Consider Ultraviolet Germicidal Irradiation

Ultraviolet germicidal irradiation (UVGI) has been used successfully for many years to control airborne infective microorganisms such as *Mycobacterium tuberculosis*, the bacterium that causes tuberculosis. Ultraviolet light at all wavelengths but especially at around 265 nanometers (NM) (modern ultraviolet lamps have an optimal discharge at 254 NM) damage the DNA of irradiated microorganisms (Martin et al. 2008). Ultraviolet light emitted and localized in the upper portion of room air (referred to as *upper-air UVGI*) has been used for controlling tuberculosis, especially in poorly ventilated or crowded indoor spaces where other interventions such as increasing HVAC outdoor air ventilation rates or raising filtration efficiency are not practical (Nardell 2002; Nardell et al. 2008). Droplet nuclei[1] from infected occupants in a room can migrate on air currents into the upper (room) air to be inactivated by UVGI from lamps along upper portions of walls. Inactivation of airborne microorganisms depends on both the intensity of the UVGI and the length of time that the particle containing the microbe is irradiated.

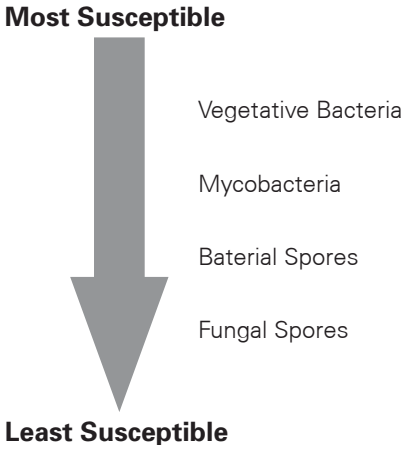


Figure 4.5-A Susceptibility of Microorganisms to UGVI
Adapted from ASHRAE (2008c), Chapter 11, Figure 2.

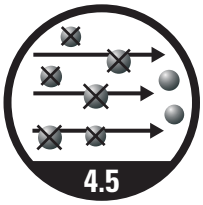
In addition to inactivating airborne microorganisms, UVGI directed at environmental surfaces can damage culturable microorganisms present or growing on the surface. Lower-intensity UVGI is effective for surface inactivation because irradiation is applied continuously. UVGI from lamps in AHU plenums has been used successfully to inactivate microorganisms present on airstream surfaces such as on cooling coils and drain pans (Menzies et al. 1999, 2003).

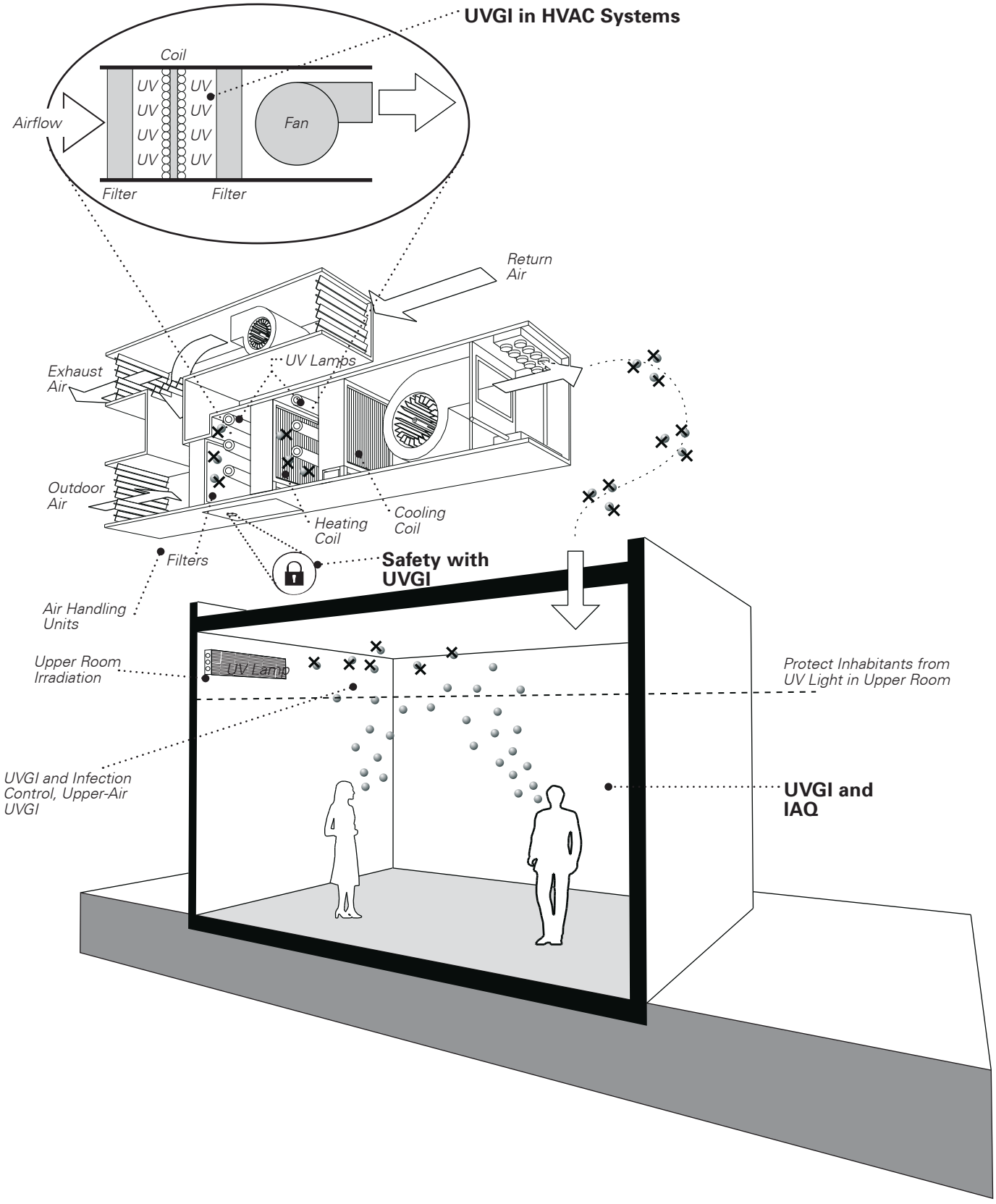
Vegetative bacteria including *Mycobacterium tuberculosis* are most susceptible to UVGI. Fungal and bacterial spores are more resistant to UVGI inactivation (see Figure 4.5-A). It needs to also be noted that viruses are among the most susceptible microorganisms to UVGI (Wells 1943; Perkins et al. 1947).

Studies by Menzies et al. (1999, 2003) have shown that occupants in several office buildings in Montreal reported a reduction in building-related symptoms when UVGI lamps in AHUs were turned on (as compared to time periods when the lamps in the same AHUs were deactivated.) Environmental microbiology tests in buildings studied by Menzies et al. determined that there was a significant decline in culturable bacteria and fungi on irradiated surfaces on cooling coils and in drain pans. However, these intervention studies did not find any decline in culturable fungi or endotoxins in workplace (office) air when UVGI lamps in AHUs were turned on. Air sampling in offices when UVGI lamps were turned on did show a slight, but not significant, decline in culturable bacteria on blood agar medium (not optimal for environmental bacteria). Thus, while Menzies et al. did find a significant decline in building-related symptoms associated with use of UVGI in

[1] Small particles originating from the human respiratory tract; as water evaporates, the particles become smaller and remain airborne because of their small aerodynamic size.

Strategy 4.5


4.5


UVGI in HVAC Systems
Coil
UV
Airflow
Fan
Filter
Filter
Return Air
UV Lamps
Exhaust Air
Outdoor Air
Heating Coil
Cooling Coil
Filters
Safety with UVGI
Air Handling Units
Upper Room Irradiation
UV Lamp
Protect Inhabitants from UV Light in Upper Room
UVGI and Infection Control, Upper-Air UVGI
UVGI and IAQ

AHUs, significant declines in airborne levels of culturable fungi and bacteria as well as endotoxins were not detected in the office workplace.

Studies by Bernstein et al. (2006) in Cincinnati homes with asthmatic children showed an association between decline in airway hyper-responsiveness and use of UVGI in home ventilation systems. However, significant declines in concentrations of airborne fungi and bacteria associated with UVGI intervention were not detected. Thus, while both Menzies et al. (1999, 2003) and Bernstein et al. did find positive benefits associated with use of UVGI in HVAC systems, the environmental cause(s) for the reduction in building-related symptoms remains obscure and a topic for future research.

The designer needs to be aware that the use of UVGI lamps in AHUs, ductwork, and upper air requires careful attention to safety considerations to prevent inadvertent exposure of people to ultraviolet light. For example, lockout/tagout procedures are necessary to prevent accidental turning on of UVGI lamps when facility maintenance personnel are working in AHUs. Refer to Chapter 16 of the *ASHRAE Handbook—HVAC Systems and Equipment* (ASHRAE 2008c) for a comprehensive review of safety considerations associated with the use of UVGI in buildings. Well designed upper-air UVGI systems have been used safely for many years (Nardell et al. 2008).