How Steril-Aire UVC Can Cut Energy and Operational Costs

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Executive Summary

What if there was an investment that paid measurable, almost immediate benefits by reducing energy and maintenance costs? What if you could restore your heating, ventilation and air conditioning (HVAC) system to as-built design and keep it in a clean state without harmful chemicals or pressure washing? What kind of a financial impact could maximizing chiller performance have on your bottom line? And, imagine what facility engineers could do with the time lost to logging, managing and troubleshooting thermal comfort complaints.

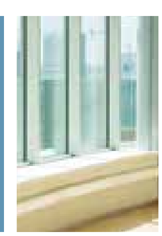
This report provides an overview of the challenges of keeping complex HVAC systems running efficiently and at optimal performance to reduce energy and operational costs. It will introduce you to the power and science of UVC and its germicidal effectiveness in cleaning fouled cooling coils and drain pans and the importance of improving cooling coil heat transfer and optimizing chiller performance.

This white paper explores how Steril-Aire UVC has helped organizations like yours to meet top operational goals: improving occupant comfort, reducing energy costs that are sustainable while improving utilization of scarce facility resources.

Introduction

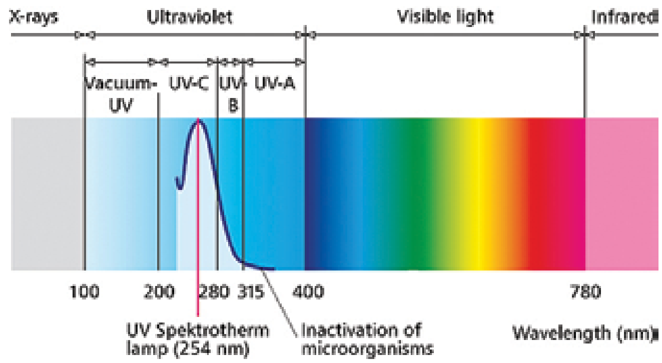
Biological fouling of indoor fin and tube heat exchangers, particularly air conditioner evaporators, is a key contributor to decreased capacity and efficiency and overall energy use and peak electricity demand. This biological fouling acts as an insulator and reduces heat transfer in the HVAC system. To maintain the building at the desired temperature, the fans have to work harder. The chilled water temperature may be lowered, making the chiller and compressor work more, resulting in increased energy costs.

Air conditioning is the largest user of energy in commercial and institutional buildings and the largest user of energy within the air conditioning system is the chiller plant. In fact, HVAC systems account for an estimated 40-60% of energy use in buildings. Considering the fact that fouled coils can add another 30% (Federal Energy Management Program) to building costs while producing 10% less cooling (J. Siegel, et al, 2002), performance and energy efficiency become key factors in the bottom line.

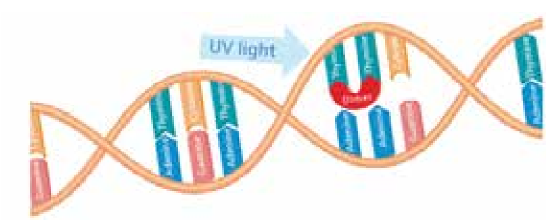



The Science of Ultraviolet Light

Ultraviolet (UV) light is one form of electromagnetic energy produced naturally by the sun. UV is a spectrum of light just below the visible light and it is split into four distinct spectral areas–Vacuum UV (100 to 200 nm), UVC (200 to 280 nm), UVB (280 to 315 nm) and UVA (315 to 400 nm).



The entire UV spectrum can kill or inactivate many microorganism species, preventing them from replicating. UVC energy at 253.7 nanometers provides the most germicidal effect. The application of UVC energy to inactivate microorganisms is also known as Germicidal Irradiation or UVGI.

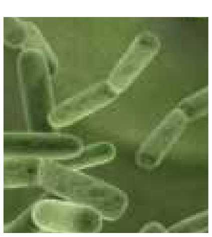


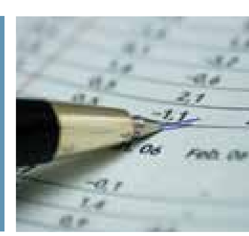
Dimerization or Altering of the Molecular Bonds of a Bacteria's DNA by UVGI

UGVI exposure inactivates microbial organisms such as bacteria and viruses by altering the structure and the molecular bonds of their DNA (Deoxyribonucleic acid). DNA is a "blue print" these organisms use to develop, function and reproduce. By destroying the organism's ability to reproduce, it becomes harmless since it cannot colonize. After UVGI exposure, the organism dies off leaving no offspring, and the population of the microorganism diminishes rapidly.

Ultraviolet germicidal lamps provide a much more powerful and concentrated effect of ultraviolet energy than can be found naturally. UVGI provides a highly effective method of destroying microorganisms. The recirculating air in HVAC systems creates redundancy in exposing microorganisms to UV, ensuring multiple passes so the light energy is effective against large quantities of microorganisms.

For optimum performance in the HVAC environment, Steril-Aire recommends the UVC device be manufactured to deliver output of nine microwatts per linear inch of glass



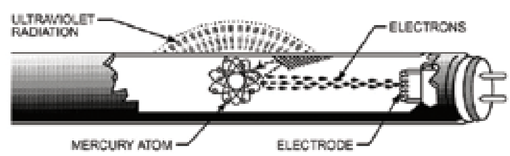



measured from a distance of one meter, tested at an air velocity of 400 fpm (feet per minute), and situated in a temperature of 50° F. This is critical because UVC output declines over time, reaching a half-life after 9,000 operating hours or slightly over one year when running on a 24/7 basis. It is necessary to start at a high enough output, based on microwatts per linear inch of glass to ensure adequate output will be maintained throughout the service life of the device. Otherwise, the device may not be able to maintain effective microbial control.

How Does UVC Work?

Today UVC is artificially made using specialized lamps producing germicidal UV at 253.7 nm. UVC lamps are filled with inert gas and mercury with electrodes on either end. A high-voltage electric current runs through the gas between the electrodes. When one of the electrons from that current strikes a mercury molecule, part of its energy is absorbed, exciting the mercury. The mercury then shoots out the energy as a photon of ultraviolet light. Although UVC is invisible to the human eye, small amounts of energy released at visible wavelengths produce the blue glow commonly associated with UVC lamps.

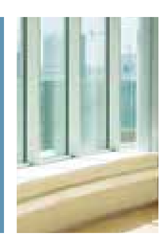
Picture Source: Steril-Aire



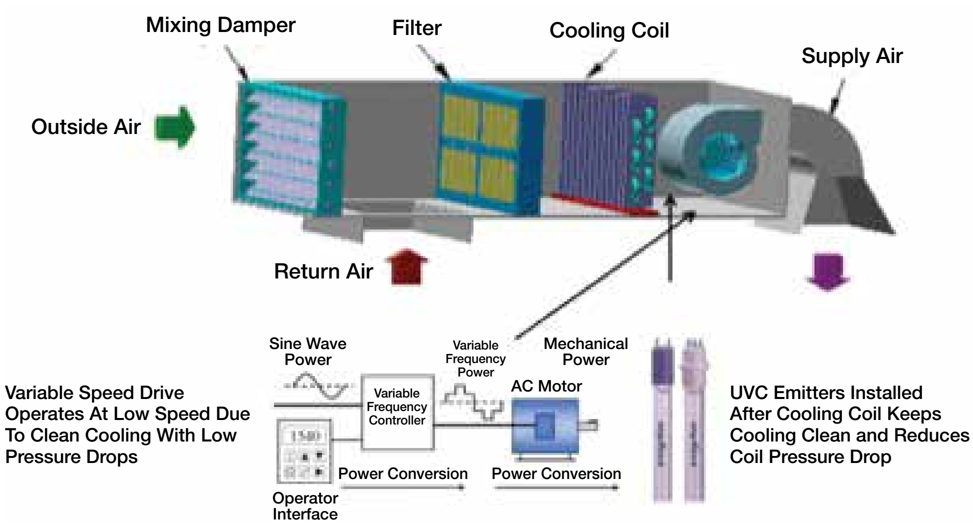
Picture Source: 2008 ASHRAE Handbook

Application of UVC Emitters in HVAC System

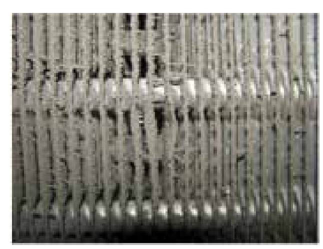
For the most effective microbial control, the UVC should be installed on the supply side of the system, downstream from the cooling coil and above the drain pan. This location provides the most effective biofilm and microbial control than in-duct installations because the UVC irradiates the contaminants at the source and delivers simultaneous decontamination of surface and airborne microorganisms.

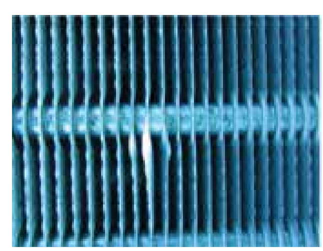


UVC systems are designed to rapidly clean the cooling coil surfaces and to subsequently penetrate the gaps between the coil fins and clean within the coils. The following photos clearly demonstrate the ability of high output germicidal UVC installed facing the coil and drain pan, to remove biofilm deep in the coil fins and eliminating microbial activity. This type of successful microbial growth removal was achieved in a matter of days.

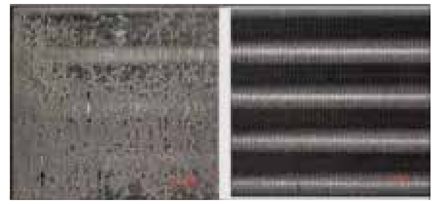


The objective in removing the microbiological contamination in cleaning the coils is to reduce air-side resistance or pressure drop and enhance the air-side heat transfer, improving the system energy efficiency. Reduced cooling coil pressure drop helps to save fan energy while improved cooling coil heat transfer efficiency allows the chiller plant to operate more efficiently.

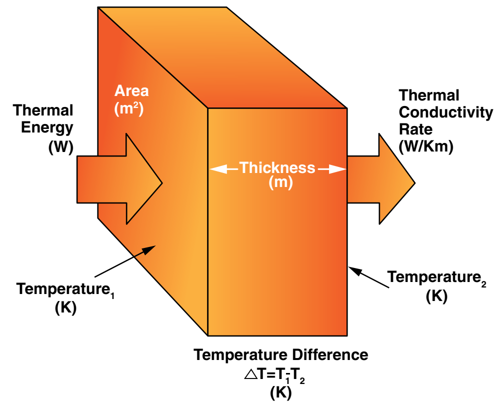

Cooling coil fins before UVC


Cooling coil fins 60 day after UVC

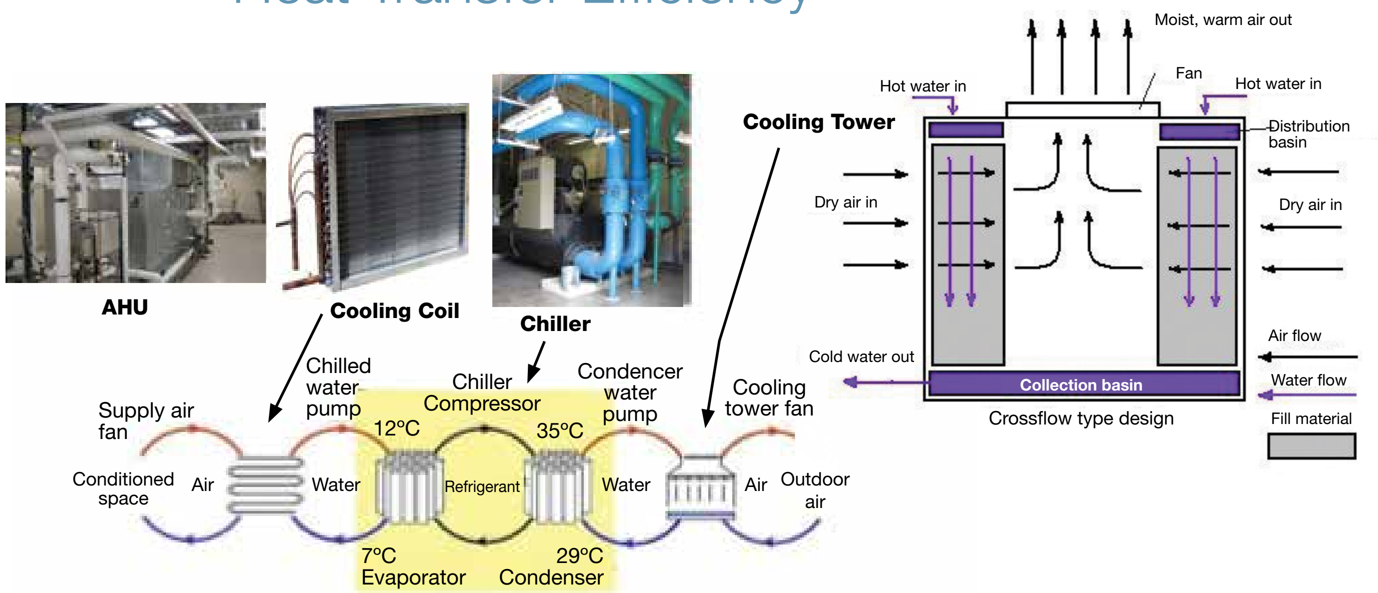
The heat conductivity of aluminum is approximately 200 W/mK while that of biofilm is approximately 0.2 W/mK. As conductivity has fundamental implications on heat transfer, clean coils devoid of biofilm offers significant efficiency advantages (Abstract from Refrigeration & Air Conditioning, Stoecker, W.F., Jones J.W. McGraw Hill, NY.)



Another benefit is improved indoor air quality, resulting from reduced entrainment of microbes and mold into air passing over the coil before the air enters rooms and building spaces. Numerous studies have demonstrated that the HVAC system is a viable reservoir of pathogenic and opportunistic bacteria, viruses and mold that can be amplified and transported throughout the building.



Importance of Improving Cooling Coil Heat Transfer Efficiency



The air conditioning system is fundamentally a series of heat transfers. Heat from the conditioned building spaces is pulled by the AHU fan back to the cooling coil where the heat from the warm air is transferred to the cooling coil. Chilled water from the chiller evaporator picks up the heat from the cooling coil. This heat is transferred to the chiller condenser. Cooled condenser water from the cooling tower continuously removes heat from the chiller condenser. The heat from the condenser water is finally released into the atmosphere via the cooling tower.

Heat transfer efficiency at the cooling coil, chiller condenser and cooling tower all play an important role in the overall system efficiency of the HVAC system.

The role played by UVC lamps in reducing and eliminating coil fouling at the cooling coil is similar to the role played by the auto condenser tube cleaning system in keeping the condenser tubes clean at the chiller condenser.

Importance of Maximizing Chiller Performance

A lot of effort has been put into maximize chiller plant energy performance by adopting the use of efficient chillers (low kW/ton, good part-load performance via VSD chillers, magnetic bearing technology with very little friction loss, etc.) and VSD-driven pumps and cooling towers. To further enhance the energy performance of the chiller plant, it is extremely important to operate and control the chiller plant using the most optimum parameter settings such as:

- High chilled water supply temperature setpoints (energy savings of 3% to 4% for chillers for each °C raise of chilled water supply temperature).
- High chilled water ΔT (difference between chilled water return and supply temperatures) to enable minimum chilled water flow.
- Maximize the chilled water load that can be handled by each chiller to ensure that the minimum number of chillers are run at all times.


The ability of UVC to eliminate biofilm and other organic build-up on cooling coil surfaces helps to maximize cooling coil heat transfer and hence allows the chiller plant to operate under optimum conditions – higher chilled water supply temperature and lower chiller water pump speed.

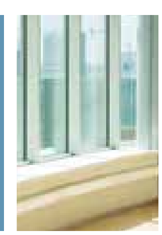
By eliminating biofilm and organic build-up between the cooling coil fins, much air resistance is removed. This allows the free flow of air through clean coils and ensures that variable speed-driven fans can operate at much lower speed to conserve energy.

Additional Operational Efficiency and Cost Savings

In addition to reducing energy consumption, UVC provides additional operational efficiency and cost savings. Installed on the supply side of coil, UVC continuously cleans the coils, eliminating the need for costly and time-consuming manual coil and duct cleaning. UVC also reduces HVAC chemical cost for coil cleaning with no toxic fumes or irritants. UVC is safe and non-toxic.

Biofilm can accelerate oxidation and corrosion of the cooling coil that is often caused by sulphuric acid secreted by common bacteria, significantly reducing HVAC equipment life. Removal of biofilm with UVC not only brings the HVAC equipment performance to the original equipment specification, it also prolongs the time frame for HVAC equipment replacement and capital investment.

Energy conservation and reduced carbon emissions can also contribute greatly to the value of any project. Many projects may qualify for government incentives, utility rebates, or reduction in taxes or avoidance of environmental penalties.



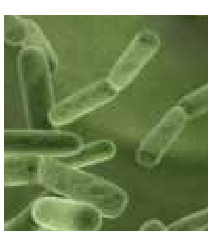
UVC Emitter Energy and Operational Efficiency Case Studies

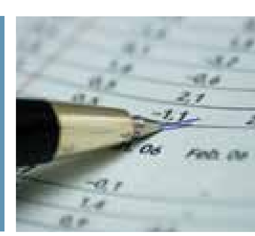
All the energy case studies listed below were undertaken with Steril-Aire UVC Emitters™ which are specially designed for HVAC conditions with cold moving air. Installed just after the cooling coils, Steril-Aire UVC Emitters are able to produce strong germicidal light output for effective cooling coil decontamination and biofilm removal. This results in very clean cooling coils that maximize cooling coil heat transfer and energy savings.

Parliament House, Singapore

Steril-Aire UVC Emitters can play an important role in maximizing a chiller plant's ΔT (difference between the chilled water supply and return temperatures) which leads to reduced pumping energy, setting of higher chilled water temperature setpoints and higher chiller efficiencies. In 2009, the Singapore Parliament House decided to go for Green Mark certification. A key prerequisite of the Green Mark requirements under Existing Buildings Ver 2.1 is a minimum overall chiller plant efficiency of 0.9 kW/ton. A chiller plant audit was conducted in July 2009 and the chiller plant efficiency was determined to be about 1.1 kW/ton.

The Green Mark team set forth to improve the chiller plant efficiency by introducing Steril-Aire UVC Emitters into the AHUs and adopting more energy-efficient parameter settings for the chiller plant. With better heat transfer efficiency at the cooling coils, the chilled water setpoint was progressively raised from 6.6 °C to 8.5 °C. The parameters (tonnage and chilled temperature) for the cutting-in and cutting-out of the chillers were readjusted to 'stretch' the chillers to maximize the chiller efficiency. After the fine-tuning process, the return chilled water temperature was raised from the previous 9.8 °C to 13.6 °C.





As a result, the chilled water ΔT was increased from 3.2 °C to 5.1 °C. The overall chiller plant efficiency improved from 1.1 kW/ton to 0.86 kW/ton (an improvement of 21.8% in chiller plant efficiency), enabling the Singapore Parliament House to secure the Green Mark Gold Award. The fine-tuning process was carried out gradually over a few weeks to ensure that the chiller plant efficiency was achieved without any negative impact on occupant thermal comfort.

Data Showing Improvement in Chiller Plant Efficiency with Contribution from Clean Coils Installed with Steril-Arie UVC Emitters

BEFORE IMPROVEMENT

Chilled Water Supply Temp	6.6 °C
Chilled Water Return Temp	9.8 °C
ΔT	3.2 °C
Chiller Plant Efficiency	1.1 kW/ton

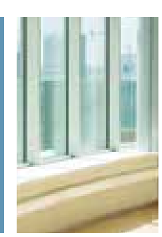
AFTER IMPROVEMENT

(UVC for AHUs, Resetting of Chiller Plant Control Parameters)

Chilled Water Supply Temp	8.5 °C
Chilled Water Return Temp	13.6 °C
ΔT	5.1 °C
Chiller Plant Efficiency	0.86 kW/ton

University of New Mexico, New Mexico, USA

The University of New Mexico Manager of Maintenance and Planning was receiving so many "hot" calls during the summer months, he had to find a solution to the poor performance of their HVAC system. It seemed the only answer was to replace the coils in all five AHUs serving the building. When the facility manager learned it would cost $500,000 to replace the coils, they turned to Steril-Aire for a better solution.

Installation and testing by a certified air and balance company before and after the Steril-Aire installation for one AHU demonstrated such significant results, they expanded the UVC solution to their entire building resulting in:

- $60,000 annual energy savings
- 208% increase in net cooling capacity
- Increased chiller efficiency
- Elimination of coil cleaning
- A return on investment of 8.2 months

American Electric Power (AEP), Dallas, USA

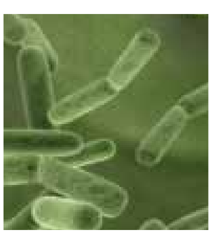
When Public Service Company of Oklahoma (PSO), an AEP subsidiary in Tulsa, USA, purchased Steril-Aire UVC Emitters in 1998, they were not looking for energy savings. Their motivation was indoor air quality.

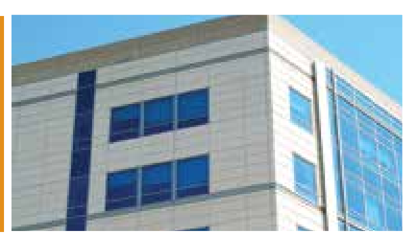
Due to the germicidal performance of the Steril-Aire UVC Emitters, AEP eliminated their four-times-a-year coil, drain pan and plenum cleaning program. What they did not anticipate was the significant drop in pressure across the coils as the Steril-Aire UVC restored the fouled coils to 'like new' condition, resulting in net-cooling capacity increase that led to lower fan speed. This translated into annual energy savings of US $139,000 (15.2%).

American Electric Power (Dallas) UVC Savings Summary

MONTH	KWH 1997/1998	KWH 1999/2000	DIFFERENCE	% SAVINGS	$ SAVINGS
JUNE	1,447,239	1,338,601	108,638		$5,769
JULY	1,481,012	1,527,043	- 46,031		-$2,444
AUGUST	1,413,466	1,338,601	74,865		$3,978
SEPTEMBER	1,514,785	1,307,194	207,591		-$11,024
OCTOBER	1,413,466	1,244,380	169,086	12.0	$8,978
NOVEMBER	1,548,558	1,244,380	304,178	19.6	$16,153
DECEMBER	1,582,331	1,038,825	543,506	34.3	$28,862
JANUARY	1,548,558	1,260,084	288,474	18.6	$15,319
FEBRUARY	1,379,693	1,121,047	258,646	18.7	$13,735
MARCH	1,278,774	997,714	281,060	22.0	$14,925
APRIL	1,345,920	1,162,158	183,762	13.7	$9,758
MAY	1,425,513	1,163,548	261,965	18.4	$12,909
Total kWh difference			**2,635,740**	**15.2**	**$138,964**

Before the implementation of Steril-Aire UVC, the building had to run four 300-ton chillers. Now only two chillers are run even though the chiller plant has to supply chilled water to a neighboring building and a new build-out totaling 25,000 sq. ft.

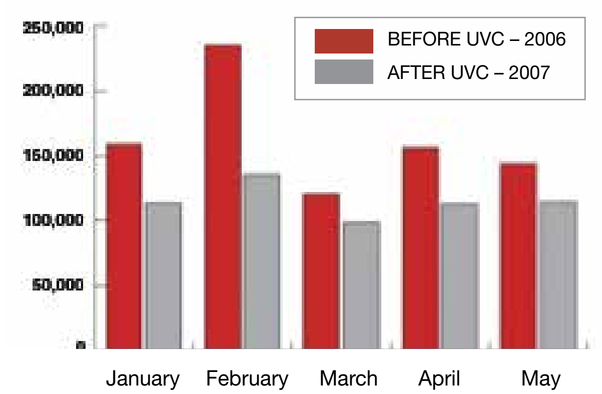




Rio Grande Regional Hospital, Texas, USA

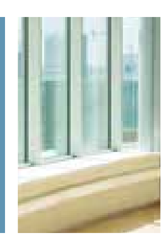
The Rio Grande Regional Hospital had 17 AHUs that were nine years old. The capacity of these AHUs ranged from 20 tons to 80 tons. There were 9 AHUs which are four years old. The capacity of these AHUs ranged from 70 tons to 80 tons.

RIO GRANDE REGIONAL HOSPITAL'S ELECTRICAL COSTS IN 2006 AND 2007



This graph shows the energy savings achieved at Rio Grande Hospital in 2007 as compared to energy consumed in 2006.

Prior to the introduction of Steril-Aire UVC, the four 465-ton chillers were running at 99% capacity. After the UVC installation, the hospital was able to shut down two chillers completely along with the accompanying chilled-water pumps, condenser water pumps, and cooling towers. Electrical usage in kWh dropped 20.64% and this essentially canceled out an equivalent rise in utility rates from US $0.06 per kWh to US $0.08 per kWh. As a result, with the addition of Steril-Aire UVC throughout the hospital from 2005 to 2006, the electrical energy costs from 2005 to 2006 remained at constant average of US $166,900 per month. This facility achieved a $500,000 annual savings in energy costs while reducing maintenance and chemical costs.



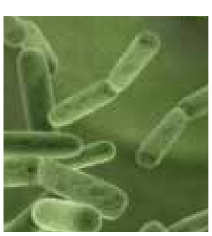
US Air Conditioning Distributors, California, USA

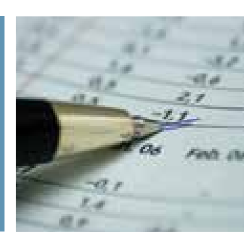
US Air Conditioning Distributors, one of the world's largest HVAC distributors, wanted to investigate indoor air quality (IAQ) improvement methods in its 30-year-old administrative facility located in Southern California. They knew from visual inspections that there were typical accumulations of dirt and mold around the cooling coil and drain pan in the central station air handler. They believed this condition might tie the source of non-specific odors in the building and knew it was impeding cooling coil heat transfer efficiency.

Prior to installation, microbial sampling was performed on and around the cooling coils and drain pan. Laboratory testing on the samples showed average to high counts of mold and bacteria growth. Also, pressure drop readings across the cooling coils were recorded, along with air entering and air leaving dry and wet bulb temperatures, to determine the system's existing cooling capacity. These steps established a baseline that would determine whether any of the system's existing performance characteristics would actually change and by how much.

Steril-Aire UVC Emitters were installed on 28 August, 1997 on a 16,000 cfm constant air volume DX system. The following results were achieved:

- Within a short time, the mold and bacteria in the system and the associated odors disappeared
- Identical microbial sampling gathered only a few days after the installation verified an average 99% drop in colony-forming units over the original samples
- Pressure drop across the cooling coil decreased by over 30% (Fig 1)
- System air flow went from 16,000 cfm to 17,400 cfm – an increase of 8.6% (Fig 2)
- Wet and dry bulb leaving temperatures also dropped (Fig 3 and 4), thus providing a greater temperature differential between entering air and leaving air



This combination of factors has brought about an increase in cooling capacity. Because the rejuvenated coils allow more heat transfer and air volume, US Air Conditioning Distributors is enjoying a 30% increase in total system cooling capacity from 548,502 (prior to UVC installation) to 797,094 BTU. Testing performed over the next year showed equal or better results, thereby maintaining the increased capacity and energy efficiency.

Based on a conservative 3,000 annual operating hours, an energy efficiency ratio (EER) of 8, and an energy cost of US $0.10 per kWh, the company realized a first year energy improvement of over US $5,000. Subtracting initial UVC installation and operating costs from this total, US-Air achieved a complete payback in the first year. In subsequent years, US Air Conditioning Distributors achieved an annual savings of over US $4,000.

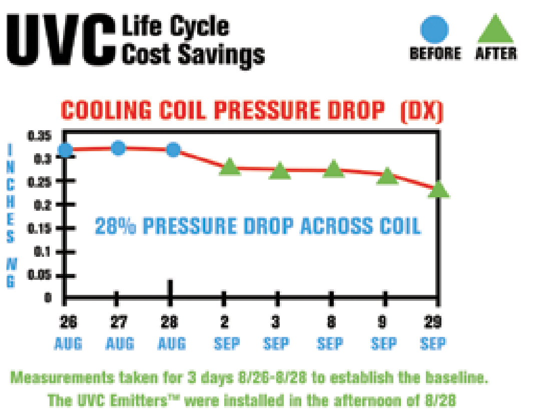


Figure 1

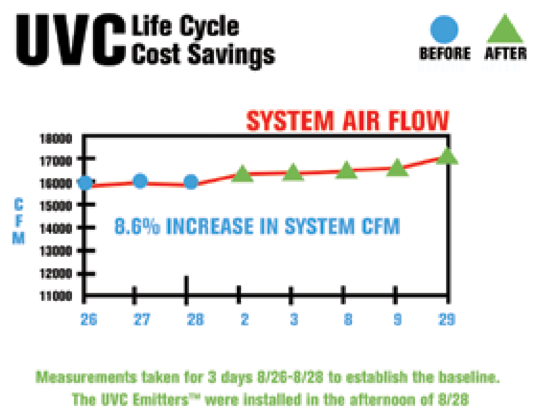


Figure 2

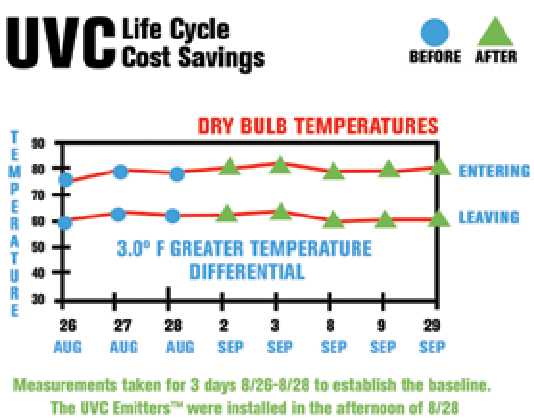


Figure 3

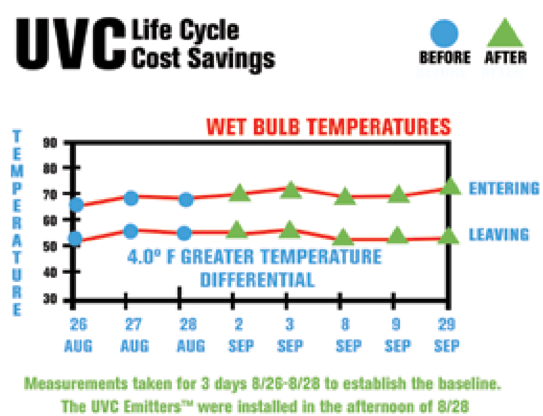
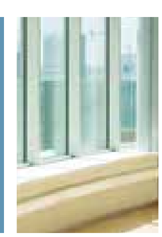


Figure 4



Auckland Airport, New Zealand

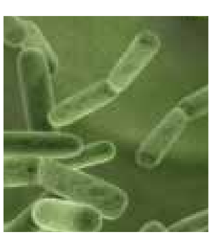
As the passenger traffic of this major international airport increased by 4.9%, Auckland Airport was tasked to reduce the carbon footprint by 5% before 2012. This ambitious goal was met by 2010 – two full years ahead of schedule with some truly remarkable developments through the use of Steril-Aire UVC Emitters:

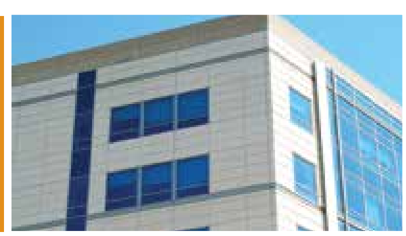
- Reduction in energy costs of US $272,000 per year
- Reduction in carbon emissions
- Reduction of AHU microbial load by 99% within 31 days
- Air quality for 13 million passengers a year was drastically improved by air and cooling coil decontamination
- All work was completed with NO disruption of service and NO passenger interruption
- Tremendous operating cost savings were realized

UVC Inclusion by Key Global Organizations

World leaders are focused on reducing greenhouse gas (GHG) pollution and sustainability. As called for in the U.S., Executive Order 13514, the U.S. Federal Government is committed to reducing its GHG pollution by 28 percent by 2020 and ensuring the Federal Government leads by example in improving the environmental, energy and economic performance. Other countries have initiated GHG compliance guidelines and some have levied GHG emission taxes. The U.S. Green Building Council and other sustainability rating systems recognize buildings that have met stringent guidelines for energy conservation, water conservation and improve indoor environmental quality.

Government agencies around the world and the HVAC community are increasingly aware of the benefits of UVC. The U.S. General Services Administration specifies that UVC be included in cooling coil air-handling units for all new facilities and alteration projects, recognizing the importance of UVC in reducing energy consumption and improving indoor air quality. The U.S. Centers for Disease Control and Prevention supports the use of UVC as an adjunct to mechanical ventilation and filtration to prevent and control the spread of tuberculosis. The Federal Emergency Management Agency and Environmental Protection Agency (EPA) note that UVC technologies can be used to provide protection against bioterrorism.



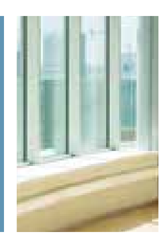



ASHRAE Position

The use of UVC for HVAC systems has been identified by ASHRAE – the world's foremost authority on air conditioning. The importance of UVC as an effective engineering tool in combating fungal and microbial growth in air conditioning systems and maintaining clean cooling coils has prompted ASHRAE to include a chapter on "Ultraviolet Lamp Systems" in the 2008 ASHRAE Handbook and a chapter on "Ultraviolet Air and Surface Treatment" in the 2011 ASHRAE Handbook.

The following is an excerpt from "Ultraviolet Lamp Systems" from the 2008 ASHRAE Handbook:

> *"UVGI (Ultraviolet Germicidal Irradiation) can be readily applied to HVAC systems to help maintain system cleanliness (Blatt et al. 2006). It is used to complement system maintenance by keeping coils, drain pans, and other surfaces clean and free of microbial contamination. Stationary surfaces receive UVC doses many orders of magnitude higher than microbes in moving air do, making it relatively easy, using lower levels of UV, to maintain heat exchange efficiency, design airflow, and to improve indoor air quality by reducing the growth of bacteria and mold on system components.*
>
> *UVGI reduces microbial levels on HVAC surfaces and often in the air (RLW Analytics 2006). Coil pressure drop is restored and, therefore, airflow is restored (Witham 2005). Because heat transfer also is restored, this combination can result in energy savings (Levetin et al. 2001), which can be significant, with payback of possibly less than two years (Montgomery and Baker 2006). In addition, the associated improvements in air quality may reduce respiratory distress symptoms and thus improve attendance and work performance in occupied spaces (Bernstein et al. 2006, Menzies et al. 2003)."*



Other Government and Healthcare Authorities and Professional Bodies Recognizing the Effective Use of UVC

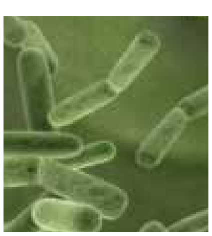
- **CNTC** (Francis J Curry National Tuberculosis Center)
- **USACHPPM** (U. S. Army Center for Health Promotion and Preventive Medicine)
- **HCHSA** (Health Care Health and Safety Association of Ontario)
- **BCA** (Singapore Building Construction Authority – “Green Building Design Guide”)
- **National University of Singapore** (Publication titled “Sustainability”)

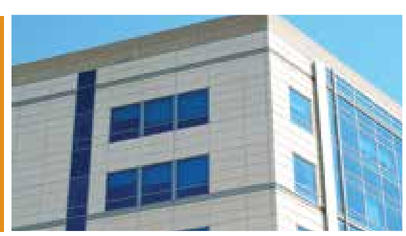
Summary

There is sufficient scientific and anecdotal evidence of effective use of UVC in air conditioning applications to maximize energy savings, reduce maintenance and operational costs and improve indoor air quality.

Studies of Steril-Aire UVC installations demonstrate a return on investment of less than two years through energy and maintenance savings. By continuously cleaning the coils and drain pans, Steril-Aire UVC destroys mold and bacteria in the HVAC system, resulting in maximum heat transfer across the coil and improved airflow. The HVAC system performs to original specification and optimum energy efficiency. Steril-Aire UVC Emitters supports maximizing the chiller plant performance, leading to reduced pumping energy, setting of higher chilled water temperature setpoints and higher chiller efficiencies.

Additionally, Steril-Aire UVC eliminates the need for costly and environmentally-damaging chemical cleaning of the coils. Cooling coil decontamination using Steril-Aire UVC has proven to have dramatic impact in energy and carbon emission reduction and improved HVAC operational efficiency.



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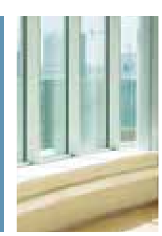

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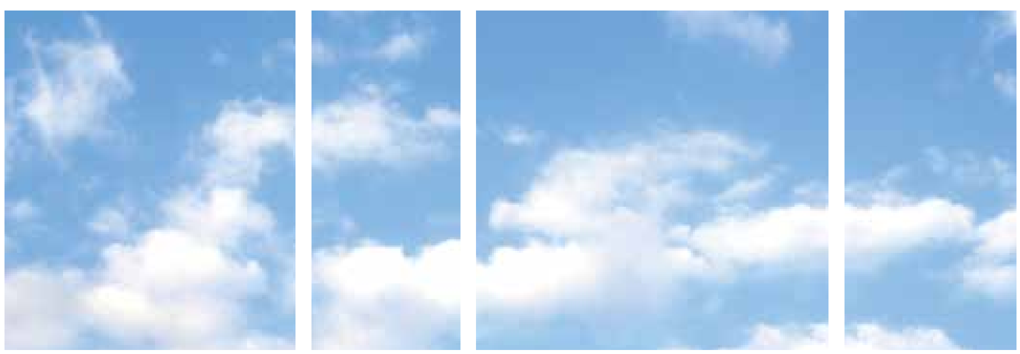
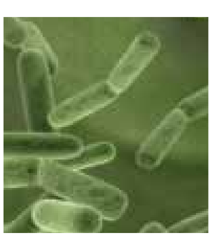
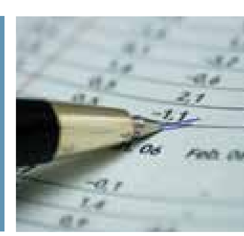




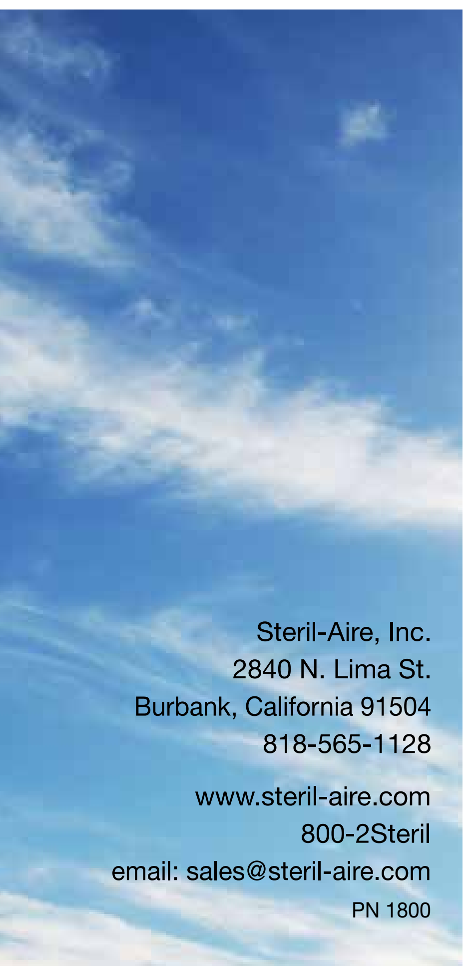


Sustainable solutions for healthier buildings

Founded in 1994 after a decade of intensive research and development, Steril-Aire launched an industry with its multi-patented devices that are systems-engineered specifically for the cold, moving air of an HVAC system.

Today, Steril-Aire remains the unrivaled leader in IAQ improvement in residential and commercial heating, ventilating, air conditioning and refrigeration systems. All products are manufactured in an ISO 9001:2008 facility.

From reducing energy consumption and controlling costs, to optimizing both human and mechanical productivity, UVC solutions from Steril-Aire pay measurable dividends to your bottom line.



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