SHINING A SPOTLIGHT ON HVAC ULTRAVIOLET TECHNOLOGIES TO FIGHT DISEASE TRANSMISSION

July 2020

The emergence of SARS-CoV-2, the novel coronavirus responsible for COVID-19, has renewed focus on commercial buildings as a crucial line of defense in fighting the spread of disease. Building owners and engineers who adopt a "layered" strategy of comprehensive planning, strengthened administrative controls, and optimized HVAC systems and practices can improve their capacity to minimize disease transmission in the workplace. (For more about this layered strategy, see our recent white paper — "Air-cleaning and Filtration: Addressing the Unseen in the 'New Normal.'")[1]

Because the SARS-CoV-2 virus is transmitted primarily through large respiratory droplets, and may also be spread by smaller, infected aerosol particles that remain suspended in the air, HVAC systems can be especially effective in reducing transmission of this virus in the built environment.[2]

Below, we discuss one set of specialized solutions that has been found, in combination with enhanced air filtration technologies, to improve indoor air quality (IAQ) and reduce the transmission of COVID-19. Ultraviolet germicidal irradiation (UVGI) works by degrading and inactivating bacteria, mold spores, fungi and viruses. This white paper describes:

- UVGI technology
- UVGI applications and solutions
- Resources and Carrier product solutions

With the help of qualified engineers, UVGI technology may be installed safely and affordably to augment existing HVAC system performance with no impact to occupant comfort and while improving safety and health of the occupants. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) writes that air filtration and UVGI solutions "can be applied to new buildings at moderate additional cost and can be applied quickly in existing building systems to decrease the severity of acute disease outbreaks."[3] The Illuminating Engineering Society (IES) agrees, saying, "There is no reason not to make full use of UVGI with appropriate precautions in this 'war' against COVID-19."[4]

UVGI Technology

UVGI is a proven technology, first used for disinfecting surfaces in 1877 and for air in 1935, including the control of the airborne transmission of tuberculosis. Hospitals have used UVGI for years to reduce the spread of superbugs and to disinfect surgical suites.[5]

Ultraviolet-C (UV-C) refers to the short-wavelength (200-280 nanometers) radiant energy used in UVGI applications. The typical source of artificial ultraviolet disinfection is a low-pressure mercury vapor lamp that provides radiant energy at approximately 254 nanometers UV, close to the most effective germicidal wavelengths.[6] Current research into far UV (~222 nanometers) looks promising for pathogen inactivation with lowered risk to humans.

UVGI solutions have been widely deployed in the HVAC industry to eradicate the mold and fungus that accumulate on wet surfaces of HVAC units such as the evaporator coil and drain pan. Known as “biofilm source control,” this method focuses UV-C energy on these static contaminated surfaces, successfully eliminating the objectionable “dirty sock” odor that once plagued HVAC systems. We know that a clean coil has lower pressure drop than a biofilm-clogged coil, thereby preserving original performance. Used consistently in an HVAC system, non-ozone producing UV-C lamps — selected to provide maximum dosage at 45 to 55 degrees F (7 to 13 degrees C) in a rapidly moving airstream — will ultimately destroy organisms on the coil and condensate pan. This process can return these components to an “as installed” condition and virtually eliminate the need for coil cleaning.[7]

With the rise of COVID-19, UVGI applications have taken on a new and immediate role in protecting and improving the workplace. A recent study published by the American Society for Microbiology Journals demonstrated that 10 minutes of UV-C light inactivated 99.999% of CoVs tested on surfaces, including SARS-CoV-2.[8]

The Centers for Disease Control (CDC) guidelines conclude that, “as a supplemental air-cleaning solution, UVGI is effective in reducing the transmission of airborne bacterial and viral infections in hospitals, military housing and classrooms.”[9] Introduced in the HVAC systems of commercial buildings alongside increased outdoor air ventilation, proper humidity controls and upgraded filtration technologies, UVGI solutions can provide an effective technology in the war against the SARS-CoV-2 virus.[10]

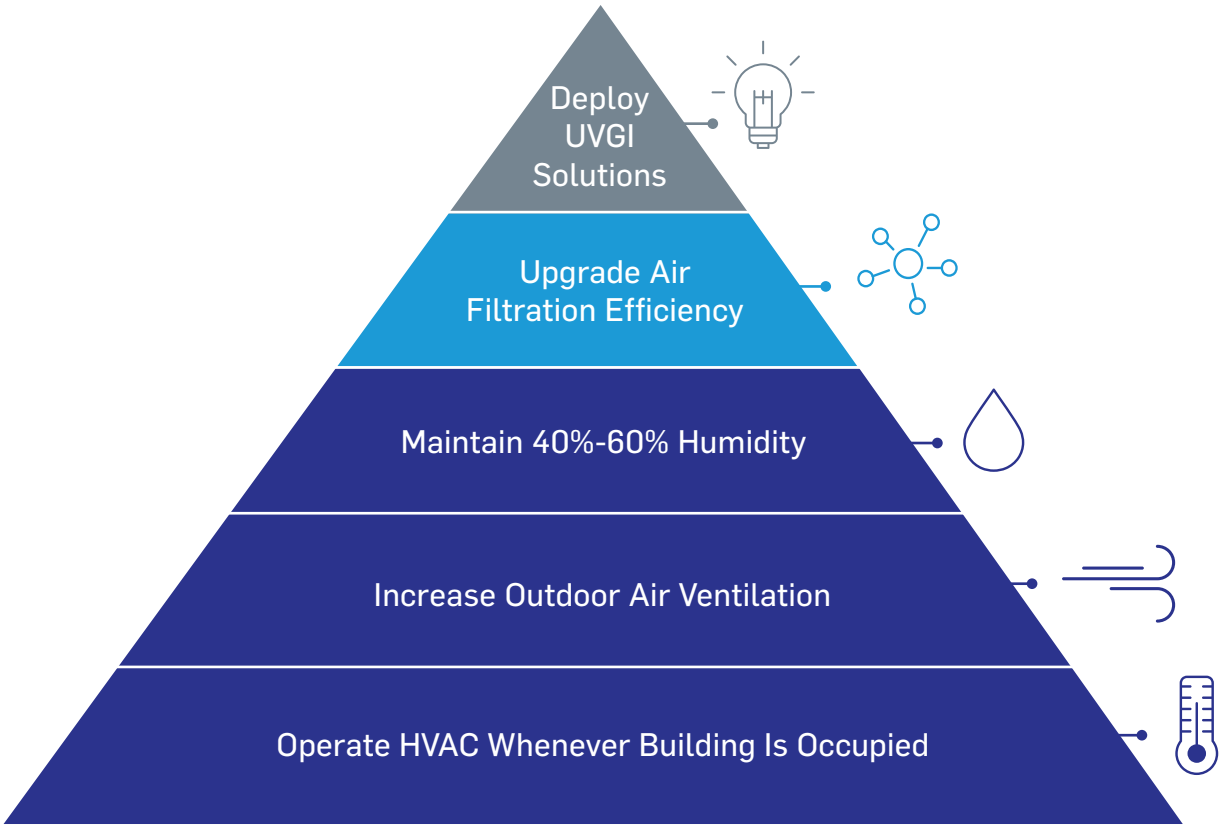


Figure 1: Optimizing HVAC Systems to Reduce COVID-19 Transmission

UVGI Applications and Solutions

UVGI offers a range of potential disinfectant strategies for the built environment. In-room irradiation of unoccupied spaces by autonomous robots armed with an array of UV-C lights is being deployed in patient rooms and operating theaters in Europe, China and North America. Standing nearly 6 feet tall and equipped with lidar sensors, these robots follow a digital map, traveling to and from their charging stations (including up and down elevators) to disinfect rooms in about 15 minutes. For safety, they are programmed to stop immediately if they detect motion.[11]

Amazon is testing a similar solution by deploying rolling robots designed to disinfect surfaces in Whole Foods stores and warehouses during non-occupied periods.[12]

When workers have the proper personal protective equipment, in-room irradiation of occupied spaces, such as medical building operating suites, is a possible though less common solution.

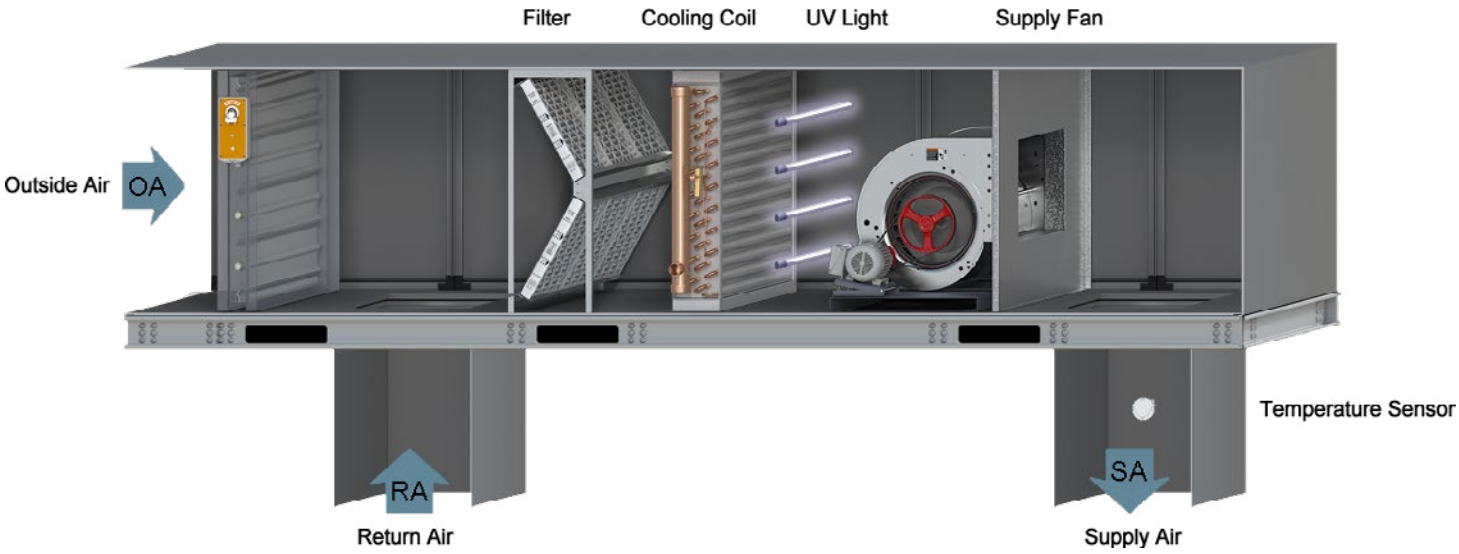
In-duct UVGI air disinfection systems provide UV-C radiation along the length of an air-handling unit and its associated ductwork. These systems must be sized to accommodate air residence time, a function of air velocity. While such solutions are feasible, "experience suggests," ASHRAE writes, "that control of a moving airstream does not provide favorable killing rates because of short dwell time."[13]

Today, two UVGI solutions are practical and effective in the greater built environment. The first, possible when ceiling height and other conditions permit, is to create a controlled UV-C field above the heads of occupants by disinfecting air in the "upper room." In this solution, UV-C light fixtures are mounted at least 7 feet (2 meters) above the floor, with another foot above the fixture to allow space for decontamination. This solution can be effective in treating spaces with minimal ventilation, or in high-traffic areas such as cafeterias and lobbies. If air change rates are greater than six per hour, however, upper-room UVGI may be less effective due to insufficient exposure of infected particles to radiation.[14]

The UVGI solution designed to reduce biofilm growth within HVAC systems in a practical and affordable way involves the placement of specialized UV-C lights in air handlers. These UV germicidal emitters are most effectively positioned on the downstream side of the evaporator coil over the condensate pan, irradiating both areas, though UV-C energy may also be focused on filters or the plenum. Carrier Corporation's "Selection Guide: Ultraviolet Germicidal Lamp" presents an in-depth guide for determining the optimal UVGI solution, including protecting man-made materials from UV-C energy.[15]

UVGI applications for HVAC systems are more beneficial when paired with particulate filters. For example, if a particulate filter removes 85% of a given agent in an incoming airstream, and a UVGI solution with a single-pass efficiency of 85% is added in series, the combined single-pass capture and inactivation rate of the system increases to 98%. ASHRAE further recommends that qualified building engineers review a range of combinations of air filtration and UVGI options to optimize air quality, energy use and financial return.[16]

UVGI solutions on their own do not provide filtration, meaning that inactivated particles such as dead fungal spores may remain in the airstream and present negative health effects. This possibility reinforces the view that a UVGI solution should be paired with air-filtration technologies.



The costs of deploying a biofilm reduction/elimination-HVAC UVGI solution includes the purchase and installation of equipment, lamp replacement and the cost of lamp operation. The return on investment will include improvements to system efficiency and lower maintenance costs resulting from better heat transfer by returning to “as installed” equipment conditions.

Of course, in an environment where the transmission of COVID-19 is possible, the payback of improved IAQ to worker health and well-being can be incalculable. For example, one study has shown significant benefits to work-related, self-reported acute health symptoms when UV-C lamps were added to cooling coils and drain pans.[17] Another study concludes that “predicted health benefits of UVGI and other air treatment technologies are large — so large that they overwhelm costs in a cost-benefit analysis.”[18]

A healthy built environment is also reflected in a building’s longer-term market competitiveness.

Resources – Carrier Product Solutions

Carrier's "Selection Guide: Ultraviolet Germicidal Lamp" provides a detailed overview of UV-C and its application to biofilm source control. The IES Photobiology Committee of the Illuminating Engineering Society offers a helpful set of Frequently Asked Questions about GUV and its application. In addition, three ASHRAE documents provide insight into the use of UV-C energy in the built environment, including "ASHRAE Position Document on Airborne Infectious Diseases," "ASHRAE Position Document on Filtration and Air Cleaning" and chapter 62 of *2019 ASHRAE Handbook — HVAC Applications* entitled "Ultraviolet Air and Surface Treatment."

Carrier offers UV-C lamps in many products, such as Carrier air-handling units like the Aero® 39M as well as applied rooftop units, which are designed to kill organisms that grow on the evaporator coil of a cooling system.

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