

AIR CONDITIONING AND REFRIGERATION Journal

The magazine of the Indian Society of Heating, Refrigerating and Air Conditioning Engineers

Issue : October-December 2005



A typical dirty cooling coil



A typical clean coil after installation of UVC lamps.

UVC Lamps Can Keep AHUs Clean

and also improve indoor air quality, restore cooling capacity, reduce maintenance costs and save energy

By Ashoke Sarkar

General Manager, Customer Service

Blue Star Ltd., Mumbai

(Product Champion: Steril-Aire UVC)

Ashoke Sarkar is a mechanical engineer from Maulana Azad College of Technology, Bhopal. He has 20 years experience with Blue Star Ltd. in both Projects and Customer Service departments. Currently he handles sales and marketing of new Service products. He is an ISHRAE member and can be reached at ashoksarkar@bluestarindia.com

Air handling units are a very important part of the air conditioning system in every commercial, industrial and institutional building. Cooling coils inside such AHUs function in a dark cool environment and with copious condensation in our humid atmosphere, provide a moist garden for the propagation of mold and other micro-organisms. These

organisms multiply 24×7 to huge concentrations (see **Figure 1**) creating a hidden biofilm of mold deep inside the HVAC system.

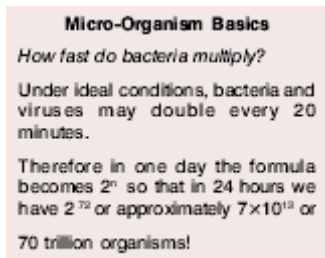


Figure 1

These microbial contaminants travel from the coil through the airstream accounting for much of the illness and discomfort in buildings today. Drain pans below the cooling coils are equally affected. Dust and debris which passes through inefficient filters or bypasses poorly installed filters combines with the microbial contaminants forming a black sludge that helps choke the coil between fins cutting down air quantity supplied by the AHU's blower due to increase in pressure drop across the coil. Increasing fan speed only helps to boost the power consumed by the fan motor. Operating and maintenance problems are the end result.

Chemical Cleaning of Coils

Chemical cleaning cannot be carried out every day or every month for that matter because of the extensive and messy procedure involved in the cleaning process. However, formation of mold and collection of dust and dirt goes on as long as the AHU keeps operating. Most maintenance people will resort to chemical cleaning once or twice a year, if at all, and usually the work is entrusted to sub-contractors who employ poor labor that does not mind being exposed to chemicals required for the task. The AHU must be shut down for several hours for the cleaning work to be effectively completed and after start up, traces of the chemical are carried by the airstream into human-occupied spaces. Pharmaceutical plants will not tolerate the use of chemicals for fear of contaminating the manufacturing process.

Air Handling Units

For many years the design and manufacture of air handling units has been neglected, as it was considered a very simple product best left to sheet metal duct work fabricators. Very often galvanized sheet construction was down graded to mild steel and rust was a common problem with the "insides" of the unit and the debris that would collect inside the coil.

With a framework of extruded aluminium, double skin insulated panels and stainless steel drain pans, AHU design and construction has progressed to a point when only specialist manufacturers are now involved. But the physical location of these units, with adequate service space all around is still limited by the constraints of space and the unwillingness of architects to allocate the right room size required. A new hospital in Mumbai had an AHU tucked above a false ceiling with practically no service space, let alone adequate space for carrying out chemical cleaning of the coil.

Under such circumstances, maintenance staff can hardly be blamed if coils have not been cleaned and drain pans never touched after installation.

Now Enters UV Technology

UV light (Figure 2) in the form of germicidal lamps has been used since the late 1800s to kill the same types of microorganisms that typically cause IAQ problems. Niels Ryberg Finsen (1860 to 1904), a Danish physician, was the first to employ UV rays in treating disease and ultimately invented the Finsen curative lamp, which was used successfully into the 20th century.

Since then UV radiation in the short wave or C band range (200 to 280 nanometers) has been used in a wide range of germicidal applications to destroy bacteria, mold, yeast and viruses. After World War II, the use of UVC increased rapidly for upper air (where UV was directed as a beam across the ceiling of a room) and other applications. Typical examples included hospitals, beverage production, meat storage and processing plants, bakeries, breweries, dairies, kitchens, pharmaceutical production and animal labs - virtually anywhere that microbiological contamination was of concern.

As mechanical ventilation of these spaces became popular, however, it was found to have an adverse effect on UVC performance. The introduction of moving air over the tubes, especially below 77 F, decreased the output and service life of conventional UVC products and thus their ability to destroy viable organisms. Additional lamps were installed and changeout cycles accelerated to compensate for these problems.

During the 1950s when tuberculosis (TB) infections were on the rise, the use of UVC broadened further in scope. In addition to upper air applications, it found its way into air handling equipment and became a major component in the control and eradication of TB.

Over the next decade, with the availability of new drugs, sterilizing cleaners, and control procedures (gowning, etc.), concern over microbiological problems began to wane. This trend, coupled with the performance problems of UVC lamps in air handling systems (impaired output, short tube life and high maintenance), caused the use of UVC in HVAC

equipment almost to disappear. Despite this fact, ASHRAE has acknowledged the effectiveness of UVC, stating that “Sterilizing lamp installations in duct systems have been reported to be highly efficient.”



Figure 2

High-output Emitters

Recently, there have been significant strides in the development of UVC light production sources. A patented UVC emitter seems to defy the accepted operating principles of germicidal lamps manufactured over the last 50 to 70 years in that its output actually increases in the “hostile” operating environments of cold and/ or moving air. In development for 16 years, this new technology combines unusual voltages, excitation wave forms, discharge ignition and a unique blend of gases and vapors to produce a high output and very stable broad-band ultraviolet energy.

Germicidal UVC energy penetrates the outer structure of the cell and alters the DNA molecule. This prevents replication, causing cell death. Germicidal effectiveness of UVC is directly related to the dose applied, and the dosage is the integral product of time and intensity. A high intensity for a short period of time and low intensity for a long period of time are nearly reciprocal and are equal in killing power, therefore, the energy required to destroy microorganisms is given as microwatt-seconds (or microjoules) per square centimeter.

Independent testing performed by Rapid Precision Testing Laboratories, Cordova, Tenn. has shown that when compared to the older generation of UVC lamps, high-output UVC emitters specifically designed for HVAC use:

- Consume only 1.75 times the electrical power yet produce 2.5 to 6 times the output at temperatures ranging from 32 to 90 F.

- Produce over five times the output at conditions most often found in HVAC systems.
- Produce a wider band width for more killing power at a broader spectrum.
- Provide a significant increase in output per inch (arc length) of tube (foot-print) as well as an increase in tube life, meaning that fewer tubes can be used for a longer period of time. Significant life-cycle cost reductions over conventional designs are the end result.

Scientific research has concluded that maximum germicidal effectiveness occurs at about 265 nm. There are no low-pressure, mercury vapor UVC devices currently available that produce this optimum spectral line. However, some high-output emitters can deliver a broader band of total output (250 to 260 nm), so in addition to the benefit of increased output, they are closer to the optimum wave length, thus further enhancing available effectiveness.

Field experience to date with high-output emitters has been uniformly positive. For example, a southern California hospital, which is taking a highly proactive approach to IAQ control, recently brought in expert diagnosticians to measure microbial activity. Their analysis uncovered the presence of various types of mold spores in one of the air handling systems despite the use of 95- percent ASHRAE efficiency filters in a tightly sealed housing. It is important to recognize that high-efficiency ASHRAE filters do not remove all microorganisms and that mold may still develop when organism- laden air is permitted to enter the air handling system - e.g., during time-clock operated shutdown (back-draft), when access doors are opened for filter changes, etc.

Though the initial mold count (taken during winter months) was low, the hospital wanted to guard against the typical summer mold proliferation and installed three highoutput UVC emitters downstream of the filters - enough irradiance to provide effective kill of surface organisms within the 8000 cfm system. Subsequent surface testing of the area showed that the UVC lamps yielded a tenfold reduction in mold count. By doubling the number of lamps to six, the hospital expects to achieve a hundred-fold reduction in both surface and potentially airborne microorganisms.

How UVC Lamps Help Maintenance Staff

Many actual users have found that high-output ultraviolet-C lights installed in the AHUs reduce or eliminate coil cleaning programmes - yielding ongoing energy savings, a

reduction in HVAC system maintenance and the elimination of cleaning chemicals. I quote the experience of Florida Hospital's Orlando Campus:

“To test the efficacy of the UVC devices, we decided to install the lights in AHU#107, a 27-year-old 6,000 cfm unit located at the main Orlando campus. A UVC Emitter™ was specified for this and for subsequent installations. We selected AHU#107 because the coil and drain pan areas had a very visible buildup of mold, and the coil was clogged to approximately 50%.

Within weeks after the UVC installation, static pressure over the coil decreased from 1.8 in. wg. to just 0.7 in wg. Air velocity over the coil more than doubled, from 230 fpm to 520 fpm. Both the coil and drain pan areas looked absolutely clean, with no more visible evidence of mold or organic buildup. The air exiting wetbulb temperature from the AHU also decreased significantly, from 57°F (before UVC) to 53° (with UVC).

We calculated the increase in capacity to be 95,245 Btuh or approximately 7.9 tons of air conditioning. If we use 1 kW/ton and multiply by 24 (hours/day) by 365 (days/year) by \$0.07 (our electric rate), we arrive at a total of \$4,867 in savings for this one unit. The total installed cost of the UVC Emitters was less than \$2,000. Given the number of our facilities and the number of AHUs in these facilities, we estimate yearly energy savings well into the six figures. This estimate does not include additional savings for reduced maintenance.

Stated another way, we project that the hospital is conservatively saving 15% in HVAC system energy costs, and probably much more. These results are consistent with long-accepted industry studies documenting that just a one-micron buildup of dirt or debris on coil surfaces can lead to a 15% loss in operating efficiency.

AHU#107 has essentially returned to its original performance specifications and has continued to operate like a “new” system since we installed the UVC devices more than four years ago. The coil and drain pan areas have also maintained their clean condition, eliminating the necessity for the monthly inspections and twice annual cleaning that used to be required. How is this possible? We have found that the high output UVC energy kills or inactivates both coil and drain pan mold and bacteria (to eliminate their toxins, VOC and spore production, and allergens) as well as ordinary coil and drain pan debris. The result is a continuous form of source control.”

Experience at an Installation in India

At an IT office in Mumbai UVC Emitters™ were installed on an existing air handling unit and the following performance readings were noted:

The increase in capacity was 50,942 Btu or approximately 4.25 tons of air conditioning. If we consider energy consumption as 1kW/ton and considering 24 hours operation for 365 days and taking Rs. 5/- as electricity tariff, we arrive at a total saving of Rs. 1,86,150/- for this one unit. Savings on account of coil cleaning chemical and labour for maintenance of the AHU and the overall increase of the life span of the coil comes as an additional saving.

The initial installation cost of the UVC Emitters™ for the above unit was approximately Rs. 1,50,000/-. The subsequent replacement cost of UVC lamps after every year will be approximately Rs. 30,000/- only.

As such, a typical installation can pay for itself in a few months and save lakhs of rupees thereafter in energy and maintenance cost.

Description	Day one	Day 30th
Avg. cfm across filter (Avg. of 24 readings)	12264 cfm	13252 cfm
Return air		
Dry bulb temp.	78°F	78°F
Wet bulb temp.	68°F	66°F
Supply air		
Dry bulb temp.	61°F	57°F
Wet bulb temp.	58°F	55°F
Pressure drop across coil	19mm of WG	17mm of WG
Total Capacity-Btuh	402872	453814
Latent Heat-Btuh	225167	300555
Sensible Heat-Btuh	177705	153259
Net Capacity Gain-Btuh	50942	

Some Common Questions

1. What is UVC?

UVC is a type of ultraviolet (UV) energy in the 260-nanometer frequency. The “C” wavelength is the most germicidal in the UV spectrum.

2. How does it affect germs?

The “C” wavelength targets the DNA of microorganisms, causing cell death or making replication impossible. The UVC energy kills or inactivates microbes, eradicating surface and airborne mold, as well as viruses and bacteria.

3. **Does it work?**

Yes, UVC Emitters improve IAQ (indoor air quality); kill or inactivate surface and airborne microorganisms; prevent the spread of infectious diseases caused by bacteria; continuously clean coils, drain pans, plenums and ducts, and improve product quality, shelf-life and yield in processing plants.

4. **Does UVC relate to UVGI?**

The two terms are basically synonymous. Ultraviolet Germicidal Irradiation (UVGI) is a term used by Federal Agencies such as OSHA, NIOSH and the CDC when referring to UVC.

5. **Can UVC save energy?**

Yes, UVC devices degrade organic buildup in coils, keeping coils continuously clean. This lowers HVAC energy costs by improving heat transfer and increasing net cooling capacity.

6. **Will it help allergies?**

Bioaerosol-related allergies have shown abatement and complete remission when UVC is used in HVAC equipment. Even simple stuffy noses are reported cleared.

7. **Will UVC kill mold in ducts?**

Yes, applying UVC at the coil dramatically reduces the overall activity in the rest of the A/C system as well as the space.

8. **Will UVC kill 100% of all airborne micro-organisms?**

No, however it will kill up to 99+% depending on the organisms and the required design.

9. **Will UVC kill dust mites?**

No.

10. **Does it produce ozone?**

No. UVC devices do not produce ozone or other secondary contaminants.

11. **Where is it installed?**

Most UVC fixtures are designed specifically for installation in HVACR applications. On existing systems, infestations always exist. Therefore, the best results are obtained when the light is located downstream of and facing the coil. In this location the user can expect the highest efficacy in eliminating surface (coil and plenum), drain pan and airborne microbes. On new systems, it can be placed either up or downstream of the coil and aimed at the coil.

12. How do you size it?

For IAQ, improved heat transfer, reduced maintenance and odor, the rule of thumb calls for about 24" of UVC Emitter™ length for every 4 square feet of coil face area. The factory should always size applications involving infectious disease applications.

13. Do you clean a coil first?

UVC will degrade all of the organic material on and within a coil, usually within 30 days or less. Prior cleaning of the coil is not necessary, and may delay the benefits of UVC.

14. What are the limits of temperature, humidity and velocity?

Limit rules of thumb are 32- 170°F, 99% RH and 1000 fpm, respectively.

15. How will the customer know it is working?

There are several ways to demonstrate the many things taking place: One is to use a contact plate containing specialized agar before the lights are installed. Thirty days after the lights are installed repeat the procedure and compare results.

A visible reduction of mold will be seen in a very short period of time. Coil pressure drop will fall and can drop as much as 30% in 30 days or less (depending on coil cleanliness and water activity). The system's airflow will usually increase as a result. Drain pans and drain pan water become significantly cleaner. All line-of-site surfaces, i.e. insulation, will start to look like new. Most of the space odor will disappear and the air will seem fresher.

16. Is UVC harmful?

UVC is only harmful under prolonged direct exposure – which is not generally an issue, since the devices are installed inside air conditioning equipment or are otherwise shielded to prevent exposure. Use of safety goggles and gloves is recommended as a precaution during installation to protect the eyes and skin.

17. Should the Emitters be cycled with the fan or run continuously?

For optimum IAQ and most efficient performance, the devices should be run continuously if possible.

18. How do you know when to change the Emitters?

For large or critical applications, change out should be performed when Emitter output decreases by 40% as measured by our radiometer, after about 9,000 hours or 12 months. For installations with no radiometer, change Emitters annually (after about 9,000 hours).

Conclusion

UVC devices have performed beyond expectations for their originally intended maintenance function - to reduce or eliminate coil and drain pan cleaning. Downtime is eliminated. The air handling unit can keep performing all the time improving customer comfort.

By keeping coils in a constantly clean state, UVC improves heat transfer efficiency, improves airflow through the system and allows air handlers to operate at peak performance. The resulting savings in HVAC system energy will be enough to pay back the cost of the UVC installation very quickly.