How many facility engineers does it take to change a light bulb?

Up to 80% of building engineers forget to regularly replace their facility's UV-C lamps, leading to reduced HVAC/R system performance and losses in energy and indoor environmental quality

By Daniel Jones

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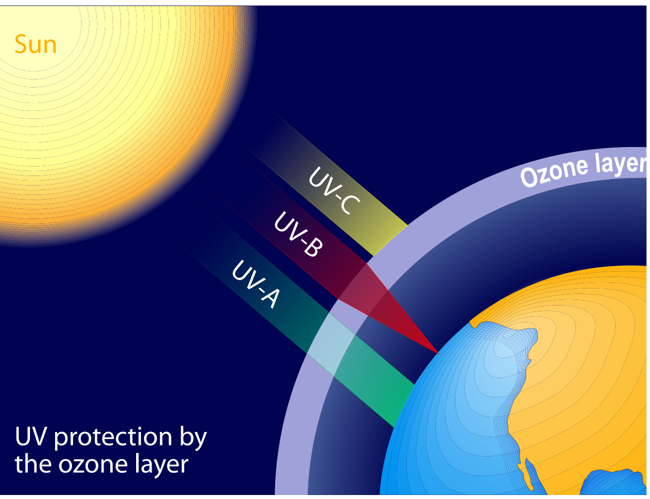
The global growth rate for microbial ultraviolet (UV) disinfection equipment has been increasing annually as more facility managers and building engineers recognize its energy savings and decontamination value. By 2020, the total UV market is estimated to be worth nearly $3 billion.[1]

When it comes to indoor air applications, the premise of ultraviolet-C (UV-C) technology is simple. It uses light energy in the UV-C spectrum to kill, or prevent the growth of, virtually all known microorganisms living in upper air streams or HVAC/R components such as cooling coils and drain pans.



By disinfecting HVAC/R components and/or air streams, UV-C maximizes system efficiencies,
reduces the need for manual maintenance and improves indoor environmental quality. 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 at reference conditions.[2]

These long-term benefits more than pay for the UV-C, which has an average installed cost of $0.15 per CFM, with many users reporting that their cost for an installed UV-C system featuring high output lamps was even less.

Like any lamp, however, UV-C eventually "burns" out. Yet, only 20 to 30 percent of building engineers actually replace their lamps. There's two main reasons for this: 1) UV-C lamps are often installed out of sight in hard-to-reach areas, making maintenance easily forgettable; 2) Engineers see a blue hue and assume that the lamp is functioning properly.

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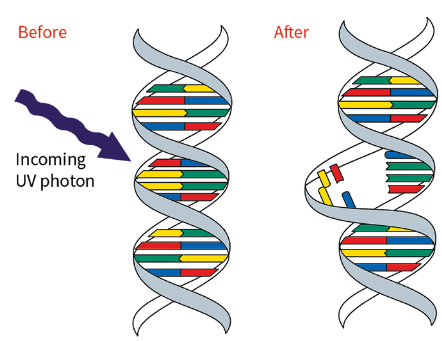
The problem is that, in the case of UV-C, the lamp's blue hue continues long after its effective germicidal output has decreased. This is not a lamp defect, but rather a function of the useful life of a lamp. Essentially, building engineers cannot assume the proper disinfection of HVAC/R components based on a visual inspection when, in actuality, the blue light is not a determinate of UV-C output.

Maintaining UV-C's Effectiveness

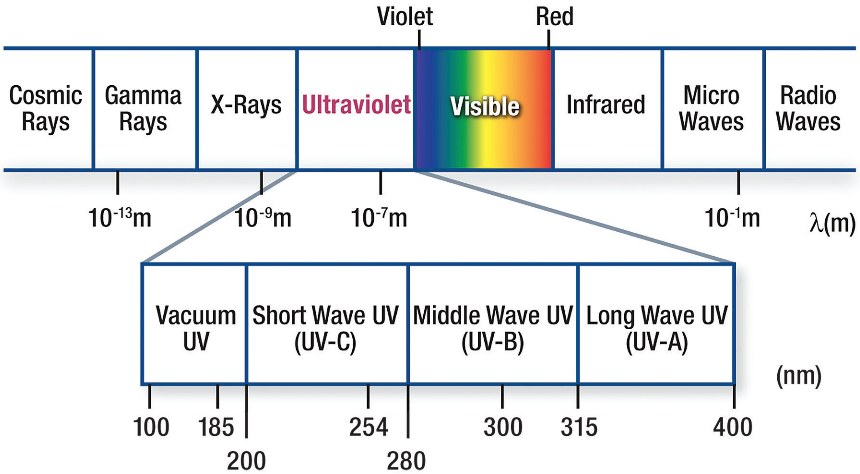
UV lamps share many similarities with regular fluorescent lamps. The difference is that the UV-C wavelength (253.7 nm) is invisible to the eye; the visible blue light that one sees represents only five percent of the total output of the lamps (the blue color actually



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.

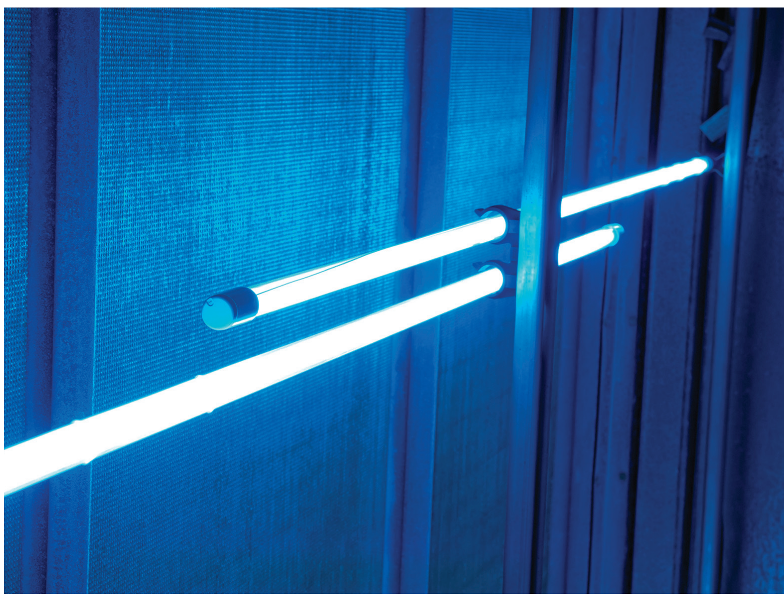
comes from the inert argon gas within the lamp).

As a result, the blue light is not an indicator of lamp performance. After roughly 9,000 working hours, the lamp may continue to emit blue light even after UV-C output has decreased by 20 to 50 percent, thereby jeopardizing the AHU's heat exchange efficiency, energy use and a building's air quality. Meanwhile, as performance worsens, the owner or facility manager is none the wiser.



ABOVE: 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 are installed primarily to destroy microorganisms that accumulate on HVAC/R components, thereby boosting energy efficiency and indoor environmental quality (IEQ) and comfort. Retrofitted UV- C lamps can help return A/C units to initial capacity and reduce or eliminate costly coil and plenum cleanings in as little as 90 days, while new system installations maintain "as-built" conditions. The UV-C energy reaches deep into the coil to eliminate build-up that cannot be reached by either mechanical (pressure washing) or chemical treatment, and the overall improved heat transfer efficiency and reduced coil pressure drop can slash energy use by 10-25 percent on average.



As discussed, UV-C can do all of this cost- effectively. Using a 10,000 cfm system as the example, the UV-C fixtures would cost $1,500, with an annual operating cost of $188 at $0.10/kW – operating 24/7/365. That is less than one percent of the average 18 percent power savings gained through a more efficient (better heat transfer & lower pressure drop) air conditioning system.

Furthermore, field reports indicate that the initial cost of a UV-C system is about the same as one properly performed coil-cleaning procedure, and less when system shutdowns, off-hours work with the associated overtime, and/or contractor labor costs, are considered. Indeed, without UV-C, cleanings are recommended at least once per year to prevent mold growth and capacity loss and to keep contaminants from compacting deep within the coil. With staffs and budgets shrinking, however, time and money for in-house or contracted coil cleaning is becoming scarce. As a result, it might be more rational to make a one-time investment in a UV-C system that will keep cooling coils at as-built conditions.

Of course, proper performance depends on right-sizing the lamps for the particular application. To do so, engineers must take such factors into account as temperature, reflectance and the minimum amount of energy at the coil's farthest points. This will ensure that UV-C lamps provide the required level of irradiance.[3]

In some applications, especially in the healthcare industry, UV-C lamps are installed via wall-mounted units that irradiate the upper air region of a given space, killing viruses, bacteria and other harmful disease-causing microorganisms. A 2013 CDC-funded study conducted in two hospitals found that UV-C reduced the total number of colony-forming units of any pathogen in a room by 91 percent.[4] ASHRAE, too, has recognized that the UV-C wavelength inactivates virtually all microorganisms living on HVAC/R surfaces with a kill ratio of 90 percent or higher, depending on UV-C intensity and length of exposure.[5]

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Regular replacement of UV-C lamps is therefore necessary. After all, occupants' comfort, pocketbooks and, in the case of vulnerable hospital patients, lives, depend on it. When UV-C lamps are not replaced, and their output falls below effective operating levels, the facility may see decreased HVAC/R performance, higher energy bills and reduced human comfort, as if UV-C had never been installed.

Historically, replacing UV-C lamps had a significant impact on a facility's budget, but this has changed in recent years. As the use of UV-C fixtures in HVAC/R systems has increased, lamp costs have been significantly reduced. Typically, high output lamps can be replaced at less than $0.03 per CFM.

When to Replace

It's been established that all UV-C lamps will lose output over time, regardless of their make or model. It's also been established that this, in most cases, will not be evident from visual inspection, but the resulting effects on performance could negatively impact energy efficiency and IEQ. For these reasons, ASHRAE has recommended regular lamp replacement.[6] But how often is ideal?

Most lamp manufacturers (Phillips, GE, and Sylvania, etc.) recommend replacing UV lamps every 9,000 hours, or, since there are 8,760 hours in a year, most facility managers employ an annual re-lamping schedule. Quality lamps will still emit at least 80 percent of their original UV-C germicidal output rating at the end of one year, but it will be a matter of time before they too lose effectiveness.

Measuring Lamp Output

Lamp monitoring can take different forms. A portable radiometer can measure the level of UV-C output in the 253.7 nm wavelength. However, it raises safety concerns, as the measurement process requires someone to enter the plenum where the UV-C is located, which risks exposure to the harmful effects of the germicidal light. Stationary radiometers have also been used; they are mounted on the outside of the plenum, with their UV sensors being mounted inside the plenum, and offer a relative indication of UV-C output (some even provide an hour meter). In "remote" systems that are out of sight, for example in mechanical rooms, interstitial spaces, etc., there are accessories available for continuous monitoring of lamp-ballast functionality that communicate with building management systems (BMS). Lamp-on hour meters can provide BMS feedback as well.

Best Practices for Replacement

When it comes to replacing UV-C lamps, certain practices should be avoided. A common mistake many make is replacing them only as they stop functioning. This method is highly labor intensive and inefficient, requiring routine inspections of the individual lamps to determine the need for replacement. Furthermore, as that 9,000 hour mark passes, as noted above, the lamps' germicidal effectiveness begins to diminish, potentially causing HVAC/R system performance to be compromised.

A more advisable solution is to establish an annual replacement schedule whereby all lamps are methodically swapped out at a designated interval.

Such a strategy eliminates the need to carry a large inventory of replacement lamps (with the exception of a few spares in case of breakage). Instead, it offers plenty of lead time and a more logical routine or schedule.

Annual replacement is also more cost-effective. Individual replacement means higher lamp and labor costs and downtime during each procedure—not to mention frequent monitoring by staff members. An annual schedule consolidates change-outs into one service interval, allowing the facility to purchase lamps in larger quantities to save money and time. This also reduces the need, with the exception of critical environments, to invest in an expensive radiometer or other equipment to monitor individual UV-C output. Knowledge that lamp replacement will simply be "taken care of" each year will allow peace of mind for building managers.

Most important of all, annual replacement guarantees that UV-C output will never fall below effective levels and HVAC/R efficiency and IEQ will not be compromised. By implementing such a schedule, you are doing your duty to protect both your building occupants (and your pocketbook), as well as your equipment from the efficiency-robbing effects of microbial buildup. ■

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.

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