



# 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:

1. <a href="#">Introduction</a> .....	2
2. <a href="#">Background</a> .....	3
3. <a href="#">HVAC Design Guidelines for New Disease Isolation Bedrooms</a> .....	6
4. <a href="#">HVAC Design Guidelines for Existing Disease Isolation Bedrooms</a> .....	12
5. <a href="#">HVAC Design Guidelines for Other Hospital and Clinical Areas</a> .....	17
6. <a href="#">Recommendations for HVAC System Testing and Maintenance</a> .....	24
7. <a href="#">Alternate Engineering Controls and Respirator Protection</a> .....	33
Appendix A, <a href="#">References</a> .....	45
Appendix B, <a href="#">Abbreviations</a> .....	47
Appendix C, <a href="#">CHPPM Form 250-R, Request for Services</a> .....	48

*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.*

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.<sup>67</sup>

### **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.<sup>68</sup> 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.<sup>69</sup>

7-3.1.3. UVGI can be used as a method of air disinfection to supplement other engineering controls.<sup>70</sup> 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.<sup>71</sup>

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.

---

<sup>67</sup> Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 84.

<sup>68</sup> 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.

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

<sup>70</sup> Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 89.

<sup>71</sup> 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.<sup>72</sup>

### 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 residence time to kill the bacteria.<sup>73</sup>

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.<sup>74</sup>

### 7-3.3. Upper-Room Air Irradiation Systems.

---

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

<sup>73</sup> Hitchings, D.E. Preventing Transmission of TB in Health Care Facilities: An Engineering Approach.

<sup>74</sup> 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 marcescens, 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.”<sup>75</sup>**

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.<sup>76</sup>

7-3.4. UVGI Maintenance.

---

<sup>75</sup> Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 90.

<sup>76</sup> 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".<sup>77</sup>

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.<sup>78</sup>

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.

---

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

<sup>78</sup> 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.<sup>79</sup>

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  $\leq 5\%$ , given flow rates of up to 1.75 CFM.<sup>80</sup>

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.<sup>81</sup>

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.<sup>82</sup>

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,

---

<sup>79</sup> Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 91.

<sup>80</sup> Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 97.

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

<sup>82</sup> Centers for Disease Control and Prevention. Guidelines for Preventing the Transmission of Mycobacterium Tuberculosis in Health-Care Facilities, p. 98.