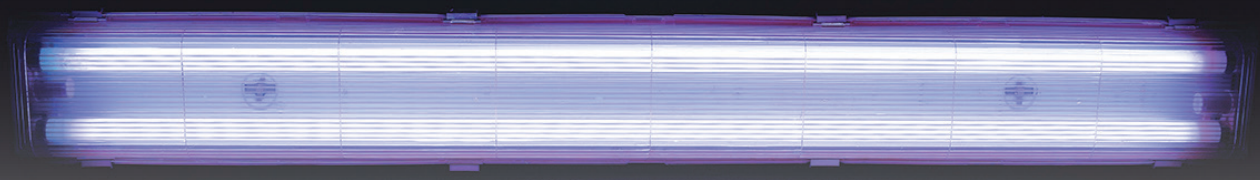

New Requirements for Worker Safety

HVAC UV Germicidal Irradiation UV-C Fixtures

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Since the 1990s, ultraviolet germicidal irradiation (UVGI), or light in the UV-C wavelength (specifically 253.7 nm), has been used in HVAC&R equipment to maintain or return cooling capacity to as-built conditions by maximizing heat exchange efficiency. The technology deactivates biological growth on surfaces within an air handler to save energy, boost airflow levels and protect indoor air quality.

ASHRAE Technical Committee (TC) 2.9, Ultraviolet Air and Surface Treatment, helps oversee the safety standards that protect installers and service personnel from accidental UV-C exposure. Complementary HVAC&R equipment requirements in this area are published in the UL 1995 safety standard for heating and cooling equipment.

In May 2009, UL LLC, the testing, inspection and certification part of Underwriters Laboratories, Inc., which is the entity responsible for developing HVAC equipment safety standards, approached the TC 2.9 committee with a proposal to update the fourth edition of the UL 1995 standard.

A collaborative effort ensued and work culminated in July 2015 with the release of the fifth edition of UL 1995, which carries a Nov. 2019 compliance date. This article provides an overview of how these safety enhancements will protect installers and service personnel from accidental UV-C exposure from HVAC&R equipment.

Limiting UV-C Exposure

Ultraviolet light is separated into three main segments along the electromagnetic spectrum. The most well-known wavelengths are UV-A and UV-B, which are responsible for sunburns. UV-C is also produced by the sun, but cannot penetrate the atmosphere due to its shorter wavelength. When generated by artificial sources, however, close proximity to UV-C irradiation is powerful enough to break down the skin's collagen proteins, causing redness and irritation. It can also damage the surface layer of the cornea in the eye, resulting in photokeratitis (the same condition welders can experience with arc flashes).

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Not all HVAC&R technicians receive UV-C safety training, and some may not be aware that the UV-C light in an air-handling unit (AHU) can potentially pose a safety hazard. Unlike some dangers, exposure to ultraviolet light does not offer an avoidance response (e.g., blinking of eyes) or a physical cue that protection is necessary (e.g., heat radiating from a hot stove). Furthermore, the physiological effects of an adverse dosage of UV-C exposure are delayed and can appear up to six hours later. While damage from UV-C is reversible, the HVAC&R industry takes steps to safeguard service personnel from avoidable ultraviolet exposure and the consequences of its short-term or chronic effects.

Many HVAC&R and UV-C equipment manufacturers have voluntarily implemented safeguards against the risks of UV-C exposure. Instructions and signage advise service personnel that the UV system should be turned off before performing any work in the AHU. A maintenance worker can easily take this step before opening the AHU to service the motor, change fan belts, replace filters, check coils, or drain pans. Some manufacturers include a door safety switch or lockout/tagout feature to keep the AHU closed until the UV lamp power has been disconnected.

Despite these precautions, reports from the field indicate that safeguards are not uniformly implemented or equally effective. Even if workers had been adequately briefed about UV radiation, UL recognized that opportunity existed to reduce the risk to installers, service personnel, and facility managers by standardizing equipment design safeguards.

By implementing safety features within the AHU, the new UL 1995, fifth edition, standard seeks to eliminate variations in equipment design that might lead to accidental exposure. The International Commission on Non-Ionizing Radiation Protection (ICNIRP) favors this approach: "engineering control measures are preferable to protective clothing, goggles and procedural safety measures."[1] In other words, deliberately designing-for-safety to protect workers from potential hazards is more important than supplemental warning systems.

A Look at the New Requirements

The safety requirements in UL 1995 apply to UV lamps that are factory and field installed for HVAC&R equipment manufactured after Nov. 2019. These updated requirements will help ensure that the risk to service workers is reduced irrespective of their proximity to the UV-C source. Highlights of the new requirements are as follows:

Permitted Irradiance Levels

The primary source of UV used for inactivation of biological growth is low pressure mercury lamps. The lamp construction emits most of its UV at 254 nanometers (nm). Therefore, the irradiance levels from HVAC&R equipment sources were chosen based on the threshold limit value (TLV) of 6.0 microwatts per centimeter squared ($\mu W/cm^2$) of weighted UV at 254 nm.[2] The ultraviolet (UV) emissions are measured at the nearest point of accessibility.

- No opening shall permit leakage of UV-C greater than 0.1 microwatts per centimeter squared ($\mu W/cm^2$).
- Enclosure doors, covers, and access panels, when accessed, shall have no UV-C irradiance greater than 1.7 $\mu W/cm^2$.
- The occupancy or space around the HVAC&R equipment shall not exceed 0.1 $\mu W/cm^2$.
- Adjoining compartments inside the unit without an interlocking switch shall be no greater than 1.7 $\mu W/cm^2$.

Enclosure Doors, Covers, and Access Panels

- These points of intentional access to UV sources must be equipped with an interlocking mechanism that de-energize the source.
- Access panels and components that are removable for cleaning and servicing, which also provide access to other areas inside a unit, shall require an interlock switch if the UV-C irradiance exceeds 1.7 $\mu W/cm^2$.

Equipment Markings

- Models with interlocking doors shall be marked with the words "WARNING UV LIGHT SOURCE."
- Those without interlocking doors shall have the same wording plus "DISCONNECT POWER BEFORE SERVICING."

In addition, the equipment shall be plainly marked, in a permanent manner, with the following:

- Details on the UV source manufacturer's name and model designations that can be installed in the AHU. The details can be provided as a label that allows the AHU manufacturer to "check off" the lamp system installed.
- The ratings of the system lamps, maximum lamp rating in watts, and voltage of the unit with the ultra-

violet UV lamp assembly installed shall be provided and clearly visible.

Housing Materials

- Polymeric cabinet, structural and current carrying parts and wiring that are subjected to irradiance from a UV lamp system shall be shielded from the UV-C light or constructed of a material that is capable of withstanding UV-C exposure levels expected in the product without degrading.

The new requirements are in line with OSHA 1910.1096 for ionizing radiation.[3] The government agency for workplace safety advocates for reasonable protections, including safety briefings, caution signs, personal protective equipment (PPE) and "a control device which shall either cause the level of radiation to be reduced or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering and the employer or a supervisor of the activity are made aware of the entry."

The enhancements to the UL standard are intended to address safety and will not impact the performance of the air handler or UV-C device. The new safety requirements are not retroactive and do not apply to existing units so manufacturers are not expected to recall products, nor are building owners required to replace equipment prematurely. However, building owners and engineers may want to proactively review AHUs that currently have UV-C devices to ensure proper safety measures are in place.

Changes Moving Forward

The most significant impact on AHU manufacturers from the new UL 1995, fifth edition, standard will be the need to perform an additional irradiance test on their equipment using a qualified Nationally Recognized Testing Laboratory (NRTL). (UL has such laboratories.) In-house testing by the AHU manufacturer can also be done if it is qualified to test to UL 1995 or if the test is conducted while being witnessed by a qualified NRTL representative. The test must be done in a controlled environment with an ambient temperature of approximately 80°F (27°C) using either a scanning spectroradiometer or a narrow band range radiometer if the UV wavelength is known (i.e., 254 nm). The test should also be conducted with all components opened to the widest degree possible so measurements represent any point/degree of exposure within the service area.

The standard is intended for type-certification and does not require companies to test every unit that is shipped. Manufacturers can choose to certify a representative AHU "box." The box will be tested for the maximum amount of UV energy that it can safely accommodate (total of the cumulative lamp watts printed on the lamp surface, e.g., 145 W). Should the manufacturer use a lower cumulative UV-C lamp wattage on future production units than the representative tested unit, testing will not be necessary.

UL 1995 distinguishes between UV-C lamps located within the AHU and duct-mounted or non-integral field-installed systems, which are predominantly found in residential applications. Though the requirements are substantially the same, UL 1995 offers "Supplement SA" that requires the use of many of the same safety precautions. For the purposes of this standard, UV-C lamps are limited to the low pressure fluorescent type construction with a predominate output of 254 nm.

The Value of UV-C

UV-C is a low-cost solution to disinfect cooling coils, drain pans and duct surfaces that have accumulated mold and bacteria growth. The technology disrupts a microorganism's DNA, triggering a chain reaction that leads to cellular death. Because the lamps operate continuously, biofilms are unable to regenerate, provided the UV-C source is properly maintained. This technology is frequently used to address many sources of poor indoor air quality that contribute to employee discomfort and absenteeism.

Contaminants, particularly the presence of fungi (mycotoxins), can trigger serious health problems to building occupants. As noted in an *Applied and Environmental Microbiology* study, "fungi have been found growing on air filters, insulation and cooling coils, as well as in ducts. This contamination often contributes to building-related diseases, including both infectious diseases and hypersensitivity diseases, such as allergic rhinitis, asthma and hypersensitivity pneumonitis. Also, acute toxicosis and cancer have been attributed to respiratory exposure to mycotoxins."[4] A building's HVAC system can also inadvertently transmit rhinoviruses (common cold), tuberculosis, measles, SARS and influenza.

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"The effectiveness of a UV-C system to inactivate microorganisms in the air and/or on surfaces has been amply demonstrated; the best results were obtained for the long-term irradiation of downstream coil surfaces to avoid fungal amplification on wet surfaces," notes a 2015 ASHRAE Position Document on Filtration and Air Cleaning.[5]

As an added value, its ability to constantly clean the interior workings of the AHU can extend the equipment's life for prolonged savings. Biofilms on coil fins adversely affect heat transfer to/from the airstream. If mechanical cleanings are incomplete or ignored, up to 25% of cooling capacity can be lost in as little as five years. Another factor is the lack of personnel or labor hours to routinely address coil maintenance. UV-C sources help restore an AHU to its original operating capacity.

The HVAC application of UV-C is nearly universal, including offices, schools, hospitals, correctional facilities, laboratories and assisted living. UV-C sources represent a small investment (roughly 3%) relative to the overall cost of the AHU, or roughly $0.15 per cfm, and are easy to retrofit. Building owners can achieve a 10% to 25% increase in HVAC efficiency by adding a UV-C device. The safety updates in the fifth edition of UL 1995 will help ensure service personnel are protected from accidental exposure, while maintaining the effectiveness of UV-C to eradicate biological contaminants.

References

1. International Commission on Non-Ionizing Radiation Protection. 2004. "guidelines on limits of exposure to ultraviolet radiation of wavelengths between 180 nm and 400 nm (incoherent optical radiation)." *Health Physics* 87(2):171–186.

2. ACGIH. 2016. *TLVs and BEIs*. Cincinnati: American Conference of Governmental Industrial Hygienists.

3. OSHA. 2016. "Regulations (Standards-29 CFR), 1910.1096, Ionizing Radiation." http://tinyurl.com/z4rl3cz.

4. Levetin, E., R. Shaughnessy, C.A. Rogers, R. Scheir. 2001. "Effectiveness of germicidal UV radiation for reducing fungal contamination within air-handling units." *Applied and Environmental Microbiology* 67(8):3712–3715.

5. ASHRAE. 2015. "ASHRAE Filtration and Air Cleaning Position Document Committee," p. 10. ■

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