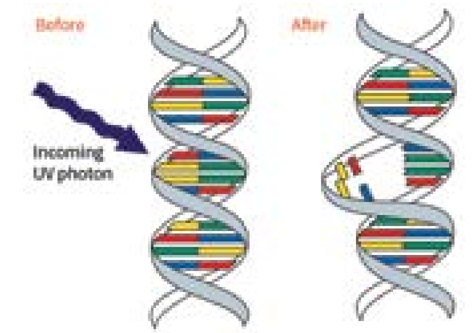
HOW ULTRAVIOLET-C ENERGY IMPROVES HVAC/R EFFICIENCY

Learn how UV-C light is applied in HVAC/R systems to boost heat exchange efficiency, improve airflow, restore IAQ and reduce maintenance needs.

By Daniel Jones

As air-conditioning / refrigeration equipment ages, its ability to maintain temperatures and humidity levels declines. Most often, the culprit is reduced coil heat-transfer effectiveness, or the ability of air-handling-units' (AHU) cooling coils to remove heat and moisture from the air.

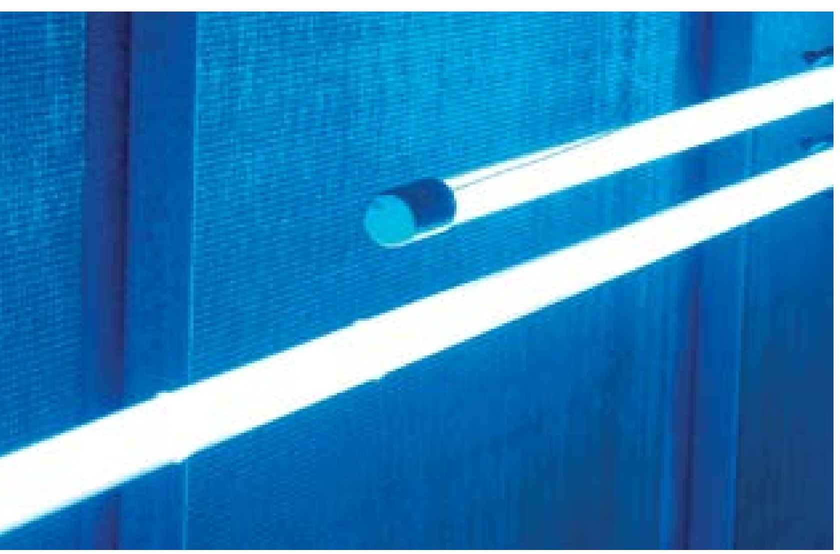
These inefficient heat-transfer rates derive primarily from the buildup of organic contaminants on, and through, the coil's fin areas. Such buildup is eliminated through the use of ultraviolet germicidal energy or light energy in the UV-C wavelength (253.7nm). UV-C works by disassociating molecular bonds, which in turn disinfects and disintegrates organic materials.



RIGHT: The 253.7 nm germicidal C-band wavelength inactivates virtually all microorganisms living on HVAC/R surfaces with a kill ratio of 90 percent or higher, depending on UV-C intensity, length of exposure, lamp placement and lamp life cycle.

RESTORING COOLING CAPACITY

UV-C lighting systems are not an exotic, new technology. They have been used extensively since the mid-1990s to significantly improve HVAC/R airflow and heat-exchange efficiency, which can reduce HVAC/R energy use by up to 25 percent. Although UV-C by itself doesn't save energy, it restores cooling capacity and airflow to increase the potential for energy savings.



In fact, researchers have found that exposing a fouled cooling coil to UV-C resulted in a 10 percent decrease in pressure drop and a 14.55 percent increase in heat transfer coefficient levels at reference conditions.[1]

In new/OEM equipment, UV-C keeps cooling coil surfaces, drain pans, air filters and ducts free from organic buildup for the purpose of maintaining "as-built" cooling capacity, airflow conditions and IAQ. In retrofit applications, UV-C eradicates organic matter that has accumulated and grown over time and then prevents it from returning.

Although UV-C is a relatively simple technology, i.e., shining lamps onto surfaces and adding simple on/off controls to facilitate maintenance, many professionals are mystified about how UV-C works and how to apply it cost effectively. This article addresses these aspects of UV-C technology and the applications that seem the most confusing. Our guidance closely follows ASHRAE industry advice found in Chapter 60.8: Ultraviolet Air and Surface Treatment in the 2015 ASHRAE Handbook – Applications.[2]

UV-C BASICS

We all are familiar with the harmful effects of UV from sunlight in the UV-A and UV-B wavelengths, giving rise to sunburn and the need for UV inhibitors, or blocking agents, which are found in such things as glasses and lotions.

However, unlike UV-A and UV-B radiation, the UV-C wavelength has more electron volt energy and is well absorbed (not reflected) by all organic substances, increasing its destructiveness. Given these properties, why don't we hear more about protecting ourselves from UV-C exposure outdoors? The reason is that UV-C is absorbed by the ozone layer and much of the atmosphere, and does not reach the Earth's surface.

So how much UV-C is needed to destroy organic matter? A 2010 study commissioned by ASHRAE and the Air Conditioning, Heating, and Refrigeration Institute (AHRI) found that even the most sophisticated organic compounds suffer from exposure to HVAC/R dosages of UV-C energy. Because UV-C lamp installations in HVAC/R applications operate continuously 24/7/365, a well-distributed dose similar to visible light is all that's needed.

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UV-C LAMPS AND LAMP REPLACEMENTS

Modern UV-C lamps are very similar to fluorescent lamps typically found in ceiling fixtures. Both types of lamps operate using identical electrochemical processes: i.e. an electric discharge through argon gas striking mercury vapor to generate a photon with a wavelength of 253.7 nm (typically called UV-C), which, in and of itself, is invisible.

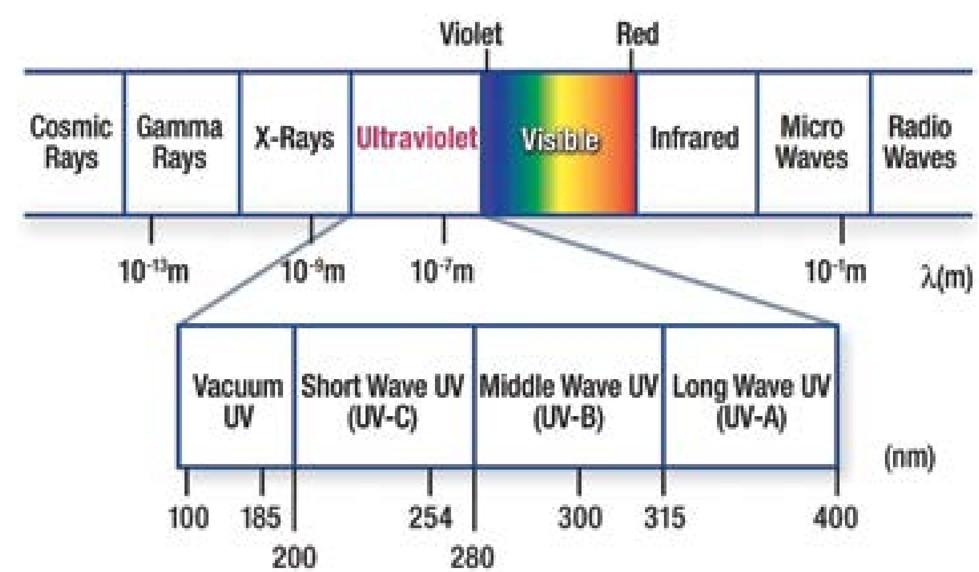


FIGURE 1: The electromagnetic spectrum, with a breakout of visible light segments – colors. The UV spectrum ranges from 100 nm to 400 nm and is invisible.

UV-C lamps differ slightly from their fluorescent counterparts in that the UV-C lamp's glass envelope must be a highly engineered, UV-C transparent shell. This allows the 253.7 nm wavelength to escape through the lamp envelope unfiltered. Fluorescent lamps, however, use ordinary glass which blocks the UV-C wavelength. The glass is also internally coated with phosphors. The UV-C energy is "contained" to excite the phosphors to glow (fluoresce) in the visible light range.

A typical UV-C lamp produces about 90 percent of its energy in the UV-C wavelength. About 4 percent of its energy is given up as heat, and the rest (~5 percent) is in the visible light range that is medium blue in color (Figure 1). This blue color, shown in Figure 2, results from the argon gas in the lamp envelope.

CHANGE ANNUALLY

UV-C lamps typically provide more than 80 percent of their initial output over a 9,000-hour period. Because UV-C lamps should be operated continuously, the corresponding 8,760 hours of a 24/7 schedule also fits conveniently into annual re-lamping schedules of lighting lamps.

FIGURE 2: UV-C's blue color results from the argon gas in the lamp envelope.

Attempting to run UV-C lamps longer than 9,000 hours will produce individual lamp outages, requiring maintenance staff to monitor them routinely to verify operation. This individual monitoring of lamps requires a larger inventory of replacements for when the lamps begin to fail in larger numbers.

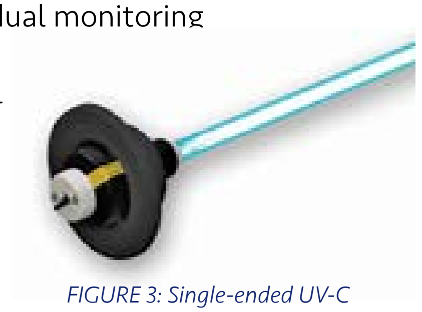


FIGURE 3: Single-ended UV-C fixtures can be easily mounted from the exterior of any HVAC plenum or duct, making them ideal for hard-to-access equipment.

Like fluorescent lamps, UV-C lamps come in a variety of types and sizes, including single-ended and double-ended. The single-ended lamps are used in several lamp systems, some of which allow the lamps to be inserted through a plenum or duct into the air stream, typically downstream of the cooling coil (Figure 3). Double-ended lamps have pins at both ends, and are installed into specific length fixtures usually containing the ballast like a fluorescent fixture. Typically, all types are available in standard output (SO) and high output (HO) models. The difference between the two is their Watt and ballast rating. HO lamps are usually recommended because they are less expensive on a per-lamp-Watt basis.

Another consideration for contractors is opting for encapsulated lamps, which have a transparent Fluorinated Ethylene Propylene (FEP) coating over the glass envelope. Encapsulated lamps hermetically seal UV-C lamps in case of breakage. Should an accident occur, broken glass and mercury will remain safely within the lamp.

UV-C BENEFITS

UV-C systems provide several benefits when applied to HVAC/R systems: Efficiency; occupant comfort/indoor air quality, environmental impacts and economic impacts.

HVAC/R system efficiency: UV-C eliminates and/or prevents the buildup of organic material on the surfaces of coiling coils, drain pans, and interior air-handler surfaces. This improves airflow and returns/maintains heat-transfer levels of cooling coils to "as-built" capacity. As a result, the HVAC/R system does not use more energy to provide the desired amount of cooling effect and ventilation capacity, which maintains system energy efficiency. On average, UV-C coil installations on existing systems reduce HVAC/R energy use by between 10 and 25 percent.

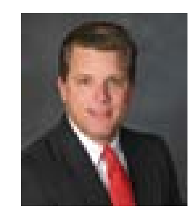
Comfort and IAQ: Clean coils and drain pans don't contribute odors, allergens, or pathogens to air streams and help the HVAC/R system sustain design temperatures and airflow rates. This means that functional and performance goals communicated by codes, standards and the owner's project requirements can be met. In doing so, UV-C systems help deliver quality comfort and IAQ that lead to occupant productivity, reduction of sick days, and reduced hot/cold calls and other service requests.[3]

Environmental impacts: UV-C systems have several characteristics that are consistent with green/clean technologies: they eliminate the need for chemical and mechanical (water) cleaning, which also reduces waste disposal issues. With a more efficient AHU, a UV-C system will save energy and reduce carbon footprints. Furthermore, UV-C lamps can be recycled with fluorescent lamps and be integrated with a facility's annual re-lamping program.

Economic impact: Reducing energy costs, sick calls, service calls and system downtime for maintenance translate into significant cost savings for applying UV-C in commercial HVAC/R systems. It can also be inferred that buildings with highly functioning HVAC/R systems that deliver the benefits described above will increase the value of building tenant leases because they will have lower HVAC/R-related overhead and lower occupant turnover.

SUMMARY

UV-C light is an incredibly effective and affordable technology for keeping critical components of commercial HVAC systems clean and operating to "as-built" specifications. Benefits of applying UV-C lamps in HVAC systems include greater energy efficiency, lower operating expenses, fewer occupant complaints, and better IAQ. For all these benefits, UV-C is relatively easy to apply – it's basically installing a bank of UV-C lamps in an air handler, or in a rooftop packaged system, and then replacing the lamps once per year. ■



The president and co-founder of UV Resources, a provider of UV solutions and replacement lamps for HVAC systems, Daniel Jones is an ASHRAE Member and a corresponding member of the ASHRAE Technical Committee 2.9 and ASHRAE SPC-185.2, devoted to Ultraviolet Air and Surface Treatment. He may be reached at dan.jones@uvresources.com.

[1] (Firrantello 2016). Firrantello, J.T., Bahnfleth, W. P., Montgomery, R., Kremer, P. K., "Field Study of Energy Use-Related Effects of Ultraviolet Germicidal Irradiation of a Cooling Coil," 12th REHVA World Congress CLIMA 2016, May 22-25, 2016, Aalborg, Denmark.
[2] 2015 ASHRAE Handbook—HVAC Applications -HVAC Systems and Equipment. ASHRAE. Chapter 60: "Ultraviolet Air and Surface Treatment."
[3] Menzies D, Popa J, Hanley J, Rand T, Milton D. Effect of ultraviolet germicidal lights installed in office ventilation systems on workers' health and wellbeing: double-blind multiple crossover trial. THE LANCET 2003; 362:pp1785-1791.