Organizations (JCAHO) interpretations.[14] All construction gaps surrounding the suite shall be properly sealed. In the past, improperly protected partition-ceiling joints, floor joints, and gaps around window seals have made it difficult to establish a design negative pressure.

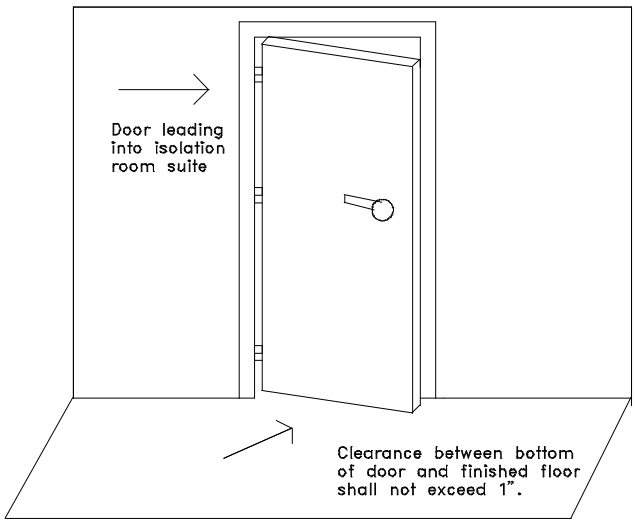


Figure 1. Corridor Door Clearance

3-2.5. It is essential that doors and windows remain closed to ensure proper pressurization ratios. Doors leading into the isolation room and anteroom shall be equipped with self-closing devices. Doors shall not be held open with door wedges, chocks, or other similar devices under any circumstances.[15]

3-2.6. "Switchable" HVAC systems in isolation bedrooms from negative (disease isolation) to positive (protective isolation) and vice versa, shall be prohibited.

Section 3-3. Comfort.

3-3.1. HVAC supply systems shall be designed to maintain a temperature of 75° Fahrenheit year round in the isolation bedroom. It is recommended that each patient room have an individual temperature control. Anterooms, if provided, and bathrooms

[14] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101). 2000, Quincy, MA, http://www.nfpa.org.

[15] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

shall be maintained at 78° in the summer and at a design temperature of 72° in the winter.[16]

3-3.2. It is recommended that isolation bedrooms and anterooms, if provided, maintain 50% relative humidity levels in the summer and 30% relative humidity levels in the winter.[17]

3-3.3. All patient rooms shall be provided with an outside window, in accordance with NFPA criteria. The maximum allowable sill height shall not exceed 36" above the floor.

3-3.3.1. The window sill in special nursing care areas, such as ICUs, where disease isolation rooms may be located, shall not exceed 60" above the floor.

3-3.3.2. Windows in atrium walls shall be considered outside windows for the purposes of this requirement.[18]

Section 3-4. Airflow Patterns.

3-4.1. HVAC systems shall be designed to provide optimal airflow patterns. Systems shall be designed to prevent "short-circuiting," defined as airflow directly from the supply to the exhaust without adequate mixing with the air in the room. Air stagnation shall be prevented with proper design. The air supply should originate where health care workers are likely to work, and then flow across the infectious patient, and into the exhaust register.

3-4.2. Two recommended methods to provide air movement in the isolation bedroom are the Horizontal and Vertical Quasi-Laminar Airflow Methods (see Figure 2). Airflows originate away from the patient via non-aspirating, unidirectional diffusers then pass into the areas occupied by the infectious patient, and are then exhausted. The Vertical Quasi-Laminar Method is recommended in areas where the supply air temperature is generally lower than the ambient room temperature. In both designs, health care workers are not positioned between the infectious patient and the exhaust registers.[19]
NOTE: In cold climates, a perimeter heating system may be required to prevent window condensation. The addition of such a system may reduce the effectiveness of the systems described above. Consideration should be given by the design engineer to other systems

[16] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). Heating, Ventilating, and Air-Conditioning Applications. 1995, Atlanta, GA, p. 7-6, http://www.ashrae.org.

[17] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). Heating, Ventilating, and Air-Conditioning Applications. p. 7-6.

[18] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

[19] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities.) p. 74.

which can provide good air mixing, without depending upon uniform flow. Future updates to MIL-HDBK-1191 will include information on these designs.

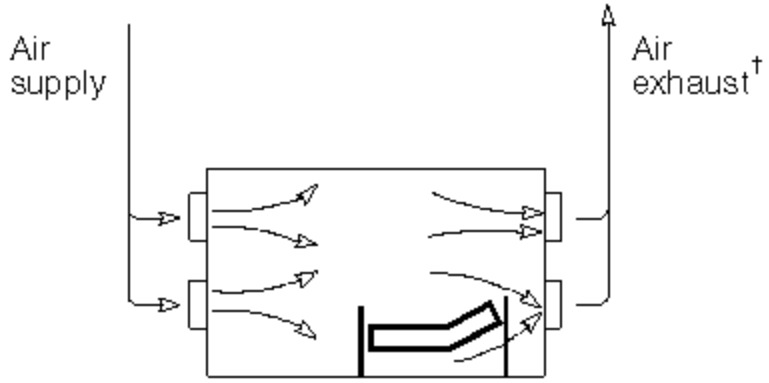
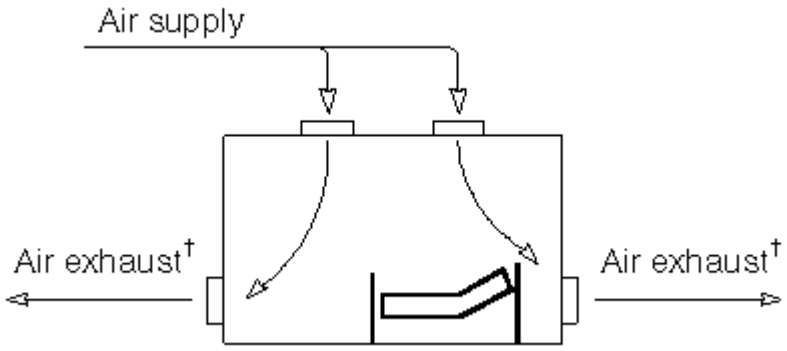


Figure 2. Location of Registers in the Bedroom[20]
(Horizontal Quasi-Laminar Airflow)



(Vertical Quasi-Laminar Airflow)

3-4.3. It is imperative that any design provide an acceptable level of patient comfort, in terms of noise level. Noise levels shall be in accordance with the latest version of MIL-HDBK-1191.

3-4.4. Supply and exhaust registers in the anteroom, if applicable, shall be located to prevent stagnation and "short-circuiting." The exhaust register in the bathroom shall be located away from the bathroom door to prevent air stagnation.

3-4.5. Airflow patterns can be affected by the physical configuration of the isolation room and the location of furniture. Appropriate measures shall be taken by staff to ensure that registers are not obstructed and that the intentions of this subsection are met.

[20] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities.) p. 75.

Section 3-5. Air Exchange Rates.

3-5.1. The disease isolation bedroom shall be provided a minimum 12 air changes per hour (ACH), in accordance with accepted national and military guidelines. A minimum of 2 ACH of outdoor air shall be provided as part of the required 12 ACH.

3-5.2. The anteroom, if applicable, shall be provided a minimum 10 ACH. A minimum of 2 ACH of outdoor air shall be provided as part of the required 10 ACH.

3-5.3. The bathroom shall be provided a minimum 10 ACH, under full exhaust.[21]

Section 3-6. Exhaust Systems.

3-6.1. All air shall be exhausted directly to the outdoors. Exhaust from the isolation room shall not be recirculated.[22] Exhaust from more than one disease isolation room suite may be combined into a central, dedicated exhaust system.

3-6.2. The exhaust ductwork from these rooms shall be maintained at a negative pressure throughout the duct up to the exhaust fan. Exhaust fans shall be located at the end of the duct run.

3-6.3. High-efficiency particulate air (HEPA) filters may be used to supplement the direct exhaust system.

NOTE: Such use is "unnecessary", provided the air cannot re-enter the ventilation system supply, according to the CDC.[23] Also, preserving the man-hours and cost associated with the upkeep of the filters (see Section 6-3) may outweigh the benefits of "minimal" supplemental protection. It is recommended a risk assessment be done during the design phase to determine if HEPA filters are necessary.

3-6.4. The exhaust shall be discharged above roof level whenever possible. Exhausts that discharge other than above roof level should be located away from operable windows, walkways, public areas, and parking areas. Adequate stack height shall be incorporated within the design of the system to prevent air from potential re-entry into the facility. The use of portable air units, mounted in windows shall be discouraged. Outdoor air intakes for air handlers shall be located not less than 30 feet, horizontal distance, from disease isolation room exhaust fans.

---

[21] Defense Medical Facilities Office. MIL-HDBK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria.

[22] Defense Medical Facilities Office. MIL-HDBK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria.

[23] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities., p. 82.

3-6.5. Labels with the words "Contaminated Air - Respiratory Protection Required" shall be placed at all points where ducts are accessed prior to and at HEPA filter locations and at duct access points, fans, and discharge outlets of non-HEPA filtered direct discharge systems.[24]

3-6.6. Where exhaust ductwork passes through fire rated barriers, the ductwork shall be either provided with fire dampers or enclosed in a fire rated chase in accordance with the latest editions of NFPA 90A and NFPA 101.

[24] Occupational Safety and Health Administration. Proposed Tuberculosis Standard. October 1997, Washington, DC, http://www.osha.gov.

Chapter 4. HVAC Design Guidelines for Existing Disease Isolation Bedrooms

Section 4-1. General.

4-1.1. These requirements shall apply to existing facilities. The following requirements are provided to evaluate disease isolation areas for compliance with accepted national and military standards. Any major renovation of an existing facility must comply with Chapter 3 of this technical guide. Care should be taken to ensure rooms are designed in accordance with the most current guidance from military handbooks and other nationally recognized standards.

4-1.2. Existing disease isolation bedrooms need not be designed for use by TB patients, unlike new isolation bedrooms. For simplification, the term "isolation bedroom" shall be used to describe both TB and general isolation bedrooms. Any discrepancies between the types of rooms will be noted within the section.

4-1.3. Supply, return, and exhaust ventilating systems serving isolation bedroom suites shall be arranged for either delayed automatic or manual connection to the equipment branch of the emergency power system.[25]

Section 4-2. Pressurization.

4-2.1. If equipped with an anteroom, between the corridor and isolation bedroom, the bedroom shall be under negative pressure, with respect to the anteroom. The anteroom shall be under negative pressure, with respect to the corridor. The anteroom shall be provided a minimum 10% negative pressure.

4-2.2. The disease isolation bedroom shall be under negative pressure. The bedroom shall be provided a minimum 10% negative pressure, 20% negative pressure where equipped with an anteroom, to ensure bedroom is negative with respect to the anteroom.

4-2.3. The bathroom shall be under negative pressure, with respect to the isolation bedroom. (Note: This simply means that smoke from a tube held at the base of the door between the bathroom and the isolation bedroom will flow into the bathroom. It does not imply that there must be a greater **quantity** of air (cfm) exhausted from the bathroom than from the isolation bedroom). The bathroom shall be provided 100% negative pressure, thus no supply registers shall be located within the bathroom. If desired, a louvered door may be installed to the bathroom, in accordance with NFPA criteria, to allow for proper make-up air.

4-2.4. The door from the corridor to the anteroom (if provided) or isolation room shall be permitted to have a clearance no greater than 1" from the finished floor, to allow for air

[25] National Fire Protection Association. National Electric Code (NFPA 70). 1999, Quincy, MA, http://www.nfpa.org.

pressurization. This is in accordance with the Life Safety Code® and JCAHO interpretations.[26]

4-2.5. It is essential that doors and windows remain closed to ensure proper pressurization ratios. Doors leading into the isolation room and anteroom shall be equipped with self-closing devices. Doors shall not be held open with door wedges, chocks, or other similar devices under any circumstances.[27] Doors to bathrooms should also be kept closed to maintain pressure differentials.

4-2.6. "Switchable" Rooms.

4-2.6.1. For "switchable" rooms, HVAC controls shall be designed to permit the manual selection, at a switch mounted within or adjacent to the space, of either positive or negative pressurization of the isolation bedroom. This control equipment shall be connected to the critical circuit branch of the emergency power system in accordance with 4-1.3.

NOTE: Having "switchable" rooms is not recommended by this office or other national organizations (see Section 3-2.6). It is recommended that existing Medical Treatment Facilities (MTFs) evaluate the need for "switchable" rooms, with the consultation of the infection control department, to optimize patient and health care worker safety.

4-2.6.2. Rooms designed to be "switchable," and used in such capacity, shall have reliable engineering controls to monitor room pressure. If these "switchable" systems are still used, nursing staff shall be trained to operate all necessary controls.

Section 4-3. Comfort.

4-3.1. HVAC supply systems shall be designed to maintain a temperature of 75° Fahrenheit year round in the isolation bedroom. It is recommended that each patient room have individual temperature control. Anterooms, if provided, and bathrooms shall be maintained at 78° in the summer and at a design temperature of 72° in the winter.[28]

4-3.2. It is recommended that isolation bedrooms and anterooms, if provided, maintain 50% relative humidity levels in the summer and 30% relative humidity levels in the winter.[29]

---

[26] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

[27] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

[28] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). Heating, Ventilating, and Air-Conditioning Applications, p. 7-6.

[29] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). Heating, Ventilating, and Air-Conditioning Applications, p. 7-6.

4-3.3. All patient rooms shall be provided with an outside window, in accordance with NFPA criteria.

4-3.3.1. Rooms intended for occupancy for less than 24 hours, such as recovery beds, need not be provided with outside windows.

4-3.3.2. Windows in atrium walls shall be considered outside windows for the purposes of this requirement. [30]

Section 4-4. Airflow Patterns.

4-4.1. HVAC systems shall be designed to provide optimal airflow patterns. Systems shall be designed to prevent "short-circuiting," defined as airflow directly from the supply to the exhaust without proper mixing with room air. Air stagnation shall be prevented with proper design. The air supply should originate where health care workers are likely to work, and then flow across the infectious patient, and into the exhaust register.

4-4.2. One example of such a design involves placing the supply register at the side of the room opposite of the patient, typically near the patient room door. The exhaust register is then located near the head end of the patient bed.

4-4.3. Supply and exhaust registers in the anteroom, if applicable, should be located to prevent stagnation and "short-circuiting." The exhaust register in the bathroom should be located away from the bathroom door to prevent air stagnation.

4-4.4. Airflow patterns can be affected by the physical configuration of the isolation room and the location of furniture. Appropriate measures shall be taken by staff to ensure that registers are not obstructed and that the intentions of this subsection are maintained.

Section 4-5. Air Exchange Rates.

4-5.1. All existing disease isolation bedrooms shall be provided a minimum 6 ACH, in accordance with accepted national and military guidelines. A minimum of 2 ACH of outdoor air shall be provided as part of the required 6 ACH. The number of air changes in isolation bedrooms used to house TB patients is *recommended* to be 12 ACH, including 2 ACH minimum of outside air. NOTE: Refer to Chapter 7 for supplemental engineering controls if the intent of this section cannot be satisfied.

4-5.2. The anteroom, if applicable, shall be provided a minimum 10 ACH. A minimum of 2 ACH of outdoor air shall be provided as part of the required 10 ACH.

[30] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

4-5.3. The bathroom shall be provided a minimum 10 ACH, under full exhaust.[31]

Section 4-6. Exhaust Systems.

4-6.1. Methods of Exhaust.

4-6.1.1. Dedicated Exhaust Systems.

4-6.1.1.1. All existing isolation rooms should be directly exhausted to the outside (NOTE: Refer to Section 3-6.2 for additional information). High-efficiency particulate air (HEPA) filters may be used, but are not required, to supplement the direct exhaust system. If direct exhaust is not physically possible, see Section 4-6.1.2.

4-6.1.1.2. The exhaust should be discharged above roof level, whenever possible. Exhausts that discharge other than above roof level should be located away from operable windows, walkways, public areas, and parking areas. Exhaust stacks shall be designed so that air cannot re-enter the facility. The practice of directing air through non-HEPA protected exhaust units, mounted in windows, is prohibited. Outdoor air intakes for air handlers shall be located not less than 30 feet, horizontal distance, from disease isolation room exhaust fans.

4-6.1.2. Return Air Systems. Where direct exhaust is not possible, for example in existing facilities where system configuration makes a direct exhaust system to the outside impossible, HEPA filters are required in the exhaust duct leading from the room into the recirculating system, before any other branches intersect the ductwork, to filter infectious organisms and particulates.[32] This applies to both TB and general isolation rooms.

4-6.1.3. Recirculation of HEPA-filtered Air Within a Room. Refer to Section 7-2.

4-6.2. Labels with the words "Contaminated Air - Respiratory Protection Required" shall be placed at all points where ducts servicing TB isolation rooms are accessed prior to and at HEPA filters, and at duct access points, fans, and discharge outlets of non-HEPA filtered direct discharge systems.[33] This practice is also recommended for general isolation rooms.

---

[31] Defense Medical Facilities Office. MIL-HDBK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria. 1996 (New Version Under Revision), Washington, D.C..

[32] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 82.

[33] Occupational Safety and Health Administration. Proposed Tuberculosis Standard. October 1997, Washington, D.C.

4-6.3. Where exhaust ductwork passes through fire rated barriers, the ductwork shall be either provided with fire dampers or enclosed in a fire rated chase in accordance with the latest editions of NFPA 90A and NFPA 101.

Chapter 5. HVAC Design Guidelines for Other Hospital and Clinical Areas

Section 5-1. Treatment Rooms.

5-1.1. This sub-section shall be applied to exam or treatment rooms and dental treatment areas for patients requiring disease isolation protection.

5-1.2. New Facilities.

5-1.2.1. General.

5-1.2.1.1. Refer to Section 3-1.1.

5-1.2.1.2. If appropriate, dental procedures or cough-inducing procedures on patients who have TB should be postponed until the patient is no longer infectious.

5-1.2.1.3. Emergency power shall be provided as required per NFPA 70. Clinics, classified as business occupancies, will not be provided with an emergency generator, unless authorized by MIL-HDBK-1191 and the DoD Healthcare Facilities Steering Committee.

5-1.2.1.4. Staff shall have ample personal protective equipment, such as respirators, readily available in the event of a power or mechanical failure.[34]

5-1.2.2. Pressurization.

5-1.2.2.1. An anteroom is not required to separate the isolation treatment room from the corridor.

5-1.2.2.2. The treatment room shall be under negative pressure, with respect to the corridor. The room shall be provided a minimum 20% negative pressure.

5-1.2.2.3. Bathrooms. Reserved.

5-1.2.2.4. Door clearances shall be in accordance with Section 3-2.4.

5-1.2.2.5. Self-closing devices are recommended on doors to ensure proper pressurization ratios. Self-closers may be required as indicated in NFPA 101.[35]

---

[34] Defense Medical Facilities Office. MIL-HDBK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria.

[35] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

5-1.2.2.6. "Switchability" of HVAC systems in treatment areas from negative to positive pressure, and vice versa, shall be prohibited.

5-1.2.3. Comfort.

5-1.2.3.1. Temperature ranges shall be accordance with MIL-HDBK-1191.

5-1.2.3.2. Humidity levels shall be in accordance with MIL-HDBK-1191.

5-1.2.3.3. Treatment or exam rooms are not required to have an outside window.

5-1.2.4. Airflow Patterns.

5-1.2.4.1. Systems shall be designed in accordance with Section 3-4.1.

5-1.2.4.2. One example of such a design involves placing the supply register at the side of the room opposite of the patient, typically near the patient room door. The exhaust register is then located near the head end of the exam table.[36] Supply and exhaust registers shall be ceiling-mounted.

5-1.2.4.3. If applicable, anterooms and bathrooms located in the treatment space shall be designed in accordance with Section 3-4.3.

5-1.2.4.4. Obstructions shall be avoided in accordance with Section 3-4.4.

5-1.2.5. Treatment rooms for disease isolation patients shall be provided a minimum 12 air changes per hour (ACH), in accordance with accepted national and military guidelines. A minimum of 2 ACH of outdoor air shall be provided as part of the required 12 ACH..

5-1.2.6. Exhaust systems shall meet the provisions of Section 3-6.

5-1.3. Existing Facilities.

5-1.3.1. General.

5-1.3.1.1. Refer to Section 4-1.1.

5-1.3.1.2. If appropriate, dental and cough-inducing procedures on patients who have TB should be postponed until the patient is no longer infectious.

5-1.3.1.3. Emergency power shall be provided as required per NFPA 70. Clinics, classified as business occupancies, will not be provided with an emergency generator,

[36] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 74.

unless authorized by MIL-HDBK-1191 and the DoD Healthcare Facilities Steering Committee.

5-1.3.1.4. Medical staff should have ample personal protective equipment, such as respirators, readily available in the event of power or mechanical failure.

5-1.3.2. Pressurization.

5-1.3.2.1. An anteroom is not required to separate the isolation treatment room from the corridor.

5-1.3.2.2. The treatment room shall be under negative pressure, with respect to the corridor. The treatment room shall be provided a minimum 10% negative pressure.

5-1.3.2.3. Bathrooms. Reserved.

5-1.3.2.4. Door clearances shall be in accordance with Section 4-2.4.

5-1.3.2.5. Self-closing devices are recommended on doors to ensure proper pressurization ratios. Self-closers may be required as indicated in NFPA 101.[37]

5-1.3.2.6. Treatment rooms used for disease isolation shall not be permitted to be "switchable."

5-1.3.3. Comfort.

5-1.3.3.1. Temperature ranges shall be in accordance with MIL-HDBK-1191.

5-1.3.3.2. Humidity levels shall be in accordance with MIL-HDBK-1191.

5-1.3.3.3. Treatment and exam rooms are not required to have an outside window.

5-1.3.4. Airflow Patterns.

5-1.3.4.1. Systems shall be designed in accordance with Section 4-4.1.

5-1.3.4.2. "Switchability" of HVAC systems in treatment areas from negative to positive pressure, and vice versa, is not recommended. Treatment areas, unlike bedrooms, can hold more than one patient per day. The time required for a HVAC system to compensate per patient type (infectious vs. immune-suppressed) may not be effective in clearing the room of any infectious particulates.

[37] National Fire Protection Association. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101).

5-1.3.4.3. Proper airflow patterns may be achieved by placing the supply register at the side of the room opposite of the patient, typically near the patient room door. The exhaust register is then located near the head end of the exam table.[38] Supply and exhaust registers shall be ceiling-mounted.

5-1.3.4.4. If applicable, anterooms and bathrooms located in the treatment space shall be designed in accordance with Section 4-4.3.

5-1.3.4.5. Obstructions shall be avoided in accordance with Section 4-4.4.

5-1.3.5. Air Exchange Rates.

5-1.3.5.1. All isolation treatment rooms shall be provided a minimum 6 ACH. A minimum of 2 ACH of outdoor air shall be provided as part of the required 6 ACH. Isolation treatment rooms for suspected TB patients are *recommended* to provide a minimum 12 ACH, if feasible, including 2 ACH minimum of outside air.
NOTE: Refer to Chapter 7 for supplemental engineering controls if the intent of 5-1.3.5.1 cannot be satisfied.

5-1.3.6. Exhaust systems shall meet the provisions of Section 4-6.

Section 5-2. Operating Rooms.

5-2.1. If appropriate, operative procedures on patients who have TB should be postponed until the patient is no longer infectious.

5-2.2. Recommended Practice in New and Existing Facilities.

5-2.2.1. Since operating rooms are designed to be under positive air pressure, the following precautions should be reviewed to minimize the potential for exposure.

5-2.2.2. Operating Rooms Equipped with Anterooms.

5-2.2.2.1. Operating rooms equipped with anterooms should be used for surgery. Designers of new/renovated facilities should consider providing one operating room with an anteroom. This recommendation shall be based on findings provided by the infection control nurse and relevant data to support the number of surgical patients seen with active TB.

5-2.2.2.2. Anterooms shall be under negative pressure to prevent air from entering the corridor. The anteroom shall be provided a minimum 10% negative pressure.

5-2.2.2.3. Scrub rooms connecting operating rooms shall be under negative pressure. The scrub room shall be provided a minimum 10% negative pressure.

[38] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 74.

5-2.2.3. Exhaust systems in operating rooms shall be functioning properly at all times.

5-2.2.4. Consideration shall be given to special purpose operating rooms, which may be "switched" to neutral or slightly negative pressure.

5-2.2.5. Doors to operating rooms and anterooms, if so equipped, shall be closed during all procedures. Traffic shall be minimized to reduce the quantity of air transferred from the operating room to the corridor.[39]

5-2.2.6. Surgical procedures on TB patients should be performed during low occupancy hours.

5-2.2.7. A bacterial filter may be inserted into the endotracheal tube (or at the expiratory side of the breathing circuit of a ventilator or anesthesia machine, if these are used). Filters can reduce the risk of contaminating equipment or releasing bacilli into the environment.[40]

5-2.2.8. HEPA filtration may be located in the exhaust ductwork leading from the room into the recirculating system, if the operating rooms are not provided with direct exhaust systems. This is recommended if the operating room is used periodically for infectious patients. Hospitals who routinely perform surgeries on infectious patients should consider providing one or more operating rooms with a direct exhaust system.

5-2.2.9. Respiratory protection is recommended for staff in the operating room, when performing surgery on infectious patients. Respirators shall conform to the requirements of Section 7-4.

5-2.2.10. After surgery, patients shall be taken to isolation bedrooms designed in accordance with Chapters 3 and 4.

Section 5-3. Autopsy Rooms.

5-3.1. Autopsy rooms shall be under negative pressure. Ventilation shall provide a minimum 10% negative pressure.

5-3.2. Autopsy rooms shall be directly exhausted to the outside. There are no exceptions for HEPA-filtered recirculation systems.

[39] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 50.

[40] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 50.

5-3.3. Ventilation in autopsy rooms shall provide a minimum 12 ACH. 2 ACH of outdoor air shall be provided as part of the required 12 ACH.[41]

5-3.4. Respiratory protection shall be worn by staff while performing autopsies on persons who may have had TB at the time of death.[42] Respirators shall conform to the requirements of Section 7-4.

5-3.5. Ultraviolet Germicidal Irradiation (UVGI) and in-room HEPA filtration units may be used as supplemental engineering controls to reduce the risk of exposure to infectious particulates.[43]

Section 5-4. Waiting Areas.

5-4.1. The following requirements apply to waiting areas found in emergency rooms, pulmonary clinics, and acute care clinics, where nosocomial transmission from infectious patients is possible.

5-4.2. Where possible, sectional waiting areas with partitions should be used to segregate suspected TB patients.[44]

5-4.3. Waiting areas shall be under negative pressure. Ventilation shall provide a minimum 10% negative pressure.

5-4.4. Waiting areas for infectious patients shall be directly exhausted to the outside in new facilities. Existing facilities shall be permitted to use recirculating exhaust systems in accordance with Section 4-6.

5-4.5. Ventilation in waiting areas for infectious patients shall provide a minimum 15 ACH. A minimum of 2 ACH of outdoor air shall be provided as part of the required 15 ACH.[45]

5-4.6. In areas where ventilation may be questionable, infectious patients may be segregated from the general waiting area by using negative-pressure enclosures, such as

---

[41] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). Heating, Ventilating, and Air-Conditioning Applications, p. 7-5.

[42] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 51.

[43] American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). Heating, Ventilating, and Air-Conditioning Applications, p. 7-5.

[44] Hitchings, D.E. Preventing Transmission of TB in Health Care Facilities: An Engineering Approach. 1996. Hitchings Associates, PC. http://www.safelab.com/TECH_PAPERS.

[45] Defense Medical Facilities Office. MIL-HDBK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria.

tents or booths. These booths shall be designed to conform to guidelines published by the CDC.[46] Negative-pressure enclosures should be located in concealed areas, as to not make a patient feel "segregated" in a high-traffic area such as a waiting room.

[46] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 70.

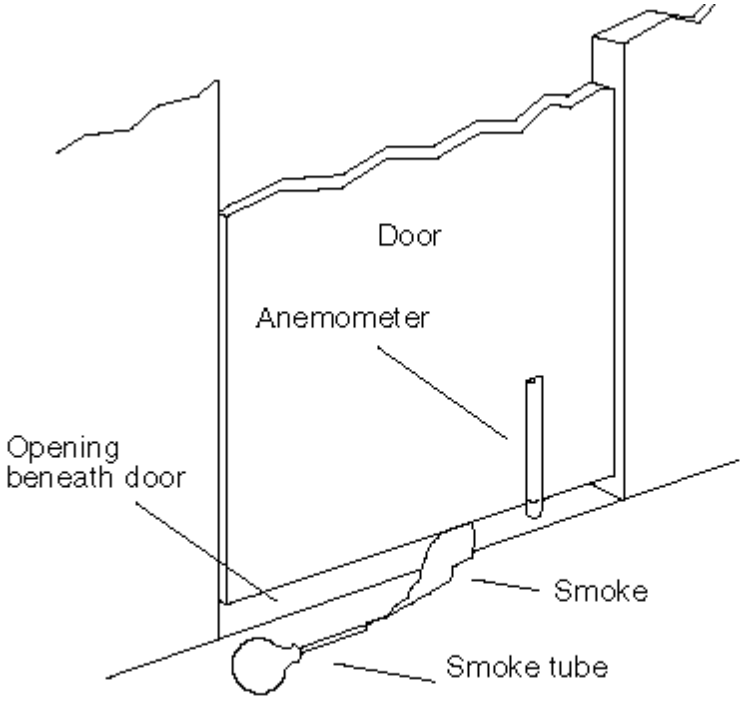
Chapter 6. Recommendations for HVAC System Testing and Maintenance

Section 6-1. Monitoring Negative Pressure and Airflow.

6-1.1. Traditional Approach.

6-1.1.1. Measurements Using Smoke Tubes.

6-1.1.1.1. Smoke tubes may be used to verify negative pressure and airflow patterns.



*Smoke flowing into the room indicates the room is at negative pressure relative to the corridor, and smoke flowing out of the room indicates the room is at positive pressure relative to the corridor. The anemometer, if used, is placed with the sensor in the airflow path at the bottom of the door.

Figure 3. Smoke Tube Testing and Optional Anemometer Placement[47]

6-1.1.1.2. The smoke tube shall be held at the bottom of the room door, approximately 2 inches in front of the closed door. The bulb is then squeezed, releasing smoke under the door. The smoke will migrate toward areas of negative pressure. Smoke tubes may be used inside of the individual rooms to verify airflow patterns, from the supply to the exhaust registers. An anemometer may be used to calculate airflow speed underneath the door. Results are usually indicated in feet per minute (fpm). The anemometer must be calibrated in accordance with manufacturers recommendations. The area underneath the

[47] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 79.

door must be measured (in square feet). The multiplication product of the two values will produce the volume, in CFM, of air passing underneath the door.

6-1.1.1.3. Smoke is produced when titanium tetrachloride inside of the tube reacts with moisture in the atmosphere to form titanium dioxide. The resulting smoke is irritating and should be handled with care. Do not use smoke tubes in occupied areas.

6-1.1.1.4. If the test indicates a problem in the area achieving negative pressure, the procedure outlined in 6-1.1.2 shall be used to determine airflow volumes and air exchanges.

6-1.1.2. Measurements Using a Balometer.

6-1.1.2.1. A balometer is an instrument used to measure airflow volumes. Balometers calculate volumes based on a series of internal pitot tubes, which record air velocities. New balometers measure flow volumes digitally, with a high degree of accuracy. The balometer must be calibrated as recommended by the manufacturer.

6-1.1.2.2. When measuring a room, all doors shall be closed. The volume of the room should then be measured, using measuring tape or other acceptable device.

6-1.1.2.3. The balometer has two settings, one for measuring supply air (into the room) and one for measuring exhaust air (leaving the room). Ensure that the balometer is on the correct setting for the airflow being measured. The balometer shall then be placed so that it covers the register. Most balometers have interchangeable hoods, which allow them to properly cover registers of different sizes. The balometer shall be held over the register for a minimum of 10 seconds, to gain an accurate airflow reading.

6-1.1.2.4. Each supply register shall be measured; the sum of these measurements is Qs. Each exhaust grille shall be measured; the sum of these measurements is Qe. Qs and Qe can then be used to determine air changes within the area (see Section 2-7.4).

6-1.2. Using Differential Pressure-Sensing Devices.

6-1.2.1. These devices can provide either periodic or continuous pressure monitoring.

6-1.2.2. Devices should measure the pressure drop between the room and corridor. Sensors should be placed directly in the corridor, near the door and at a fixed point in the room, preferably near the patient area.

6-1.2.3. Devices should provide an audible and/or visible signal when negative air pressure is low. Care should be taken with an audible system, so that patients are not under the misconception that the fire or other alarm has been activated.

6-1.2.4. Fluctuations in pressure are to be expected once a door is opened. Devices shall be equipped with a time-delay feature to activate when the door to the room is opened, so that the alarm is not sounded. The delay must include time for the ventilation system to

reestablish the correct pressure differential after the door is closed; otherwise nuisance alarms will be a problem.

6-1.2.5. Care should be taken with selection and maintenance of such devices, as the instruments are required to be very sensitive to low pressure differentials (as low as 0.001 inches of water). Devices may clog easily with lint and dust. Staff shall maintain the equipment and validate the operation of the sensing devices as recommended by the manufacturer.[48]

6.1.2.6. Devices can be used to alter airflow rates via an interface with the building's management system (i.e., to change damper position) or via an interface with a trained operator.

6-1.3. Other Devices.

6-1.3.1. Within the past few years, computerized airflow and pressure controls have been designed and incorporated to adjust HVAC systems electronically to control negative pressure. These devices can also provide airflow readings, using sensors installed in the ductwork (see Figure 4). The controls can alter airflow rates via an interface with the building's management system (i.e., to change damper position).

6-1.3.2. These devices shall be installed by properly trained individuals and maintained accordingly. The use of traditional testing methods can ensure validation of these systems.

6-1.3.3. For ventilated anterooms, dual pressure monitoring of the isolation room relative to the anteroom and the anteroom relative to the corridor should be provided.

[48] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 79-80.

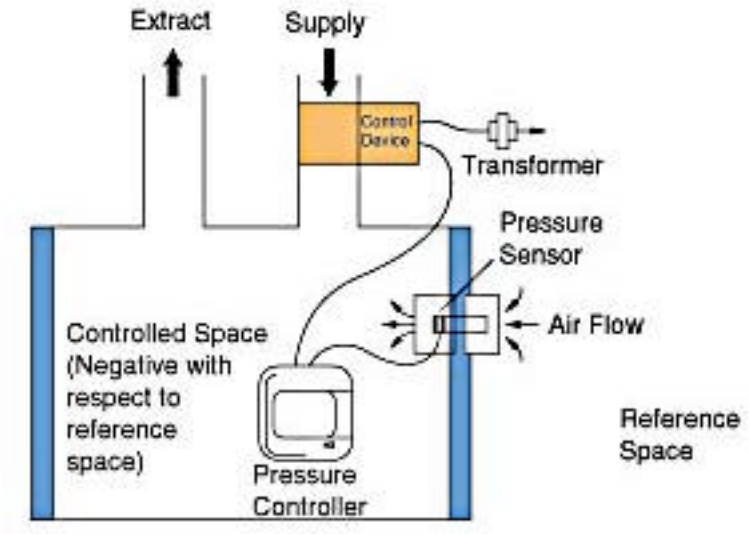


Figure 4. Pressure Sensor

The pressure sensor measures the pressure differential between a controlled space and a reference space by measuring the average velocity of air flowing through the sensor located between the two spaces. The velocity of the airflow is a direct function of the pressure differential driving it.[49]

6-1.4. Frequency of Monitoring Negative Pressure and Airflows.

6-1.4.1. Rooms being used for TB isolation shall be checked daily for negative pressure when occupied by a TB patient. At a minimum, rooms equipped to house or treat TB isolation patients shall be inspected monthly for proper negative pressure. This shall be accomplished with a smoke tube or a manometer. These tests shall be performed regardless of whether or not the room is equipped with a pressure-serving device. Smoke tubes should be used when the room is temporarily unoccupied (i.e., patient is in shower, etc.). All inspections shall be documented.

6-1.4.2. All general isolation rooms, not including those used to house or treat TB patients, shall be inspected, at a minimum, monthly for proper negative pressure. These inspections shall be performed in accordance with 6-1.1.1.

6-1.4.3. Air balancing shall be measured and documented quarterly in all isolation rooms, to include TB isolation rooms. *Exception.* The rate of airflow in rooms equipped

[49] Courtesy of TSI Products. http://www.tsi.com.

with automated flow rate devices shall be measured and documented semi-annually in accordance with 6-1.1.2.

Section 6-2. System Balancing and General Maintenance.

6-2.1. Only trained personnel will balance HVAC systems.

6-2.2. Based on testing conducted in Section 6-1, trained personnel should review the following system components for proper operation: supply air handlers, damper positioning, condition of ductwork, VAV boxes (if applicable), filter efficiencies, control system and exhaust fans.

6-2.3. A facility's preventive maintenance plan should reflect special consideration in dealing with TB isolation areas.

6-2.4. Appropriate personal protective equipment (PPE) shall be worn while performing maintenance procedures to prevent exposures. At a minimum, respiratory protection and protective gloves shall be used to service isolation room systems.

NOTE: PPE is a major concern when servicing areas used by TB patients; however, consideration shall also be given when servicing general isolation areas, to prevent exposure to a multitude of communicable diseases. It is recommended to treat all isolation areas with the same safety provisions.

6-2.5. Nursing staff located in isolation room areas shall be notified when maintenance work is being performed. Re-balancing of the system should take place only when the affected rooms are unoccupied.

6-2.6. When re-balancing a system, ensure that all doors are closed in the affected areas, so not to create pressure fluctuations and subsequent invalid flow rates and pressurization ratios.

6-2.7. While working on the HVAC system, registers and ductwork should be observed for dust and other contaminants. Facilities should consider a complete cleaning, upon inspection, of all HVAC systems once every 10 years.[50]

NOTE: Proper filter maintenance, housekeeping, and other routine system inspections can prolong the above recommended time cycle. Currently, there are no industry standards for the timeframe of cleaning ductwork. It is at the discretion of the facility to determine when a system needs to be cleaned.

6-2.8. Upon completion of any maintenance, qualified personnel shall re-test the affected systems in accordance with Section 6-1.

[50] Telephone Conversation with HQ, USAMEDCOM, December, 1996.

Section 6-3. Servicing of HEPA Filters.

6-3.1. The scope of this subsection covers HEPA filters in dedicated exhaust systems, recirculating air systems, and portable air units. Refer to Chapter 7 for more information concerning portable air recirculation systems.

6-3.2. Proper installation, testing, and maintenance are critical, especially if the system is recirculating air throughout the facility. Improper design, installation, and maintenance can allow droplet nuclei to escape into other areas of the facility.[51]

6-3.3. A regularly scheduled maintenance program is required to monitor the HEPA filter for leakage and filter loading.[52] Filters shall be evaluated at intervals based upon the usage of the isolation areas. At a minimum, filter performance shall be evaluated semi-annually.

6-3.4. Changing and Replacing HEPA Filters.

6-3.4.1. General.

6-3.4.1.1. HEPA filters, by definition, effectively remove 99.97% of particulates ≥ 0.3 microns in diameter. M. tuberculosis droplet nuclei range in size from 1 to 5 microns in diameter. In other words, a properly manufactured and installed HEPA filter should remove nearly all tuberculosis nuclei. HEPA filters are also used in biological safety cabinets, as well as newer vacuum cleaners and air-purifiers.

6-3.4.1.2. HEPA filters in properly maintained system may have a life up to 3 years. Filter manufacturers generally provide specific guidelines for filter replacement. The guidelines provided in this subsection should be used as a supplement.

6-3.4.1.3. HEPA filters will require replacement when they become so loaded that sufficient airflow can no longer be maintained.[53]

6-3.4.2. Testing Filters to Determine if Removal is Necessary.

[51] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 85.

[52] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 85.

[53] Centers for Disease Control and Prevention and National Institutes of Health. Selection, Installation, and Use of Biological Safety Cabinets. September, 1995, U.S. Department of Health and Human Services, Washington, D.C. http://www.orcbs.msu.edu/biological/bsc/bsc.htm.

6-3.4.2.1. A manometer or other pressure-sensing device should be installed in the filter system to provide an accurate and objective means of determining the need for replacement.[54]

6-3.4.2.2. Manufacturers shall provide specific pressure drop characteristics of HEPA filters. When the pressure drop range is exceeded, the filter shall be replaced.

6-3.4.2.3. Dioctylphthalate Testing and Leakage Testing.

6-3.4.2.3.1. A quantitative leakage and filter performance test, such as the dioctylphthalate (DOP) penetration test or another reliable leakage test, should be performed when a HEPA filter is initially installed and if a filter has a suspected leak or an unexpected pressure drop. *Exception.* Approved DOP tests performed by the filter manufacturer may be substituted for initial testing.

6-3.4.2.3.2. The DOP test involves 0.3 micron particles of dioctylphthalate being drawn through the HEPA filter. Efficiency is determined by comparing the downstream and upstream particle counts. Only 3 particles of 0.3 micron size can pass for every 10,000 particles fed to the filter. The DOP test is not destructive, so leaks can be repaired and filters can be reused.[55]

6-3.4.2.3.3. HEPA filters shall be located on the negative pressure side of the fan blower. This will reduce potential exposure to DOP during filter testing. DOP has been labeled a class 2B carcinogen by the International Agency for Research on Cancer. Liquid DOP, a thick oil, should be handled only with personal protective equipment, such as gloves made of butyl rubber, viton, or nitrile membrane.[56]

6-3.4.2.3.4. Filter manufacturers should be contacted for more information concerning DOP testing and specific procedures for testing.

6-3.4.3. Changing of Filters.

6-3.4.3.1. Only trained staff shall perform HEPA filter maintenance.

6-3.4.3.2. Personal protective equipment shall be worn in accordance with Section 6-2.4.

[54] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 85.

[55] American Conference of Governmental Industrial Hygienists. Industrial Ventilation, 23rd Edition. 1998, ACGIH Press, Cincinnati,OH http://www.acgih.org., p. 4-32.

[56] U.S. Department of Energy, Industrial Hygiene Programs Division. Health Hazard Alert: Dioctyl Phthalate. Issue 93-1, Washington, D.C., http://nattie.eh.doe.gov/docs/hha/hha.0002.txt.

6-3.4.3.3. A bag-in/bag-out (BIBO) filter assembly is recommended, especially when HEPA filtration is necessary for operations involving biohazardous materials and hazardous and toxic chemicals. The procedure protects the worker and the environment.[57]

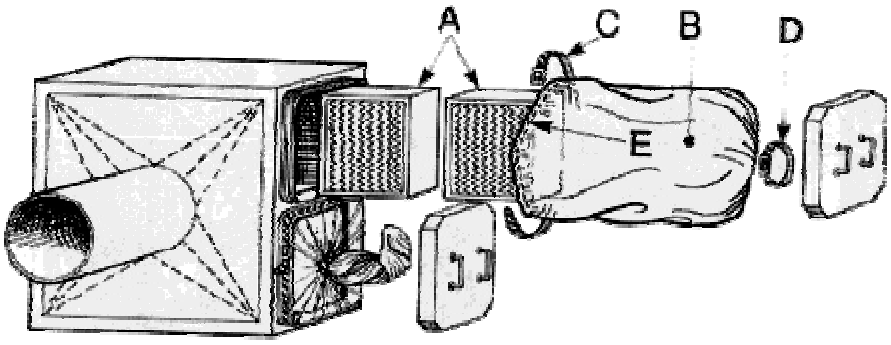


Figure 5. A BIBO Assembly.[58]

Key: A = Filters C = Safety Straps
B = Bags D = Cinching Straps
E = Shock Cord, located in the mouth of the PVC bag, restricts the bag around the second rib of the housing lip.

6-3.4.3.4. Where a BIBO assembly is not supplied, filters should be disinfected prior to replacement. The duct assembly should be opened and the filter should be sprayed with a disinfectant, such as phenol paraformaldehyde. The filter should be allowed to soak for approximately an hour, to allow for thorough disinfecting. The filter is then pulled from the housing. The used filter should be bagged for disposal. A new filter is then placed into the duct housing.
NOTE: Phenol is a strong oxidizer and can attack stainless steel ductwork. Oversoaking of filters shall be avoided.[59] When spraying phenol paraformaldehyde, respirators shall be used in accordance with OSHA 29 CFR 1910.1048. Other PPE, including protective gloves, goggles, and protective clothing shall be used in accordance with this standard.[60]

[57] Centers for Disease Control and Prevention and National Institutes of Health. Selection, Installation, and Use of Biological Safety Cabinets.

[58] Centers for Disease Control and Prevention and National Institutes of Health. Selection, Installation, and Use of Biological Safety Cabinets.

[59] Telephone Conversation with HVAC Maintenance Engineer, National Institutes of Health, Bethesda, MD. January, 1999.

[60] Occupational Safety and Health Administration. Standards 29 CFR 1910.1048. 1999, Washington, DC, http://www.osha.gov.

6-3.4.3.5. As mentioned above, BIBO assemblies are preferred over general "reach-in and remove" systems. Not only do these assemblies potentially involve less exposure to harmful bacteria, BIBO assemblies avoid having to decontaminate HEPA filters prior to disposal and help protect the ductwork from harmful chemicals.

6-3.5. Recommended Practice for the Disposal of HEPA Filters.

NOTE: There are minimal guidelines for the disposal of HEPA filters potentially infected with TB bacteria. The following are recommendations from industry experts who deal with the maintenance of such systems.

6-3.5.1. HEPA filters from disease isolation areas shall ideally be treated as regulated medical waste. Whenever possible, these filters shall be incinerated in compliance with federal and state guidelines for hazardous waste, especially if the filter has not been disinfected.

6-3.5.2. HEPA filters treated with disinfectants, such as phenol, may be disposed as general waste, when deemed appropriate by the facility infection control nurse.

6-3.6. Supplemental Filtration.

6-3.6.1. One or more lower efficiency disposable prefilters installed upstream from the HEPA filter will extend its life. A single disposable filter can increase HEPA filter life by 25%.

6-3.6.2. A disposable filter, supplemented with a 90% extended surface filter, installed upstream from the HEPA filter, can extend the life of a HEPA filter by 900%.[61]

6-3.6.3. These filters shall be maintained and disposed of in the same matter as HEPA filters. Care should be taken during installation to maintain an acceptable pressure drop across all filters.

[61] American Conference of Governmental Industrial Hygienists. Industrial Ventilation, 23rd Edition. 1998, p. 4-32.

Chapter 7. Alternate Engineering Controls and Respirator Protection

Section 7-1. General. This chapter covers systems, which may be used to supplement new and existing HVAC systems. Section 7-2 covers HEPA-filtered recirculation units and Section 7-3 details ultraviolet germicidal irradiation (UVGI) units. This chapter also addresses the issue of respiratory protection in Section 7-4.

Section 7-2. HEPA-Filtered Recirculation Units.

7-2.1. General.

7-2.1.1. HEPA-filtered recirculation units shall not be permitted in new facilities. The provisions of Chapter 3 shall only apply for new facilities.

7-2.1.2. Recirculation units are permitted in existing facilities, in individual rooms, where one of the following conditions exist:

(1) There is no existing ventilation system and renovations to install a fully ducted system are cost-prohibitive; or

(2) There is an existing ventilation system incapable of producing adequate airflow and pressurization; or

(3) Where an increase in ventilation is desired without affecting the current supply or exhaust system.

7-2.1.3. Ideally, exhaust airflow from isolation areas shall be direct to the outside. Where exhaust from an isolation area is part of a recirculating air system, HEPA filters are required in the exhaust duct leading from the room into the recirculating system, before any other branches intersect the ductwork, to filter infectious organisms and particulates.[62] *Exception*. Existing exhaust registers (in recirculating HVAC systems) may be permitted to be permanently sealed, provided a bleed air duct is attached to the portable recirculation unit, to remove the amount of return air necessary for negative pressure. The bleed air duct shall be located downstream from the HEPA filter located in the portable unit. The bleed duct shall provide, at minimum, 10% airflow to the outside to ensure negative pressure within the room.[63] A bleed air duct may be either directly exhausted to the outside or recirculated into a return air system.

7-2.1.4. There are three types of recirculating systems. The following systems are listed in order of design preference.

7-2.2. Fixed, Ducted, Recirculation Systems.

[62] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 82.

[63] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 84.

7-2.2.1. This system is actually a fixed system, typically installed above the ceiling. Air is ducted through actual registers into a combination HEPA filter/blower assembly. A minimal amount of air is then removed through a bleed valve, in accordance with Section 7-2.1.3; the remainder is pushed back into the room as supply air (see Figure 6).

7-2.2.2. Register location shall be in accordance with Section 4-4.2.

7-2.2.3. This method is ideal for rooms not capable of producing the minimum required number of air changes or incapable of proper pressurization rates. The system can be used to supplement an existing HVAC arrangement.

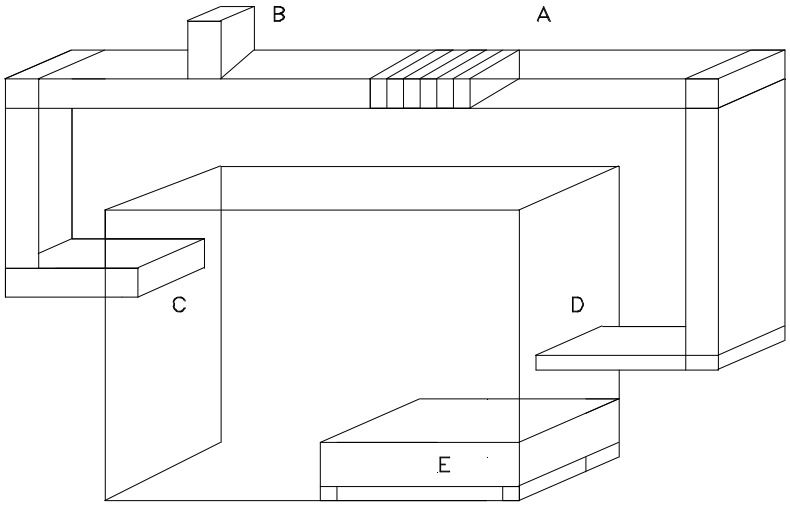


Figure 6. A Fixed, Ducted Room-Air Recirculation System.

Key: A = HEPA Filter / Blower Unit
B = Bleed Valve (Exhaust to Outside)
C = Supply Register
D = Exhaust Register
E = Patient Bed or Exam Table

7-2.3. Unducted, Fixed Blower Systems.

7-2.3.1. These systems are ceiling or wall-mounted. Contaminated air is drawn from the patient zone into the HEPA-filter/blower unit. Air is purified and then either exhausted to the outside, via a flexduct, or supplied back into the room. A bleed valve shall be designed into the system to ensure negative pressure; where there are no approved exhaust registers in the room, in accordance with Section 7-2.1.3.

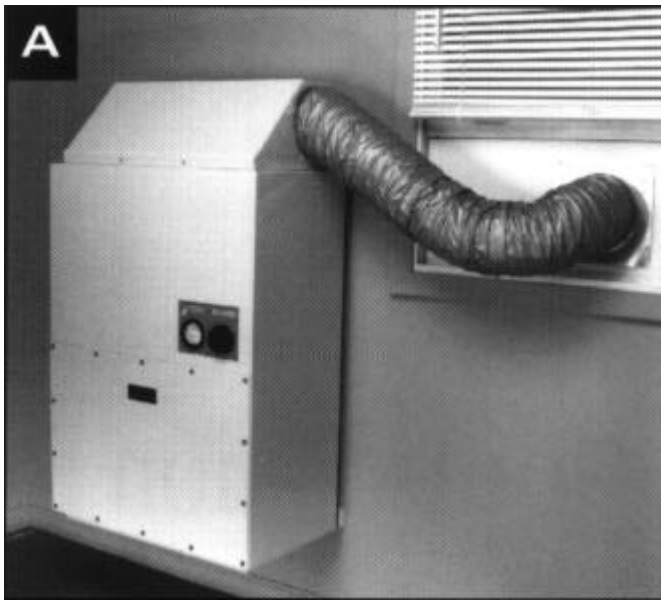


Figure 7. A Wall-Mounted HEPA-Filtered Blower Unit (With Direct Exhaust to the Outside)[64]

This unit can also be used to recirculate air. Here it is shown in a negative pressure isolation room. The advantage with this model, over recirculating units, is the obvious benefit of exhausting air (via a flexduct) to the outside. The air is passed through the HEPA filter to reduce potential exposures outside of the facility.

7-2.3.2. This method is ideal for rooms either incapable of producing the minimum required number of air changes or not equipped with a general ventilation system.

7-2.3.3. A drawback to using these devices is their fixed location, with respect to the patient bed or table. Care should be taken to ensure furniture is properly situated, to take advantage of potential air currents, in accordance with Section 4-4.4. Also ensure that the exhaust is carried away from any outdoor air intakes, other windows, and pedestrian traffic.

7-2.4. Portable Air Recirculation Systems.

7-2.4.1. Portable HEPA filtration units may be considered when the present HVAC system is incapable of providing adequate airflow, or where increased effectiveness in room airflow is desired.[65] Use of these systems in rooms with air handlers that recirculate

[64] Courtesy of Berriman Associates, http://www.berriman-usa.com.

[65] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 84.

air to other areas of the building does not meet the intent of the CDC Guidelines to prevent the escape of droplet nuclei into other areas of the building. If rooms using portable HEPA filtration units have recirculating HVAC ducted systems servicing other building areas, HEPA filters must be provided in the return air ductwork, as the ductwork exits the room, to prevent contamination of adjacent areas (see Section 7-2.1.3).

7-2.4.2. The effectiveness of the portable unit depends on a variety of factors. Care should be taken when locating these units. The unit should be located so that a majority of the air in the room is filtered and recirculated. Room configurations and the location / geometry of walls can have a drastic effect on efficiency. These portable units should be located in such a manner that air expelled from the patient is immediately filtered to protect staff. The unit should be located near the patient bed/table, away from interfering with the staff in the room.

7-2.4.3. Portable units shall not be used in rooms where there is no general ventilation. A portable air recirculation unit cannot bleed air to the outside in order to create negative room pressure.

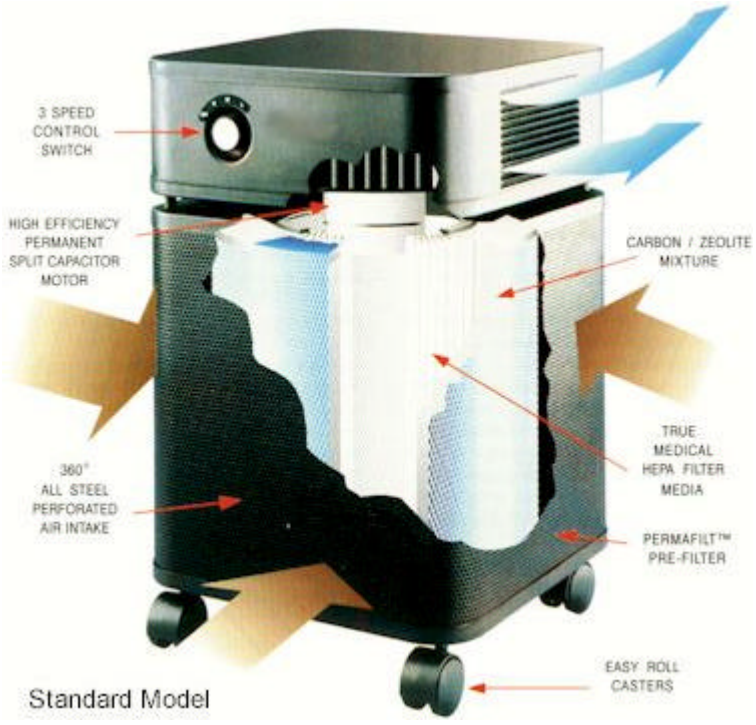


Figure 8. A Typical Portable HEPA-Filtered Unit.[66]

7-2.4.4. Portable systems shall have tamper-proof controls, to avoid patient interference with the unit.

7-2.4.5. Portable HEPA filtration units should be designed to achieve the airflow equivalent of 12 ACH or greater. They should also be designed to ensure adequate air

[66] Courtesy of Berriman Associates, http://www.berriman-usa.com.

mixing in all rooms in which they are used, in accordance with 7-2.4.2. They should also not interfere with the operation of the room ventilation system.[67]

Section 7-3. Ultraviolet Germicidal Irradiation (UVGI) Units.

7-3.1. General.

7-3.1.1. UVGI units have been demonstrated in various experiments to be effective in either killing or deactivating TB and other bacteriological infections.[68] Ongoing experiments are attempting to quantify the efficiency of UVGI units, as compared to the efficiency of increased ventilation.

7-3.1.2. Protection consists of specially designed lamps, capable of emitting ultraviolet waves. Commercially available UV lamps used for germicidal purposes are low-pressure mercury vapor lamps that emit radiant energy in the UV-C range, with a measured wavelength of 253.7 nanometers.[69]

7-3.1.3. UVGI can be used as a method of air disinfection to supplement other engineering controls.[70] UVGI shall not be used alone as an engineering control for disease isolation areas. UVGI shall be used in conjunction with an engineered HVAC system, designed in accordance with Chapters 3, 4, and 5.

7-3.1.4. UVGI systems shall not be used in areas subject to humidity levels greater than 70%. Water vapors absorb significant amounts of UV-C radiation and high levels of humidity can impair a system's efficiency.[71]

7-3.1.5. UV-C radiation may fade colored plants and fabrics. Care shall be taken in choosing furnishings in these areas. Consult the UVGI system manufacturer for more details.

7-3.1.6. There are two methods of UVGI protection, duct irradiation and upper-room air irradiation systems.

---

[67] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 84.

[68] Linamen, David R. Designing HVAC Systems for Hospital Isolation Rooms, A Short Course. 1997, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), Atlanta, p. 37.

[69] Illuminating Engineering Society of North America (IESNA). IES Lighting Handbook, 8th Edition. 1993, IESNA, New York. http://www.iesna.org.

[70] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 89.

[71] Hitchings, D.E. Preventing Transmission of TB in Health Care Facilities: An Engineering Approach.

7-3.1.7. Circuits connecting UVGI units shall be arranged for either delayed automatic or manual connection to the equipment branch of the emergency power system, when facilities are provided with emergency power.[72]

7-3.2. Duct Irradiation Systems.

7-3.2.1. This type of system involves mounting UV lights directly in exhaust ductwork to decontaminate air prior to recirculation. The lamps are installed perpendicular to the airflow.

7-3.2.2. Duct irradiation is recommended for isolation and treatment rooms where air is recirculated solely within the room (see Section 7-2.2) where the system is not equipped with HEPA filtration. Duct irradiation units are also recommended for general, recirculating exhaust systems found in patient, waiting, emergency rooms, and other general use areas where there may be unrecognized infectious patients. Duct irradiation units may not be used as a substitute for HEPA filter requirements.

NOTE: It is the opinion of the writer that until further studies conclude the effectiveness of irradiation units in ductwork that is part of a general return system servicing other areas of a facility, irradiation units shall not be substituted for HEPA filtration as required in Chapters 4 and 5.

7-3.2.3. Professionally trained individuals shall install duct irradiation units to ensure proper sizing of lamps and their respective wattage.

7-3.2.4. Particle residence time, the radiation field created by the lights, and the field intensity are all relative to the system's efficiency in killing bacteria. Duct velocity should be in accordance with the design requirements of the irradiation system to provide adequate resistance time to kill the bacteria.[73]

7-3.2.5. Lamps shall be located downstream of an efficient filter bank and shall be cleaned regularly in accordance with 7-3.4.

7-3.2.6. Access doors shall be provided in ductwork. These doors should have an inspection window for checking dust levels or lamp failure, additional devices such as warning lights should be considered. Signs shall also be posted warning staff not to look directly into the lamp tubing. A lock on these access doors, interlocked to de-energize UV lamps upon entry into the ductwork, is recommended.[74]

7-3.3. Upper-Room Air Irradiation Systems.

---

[72] National Fire Protection Association. National Electric Code (NFPA 70). 1999, Quincy, MA, http://www.nfpa.org.

[73] Hitchings, D.E. Preventing Transmission of TB in Health Care Facilities: An Engineering Approach.

[74] Linamen, David R. Designing HVAC Systems for Hospital Isolation Rooms, A Short Course, p. 41.

7-3.3.1. This type of system involves suspending UV lights from ceiling or wall mounts in isolation areas to decontaminate air inside the room.

7-3.3.2. Upper-room irradiation systems are recommended for isolation and treatment rooms as a supplemental method of air cleaning. These systems are also recommended for patient, waiting, and emergency rooms, and other general use areas where there may be unrecognized infectious patients.

7-3.3.3. Room-mounted systems may be used to supplement the existing ventilation if the HVAC system is incapable of producing the required number of air changes listed in Chapters 4 and 5 for existing facilities. Room-mounted systems shall not be used for this purpose in new and renovated facilities. At a minimum, TB isolation rooms shall be provided with 6 ACH and a direct exhaust system, when equipped with this method of UVGI protection.

NOTE: The CDC reported that, "Serratia maracesens, was aerosolized in a room with a ventilation rate of 6 ACH. These reports estimated the effect of UVGI to be equivalent to 39 ACH. This bacteria is less resistant to UVGI than mycobacterium tuberculosis."[75]

7-3.3.4. Upper room-air irradiation systems shall not be used when a room is connected to a recirculating HVAC system.
Exception. A recirculating system, installed in accordance with 4-6.1.2, can be supplemented by an upper-room air irradiation system.

7-3.3.5. Lamps shall be designed with shields, such that radiation is directed upwards to decontaminate air in the upper section of the room and minimize exposure to the patient and staff.

7-3.3.6. The location of air registers is important to ensure proper convective air currents. Supply air shall be drawn from the register, through the radiation field. This irradiated air shall pass down into the room, over the patient, and out through the exhaust register.

7-3.3.7. Only professionally trained individuals shall install upper-room irradiation systems. The effectiveness of a UVGI room-air system depends on room configuration, lamp placement, light intensity, and the time-contaminated air is in the irradiated area.[76]

7-3.4. UVGI Maintenance.

[75] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 90.

[76] Linamen, David R. Designing HVAC Systems for Hospital Isolation Rooms, A Short Course, p. 39.

7-3.4.1. A monitoring program shall be developed by appropriate personnel to identify possible overexposures to staff, patients, and others. A maintenance schedule shall be developed in accordance with manufacturer's guidelines.

7-3.4.2. Warning signs shall be posted on lamps and wherever UV irradiation is present, including upper-room air space and access to ducts where UV lights may be mounted. Signs shall post warnings such as "Caution: Ultraviolet Energy: Turn Off Lamps Before Entering Upper Room" or "Caution: Ultraviolet Energy: Protect Eyes and Skin".[77]

7-3.4.3. Maintenance personnel shall turn off all lights in upper-room air irradiation systems before servicing the equipment. Protective equipment (gloves, face shields) shall be worn when servicing equipment to prevent UV overexposures.[78]

7-3.4.4. Lamps shall be monitored periodically for dust buildup. If dirty, lamps shall be allowed to cool and wiped with a damp cloth.

7-3.4.5. Lights shall have tubes replaced if tubes begin to flicker.

7-3.4.6. UV measurements shall be made periodically, as recommended by the irradiation system manufacturer. Testing equipment used shall be maintained and calibrated on a regular schedule, as deemed appropriate by the testing equipment manufacturer.

7-3.4.7. Any isolation rooms, equipped with upper-air irradiation systems shall be monitored for areas where the NIOSH relative exposure limit (REL) may be exceeded. An industrial hygienist or a trained individual accustomed to making measurements should do all testing. Further guidance on exposure limits may be found in *Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health Care Facilities*, Reference #3. Rooms exceeding the REL shall be serviced promptly to correct system deficiencies.

7-3.5. UVGI Limitations.

7-3.5.1. The effectiveness of UVGI systems has not been quantified, unlike studies done with air exchange rates for example. System efficiency will vary based upon the factors described in this section.

7-3.5.2. Based upon system limitations, UVGI shall not be used as a substitute for the following:

(1) HEPA filtration, if it is necessary to recirculate air from TB isolation rooms into other areas.

---

[77] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 93-94.

[78] Linamen, David R. Designing HVAC Systems for Hospital Isolation Rooms, A Short Course, p. 41.

(2) HEPA filtration or local exhaust from booths, tents, cough-inducing chambers.
(3) Negative pressure.
(4) UVGI shall not be installed in series with HEPA filtration, since there are no additional benefits, provided HEPA filters are properly maintained. The particulates will accumulate in the filter at the same rate.[79]

7-3.5.3. The UVGI systems require periodic maintenance as determined by the manufacturer. Ensure that there are adequate staff at the facility to perform the maintenance duties on these pieces of equipment.

Section 7-4. Respiratory Protection.

7-4.1. Performance Criteria.

7-4.1.1. Particulate Respirators.

7-4.1.1.1. Only certain certified respirators will protect against TB. There are several types of particulate respirators that are available. They are identified as HEPA, N, P, or R series certified respirators. N-100 respirators are HEPA respirators and are preferred in a hospital environment. Respirators shall have the ability to filter particles 1 micrometer in size in the unloaded filter stage, with a filter leakage of ≤ 5%, given flow rates of up to 1.75 CFM.[80]

7-4.1.1.2. Respirators will be fit tested in a reliable manner to obtain a preferred face-seal leakage of 1%. Quantitative fit-testing shall be used to accomplish this level of protection.

7-4.1.1.3. Respirators shall be available in a minimum of 3 sizes in at least 2 different brands, to accommodate different staff facial sizes.[81]

7-4.1.1.4. Respirators shall be checked for proper facepiece fit, in accordance with accepted industrial hygiene practice, by staff each time the respirator is worn.[82]

7-4.1.1.5. Disadvantages with using particulate respirators include possible "fogging" of the lenses (when using a full faceplate), difficulty in verbal communication,

---

[79] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 91.

[80] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 97.

[81] Occupational Safety and Health Administration. Standards 29 CFR 1910.1025. 1999, Washington, DC, http://www.osha.gov.

[82] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 98.

uncomfortable fittings, incompatibility when wearing eyeglasses, and the potential for contaminated air to leak into the facepiece.

7-4.1.2. Powered Air-Purifying Respirators.

7-4.1.2.1. Powered Air-Purifying Respirators (PAPRs) should be used in a procedure where an advanced level of respiratory protection is desired. Prior to the procedure, a risk assessment should be done by qualified personnel to determine if PAPR protection is appropriate. An example of such a situation may include a bronchoscopy performed on a patient suspected of having TB or an autopsy performed on a patient who suffered from an acute case of TB.[83]

7-4.1.2.2. A PAPR uses a blower to pass contaminated air through a HEPA filter, which removes particulates (see Figure 9).[84]

Figure 9. A PAPR Unit (Courtesy of NIOSH).

7-4.1.2.3. A PAPR is typically more comfortable than a particulate respirator and enough air is delivered to the headpiece that any leakage is directed outward. However, a PAPR is very cumbersome, noisy, and communication through the headpiece is difficult.[85] The cartridges used by a PAPR do not last but for a short period of time. A PAPR with measurable leakage should not be used in operatory procedures for reasons stated in Section 7-4.2.

7-4.1.3. Positive-Pressure Supplied-Air Respirators.

7-4.1.3.1. These respirators use compressed air from a stationary tank or compressor delivered through a hose under pressure to either a half or full facepiece.

7-4.1.3.2. These respirators may be used when a risk assessment done by a qualified industrial hygienist concludes that advanced protection is necessary for a certain

[83] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 99.

[84] National Institute for Occupational Safety and Health. Respirator Information – Factsheet. http://www.cdc.gov/niosh/tb-ii/html.

[85] National Institute for Occupational Safety and Health. Respirator Information – Factsheet.

procedure. These respirators should not be used in sterile procedures, since exhaust air from the health care worker can contaminate the environment (see Section 7-4.2). Face shields should be considered to provide protection from contaminated fluids.[86]

Figure 10. A Positive Pressure Supplied-Air Respirator (Courtesy of NIOSH).

7-4.1.3.3. Respirators shall be available in a minimum of 3 sizes in at least 2 different brands, to accommodate different staff facial sizes.[87]

7-4.2. Respiratory Protection in Operatory Procedures.

7-4.2.1. Respirators should protect health care workers from infectious nuclei that may be expelled by the patient or generated in a medical procedure.

7-4.2.2. Respirators shall protect the sterile field from secretions from the health care worker. Respirators with expiration valves and positive pressure shall not be used in operatory procedures, because they do not protect the sterile field.[88] These respirators, however, may be used in autopsy rooms.

7-4.3. Patient Usage in Non-Operatory Areas. Surgical masks are designed to prevent the respiratory secretions of the person wearing the mask from entering the air. When not in a TB isolation room, patients suspected of having TB should wear surgical masks to reduce the expulsion of droplet nuclei into the air. These patients do not need to wear particulate respirators, which are designed to filter the air before the person wearing the mask inhales it.[89]

---

[86] National Institute for Occupational Safety and Health. Respirator Information – Factsheet.

[87] Occupational Safety and Health Administration. Standards 29 CFR 1910.1025. 1999, Washington, DC, http://www.osha.gov.

[88] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 98.

[89] Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 26.

7-4.4. Mandatory Requirements for Respirator Usage by Health Care Workers. Based on the requirements of OSHA 1910.134 – Respirators, 1910.139 – Respirators for Use with TB, and the CDC, respirators shall be provided when health care workers are:

(1) present during the performance of procedures or services for individuals with suspected or confirmed infectious TB,

(2) transporting an individual with suspected or confirmed infectious TB in an enclosed vehicle,

(3) replacing, repairing, or maintaining air systems or equipment that may reasonably contain TB bacteria,

(4) working in the residence of an individual with suspected or confirmed infectious TB,

(5) transporting an individual with suspected or confirmed infectious TB within the facility when that individual is not masked,

(6) working in a lab where aerosols of tuberculosis cannot be safely contained, and

(7) working in an area where an unmasked individual with suspected or confirmed infectious TB has been segregated while awaiting transfer.[90]

[90] Abrams, David S., CIH, and Gross, Liz, CIH, Respirator Use in Health Care: New Requirements, TB and Other Issues, American Industrial Hygiene Conference and Exposition, Toronto, ONT, 1999.

APPENDIX A
References

1. Code for Safety to Life from Fire in Buildings and Structures (NFPA 101), National Fire Protection Association, Quincy, MA, http://www.nfpa.org., 2000.

2. Designing HVAC Systems for Hospital Isolation Rooms, A Short Course, David R. Linamen, ASHRAE, Inc., Atlanta, GA, http://www.ashrae.org., 1997.

3. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, Centers for Disease Control and Prevention, MMWR 1994, 43 (No. RR-13), Atlanta, GA, http://www.cdc.gov., 1994.

4. Health Hazard Alert: Dioctyl Phthalate, U.S. Department of Energy, Industrial Hygiene Programs Division, Washington, DC, http://nattie.eh.doe.gov/docs/hha/hha.0002.txt., 1993.

5. Heating, Ventilating, and Air-Conditioning Applications, American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA, http://www.ashrae.org., 1995.

6. Illuminating Engineering Society Lighting Handbook, 8th Edition, Illuminating Engineering Society of North America, New York, NY, http://www.iesna.org., 1993.

7. Industrial Ventilation, 23rd Edition, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, http://www.acgih.org., 1998.

8. MIL-HDBK-1191: DoD Medical Military Construction Program Facilities Design and Construction Criteria, Defense Medical Facilities Office, Falls Church, VA, 1996 (New Version Under Revision).

9. National Electric Code (NFPA 70), National Fire Protection Association, Quincy, MA, http://www.nfpa.org., 1999.

10. OSHA News, Safetyadvantage, http://www.safetyadvantage.com., December 1998.

11. OSHA Regulations (Standards – 29 CFR), 1910.134 - Respirators, Occupational Safety and Health Administration, Washington, DC, http://www.osha.gov, 1999.

12. OSHA Regulations (Standards – 29 CFR), 1910.139 – Respirators for use with Tuberculosis, Occupational Safety and Health Administration, Washington, DC, http://www.osha.gov, 1999.

13. OSHA Regulations (Standards – 29 CFR), 1910.1025 – Lead, Occupational Safety and Health Administration, Washington, DC, http://www.osha.gov, 1999.

14. OSHA Regulations (Standards – 29 CFR), 1910.1048 - Formaldehyde, Occupational Safety and Health Administration, Washington, DC, http://www.osha.gov, 1999.

15. Policy Memorandum – Design and Construction of Inpatient TB Isolation Rooms in Army Medical Treatment Facilities, Office of the Surgeon General, 1 May 1998.

16. Preventing Transmission of TB in Health Care Facilities: An Engineering Approach, D.E. Hitchings, Hitchings Associates, PC, http://www.safelab.com/TECH_PAPERS., 1996.

17. Proposed Tuberculosis Standard, Occupational Safety and Health Administration, Washington, DC, http://www.osha.gov., October, 1997.

18. Respirator Information – Factsheet, National Institute for Occupational Safety and Health, Cincinnati, OH, http://www.cdc.gov/niosh/tb-ii.html., 1999.

19. Respirator Use in Health Care: New Requirements, TB and Other Issues, Abrams, David S., CIH, and Gross, Liz, CIH, American Industrial Hygiene Conference and Exposition, Toronto, ONT, 1999.

20. Selection, Installation, and Use of Biological Safety Cabinets, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Washington DC, http://www.orcbs.msu.edu/biological/bsc/bsc.html., September, 1995.

21. Standard for the Installation of Air-Conditioning and Ventilating Systems (NFPA 90A), National Fire Protection Association, Quincy, MA, http://www.nfpa.org., 1996.

22. Telephone Conversation with Headquarters, U.S. Army Medical Command, Reference: Maintenance and Cleaning of HVAC Systems, December, 1996.

23. Telephone Conversation with Mr. Sandro Portuesi, HVAC Maintenance Engineer, National Institutes of Health, Bethesda, MD, Reference: Maintenance of HEPA Filters, January, 1999.

24. Tuberculosis – Fact Sheet No. 104, World Health Organization, http://www.who.int., February 1998.

25. Tuberculosis – On the Rebound? Newsletter, Mayo Clinic, http://www.mayohealth.org., 1997.

26. White Paper on Occupational M. Tuberculosis, American Industrial Hygiene Association, http://www.aiha.org/papers/tb2.html., 22 March 1995.

APPENDIX B
Abbreviations

ACH	Air Changes per Hour
AIHA	American Industrial Hygiene Association
BIBO	Bag-in / Bag-out
CDC	Centers for Disease Control
CFM	Cubic Feet per Minute
CHPPM	Center for Health Promotion and Preventive Medicine
DMFO	Defense Medical Facilities Office
DOP	Dioctal Phthalate
FPM	Feet per Minute
HEPA	High-Efficiency Particulate Air
HVAC	Heating, Ventilation, and Air-Conditioning
JCAHO	Joint Commission on the Accreditation of Healthcare Organizations
MEDCOM	Medical Command
MTF	Medical Treatment Facility
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
Qe	Volumetric Flow Rate of Exhaust Air
Qs	Volumetric Flow Rate of Supply Air
REL	Relative Exposure Limit
TB	Tuberculosis
TG	Technical Guide
USA	United States Army
USACE	United States Army Corps of Engineers
UVGI	Ultraviolet Germicidal Irradiation
WHO	World Health Organization

APPENDIX C
CHPPM Form 250-R

REQUEST FOR SERVICE

The proponent of this form is USACHPPM

USACHPPM TG 252 November 2000

*See instructions on reverse side of form.

1. DESCRIPTION OF SERVICE REQUESTED.

Program _____

Service Desired: _____

2. REQUESTOR INFORMATION:

Organization _____

Installation _____

Mailing Address _____

MACOM/Sub-MACOM _____

Name of POC _____

Phone Number DSN _____ COMMERCIAL _____

Requestor's Prioritization: (*circle one*)

IMMEDIATE HIGH MEDIUM LOW

Impact if Service is Not Performed (*Optional*) _____

3. CHPPM Point of Contact *(if known)*: _____

MACOM INFORMATION: Control Number _____

Name/Title of MACOM POC _____

Phone Number DSN _____ COMMERCIAL _____

MACOM Prioritization: (*circle one*)

IMMEDIATE HIGH MEDIUM LOW

Preferred Quarter _____

Signature _____ Date _____

MACOM POC

CHPPM Form 250-R-E, 1 MAY 95 (MCHB-DE-S) *PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE*