THE PROPER WAY TO IMPLEMENT UV-C SYSTEMS

Published By: Alexei A. Zemskov, P.E., LEED AP | SETTY

Executive Overview

Covid-19 caught the building, engineering, and construction industries off guard and as we collectively work to make buildings safe again, there are critical steps and safeguards to take to get people back to work and kids back in school. Reducing airborne infectious aerosol exposure is the top priority and there are core recommendations the industry should consider and implement as we attempt to return occupants to buildings. As these IAQ decisions and upgrades are made, it's crucial to work with engineering experts with the experience and knowledge to make sure new and existing buildings are constructed and outfitted properly.

In this paper, we'll offer insights on key challenges, considerations, and top-level recommendations related to improving indoor air quality in new and existing buildings, specifically focused on UV-C systems.

Introduction

With the onset of Covid-19, interest in UV lights as a germicidal has increased. The entire UV spectrum is capable of inactivating microorganisms, but UV-C energy (wavelengths of 100 – 280 nm) provides the most germicidal effect. The optimum wavelength for damaging DNA and RNA is 265 nm, destroying their ability to replicate and cause/spread disease. For decades, ultraviolet germicidal irradiation (UVGI) has been used to kill or mitigate viral, bacterial, and fungal species on surfaces. As Covid-19 persists, the use of UV energy to help combat the virus in the air has become an essential addition for IAQ management in all new and existing buildings.

Given its effectiveness and versatility, how do we ensure that buildings, both new and existing, are implementing this method correctly? What do we need to do to make – and keep – buildings safe for occupancy using UV-C systems?

Background

Effective airstream disinfection is achieved by installing high intensity UV-C light tubes into either AHU/RTU or into the associated supply or return ductwork. Keep in mind, UV-C light system installation into the existing mechanical equipment such as AHU and RTU can be challenging due to the fact that there are no provisions for the placement of this system inside the equipment.

The majority of modern UVGI lamps create UV-C energy with an electrical discharge through a low-pressure gas (including mercury vapor) enclosed in a soft glass or quartz tube, similar to fluorescent lamps. Roughly 95% of the energy produced by these lamps is emitted at a near-optimal wavelength of 254 nm. Currently, there are several types of disinfection systems using UV-C energy including, in-duct air disinfection, upper-room or upper-air disinfection, in-room surface disinfection, and portable room decontamination. Important note: UV-C light is harmful and requires special PPE to prevent damage to eyes and/or skin from overexposure.

Installation Recommendations for UV-C In-Duct Air Disinfection

When installing UV-C lights inside existing HVAC units or associated ductwork, make sure to position the banks of UV-lamps parallel or perpendicular to airflow. As the dose for the UV-C light is configured, remember that an increased dose of UV is needed to inactivate microorganisms on-the-fly as they pass through the disinfection zone. Air particles and airflow have limited exposure time, and we recommend the following for in-duct installations:

- Minimum target UV dose of 1,500 µW•s/cm2 (1,500 µJ/cm2)

- Designed for low airstream velocities
- Minimum irradiance zone of two feet long
- Minimum UV exposure time of a fraction of a second

UV-C airstream disinfection should be coupled with mechanical filtration where feasible. Layering the technologies significantly increases overall air cleaning/disinfection through capture and/or viral inactivation.

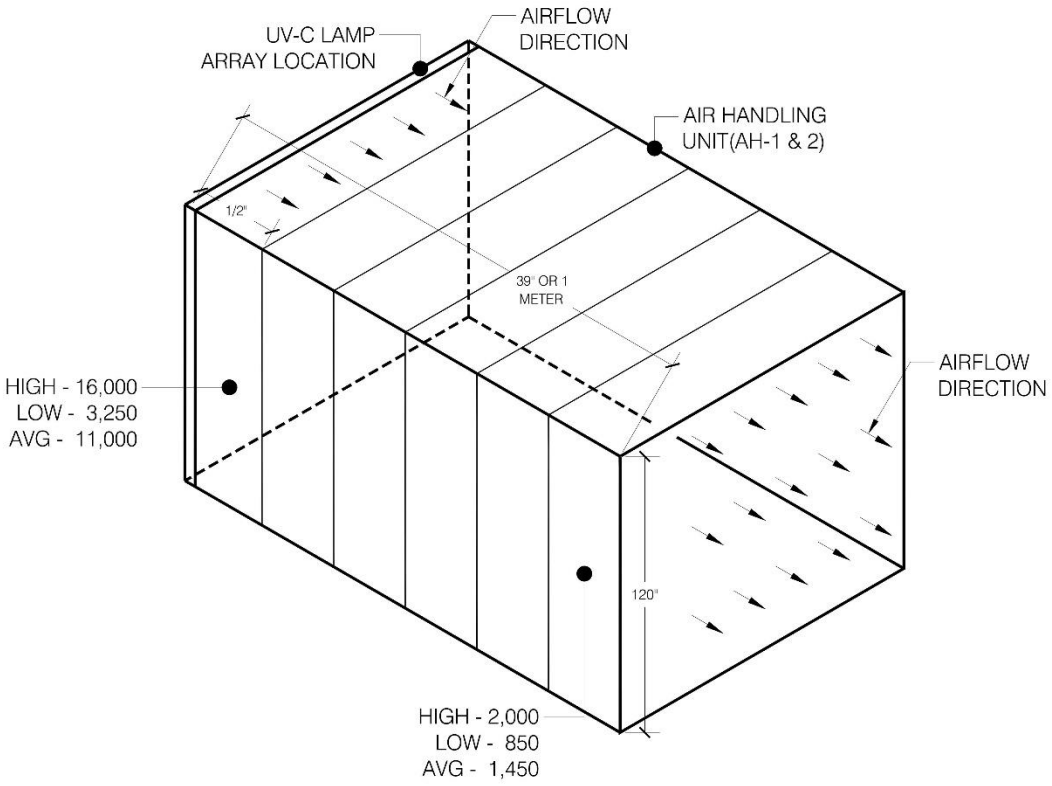

Figure 1: Estimated UV-C Lamp Intensity (µW/CM²)

Installation Recommendations for Air Disinfection at AHUs and RTUs

Much like in-duct systems, UV-C light systems specified for air disinfection at AHUs and RTUs should have a specified wavelength – and these specific UV-C dose values should be used during the design process. Long-term UV-C system effectiveness depends on the four following factors:

- Maximum air velocity across or along the UV-C light tubes system (ft/min)
- Available active distance for air sanitization by UV-C light (inch)
- Airstream exposure time to UV-C light (sec.)
- UV-C light intensity (W/cm2)

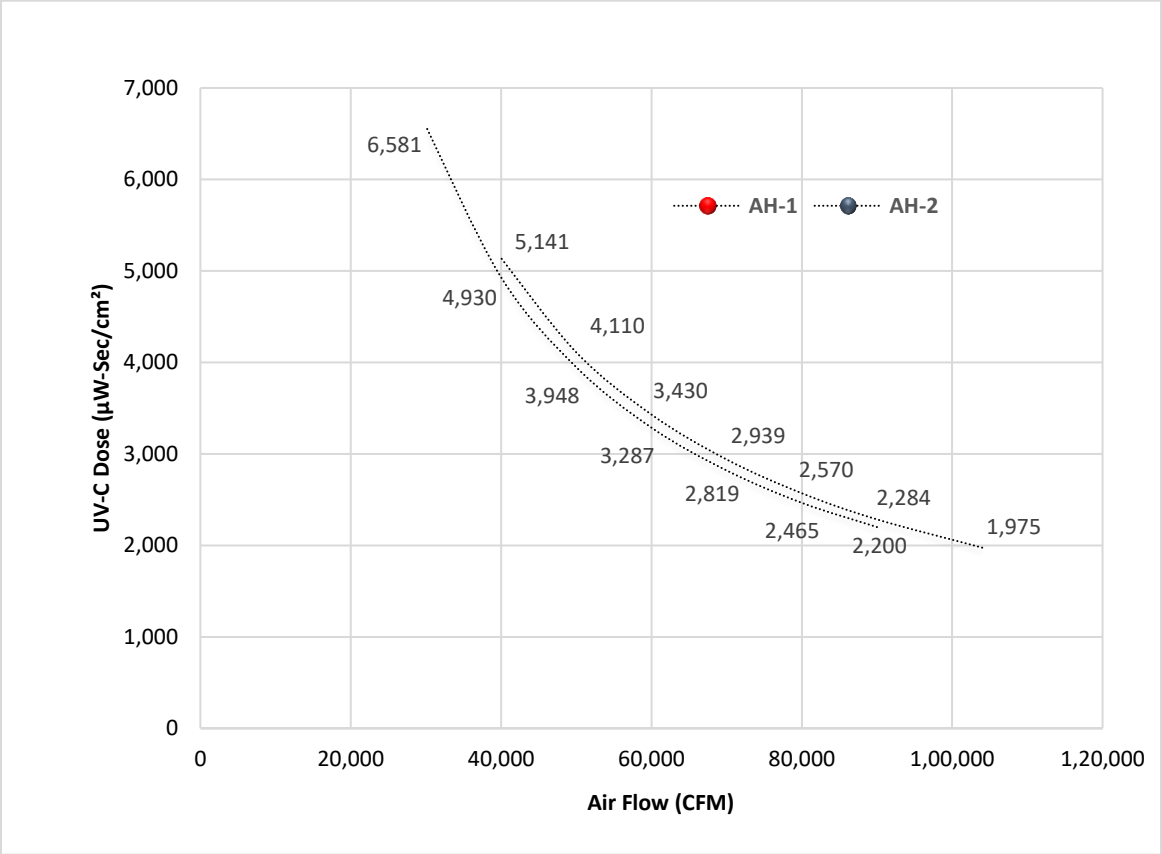

Figure 2: UV-C Dose Level v/s Supply Air Curve

When installed at AHUs/RTUs, the UV-C light system should be placed on the wet side (immediately downstream) of the cooling coil. Keep in mind that the active distance is crucial for calculating UV-C light intensity. The shorter the active distance, the higher the UV-C light intensity needed for the same virus "kill" effectiveness. This is a critical part of the design and installation process.

Light intensity is an important difference between in-duct UV-C systems and those installed at the AHU/RTU. When installed inside the supply or return sheet metal ductwork, UV-C systems will have higher light intensity compared to the AHU/RTU installation due to shortened UV-C light exposure time and elevated air velocities.

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The life and degradation of UV-C light tubes must also be considered. Average degradation in high intensity UV-C tubes is 10-15% (or higher) over the calendar year period. Therefore, initial UV-C light intensity selected by the engineer or designer needs to account for this degradation. Engineers should also know that not all UV-C lamps are suitable for airflow disinfection.

Conclusion

While UV-C lights have long been used to disinfect surfaces, the industry has just recently used UV-C systems in the fight against airborne disease. It's an effective additional measure for new and existing buildings to implement as we continue to battle Covid-19 as well as any future airborne viruses. Moving forward, UV-C systems should be an integral part of keeping building operations safe.
