EFFECTIVENESS AND SAFETY OF ULTRAVIOLET GERMICIDAL IRRADIATION LAMPS USED FOR AIR AND SURFACE DISINFECTION

TIP No. 24-103-0320

PURPOSE

To provide information on the usefulness and limitations of Ultraviolet Germicidal Irradiation (UVGI) lamps used for air and surface disinfection and to provide guidance on the safe use of these lamps.

REFERENCES

References are provided in the Appendix A.

FACTS

UVGI Lamps for Disinfection—Effectiveness and Limitations

The 2014 outbreak of the Ebola virus and the recent spread of the coronavirus disease 2019 (COVID-19) have renewed interest in UVGI lamps for disinfection. UV radiation was first used for disinfecting surfaces in 1877, for water in 1910, and for air in 1935 (references 1–4). As of this writing, five Army medical centers use UVGI lamps to help reduce the incidence of healthcare associated infections (see Figures 1 and 2; page 2) (references 5–6), and two Army installations use UVGI for water purification (references 7-8). Autonomous UVGI disinfecting robots were used in the People's Republic of China in response to COVID-19 (reference 9). The Centers for Disease Control and Prevention (CDC) has provided guidelines for the use of UVGI lamps in upper rooms and air handling units (AHUs) as a supplemental control measure for air disinfection (references 10–12), and tabletop lamps have been used in some biomedical research laboratories. Sample images of an upper room lamp and tabletop lamps are shown in Figures 3 and 4 (page 3) respectively.

Lamp technologies include continuously emitting low- and high-pressure mercury lamps as well as pulsed xenon arc lamps. Studies have shown that these technologies—continuously emitting vs. pulsed—are comparably effective for disinfection; though pulsed sources may be more practical if rapid disinfection is required (reference 13). Light emitting diodes (LEDs) and krypton-chlorine excimer lamps which emit in narrow bands in the germicidal range (UV-C) are emerging technologies.

While UVGI is an excellent surface disinfectant, it does not penetrate surfaces and cannot disinfect soiled surfaces. The inability of the UV radiation to reach nooks and crannies of surfaces or to penetrate coverings like dust and other matter may negatively impact disinfection. For these reasons, UVGI is typically used as part of a multi-tiered approach for disinfection. A published study by Army scientists in 2005 concluded that UVGI lamps could have some effect on the spread of infectious respiratory diseases, but there was inadequate evidence to support recommending its wide use (reference 14). The CDC recognizes that UVGI has several potential applications but also has limitations and potential hazards (reference 12).

Figure 1. Pulsed Xenon UVGI Lamp at William Beaumont Army Medical Center (U.S. Army photo)

Figure 2. Low Pressure Mercury UVGI Lamp at Brian Allgood Army Community Hospital (U.S. Army photo)

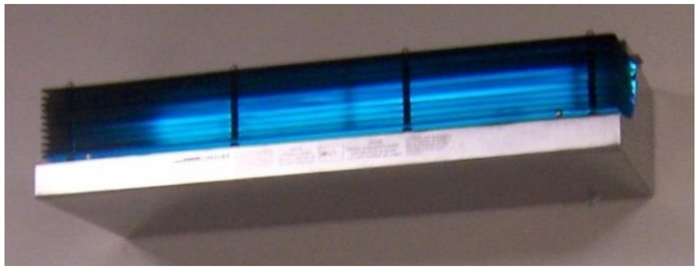

Figure 3. Upper Room UVGI Lamp for Air Disinfection (Photo by U.S. Army Public Health Center Nonionizing Radiation Division (APHC NRD))

Figure 4. Tabletop UVGI Lamps (Photo by APHC NRD)

UVGI Lamp Safety

UVGI lamp emissions can pose a workplace safety and health hazard if the lamps are improperly used or installed. However, these lamps can be used safely if workers are informed regarding the hazards and follow appropriate precautions.

Low- and high-pressure mercury UVGI lamps emit UV radiation that poses a hazard to the cornea and skin. Some UVGI LED devices emit near 270 nanometers (nm), which pose a hazard to the cornea and skin. “Far UV-C” lamps which emit near 222 nm can pose a hazard to the cornea, and recent studies have been inconsistent regarding whether far UV-C lamps pose a potential skin hazard (references 15-17). Pulsed xenon arc UVGI lamps emit UV and visible radiation that poses a hazard to the retina, cornea, and skin. Some pulsed xenon arc lamps are filtered so that only the UV radiation for disinfection is emitted. Even though these lamps can pose a UV hazard, incidental exposures in the workplace would not significantly increase one’s lifetime risk for cataract or skin cancer when compared to daily sunlight exposure (references 18 and 19).

Some types of UVGI lamps generate ozone. Ozone can pose a workplace hazard, and only lamps that are specified as “ozone free” should be used for disinfection. Maintenance and service on UVGI lamps should be performed by authorized personnel only, and workers should dispose of these lamps according to local regulations.

To ensure the safe use of UVGI lamps for surface disinfection:

- All lamps. Workers should place temporary warning signs at access points to the area being disinfected. They should either vacate the area during disinfection, or place opaque barriers between the UVGI lamp and room occupants. If these areas must be occupied during disinfection, and exposures cannot be avoided (e.g. if using a handheld disinfecting UVGI “wand”), then personal protective equipment (PPE) should be used.

- Low- and high-pressure mercury lamps, UVGI LEDs and far UV-C lamps. Workers should wear plastic or glass face shields to protect the eyes and face, nitrile gloves or work gloves to protect the hands, and full-coverage clothing with tightly-woven fabrics to protect all other exposed skin.

- Pulsed xenon arc lamps. Workers should wear welding or cutting goggles to protect the eyes, nitrile gloves or work gloves to protect the hands, and full-coverage clothing with tightly-woven fabrics to protect all other exposed skin.

To ensure the safe use of UVGI lamps for air disinfection:

- All lamps. Workers should place warning signs near upper room UVGI lamps, and on AHU access panels where internal UVGI lamps are installed. Activation switches should be clearly labeled and protected with switch guards to prevent accidental activation by unauthorized personnel. If exposures cannot be avoided, workers should wear plastic or glass face shields to protect the eyes and face, nitrile gloves or work gloves to protect the hands, and full-coverage clothing with tightly-woven fabrics to protect all other exposed skin.

- Upper room UVGI lamps. These lamps should be properly installed according to manufacturer instructions. Rooms with upper room UVGI lamps should not resume regular work activity unless the APHC NRD has confirmed that UV emissions in the lower room are within safety limits.

- AHUs with internal UVGI lamps. Access panels for AHUs with internal UVGI lamps should be interlocked with automatic shutoff switches to prevent accidental exposure to UV radiation. An inspection window that blocks germicidal UV radiation (e.g., plastic or glass) should be installed to allow workers to see if the UVGI lamp inside the AHU is operating.

Sunscreen lotions are not approved as PPE to protect the skin against UV radiation produced by UVGI lamps. Sunscreen lotions are made to protect against the UV radiation in sunlight (predominantly UV-A and UV-B). Its ability to protect against germicidal UV radiation (UV-C) has not been extensively studied.

Never use UVGI lamps for disinfecting the hands or other skin areas due to the extreme UV radiation hazard. The World Health Organization has included this warning as part of its public guidance in response to COVID-19 (reference 20).

QUESTIONS

Questions about the optical radiation hazards and protective measures for specific types of UVGI lamps should be directed to the APHC NRD at: 410-436-3932, or e-mail usarmy.apg.medcom-aphc.mbx.nonionizing@mail.mil

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APPENDIX A

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