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03 April 2012

To whom it may concern:

Re: Superior Air Solutions - Steril-Aire UVC Emitter Project Auckland International Airport

In 2010 Auckland Airport commissioned a detailed energy audit of its international terminal building. One of the recommendations from that audit was the installation of Steril-Aire UVC emitters to clean HVAC coils. This would reduce energy costs through having constantly clean coils optimizing heat transfer and cooling efficiencies.

Auckland Airport engaged Superior Air Solutions as the NZ distributor of the Steril-Aire UVC emitters. Superior Air Solutions completed several free trials, on different air handlers of differing ages, to prove the concept to us.

A full-scale installation then followed, covering over one hundred air handling units across our entire international terminal. The highlights were:

- Completed on time and on budget;
- Completed with no disruption to tenants and/or passengers;
- Verified energy savings of 2,480MWhr per annum;
- Energy costs savings of NZ$272,800 per annum;
- Carbon footprint reduction of over 400 metric tonnes;
- A simple payback of less than 1.5 years;
- Annual energy costs, as a portion of operating costs, fell below four per cent for the first time in four years.

The above figures are potentially conservative. The installation occurred during a time when there was an increasing load on the HVAC system due to:

- Significant refurbishments of both departure and arrival terminal areas; A 4.9% increase in international passenger numbers; An increase in retail space and retail tenants.

Several other benefits have not been measured:

- Maintenance savings due to a much cleaner HVAC system;
- An improved working environment, due to air in the workplace being sterilised. This could potentially lead to lower staff absenteeism;
- An improved passenger experience, and comfort, due to awareness of sterilised air in the terminal space.

I have no hesitation in recommending Superior Air Solutions and the Steril-Aire UVC product.

Yours sincerely,

M Fryer

Martin Fryer PGDip, MIEnvSc, CEnv.
Sustainability Advisor

Auckland International Airport Limited

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CPEng, MIPENZ, IntPE (NZ), BE(Mech)

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Auckland International Airport Ltd
International Terminal

Steril-aire UVC installation
AHU T2-16
AHU T2-20
AHU T3-15

Verification of energy savings

Prepared for: Martin Fryer – Sustainability Advisor

File ref: 3108-1
July 2011

Executive Summary

In the period from July to December 2010, Auckland International Airport Ltd installed ultraviolet sterilisation lamps into all of the air handling units in the International Terminal Building.

Three of the units were selected to have their performance measured pior to the installation of the UVC and after completion of the installation. The post installation measurements were carried out about one month after installation.

The suppliers of the UVC systems, Steril-aire Inc, reported on the improvements found in the measured units.

This report is to verify the claimed savings.

An individual analysis of the savings for each of the three units claimed by Steril-aire, calculating a series of key energy performance indicators from first principles, and comparing them against the figures produced by the supplier.

The conclusion from the analyses are:

. It is verified that the savings figures provided by Steril-aire are correct and are substantiated by calculations from first principles. In the majority of the indicators, these figures agree within 2% of each other. There were two cases where the variance was greater, but these have been examined and the differences justified. The calculations are included as section 5 to this report, and the comparisons between the original figures and the assessments are included as section 4 in the report.

Introduction

In the period from July 2010 to December 2010, Auckland International Airport Ltd (AIAL) contracted Excellence in Air Ltd to progressively install their Steril-aire UVC sterilisation lamp systems in all of the air handling units (AHUs) in the International Terminal Building.

The performance and energy savings on three AHUs were measured before and after the UVC installation and reported to AIAL. This report reviews the energy savings achieved, analyses and verifies the savings on the three nominated units reported by Steril-aire.

There are 92 AHUs in the building, all of which had UVC installed over the six month programme.
The AHUs tested were:
AHU T2-16, installed in the Terminal 2 area, serving the Semi-Sterile Lobby, AHU
T2-20, installed in the Terminal 2 area, serving the MAF/Customs search area, AHU
T3-15, installed in the Terminal 3 area, serving parts of the Arrivals area.

Individual Analysis

Calculations were carried out on the raw data provided by Steril-aire for the three AHUs and key performance figures were determined from first principles using the ASHRAE psychrometric chart. Calculations are shown in section 5.2. These look at:

- The change in cooling capacicity through the cooling coil, both in absolute cooling kW achieved, and in percentage change
- The change in airflow through the AHU for the same fan speed. An improvement will allow reduction in fan speed and hence fan kW for the same airflow as in the “dirty” coil
- The change in airside pressure drop through the coils
- The change in effectiveness of heat transfer to the chilled water. An improve,emt will allow the chilled water supply temperature to increase, and reduce the chiller power requirement.

Comparison with Steril-aire

A summary of the key performance improvement indicators is as follows:

AHU T2-16

Indicator	Steril-aire estimate	Calculated estimate
Cooling capacity kW improvement	40.2 kW	40.8 kW
Cooling coil percentage improvement	40%	41%

Airflow increase	19%	19%
Cooling and heating coil pressure drop decrease	7%	7%
Cooling coil effectiveness improvement	25%	11%*

* The difference in cooling coil effectiveness comes from the Steril Aire estimate being based on chilled water temperature differences only assuming that chilled water flow rate remains constant. The calculated figure adjusts for a change in chilled water flow rate to achieve the coil cooling load.

AHU T2-20

Indicator	Steril-aire estimate	Calculated estimate
Cooling capacity kW improvement	19.2 kW	20.9 kW
Cooling coil percentage improvement	23%	24%
Airflow increase	14%	14%
Cooling and heating coil pressure drop decrease	15%	15%
Cooling coil effectiveness improvement	27%	26%

AHU T3-15

Indicator	Steril-aire estimate	Calculated estimate
Cooling capacity kW improvement	25.0 kW (18.6 kW)*	18.2 kW
Cooling coil percentage improvement	49% (31%)*	32%
Airflow increase	9%	9%
Cooling and heating coil pressure drop decrease	13%	13%
Cooling coil effectiveness improvement	29%	27%

* The original numbers in the original Steril-aire estimate sheet have been checked and a revised estimate sheet calculated. The numbers in brackets are the revised numbers (revised sheet is attached in section 5).

In general terms, except as noted above, it can be confirmed that the Steril-aire estimates of performance improvements give a fair representation of the gains made from the installation of the UVC system in these AHUs. It can fairly be assumed that similar improvements will be achieved with the other AHUs also.

Individual analysis

Measured values provided by Steril-Aire have converted from imperial to metric values. Energy calculations below are on the basis of the pre and post UVC measurements provided by Steril-aire.

AHU T2-16 (fixed speed)

Pre UVC installation

Item	Units	Entering air	Leaving air
Air flow	m^3/sec	4.56	
Dry bulb temperature	^oC	20.4	9.3
Wet bulb temperature	^oC	14.5	8.9
Relative humidity	%	52.5%	95.4%
Density	kg/m^3	1.197	1.245
Enthalpy	kJ/kg	40.470	26.909
Moisture content	g water/m^3 air	9.343	8.615
ChW temperature	^oC	6.4	9.2
Coil pressure drop	Pa	163	

Air mass flow = 4.56 m^3/sec x 1.197 kg/m^3

	= 5.458 kg/sec
Enthalpy change	= 40.470 kJ/kg – 26.909 kJ/kg
	= 13.561 kJ/kg
Heat removed in coil	= 5.458 kg/sec x 13.561 kJ/kg
	= 74.0 kW
Condensation in coil	= 9.343 g/m^3 – 8.615 g/m^3
	= 0.728 g/m^3
	= 0.728 g/m^3 x 4.56 m^3/sec
	= 3.320 g/sec
	= 11.95 kg/hr
Chilled water heat removal	= 74.0 kW (assuming no losses from coil)
ChW temperature rise	= 9.2^{o}C – 6.4^{o}C
	= 2.8 K
ChW mass flow	= Q/ (C_p x ΔT)
	= 74.0 kW / (1.003 x 2.8)
	= 26.3 kg/sec
Specific ChW temperature rise	= 2.8 K / 26.3 kg/sec
	= 0.106 K/(kg/sec)

Item	Units	Entering cooling coil	Leaving cooling coil
Air flow	m^3/sec	5.43	
Dry bulb temperature	^{o}C	21.1	9.1
Wet bulb temperature	^{o}C	14.7	8.1
Relative humidity	%	49.7%	87.9%
Density	kg/m^3	1.194	1.247
Enthalpy	kJ/kg	41.049	24.974
Moisture content	g water/m^3 air	9.227	7.812
ChW temperature	^{o}C	6.2	9.7
Coil pressure drop	Pa	151	

Post UVC installation

AHU T2-16 Energy Performance Indicators

Air mass flow	= 5.43 m^3/sec x 1.194 kg/m^3
	= 6.483 kg/sec
Enthalpy change	= 41.049 kJ/kg – 24.974 kJ/kg
	= 16.075 kJ/kg
Heat removed in coil	= 6.483 kg/sec x 16.075 kJ/kg
	= 104.2 kW
Condensation in coil	= 9.227 g/m^3 – 7.812 g/m^3
	= 1.415 g/m^3
	= 1.415 g/m^3 x 5.43 m^3/sec
	= 7.683 g/sec
	= 27.66 kg/hr
Chilled water heat removal	= 104.2 kW (assuming no losses from coil)
ChW temperature rise	= 9.7^{o}C – 6.2^{o}C
	= 3.5 K
ChW mass flow	= Q/ (C_p x ΔT)
	= 104.2 kW / (1.003 x 3.5)
	= 29.7 kg/sec
Specific ChW temperature rise	= 3.5 K / 29.7 kg/sec
	= 0.118 K/(kg/sec)
Improvement in air volume flow at 50Hz	= (5.43 m^3/sec – 4.56 m^3/sec) / 4.56 m^3/sec
	= 19.1%
Improvement in thermal performance	= (104.2 kW – 74.0 kW) / 74.0 kW
	= 40.8%
Improvement in heat exchange effectiveness	= change in ChW temperature rise per kg/sec water flow
	= (0.118 – 0.106) / 0.106
	= 11.3%
Reduction in coil pressure drop	= (163 Pa – 151 Pa) / 163 Pa
	= 7.4%
Design airflow from AIAL records	= 4.60 m^3/sec
Measured airflow pre UVC installation	= 4.56 m^3/sec (99% of design flow rate)
Measured airflow post UVC installation	= 5.43 m^3/sec (118% of design airflow)

AHU T2-20 (fixed speed)

Pre UVC installation

Item	Units	Entering air	Leaving air

Air flow	m^3/sec	4.76	
Dry bulb temperature	^{o}C	21.8	8.9
Wet bulb temperature	^{o}C	14.8	8.4
Relative humidity	%	46.8%	93.7%
Density	kg/m^3	1.192	1.247
Enthalpy	kJ/kg	41.295	25.710
Moisture content	g water/m^3 air	9.026	8.246
ChW temperature	^{o}C	6.0	8.7
Coil pressure drop	Pa	140	

Air mass flow = 4.76 m^3/sec x 1.192 kg/m^3
= 5.674 kg/sec

Enthalpy change = 41.295 kJ/kg – 25.710 kJ/kg
= 15.585 kJ/kg

Heat removed in coil = 5.674 kg/sec x 15.585 kJ/kg
= 88.4 kW

Condensation in coil = 9.026 g/m^3 – 8.246 g/m^3
= 0.780 g/m^3
= 0.780 g/m^3 x 4.76m^3/sec
= 3.713 g/sec
= 13.37 kg/hr

Chilled water heat removal = 88.4 kW (assuming no losses from coil)
ChW temperature rise = 8.7^{o}C – 6.0^{o}C
= 2.7 K
ChW mass flow = Q/ (C_p x ΔT)
= 88.4 kW / (1.003 x 2.7)
= 32.6 kg/sec
Specific ChW temperature rise = 2.7 K / 32.6 kg/sec
= 0.083 K/(kg/sec)

Post UVC installation

Item	Units	Entering air	Leaving air
Air flow	m^3/sec	5.43	
Dry bulb temperature	^{o}C	21.8	8.7
Wet bulb temperature	^{o}C	14.9	8.0
Relative humidity	%	47.1%	91.0%
Density	kg/m^3	1.191	1.248
Enthalpy	kJ/kg	41.729	24.829
Moisture content	g water/m^3 air	9.158	7.917
ChW temperature	^{o}C	6.3	9.7
Coil pressure drop	Pa	119	

Air mass flow = 5.43 m^3/sec x 1.191 kg/m^3
= 6.467 kg/sec

Enthalpy change = 41.729 kJ/kg – 24.829 kJ/kg
= 16.900 kJ/kg

Heat removed in coil = 6.467 kg/sec x 17.073 kJ/kg

= 109.3 kW

Condensation in coil = 9.158 g/m^3 – 7.917 g/m^3
= 1.241 g/m^3
= 1.241 g/m^3 x 5.43 m^3/sec
= 6.739 g/sec
= 24.26 kg/hr

Chilled water heat removal = 109.3 kW (assuming no losses from coil)
ChW temperature rise = 9.7°C – 6.3°C
= 3.4 K
ChW mass flow = Q/ (C_p x ΔT)
= 109.3 kW / (1.003 x 3.4)
= 32.1 kg/sec
Specific ChW temperature rise = 3.4 K / 32.1 kg/sec
= 0.106 K/(kg/sec)

AHU T2-20 Energy Performance Indicators
Improvement in air volume flow at 50Hz = (5.43 m^3/sec – 4.76 m^3/sec) / 4.76 m^3/sec
= 14.1%
Improvement in thermal performance = (109.3 kW – 88.4 kW) / 88.4 kW
= 23.6%
Improvement in heat exchange effectiveness = change in ChW temperature rise per kg/sec water flow
= (0.105 – 0.083) / 0.083
= 26.5%
Reduction in coil pressure drop = (140 Pa – 119 Pa) / 140 Pa
= 15.0%
Design airflow from AIAL records = 5.70 m^3/sec
Measured airflow pre UVC installation = 4.76 m^3/sec (84% of design flow rate)
Measured airflow post UVC installation = 5.43 m^3/sec (95% of design airflow

AHU T3-15 (VSD volume control)
Pre UVC installation

Item	Units	Entering air	Leaving air
Air flow	m^3/sec	4.105	
Dry bulb temperature	°C	19.8	10.0
Wet bulb temperature	°C	13.9	9.1
Relative humidity	%	51.8%	88.6%
Density	kg/m^3	1.200	1.242
Enthalpy	kJ/kg	38.895	27.286
Moisture content	g water/m^3 air	8.903	8.402
ChW temperature	°C	6.6	9.0
Coil pressure drop	Pa	204	

Air mass flow = 4.105 m^3/sec x 1.200 kg/m^3
= 4.926 kg/sec

Enthalpy change = 38.895 kJ/kg – 27.286 kJ/kg
= 11.609 kJ/kg

Heat removed in coil = 4.926 kg/sec x 11.609 kJ/kg

= 57.2 kW

Condensation in coil = 8.903 g/m^3 – 8.402 g/m^3
= 0.501501449 g/m^3 x 4.105 m^3/sec
= 2.057 g/sec
= 6.40 kg/hr

Chilled water heat removal = 57.2 kW (assuming no losses from coil)
ChW temperature rise = 9.0^{o}C – 6.6^{o}C
= 2.4 K
ChW mass flow = Q/ (C_p x ΔT)
= 57.2 kW / (1.003 x 2.4)
= 23.8 kg/sec
Specific ChW temperature rise = 2.4 K / 23.8 kg/sec
= 0.101K/(kg/sec)

Post UVC installation

Item	Units	Entering air	Leaving air
Air flow	m^3/sec	4.475	
Dry bulb temperature	^{o}C	18.7	8.7
Wet bulb temperature	^{o}C	13.9	8.0
Relative humidity	%	58.6%	91.0%
Density	kg/m^3	1.204	1.248
Enthalpy	kJ/kg	38.836	24.829
Moisture content	g water/m^3 air	9.443	7.917
ChW temperature	^{o}C	6.2	9.3
Coil pressure drop	Pa	178	

Air mass flow = 4.475 m^3/sec x 1.204 kg/m^3
= 5.388 kg/sec

Enthalpy change = 38.836 kJ/kg – 24.829 kJ/kg
= 14.007 kJ/kg

Heat removed in coil = 5.388 kg/sec x 14.007 kJ/kg
= 75.5 kW

Condensation in coil = 9.443 g/m^3 – 7.917 g/m^3
= 1.526 g/m^3
= 1.523 g/m^3 x 4.475 m^3/sec
= 6.829 g/sec
= 24.58 kg/hr

Chilled water heat removal = 75.5 kW (assuming no losses from coil)
ChW temperature rise = 9.3^{o}C – 6.2^{o}C
= 3.1 K
ChW mass flow = Q/ (C_p x ΔT)
= 75.5 kW / (1.003 x 3.1)
= 24.3 kg/sec
Specific ChW temperature rise = 3.1 K / 24.3 kg/sec
= 0.128 K/(kg/sec)

AHU T3-15 Energy Performance Indicators

Improvement in air volume flow at 50Hz	= (4.475 m^3/sec – 4.105 m^3/sec) / 4.105 m^3/sec
	= 9.0%
Improvement in thermal performance	= (75.5 kW – 57.3 kW) / 57.3 kW
	= 31.8%
Improvement in heat exchange effectiveness	= change in ChW temperature rise per kg/sec water flow
	= (0.128 – 0.101) / 0.101
	= 26.7%
Reduction in coil pressure drop	= (204 Pa – 178 Pa) / 204 Pa
	= 12.7%
Design airflow from AIAL records	= 4.845 m^3/sec
Measured airflow pre UVC installation	= 4.105 m^3/sec (85% of design flow rate)
Measured airflow post UVC installation	= 4.475 m^3/sec (92% of design airflow

STERIL-AIRE™, Inc. ©

LIFE CYCLE COST - ESTIMATE SHEET

AIAL
Terminal 3

AHU T3-15

26-Jul-11
Martin Fryer
IAF
Econair

Fill In All Yellow Blo **Answers Are InGreen and ›rey**

Project Name:Date: Location:Contact:

Engineer:

AHU Tagging:Contractor:

UVC Installation	**Before**				**After**	
Date			21-Jul-10		8-Oct-10	
Measured Air Flow m3/h (CFM)			14,778	8698	16,110	9482
Entering Air Temperature - Dry Bulb °C (F°)			19.80	67.6	18.70	65.7
Entering Air Temperature - Wet Bulb °C (F°)			13.90	57.0	13.90	57.0
Leaving Air Temperature - Dry Bulb °C (F°)			10.00	50.0	8.70	47.7
Leaving Air temperature - Wet Bulb °C (F°)			9.10	48.4	8.00	46.4
Total Cooling Capacity - Watt (BTU)			60,491	206,273	79,082	269,668
Sensible Heat -Watt (BTU)	48,595	165,707				54,056 184,330
Latent Heat - Watt (BTU)	11,897	40,566				25,026 85,338
Net Cooling Capacity Gain - Watt				18,591		

Pressure Drop "Across Cooling Coil" (Wg)	0.819" WG		0.715" WG	
Pressure Drop "Across Cooling Coil" (Pa)	204	Pa	178	Pa
Pressure Drop Reduction	0.104" WG			
Pressure Drop BHP Reduction	0.260	EER:	7.0	
Annual Operating Hours	2,190		BEFORE	
Energy Cost per kWh	$0.12	EER:	8.6	2.54
Annual Improvement (kWh cost)	$2,471.47		AFTER	
Annual Coil Cleaner & Biocide Cost	$250.00 $1,800.00			

	1st Year	2nd Year	3rd Year	4th Year
Annual Coil Cleaning Labour Cost				
Annual Drain Pan Cleaner & Biocide Cost	$2,050.00			
Annual Drain Pan Labour Cost				
Annual Maintenance Costs				
Total Annual Improvement	$ 4,521.47			
Installation Costs	1st Year	2nd Year	3rd Year	4th Year
Number of Fixtures	4			
Average Fixture Cost Each	520.22			
Installation Labour & Material (misc) Costs	682.50			
Fixture(s)Annual Energy Cost (8760 hrs)	314.31	314.31	314.31	314.31
Emitter Replacement Cost (each)		230.00	230.00	230.00
Annual Emitter Replacement Cost		$920.00	920.00	920.00
Total Installed & Operating Cost	$3,077.69	$1,234.31	$1,234.31	$1,234.31
Annual Improvement (Less Costs)	$1,443.78	$3,287.16	$3,287.16	$3,287.16
Estimated Return on Investment (Months)	8.2			
Cumulative Improvement	$1,443.78	$4,730.94	$8,018.10	$11,305.27

Pure Air. Real Science.™

An Energy Saving, Indoor Air Quality, Bio-Security & Sustainability Initiative

For

UVC Study Report

Terminal 3 AHU T3-15

Terminal 2 AHU T2-16 Semi-Sterile Lobby

Terminal 2 AHU T2-20 MAF/Customs Search

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Table of Contents

Martin Fryer
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Auckland International Airport Ltd

February 5th , 2011

Study Introduction

Product Technology Overview

Steril-Aires world leading UVC technology provides multiple benefits with a short return on investment.

Energy Saving:

The biofilms that build up on the cooling and heating exchange plates (or fins) inhibit the heat transfer process and reduce the airflow.

Steril-Aire's Emitters™ destroy these biofilms restoring and maintaining coils to their `original' as near original performance and efficiency. Typical savings are 10-30%.

Maintenance Savings:

By destroying the biofilm and organic build up on the cooling coils Steril-Aires Emitters™ eliminate the need for manual cleaning and chemical usage. Coils, drain pans and plenums stay free of mould and bacteria.

Duct cleaning can also be reduced or eliminated (depending on the severity of contamination and filtration standards) as the cooling coils and drain pans are the food source for the mould that grows downstream in the duct work. The high output UVC Emitters™ destroy the food source so the mould in the duct work starves and dies.

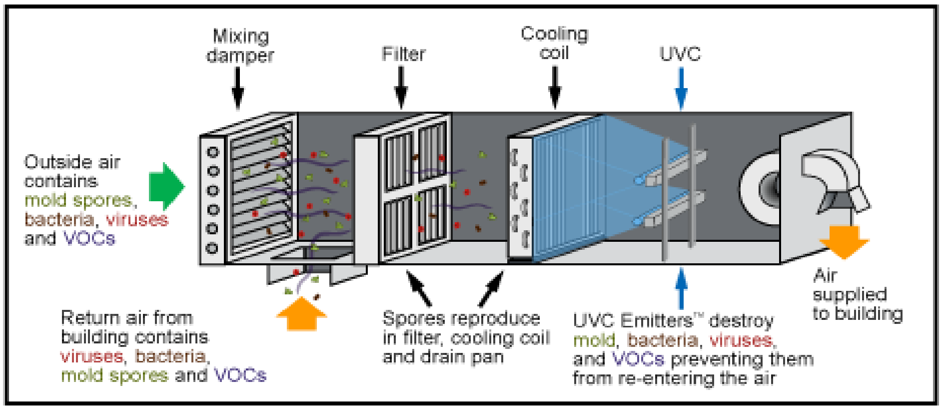
Other maintenance benefits include free flowing drain pans and drain lines (no slime/algae build up) and removal of odours caused by the mould growing in HVAC system and also odours created within the building.

Health:

Steril-Aire EmittersTM can eliminate up to 99.9% of airborne viruses and bacteria and other microbes, significantly improving indoor air quality (IAQ).

Provide staff and passengers protection against future pandemics. Steril-Aires high output UVC is very effective against viruses such as flu strains, SARS, pneumonia, TB (incl new super strains recorded around Australasia) and the common cold.

Reduced allergy and asthma symptoms triggered by biofilm and mould. Independent studies have shown up to 60% reductions in Hospital Acquired Infections, 50% reduction in school staff absenteeism and improved productivity when using Steril-Aire UVC Emitters.



Sustainability:

This can be achieved in many ways with the use of Steril-Aires EmittersTM:

- **Destroys Bacteria in condensate water from the drain pans allowing it to be recycled. An example is make-up water in cooling towers, resulting in a reduction in water and chemical consumption.**
- **Reducing chemicals used within the building**
- **Reduce Ozone created within the building from photo copiers, furniture etc**
- **Extending the life of the air conditioning equipment by restoring and keeping components and interior surfaces clean and free of mould and organics containing moisture causing corrosion and degredation.**

A simple effective way of reducing carbon footprint with so many other benefits.

Study Objectives

To show significant performance improvements:

- **Visual difference in cleanliness of cooling coils and drain pans**
- **Efficiency improvement from better coil heat transfer resulting in a 10-30% energy reduction**
- **Improved Indoor Air Quality**
- **Reduction in mould growth within system**
- **Produce clean condensate water suitable for recycling**
- **Return on Investment in under 2-Years**

Tests to be conducted before and after UVC installation:

- **Wet and Dry Bulb temperatures before and after cooling coil**
- **Cooling coil pressure drop**
- **Airflow/velocity readings**
- **CHW Delta T**
- **Coil and drain pan surface contact plates**

Using the above data, AHU manufacturers design performance and basic HVAC guidelines from ASHRAE/AIRAH we can calculate efficiency improvements.

AHU-T3-15 Test Results @ 32 Days

Manufacturer: **Clever MC190 4700 l/s 9958 CFM Variable Speed Drive**
Commissioned: **2008**

Pre Testing Date: 21/07/10
UVC Operational Date: 06/09/10
Post Testing Date: 08/10/10 (32 days of UVC operation)

AHU T3-15 Condition: Well maintained. Meets NZ/AS3666.2 except no access to air off side of Cooling Coil & air on side of Heating Coil.

PO Box 73 Manukau City, 2108 Auckland
Phone: 0800 000 510 Fax: 09 536 5840 Email: robyn@excellenceinair.co.nz

Testing for AHU T3-15 included:

- AHU entering and leaving Temperature (wet and dry bulb) using data loggers.
- Airflow using BMS supply air sensors, VSD and digital vane anemometer at return air transom.
- Variable Speed drive (VSD) inputs and outputs.
- Pressure drop across the cooling coil using a dual port manometer (filters removed).
- Chilled Water coil entering and leaving temperatures.
- Rodac contact plates used for checking before and after microbial counts on coils and drain pans.

Each testing period is carried out with the system at 100% load (50HZ output on VSD).

Note: There is no access to Cooling Coil air off side or Heating Coil air on side for manual cleaning. UVC light has to pass through heating coil before treating biofilm on Cooling coil.

As coil cleaning of Cooling coil air off side is not possible the cost to remove the coils for cleaning annually to meet NZ/AS 3666.2 is reflected in the Life Cycle Estimate.

Airflow:

AHU-T3-15 Supply Air Duct (metres/sec) measured by BMS	21/07/10	8/10/10
VSD @ 50HZ	7.6 m/s	8.2 m/s
Improvement	**9%**	

Variable Speed drive (VSD):

AHU-T3-15 Supply Air Duct (metres/sec) measured by BMS	21/07/10	8/10/10
VSD output @ 7.6 m/s	50HZ 10.9 Amps 5.5 kW	45HZ 9.3 Amps 4.3 kW
Fan Motor Reduction	**22% reduction in power 1.2 kW**	

Variable Speed Drives (VSD) do not achieve maximum motor energy savings unless AHU coils are kept perpetually clean, and at the same time the improved heat transfer from bathing the coils in Steril-Aire very high output UVC Technology results in significant additional energy savings at the chiller plant.

Coil Pressure drop:

21/07/10 VSD@50HZ	8/10/10 VSD@50HZ
204 Pa (pascal)	178 Pa (pascal)
Coil Pressure Drop Reduction **13%**	

The reduction in static pressure shows that the UVC is destroying the build-up of biofilm on the Cooling fins. Less restriction means more airflow and better heat transfer.

Chilled Water Coil – Entering/Leaving Delta T:

21/07/10 VSD@50HZ		8/10/10 VSD@50HZ	
CHW Entering Temp	6.6 deg C	**CHW Entering Temp**	6.2 deg C
CHW Leaving Temp	9.0 deg C	**CHW Leaving Temp**	9.3 deg C
CHW Delta T	2.4 deg C	**CHW Delta T**	3.1 deg C

Heat Transfer Efficiency Improvement: **29%**

An increase in the chilled water entering and leaving temperature difference (Delta T) is a clear indication that the coil is operating more efficiently. The chilled water pumped through the coil is absorbing more heat from the air as it passes through the clean cooling fins.

AHU T2-16 Semi-Sterile Lobby Test results @ 31 Days

Manufacturer: **York 40X60 5700 l/s 12077 CFM (Constant Volume) Commissioned: 1997**

Pre Testing Date: 19/07/10
UVC Operational Date: 07/09/10
Post Testing Date: 08/10/10 (31 days of UVC operation)

AHU T2-16 Condition: Well maintained. Meets NZ/AS3666.2 except no access to air-off side of Cooling Coil & air-on side of Heating Coil.

Testing for AHU-T2-16 included:

- AHU entering and leaving Temperature (wet and dry bulb) using data loggers

- Airflow at AHU supply duct sample points using a Hot Wire anemometer. Readings taken as a mean average over 30 seconds at each point (filters removed).

- Pressure drop across the cooling coil using a Magnehelic gauge (filters removed).

- Rodac contact plates used for checking before and after microbial counts on coils and drain pans.

Each testing period is carried out with the system at 100%. Chilled water valve at 100% open. Outside air dampers closed and return air 100% open.

Note: Heating Coil is bolted directly onto the Cooling coil. There is no access to Cooling Coil air off side or Heating Coil air on side for manual cleaning. UVC light has to pass through heating coil before treating biofilm on Cooling coil.

As coil cleaning of Cooling coil air off side is not possible the cost to remove the coils for cleaning annually to meet NZ/AS 3666.2 is reflected in the Life Cycle Estimate.

Airflow:

AHU-T2-16 Return Air Duct Sample points (metres/sec)	19/7/10	8/10/10
Total Average	5.32 m/s	6.34 m/s
Improvement	**19%**	

Cooling Coil Pressure drop:

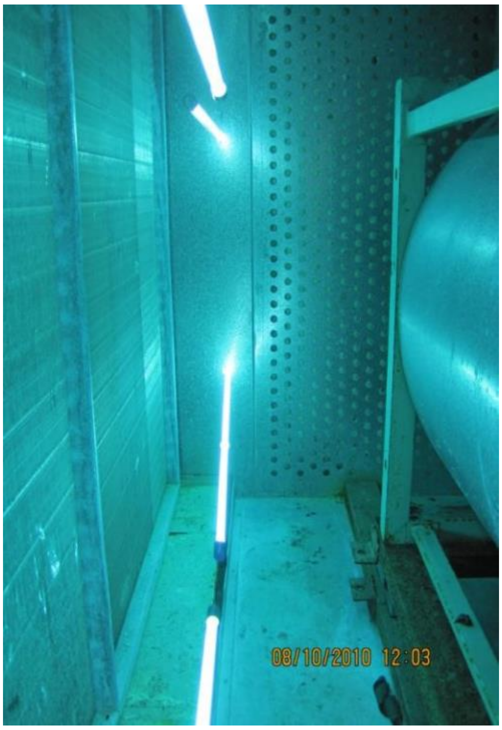
19/07/10	**8/10/10**
163 Pa (pascal)	151 Pa (pascal)
Coil Pressure Drop Reduction	**7 %**

The reduction in static pressure shows that the UVC is destroying the build-up of biofilm between the Heating and Cooling fins. Less restriction means more airflow and better heat transfer

Chilled Water Coil – Entering/Leaving Delta T:

19/07/10		8/10/10	
CHW Entering Temp	6.4 deg C	**CHW Entering Temp**	6.2 deg C
CHW Leaving Temp	9.2 deg C	**CHW Leaving Temp**	9.7 deg C
CHW Delta T	2.8 deg C	**CHW Delta T**	3.5 deg C
Heat Transfer Efficiency Improvement:	**25%**		

An increase in the chilled water entering and leaving temperature difference (Delta T) is a clear indication that the coil is operating more efficiently. The chilled water pumped through the coil is absorbing more heat from the air as it passes through the clean cooling fins.



Steril-Aire single ended fixtures mounted downstream of Heating Coils on AHU T2-16 (no access to cooling coil) bathing AHU plenum, drain pan and coils in 253.7 nanometer germicidal UVC.

AHU T2-20 MAF/Customs Search Test Results @ 31 days

Manufacturer: **York 40X60 5700 l/s 12077 CFM (Constant Volume) Commissioned: 1997**

Pre Testing Date: 19/07/10
UVC Operational Date: 07/09/10
Post Testing Date: 08/10/10 (31 days of UVC operation)

AHU T2-20 Condition: Well maintained. Meets NZ/AS3666.2 except no access to air off side of Cooling Coil & air on side of Heating Coil.

Testing for AHU-T2-20 included:

- AHU entering and leaving Temperature (wet and dry bulb) using data loggers
- Airflow at AHU supply duct sample points using a Hot Wire anemometer. Readings taken as a mean average over 30 seconds at each point (filters removed).
- Pressure drop across the cooling coil using a Magnehelic gauge (filters removed).
- Rodac contact plates used for checking before and after microbial counts on cooling coils and drain pans.

Each testing period is carried out with the system at 100%. Chilled water valve at 100% open. Outside air dampers closed and return air 100% open.

Note: Heating Coil is bolted directly onto the Cooling coil. There is no access to Cooling Coil air off side or Heating Coil air on side for manual cleaning. UVC light has to pass through heating coil before treating biofilm on Cooling coil.

As coil cleaning of Cooling coil air off side is not possible the cost to remove the coils for cleaning annually to meet NZ/AS 3666.2 is reflected in the Life Cycle Estimate.

Airflow:

AHU-T2-20 Supply Air Duct Sample points (metres/sec)	19/7/10	8/10/10
Total Average	6.64 m/s	7.51 m/s
Improvement	**14%**	

Cooling Coil Pressure drop:

19/07/10	8/10/10
140 Pa (pascal)	119 Pa (pascal)
Coil Pressure Drop Reduction **15 %**	

The reduction in static pressure shows that the UVC is destroying the build-up of biofilm between the Heating and Cooling fins. Less restriction means more airflow and better heat transfer.

Chilled Water Coil – Entering/Leaving Delta T:

19/07/10		8/10/10	
CHW Entering Temp	6.0 deg C	**CHW Entering Temp**	6.3 deg C
CHW Leaving Temp	8.7 deg C	**CHW Leaving Temp**	9.7 deg C
CHW Delta T	2.7 deg C	**CHW Delta T**	3.4 deg C
Heat Transfer Efficiency Improvement: **27%**			

An increase in the chilled water entering and leaving temperature difference (Delta T) is a clear indication that the coil is operating more efficiently. The chilled water pumped through the coil is absorbing more heat from the air as it passes through the clean cooling fins.

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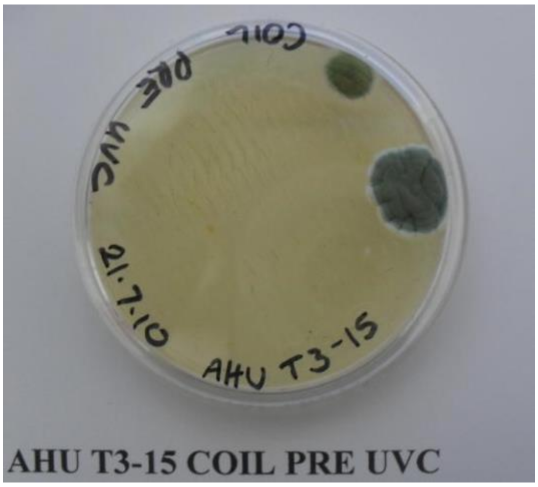
AHU T2-20 plenum with Steril-Aire very high output UVC Emitters™ installed

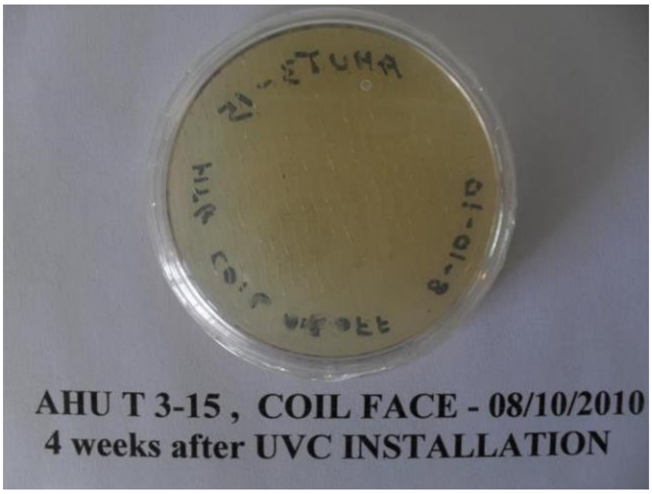
Microbial Testing: Auckland International Airport

Method: Surface sampling of Cooling Coils, Condensate Drain Trays and internal insulated Plenum walls using Rodac Contact Plates to indicate fungal and bacteria CFU's.

Plates: Certified Sabouraud Dextrose Agar, enough to form a positive meniscus.

Microbial Testing – AHU T3-15 @ 32 Days





Pre-UVC **Post-UVC**

Microbial Testing – AHU T2-16 @ 31 Days

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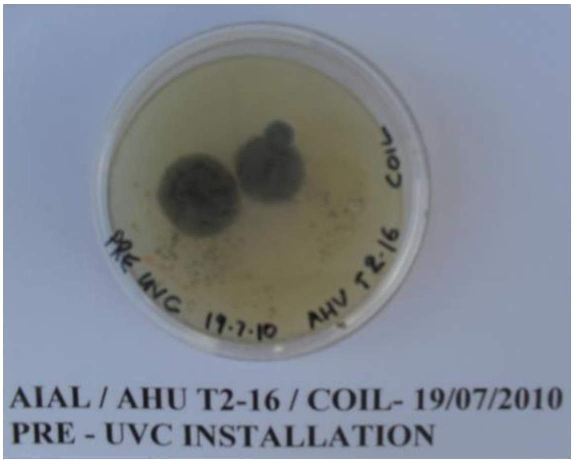
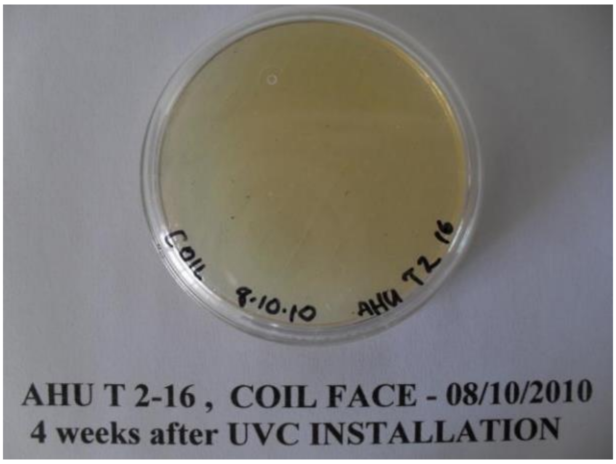
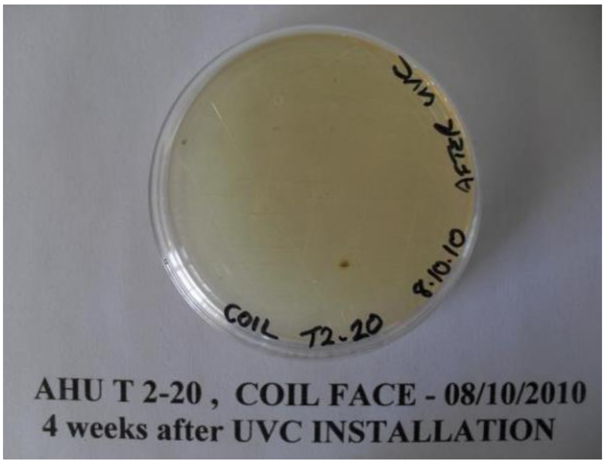




Pre-UVC

Post UVC
(Only non-organic particulate matter)

Microbial Testing – AHU T2-20 @ 31 Days



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Pre-UVC **Post-UVC**

Post samples show a 90% plus reduction in plate mould and bacteria Colony Forming Units (CFU)

Pre-UVC **Post-UVC (31 days)**

Removal of organic and non-organic material from the AHU T2-16 Heating Coil Air-Off side

Life Cycle Estimate:

The Life Cycle Estimate program provides a way of showing savings that can be achieved by using Steril-Aires Emitters™. The attached document entitled `Enthalpy' explains in detail how the program works.

In summary, the data retrieved during testing and associated costs with installing the Emitters™ is entered in to the program. The program then provides indications of the achievable savings over a 4Year period.

Please see attached Life Cycle Cost – Estimate Sheet for details
Data Logger Temperature and Humidity graphs used in Life Cycle Estimate attached

Summary of improvements: AHU-T3-15 (4700 l/s / 9958 CFM) @50HZ (except motor kWh)	
Cooling Capacity Gain:	**25 kW**
Airflow increase:	**9%**
Coil Pressure Drop Reduction:	**13%**
Cooling Coil Heat Transfer Efficiency Improvement:	**29%**
Motor kWh with VSD @7.6 m/s (All dampers 100%)	**22% Reduction**
Rodac Plates (Microbial):	**99% Reduction**
Return on Investment:	**7 Months**

Summary of improvements: AHU-T2-16 (5700 l/s / 12077 CFM)	
Cooling Capacity Gain:	**29.2 kW**
Airflow increase:	**19%**
Coil Pressure Drop Reduction:	**7%**
Cooling Coil Heat Transfer Efficiency Improvement:	**25%**
Rodac Plates (Microbial):	**99% Reduction**
Return on Investment:	**6.2 Months**

Summary of improvements: AHU-T2-20 (5700 l/s / 12077 CFM)	
Cooling Capacity Gain:	**19.2 kW**
Airflow increase:	**14%**
Coil Pressure Drop Reduction:	**15%**
Cooling Coil Heat Transfer Efficiency Improvement:	**27%**
Rodac Plates (Microbial):	**99% Reduction**
Return on Investment:	**8 Months**

Note: UVC Emitters will continue to make improvements to the cleanliness & efficiency of the systems

Carbon Emission Reduction:

We can estimate Carbon Emission Reductions based on the following:

- Greenhouse gas emission factors for New Zealand electricity: **174.5Kg CO2-e /MWhr**
- Unit cost of $0.12 per kWh of electricity
- Life Cycle Estimate kWh improvement s after installation and operating costs

AHU T3-15	Notes	Reduction in kWh	Reduction in Co2-emissions
1st Year	Installation & annual operating costs deducted	19’900 kWh	3,472 Kg of Co2-e
2nd Year & each Year after	Annual operating costs deducted Including Emitter replacements	35’258 kWh	6,152 Kg of Co2-e

AHU T2-16	Notes	Reduction in kWh	Reduction in Co2-emissions
1st Year	Installation & annual operating costs deducted	24’141 kWh	4,212 Kg of Co2-e
2nd Year & each Year after	Annual operating costs deducted Including Emitter replacements	39’508 kWh	6,894 Kg of Co2-e

AHU T2-20	Notes	Reduction in kWh	Reduction in Co2-emissions
1st Year	Installation & annual operating costs deducted	13’408 kWh	2,339 Kg of Co2-e

2nd Year & each Year after	**Annual operating costs deducted Including Emitter replacements**	**28’775 kWh**	**5,021 Kg of Co2-e**

Specification of Steril-Aires UVC Emitter output to achieve results:

Minimum 9 μW/cm^2 total output per 2.5 cm arc length of glass, measured at 1 metre distance in a 2.5 metres/sec airstream at a temperature of 7° C.

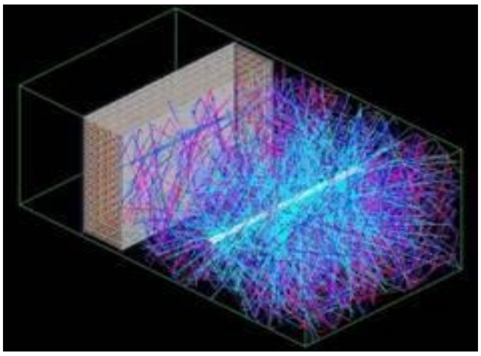
The minimal UVC energy striking the leading edge of all the coil fins shall not be less than 820 μW/cm^2 at the closest point and through placement, not less than 60% of that value at the farthest point.

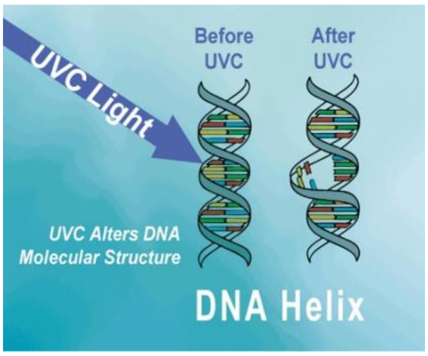
Study Summary:

The study results show that routine manual cleaning as per NZ/AS:3666.2 does not maintain HVAC equipment efficiencies.

Microbial results show that biofilm within the coils, surface mould and bacteria can easily reach levels that potentially affect building occupants.

Steril-Aire very high output UVC Emitters™ prove that efficiencies can be restored and maintained, energy and maintenance savings achieved and by keeping the coils, drain pans and plenum walls perpetually clean, overall system hygiene is significantly improved.





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Acknowledgements:

Econair for assistance in Testing and Verification
Siemens - BMS/VSD data
Excellence In Air Ltd (New Zealand Steril-Aire Distributor)

Report Written by: Malcolm Cain
Superior Air Solutions

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LIFE CYCLE COST - ESTIMATE SHEET

Fill In All Yellow Blocks		Answers Are In Green and Gray	
Project N	AIAA	Date:	05-Feb-11
Loca	Terminal 3	Contact:	Martin Fryer
AHU		Engineer:	MC
Tagging:	AHU T3-15	Contractor:	Econair

UVC Installation	Before		After
Date Sampled:			
CFM - Measured or Selected (VAV)	21-Jul-10		8-Oct-10
Entering Air Temperature - Dry Bulb °F			
Entering Air Temperature - Wet Bulb °F	8,697		9,480
Leaving Air Temperature - Dry Bulb °F	67.6		65.7
Leaving Air Temperature - Wet Bulb °F	57.0		57.1
Total Cooling Capacity - Btuh	50.0		47.7
Sensible Heat -Btuh	48.3		46.4
Latent Heat - Btuh **Net Cooling**	181,202		269,611
Capacity Gain - Btuh	164,843		184,291
	16,359		85,320
	→	88,409	

Pressure Drop "Across Coil"	0.82 " WG		0.71 " WG
Pressure Drop Reduction	0.11 " WG		
Pressure Drop BHP Reduction	0.273	EER:	7.0
Annual Operating Hours	2,190		Before
Energy Cost per kWh **Annual**	$0.12	EER:	9.3
Improvement (kWh cost)	$3,415		After

Annual Coil Cleaner & Biocide Cost	$250
Annual Coil Cleaning Labor Cost	$1,800
Annual Drain Pan Cleaner & biocide Cost	
Annual Drain Pan Labor Cost	
Annual Maintenance Costs	$2,050
Total Annual Improvement	$5,465

Installation Costs	1st Year	2nd Year	3rd Year	4th Year
Number of Fixtures	4			
Average Fixture Cost Each	520.22			
Installation Labor Cost	682.50			
Fixture(s) Annual Energy Cost (8760 hrs)	314.31	314.31	314.31	314.31
Emitter Replacement Cost (each)		230.00	230.00	230.00
Annual Emitter Replacement Cost		920.00	920.00	920.00

 For additional assistance please contact your local Steril-Aire representative or Steril-Aire direct at (562)467-8484.

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LIFE CYCLE COST - ESTIMATE SHEET

Fill In All Yellow Blocks

Answers Are In Green and Gray

Project Name: AIAA
Location: Terminal 3

AHU T2-16

Date: 05-Feb-11
Contact: Martin Fryer
Engineer: MC
Contractor: Econair

Total Installed & Operating Cost	$3,077.69	$1,234.31	$1,234.31	$1,234.31
Annual Improvement (Less Costs)	$2,388	$4,231	$4,231	$4,231
Estimated Return (years)	0.563			
Cumulative Improvement	$2,388	$6,619	$10,850	$15,081

AHU Tagging:

UVC Installation	Before		After
Date Sampled:	19-Jul-10		8-Oct-10
CFM - Measured or Selected (VAV)	9,663		11,500
Entering Air Temperature - Dry Bulb °F	68.8		70.0
Entering Air Temperature - Wet Bulb °F	58.1		58.5
Leaving Air Temperature - Dry Bulb °F	48.8		48.3
Leaving Air Temperature - Wet Bulb °F	48.0		46.6
Total Cooling Capacity - Btuh	256,987		360,180
Sensible Heat -Btuh	209,013		269,762
Latent Heat - Btuh	47,974		90,418
Net Cooling Capacity Gain - Btuh	→	103,193	

Pressure Drop "Across Coil"	0.654 " WG		0.606 " WG	
Pressure Drop Reduction	0.048 " WG	EER:	7.0	Before
Pressure Drop BHP Reduction	0.145			
Annual Operating Hours	2,190	EER:	9.0	After
Energy Cost per kWh	$0.12			
Annual Improvement (kWh cost)				

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LIFE CYCLE COST - ESTIMATE SHEET

Fill In All Yellow Blocks | **Answers Are In Green and Gray**

Project Name:
Location:

	$3,925			
Annual Coil Cleaner & Biocide Cost	$250			
Annual Coil Cleaning Labor Cost	$1,800			
Annual Drain Pan Cleaner & biocide Cost				
Annual Drain Pan Labor Cost				
Annual Maintenance Costs	**$2,050**			
Total Annual Improvement	**$5,975**			
Installation Costs	1st Year	2nd Year	3rd Year	4th Year
Number of Fixtures	**4**			
Average Fixture Cost Each	**520.22**			
Installation Labor Cost	**682.50**			
Fixture(s) Annual Energy Cost (8760 hrs)	**314.31**	**314.31**	**314.31**	**314.31**
Emitter Replacement Cost (each)		**230.00**	**230.00**	**230.00**
Annual Emitter Replacement Cost		**920.00**	**920.00**	**920.00**
Total Installed & Operating Cost	**$3,077.69**	**$1,234.31**	**$1,234.31**	**$1,234.31**
Annual Improvement (Less Costs)	**$2,897**	**$4,741**	**$4,741**	**$4,741**
Estimated Return (years)	**0.515**			
Cumulative Improvement	**$2,897**	**$7,638**	**$12,379**	**$17,120**

 For additional assistance please contact your local Steril-Aire representative or Steril-Aire direct at (562)467-8484.

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LIFE CYCLE COST - ESTIMATE SHEET

Fill In All Yellow Blocks		Answers Are In Green and Gray	
Project N	AIAA	Date:	05-Feb-11
Loca	Terminal 3	Contact:	Martin Fryer
AHU		Engineer:	MC
Tagging:	AHU T2-20	Contractor:	Econair

UVC Installation	Before		After	
Date Sampled:				
CFM - Measured or Selected (VAV)	19-Jul-10		8-Oct-10	
Entering Air Temperature - Dry Bulb °F				
Entering Air Temperature - Wet Bulb °F	10,090		11,502	
Leaving Air Temperature - Dry Bulb °F	71.2		71.3	
Leaving Air Temperature - Wet Bulb °F	58.6		58.9	
Total Cooling Capacity - Btuh	48.0		47.6	
Sensible Heat -Btuh	47.2		46.4	
Latent Heat - Btuh **Net Cooling Capacity Gain - Btuh**	292,408		360,243	
	252,815		294,033	
	39,593		66,210	
	→	67,834		
Pressure Drop "Across Coil"	0.562 " WG		0.477 " WG	
Pressure Drop Reduction	0.085 " WG			
Pressure Drop BHP Reduction	0.256	EER:		
Annual Operating Hours			7.0	
Energy Cost per kWh **Annual**	2,190	EER:	Before	
Improvement (kWh cost)	$0.12		8.3	
	$2,637		After	
Annual Coil Cleaner & Biocide Cost	$250			
Annual Coil Cleaning Labor Cost	$1,800			
Annual Drain Pan Cleaner & biocide Cost				
Annual Drain Pan Labor Cost				
Annual Maintenance Costs	$2,050			
Total Annual Improvement	$4,687			
Installation Costs	1st Year	2nd Year	3rd Year	4th Year
Number of Fixtures	4			
Average Fixture Cost Each	520.22			
Installation Labor Cost	682.50			
Fixture(s) Annual Energy Cost (8760 hrs)	314.31	314.31	314.31	314.31
Emitter Replacement Cost (each)		230.00	230.00	230.00
Annual Emitter Replacement Cost		920.00	920.00	920.00

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LIFE CYCLE COST - ESTIMATE SHEET

Fill In All Yellow Blocks — Answers Are In Green and Gray

Project Name:
Location:

Total Installed & Operating Cost	$3,077.69	$1,234.31	$1,234.31	$1,234.31
Annual Improvement (Less Costs)				
	$1,609	$3,453	$3,453	$3,453
Estimated Return (years) Cumulative Improvement	0.657			
	$1,609	$5,062	$8,515	$11,967

 For additional assistance please contact your local Steril-Aire representative or Steril-Aire direct at (562)467-8484.

Enthalpy – Life Cycle Cost Estimate

Steril-Aire has obtained an application patent for the placement of its high output UVC Emitters around the coil area. One of the reasons for this location is that of returning the coil to its original heat exchange efficiency. The process includes the degradation of mold, bacteria and other residual organic material… essentially cleaning the coil. This process has proven to be much more effective than the classical methods of coil cleaning, which leave much of the material behind, can damage the coil, and are a short term only solution. On the other hand, Steril-Aire Emitters provide a complete and continuous cleaning without dangerous chemicals.

Coils can lose as much as 30% of their capacity in as little as one year. This loss is referred to as the "total heat" loss. Determining the loss is dependent on system operating characteristics. The purpose of this chapter is to explain some of the elementary concepts of total heat, as a quick reference, for those who don't work with them regularly. It also provides the background as was used in the construction of the Steril-Aire Life Cycle Cost diskette. This should give one the confidence of utilizing UVC Emitters on the merits of coil cleaning alone. Yes, UVC can be as much a maintenance tool as a microbe killer and as such, has paid for itself in as little as four months! What is discussed are the properties of coil pressure drop, its air temperatures (wet and dry bulb) both entering and leaving the coil, and system airflow.

Coil Pressure Drop – inches of water gauge

That a coil has a pressure drop associated with it indicates that air requires energy to get through it. The percent increase is the result of a decrease in open area. An increase in coil pressure drop is therefore an indication that a cooling coil is losing heat transfer capability. Assuming similar system characteristics, coil pressure drop can only increase when the coils open area decreases. Decreased open area results from an increase in coil fin thickness and this increase is associated with the build up of material on the coil. Two things happen as a result, (i) system air volume is decreased and (ii) the time required for a given amount of heat to transfer increases and so it is this decreased amount of heat times a lower volume of air that results in less heat transferred. The "air leaving temperature" rises several degrees from when new (clean), while at the same air entering temperature. This temperature is referred to as "dry bulb" or sensible heat temperature.

Properties of Air – Psychrometric Chart

The properties of air are best understood by observing a psychrometric chart and visualizing a container filled with "one pound of air". For the following examples, this one pound of air will be at typical comfort conditions of 70° F and 50% relative humidity. Knowing these two properties allows one to determine all other air properties by using a psychrometric chart.

Dry bulb temperature - degrees Fahrenheit

In the example above, the temperature is 70 degrees, which is commonly referred to as dry bulb temperature or what is read from a standard thermometer. This is also called the "sensible" temperature of air or the heat that can be sensed by a dry thermometer. As described later, a wet thermometer measures the "wet-bulb" temperature. On the psychrometric chart, the dry bulb temperature of air is displayed at the bottom, increasing numerically from left to right.

Relative humidity - percent of saturation

The example air is at 50% relative humidity which means its half of what the air could hold if it were saturated (i.e. 100% RH or maximum). Heating the container of 50% RH air to 95° F would reduce its relative humidity to 20%. Cooling the container air to 49° F would raise the relative humidity to 100%. If it were 70° F, we would back at the example of 50% RH.

This can be demonstrated on the psychrometric chart. Relative humidity is the series of curves originating from the left of the chart (100% relative humidity or “saturation curve") curving up to the right boundary. If one goes to the bottom of the chart and finds the vertical 95° F line then follows this line up vertically to the 20% saturation curve (relative humidity), this is the intersect of 95° F and 20% RH. If we go horizontally left to the saturation curve (100% RH) we note that when we go straight down we are at 49° F! If we go horizontally right to the vertical 70 ° F line we are almost at the 50% RH curve. In this example, the amount of water in the air was always the same, only the temperature varied. In other words, the same amount of water in the air was “relative” to the airs’ temperature and thus the term relative humidity.

Important: Relative humidity relates more to the comfort zone than temperature; therefore, a coil must often control (remove) air moisture as a part of its overall cooling function (wet coil and drain pan). When this capability is compromised (dirty coil), the air could be 70° F but the RH may be at 70%. This would be an uncomfortable (but not uncommon) set of conditions.

Specific Humidity - pounds of moisture per pound of air

To define the specific amount of moisture (water) in the air, one can use its weight compared to the weight of the air. In the example of 70° F and 50% RH, its specific humidity is 0.0078 Lbs. of water per the one pound of air, or 0.0078 Lbs. of its total weight is water vapor (moisture). Some charts will give this in grains. As 7000 grains equal one pound then 0.0078 x 7000 = 55 grains of moisture, therefore, 6945 grains of the total weight is the weight of the air.

On the psychrometric chart, locate the 70° F and 50% RH intersect point and trace a horizontal line to the charts right edge. The scale here indicates the weight of the moisture (or water) in Pounds Moisture per Pound of Dry Air or the specific amount of moisture in the air sample. Go back to the Relative Humidity paragraph above and retrace the 95, 70 and 49° F examples and note they are always on the same “Pounds of Moisture per Pound of Dry Air” line.

Dew point temperature - degrees Fahrenheit

Wet coils and drain pans can be associated with the psychrometric charts saturation line. If moist air is cooled enough, it cannot hold the same amount of moisture and the moisture will condense. The temperature at which water condenses depends on the amount of moisture in the air, and is called the *dew point temperature*. The higher the amount of moisture in the air, the higher the dew points temperature.

The examples air moisture content is 55 grains and some of this moisture must condense if the air temperature were dropped below 49° F (100% RH). For instance, if a beverage were taken from a refrigerator and placed in the air sample, the beverage container surface will cool the surrounding air from 70° F to less than 49° F and moisture in the air next to the container will condense. Air cannot be over 100% relative humidity, therefore, dehumidification occurs when we remove moisture from the air by cooling it below its dew point temperature.

Wet-bulb temperature - degrees Fahrenheit

Wet-bulb temperature is taken by surrounding a thermometer with a wet wick and measuring the temperature as the wick water evaporates. As it evaporates, it draws heat from the thermometer bulb, cooling it in “proportion to the amount of evaporation”. In the example of 70° F and 50% RH, the wet bulb thermometer would be cooled from 70° F to “58.5° F” by the evaporation, so the “wet bulb temperature” is 58.5° F. If the

RH were higher, the thermometer would not be cooled as much. If the air were drier, the wet bulb temperature would be lower than 58.5° F.

On the psychrometric chart, the wet bulb lines start at the saturation curve and slant down to the right. At the saturation curve, the wet bulb and dry temperatures are the same. The wet bulb temperature is most useful, as it the way to determine "total heat". We will do this later.

Enthalpy – Btu' s per pound of air

Enthalpy is the measure of the total energy in the air. When air is hot and/or moist, its enthalpy is high. This is because we must add heat to evaporate moisture into the air and remove heat to condense it. Every pound of water requires some 1061 Btu's to evaporate it (or remove it), so the more moisture in the air the more heat the air contains and the more we have to remove to make our sensible temperature. Enthalpy then is a function of its sensible temperature (dry bulb) and the absolute amount of moisture it contains (wet bulb). Air pressure also plays a role.

For A/C work, enthalpy is defined as the "sum" of the sensible and latent heat in the air or "total heat". The term "latent heat" is another way of expressing the amount of "moisture" in the air but that heat is latent or it cannot be "sensed" by a dry bulb thermometer. On the psychrometric chart, the lines of constant enthalpy are located to the left of the saturation curve and slant down from left to right nearly parallel to the wet bulb lines. In the example the enthalpy at 70° F and 50% RH is 25.4 Btu's per pound of air. If we deduct the sensible heat Btu's from enthalpy, we are left with the latent heat Btu's.

Total Heat – System cooling capacity

Expressing enthalpy in Btu's allows us to quickly calculate the energy difference or total heat of one condition to any other condition. This is extremely useful for determining coil capacity gain or loss, but especially gain when using UVC Emitters to clean the coil. For example, if we normalize barometric pressure at 29.92 inches of mercury (air pressure) and assume we are always within A/C temperature conditions, we can use the wet bulb temperature to calculate system capacity. By measuring the air entering and leaving wet bulb temperatures, we can calculate the heat in and the heat out with the difference being the total heat removed.

As noted previously, air at 70° F and 50% would yield a wet bulb temperature reading of 58.5° F, this wet bulb reading would also contain 25.4 Btu's. So if this were the coils air leaving wet bulb temperature and the air entering wet bulb temperature was 68° F, at 68° F it would contain 32.4 Btu's. Therefore, the difference between air entering and leaving heat is 32.4 – 25.4 Btu's or "7 Btu's per pound of dry air". To relate this to system capacity, we need to know the system airflow and we're almost there.

Calculations – Simplified

At sea level or 29.92 inches of mercury, air weighs 0.075 pounds per cubic foot. Therefore, in one hour (Btu's per hour), one CFM would correspond to 4.5 pounds (60 min. x 0.075 = 4.5) or 4.5 pounds of air per hour equals 1 CFM. Total heat in Btu's per hour then becomes CFM x 4.5 x the difference between the air entering wet bulb (Btu content) and air leaving wet bulb (Btu content) or:

$$\text{Btu/hr.} = \text{CFM} \times 4.5 \times (h_1 - h_2)$$

Where: h_1 = total heat (Btu's) of air entering wet bulb temperature
h_2 = total heat (Btu's) of air leaving wet bulb temperature

The example under Total Heat, second paragraph, resulted in a difference of 7 Btu's per pound of dry air. If the systems airflow were 10,000 CFM, it would be as follows:

$$\text{Btu/hr.} = 10{,}000 \times 4.5 \times 7 \text{ or } 315{,}000 \text{ Btu's per hour}$$

If this system lost 30% of its capacity, the 7 Btu's per pound would be reduced to 5 Btu's per pound or 225,000 Btu's per hour. Now one can see what a 30% loss will do! Also, 12,000 Btu's per hour equals 1 ton of refrigeration, so 315,000 ÷ 12,000 = 26.25 tons of operating capacity, 225,000 Btu's per hour would equal 18.75 tons! Under these different conditions, the same unit will yield a capacity in tons different than the systems rating, which is usually conservative. However, the rating can be determined using an industry standard of: 400 CFM equals 1 Ton or in our case, 10,000 ÷ 400 = 25 tons.

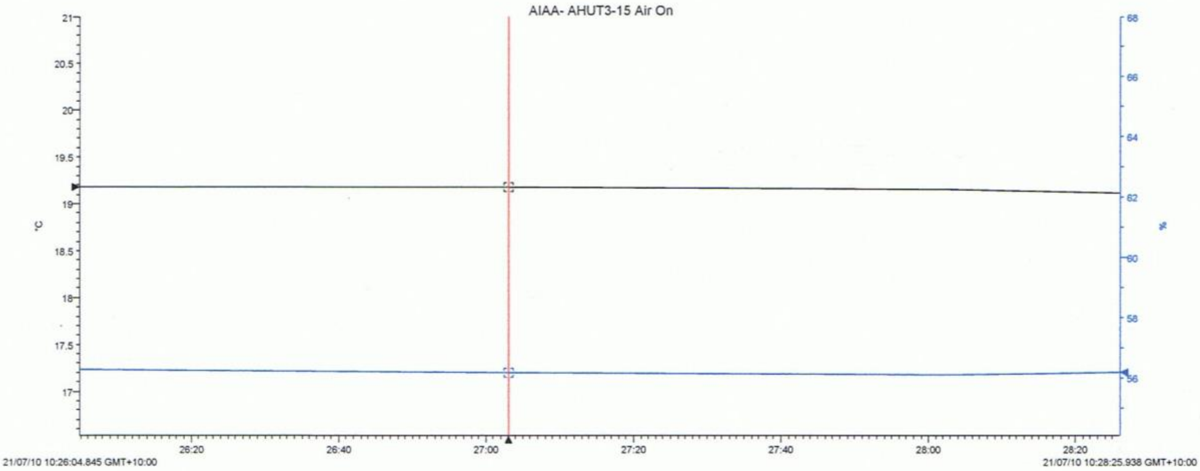
Steril-Aire Life Cycle Costing Program

With the experience gained from above, one can use the Steril-Aire Life Cycle Costing program. It does the calculations and more. The following system data is needed "before" installing UVC Emitters and "after". The after is the new system data – after the UVC Emitters clean the coil.

1. CFM
2. Cooling coil air pressure drop
3. Air entering and leaving wet bulb
4. System operating hours
5. The cost per kWh
6. Current maintenance costs

While entering this data, the program calculates the before and after costs associated with brake horsepower, capacity and maintenance. For capacity, the program uses a Lookup table (hidden in sheet 2) that contains the Btu content of wet bulb temperatures from 30 to 85° F. The table is from Chapter 3 of the 1961 ASHRAE Guide and Data Book. The program also includes other items such as fixture cost, labor to install, fixture energy consumption (operating 24 hours per day all year) and tube replacement cost. The results are expressed in payback and future savings through four years. One can get an educated look of what to expect if the original submittal data is available and if it indicates the design air entering and leaving wet bulb conditions. Simply collect the current data shown above and then input the design data in the after column, the program will do the rest.

Steril-Aire hopes that the foregoing has been informative and that it helps you to utilize the Steril-Aire life Cycle Costing program to demonstrate the near amazing ability of Steril-Aire UVC Emitters to return A/C system coil performance to as new specifications. Combining this feature with the products' ability to kill surface mold and bacteria, fly-by infectious disease organisms and the reduction of VOC's and other odors, makes the product a "must have" for any and all HVAC systems already installed or on the designers board.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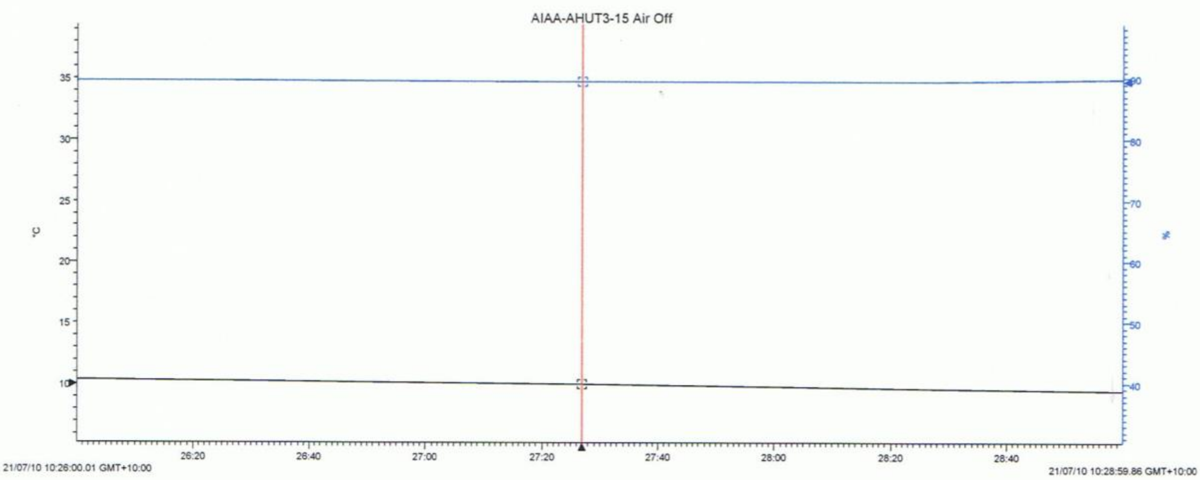
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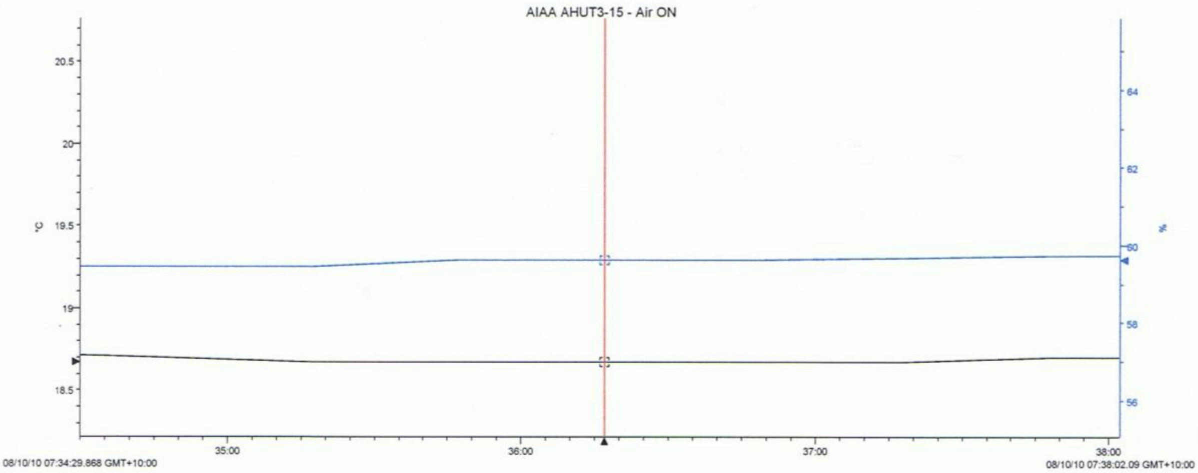
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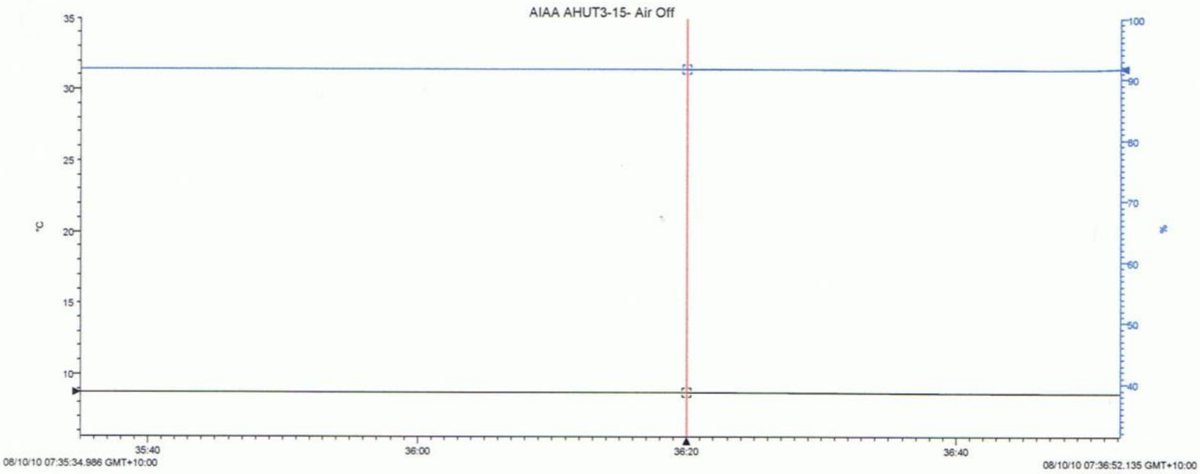
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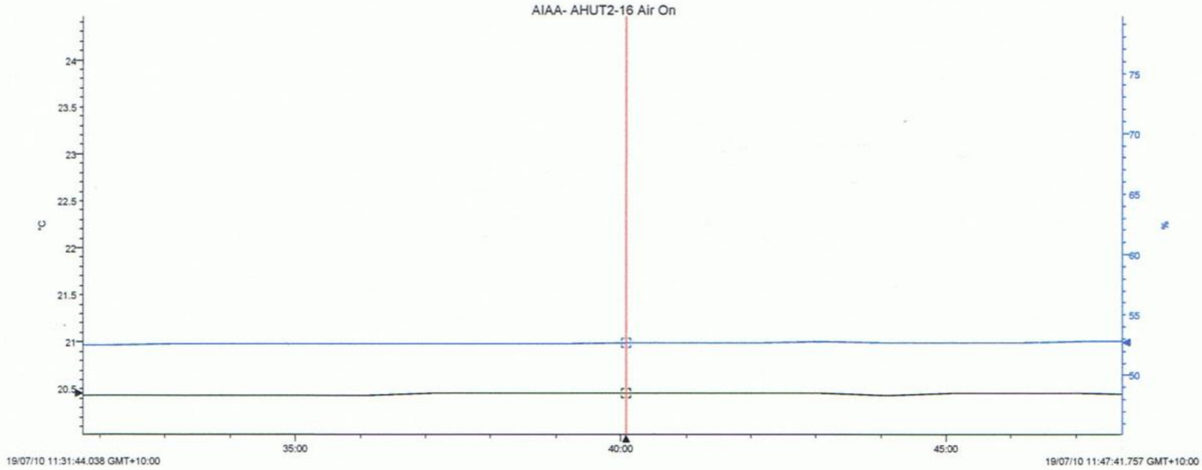
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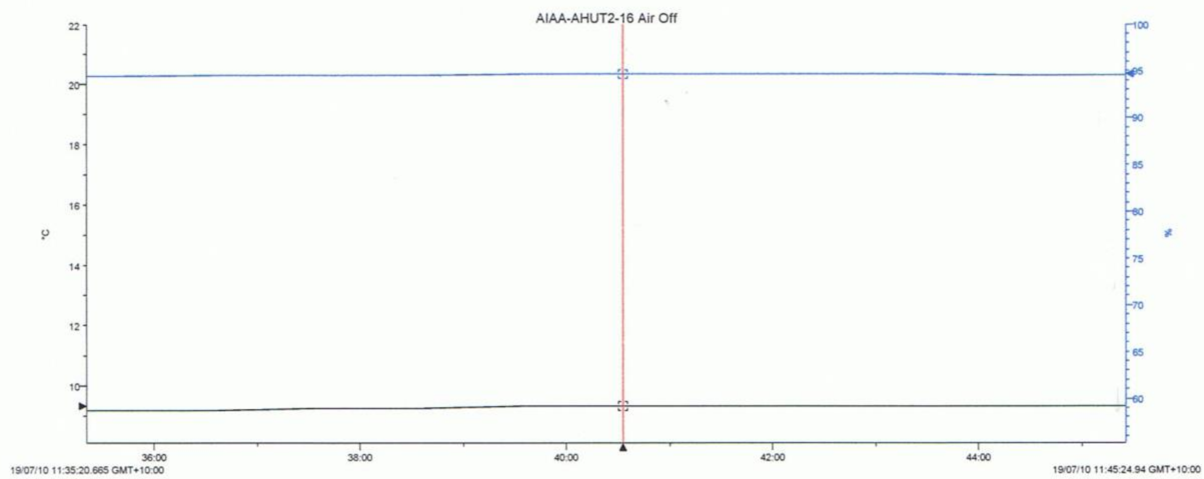
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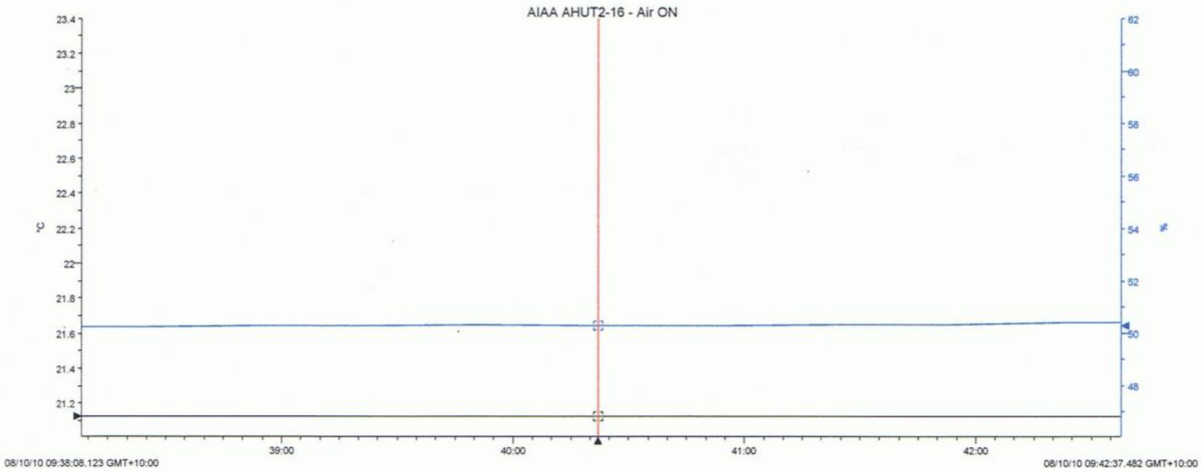
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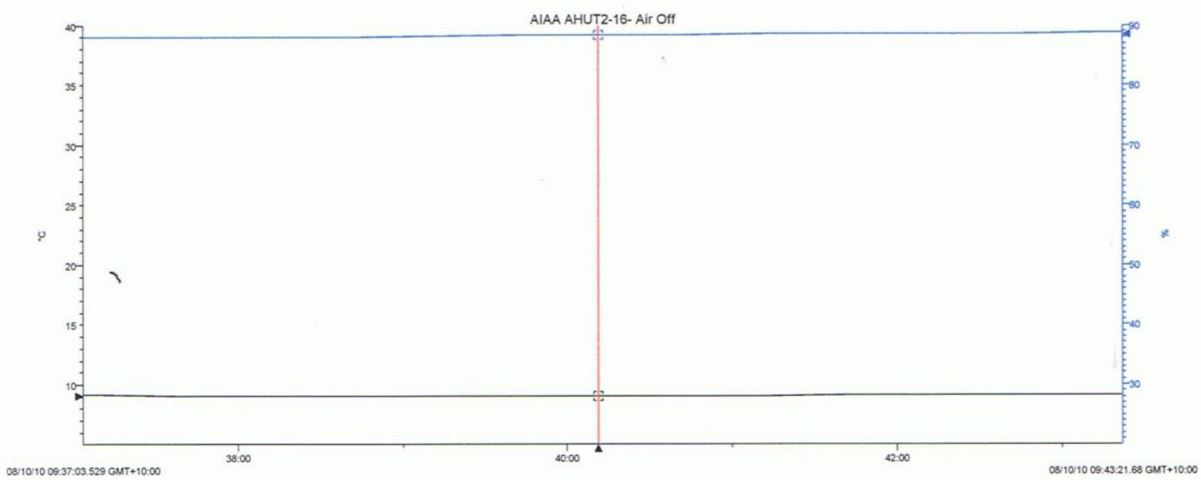
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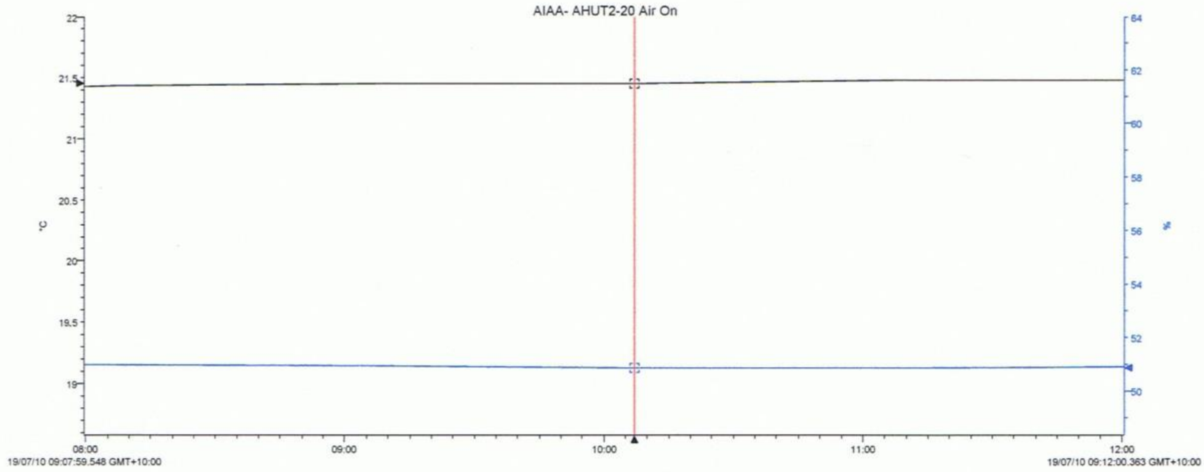

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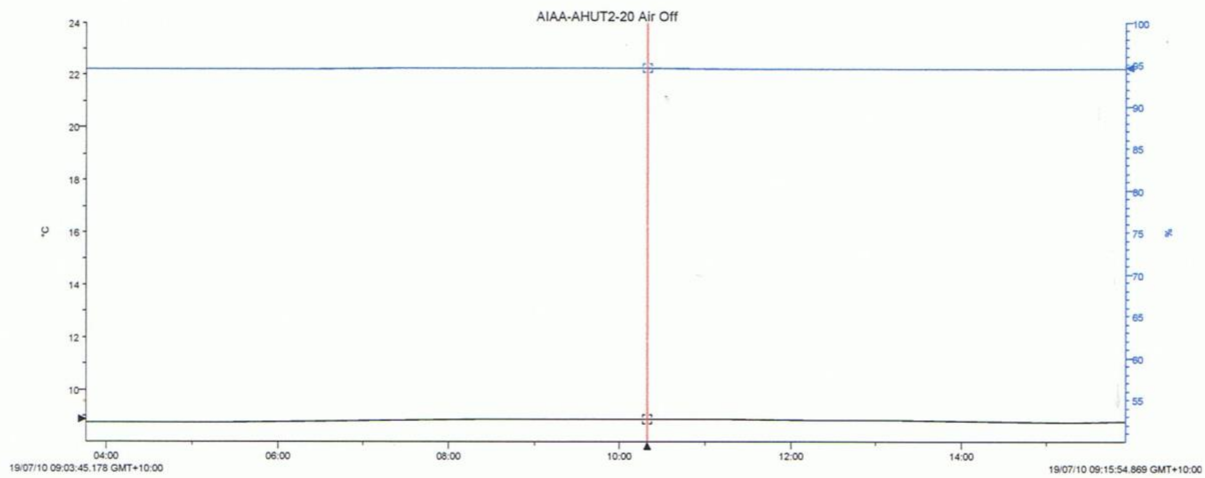

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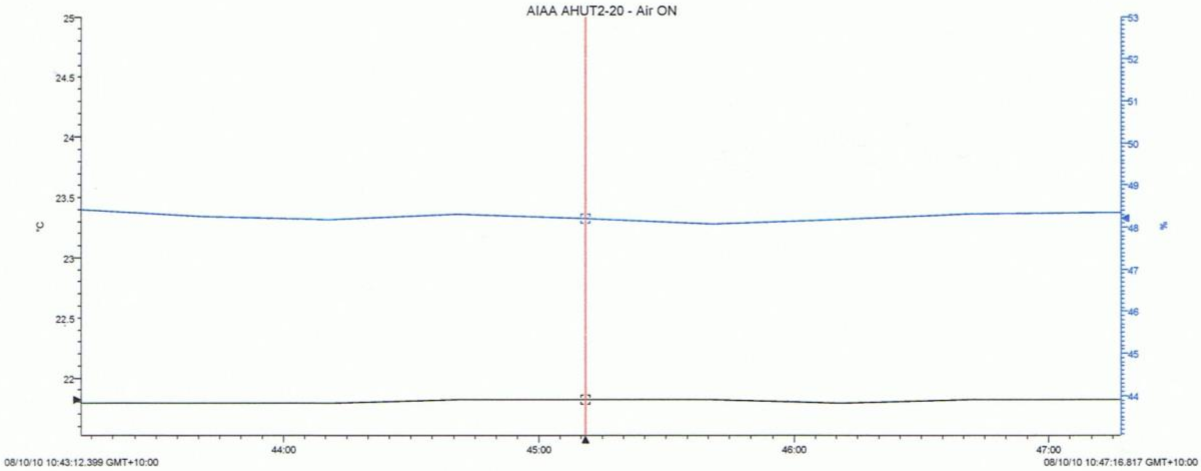
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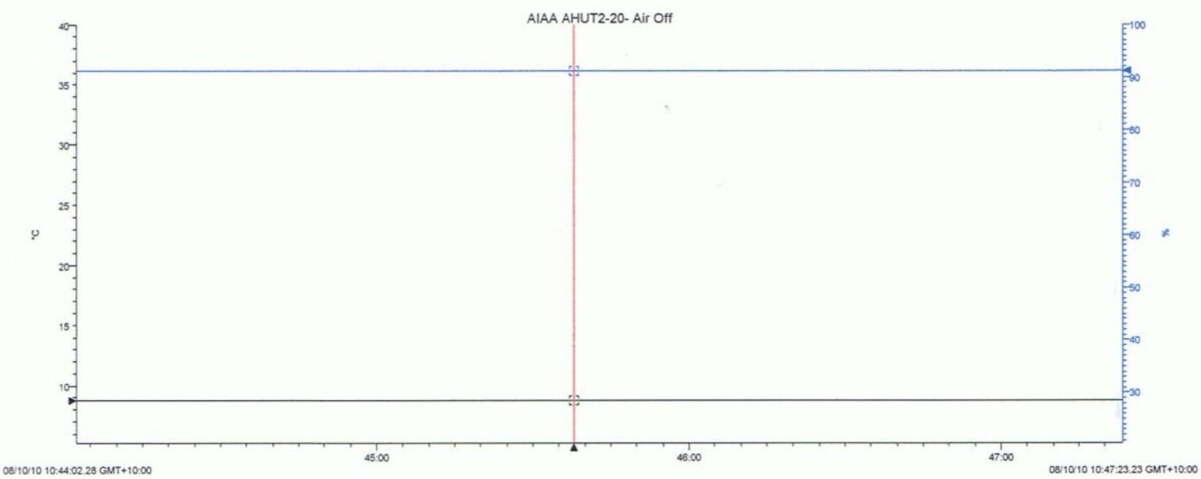
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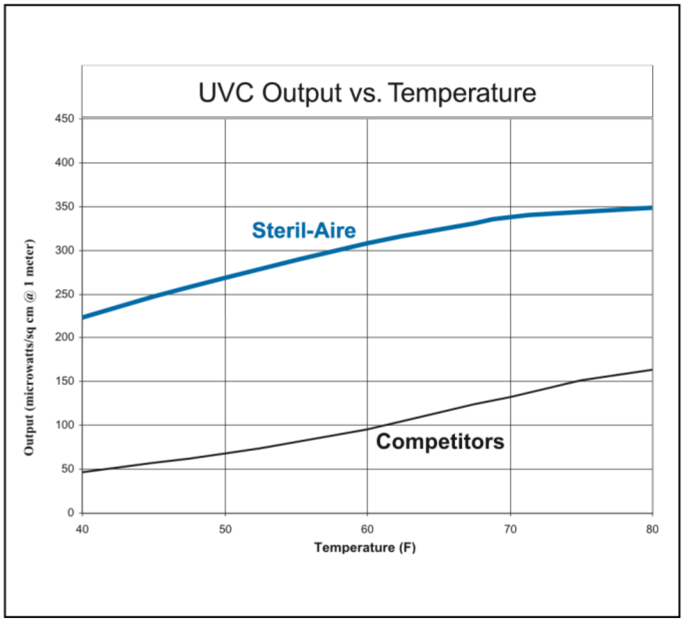
Steril-Aire's multi-patented UVC Emitter™ provides the best and longest-lasting UVC performance available. As shown in the comparison graph *(above)*, it has been independently tested to deliver an average of 5 times the output of other ultraviolet devices under HVAC operating conditions (45^{o} F @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

Competitive UVC lights must be changed every 3-4 months because they quickly lose the output or "killing power"

UVC for HVAC™

Model SE Series UVC Emitters™

Single-Ended, Very High Output Germicidal Light Source for HVAC Systems



needed to maintain microbial control. The UVC Emitter, by contrast, has a 12-month service life – and even after a full year, it has 2-1/2 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.

Applications

Steril-Aire Single-Ended (SE Series) fixtures install from the exterior of HVAC equipment, making them ideal for germicidal sites that are difficult to access. They are easily installed by making a one-inch hole in the equipment wall and/or duct, and then simply mounting the fixture to the unit exterior. Only the lamp or tube penetrates into the system, while the power supply remains external. Choose from six tube lengths (16", 20", 24", 30", 36" and 42") and four voltage options (115, 208, 230 or 277 Vac) to fit most applications, including:

- Fan coils, heat pumps, unit ventilators, terminal units and ductwork.

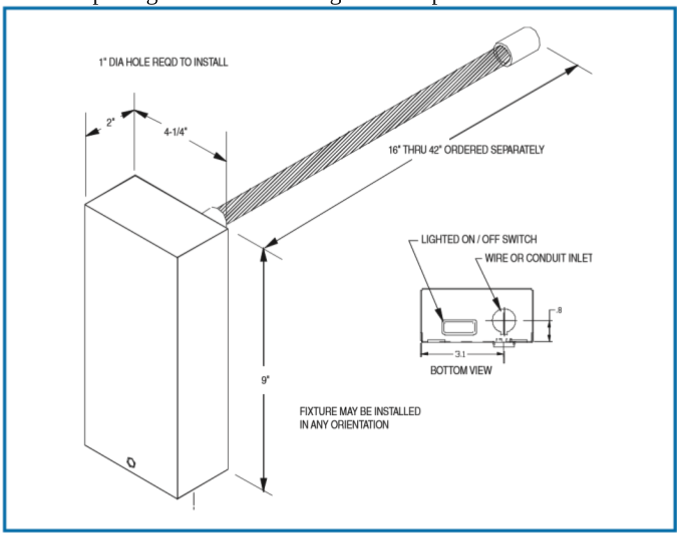
Benefits

- Kills or inactivates surface and airborne microorganisms that contribute to poor IAQ and/or the spread of infectious disease, including: mold and mold spores, bacteria *(including TB, Legionella, E. coli, Listeria, salmonella and whooping cough);* and viruses *(including colds, flu, measles).*
- Delivers an average of 5 times the output of competitive UVC products at HVAC operating temperatures, for 3-4 times longer life and more reliable germicidal control.
- Uses patented state-of-the-art solid-state electronic power supply for enhanced reliability and performance.
- Continuously cleans coils, drain pans, plenums and ducts, eliminating costly cleaning programs and the use of harmful chemicals and disinfectants.
- Lowers HVAC energy costs by restoring heat transfer and netcooling capacity.
- Produces no ozone or other secondary contaminants – will notharm building occupants, equipment or furnishings.
- Offers lowest life-cycle cost of any UVC product. Return oninvestment is often less than one year.
- Installs quickly and easily, with no need to open equipment – ideal for small systems and/or ducts.

Model SE Specifications

The UVC Emitter™ and fixture shall be factory assembled and tested. They shall consist of a housing, power source, Emitter socket and Emitter.

The housing shall be constructed of 304 stainless steel to withstand HVAC environments and shall be equipped with a 1/2" electrical conduit opening to facilitate wiring. All components shall be



This product may be covered by one or more of the following patents, others pending: 5,334,347/ 5,866,076/ 5,817,276/ 6,372,186/ 6,313,470/ 6,245,293/ 6,267,924/ 6,280,686/ 6,423,882.

incorporated into one integral assembly that maximizes serviceability. It shall be designed for mounting from outside the airstream with only the Emitter in the conditioned air. Emitter shall be held in place and supported in the airstream by a patented integral collar, o-ring and heavy-duty spring wire fastener. The housing shall include an onoff switch and an indicator light to verify unit function. **The power supply** shall be a Class P2, electronic rapid start type with a power factor of >0.95 and a power conversion of >75%. It shall be available in 115-208/230 or 277 Vac, 50/60 Hertz, and single phase. It shall be designed to maximize photon production, irradiance and reliability in cold or moving airstreams of 35-170° F, 100% RH and up to 2000 fpm. The design shall include RF and EMI suppression.

The socket shall be a Circline® 4 pin type with sufficient wire length to facilitate service.

The Emitter shall be a very high output, hot cathode, T5 diameter, Circline® cell-base type that produces a UVC band of 250-260 nm. Each tube shall be capable of producing the specified output at up to 2000 fpm velocity and temperatures of 35-170° F. It shall produce no ozone or other secondary contaminants.

Independent testing: The unit shall be tested by an independent test laboratory in accordance with the general provisions of IES Lighting Handbook, 1981 Applications Volume, and shall be verified through independent testing to provide output per 1" arc length of not less than 10 µW/cm2 at 1 meter in a 400 fpm airstream of 45° F.

Unit shall comply with UL Standard 1995 for use in HVAC equipment and shall carry the "UL" and "ULC" labels.

Ordering Information

SE 1 VO	11001900	Single-Ended Fixture	N/A	115, 208, 230V: 70-85 watts	3.0 lb.
SE 1 VO	11002100	Single-Ended Fixture	N/A	277V: 70-85 watts	3.0 lb.
GTS 16 VO	21000100	UVC Emitter	16"	N/A	0.15 lb.
GTS 20 VO	21000200	UVC Emitter	20"	N/A	0.15 lb.
GTS 24 VO	21000300	UVC Emitter	24"	N/A	0.20 lb.
GTS 30 VO	21000400	UVC Emitter	30"	N/A	0.20 lb.
GTS 36 VO	21000500	UVC Emitter	36"	N/A	0.25 lb.
GTS 42 VO	21000600	UVC Emitter	42"	N/A	0.25 lb.

Corporate Office: **Steril-Aire, Inc.**

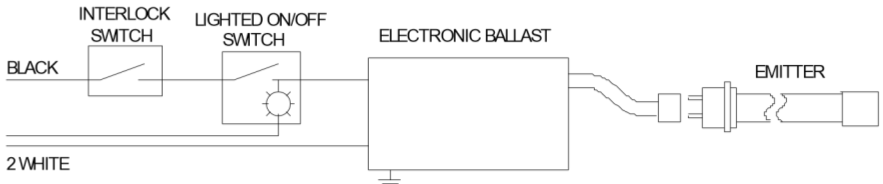
2840 N. Lima St.
Burbank, CA 91504
Telephone: 800-2STERIL or 818-565-1128
Fax: 818-565-1129

Website: *www.steril-aire.com*
Email: *sales@steril-aire.com*

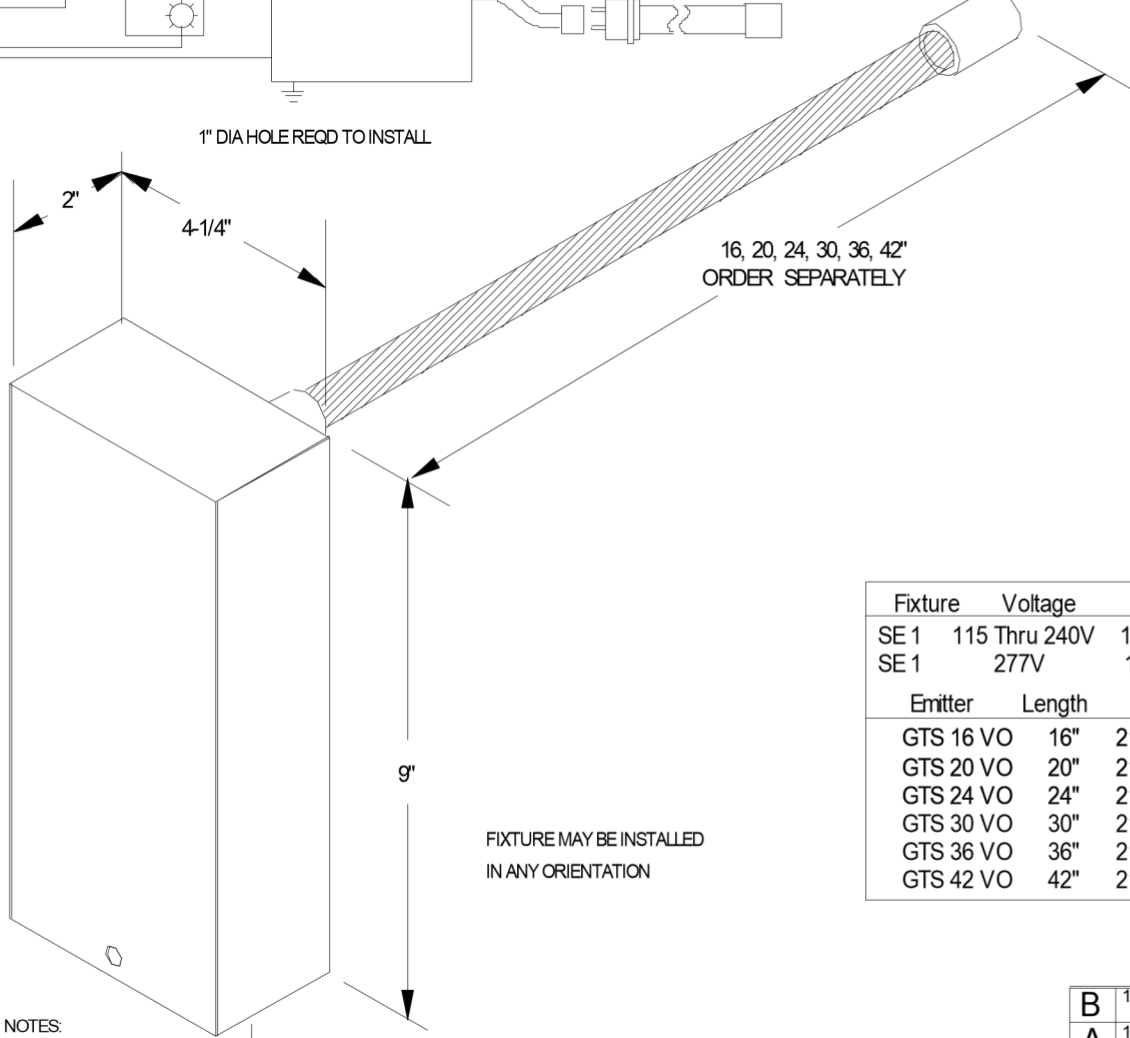
 1101-07/05

C UL US *Complies with current U.S. and Canadian UL Standards for use in HVAC equipment.*

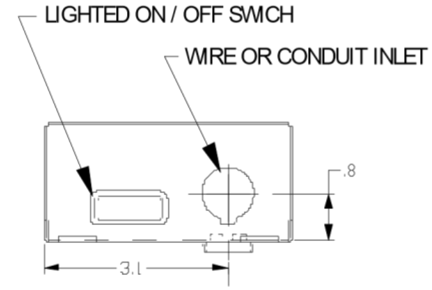
Represented By:



1" DIA HOLE REQD TO INSTALL



FIXTURE MAY BE INSTALLED
IN ANY ORIENTATION



BOTTOM VIEW

Fixture	Voltage	P/N	Wt	Amp Draw
SE 1	115 Thru 240V	11001900	3.0	
SE 1	277V	11002100	3.0	

Emitter	Length	P/N	Wt	120V	208V	230V	277V
GTS 16 VO	16"	21000100	0.15	0.44	0.25	0.23	0.19
GTS 20 VO	20"	21000200	0.15	0.53	0.31	0.28	0.23
GTS 24 VO	24"	21000300	0.20	0.60	0.35	0.31	0.26
GTS 30 VO	30"	21000400	0.20	0.72	0.42	0.38	0.31
GTS 36 VO	36"	21000500	0.25	0.84	0.49	0.44	0.36
GTS 42 VO	42"	21000600	0.25	0.95	0.55	0.50	0.41

NOTES:

1. UNIT & LAMP SHIPPED SEPARATE (DO NOT TOUCH GLASS)
2. REPLACEMENT UVC EMITTER, SEE SCHEDULE
3. OUTPUT: 10 uW/cm/INCH ARC LENGTH @ 1 METER AND 400 FPM @ 55 F
4. CONSTRUCTED OF 304 STAINLESS STEEL
5. PRE-PUNCHED MOUNTING HOLES, USE #10 SCREWS, 4 REQD
6. USE ELECTRICAL INTERLOCK ON DOORS OR PANELS
7. ELECTRICAL REQUIREMENTS: 115 - 240 & 277 VAC, 50/60 HZ, SINGLE PHASE

This product may be covered by one or more of the following patents, others pending:
5,334,347 / 5,866,076 / 5,817,276 / 6,372,186 / 6,313,470 / 6,245,293 / 6,267,924 / 6,280,686 / 6,423,882

REV	DATE		DFT
B	12/10 03	ADD WIRING DIAGRAM	RMC
A	10/10 03	FIRST ISSUE	RMC

NEXT ASS'Y: 11001900, 11002100 | WT.

UL CLASSIFIED STD. 1995
UL APPROVED SINGLE-ENDED FIXTURE
MODEL SE 1 VO

STERIL-AIRE

DRAWING NO. 0310096 | REV. B