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UV Lighting Part II - Fundamantals

Introduction

Ultraviolet Germicidal Irradiation (UVGI) technology can be used to deactivate or kill microbial and bacterial microorganisms. The technology was developed several decades ago, and its efficacy has been studied and analyzed since then, specifically in the healthcare industry. UVGI is not only used in healthcare facility HVAC applications, but also in the treatment of hard, non-porous surfaces such as stainless steel and plastics, where under certain ambient conditions viruses like influenza may survive 24 to 48 hours due to subpar ventilation. UVGI technology is also used in water treatment and has even been applied outside the healthcare industry.

UVGI Applications in Healthcare

The HVAC system maintains the ideal indoor air quality (IAQ) as well as the proper air pressurization for individual rooms and throughout the facility.

Figure 1 – Downward UVGI Lamps

However, despite the IAQ and air pressurization control, fungi, bacteria, and viruses (including those that cause non-infectious diseases) may still be present on clean surfaces.

Figure 2 – Robotized UV Disinfection

One common application of UVGI technology is disinfection: a passive UVGI fixture is installed in an occupied zone, where it produces a field of UV energy above the occupied area (see Figure 1). The efficacy of these UVGI lamps must be carefully evaluated in conjunction with other environmental factors. Serious consideration should be given to whether the room will be in use during UVGI operation; for example, if UVGI is used in an operating room (OR), occupants will need appropriate protective clothing and eye protection for the downward UV irradiation. Other types of UVGI room sterilization are also available, including robotized UV disinfecting units (see Figure 2).

Many studies indicate that a microorganism's size and DNA structure affect the efficacy UVGI. Specifically, UVGI may not be very effective on large bacteria and spores, and a capturing element such as a high-efficiency filter working in tandem with the UVGI is necessary. Many environmental factors influence the presence and activity of infectious agents, including air temperature, velocity, and room-to-room pressure differentials, and all these factors should be considered when evaluating the efficacy of the grouping design.

UVGI can also be used to deactivate infectious and non-infectious viruses and bacteria as part of the water treatment process; however, such process cannot rely strictly on UVGI. As with HVAC system applications, UVGI should only be part of the equation, because deactivating harmful microorganisms in water requires a multi-step water treatment process. This process should begin with identifying the desired water treatment level, which will determine various elements of the system such as filters, flow rate, and UVGI lamp specifications. UVGI is normally the final step of the water treatment process because it purifies the water after larger microorganisms have been filtered out.

UVGI Maintenance

It is important to consider the human health risks that accompany the use of UVGI technology. A poorly designed and installed UVGI system may have harmful effects on humans, be they building occupants or maintenance personnel. As a result, whenever UVGI lamps are used, proper standard operating procedures (SOP) must be established for safe operation and maintenance. The reliability and efficacy of the UVGI depends on how the system has been designed and maintained, so installation and maintenance of UVGI lamps must be done with care. Manufacturer recommendations for proper installation and maintenance vary, but basic aspects of UV lamp design and care should be evaluated, including:

- Cleanliness: This will ensure its maximum UVGI power.
- Bulb lifecycle and decay: Selecting the correct lamp type with consideration for bulb power, distance to treated area will enhance efficacy, and UV lamp replacement plan.
- Room/equipment air quality: Environmental conditions such as humidity and temperature may negatively impact UV lamp efficacy.

Applications Beyond Healthcare and HVAC

UVGI is primarily used for sterilization and disinfection, but other industries have expanded its uses to include surface curing, disinfection of filtering facepiece respirator (a technique normally implemented during a pandemic of infections respiratory diseases). In the food industry, UVGI enhances product shelf-life as part by implementing UVGI air and water treatment to sterilize products, packaging, and transportation. UV technology is also used in manufacturing as an inspection tool.

Conclusion

UVGI technology has many advantages and uses, but it should not be considered a standalone disinfection or sterilization source. Its use must be carefully planned and selected to achieve the proper level of efficacy necessary for the given application. UVGI technology must be part of a comprehensive disinfection and sterilization system and program, both to achieve the desired results and to keep people safe.

Reference for Further Reading

1. Solving Office Complex IAQ Issues Through Ultraviolet-C Technology https://www.achrnews.com/articles/142371-solving-office-complex-iaq-issues-through-ultraviolet-c-technology
2. A How UV-C energy works in HVAC applications: Part 2 https://www.csemag.com/articles/how-uv-c-energy-works-in-hvac-applications-part-2
3. Bacteria-Killer Robot Armed with Ultraviolet Light https://www.asme.org/topics-resources/content/bacteria-killer-robot-armed-with-ultraviolet-light