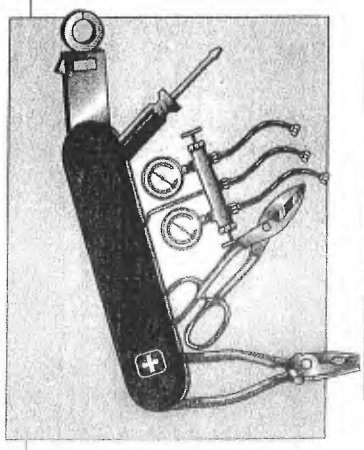


Coil Cleaning: MYTHS AND MISREPRESENTATION

William M. Dillard and Justin S. Salmon

When you discover severely restricted air flow through a coil during normal service, it may be time to suggest a replacement, since attempting to clean such a coil may only make matters worse.

A Case Study

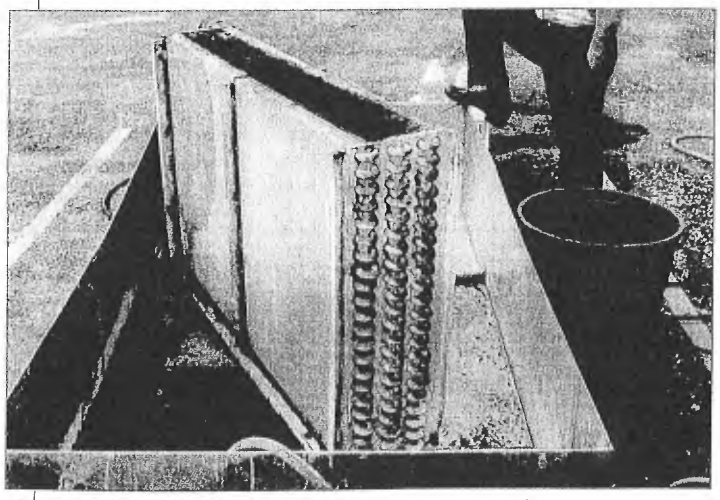
We've long touted the benefits of coil cleaning to our customers. It's only been in the last three to four years that we've questioned the validity of the processes we'd gone through to clean their coils, tested for results, and come up with some surprising conclusions.

First let me state that we've tested a wide variety of coil cleaners, and for extreme cleaning, we now use an industrial pressure sprayer/boiler that supplies 180F water to apply such cleaners.

In this case, our customer was getting repeated complaints from tenants that there was "black stuff coming out of the vents." It was a recurring problem that a number of other contractors had attempted to correct.

Our Environmental Services Group re-cleaned the coils (25 sq. ft., 4 row) using 180F water and an aggressive new coil cleaner we'd been wanting to try. We had our technicians collect all the water in a 55-gal. drum, decant the mixture and strain the residue through a standard paint strainer.

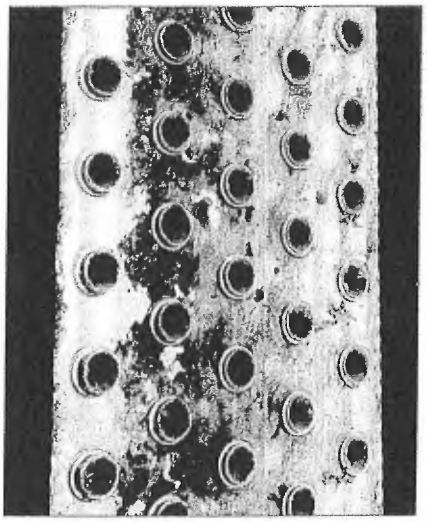
The result was about 1 lb. of sludge that looks remarkably like the material that was landing on the desks of people at the end of the line served by that air handling system. Under the microscope at Grove Scientific (an Industrial Hygiene Group we partner with) we could see vibrant life in what should have been sterile sludge after being blasted with 180F water and coil cleaner. What's the bottom-line? In cases where coils have been neglected, it's often far cheaper to replace them than to try to clean them.



When this coil was removed from service, an interior packed with dirt and grime was revealed, despite hours of cleaning effort.

Why? Because we simply aren't getting coils clean with traditional coil cleaning strategies.

No matter how good the coil cleaner, no matter how good the sprayer used to apply the cleaner, what we've really been doing is "packing" the coil with organic and biologically active matter. The packing process occurs using the traditional cleaning methods (which include applying coil cleaner according to manufacturer's recommendations and then using a high-pressure sprayer/boiler to wash the particulate out of the coils.



Dissection of this coil, after it was removed from service, revealed excessive internal contamination. It appears that previous cleaning efforts had little effect, reaching only an inch or so into the coil.

Many sources advise cleaning the coil from one side to prevent this packing but modern fin design can severely restrict the effectiveness of the pressure sprayer beyond about one inch into the coil. Better "visible" results are obtained by cleaning from both sides, but unfortunately, this often packs the par-

ticulate further into the coil interior causing an increase in the air pressure drop through the coil.

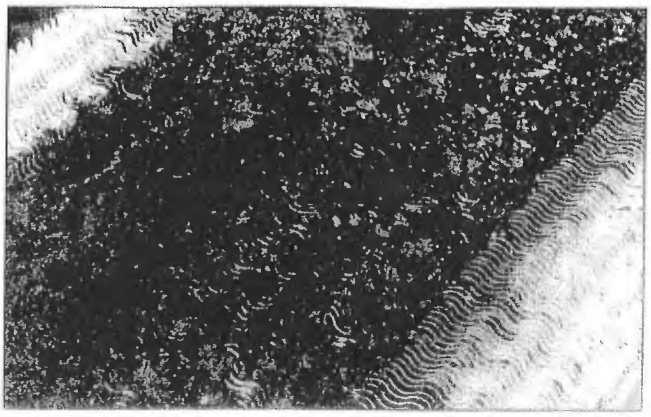
How do we know? We simply use basic National Environmental Balancing Bureau NEBB test and balance procedures to measure air pressure drop and air volume across the coils and compare them with factory conditions. In coils that have been poorly maintained, the pressure drops consistently exceed the manufacturers ratings indicating the packed conditions we've confirmed by dissecting such coils.

When the material still resident in the coils is tested, it's almost always biologically active — meaning it's alive with multiplying organisms that live and grow in that wonderful, nutrient-rich, wet atmosphere known as the cooling coil.

That kind of research has driven us to a higher standard when attacking this problem.

In order to determine the condition of the coil, it's necessary to measure both the pressure drop and the airflow through that coil (a dirty coil will exhibit a decrease in air volume and an increase in pressure drop). Then, a simple calculation to predict pressure drop at design air volume will complete the picture.

To illustrate this, let's imagine a coil designed for 4,000 CFM at .4-in. WG pressure drop. Your test measurements indicate only 3,000 CFM (25% low) at .5-in. WG (25% high). Neither of these results looks too serious, but using the fan law formula:



Full-strength coil cleaner applied to the surface of cooling coils then flushed with high-pressure hot water will result in a coil that appears to be clean, but may actually be a hotbed for microbial growth. Increased pressure drop and reduced air volume through such coils is a red flag that says it's time for a replacement.

$$\frac{SP2}{SP1} = \frac{(CFM2)^2}{(CFM1)^2}$$

where CFM2 = 4,000, SP1 = .5-in., and CFM1 = 3,000 CFM

The result is that SP2 (the static pressure that it would take to push the design air volume through the dirty coil) equals =

$$\frac{4{,}000 \times 4{,}000 \times .40}{3{,}000 \times 3{,}000}$$

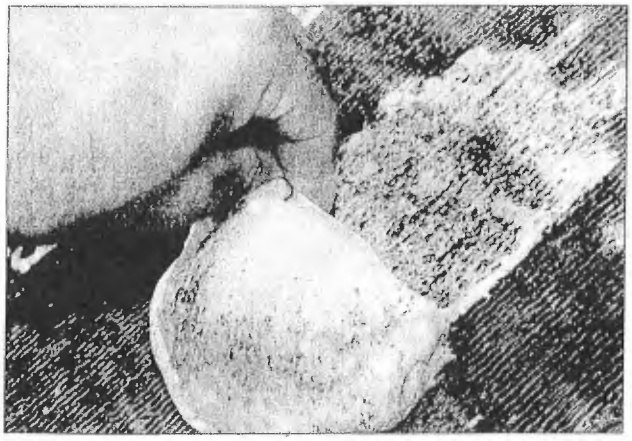
which = .71 in., more than 1.75 times the design pressure drop.

A Time To Change

Based on the above, and our hands-on coil cleaning experience, if your calculated pressure loss for a cooling coil that's over four rows in thickness is in excess of 1.5 to 3 times the factory ratings, it's time to consider a coil change. Why? Simply because you're not going to get that coil clean with presently known cleaning procedures.

You've reached the point where the labor cost to attempt cleaning such a coil is likely to exceed the cost of materials and labor to replace it. And, chances are your efforts to clean it will fail anyway.

What about all the claims by the producers of coil cleaning products regarding those products' ability to clean such surfaces?



If properly maintained and regularly cleaned with coil cleaners and hot water, a coil's interior as well as its exterior can be kept clean. The bubbling action of foaming cleaners can actually lift the dirt from the coil's interior.

We've removed contaminated coils, soaked them in various coil cleaners (overnight) and were still unable to remove the "packed" biological mass from the interior fin surfaces. (see the accompanying photos)

This article isn't meant to attack coil cleaning product manufacturers, or their performance claims. Our experience merely points out that the accepted industry cleaning procedures aren't adequate in cases where coils have been neglected. Depending on the environment that cooling coils operate in, a coil doesn't have to be very old before it requires replacement versus standard cleaning procedures.

What We've Learned

What have we learned from all our research?

First, good coil cleaning procedures have to start when coils are put into operation, not two or three years down the road!

Second, in cases where the pressure drop exceeds 1.5 to 3 times the rated capacity, it's time to estimate a coil replacement. If you complete the estimate and you're still not sure of the economics in the cost of the fan energy required to deliver air at the new pressure drop, remember that increasing the pressure drop through the coil dramatically increases the amount of fan energy required to deliver the designed air quantities.

By suggesting a changeout when coils become impacted, you'll be doing your customer a tremendous favor because he/she will be saving both energy and improving the indoor environment. And, after you've changed that coil, don't forget to upgrade those filters — after all, that's the primary reason you had to change the coil in the first place. CB

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YOU'LL WANT TO KNOW

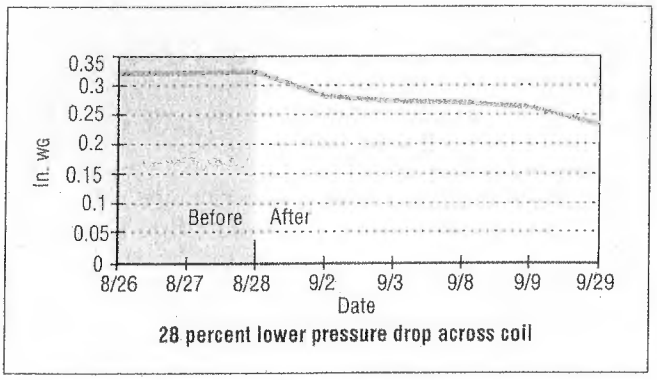
UVC Lights Enhance IAQ, Reduce AHU Operating Costs

CITY OF INDUSTRY, CALIF.—Southern California Air Conditioning Distributors (SCACD), the world's largest Carrier distributor, wanted to investigate additional indoor air quality (IAQ) improvement methods in its 30-year-old administrative facility located here. According to Bruce Fuhrmann, commercial manager for SCACD, he knew from visual inspections that there were typical accumulations of dirt and mold around the cooling coil and drain pan in the central station air handler. He believed that this condition might be the source of non-specific odors in the building and knew it was impeding heat transfer efficiency.

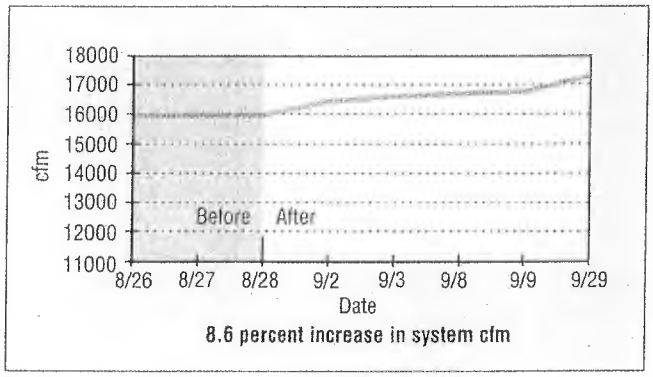
Fuhrmann had heard that a new, high-output UVC light source designed for HVAC applications was being marketed specifically for these problems. He had also heard about this product's ability to degrade accumulated organic materials, so he decided to try it and evaluate the results.

SCACD had another reason for testing the UVC Emitter™, manufactured by Steril-Aire, Inc. If it worked, SCACD would market the device to the engineering community and commercial and residential customers through its network of contractors and dealers. Before taking that step, they needed to be sure that the device worked as claimed.

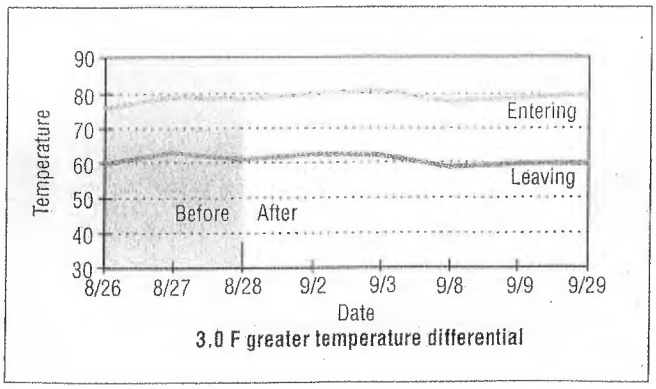
The product is a multi-patented, germicidal device that uses a newly developed combination of tube construction and



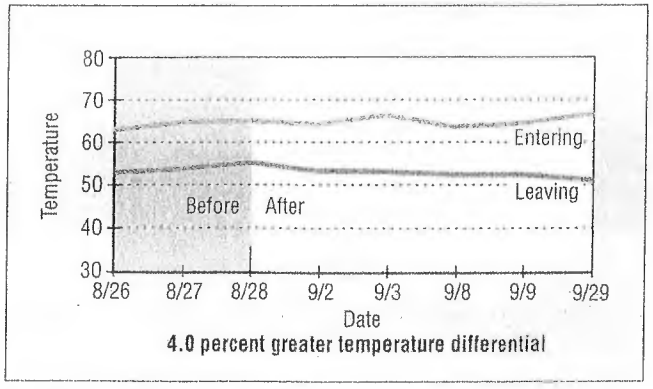
1 Cooling coil pressure drop (DX).



2 System air flow.



3 Dry bulb temperatures.



4 Wet bulb temperatures.

Effectiveness of Germicidal UV Radiation for Reducing Fungal Contamination within Air-Handler Units

ESTELLE LEVETIN[1], RICHARD SHAUGHNESSY[2], CHRISTINE ROGERS[1], AND ROBERT SCHEIR[3]
Faculty of Biological Science[1] and Department of Chemical Engineering[2] The University of Tulsa, Tulsa, Oklahoma

This is a summary of research completed on the fungi growing on insulation within air-handling units (AHUs) in an office building and levels of airborne fungi within the AHUs measured before the use of germicidal UV lights and again after 4 months of operation.

Fungal contamination in air-handling units is a problem in many buildings with central heating, ventilation and air conditioning systems and is a potential source of contamination for occupied spaces. Control of fungi in indoor environments has traditionally focused on source control or air cleaning as methods of removal. UV irradiation, used to disinfect indoor environments in hospitals and other healthcare facilities has various effects on fungi. This investigation was undertaken to determine the effectiveness of germicidal UV radiation on reducing fungal contamination within AHUs.

The test facility was a 286,000 square foot building in Tulsa, Oklahoma and was originally constructed in the 1920's and completely remodeled in 1976. Each of the floors of the 4-story facility is equipped with four primary AHUs and two perimeter units. When the study was undertaken in 1996, acoustical insulation within many of the AHUs exhibited abundant mold growth, as did the drain pans. Preliminary air and insulation samples were collected to develop the sampling protocol.

Two floors were selected for investigation; no UV lamps had been installed in these units. The floors were designated the study floor and the control floor. In May 1997, air samples and insulation samples were collected from the eight AHUs. UV lamps were installed on both floors – each AHU being retrofitted with 10 lamps, installed downstream of the coils. Output of the lamps was 158 microwatts per square centimeter at 1 meter or 10 microwatts per square centimeter for every 2.54 centimeters of tube length.

UV lamps on the control floor were not operated and on the study floor were operated 24/7 throughout the summer and early fall months – while the AHUs were in the air conditioning mode. Sampling was done using paired-stage Anderson (N-6) samplers with malt extract agar for viable fungi and paired Burkard personal samplers for total spores. Two-minute Anderson and 5-minute Burkard samples were collected approximately 40 centimeters downstream of the cooling coils. Pieces of the insulation, approximately 60 square centimeters, were cut from the ductwork directly opposite the cooling coils. Dominant fungi found within the AHUs for both air and insulation included Penicillium corylophyllum, Aspergillus versicolor and a strain of an unidentified Cladosporium species.

In May, before the UV lights were initiated, mean concentrations of the total fungi isolated from the insulation on the two floors were similar in type and quantity (see table 1), while the total concentration of viable fungi in the AHUs on the study floor and control floor in the fall were significantly different.

While this study indicated that concentrations of fungi were significantly lower when UV lamps were in use, the study did not show what stages of fungal growth were most susceptible, nor did it show whether there was a reduction in spore viability. Also, the study was not able to show if all of the fungi obtained from the AHUs were susceptible to UV light. Asthana and Tuveson (2) showed that germicidal effects were highly selective for certain species.

In summary, this study indicates that germicidal UV irradiation may be an effective approach for reducing fungal contamination with AHUs. The use of germicidal UV lamps in AHUs resulted in significantly lower levels of fungal contamination in insulation lining of the study floor as opposed to the control floor (see Table 1). Also, there were significantly lower levels of viable and total airborne fungi than in the study floor units than in the control floor units when samples were taken during the periods (see Tables 2 & 3).

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Table 1. Mean concentrations of fungi isolated from insulation samples in AHUs before and after installation of germicidal UV lamps

Fungal taxon isolated	Concn (10^3 CFU/cm^3)			
	Study floor[a]		Control floor	
	May[b]	September	May[b]	September
Acremonium		0.65 (0.65)	5.81 (5.81)	23.81 (23.68)
Aspergillus versicolor	64.87 (38.56)[c]	0.96 (0.56)[d]	87.58 (32.95)	1,765.46 (1,702.1)[d]
Cladosporium (unknown)	135.28 (50.38)	8.42 (5.22)[d]	22.68 (10.19)	95.31 (37.74)[d]
Cladosporium cladosporioides	0.26 (0.26)	5.04 (5.04)	0.65 (0.39)	228.59 (226.92)
Cladosporium (other)		0.13 (0.13)		1.72 (1.60)
Curvularia		0.05 (0.05)		
Hyalodendron	4.65 (3.84)	13.95 (13.95)	83.96 (83.10)	109.66 (72.09)
Penicillium	8.16 (4.35)	1.05 (0.63)	9.27 (8.11)	16.0 (15.59)
Sporothrix	0.01 (0.01)			
Nonsporulating colonies	0.04 (0.04)		1.94 (1.94)	
Total	213.27 (82.53)	30.51 (24.85)[d]	211.89 (10.80)	2,240.55 (1,622.4)[d]

[a] UV lamps were used only on the study floor [b] May concentrations were measured before the UV lamps were turned on [c] Mean (standard error). [d] The concentrations on the control floor and the study floor were significantly different after the use of germicidal UV lamps ($P < 0.05$).

Table 2. Mean concentrations of viable airborne fungi during disturbance sampling within AHUs before and after installation of germicidal UV lamps

Fungal taxon isolated	Concn (10^3 CFU/m^3)			
	Study floor[a]		Control floor	
	May[b]	September	May[b]	September
Acremonium	0.11 (0.10)[c]		0.16 (0.10)	0.10 (0.10)
Alternaria	0.02 (0.01)	0.01 (0.01)	0.02 (0.01)	
Aspergillus	3.08 (2.58)	0.91 (0.48)[d]	1.89 (0.27)	7.46 (3.37)[d]
Cladosporium	15.64 (8.83)	1.28 (0.5)d	14.75 (9.25)	11.87 (1.99)[d]
Epicoccum				0.04 (0.04)
Humicola			0.01 (0.01)	
Hyalodendron	0.07 (0.03)		0.02 (0.02)	
Penicillium	2.18 (0.28)	0.68 (0.28)[d]	5.39 (2.36)	220.05 (63.06)[d]
Sporothrix	0.11 (0.11)			
Yeast	0.10 (0.03)	0.05 (0.02)	0.06 (0.03)	
Nonsporulating	0.33 (0.09)	0.06 (0.02)	0.25 (0.03)	
Total	21.65 (11.27)	2.98 (1.06)[d]	22.55 (11.1)	239.52 (58.55)[d]

[a] UV lamps were used only on the study floor [b] May concentrations were measured before the UV lamps were turned on [c] Mean (standard error). [d] Concentrations on the control floor and the study floor were significantly different after the use of germicidal UV lamps ($P < 0.05$).

Table 3. Concentrations of total airborne fungal spores during disturbance sampling within AHUs before and after installation of germicidal UV lamps

Fungal taxon isolated	Concn (10^3 spores/m^3)			
	Study floor[a]		Control floor	
	May[b]	September	May[b]	September
Alternaria	0.04 (0.03)[c]			
Cladosporium	29.54 (8.75)	5.43 (3.35)[d]	19.00 (14.16)[d]	68.42 (30.91)[d]
Penicillium-Aspergillus	27.49 (20.92)	6.69 (2.09)[d]	5.63 (2.55)	186.56 (52.51)[d]
Ascospores	0.01 (0.01)	0.01 (0.01)	0.03 (0.01)	
Basidiospores	0.12 (0.06)	0.04 (0.02)	0.05 (0.03)	0.06 (0.04)
Smuts	0.03 (0.01)		0.01 (0.01)	0.04 (0.02)
Other	0.70 (0.25)	0.24 (0.06)	0.47 (0.2)	1.46 (1.09)
Total	57.92 (25.09)	12.41 (4.47)[d]	25.19 (16.73)	255.54 (82.27)[d]

[a] UV lamps were used only on the study floor [b] May concentrations were measured before the UV lamps were turned on [c] Mean (standard error). [d] Concentrations on the control floor and the study floor were significantly different after the use of germicidal UV lamps ($P < 0.05$).

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Engineered Systems

Breaking The Mold

The basics are the same as ever, but it is still easy to overlook some places (and times) where fungus can flourish in a building. Review your tactics to keep mold from becoming a problem that grows on you.

IAQ ISSUE / HUMIDITY CONTROL / AIR DISTRIBUTION / SPOT COOLING

MOLD & M

In Commercial

We like to talk about breaking the mold around here, but this month, we're talking about stopping the ominous, fungal kind. Mold has several opportunities to creep in, starting before the building is even finished. Consider the risks during renovation, and the relationship between climate and building envelope, and perhaps the section on remediation won't become relevant.

MOISTURE Buildings

by Carl C. Schultz, P.E.

Readers of this magazine should have a natural interest in the topic of mold and moisture in buildings, as HVAC systems can sometimes contribute to mold and moisture problems and, when properly designed, can help to control or eliminate them.

Designers of HVAC systems may also be asked to provide input on building envelope design with regard to insulation thickness and placement of vapor barriers. Additionally, mechanical systems can spring leaks and cause water damage that require the immediate attention of maintenance personnel. With all of the litigation and bad press associated with mold, it is wise to review the basics and make sure that the mechanical systems that you may be associated with are not contributing to mold and moisture problems.

MOLD BASICS

Mold is a member of the fungi kingdom, which, according to some scientists, includes some of the most important organisms on the planet. These would include obvious choices, such as the fungi used to produce penicillin, and those that we eat, such as mushrooms and truffles.

More importantly, fungi break down dead organic material and help vascular plants absorb essential nutrients. If it were not for fungi, we would be overwhelmed with large amounts of dead plant matter.

Besides being helpful, fungi also cause problems, as they are associated with many plant and animal diseases such as athlete's foot. On a more serious note, it is estimated that roughly 1,000 hospital patients die each year from invasive aspergillus. Generally speaking, fungi are great as long as they stay outdoors where they belong. But this is not a reasonable expectation since molds produce spores that are virtually everywhere, can be easily dispersed in the air, and can remain dormant for extended periods of time.

Fungi cannot make their own food, and thus they colonize on carbon-based, moist material that resides at a moderate temperature. In order to flourish, all fungi need is a food source, moisture, and a proper temperature range usually between 40° and 100°F. Unfortunately, many building materials, such as ceiling tiles and the paper facing of gypsum board that may get wet, are favorite foods of mold. So the key to stopping mold growth in buildings is stopping moisture accumulation in buildings.

MOISTURE IN BUILDINGS

A building should be designed to repel water, not collect it, and although this is the domain of the architect, it is good to review the principles here. Pitched roofs and building elements that protect exterior walls from the saturating effects of wind-driven rain such as overhangs and soffits can prove beneficial in this regard. Unfortunately, these "bourgeois" features became unpopular earlier in the last century through the influence of notable architects such as Gropius, Le Corbusier, and Mies van der Rohe. Exterior finishes that resist water penetration are obviously more desirable than porous materials that can store water long after a heavy rain. Additionally, a properly sloped building site can aid in the rapid removal of water away from a building after a storm, helping to keep spaces that are located at or below grade dry.

Water vapor can also enter a building by way of air leakage through gaps and holes and though solid objects in a process called diffusion. Of the two, air leakage has the potential to transport much more water vapor into the building than diffusion. Therefore, an airtight building is a good start in preventing mold and moisture damage. Limiting vapor diffusion is the role of vapor retarders, which are classified in Table 1.

A perm is a measure of the number of grains of water passing through a square foot of material per hour at a differential vapor pressure equal to one inch of mercury. A vapor barrier is defined as a Class I vapor retarder and the International Building Code defines a vapor retarder as having a permeability of 1.0 perm or less (Class II).

A building's envelope or, as they say in Europe, the fabric, should be designed so that it does not trap moisture inside of itself. If it does, then the growth of mold may follow.

Facilities built in cold climates have typically been designed so that the envelope dries toward the cold and dry outdoor environment. This is accomplished by placing a vapor barrier near the warm

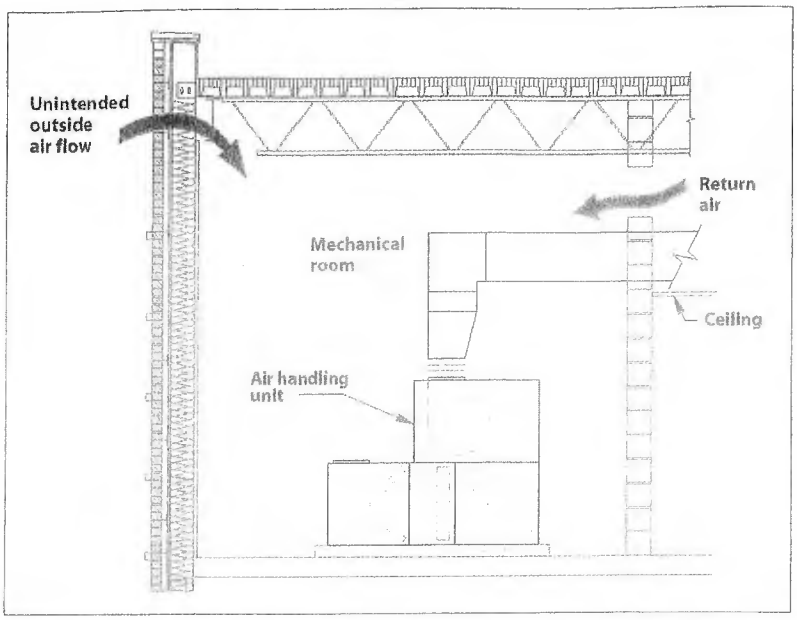

FIGURE 1. HVAC systems can pull in warm, moist air that may then condense in building cavities.

or inside of the envelope.

Buildings built in hot and humid climates on the other hand, would tend to be designed so that the envelope dries to the cooler and drier indoor environment. Current thinking would limit the use of vapor barriers to cold and very cold climates and use vapor retarders and air barriers in hot and humid climates.

Renovation projects where building use or occupancy changes occur are prime candidates for envelope moisture problems. Classic examples involve facilities located in cold climates that are converted to data centers, museums, or similar uses where winter humidification is required. The architect who is responsible for upgrading the building envelope needs guidance from the mechanical engineer on placement of insulation and the vapor barrier in these types of projects. Many of these older facilities have masonry façades, with little insulation and no vapor barrier. The building exterior in these instances can suffer severe damage from repeated freeze and thaw cycles resulting from the moisture that accumulates in the masonry during the winter months.

HVAC SYSTEMS

Except in those applications mentioned above where humidity must be added such as in data centers, operating rooms, and museums, the building's HVAC system should work to dry the building. There are many examples of where HVAC equipment and systems are misapplied and result in elevated indoor moisture levels. For instance, certain types of HVAC systems and equipment such as fancoil units, unit ventilators, and packaged terminal air conditioners are not necessarily designed to handle large latent loads sufficient to overcome deficiencies in building envelope design or those that are associated with high ventilation demands. Their use should be thoroughly reviewed and may need to be supplemented with equipment designed to accommodate these latent loads.

Oversizing DX equipment is also a common contributor to elevated indoor humidity levels, as this will cause the equipment to cycle excessively under low-load conditions. This behavior will keep the evaporator coil from becoming cold enough for any length of time to do the latent cooling required to remove moisture from the air.

The General Services Administration (GSA) should be commended for taking a leadership role in setting the standard for IAQ with its manual *Facilities Standards for the Public Buildings Service* that was published in 2003. For instance, the GSA recommends limiting coils to 12 fins/in. and 8 rows for effective and efficient cleaning. Drain pans are not only to be adequately sloped but are to be constructed of stainless steel and are to be insulated.

On the subject of filters, the GSA requires 30% to 35% pre-filters and 85% final filters, which is based upon the older 1992 ASHRAE Standard 52.1, which measured dust arrestance. ASHRAE's newer Standard 52.2, issued in 1999, measures particle size efficiency and would equate to minimum efficiency reporting value (MERV) 8 for the prefilters and MERV 13 for the final filters. Although many engineers have been instituting these practices for years, it is good to see these standards incorporated into a widely used design manual.

The GSA is also taking the initiative by requiring UV light to be "incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer." Although the control of airborne microbes is mentioned in this standard, it is believed that the primary purpose here is to keep coils and drain pans clean. There are more complex applications of UV equipment where the purpose is to kill airborne biological agents passing through the airstream. This type of application may require additional research to back up the benefits before this practice can be widely applied.

Not only is it important for the HVAC system to dry the air prior to its delivery to the space, but it must also work to dry out the building envelope during warm, humid periods by keeping the building under positive pressure especially in the summer months. Some HVAC systems can work in a detrimental manner by pulling in this moist air where it can condense inside wall cavities. Fancoils concealed in soffits and AHUs utilizing mechanical rooms and ceiling plenums as return air paths can cause portions of the building envelope to operate at pressures less than those of the outdoors.

Another common problem are exhaust fans that run during unoccupied periods when the other HVAC systems are shut off, causing them to play catch-up with the latent load early the next morning.

One way to avoid these types of problems is to provide a DOAS that dehumidifies the ventilation air and works to keep the building positively pressurized by moving dry air through the building cavities from indoors to the outdoors. The GSA now requires that air-handling systems be designed to ensure continuous positive pressure in the building with respect to the outdoors until the outdoor temperature falls below 40°. At this time, the building is specified to be neutral pressure with respect to the outdoors. Mechanical concepts developed to carry out this requirement include DOAS for both perimeter and interior zones that are sized to meet the ventilation requirements of these respective zones.

CONSTRUCTION MOISTURE

The construction process itself can often be the culprit in the cause of mold growth, since a building can be open to the elements for long periods of time allowing snow and rain to saturate construction materials. Even after the building is closed in, activities such as concrete curing, wallboard finishing, and painting liberate significant quantities of moisture. This moisture needs to be removed to prevent mold growth. Certainly, closing the building up as soon as practical is important, but also keeping it closed by utilizing temporary construction doors is wise.

Occasionally, there will be a push to get the building's HVAC system operating before interior work starts with the thought that temporary heating and cooling can be economically provided in this manner. It is also hoped that the cooling function will help to dry out building materials and speed the construction process. This strategy should be discouraged as construction dust and dirt can foul the ductwork and equipment and eventually serve as a potential food source for mold.

Additionally, the HVAC systems are typically not suited for reducing

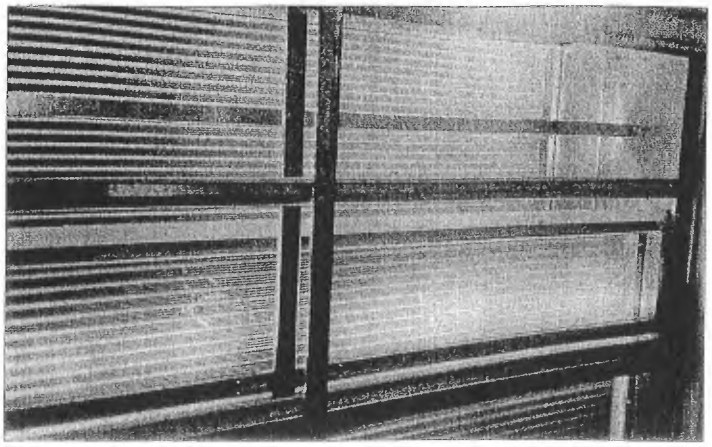

FIGURE 2. UV light in AHU applications can be used to control biological growth on cooling coils. (Photo courtesy of Steril-Aire.)

the large amounts of moisture that can accumulate during the course of construction. A better approach is to use construction drying equipment that is specifically designed for this purpose. This equipment uses a desiccant dehumidification process that relies on natural gas or propane heating for the reactivation of the desiccant wheel. A construction drying contractor would provide the required equipment and technicians who would monitor moisture content of building materials and move the equipment around as required to "chase" the moisture. This approach can keep a project schedule on track by increasing the drying rate of construction materials.

MOLD REMEDIATION

What do you do if you come across a facility that has a mold problem? First, you need a plan that not only assesses the size of the mold and moisture problem, but also identifies the source of the water and moisture. Without discovering and subsequently solving the water problem, the mold will likely reappear shortly after the remediation attempt.

Equally important is that care be taken not to disturb the discovered mold before appropriate containment precautions are in place. For instance, moldy wallboard may have 1 to 10 million spores per square inch and inappropriate investigative techniques could liberate them to spread throughout the facility. Mold covered items should not be touched with bare hands and it is not good to get spores in the eyes or breathe them.

Consequently, it is important to wear personal protective equipment (PPE) when disturbing mold. PPE can range from the minimum requirements of gloves, goggles, and N-95 mask to the maximum, which includes disposable full body clothing, foot coverings, and full-face respirator with HEPA filter.

Water damage needs to be addressed immediately, as items such as carpet and backing need to be dried within 24 to 48 hours to be successful in preventing mold growth. Removing water with an extraction vacuum along with the use of fans and dehumidifiers helps to accelerate the drying process. Ceiling tiles and insulation that are wet should be discarded. Replaceable books and paper items should also be thrown away. If valuable, they can be photocopied before discarding or they can be dried in a frost-free freezer or meat locker. Water-damaged wallboard can be dried in place if there are no obvious signs of swelling and if the seams are intact; otherwise, discard and replace. It is also suggested that the wall cavity be ventilated if possible to facilitate drying. Hard surfaces can be vacuumed and damp wiped with a mild detergent.

A limited containment enclosure is recommended when there are between 10 and 100 sq ft of mold contaminated surfaces. Beyond this, full containment is recommended. Limited containment consists of polyethylene sheeting from the floor to the ceiling with a slit entry and covering flap. The supply and return vents would be sealed off, and negative pressure would be applied through a HEPA-filtered fan system. Full containment differs in that two layers of fire-retardant polyethylene sheeting are used, a an air lock chamber is created for the entry.

Class	Permeability	Example
I	0.1 perm or less	Polyethylene sheeting
II	Between 0.1 and 1.0 perm	Kraft-faced fiberglass batt insulation
III	Between 1.0 and 10 perm	Gypsum board with one coat of latex paint

TABLE 1. Classification of vapor retarders.

CONCLUSION

Moisture in commercial facilities can cause damage to building mat rials and foster the growth of mold. Mold, in turn, can cause adve health conditions and trigger litigation. Attention to current thinki with regard to building envelope and mechanical system design can g long way in limiting exposure to the problems associated with mold a moisture in buildings. ES

Schultz is chief mechanical engineer with URS Corporation in their Columbus, OH office. He is a graduate of The Ohio State University with a BSME and has 17 years of experience designing mechanical systems for hospitals, laboratories, prisons, data centers, and large office complexes. In addition, he has extensive design experience with central steam, high temperature hot water, and chilled water plants. He has earned two Technical Excellence Awards during his tenure at URS Corporation. He is a registered professional engineer in over a dozen states and is the author of many technical articles related to HVAC and plumbing system design. Contact him at **carl_schultz@urscorp.com.**

URS is a global leader in engineering and architectural services with over 300 offic worldwide. Professional staff includes planners, engineers, architects, scientists, ar construction managers. URS provides technical solutions in numerous sectors suc as facilities, air and surface transportation, water, wastewater, industrial, and env ronmental. The diverse facilities practice encompasses health care, aviation, educa tion, and government. For more information, visit the company website www.urscorp.com.

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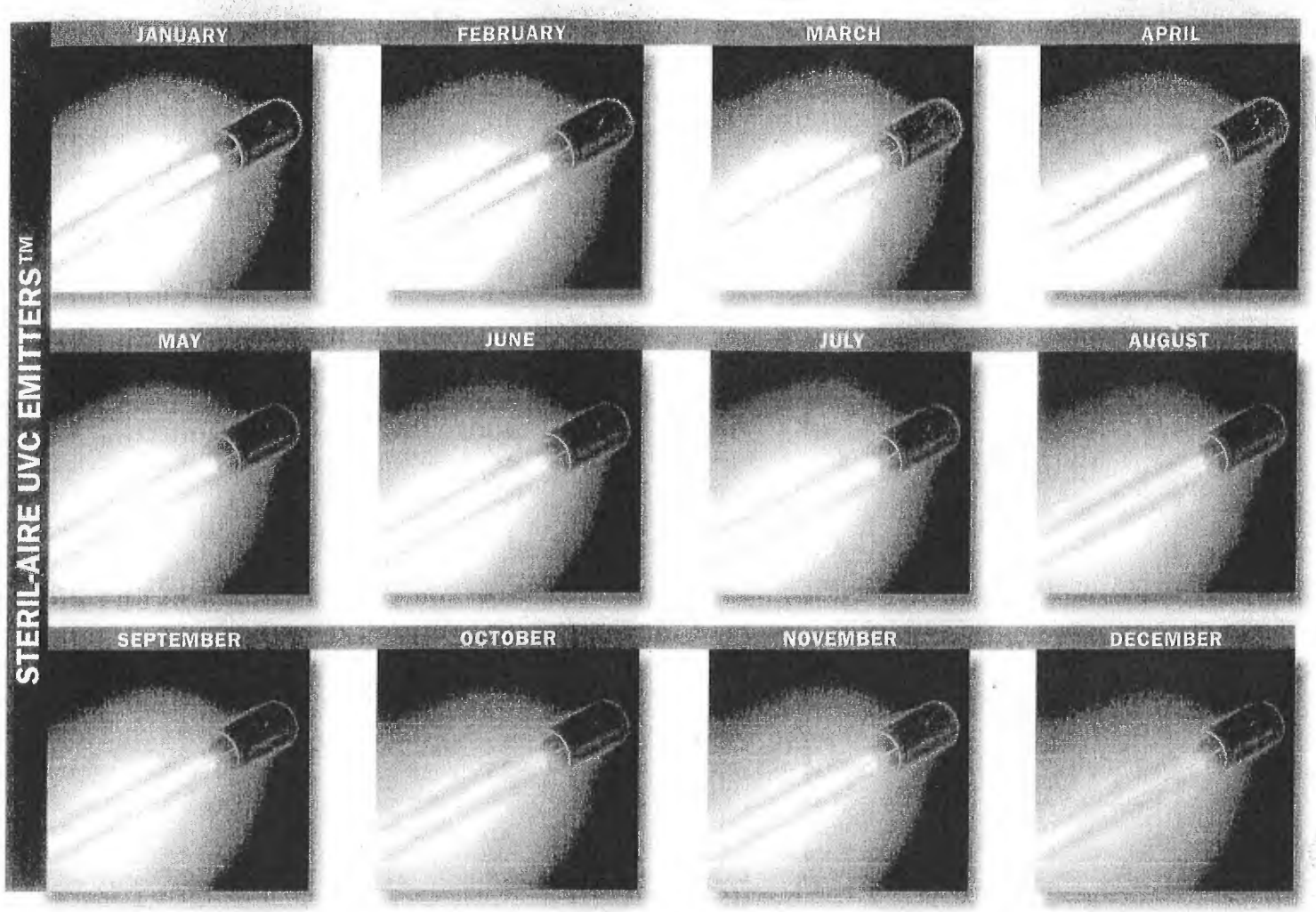
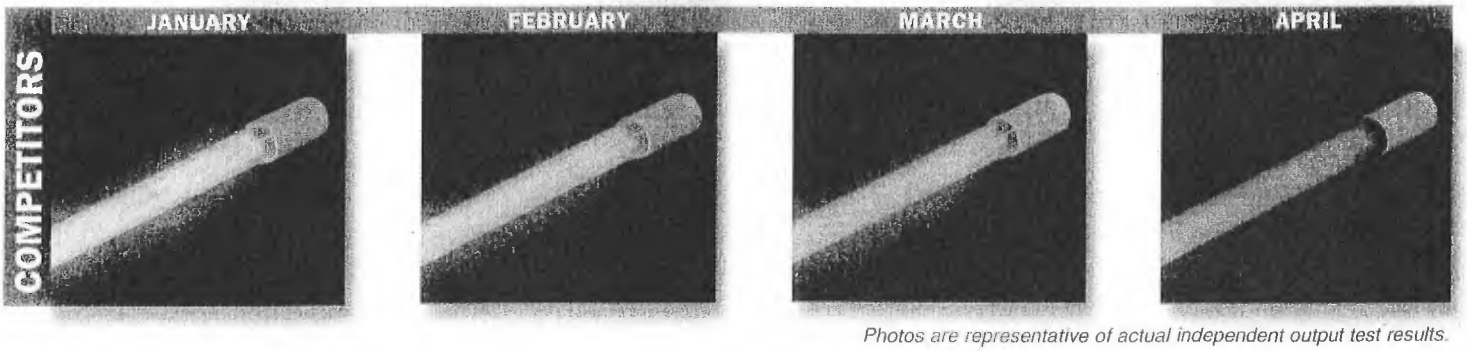


And some go dark around Easter.



Photos are representative of actual independent output test results.

When you use UVC light to control mold and microbes, output is all-important. Higher output equals better "killing power" over a longer time.

Steril-Aire's multi-patented UVC Emitter™ has been independently tested to deliver an average of 5 times the output of other UVC devices under HVAC conditions. Even in December, it glows brighter and has greater UVC output than the competition did last January! Only Steril-Aire can ensure the UVC performance you need and deserve, for 3–4 times longer than the others. Contact us today for details.

STERIL AIRE

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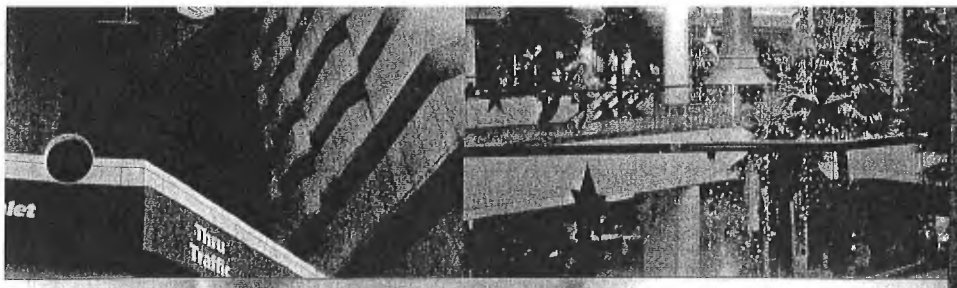


STERIL-AIRE

UV Systems

For microbial control, enhanced IAQ and energy savings

Product Catalog

UVC FOR HVAC™: PROTECTING INDOOR ENVIRONMENTS WHILE REDUCING COSTS.

The air conditioning (A/C) coils in our buildings and homes provide cool, moist gardens for the propagation of mold and other microorganisms. These organisms multiply "24/7" to huge concentrations, creating a hidden biofilm of mold deep inside the HVAC system. These microbial contaminants travel from the coil through the airstreams, accounting for much of the illness and discomfort in buildings today and causing many of the maintenance and operational problems.

There *is* an effective solution to this problem: multi-patented UVC Emitters™ from Steril-Aire, the company that developed "UVC for HVAC". These devices use germicidal ultraviolet-C ("UVC") energy to eradicate both surface and airborne mold, as well as viruses and bacteria. The "C" wavelength of the UV spectrum targets the DNA of microorganisms, causing cell death or making replication impossible.

UVC lights have been used for decades in both air and water purification, but conventional devices do not function effectively under HVAC conditions. The UVC Emitter, pioneered by Steril-Aire in the 1990s for IAQ control, is designed to produce very high output in cold and moving air. It provides safe, continuous cleaning while actually saving money by reducing maintenance and energy requirements.

Four-Year Cost-Saving Example

UVC Installation	Before		After	
CFM – measured or selected (VAV)	7,000		8,000	
Entering air temperature – dry bulb °F	78.0		80.0	
Entering air temperature – wet bulb °F	67.0		67.0	
Leaving air temperature – dry bulb °F	61.0		60.0	
Leaving air temperature – web bulb °F	59.0		56.0	
Total cooling capacity – Btuh	183,960		280,080	
Sensible heat – Btuh	128,520		172,800	
Latent heat – Btuh	55,440		107,280	
Net cooling capacity gain – Btuh	→	96,120		
Pressure drop "across coil"	0.7" WG		0.5" WG	
Pressure drop reduction	0.2" WG			
Pressure drop BHP reduction	0.420		EER: 6.0	
Annual operating hours	3,400			
Energy cost per kWh	$0.08		EER: 8.1	
Annual improvement (kWh cost)	$4,510		After	
Annual coil & drain pan maintenance	$800			
Total annual improvement	$5,310			
Installation/operating costs (4 fixtures)	1st Year	2nd Year	3rd Year	4th Year
Average fixture cost each	450.00			
Installation & energy costs	509.54	209.54	209.54	209.54
Total Emitter replacement cost		340.00	340.00	340.00
Total installed & operating cost	$2,309.54	$549.54	$549.54	$549.54
Annual improvement (less costs)	$3,001	$4,761	$4,761	$4,761
Estimated return (years)	0.435			
Cumulative improvement	$3,001	$7,762	$12,523	$17,283

A Steril-Aire UVC installation offers the most rapid payback in the industry. A typical installation can pay for itself in a few months and save thousands of dollars thereafter in energy and maintenance costs.

Benefits of using UVC

- Kills or inactivates surface and airborne microorganisms that trigger allergy-asthma symptoms — including mold and mold spores, solvents and other VOCs. Also eliminates associated odors.
- Prevents the spread of infectious diseases caused by bacteria (including *TB, Legionella, E. coli, and whooping cough*) and viruses (including *colds, flu, measles, German measles, chicken pox, small pox and SARS*).
- Continuously cleans coils, drain pans, plenums and ducts, reducing or eliminating costly cleaning programs and the use of harmful chemicals and disinfectants.
- Lowers HVAC energy costs by improving heat transfer and increasing net cooling capacity.
- Improves general IAQ for better productivity and less absenteeism.
- Produces no ozone or secondary contaminants — will not harm building occupants, equipment or furnishings.
- Improves product quality, shelf life and yield in processing plants.
- Rapidly pays for itself in maintenance and energy savings.

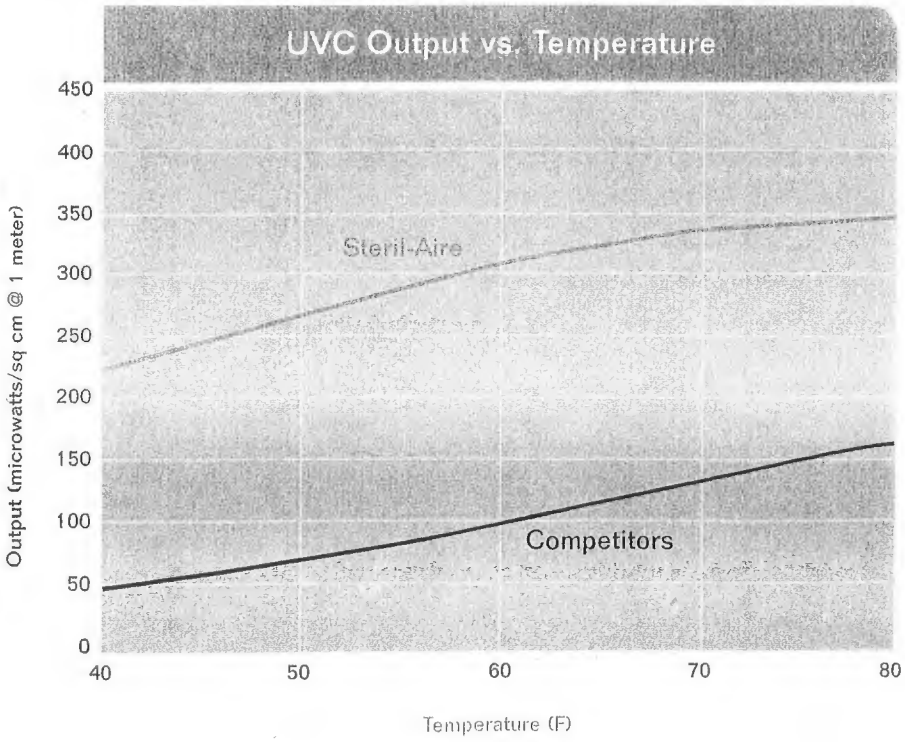
THE UVC EMITTER : THE BEST PROTECTION AVAILABLE... WITH THE LONGEST SERVICE LIFE.

Steril-Aire devices work better and last longer: The service life and germicidal effectiveness of UVC devices relate directly to how much output or intensity they deliver. There are many UVC products on the market today that claim to work just like Steril-Aire. But in truth, their performance claims are derived from tests conducted at 90° F still air rather than 45° F moving air. Buyer beware: In cold/moving air, output of these competitive lights is much lower than the advertised output at 90° F.

Independent testing proves that UVC Emitter output is significantly higher than the competition at all temperatures, especially under real-life HVAC operating conditions. Only Steril-Aire delivers:

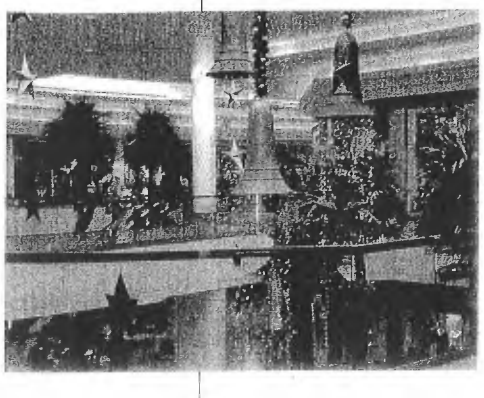
- *3-4 times longer life:* UVC lights lose up to half their output over a year. Competitive UVC devices must be changed every 3-4 months because they quickly lose the output needed to maintain microbial control. The UVC Emitter, by contrast, has a 12-month service life — and even after a full year, it has 2-3 times greater output than competitive devices deliver on Day 1! As a result, only Steril-Aire can ensure the germicidal performance you need, with no return of microbial growth, for 3-4 times longer than the competition.
- *Independently verified output:* Tested in accordance with the general provisions of the Illuminating Engineering Society's 1981 Applications Volume.
- *A patented state-of-the-art solid state electronic power supply* for enhanced reliability and performance.
- *High performance construction*, including stainless steel housings with high spectral aluminum reflectors, and thick-wall quartz tubes.
- *Many sizes and configurations* to fit the widest range of applications — externally mounted, internally mounted, and portable.
- *Complete technical and engineering support* with in-house expertise in both HVAC technology and microbiology.
- *Lowest life-cycle cost* of any UVC product.

Steril-Aire vs. Other UVC Products: Output Comparison



Steril-Aire's multi-patented UVC Emitter™ provides the best and longest-lasting UVC performance available. As shown in the comparison graph, it has been independently tested to deliver an average of 5 times the output of other ultraviolet devices under HVAC operating conditions (45° F @ 550 fpm air velocity).

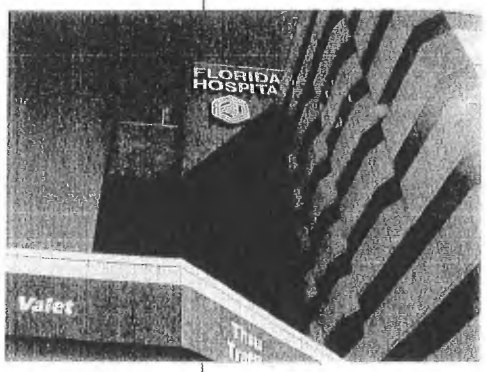
APPLICATIONS FOR UVC EMITTERS



Commercial Buildings

- Offices, government buildings, retail stores and malls, hotels, casinos, museums.
- Users report HVAC energy savings up to 25-30%, plus improved IAQ and reduced maintenance.
- Key products: DE Series, SE and SEN Series, Fan Coil UVC Kit.

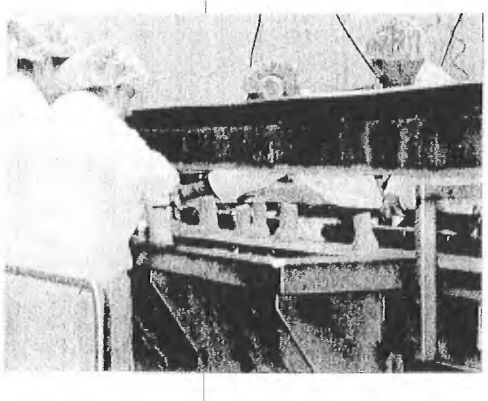
> We have eliminated our four-times-per-year coil cleaning program, and we no longer expose our maintenance people to chemicals required for this task.... By bathing our coils in UVC lights, we've also experienced a big power consumption reduction. We estimate a conservative 28% drop in total A/C system energy usage.
>
> — *American Electric Power, Dallas, Texas*



Health Care Facilities

- Hospitals and medical offices, hospices, clinics, laboratories.
- May be used for infection control or general IAQ, operational and energy savings.
- Key products: DE Series, SE and SEN Series, Fan Coil UVC Kit, SterilWand™.

> Our experiences have shown us repeatedly that UVC enhances indoor air quality and infection control, while saving on maintenance labor, materials and downtime. The substantial energy savings achieved have been a great bonus. Since our administrators now have a high confidence level in the effectiveness of UVC lights, we will continue to equip both new and existing air handling units with the devices.
>
> — *Florida Hospital, Orlando, Florida (shown in photo)*



Food and Beverage Industry

- Conveying lines, packaging containers, filling stations, cooling and drying areas, HVAC and refrigeration systems, storage rooms.
- Enhances food safety through control of mold, bacteria and viruses.
- Extends shelf life and improves production yields.
- Key products: DE, SE and SEN Series, SterilWand (all available with optional shatter-resistant tubes)

> To reduce mold counts in the room where we process butternut squash, we pressurized the space and installed Steril-Aire UVC lights. We've had a tenfold reduction in mold counts, our air quality has improved and our shelf life has increased dramatically as a result.
>
> — *Martin and Sons Farms Inc., Brockport, New York (shown in photo)*

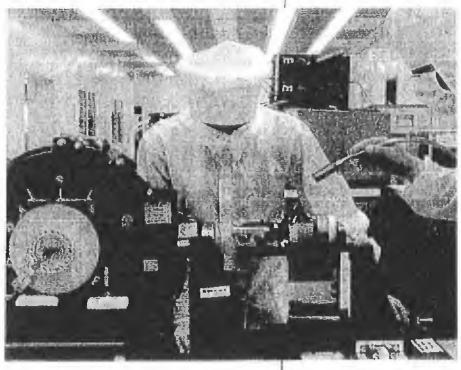
Schools and Institutions

- Classrooms, libraries, meeting rooms, auditoriums, gyms, offices.
- Stops mold problems.
- Prevents the spread of childhood diseases — reduces illness and absenteeism.
- Key products: Unit Ventilator UVC Kit, DE Series, SE and SEN Series, Fan Coil UVC Kit, SterilWand.

This winter has been an especially bad flu season for Southern California. I can say very confidently that our students and teachers have had some colds, but not the humdinger fevers and flus that other schools in our area have experienced. Since adopting the lights in the summer of 2002, we report an estimated 20% drop in absenteeism among students and a 50% drop among teachers.

— *Crescent Avenue Christian Preschool, Buena Park, California (shown in photo)*

Industrial Buildings



- Chemical, electronic, food, pharmaceutical, biotech and general manufacturing plants.
- Controls microbes that can contaminate sensitive products and processes.
- Provides dramatic energy/operational savings in cleanroom and HVAC applications through continuous cleaning of coils.
- Key products: DE Series, SE and SEN series, SterilWand.

Maintaining temperature and RH at proper levels is vitally important in the pharmaceutical industry, so HVAC equipment must be maintained at peak performance. But the chemicals used to clean coils and restore heat exchange efficiency can contaminate the manufacturing process. The use of UVC at the cooling coils provides a less costly, non-chemical solution and also helps to extend the life of our HEPA filters.

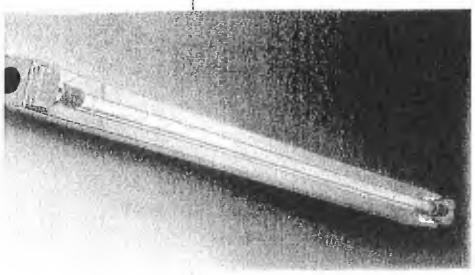
— *Pharmaceutical plant, Northeastern U.S.*

Residences

- Houses and multi-family dwellings.
- Relieves allergy and asthma symptoms through continuous mold control.
- Prevents the spread of colds, flu and other ailments.
- Key products: SteriLight™ I and II.

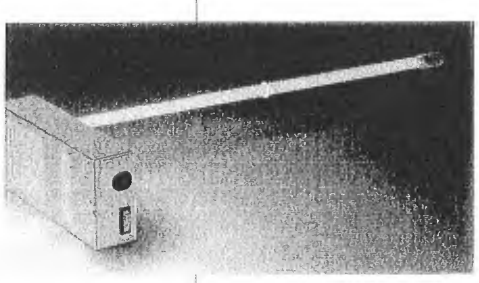
I couldn't stop coughing, I couldn't sleep at night.... Within just a couple of days [after installing SteriLight], I noticed a dramatic difference in the house. My symptoms began to ease up. As the days went by, I continued to get better and better.

— *B. Oblath, Southern California homeowner*



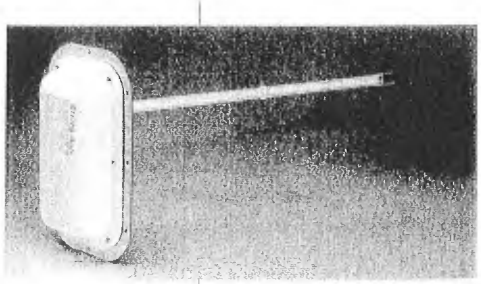
DE Series UVC Emitters

- For medium to large systems in commercial, industrial, health care and institutional buildings.
- Double-ended (DE) units are assembled end-to-end and mounted internally.
- Five sizes (18", 24", 30", 36" and 42") fit any coil width.
- Four voltage options: 115-208/230 or 277 Vac.
- The most widely used product for commercial "UVC for HVAC" — the industry standard!



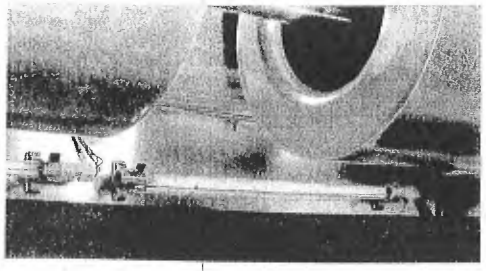
SE Series UVC Emitters

- For non-residential systems that cannot be accessed internally — fan coils, heat pumps, unit ventilators, packaged air handlers, terminal units and ductwork.
- Single-ended (SE) units are installed from the exterior and through the wall of HVAC equipment. Servicing is exterior.
- Available with six tube lengths (16", 20", 24", 30", 36" and 42").
- Four voltage options: 115-208/230 or 277 Vac.



SEN Series UVC Emitters

- For non-residential rooftop and outdoor air handlers, ductwork and other difficult-to-access sites.
- Combines the external-mounted, single-ended design of the SE Series with a NEMA 4x fixture.
- Available with six tube lengths (16", 20", 24", 30", 36" and 42").
- Four voltage options: 115-208/230 or 277 Vac.



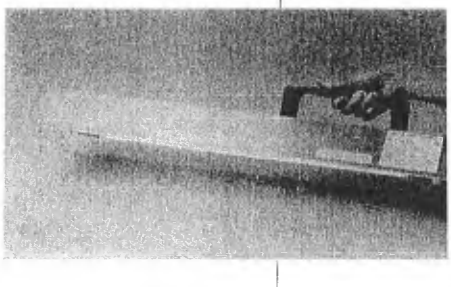
Unit Ventilator UVC Kit

- For use with all major brands of classroom unit ventilators.
- Each kit contains one UVC Emitter and all necessary installation components.
- Two to six kits typically required to serve a unit ventilator.
- Space-saving design features quick and easy snap-in installation.
- Four voltage options: 115-208/230 or 277 Vac.

Fan Coil UVC Kit

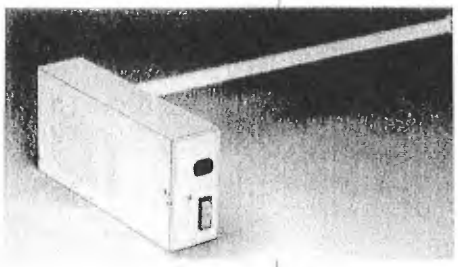
- For use with fan coils, split package systems and other room units.
- Brings enhanced IAQ to hotel rooms, dormitories, offices, patient rooms and classrooms.
- Contains one UVC Emitter and all the necessary components to retrofit a fan coil with UVC.
- Space-saving design features quick and easy snap-in installation.
- Available with six tube lengths (16", 20", 24", 30", 36" and 42") .
- Four voltage options: 115-208/230 or 277 Vac.

SterilWand™



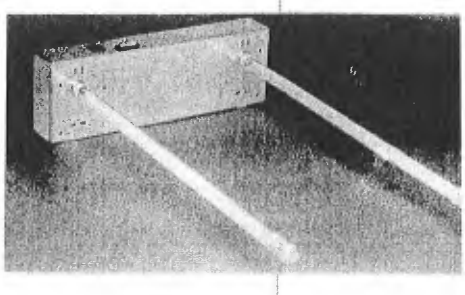
- For surface decontamination in labs, hospitals, processing areas, schools, libraries and homes.
- Hand-held device may be passed over tabletops, walls and other surfaces infested with mold, bacteria or viruses. Safety shield prevents direct exposure to UVC energy.
- Ideal for use as a mold remediation tool.

SteriLight™ I



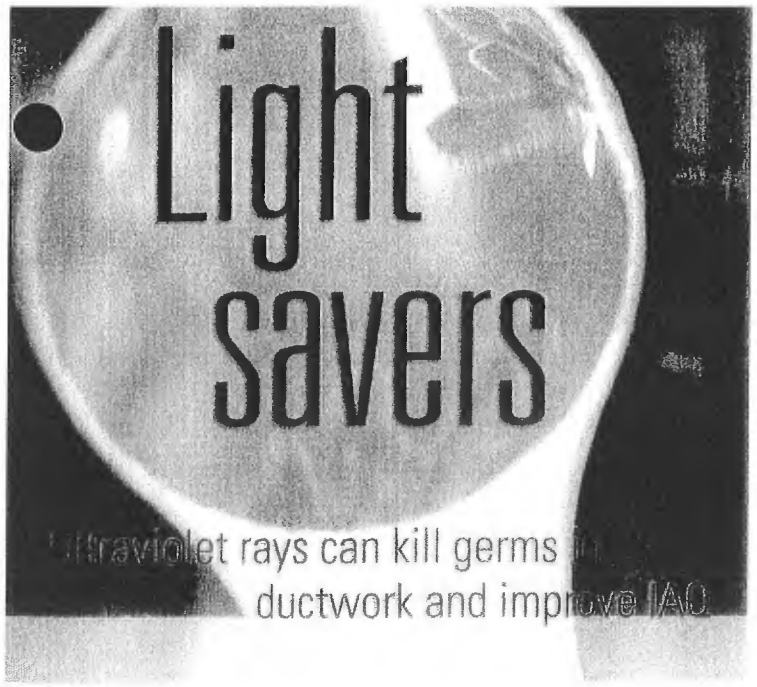
- For residential and light commercial applications.
- Single-tube device installs quickly and easily from the exterior of the coil box. Designed for use with "N" and "W" style, low-profile flat and counter-flow "A" coils.
- Offered in three tube lengths (16", 20" and 24").
- Three voltage options: 115, 208, or 230 Vac.

SteriLight™ II



- For residential and light commercial applications.
- Double-tube device installs quickly and easily from the exterior of the coil box. Designed for use with conventional "A" style, flat and slant coils.
- Offered in three tube lengths (16", 20" and 24") and configurations of 10" or 14" centerlines.

Three voltage options: 115, 208, or 230 Vac.



Light savers

Ultraviolet rays can kill germs in ductwork and improve IAQ

In 2002, the U.S. Environmental Protection Agency warned about using disinfectants, sanitizers and other types of germ killers for HVAC duct cleaning. Since then, many contractors have been searching for safe, yet effective, alternatives.

One popular solution involves the use of ultraviolet C-band energy, commonly called UVC lights. When they shine on surfaces, these lights destroy mold, viruses, bacteria and other contaminants that collect there. They vaporize the organisms, effectively removing them from the air.

The same type of lighting used in HVAC systems to improve indoor air quality and control infectious diseases is sometimes used as an alternative to conventional duct-cleaning methods. UVC lights offer contractors an effective, nonpolluting and permanent way to clean ductwork of microbial contamination.

For best results, it is important to select a UVC device engineered to deliver high output in HVAC systems. It should provide output of at least 10 microwatts per square centimeter at 1 meter, in a 400 feet-per-minute 45°F airstream.

In most cases, direct cleansing of the ductwork by UVC light is not needed. A more effective approach is to go to the source of the problem: the air-conditioning coils. That's what officials at Orlando, Fla.-based Florida Hospital discovered.

Hospital discoveries

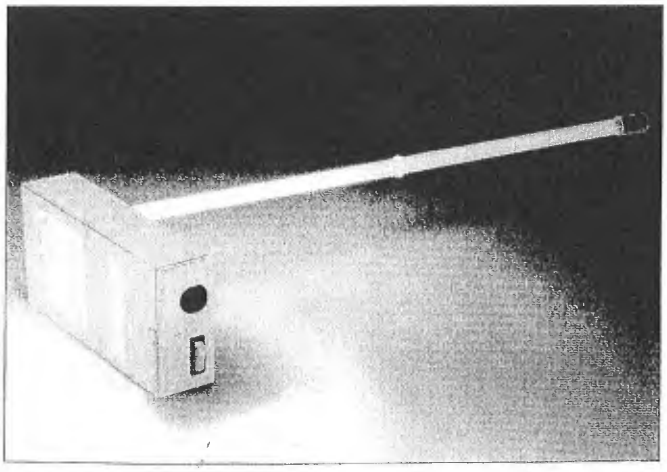
"Since installing UVC in the air handlers, we have observed that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves," said Firouz Keikavousi, a mechanical engineer in charge of facilities maintenance at the hospital.

"This phenomenon occurs because the coil — not the ductwork — is the source of mold growth in the system," he added. "Fresh inoculation coming off the coil typically migrates downstream and some of it settles in the ductwork — a process that is self-perpetuating.

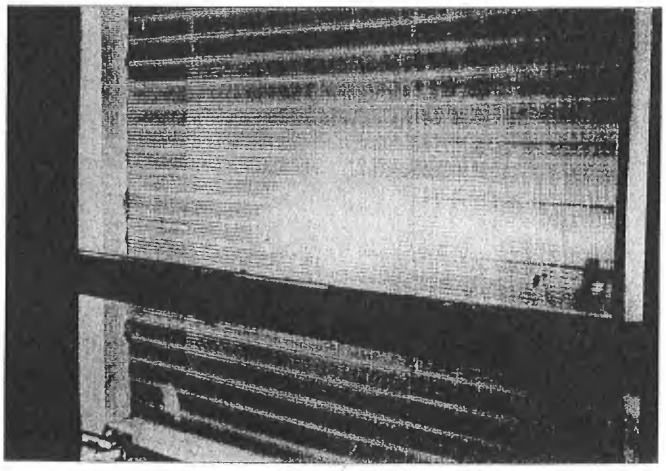
"But when UVC energy is used to destroy mold and microbial growth at the coil, the food source is eliminated and the chain is broken. As a result, the contamination that has already built up on duct surfaces will eventually decay away, a process that may take months".

However, there were times when UVC alone would not clean the ducts completely, Keikavousi said.

"Where duct surfaces are badly contaminated, it isn't always possible to wait for the effects of UVC. Therefore, in those areas where buildup was particularly heavy, we performed duct cleaning as a precaution prior to installing UVC lights," he said. "We have not experienced any recurrence of duct contamination since adopting UVC, nor do we anticipate any future duct-cleaning requirements."



This UVC device is designed for installation in ductwork. A small penetration is made into the duct wall and the UVC lamp or tube is inserted across the width of the duct. The power supply remains external. Photo courtesy of Steril-Aire Inc.



This photo shows an air-conditioning coil at Florida Hospital in Orlando, Fla., treated with high-output UVC light. Since installing them in the air handlers, the hospital has found that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves. Photo courtesy of Florida Hospital.

The ductwork from a large commercial building is contaminated with white, green and black mold. Photo courtesy of Steril-Aire Inc.

Keikavousi expects the use of the lights will save the hospital thousands of dollars in future cleaning costs.

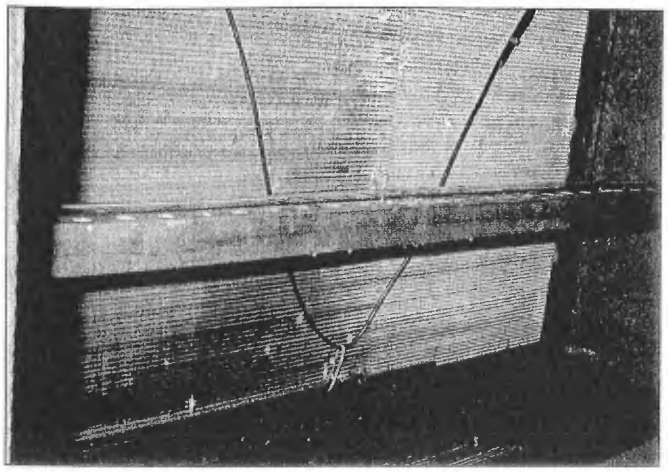
Installation tips

Experts say UVC lights should typically be installed downstream of and facing the coil, or on the return-air side, if installing it downstream is too difficult. This method allows coil surfaces to be continuously bathed in germicidal light, killing the microorganisms that grow and multiply there, not only on the visible part of the fins, but also on the surfaces within the coil, where the greatest amount of mold activity occurs.

The coil's total surface area may be three to five times that of the ductwork, but contamination on the coil tends to be less visible. When you inspect the inside of a duct and it looks moldy, many people become alarmed, not realizing that the coil is the real culprit. There is much evidence that infestation in ductwork, while it may look scary, is not a major contributor to IAQ problems. The movement of air along interior duct walls is actually very slight, so the amount of contamination coming off the ducts and into the occupied space is not usually significant.

"Since installing UVC in the air handlers, we have observed that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves," said Firouz Keikavousi, a mechanical engineer in charge of facilities maintenance at Florida Hospital.

Where duct surfaces are heavily infested, a one-time cleaning may be deemed necessary, as Florida Hospital found. Another nonchemical approach is to install supplemental UVC lights in the ductwork. Remember: If you irradiate the ducts without irradiating the coil, you are treating the symptoms and not the disease.



The right side of this air-conditioning coil has been irradiated with high-output UVC light. After a few days, the treated side of the coil is clean and nearly free of mold. Left untreated, mold originating in the coil can migrate downstream and settle in ductwork. Photo courtesy of Steril-Aire Inc.

A typical installation requires making a 1-inch penetration into the duct wall and running the light across the width of the duct. The UVC energy rapidly "cooks off" mold and other microbes, leaving ductwork free of organic buildup, with no other surface cleaning necessary.

Selection criteria

When selecting UVC lights for coil - and duct-cleaning applications, make sure the UVC-energy output is at the recommended level. For duct-cleaning applications, select a design where only the lamp or "tube" will penetrate into the ductwork and the power supply will be external. This will ensure minimum intrusion into the ductwork. The tube should ideally be long enough to extend across the width of the duct.

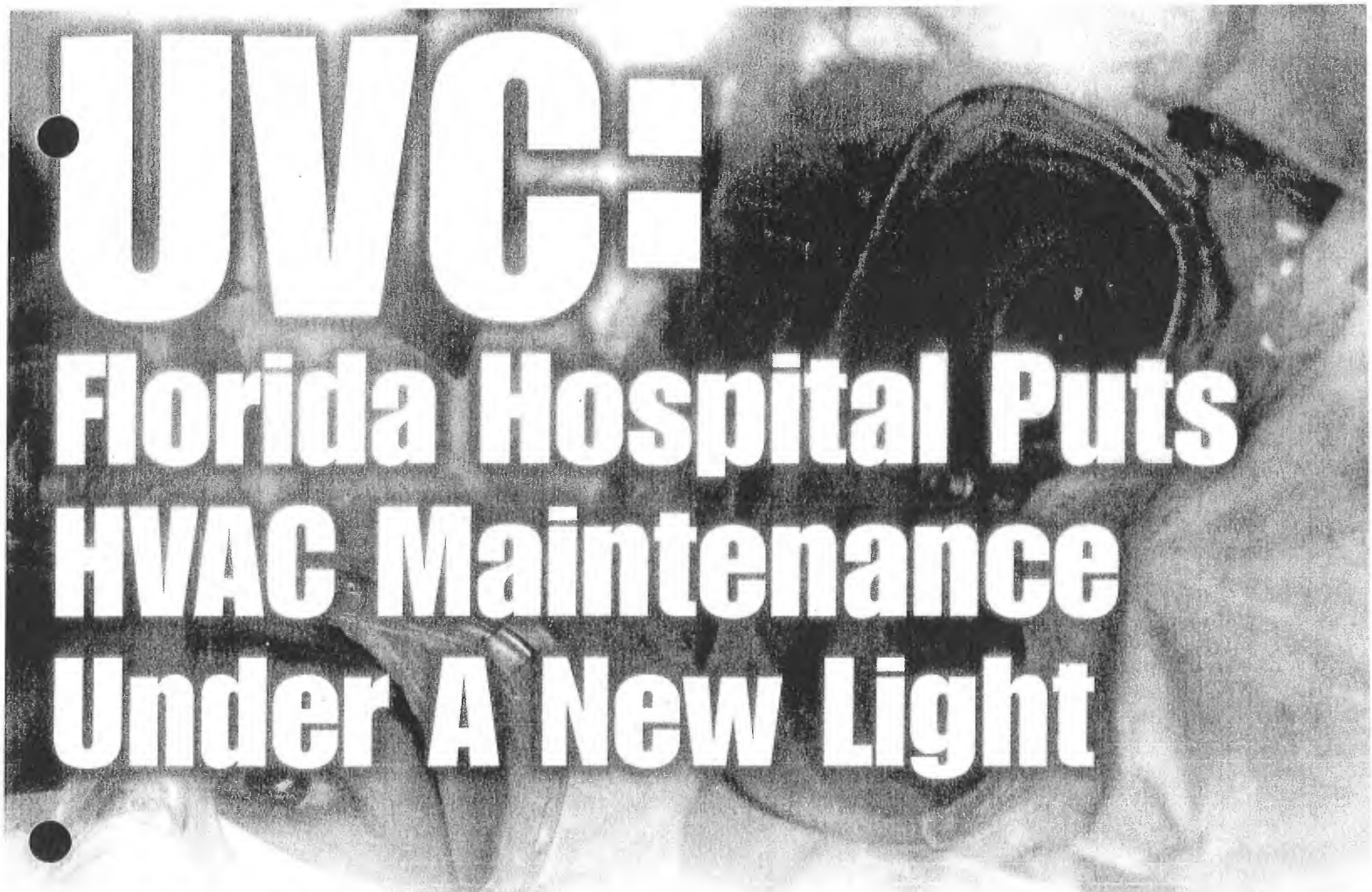
UVC devices provide line-of-sight irradiation only, with a typical effective range of about 10 feet in a ducted system. This range is related to lamp size and output, and may vary from manufacturer to manufacturer. Be sure to compare the total installed cost, which is more important than the number of lights needed.

When you install UVC to keep coils and ductwork clean, it is essentially a permanent fix: There is little to do except change the tubes about once a year, or when a radiometer indicates that the output has dropped below specified levels.

Buildings that use UVC devices report going for years without cleaning coils, ducts, drain pans or plenums. As a result, service crews and building occupants are no longer exposed to the potentially harmful chemicals associated with cleaning.

(This article was supplied by Steril-Aire Inc., a Burbank, Calif.-based manufacturer of IAQ products.)

Reprinted from March 2005 SNIPS, a BNP Media publication.



UVC: Florida Hospital Puts HVAC Maintenance Under A New Light

HVAC system downtime during coil cleaning can compromise humidity and temperature control, potentially leading to air quality or comfort problems. Florida Hospital has found that high-output ultraviolet-C lights installed in the AHUs reduce or eliminate coil-cleaning programs — yielding ongoing energy savings, a reduction in HVAC system maintenance, and the elimination of cleaning chemicals. The facility also reports IAQ and infection control benefits as the regimen continues.

BY FIROUZ KEIKAVOUSI

Florida Hospital's (FH) experience with ultraviolet-C (UVC) began in 1998 after seeing a presentation on the technology at an ASHRAE conference. A new generation of UVC devices promised to offer an improvement over the UV lights that were long ago popular for upper air disinfection in hospitals and other health care environments. Unlike the upper air devices, the newer UVC lights were engineered specifically to provide peak output under HVAC conditions. Output of these devices was reportedly so much higher than conventional UV tubes in cold and moving air that they could be installed just downstream of a cooling coil to eradicate bacteria, viruses, and mold.

Upon learning about the benefits of the new UVC fixtures, FH staff felt that the potential for the health care system was enormous. FH is an acute-care health system with more than 2,800 beds throughout Florida. With a network of 17 hospitals and 12 walk-in urgent care centers, FH treats more than a million patient visits per year and is the second busiest system in the country.

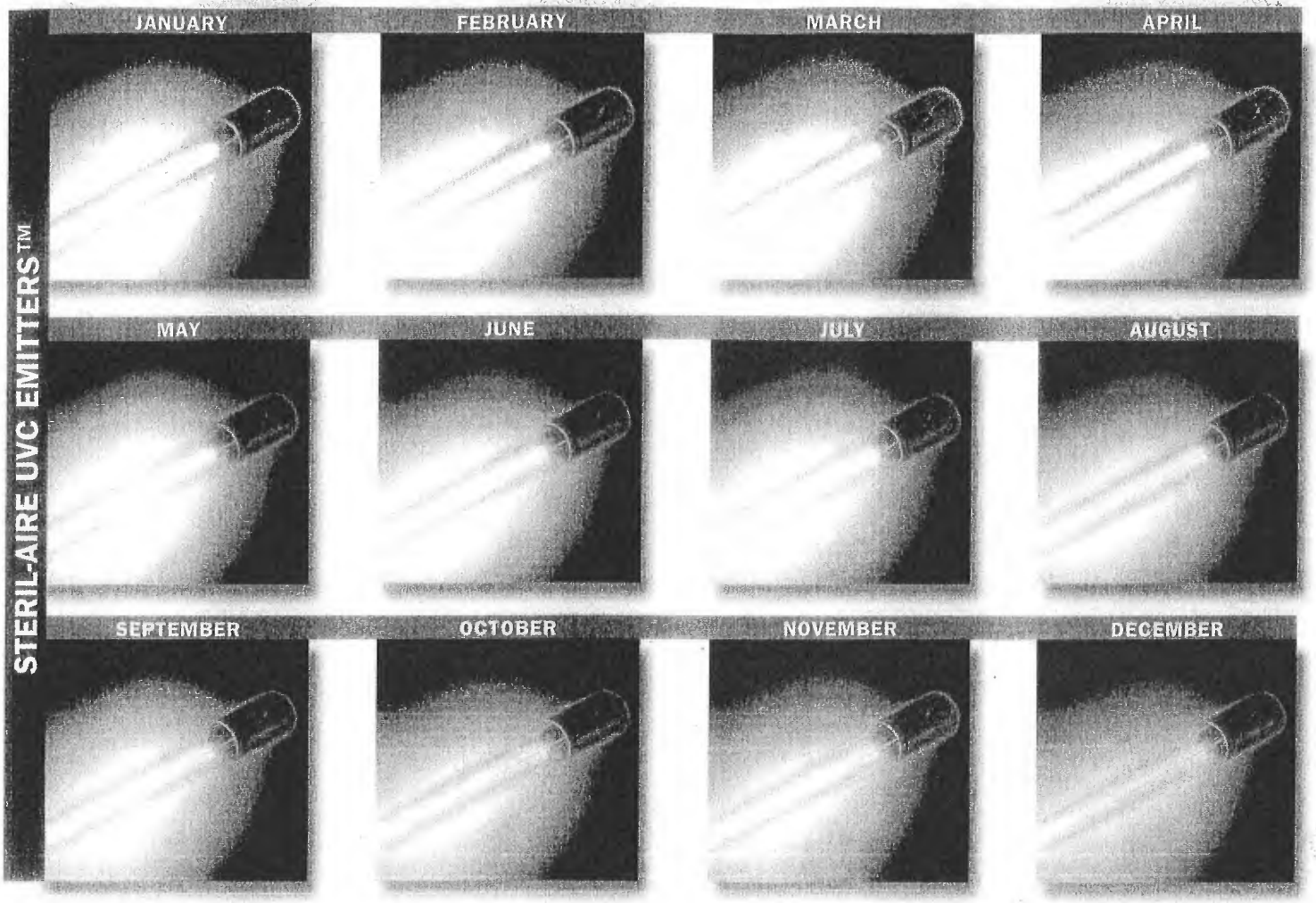
To test the efficacy of the UVC devices, we decided to install the lights in AHU #107, a 27-year-old, 6,000 cfm unit located at the main Orlando campus. A UVC Emitter™ manufactured by Steril-Aire, Inc., was specified for this and for subsequent installations. We selected AHU #107 because the coil and 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).

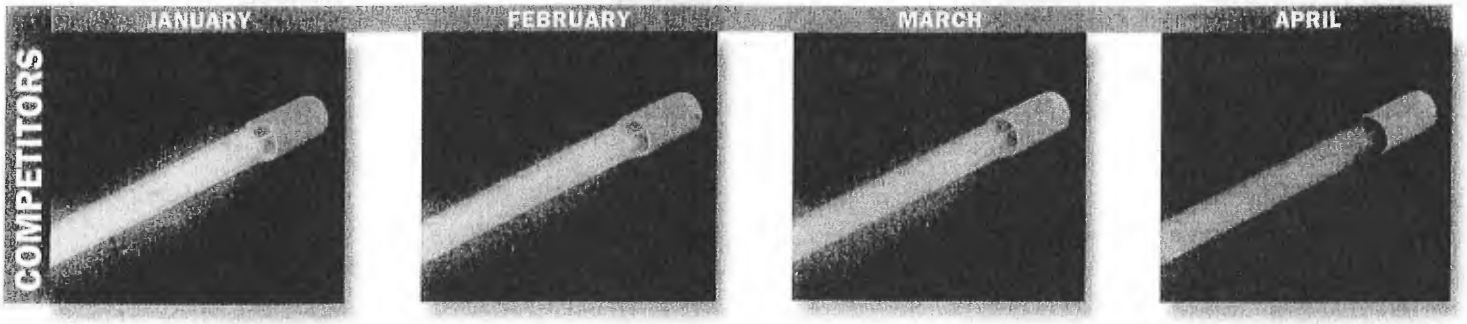
We calculated the increase in capacity to be 95,245 Btuh or approximately 7.9 tons of air conditioning. If we use 1 kW/ton and multiply by 24 (hours/day) by 365 (days/year) by $0.07 (our electric rate), we arrive at a total of $4,867 in savings for this one unit. The total installed cost of the UVC Emitters 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



And some go dark around Easter.



Photos are representative of actual independent output test results.

When you use UVC light to control mold and microbes, output is all-important. Higher output equals better "killing power" over a longer time.

Steril-Aire's multi-patented UVC Emitter™ has been independently tested to deliver an average of 5 times the output of other UVC devices under HVAC conditions. Even in December, it glows brighter and has greater UVC output than the competition did last January! Only Steril-Aire can ensure the UVC performance you need and deserve, for 3–4 times longer than the others. Contact us today for details.

STERIL AIRE

Steril-Aire, Inc.
Phone: 800-2STERIL or 818-565-1128
Fax: 818-565-1129
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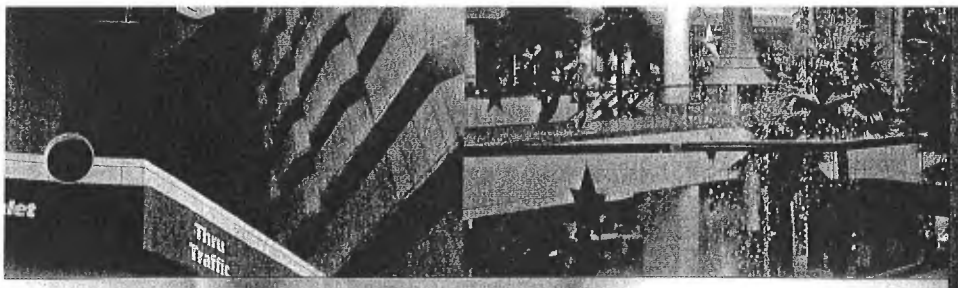


STERIL-AIRE

For microbial control, enhanced IAQ and energy savings

Products Catalog

UVC FOR HVAC™: PROTECTING INDOOR ENVIRONMENTS WHILE REDUCING COSTS.

The air conditioning (A/C) coils in our buildings and homes provide cool, moist gardens for the propagation of mold and other microorganisms. These organisms multiply "24/7" to huge concentrations, creating a hidden biofilm of mold deep inside the HVAC system. These microbial contaminants travel from the coil through the airstreams, accounting for much of the illness and discomfort in buildings today and causing many of the maintenance and operational problems.

There *is* an effective solution to this problem: multi-patented UVC Emitters™ from Steril-Aire, the company that developed "UVC for HVAC". These devices use germicidal ultraviolet-C ("UVC") energy to eradicate both surface and airborne mold, as well as viruses and bacteria. The "C" wavelength of the UV spectrum targets the DNA of microorganisms, causing cell death or making replication impossible.

UVC lights have been used for decades in both air and water purification, but conventional devices do not function effectively under HVAC conditions. The UVC Emitter, pioneered by Steril-Aire in the 1990s for IAQ control, is designed to produce very high output in cold and moving air. It provides safe, continuous cleaning while actually saving money by reducing maintenance and energy requirements.

Four-Year Cost-Saving Example

UVC Installation	Before		After	
CFM – measured or selected (VAV)	7,000		8,000	
Entering air temperature – dry bulb °F	78.0		80.0	
Entering air temperature – wet bulb °F	67.0		67.0	
Leaving air temperature – dry bulb °F	61.0		60.0	
Leaving air temperature – web bulb °F	59.0		56.0	
Total cooling capacity – Btuh	183,960		280,080	
Sensible heat – Btuh	128,520		172,800	
Latent heat – Btuh	55,440		107,280	
Net cooling capacity gain – Btuh	→	96,120		
Pressure drop "across coil"	0.7" WG		0.5" WG	
Pressure drop reduction	0.2" WG			
Pressure drop BHP reduction	0.420		EER: 6.0	
Annual operating hours	3,400			
Energy cost per kWh	$0.08		EER: 8.1	
Annual improvement (kWh cost)	$4,510		After	
Annual coil & drain pan maintenance	$800			
Total annual improvement	$5,310			
Installation/operating costs (4 fixtures)	1st Year	2nd Year	3rd Year	4th Year
Average fixture cost each	450.00			
Installation & energy costs	509.54	209.54	209.54	209.54
Total Emitter replacement cost		340.00	340.00	340.00
Total installed & operating cost	$2,309.54	$549.54	$549.54	$549.54
Annual improvement (less costs)	$3,001	$4,761	$4,761	$4,761
Estimated return (years)	0.435			
Cumulative improvement	$3,001	$7,762	$12,523	$17,283

A Steril-Aire UVC installation offers the most rapid payback in the industry. A typical installation can pay for itself in a few months and save thousands of dollars thereafter in energy and maintenance costs.

Benefits of using UVC

- Kills or inactivates surface and airborne microorganisms that trigger allergy-asthma symptoms — including mold and mold spores, solvents and other VOCs. Also eliminates associated odors.
- Prevents the spread of infectious diseases caused by bacteria (including *TB, Legionella, E. coli, and whooping cough*) and viruses (including *colds, flu, measles, German measles, chicken pox, small pox and SARS*).
- Continuously cleans coils, drain pans, plenums and ducts, reducing or eliminating costly cleaning programs and the use of harmful chemicals and disinfectants.
- Lowers HVAC energy costs by improving heat transfer and increasing net cooling capacity.
- Improves general IAQ for better productivity and less absenteeism.
- Produces no ozone or secondary contaminants — will not harm building occupants, equipment or furnishings.
- Improves product quality, shelf life and yield in processing plants.
- Rapidly pays for itself in maintenance and energy savings.

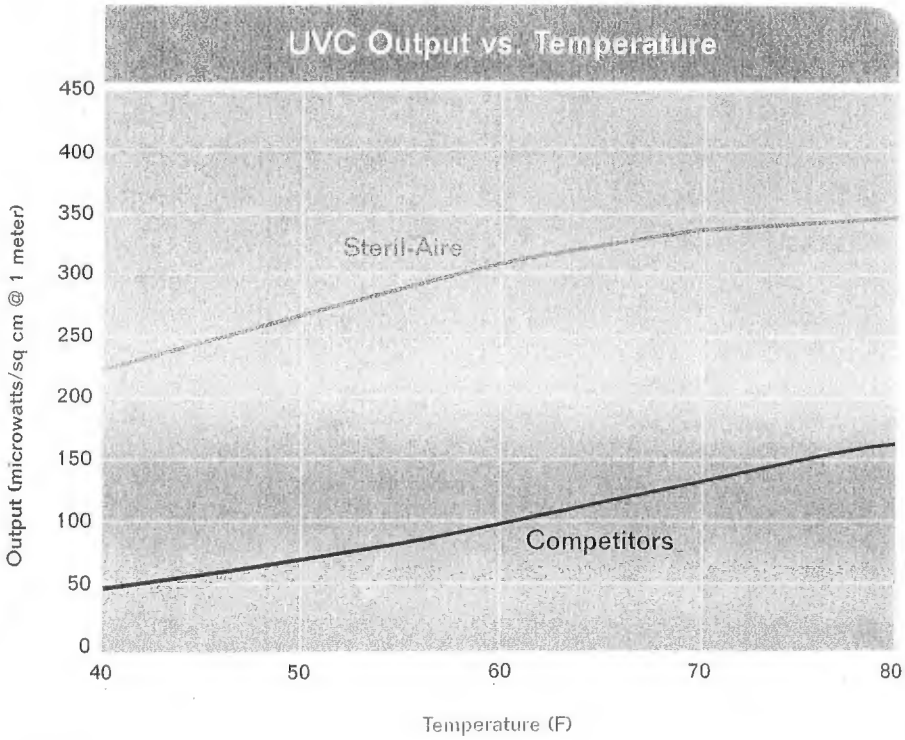
THE UVC EMITTER — THE BEST PROTECTION AVAILABLE... WITH THE LONGEST SERVICE LIFE.

Steril-Aire devices work better and last longer: The service life and germicidal effectiveness of UVC devices relate directly to how much output or intensity they deliver. There are many UVC products on the market today that claim to work just like Steril-Aire. But in truth, their performance claims are derived from tests conducted at 90° F still air rather than 45° F moving air. Buyer beware: In cold/moving air, output of these competitive lights is much lower than the advertised output at 90° F.

Independent testing proves that UVC Emitter output is significantly higher than the competition at all temperatures, especially under real-life HVAC operating conditions. Only Steril-Aire delivers:

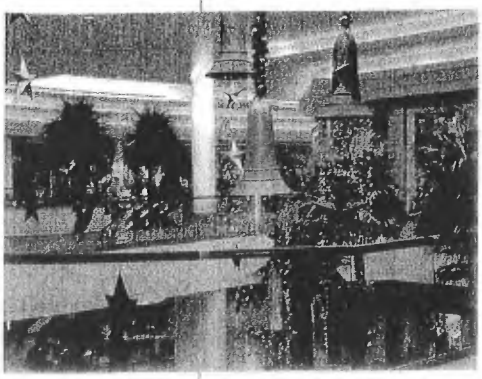
- *3-4 times longer life:* UVC lights lose up to half their output over a year. Competitive UVC devices must be changed every 3-4 months because they quickly lose the output needed to maintain microbial control. The UVC Emitter, by contrast, has a 12-month service life — and even after a full year, it has 2-3 times greater output than competitive devices deliver on Day 1! As a result, only Steril-Aire can ensure the germicidal performance you need, with no return of microbial growth, for 3-4 times longer than the competition.
- *Independently verified output:* Tested in accordance with the general provisions of the Illuminating Engineering Society's 1981 Applications Volume.
- *A patented state-of-the-art solid state electronic power supply* for enhanced reliability and performance.
- *High performance construction*, including stainless steel housings with high spectral aluminum reflectors, and thick-wall quartz tubes.
- *Many sizes and configurations* to fit the widest range of applications — externally mounted, internally mounted, and portable.
- *Complete technical and engineering support* with in-house expertise in both HVAC technology and microbiology.
- *Lowest life-cycle cost* of any UVC product.

Steril-Aire vs. Other UVC Products: Output Comparison



Steril-Aire's multi-patented UVC Emitter™ provides the best and longest-lasting UVC performance available. As shown in the comparison graph, it has been independently tested to deliver an average of 5 times the output of other ultraviolet devices under HVAC operating conditions (45° F @ 550 fpm air velocity).

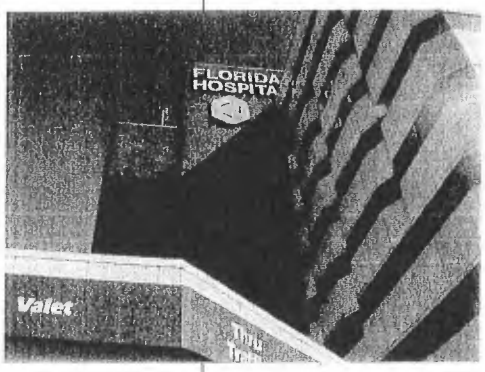
APPLICATIONS FOR UVC EMITTERS



Commercial Buildings

- Offices, government buildings, retail stores and malls, hotels, casinos, museums.
- Users report HVAC energy savings up to 25-30%, plus improved IAQ and reduced maintenance.
- Key products: DE Series, SE and SEN Series, Fan Coil UVC Kit.

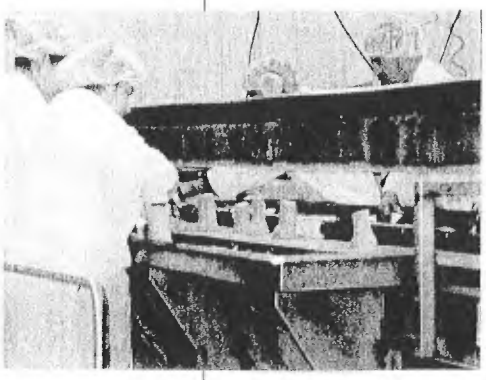
> We have eliminated our four-times-per-year coil cleaning program, and we no longer expose our maintenance people to chemicals required for this task.... By bathing our coils in UVC lights, we've also experienced a big power consumption reduction. We estimate a conservative 28% drop in total A/C system energy usage.
>
> — *American Electric Power, Dallas, Texas*



Health Care Facilities

- Hospitals and medical offices, hospices, clinics, laboratories.
- May be used for infection control or general IAQ, operational and energy savings.
- Key products: DE Series, SE and SEN Series, Fan Coil UVC Kit, SterilWand™.

> Our experiences have shown us repeatedly that UVC enhances indoor air quality and infection control, while saving on maintenance labor, materials and downtime. The substantial energy savings achieved have been a great bonus. Since our administrators now have a high confidence level in the effectiveness of UVC lights, we will continue to equip both new and existing air handling units with the devices.
>
> — *Florida Hospital, Orlando, Florida (shown in photo)*



Food and Beverage Industry

- Conveying lines, packaging containers, filling stations, cooling and drying areas, HVAC and refrigeration systems, storage rooms.
- Enhances food safety through control of mold, bacteria and viruses.
- Extends shelf life and improves production yields.
- Key products: DE, SE and SEN Series, SterilWand (all available with optional shatter-resistant tubes)

> To reduce mold counts in the room where we process butternut squash, we pressurized the space and installed Steril-Aire UVC lights. We've had a tenfold reduction in mold counts, our air quality has improved and our shelf life has increased dramatically as a result.
>
> — *Martin and Sons Farms Inc., Brockport, New York (shown in photo)*

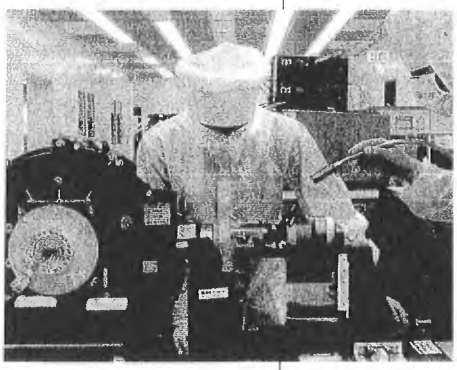
Schools and Institutions

- Classrooms, libraries, meeting rooms, auditoriums, gyms, offices.
- Stops mold problems.
- Prevents the spread of childhood diseases — reduces illness and absenteeism.
- Key products: Unit Ventilator UVC Kit, DE Series, SE and SEN Series, Fan Coil UVC Kit, SterilWand.

This winter has been an especially bad flu season for Southern California. I can say very confidently that our students and teachers have had some colds, but not the humdinger fevers and flus that other schools in our area have experienced. Since adopting the lights in the summer of 2002, we report an estimated 20% drop in absenteeism among students and a 50% drop among teachers.

— *Crescent Avenue Christian Preschool, Buena Park, California (shown in photo)*

Industrial Buildings



- Chemical, electronic, food, pharmaceutical, biotech and general manufacturing plants.
- Controls microbes that can contaminate sensitive products and processes.
- Provides dramatic energy/operational savings in cleanroom and HVAC applications through continuous cleaning of coils.
- Key products: DE Series, SE and SEN series, SterilWand.

Maintaining temperature and RH at proper levels is vitally important in the pharmaceutical industry, so HVAC equipment must be maintained at peak performance. But the chemicals used to clean coils and restore heat exchange efficiency can contaminate the manufacturing process. The use of UVC at the cooling coils provides a less costly, non-chemical solution and also helps to extend the life of our HEPA filters.

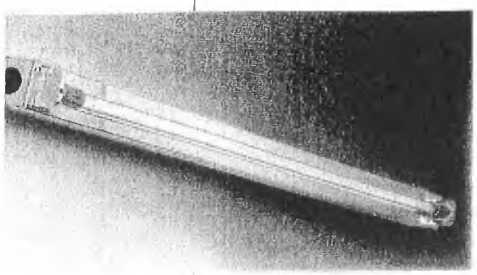
— *Pharmaceutical plant, Northeastern U.S.*

Residences

- Houses and multi-family dwellings.
- Relieves allergy and asthma symptoms through continuous mold control.
- Prevents the spread of colds, flu and other ailments.
- Key products: SteriLight™ I and II.

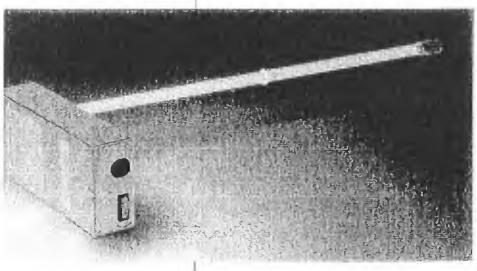
I couldn't stop coughing, I couldn't sleep at night.... Within just a couple of days [after installing SteriLight], I noticed a dramatic difference in the house. My symptoms began to ease up. As the days went by, I continued to get better and better.

— *B. Oblath, Southern California homeowner*



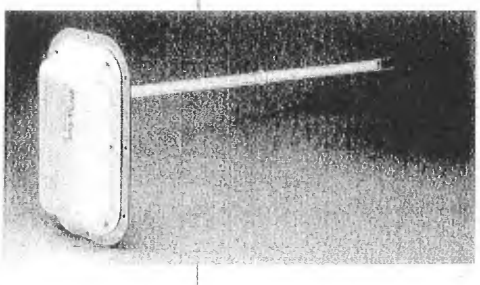
DE Series UVC Emitters

- For medium to large systems in commercial, industrial, health care and institutional buildings.
- Double-ended (DE) units are assembled end-to-end and mounted internally.
- Five sizes (18", 24", 30", 36" and 42") fit any coil width.
- Four voltage options: 115-208/230 or 277 Vac.
- The most widely used product for commercial "UVC for HVAC" — the industry standard!



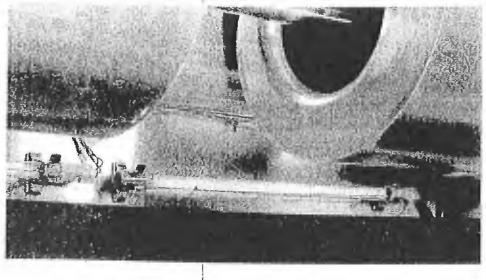
SE Series UVC Emitters

- For non-residential systems that cannot be accessed internally — fan coils, heat pumps, unit ventilators, packaged air handlers, terminal units and ductwork.
- Single-ended (SE) units are installed from the exterior and through the wall of HVAC equipment. Servicing is exterior.
- Available with six tube lengths (16", 20", 24", 30", 36" and 42").
- Four voltage options: 115-208/230 or 277 Vac.



SEN Series UVC Emitters

- For non-residential rooftop and outdoor air handlers, ductwork and other difficult-to-access sites.
- Combines the external-mounted, single-ended design of the SE Series with a NEMA 4x fixture.
- Available with six tube lengths (16", 20", 24", 30", 36" and 42").
- Four voltage options: 115-208/230 or 277 Vac.



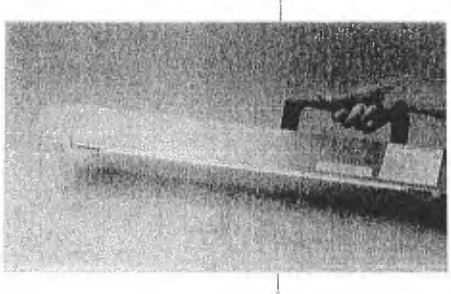
Unit Ventilator UVC Kit

- For use with all major brands of classroom unit ventilators.
- Each kit contains one UVC Emitter and all necessary installation components.
- Two to six kits typically required to serve a unit ventilator.
- Space-saving design features quick and easy snap-in installation.
- Four voltage options: 115-208/230 or 277 Vac.

Fan Coil UVC Kit

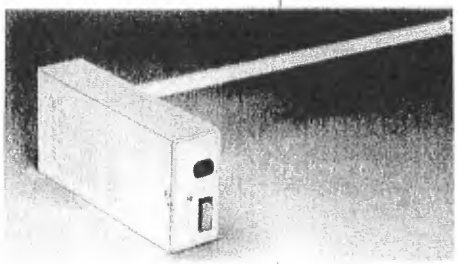
- For use with fan coils, split package systems and other room units.
- Brings enhanced IAQ to hotel rooms, dormitories, offices, patient rooms and classrooms.
- Contains one UVC Emitter and all the necessary components to retrofit a fan coil with UVC.
- Space-saving design features quick and easy snap-in installation.
- Available with six tube lengths (16", 20", 24", 30", 36" and 42") .
- Four voltage options: 115-208/230 or 277 Vac.

SterilWand™



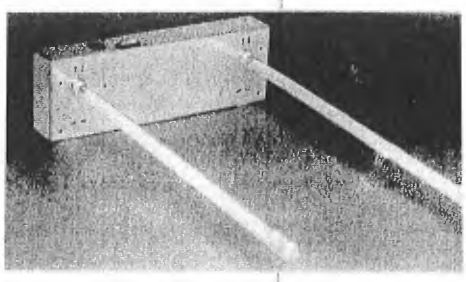
- For surface decontamination in labs, hospitals, processing areas, schools, libraries and homes.
- Hand-held device may be passed over tabletops, walls and other surfaces infested with mold, bacteria or viruses. Safety shield prevents direct exposure to UVC energy.
- Ideal for use as a mold remediation tool.

SteriLight™ I



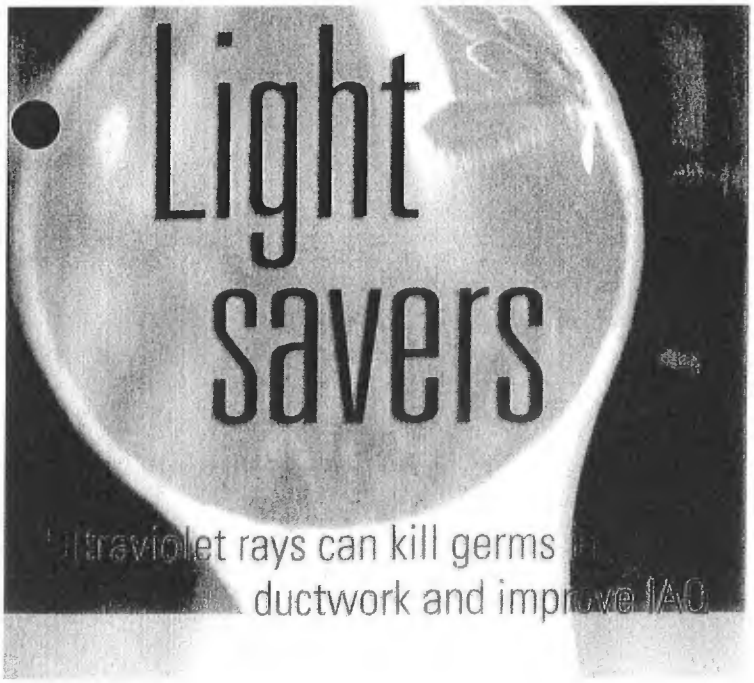
- For residential and light commercial applications.
- Single-tube device installs quickly and easily from the exterior of the coil box. Designed for use with "N" and "W" style, low-profile flat and counter-flow "A" coils.
- Offered in three tube lengths (16", 20" and 24").
- Three voltage options: 115, 208, or 230 Vac.

SteriLight™ II



- For residential and light commercial applications.
- Double-tube device installs quickly and easily from the exterior of the coil box. Designed for use with conventional "A" style, flat and slant coils.
- Offered in three tube lengths (16", 20" and 24") and configurations of 10" or 14" centerlines.

Three voltage options: 115, 208, or 230 Vac.



Light savers

Ultraviolet rays can kill germs in ductwork and improve IAQ

In 2002, the U.S. Environmental Protection Agency warned about using disinfectants, sanitizers and other types of germ killers for HVAC duct cleaning. Since then, many contractors have been searching for safe, yet effective, alternatives.

One popular solution involves the use of ultraviolet C-band energy, commonly called UVC lights. When they shine on surfaces, these lights destroy mold, viruses, bacteria and other contaminants that collect there. They vaporize the organisms, effectively removing them from the air.

The same type of lighting used in HVAC systems to improve indoor air quality and control infectious diseases is sometimes used as an alternative to conventional duct-cleaning methods. UVC lights offer contractors an effective, nonpolluting and permanent way to clean ductwork of microbial contamination.

For best results, it is important to select a UVC device engineered to deliver high output in HVAC systems. It should provide output of at least 10 microwatts per square centimeter at 1 meter, in a 400 feet-per-minute 45°F airstream.

In most cases, direct cleansing of the ductwork by UVC light is not needed. A more effective approach is to go to the source of the problem: the air-conditioning coils. That's what officials at Orlando, Fla.-based Florida Hospital discovered.

Hospital discoveries

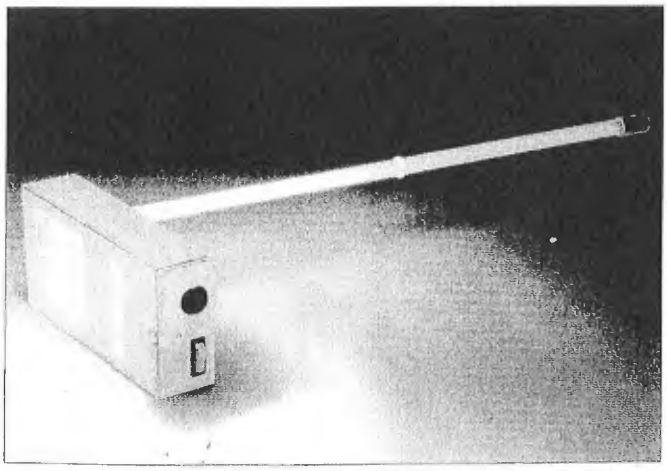
"Since installing UVC in the air handlers, we have observed that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves," said Firouz Keikavousi, a mechanical engineer in charge of facilities maintenance at the hospital.

"This phenomenon occurs because the coil — not the ductwork — is the source of mold growth in the system," he added. "Fresh inoculation coming off the coil typically migrates downstream and some of it settles in the ductwork — a process that is self-perpetuating.

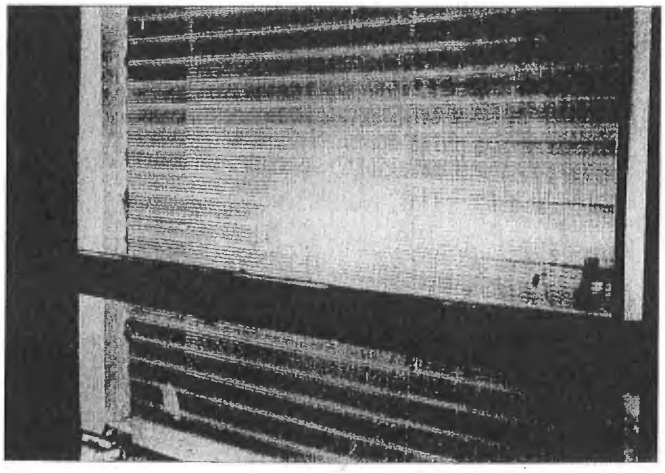
"But when UVC energy is used to destroy mold and microbial growth at the coil, the food source is eliminated and the chain is broken. As a result, the contamination that has already built up on duct surfaces will eventually decay away, a process that may take months".

However, there were times when UVC alone would not clean the ducts completely, Keikavousi said.

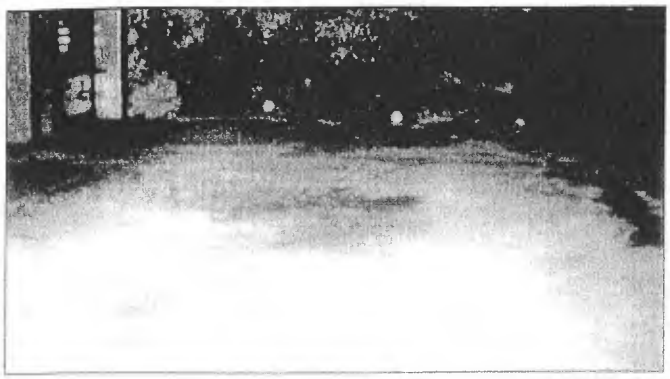
"Where duct surfaces are badly contaminated, it isn't always possible to wait for the effects of UVC. Therefore, in those areas where buildup was particularly heavy, we performed duct cleaning as a precaution prior to installing UVC lights," he said. "We have not experienced any recurrence of duct contamination since adopting UVC, nor do we anticipate any future duct-cleaning requirements."



This UVC device is designed for installation in ductwork. A small penetration is made into the duct wall and the UVC lamp or tube is inserted across the width of the duct. The power supply remains external. Photo courtesy of Steril-Aire Inc.



This photo shows an air-conditioning coil at Florida Hospital in Orlando, Fla., treated with high-output UVC light. Since installing them in the air handlers, the hospital has found that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves. Photo courtesy of Florida Hospital.



The ductwork from a large commercial building is contaminated with white, green and black mold. Photo courtesy of Steril-Aire Inc.

Keikayousi expects the use of the lights will save the hospital thousands of dollars in future cleaning costs.

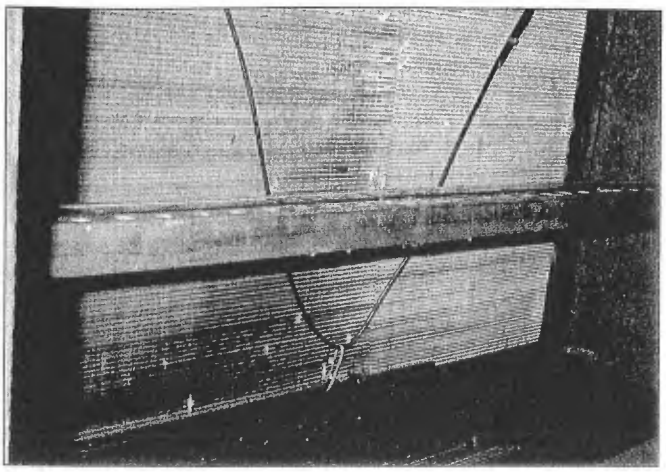
Installation tips

Experts say UVC lights should typically be installed downstream of and facing the coil, or on the return-air side, if installing it downstream is too difficult. This method allows coil surfaces to be continuously bathed in germicidal light, killing the microorganisms that grow and multiply there, not only on the visible part of the fins, but also on the surfaces within the coil, where the greatest amount of mold activity occurs.

The coil's total surface area may be three to five times that of the ductwork, but contamination on the coil tends to be less visible. When you inspect the inside of a duct and it looks moldy, many people become alarmed, not realizing that the coil is the real culprit. There is much evidence that infestation in ductwork, while it may look scary, is not a major contributor to IAQ problems. The movement of air along interior duct walls is actually very slight, so the amount of contamination coming off the ducts and into the occupied space is not usually significant.

"Since installing UVC in the air handlers, we have observed that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves," said Firouz Keikavousi, a mechanical engineer in charge of facilities maintenance at Florida Hospital.

Where duct surfaces are heavily infested, a one-time cleaning may be deemed necessary, as Florida Hospital found. Another nonchemical approach is to install supplemental UVC lights in the ductwork. Remember: If you irradiate the ducts without irradiating the coil, you are treating the symptoms and not the disease.



The right side of this air-conditioning coil has been irradiated with high-output UVC light. After a few days, the treated side of the coil is clean and nearly free of mold. Left untreated, mold originating in the coil can migrate downstream and settle in ductwork. Photo courtesy of Steril-Aire Inc.

A typical installation requires making a 1-inch penetration into the duct wall and running the light across the width of the duct. The UVC energy rapidly "cooks off" mold and other microbes, leaving ductwork free of organic buildup, with no other surface cleaning necessary.

Selection criteria

When selecting UVC lights for coil - and duct-cleaning applications, make sure the UVC-energy output is at the recommended level. For duct-cleaning applications, select a design where only the lamp or "tube" will penetrate into the ductwork and the power supply will be external. This will ensure minimum intrusion into the ductwork. The tube should ideally be long enough to extend across the width of the duct.

UVC devices provide line-of-sight irradiation only, with a typical effective range of about 10 feet in a ducted system. This range is related to lamp size and output, and may vary from manufacturer to manufacturer. Be sure to compare the total installed cost, which is more important than the number of lights needed.

When you install UVC to keep coils and ductwork clean, it is essentially a permanent fix: There is little to do except change the tubes about once a year, or when a radiometer indicates that the output has dropped below specified levels.

Buildings that use UVC devices report going for years without cleaning coils, ducts, drain pans or plenums. As a result, service crews and building occupants are no longer exposed to the potentially harmful chemicals associated with cleaning.

(This article was supplied by Steril-Aire Inc., a Burbank, Calif.-based manufacturer of IAQ products.)

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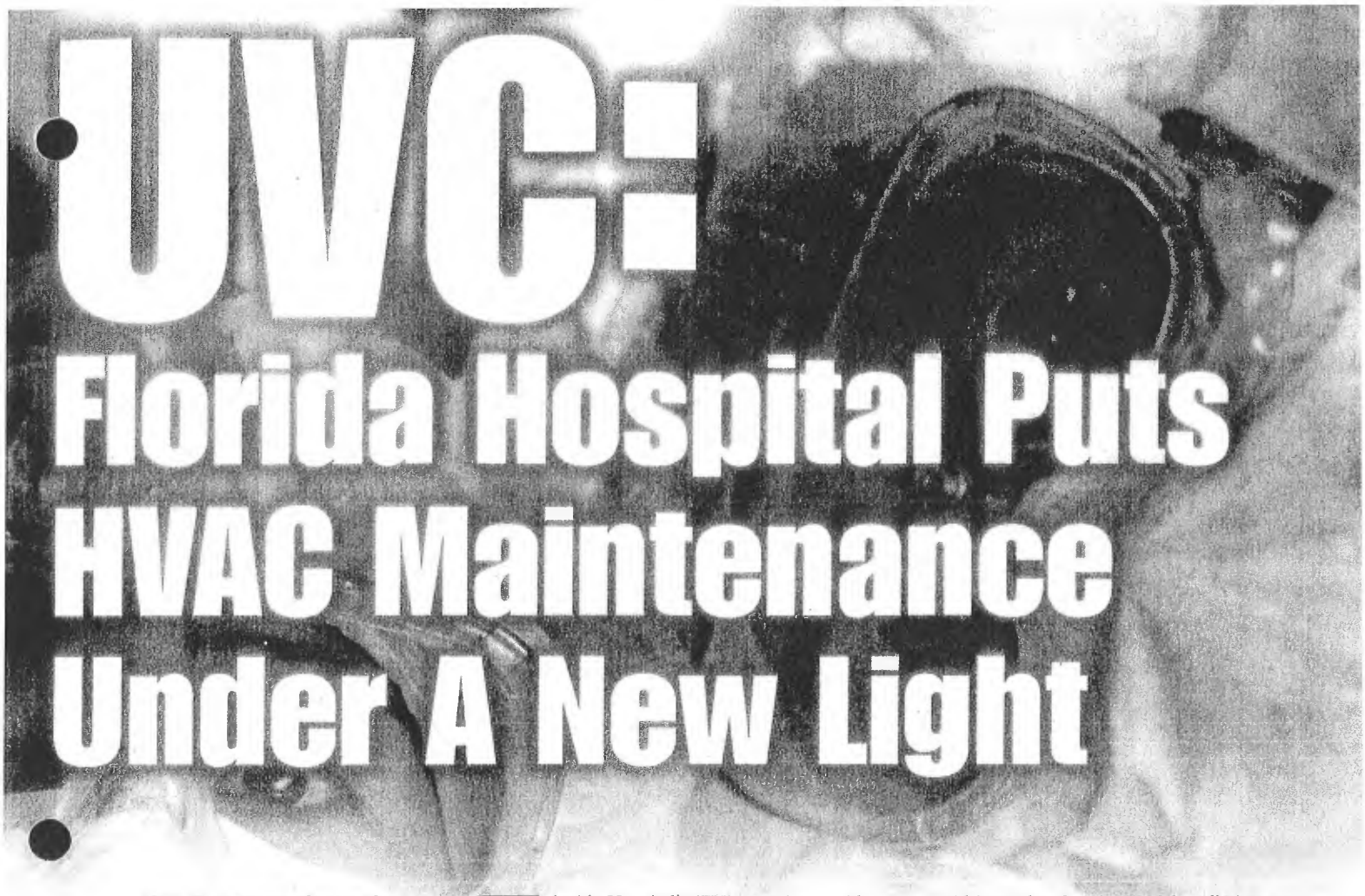


UVC: Florida Hospital Puts HVAC Maintenance Under A New Light

HVAC system downtime during coil cleaning can compromise humidity and temperature control, potentially leading to air quality or comfort problems. Florida Hospital has found that high-output ultraviolet-C lights installed in the AHUs reduce or eliminate coil-cleaning programs — yielding ongoing energy savings, a reduction in HVAC system maintenance, and the elimination of cleaning chemicals. The facility also reports IAQ and infection control benefits as the regimen continues.

BY FIROUZ KEIKAVOUSI

Florida Hospital's (FH) experience with ultraviolet-C (UVC) began in 1998 after seeing a presentation on the technology at an ASHRAE conference. A new generation of UVC devices promised to offer an improvement over the UV lights that were long ago popular for upper air disinfection in hospitals and other health care environments. Unlike the upper air devices, the newer UVC lights were engineered specifically to provide peak output under HVAC conditions. Output of these devices was reportedly so much higher than conventional UV tubes in cold and moving air that they could be installed just downstream of a cooling coil to eradicate bacteria, viruses, and mold.

Upon learning about the benefits of the new UVC fixtures, FH staff felt that the potential for the health care system was enormous. FH is an acute-care health system with more than 2,800 beds throughout Florida. With a network of 17 hospitals and 12 walk-in urgent care centers, FH treats more than a million patient visits per year and is the second busiest system in the country.

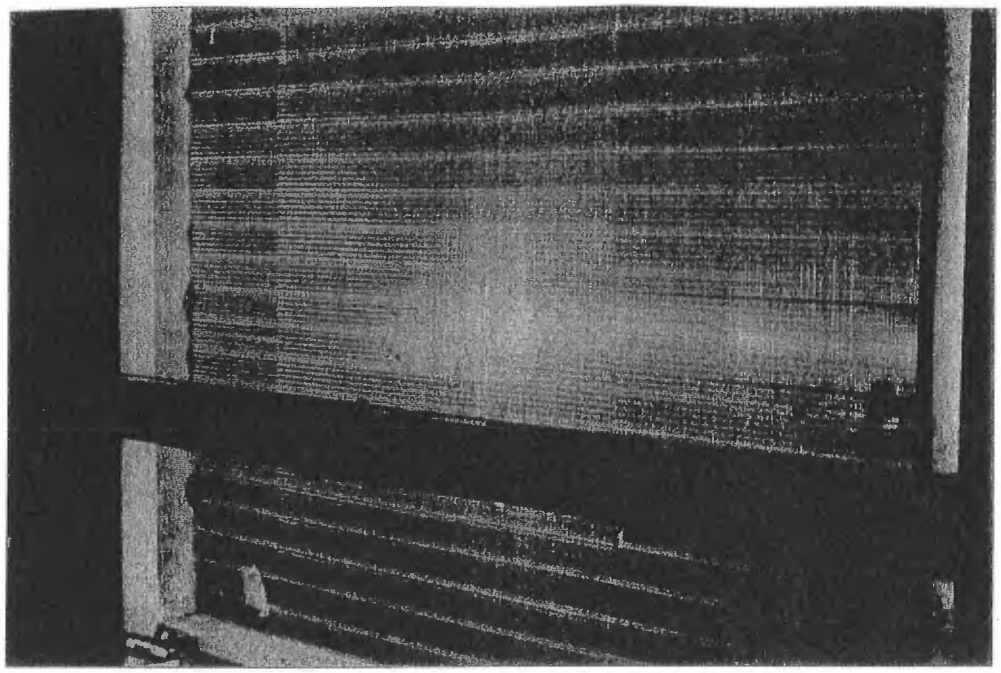
To test the efficacy of the UVC devices, we decided to install the lights in AHU #107, a 27-year-old, 6,000 cfm unit located at the main Orlando campus. A UVC Emitter™ manufactured by Steril-Aire, Inc., was specified for this and for subsequent installations. We selected AHU #107 because the coil and 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



A control unit in one of the early tests, this air handler was later equipped with UVC.

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 cleanings 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.

We next installed UVC devices in an additional unit, AHU #42, in the same hospital. In this unit, static pressure over the coil dropped from 1.4 in. wg to 0.8 in. wg, and velocity over the coil increased from 365 fpm to 468 fpm. On a parallel AHU (#43) without UVC light, we cleaned the coils to compare the results. Although the coil visually appeared to be clean, pressure drop over the coil increased by 0.3 in., and mold buildup occurred in the drain pan shortly after the cleaning.

After reviewing these initial results, the hospital administration agreed to expand the use of UVC. By the beginning of 2004, more than 100 AHUs in seven FH campuses were outfitted with the lights (Table 1), as well as some ceiling-mounted and portable air recirculating units. To obtain desired results in the AHUs, we generally follow the manufacturer's recommended guideline of 24 in. of UVC tube length for every 4 sq ft of coil face area.

Following are some of our most noteworthy experiences and observations.

CELEBRATION HEALTH

We were experiencing problems with excessive organic buildup on the coils in large (15,000 cfm) units at our Celebration Health Hospital facility. These AHUs, which have about an 8 in. thickness of coil, did not respond well to pressure cleaning. We found that this technique would tend to compress the growth inside the center of the coil, increasing airflow resistance, and allowing mold proliferation to continue. Since the cost to replace the coils would have been $16,000 to $18,000 per unit, we were seeking a more economical yet effective solution.

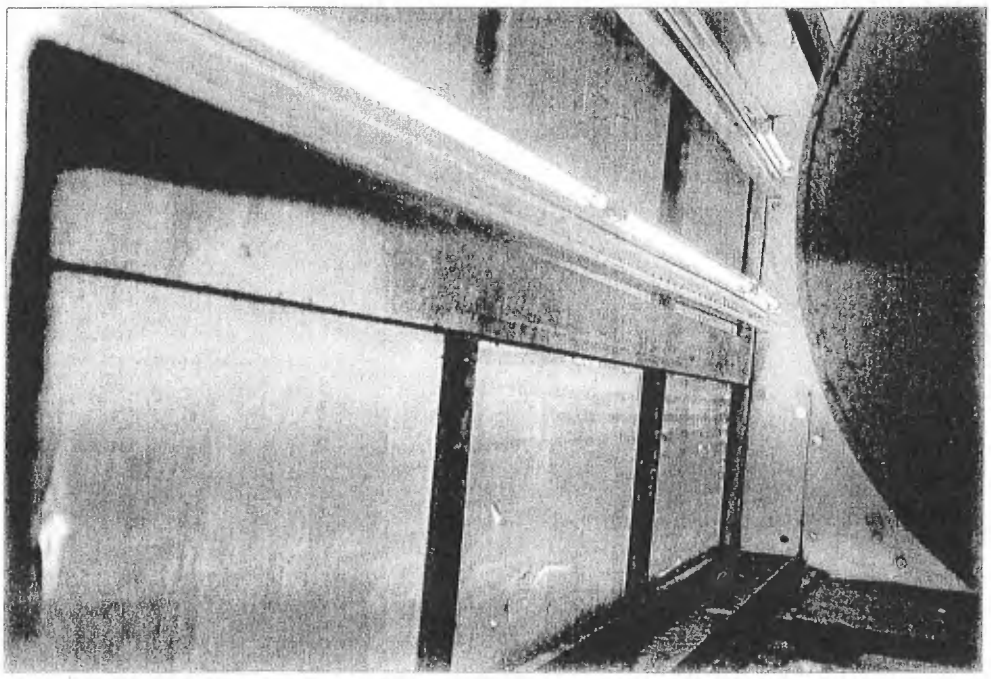
We installed UVC lights in one of the units at a cost of about $5,000. No cleaning was performed; since the lights are easy to install, system downtime was only about two hours. The UVC energy successfully "cooked away" existing buildup all the way through six rows of coil and has maintained the unit in a clean condition.

On an identical AHU, we removed the coil and immersed it in a chemical bath for 24 hrs to loosen up the debris. Although we have had mixed results with this technique in the past, it was successful in this case. Total shutdown time for this unit was 48 hrs, at a cost of more than $6,000 in labor and materials. However, the unit has required three subsequent cleanings at six-month intervals and has been operating at a much higher pressure drop than the UVC-equipped AHU.

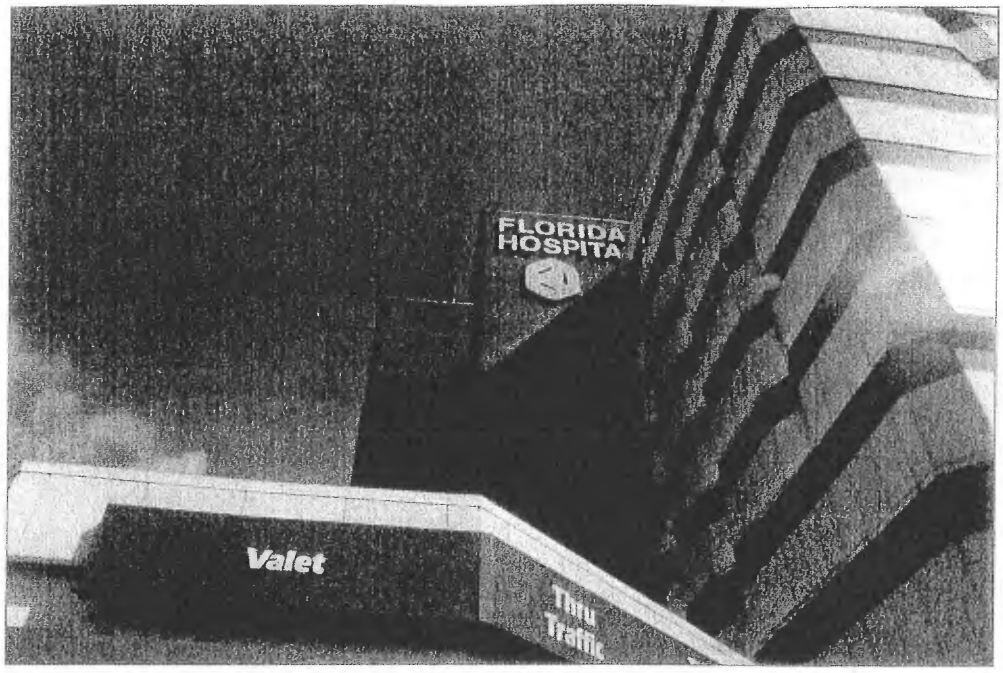
FACILITY BUILDING

A facility building on the main Orlando campus was experiencing IAQ problems. Though no patients were affected, hospital personnel in the building were reporting allergic reactions such as coughing, sneezing, and watery eyes. One employee complained of a cold that would not go away. After installing UVC lights, all of the symptoms disappeared within about a week.

Several weeks later, we were puzzled to find that the problem had reappeared. Upon inspection, we discovered that a service crew had



A recent UVC installation with a large coil.



UVC lights have been used in facilities throughout the Florida Hospital system.

turned the UVC lights off during filter changeout and neglected to turn them back on again. Mold growth had reappeared in about a month. With the lights reactivated, the problem again abated quickly and there have been no further recurrences.

DUCTWORK

Since installing UVC in the air handlers, we have observed that the devices also help to eliminate mold buildup on duct surfaces, even though there are no lights installed in the ducts themselves. This phenomenon occurs because the coil — not the ductwork — is the source of mold growth in the system. Fresh inoculation coming off the coil typically migrates downstream and some of it settles in the ductwork — a process that is self-perpetuating. But when UVC energy is used to destroy mold and microbial growth at the coil, the food source is eliminated and the chain is broken. As a result, the contamination that has already built up on duct surfaces will eventually decay away, a process that may take months.

Where duct surfaces are badly contaminated, it isn't always possible to wait for the effects of UVC. Therefore, in those areas where buildup was particularly heavy, we performed duct cleaning as a precaution prior to installing UVC lights. We have not experienced any recurrence of duct contamination since adopting UVC, nor do we anticipate any future duct cleaning requirements. This will mean thousands of dollars' additional maintenance savings in coming years.

INFECTION CONTROL

Though FH's interest in UVC has been largely maintenance-driven, we have never lost sight of the fact that infection control is one of the primary functions of this technology. Back in the 1950s and '60s, the older-style UV devices were popular for upper air disinfection of tuberculosis wards and similar areas. When air conditioning became prevalent, however, the lights suffered losses in output — and therefore, germicidal effectiveness — under the cooler temperatures, and they began to lose favor.

Since the new-style UVC lights are not subject to these limitations, we decided to introduce the devices for infection control applications. Over the past year, we have incorporated UVC into self-contained ceiling units that are equipped with prefilters, fans, and HEPA filtration.

Although HEPA filters have the capability to trap bacteria, they are not always effective against smaller microbes such as chicken pox, small pox and other highly contagious viruses.

UVC energy's ability to inactivate all types of bacteria and viruses (no matter how small) is well documented. Also, by destroying microbes trapped in the HEPA filters, the presence of UVC light may increase the service life of these components and allow for safer changeout.

The devices are installed between the fan and the HEPA filter to provide an extra level of protection against the spread of airborne diseases in such locations as ER waiting areas, endoscopy, radiology, and patient waiting rooms.

Similarly, UVC has been incorporated into 400-cfm portable recirculating units that use the same type of multistage filtration. The units are wheeled to patient rooms and isolation areas where there may be concerns about the presence of infectious disease. The manufacturer of the portable equipment has outfitted the units with UVC devices at our request. We currently have 40 UVC-equipped portable units on our various campuses, with additional units available on a rental basis.

Though we do not yet have sufficient data to measure the effectiveness of UVC as an infection control tool at our facilities, our infection control people have greeted it as a welcome enhancement to current prevention strategies.

MAINTENANCE PRACTICES

The UVC devices at our hospitals operate round-the-clock to ensure continuous eradication of mold and microbial growth. To monitor performance of the lights, we currently use portable radiometers that measure the output of these devices. The manufacturer recommends replacement of the UVC tubes if they fall below 60% of the original output. We change the tubes preventively on an annual basis even if output still exceeds the recommended changeout level, as is often the case. Tube replacement, which is literally as easy as changing a light bulb, takes only minutes to perform.

Inspection windows and similar indicators enable us to verify that the

lights are on. Access doors to many of the AHUs are equipped with switches that automatically de-activate the lights when the doors are opened, since direct exposure to UVC energy is to be avoided. As an additional precaution, maintenance personnel wear safety glasses when inspecting the devices and gloves when handling the glass tubes. Apart from these minor precautions, UVC has significantly reduced our overall HVAC system maintenance while having few maintenance requirements of its own.

CONCLUSION

- Cleaning costs: UVC devices have performed beyond expectations for their originally intended maintenance function — e.g., to reduce or eliminate coil cleaning. Given that our AHUs used to require two coil cleanings per year on average, and we have equipped more than 100 AHUs with UVC, we have succeeded in eliminating more than 200 coil cleaning procedures annually. Cost per cleaning can range anywhere from $500 (for a two-person, four-hour job, including labor and materials) to $6,000 or more for a "problem" coil requiring more extensive cleaning. Anticipated long-term savings in duct cleaning costs should also be significant.
- Reduced downtime: A reduction in the downtime associated with coil cleaning carries another important benefit. Whenever you shut down an AHU in a hospital, rh can increase dramatically, especially in the tropical Florida climate. In turn, when humidity and temperature control are compromised, patient comfort is at stake and proper IAQ control becomes more challenging. UVC helps to keep systems "up and running," minimizing the potential for these problems to occur.
- Energy savings: 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, estimated to be in the six figures annually, would be enough to pay back the cost of the UVC installation very quickly — even without the savings already realized through reduced coil cleaning.

Facility	# of beds	# UVC-equipped AHUs
Orlando (main campus)	882	53
Altamonte	258	9
Apopka	50	1
Celebration Health	60	7
East Orlando	119	3
Kissimmee	50	19
Winter Park	334	13
Totals:	1,753	105

TABLE 1. Overview of Florida Hospital UVC usage.

As an engineer for this large hospital system, my primary concerns have always been the quality of the air and the comfort of our patients, visitors, and employees. FH's experiences of the last five years have shown us repeatedly that UVC enhances IAQ and infection control, while saving on maintenance labor, materials, and downtime. The substantial energy savings achieved have been a great bonus. Since our administrators now have a high confidence level in the effectiveness of UVC lights, we will continue to equip both new and existing AHUs with the devices. ES

Keikavousi is mechanical engineer in charge of facilities management for Florida Hospital, an Orlando-based acute-care health system with more than 2,800 beds throughout Florida. A member of ASHRAE, he is a past president of the Central Florida Chapter and has held regional vice chair positions for student activity, membership, and (currently) resource and promotion. He holds a Bachelor of Science degree in mechanical engineering from The Engineering School in West Berlin, Germany. Write him at **firouz.keikavousi@flhosp.org.**