Putting UVC Under a New Light

The multiple benefits of installing ultraviolet devices in HVAC systems is boosting acceptance and awareness of this technology.

BY ROBERT SCHEIR, PH.D.

Editor's Note: Last month, we reviewed details on the benefits of ultraviolet (UV) light and indoor air quality, focusing specifically on technical issues technicians should keep in mind during the installation process. With significant reader interest on IAQ issues, we are following that article up with this feature that takes a closer look at some of the benefits of UV, how these products interact with other technologies, and how technicians and contractors can take advantage of their growing acceptance in residential and commercial applications to benefit end-users.

Ultraviolet-C (UVC) devices specially designed for installation in HVAC systems were first introduced in the mid-90s. Engineered to provide peak output under HVAC operating conditions, these high-output devices emit germicidal energy that kills or inactivates microbial contaminants, including surface and airborne mold, viruses and bacteria.

Based on their germicidal properties, UVC—also know as ultraviolet germicidal irradiation (UVGI)—lamps were first marketed solely as IAQ products. But early device users found that UVC simultaneously delivered a host of other benefits, including substantial maintenance and energy savings as a result of improved cleanliness and efficiency of HVAC systems.

Increasingly being recognized for its rapid return on investment, HVAC UVC technology has progressed from a relatively unknown technology nearly a decade ago to a swiftly adopted HVAC tool used in residences, schools, hospitals, offices, processing plants and public buildings of all types. The General Services Administration has for several years included the technology in its HVAC standard for federal facilities, which calls for UVC light installation "downstream of cooling coils and above drain pans to control airborne and surface microbial growth and transfer."

An important milestone for UVC was its recent acceptance into the Leadership in Energy and Environmental Design (LEED) program. Sammamish Commons in Washington was the first project to earn a LEED point for the use of UVC lights in air-handling units; the mechanical engineer for the project applied for and received the Innovation in Design LEED credit from the U.S. Green Building Council (USGBC) based on the product's IAQ and operational benefits. (*Editor's Note: For more information on the LEED certification process, visit www.usgbc.org/leed.)*

EPA/Homeland Security test reports

Although growing in acceptance, UVC as a component in HVAC systems is still in its infancy when compared to particulate air filtration, where well-established standards have long been in place to compare performance and select products. Groups such as American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the International Ultraviolet Association (IUVA) are trying to address this issue, but the development of a *final* UVC standard is still years away.

In the absence of a standard, the best current information available for contractors is a series of test reports commissioned by the Environmental Protection Agency (EPA) in conjunction with the National Homeland Security Research Center (NHSRC) through its Technology Testing and Evaluation Program (TTEP). This program was developed to provide reliable information regarding the performance of homeland-security related technologies.

As part of the TTEP program, this group published detailed reports in 2006 on nine leading UVC devices tested by research group RTI International. Each report describes test procedures, device specifications, mean dosage of UVC energy delivered, energy consumption, and

Anatomy of UVC: (clockwise) A large commercial A/C unit featuring UVC lighting; visual inspection are recommended for checking UVC systems, but not for making changeout decisions; an air-handling-system schematic shows proper location of UVC lamps at the downstream side of the cooling coil.

single-pass inactivation efficiencies on airborne bacteria, viruses and spores. The reports provide a useful benchmark that compares the performance of various UVC devices; these can be accessed at www.epa.gov.

Things to remember

Experience has taught some general guidelines to help ensure that UVC devices are used correctly and with optimum benefit. When selecting devices, in addition to reviewing the EPA test reports, contractors are advised to consider the following:

Proper device location—UVC lamps are currently installed in a number of locations, including ductwork and return air plenums. But the most effective location is mounted at the downstream side of the cooling coil, where it provides the most effective source control.

Why is it so important to treat the coil? There are intricate and complex matrices known as “biofilms” that grow in coils and drain pans. Biofilms are composed of different microorganisms that adhere to surfaces and produce a matrix composed of polysaccharides, proteins and nucleic acids. This matrix allows the biofilm to stick together and develop attached communities. Life within the biofilm is protected against penetration from outside agents, such as antimicrobials, but is susceptible to the germicidal effects of UVC light.

Biofilms are widely prevalent in commercial air handlers. For example, a 4 x 6-ft coil, eight rows deep with 10 fin rows/in., has a total surface area of 5,000 sq. ft plus the drain pan. That is a huge amount of surface area on which biofilm can build up, leading to a range of IAQ and operational problems that are sometimes mistakenly attributed solely to mold.

To keep coils clean and free of biofilm and other buildup, a high-output UVC-light source should be positioned perpendicular to the fins of the coil and 12 in. off the discharge coil face. When using high-output lamps to eliminate contamination from an existing system, a 24-in. centerline is recommended. With new systems, the centerline may extend to 30 in.

Proper output—UVC devices marketed for HVAC applications fall into two basic categories: those with new generation high-output lamps introduced in the ’90s; and those with conventional older-style lamps that were not specifically engineered for HVAC use. The germicidal output delivered by these devices varies widely, as documented in the EPA reports.

Output is critical because it affects a UVC lamp’s ability to perform as expected—i.e. to kill or inactivate microbial contaminants. Do high-output lamps deliver too much output? Is there such a thing as overkill? Misconceptions on this topic abound.

Some suppliers use confusing mathematical calculations to suggest that a UVC device constantly “doses” the space with germicidal energy, an action that adds up to thousands and thousands of doses over time. Using this logic, even the lowest-priced, lowest-output device should be adequate. But this argument ignores two critical facts: UVC output declines over time; and the dosing effect is not cumulative.

To effectively clean coils, a UVC

A view of UVC-equipped air handlers at Sammamish Commons in Washington, the first HVACR project to earn a LEED point for the use of UVC lights.

device should provide output measuring 8–10 μWatts/cm$_2$ per in. of glass from a distance of 1 meter, when tested in a 400 fpm airstream of 55°F. By definition, this requires the use of a high-output lamp. Older-style devices simply do not provide enough intensity to deliver the needed germicidal energy over time.

In reviewing output claims, it is important to ask some critical questions, including:

- Has output testing been performed by an independent certified test lab?
- Are output claims based on HVAC operating temperatures and conditions? (Some lamps are tested in warm, still air to yield higher output results.)
- Was testing performed from a distance of 1 meter? (Again, some manufacturers tweak results by testing lamps from much shorter distances.)
- Are output claims stated "per in. of glass? (This is the common denominator that will help provide an accurate comparison.)

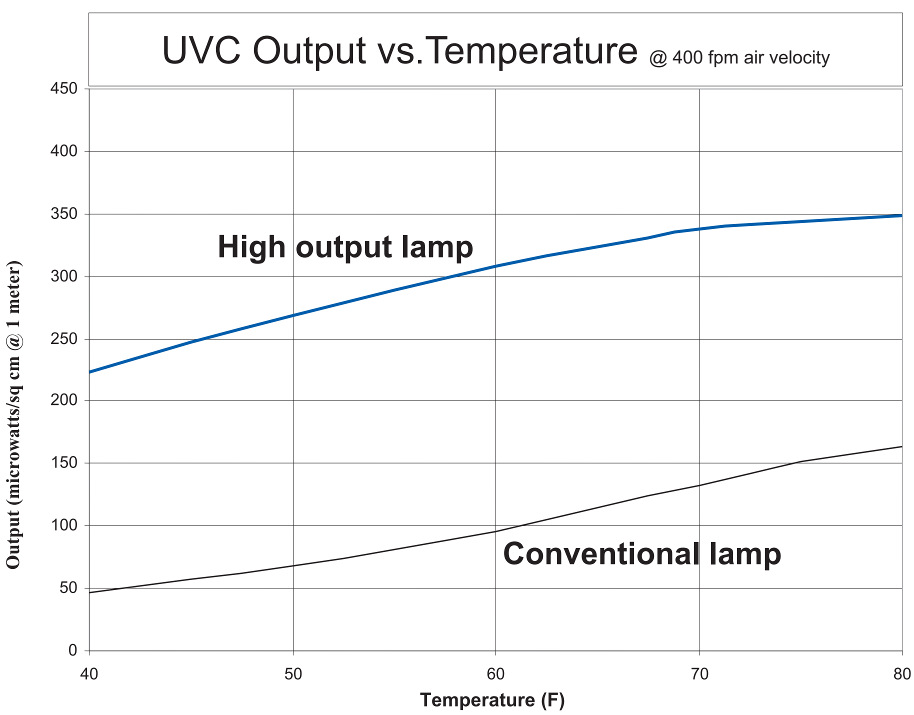
In addition to output, another useful measure of performance is "dose per watt," or the energy required for microbial control. Dose per watt considers not only germicidal output but also the electrical energy used by the device to deliver that output.

Changeout cycles—Lamp changeout cycles are closely linked to output. All UVC devices lose output on a linear basis over time, and reach their half-life after about one year or 9,000 operating hours. When low-output lamps are used in an HVAC installation, they are effective at first, but before long, output may drop below the level needed to maintain microbial control. Such devices may require changeout every few months.

For a high-output UVC device, a 12-month changeout is recommended. Such lamps may continue to deliver germicidal energy for longer periods, causing some suppliers to promote an extended two-year service life. However, insufficient output over the full time span is a very real risk, so annual changeout is considered the best practice.

As an alternative in large or critical applications, a radiometer may be installed in the system to monitor output loss and determine changeout cycles. Periodic inspections are a useful way to make sure the lights are on, but visual inspection should never be used to make changeout decisions. This is because unlike an ordinary light bulb or tube that burns out, a UVC lamp may still glow even when output has dropped well below acceptable levels.

A recent scientific study tracked three IAQ devices—particulate filters, carbon filters and UVC lights—to determine whether their changeout cycles affected clinical results in the space served by the HVAC system—a specialized laboratory. The six-year study found a direct correlation between UVC changeout and improved clinical outcomes, while no such correlation was traced to the filters.



Independent test results show performance differences between high-output UVC lamps vs. conventional older-style lamps.

The study used high-output UVC lamps with an accelerated changeout schedule of six to nine months. As long as the lamps were functioning properly and were changed on time, results were consistently positive. These findings underline the importance of selecting a UVC device with adequate output and replacing the device at required intervals to maintain that output.

The findings are supported by hundreds of anecdotal reports from users who have encountered a return of mold growth, troublesome odors or allergic symptoms among building occupants when UVC lamps are not changed often enough.

UVC with other technologies

Over the past few years, there has been an increased use of devices that combine UVC germicidal energy with other technologies. For example, some devices provide UVV energy in addition to UVC. UVV refers to a different wavelength on the UV spectrum, and marketers of these devices promote it as a tool for additional IAQ control. Buyer beware, however; the shorter wavelength of UVV light also generates ozone, which is recognized by the American Lung Association, the Food and Drug Administration and other groups as harmful to human health.

Another example is photocatalytic oxidation (PCO), a process designed to reduce volatile organic compounds (VOCs) in indoor air. In this process, UVC light is exposed to a light-activated material or photocatalyst to create a chemical reaction that oxidizes or breaks down typical VOCs. Proponents of the technology claim that it reduces VOC-contaminant levels more efficiently and with less energy than traditional control strategies, such as high-efficiency gas-phase filtration and/or increased ventilation.

Research at Lawrence Berkeley National Laboratory found that PCO reduced indoor VOCs but produced formaldehyde and acetaldehyde as byproducts. Based on their findings and calculations, the researchers concluded that more work should be done to address this issue. They reported that PCO technology needs further refinement to ensure that concentrations of undesired byproducts are below levels that would cause health concerns, or that these byproducts are somehow removed from the air before it is recirculated to the occupied space. Experts generally agree that the combination of PCO and UVC technologies is very promising as soon as these issues can be resolved.

In conclusion, as acceptance grows among government, scientific and user communities, it is clear that UVC technology is here to stay. In the absence of an official standard, however, contractors must do their homework to make sure the devices are properly selected and applied, bringing customers the IAQ and operational benefits they deserve.◆

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