

There are a host of factors to consider to properly install ultraviolet germicidal irradiation (UVGI) systems in commercial applications

BY LARRY RANDALL

# Shining Light On UVGI Installations



**A rail system mounts directly to a uni-strut. Individual lamp modules slide on to the rail and connect to each other.**

**R**ecently there has been a major push to incorporate the use of ultraviolet germicidal irradiation systems (UVGI) in both commercial and residential hvac systems. Much has been written detailing how to design UVGI systems for moving air and surface disinfection systems. This article will focus on UVGI installation.

The types of UVGI systems being installed in air handling units (AHU) fall in several categories:

- Upper air.
- In-duct systems.
- Microbial growth control.
- Room recirculation.

UVGI systems are installed in commercial hvac systems in several locations:

- Evaporator cooling coils.
- Filter banks.
- Mixing boxes.
- Return air ducts.
- Outside air ducts.

Applications include hospitals and clinics, schools and universities, commercial office buildings, government buildings, food-processing plants and other institutions. Each application requires that considerable thought be given on how to select the right product and how to install the UV fixtures and lamps.

For purposes of brevity, this article will focus on the proper installation of UVGI systems for microbial growth control on fixed evaporator coil surfaces only. This represents the majority of UVGI installations today.

The rest of the article will look at the key factors that must be considered when installing a UVGI system in a commercial hvac system. These include:

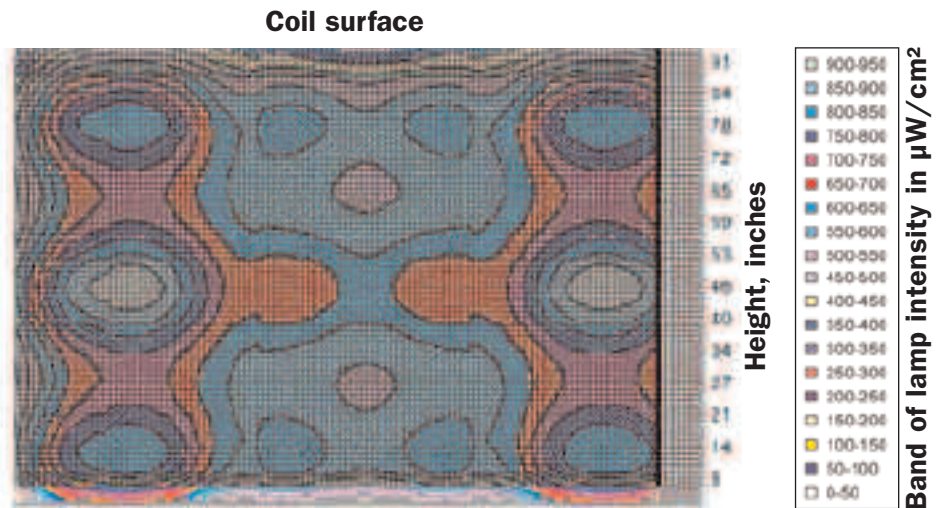
- Space available to install the system.
- Determination and selection of the proper equipment.
- Environmental factors that can affect overall system performance.
- Mounting location support frame.
- Electrical hookup of the system.
- Safety.
- Commissioning.
- Maintenance.

## Space considerations

Commercial air handlers come in a variety of sizes and configurations that make this a critical factor in the installation. Another important factor is whether the application is a new installation or a retrofit of an existing AHU.

The latter case can be challenging since there may be little or no direct access to the evaporator cooling coil itself. In this situation, it may be necessary to create actual access to mount and install the lamp fixtures themselves. The good news is that the access panel you create also can be used as a view port to verify the system is operating on an ongoing basis.

The important measurements that need to be determined include the height and width of the cooling coil along with the inside dimensions of the plenum walls. Furthermore, in the direction of airflow, one must also determine what obstacles may hinder the installation of the lamp fixtures (for example, a fan blower housing commonly is seen on smaller fan coil systems). Also, in the case of a stacked-coil system, it is



**Figure 1** The goal of a UVGI system is to provide uniform coverage across the coil. The colors indicate the lamp intensity as shown at the right.

important to note the location of each drip pan.

This is a good time to see what safety systems are present in the hvac AHU as well as the power source available (480 volts, 277 volts, 230 volts, 120 volts) and whether it is 50/60 Hz.

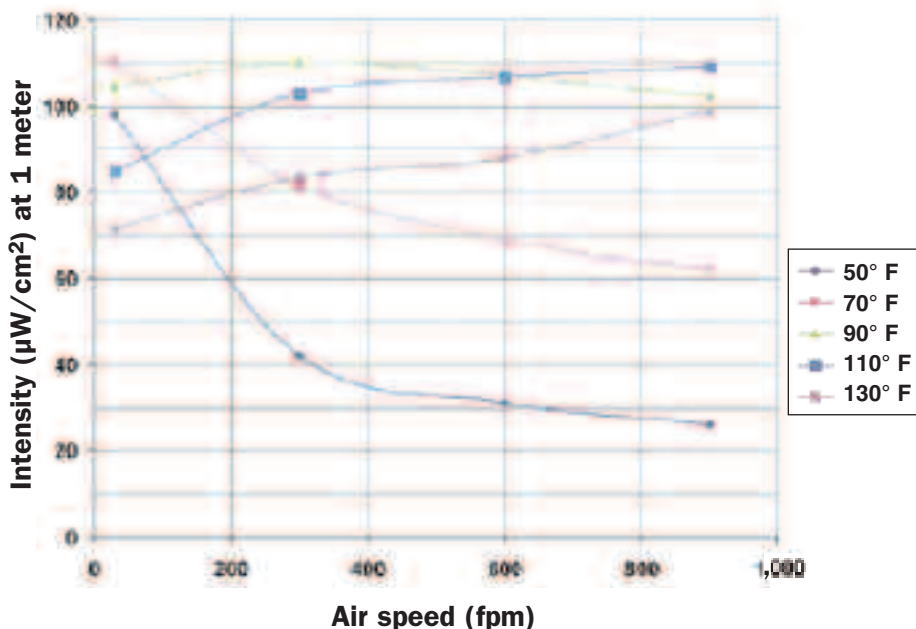
Once the actual installation geometry for the AHU is known, you can

determine the type of fixture and number of fixtures required to achieve the desired performance. For surface UVGI applications, it is important to deliver the proper dosage to effectively treat the microorganisms (bacteria and molds) that have collected, along with other dirt and debris on the external and internal coil fin surfaces.

Dosage is simply the energy applied to the surface from the lamp (typically defined as intensity in units of  $\mu\text{W}/\text{cm}^2$ ) over a given period of time. It is similar to the exposure used in digital photography. The formula is: dosage equals intensity of the lamp multiplied by the cumulative time of exposure ( $\mu\text{W}$  seconds/ $\text{cm}^2$ ).

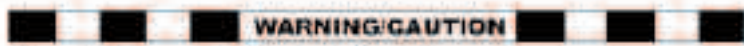
There are specific software algorithms available from each major UVGI system manufacturer to determine the type and number of fixtures for a specific application. In addition to the geometry, the operating conditions (cfm, temperatures) are inputs to the software programs. This will allow you to select the UV fixtures and lamp types necessary to obtain the desired system performance.

The software will help you determine the number of fixtures and lamps required for the installation, along with the level of intensity



**Figure 2** Lamp performance curves show the effect of operating temperature and air velocity on lamp output intensity.

# EXPOSURE TO UV CAN BE HARMFUL



UV lamp hazard, which may be harmful to skin and eyes. Can cause temporary or permanent loss of vision. Failure to install access panel interlock switch may result in accidental UV exposure to service personnel. Do not connect directly to line power.

**U**ltraviolet has existed since the sun began shining. The sun naturally produces long-wave (UV-A), mid-wave (UV-B) and short-wave (UV-C) ultraviolet. Most of the harmful UV rays are filtered out by our now infamous ozone layer. But if we spend too much time out in the sun the result can still be quite painful — sunburn.

The focus for hvac equipment and indoor air quality applications is on the germicidal wavelength — UV-C. This wavelength also can be harmful if you are exposed to it.

If there are access doors that allow entry into an area where ultraviolet is being utilized, interlock switches must be used. Finally, a warning label should be prominently displayed.

The safety switch should be wired in-line between the electrical source, the access door and the UV fixtures so that the interlock switch automatically shuts down the UV lamps when the access door is opened. Once the door is closed and the switch is engaged, the lamps energize once again. It is important that you do not wire the units to the fan — the units are designed to be on all the time. — *Larry Randall*

coverage across the coil itself. The goal is to provide uniform coverage (see Figure 1) of the entire coil surface, especially the drain pan, which is typically moist and a prime location for growth of molds.

## Environmental factors

Several environmental factors can adversely affect the performance of any UVGI system. First, the output of the lamp (intensity) is sensitive to the actual operating temperature.

A typical lamp is designed to operate at 70° F and changes in operating temperature can adversely affect the lamp output and the amount of energy that hits the coil surface. This is important for moving air disinfection applications.

However, the affect of lamp intensity level is much less important for surface coil irradiation applications because the lamps are on continuously and it is easy to reach the required dosage to kill any microorganism. Even with low-output lamps, the time required to kill the most difficult mold/spore is less than three hours.

Another factor that can affect lamp performance is surface contamination (body oils, fingerprints). Each lamp manufacturer recommends that the lamp surface be cleaned with a soft cloth and alcohol prior to installation and checked on a three-month basis.

Finally, the blow-off of moisture from the coil fins can leave water spots on the lamp surface. To minimize the affect, clean the lamp surface. The performance of the lamp also can be adversely affected by the moisture blow-off by lowering the lamp wall temperature.

You can counter this by installing the fixtures and lamps typically 12 inches from the actual coil surface. Figure 2 provides a set of lamp performance curves that shows the effect of both operating temperature and air velocity on lamp output intensity.

Each UV system manufacturer provides mounting instructions that can be tailored to their specific product. You need to make sure that the support frame that is installed is properly anchored to the floor and

ceiling of the AHU. It is common to utilize some parts of a support structure that already may exist in the AHU.

The individual mounting structures vary in complexity by manufacturer. The photo on page 22 shows a rail system that mounts directly to a uni-strut. The individual lamp modules slide on to the rail and connect to each other by simply plugging one fixture into the other.

The size of the individual fixtures and lamps can vary in order to provide full coverage of the entire coil surface for top system performance. Items to check/verify include the following:

- Make sure the lamp fixtures closely match the coil width to provide maximum effectiveness covering the full width of the coil.
- Make sure you have the proper number of fixtures for the job as stated in the original bid submittal package.
- Mount the UV fixtures in the horizontal position directly facing the coils.
- Make sure that the mounting structure is located at the recommended distance (typically 12 inches) away from the coil surface to minimize the affect of blow-off of water from the coils.
- Check the drain pans to make sure that they are clean and free of debris.
- Check all parts of the support structure to ensure all connections are tight. UV systems are typically designed to stand up to an airflow rate of 1,000 fpm.
- Remove any obstacles that could interfere with direct “line of sight” of the UV light to the coil surface and drain pan. Shadowing that occurs in stacked coil installations must be taken into account.
- Consider the time of day the units are installed. In hospital applications, it is important to schedule the installation during a time that will not interfere with the operation of critical areas such as operating rooms.

## **A key part of the installation process is to route the line power to the individual or ganged group of UV fixtures**

Another factor to consider during the installation is to make sure that you can easily replace the lamps on an annual basis. As mentioned earlier, there are access view port doors available (see Figure 3) that can allow you to easily replace the lamps themselves.

This is especially valuable for existing AHU where direct access to the evaporator coil is limited. The view port door also doubles as a way to inspect and verify that the lamps are operating properly. The view port door is designed to ensure that

no UV-C energy can leak out and expose people outside the AHU.

### **Electrical hookup**

A key part of the installation process is to route the line power to the individual or ganged group of UV fixtures. It is important to make sure that the main power source is in the off position. Some general guidelines for proper installation include:

- Install UV fixtures and wiring to local National Electrical Code regulations and local building codes; installations should be done by a licensed electrician.

- Route the circuit connected to the UV fixture through electrical interlocks placed on the hvac system duct access panels and on doors. This can prevent accidental UV exposure when accessing the air ducts (for example, changing filters).

- Figure 4 shows a typical interlock safety switch. In the example shown in the picture on page 22, the end module is hard wired through a junction box. Typically, there is one junction box installed per row of UV fixtures. The J-box is connected to the line power on one side and to the first UV fixture in each row.

- Verify that the line power matches the fixture itself. Fixtures come in 120, 230 and 270 dedicated voltage. If the power source is 480 volts, a step-down transformer must be added.

There are a number of safety-related steps to follow with any successful UVGI installation. These include protecting UV susceptible materials and ensuring that the installation and maintenance staff are not exposed to harmful UV-C radiation emitted by the germicidal UV lamps. Proper handling and disposal of the lamps themselves are important.

As part of the installation make sure:

- Both the fixture and UV-C lamp include the proper and recognized caution and warning labels (see sidebar on page 24). The labels need to be easy to read and contain the proper symbols to warn the user against possible hazards due to electrical shock and exposure of eyes



**Figure 3** Access view port doors allow techs to easily replace lamps.



**Figure 4** Here's a typical interlock safety switch, which is placed on the hvac system duct access panels and on doors to prevent accidental UV exposure.

and skin to harmful UV rays.

- The access doors and panels should have the interlock switch protection to prevent exposure to personnel during routine filter change out. Put a warning label on the access door or panel itself.

- The product fixture or the fixture/lamp packaging have the recognized labeling for the proper disposal of hazardous materials (for example, mercury in the lamps). The disposal methods should follow local and internationally recognized compliance standards.

The UV-C can destroy biological matter, such as bacteria and molds. But the same energy can attack other materials in the vicinity of the UV fixtures and lamps. Examples might include doors and seals, wiring insulation, insulating materials and pipe coverings.

To combat this unwanted exposure, it is a good idea to protect any materials within direct site of the UV source. Acceptable materials to use to shield materials are aluminum foil or aluminum tape, metal conduit or UV-resistant paints.

### **Commissioning a system**

Once the system is installed and meets all safety requirements and before putting the system in service, it is a great idea to collect specific

information. This would include measuring air flow (cfm), wet and dry bulb temperatures, and the pressure before and after the coil.

In the case of a new installation, this will establish a benchmark for future system performance. For retrofit of an existing installation, it is recommended that these measurements be taken before the UV system is installed (fouled state of the coil) and again after the UV system has been operating for four to six weeks.

In addition, it is recommended for retrofitting an existing installation that the AHU (evaporator coil and drain pan) be sampled. Standard microbial surface sampling techniques are performed to characterize the level of colony forming units (CFU), or biological load, for select bacteria and mold species. This is a good idea for new installations as well.

Since an AHU is continuously

## Check the lamps used in the UV systems every three months for signs of accumulated dirt

recirculating air and bringing in a certain percentage of outside air, there is the opportunity to bring mold and bacteria and viruses into the AHU itself. By taking a benchmark microbial sampling during the commissioning phase, you can monitor indoor air quality as well as system energy performance.

At this time you also can measure the lamp output. Most manufacturers sell portable radiometers to accomplish this task. It is important to verify that the minimum intensity of  $50 \mu\text{W}/\text{cm}^2$  intensity value is obtained at the coil and drain pan

surfaces and that the average intensity across the coil meets the  $200 \mu\text{W}/\text{cm}^2$  value.

Finally, there is the ongoing maintenance of the UV system. Check the lamps used in the UV systems every three months for signs of accumulated dirt that may have slipped through the filters or coils. Remember to clean the lamps with a clean cloth and alcohol.

Change the lamps annually because their performance will degrade to an unacceptable level after 9,000 hours of continuous operation. Cycling lamps on and off will reduce lamp life. Contact your UV equipment supplier for specific instructions.♦

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