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ENGINEERING

SYSTEM SOLUTIONS

In this issue, we make a case for the expanded use of Ultraviolet Germicidal Irradiation (UVGI) in air handling applications. The use of Ultraviolet (UV) lamps for destruction of harmful microorganisms dates back over 100 years. Now, the technology and its application have advanced to the point where it can make economic sense and improve indoor air quality (IAQ) in nearly any air handling unit application. In fact, the most recent GSA Facilities Standard for federal facilities calls for ultraviolet lights to be incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer.

In recent times, the threat of bioterrorism has been prevalent in news stories. In this article, however, we focus on the constant control that can be provided by UVGI, instead of such actions that represent single events.

UV lights supplied by Ultraviolet Devices, Inc. (UVDI) are now available as a factory-installed option on McQuay Vision™ air handlers. The combination of Vision air handlers and UVDI lights represent the only UL and ETL agency-approved application of the devices in the industry.

For more information on UV lights and Vision air handlers, contact your local McQuay Representative or visit ***www.mcquay.com****.*

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UV Lights And Air Handling Equipment

As the building design and construction industry has evolved over the past 30 years, so too has the HVAC industry, keeping pace with the ever-increasing demands placed on the products and services that we supply. Some times, the job requirements have forced tradeoffs to achieve better indoor air quality or energy efficiency. It's not often that a technology comes along that is a win, win. That technology is UV lights.

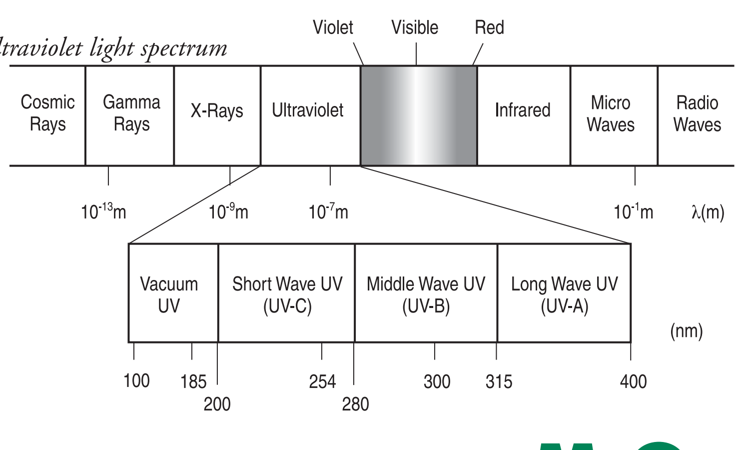
Background

The use of Ultraviolet (UV) lamps for destruction of harmful microorganisms dates back to the late 1800s. Throughout this article, we will refer to all such efforts and effects as "disinfection", although, without more detail, no claim can be made for the complete eradication of 100% of all microorganisms that could cause some illness in humans. UV light for disinfection was first used commercially in the late 1930's, and has been used widely in water and air applications.

Ultraviolet Germicidal Irradiation (UVGI) utilizes the light energy in the UV-C bandwidth (UV-A is used for tanning lamps and black lights, UV-B for dermatology) which produces germicidal effects on pathogens, scrambling their DNA, thus "killing" them and reducing the number of viable bacteria and colony forming units of mold. It has been scientifically proven effective, and thousands of drinking water plants in Europe and waste water plants in the United States use UV as one of their primary disinfectants.

The primary difference in using UV in air treatment and surface irradiation is "residence time" (i.e. the amount of UV energy a given microorganism is exposed to). With surface irradiation, there is an unlimited amount of "residence time". The UV is irradiating the surface constantly and therefore less UV energy is necessary to "kill" and maintain the surface at the desired level of disinfection. In a moving air stream, pathogens are

Ultraviolet light spectrum



McQuay® Air Conditioning

traveling at a high rate of speed and therefore may be exposed for only a fraction of a second. Because of this, it becomes important to apply more UV energy (lamps) to get the level of disinfection desired.

The dose delivered to disinfect is a product of UV intensity and time using the following equation:

$$\frac{N(t)}{N(o)} = e^{-kIt}$$

Where:
N = number of microbes
k = rate constant
I = UV intensity
t = time
o = original

Bugs Are Everywhere!

Microbiologists will tell you that mold and bacteria are everywhere (ubiquitous). They may be compared to dormant weed seeds that become active and reproduce with the first appearance of activity-conducive moisture. Control of these microorganisms can be likened to controlling mosquitoes: no matter how much we spray and/or eliminate standing rainwater from our property, the mosquitoes come back in full force with warm temperatures and high dew points (*or at least they do in my neighborhood*). And, as the recent spread of the West Nile Virus has made so apparent, microorganisms can spread as far as any plane, train, automobile or person can carry them.

Unlike mosquitoes, the majority of molds and bacteria are not sources of irritation in the concentrations we encounter in our everyday lives. However, given the right conditions – warm, humid ambient conditions and/or standing water – their ability to multiply exponentially can quickly raise concentrations to unacceptable levels, creating a biological "soup" that eventually can contribute to Sick Building Syndrome.

In terms of contaminants, mold and bacteria are classified as "Bioaerosols" – airborne products that include microorganisms, their fragments, toxins and waste products. In addition to mold and bacteria, this category includes viruses, spores, metabolic gases (e.g., CO_2), microbial volatile organic compounds (MVOC), and toxins called endotoxin and mycotoxin. Bioaerosols have been generally overlooked until recently, as all were thought to be only a very small part of air contaminants. The most recognizable of their effects in enclosed spaces are the airborne transmission of diseases we associate with the symptoms of colds and flu. However, many IAQ investigators implicate bioaerosol activity as the most significant contributor to IAQ problems.

Dilution or Removal?

A simple method of determining the hypothetical concentration of airborne contaminant would be to introduce a quantity of aerosol into an unventilated clean space, then divide the quantity of aerosol by the volume of the space. So if the space were 25' x 40' x 8' (8000 ft^3), and we introduced 20,000 particles of aerosol, it would be 20,000 ÷ 8000 or 2.5 particles per cubic foot. For a ventilated space, a simple mass balance could be used, where we eliminate the fixed quantity of aerosol and replace it with a continuous source (generation rate) of aerosol. The quantity of supply air in the equation relates to the size of the space and the number of occupants. The concentration then equals that quantity of air times the filter efficiency (removal rate) that opposes the generation rate and looks like this:

$$\text{Concentration} = \frac{\text{generation rate}}{\text{cfm x filter eff.}}$$

What becomes evident is that, if the generation rate goes up (increased number of people, activity or machines and space size, etc.), the concentration will go up too. Conversely, if the generation rate stays constant but either the airflow or removal efficiency (or both) goes up (removal rate), the concentration would come down.

Taking this a few steps further allows us to include the outdoor air amount (dilution rate, which also adds to the recirculated air for cfm), and its contaminant, which is added to the generation rate and it looks like this: (ASHRAE Standard 62-89–Appendix E)

$$Cs = \frac{N + V_o C_o (1-E_f)}{V_o + RV_r \cdot E_f}$$

Where:
Cs = steady state space concentration per cubic foot
N = internally generated contaminant rate
Vo = outdoor flow rate in cfm per person
Co = concentration of contaminant in outdoor air
Ef = efficiency of removal device in percent
RVr = returned air recirculated in cfm

If we add assumptions from Standard 62-1989 and then artificially populate the algorithm, it can help us understand what happens in a space:

7 people per 1000 ft^2 (ASHRAE 62-89)
15 CFM per person of ODA (15 x 7 = 105)
1 CFM per square foot Total Supply (105 + 895 = 1000)
Outdoor Concentration of 2500/ft^3
Generation Rate of 500/ft^3

No removal device;

$$C_s = \frac{500 + 105 \bullet .1 \bullet 2500}{105 + 895 \bullet 0} \quad 1513$$

90% efficient removal device;

$$C_s = \frac{500 + 105 \bullet .10 \bullet 2500}{105 + 895 \bullet .90} \quad 168$$

The example above could represent any contaminant, provided that the removal method is effective on the contaminant at the assumed efficiency percentage. What can be seen is that, if an offending contaminant were outdoors, minimizing the outdoor air quantity could be useful. Also, the role of the removal device becomes quite evident, as the 90% removal efficiency shown provides almost a logarithmic reduction in concentrations. Thus, as apparent from cleanroom technology, the removal rate can be far more important than attempting to dilute a space with outdoor air.

Why UV Lights?

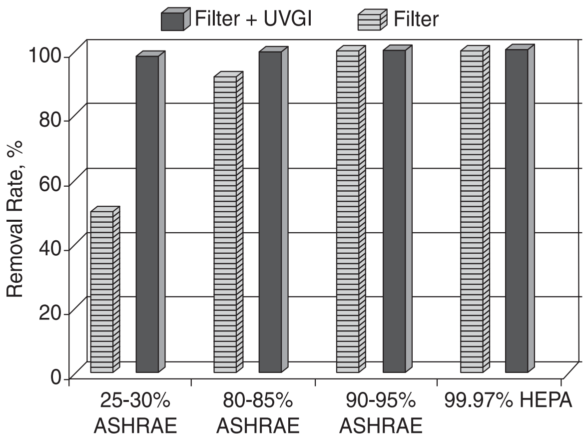
The HVAC industry has worked well for 100 years with only limited use of UV lights in clean rooms and other sensitive applications. However, UV lights are now a very logical and cost-effective addition to almost any air handling system in almost any application. This is particularly true in areas where ambient conditions routinely involve high humidity levels.

The obvious benefit of UV lights is the reduction of surface mold, bacteria and associated toxins to reduce the level of contamination on coils and drain pans (generally the most likely accumulators of moisture in an air handling system). The combination of filtration and UV lights has been shown to be very effective in improving IAQ, even when UV lights were added to an existing air handling system.

Bacteria range in size from 0.2 to 5 microns, while viruses are between 0.01 and 0.3 microns. Viruses need a host to propagate and, depending on humidity, they are generally in droplet nuclei form and/or attached to another particle. When the relative humidity drops, it is assumed they become liberated and approach their individual size, so they can more easily get past our nose hairs and cilia to cause infection (e.g., in the winter time). Conventional 30-35% efficient, 2-inch pleated filters will not arrest bacteria or viruses. Bag or cartridge filters in the 90 to 95% efficient range will arrest larger bacteria, but will be less effective against smaller pathogens. HEPA filters are 99.97% efficient at stopping 0.3 micron particles and are more efficient on these smaller particles.

While high efficiency and HEPA filters are an excellent and proven response to IAQ concerns, they can also add significant air pressure drop to the air system. (Dirty HEPA filters generally have a 2.3 inch Air Pressure Drop.) In addition, they require considerable space in the air handler cabinet, which can increase its length and cost. Adding UV lights to standard 2-inch pleated filters can offer performance against microbes approaching a much more elaborate filtration system, but for a lower initial and operating cost.

UV lights also have the advantage of destroying (as opposed to just arresting) surface mold and bacteria along with the airborne ones mentioned above. They do much of this while the fan is off, making UV lights a good addition even when high performance filtration is used.



UV Lights and Filters Augment Each Other

External to the air handling unit, UV lights can result in cleaner plenums and ductwork by reducing the total number of microbials circulated that can collect in these areas. Building tenants benefit from lower microbial counts and the odors and gasses produced by them, which can help reduce infectious disease, allergies and allergy-induced asthma. Ultimately, building owners can benefit by virtue of satisfied tenants that are more likely to rent longer, and are potentially less likely to bring litigation.

Other benefits of UV lights that are not so obvious can include reduced maintenance and peak equipment performance. The continuous "killing" action of UV lights also serves to continuously clean the coil and drain pan. While regular maintenance and cleaning is always recommended, the task should involve much less time, effort and chemicals.

Because coils remain cleaner, coil pressure drops and capacities can remain at "near new" conditions. Clean coils translate into efficient heat transfer and higher energy efficiency. Some studies show that as much as 37% additional energy is required in equipment with dirty coils. In addition, a build-up of organic material (mold and bacteria) can reduce airflow through the coils and require the air handler to work harder and consume more energy.

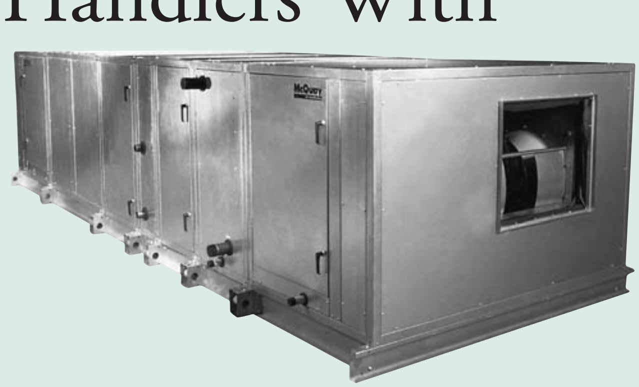
UV technology has advanced to the point where it can be easily applied in virtually any location within an air handler – at a very moderate cost – as long as there is a power source. The extremely complicated math required to determine kill rates can now be completed with simple to use software modeling programs. There are even sizing and return on investment (ROI) versions (based on psychometrics,

continued on back page.

McQuay Vision™ Air Handlers With Ultraviolet Lights

McQuay Vision™ air handlers are available with an ultraviolet (UV) light option mounted on the downstream side of all cooling coils and above the unit drain pan. The lights are supplied by UltraViolet Devices, Inc (UVDI), whose roots date back 54 years in the use of UV lights for microbial control purposes in both water and air applications.

All UV lights used in Vision air handlers are pre-engineered and factory installed for proper placement to provide maximum effectiveness. In addition, UVDI is the only UV light manufacturer to have their units UL approved to UL's Category Code ABQK specification, HVAC Accessories, Air Duct Mounted. The combination of Vision air handlers and UVDI lights represent the only UL and ETL agency-approved application of the devices in the industry.



For more information on applying UV lights in your new or existing air handler applications, contact your local McQuay Representative. To locate your local McQuay Representative, visit www.mcquay.com. For more information on UV lights, visit the UVDI website at www.uvdi.com.

continued from page 3.

operation and maintenance). Lamp maintenance has been reduced because newer lamps can last a year – even with continual use. The lights do not produce ozone or other contaminants, which mitigates environmental concerns.

UV lights have very modest power requirements. At a cost of around 12 cents/day to operate the UV lights, depending on the local utility rates, they can be economically operated continuously. Given the potential savings in maintenance costs alone, the annual energy expense for UV lights can potentially be made up in as little as one cleaning.

It is, however, important to prevent human exposure to a lit UVC lamp. Germicidal UV (UVC) can harm skin and eyes, causing burning of the skin and conjunctivitis of the eyes. In rare cases, it may even cause temporary blindness. Manufacturers have developed safety features to help prevent accidental exposure. It is also possible to install "cut-off" switches at doors and panels to help prevent exposure when accessing an area containing a UVC fixture.

Conclusion

UV technology has advanced to the point where a case can be made to apply it in virtually any air handler application. In fact, the most recent GSA Facilities Standard for federal facilities calls for ultraviolet lights to be incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer. Details can be found on the GSA website at http://gsa.gov/pbs/pc/facilitiesstandards/ under Section Five, Sub-Section 5.4, Page 130, and the paragraph titled "Drains and Drain Pans".

In addition to the IAQ benefits, the potential cost savings generated by using UV lights can more than justify the expense to install and operate the equipment. While UV lights do not replace traditional filtration, they can augment its effectiveness and potentially make any air handling system more effective at delivering good IAQ.

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