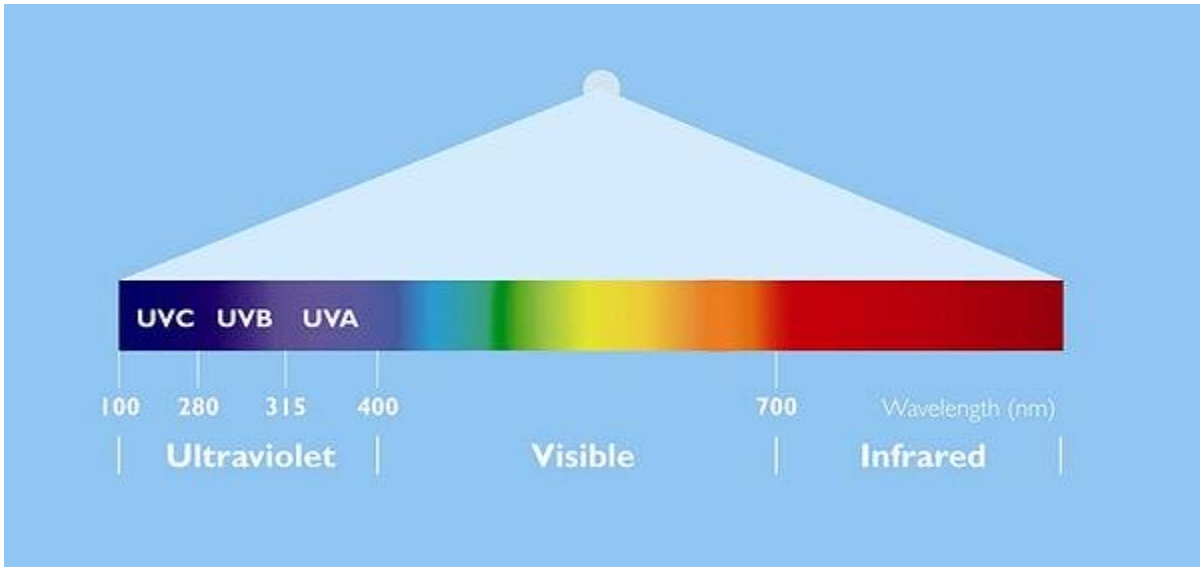
Dave Hader, CFM
Facilities Engineering Manager
JM Family Enterprises

Findings: UV Lights on HVAC Ducts

Ultraviolet germicidal irradiation (UVGI) is a disinfection method that uses short-wavelength ultraviolet (UVC) light to kill or inactivate microorganisms by destroying nucleic acids and disrupting their DNA, leaving them unable to perform vital cellular functions.

UV light is electromagnetic energy with wavelengths shorter than visible light but longer than x-rays.

The wavelength of this light ranges from 10nm to 400nm and is classified into three sub-bands; UV-A (near), UV-B (middle), and UV-C (far).



UVGI devices can produce strong enough UVC light in circulating air or water systems to make them inhospitable environments to microorganisms such as bacteria, viruses,

molds and other pathogens. Exposure comes from germicidal lamp that emits germicidal UV at the correct wavelength, thus irradiating the environment. The forced flow of air or water through this environment ensures exposure.

The application of UVGI has been an accepted practice used primarily in medical sanitation and sterile work facilities. In many systems, redundancy in exposing microorganisms to UV is achieved by circulating the air or water repeatedly. This ensures multiple passes so that the UV is effective against the highest number of microorganisms and will irradiate resistant microorganisms more than once to break them down.

According the Centers for Disease Control (CDC), “UV can kill all bacteria, including drug-resistant bacteria because UV light is actually attacking the DNA and RNA of microbes. While the amount of UV needed to kill a microbe may vary as there is a relationship between the size of DNA molecules and the effect of UV radiation, there have been no reports of microbes demonstrating an ability to build an immunity to light-based methods.”

It is important to understand the difference between sterilization, disinfection, and decontamination as these terms are often incorrectly used interchangeably, which can cause confusion in regard to the effectiveness of UVGI (as well as the avoidance of potential legal ramifications).

- Sterilization
    - Per the CDC, sterilization describes a process that destroys or eliminates all forms of microbial life and is carried out by physical or chemical methods.
- Disinfection
    - Per the CDC, disinfection describes a process that eliminates many or all pathogenic microorganisms on inanimate objects.
- Decontamination
    - To decontaminate is to make an object or area safe by removing, neutralizing, or destroying any harmful substance.
    - Basically, decontamination is the result after the processes of sterilization or disinfection.

"Sterilization" is often misquoted as being achievable. While it is theoretically possible in a controlled environment, it is very difficult to prove and the term "disinfection" is generally used by companies offering this service as to avoid legal reprimand. Specialist companies will often advertise a certain log reduction, e.g., 6-log reduction or 99.9999% effective, instead of sterilization. This takes into consideration a phenomenon known as light and dark repair (photoreactivation and base excision repair respectively), in which a cell can repair DNA that has been damaged by UV light.

The effectiveness of this form of disinfection depends on line-of-sight exposure of the microorganisms to the UV light. Environments where design creates obstacles that block the UV light are not as effective. In such an environment, the effectiveness is then reliant on the placement of the UVGI system so that line of sight is optimum for disinfection. Forced air systems by design impede line-of-sight, thus creating areas of the environment that will be shaded from the UV light.

Disinfection is a function of UV intensity and time. For this reason, it is not as effective on moving air, or when the lamp is perpendicular to the flow, as exposure times are dramatically reduced.

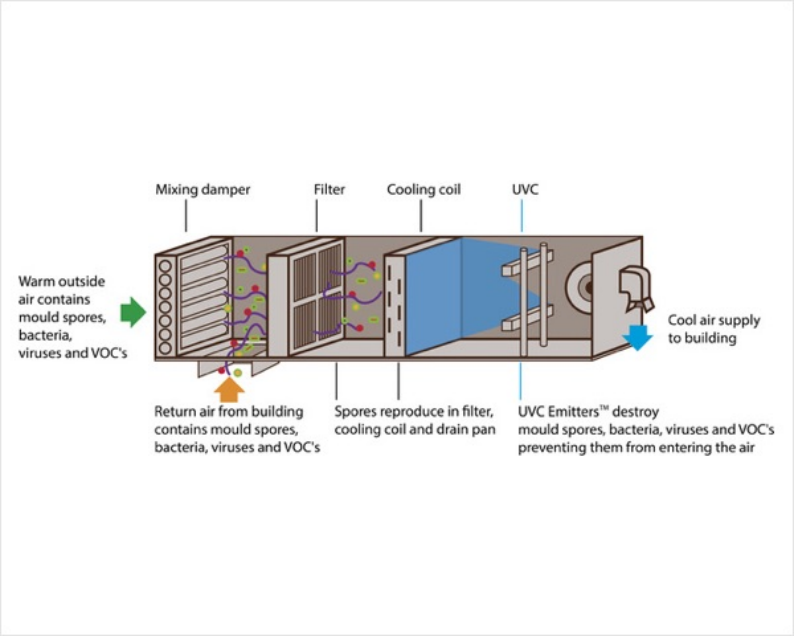
UVGI systems can be installed in the ducts of heating, ventilating, and air conditioning (HVAC) systems and irradiate the small airborne particles containing microorganisms as the air flows through the ducts.

UVGI systems in ducts also direct UV light at the cooling coils and drain pans of air conditioning systems. Irradiating the cooling coils and drain pans can dramatically reduce mold and bacteria growth on the often-wet surfaces of cooling coils and drain pans, or destroy the microbial films that previously accumulated on the irradiated surfaces

There are two reasons to irradiate coils and drain pans. First, the mold and bacteria that often grow on cooling coils and drain pans may shed particles into the air that subsequently enters the occupied spaces, posing health risks, such as risks of non-infectious respiratory health effects. Preventing growth on the coils and drain pans may reduce these health risks. Second, by keeping the coils cleaner, the UV systems may improve the energy performance of the HVAC system

The extent to which UVGI systems kill or deactivate cells depends of the intensity of the UV light, the duration of irradiation, humidity, the target organism, and other factors.

Effective destruction of molds and bacteria on surfaces of cooling coils and drain pans will keep microorganisms from forming in these naturally damp places. Surfaces are irradiated continuously while the particles in flowing air may be irradiated for a very short period.



Research has demonstrated up to 99% reductions of molds and bacteria on irradiated surfaces. The effectiveness of UV systems that irradiate microorganisms in flowing air can also be substantial but is less dramatic and depends highly on the microorganism type, air velocity, humidity, the size of the particles carrying the microorganisms, and the UV system design

Studies of the health benefits of applying UVGI systems have inconsistent results. Also, there have been very few studies of UVGI in HVAC systems outside of health care facilities.


FIGURE 1 Tampa, Fla., downstream cooling coil surface fungal colonies before coil UVGI (left) and after 13 months of coil UVGI (right).[2]

This technology has long been claimed to yield significant energy user related benefits by decreasing the airside flow resistance of cooling coils while increasing their airside heat transfer coefficients.

In conclusion, cost effective is relative. Install cost varies based on location, size, power requirements, etc. but I would initially consider $5,000 - $7,500. In addition, UV lights are typically replaced annually which again, depending on size, could be $1,500/year.