UVC and Energy/IAQ

Indoor Air Quality

Learning Objectives

- Understand the HVAC system is a significant reservoir and disseminator of pathogenic and opportunistic pathogens, critical in many environments including healthcare
- Understand how the HVAC system is colonized with the same bacteria that are attributed to greater than 80% of all Hospital Acquired Infections (HAIs)
- Understand how a properly installed HVAC UVGI system improve HVAC and environment hygiene
- Understand how to integrate UVGI in HVAC systems

Evidence Based Design – What is it?

" Technologies and materials of construction, for Facilities and Hospitals of the future, will be those demonstrating improved quality of care, understood through rigorous scientific analysis."

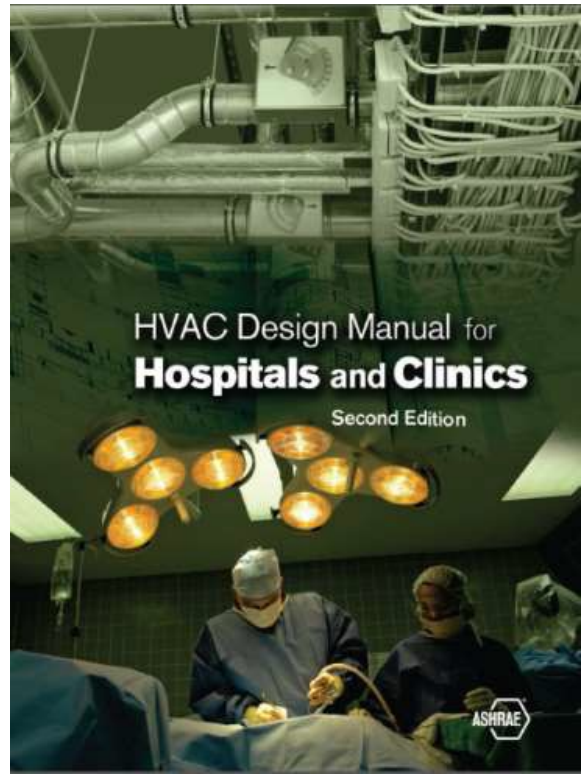
Roger S. Ulrich, PhD

Professor & Fellow Center for Health Systems & Design

Texas A & M School of Architecture

ASHRAE Design Manual

- **Section 2.2: The Role of HVAC in Infection Control**
  - Identifies HVAC as a reservoir and source of infections
- **Section 2.3: How the Human Body is Affected by Airborne Contaminants**
  - Chain of infection



ASHRAE™

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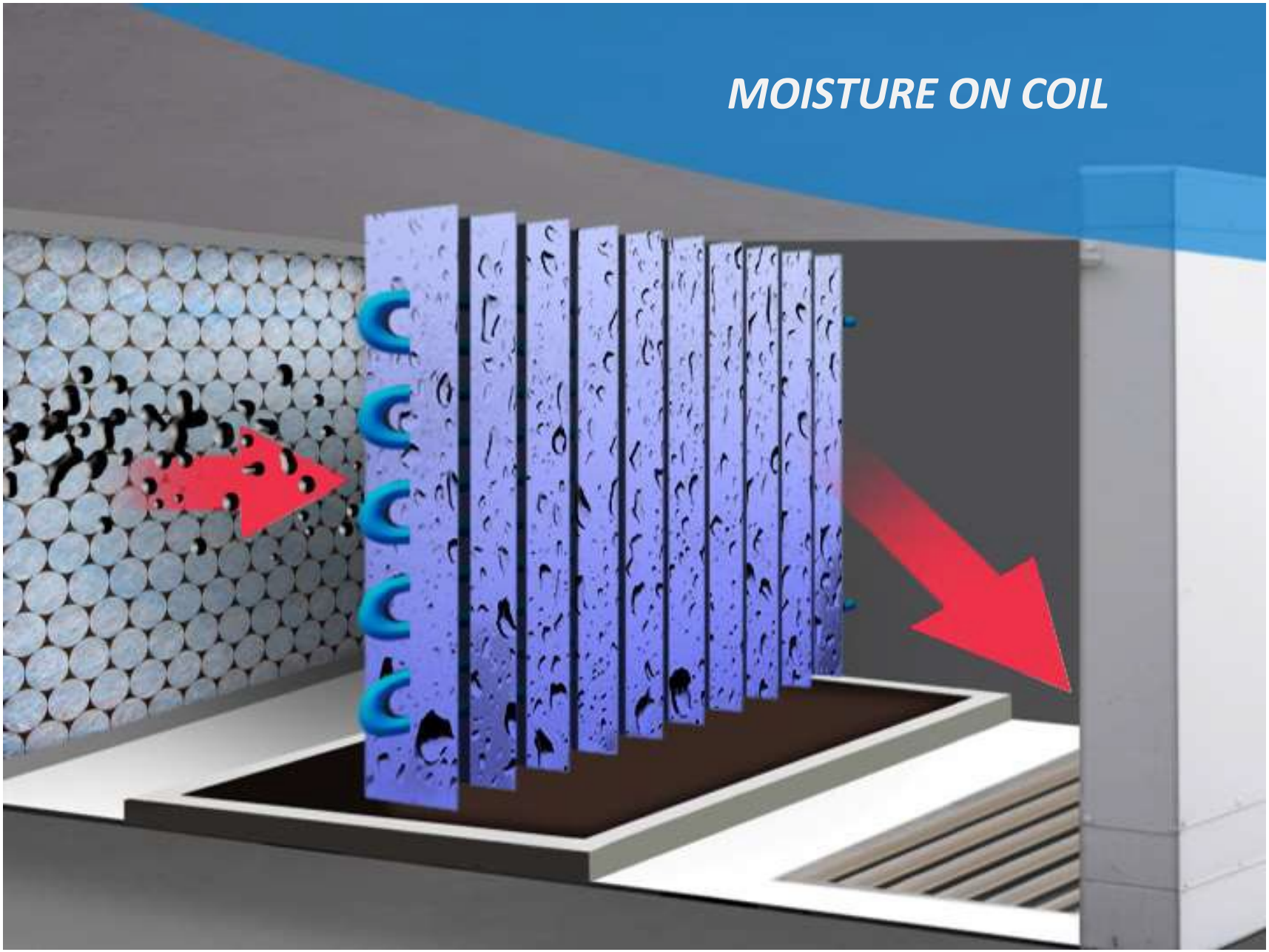
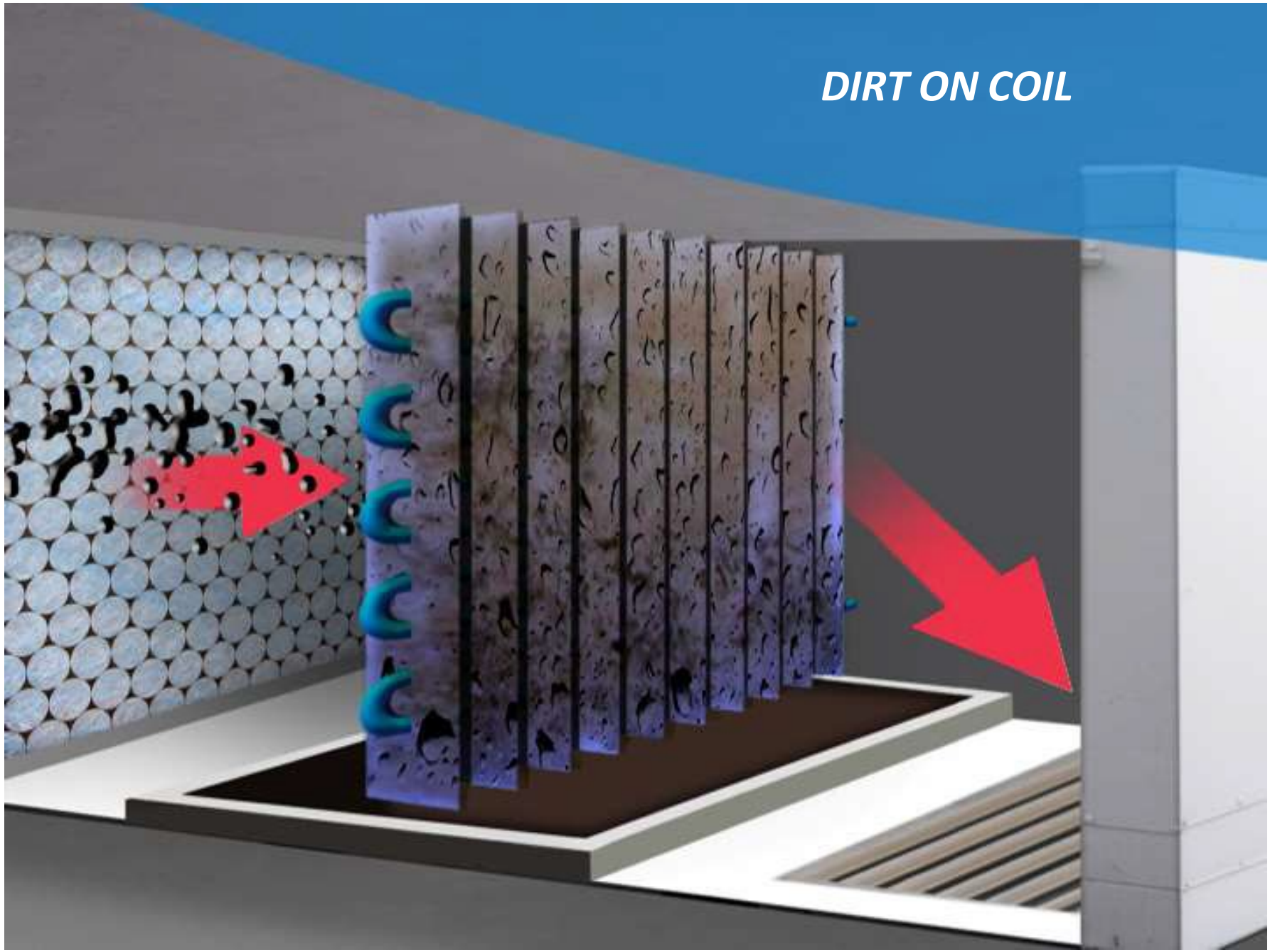
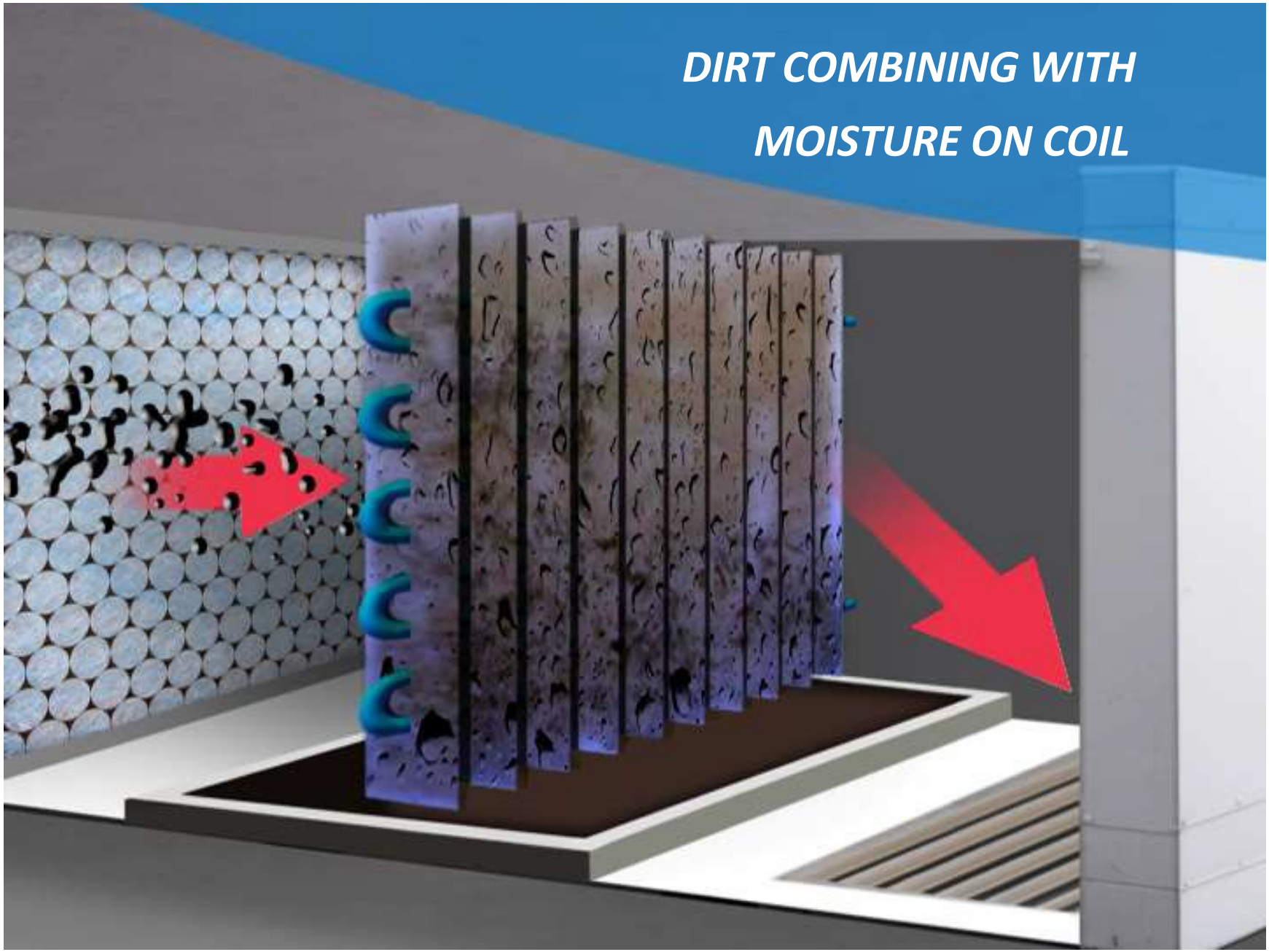
ASHRAE Position

- Many infectious diseases are transmitted through inhalation of airborne infectious particles termed droplet nuclei
- Airborne infectious particles can be disseminated through buildings including ventilation systems
- Airborne infectious disease transmission can be reduced using dilution ventilation, specific in- room flow regimes, room pressure differentials, personalized and source capture ventilation, filtration and UVGI


MOISTURE ON COIL


DIRT ON COIL



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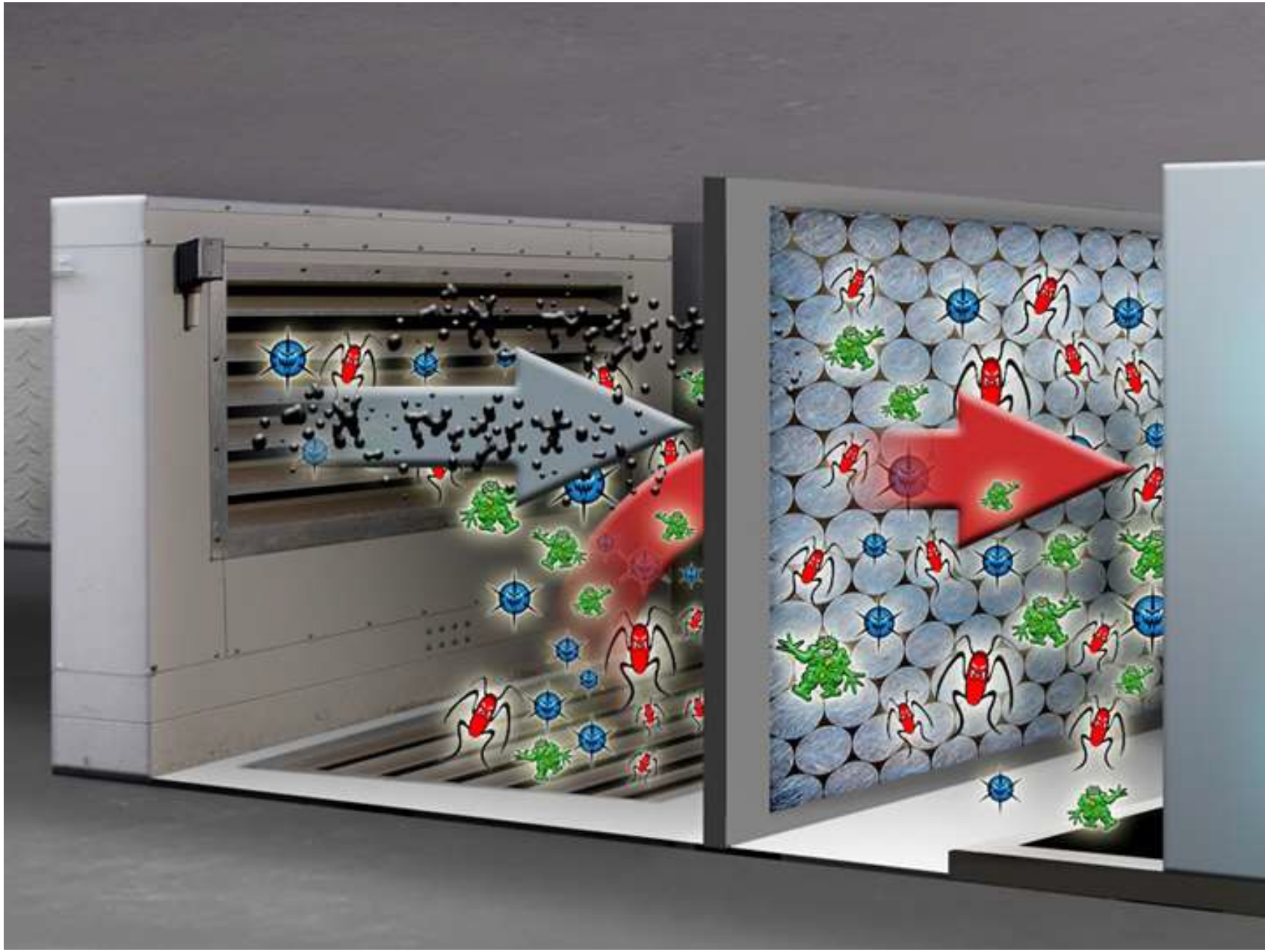

Mold Growing in AC Coil

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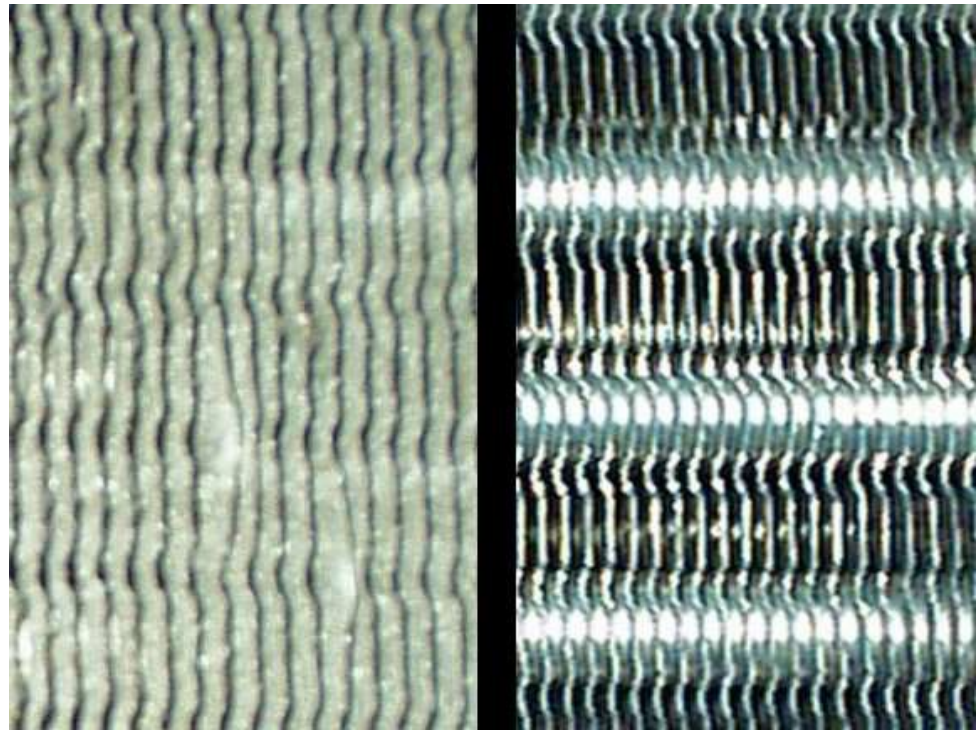
Biofilms in HVAC

- Biofilms
- The role of your HVAC system
- Biofilms and energy loss
- Biofilms, IAQ & health risks
- How UVC Emitters can help



A complex microbial matrix growing on coils and drain pans

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Biofilms

Biofilms are composed of different microorganisms adhering to surfaces and producing a matrix composed of polysaccharides, proteins and nucleic acids.

This material allows the biofilm to stick together and develop attached communities. They may form anywhere and are attached to our coils and drain pans. Life in a biofilm imparts protection from penetration of outside agents such as antimicrobial agents.

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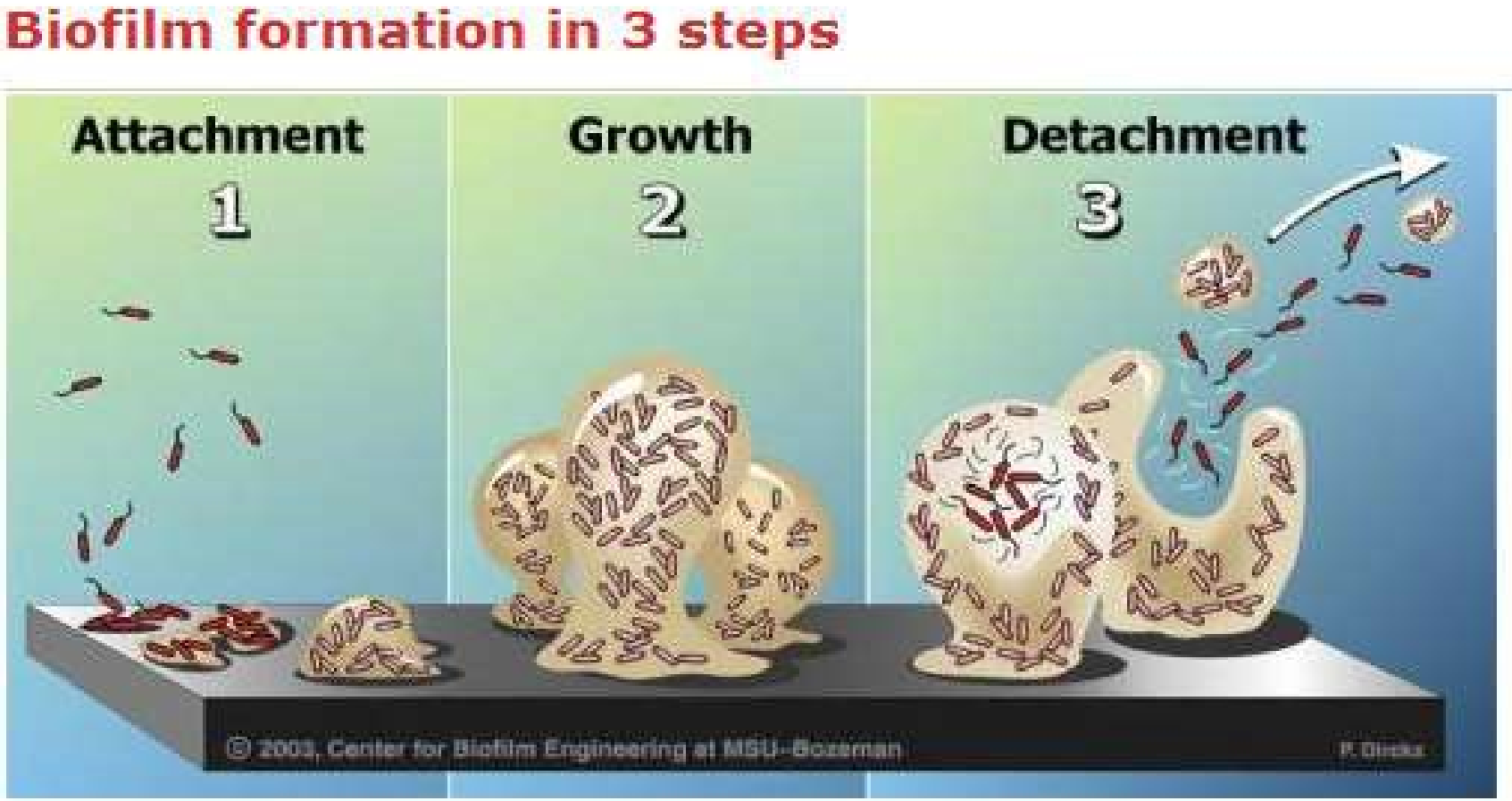
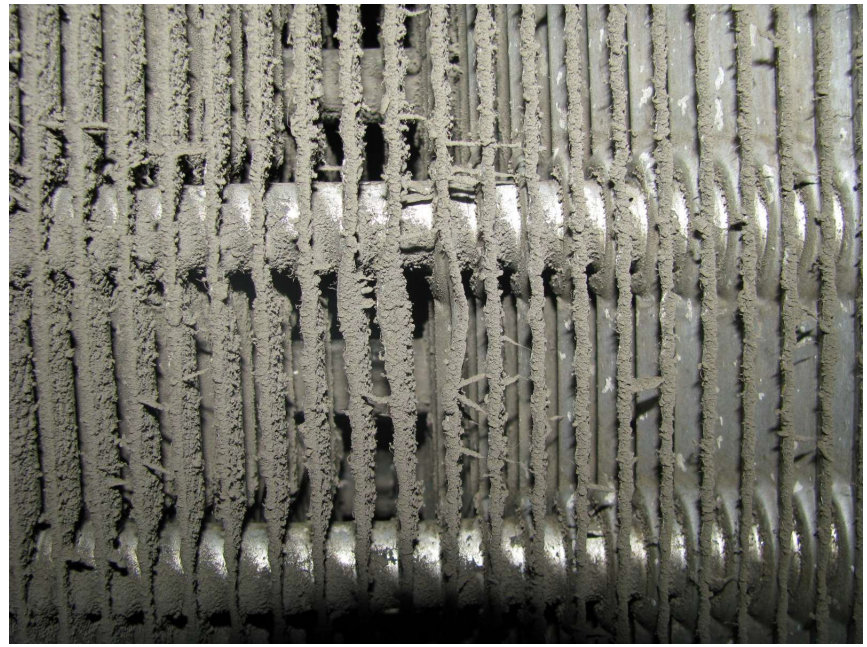
Biofilm Formation



Biofilm Effects on HVAC Coils, Drain Pans & Filters

- Insulator
  - —Reducing heat exchange efficiency
- Airflow obstruction
- Reservoir and “Amplification Device “for pathogens
- Aerosol generator
- Pathogen aerosol transmitter



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Reduced HVAC Efficiency

- Covers cooling surface
- **Creates insulation requiring colder coolant to achieve same air temperature**
- Blocks air spaces in coils
- **Requires more energy to drive fan to get same airflow**
    - Blocks drains
    - **Maintenance problems**
    - Requires cleaning
- **Labor costs and management**

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How Much Will Air-side Fin Fouling Cost ?

Fouling Thickness	Efficiency Loss
.006”	5.3%
.012”	10.8%
.024”	21.5%
.036”	32.2%

Microscopic levels of micro-organisms begin forming immediately after cleaning, rapidly multiply in volume, & have a major effect on HVAC system efficiency.

California Society for Healthcare Engineering Inc
May/June 1998 Vol. 28 No 3

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Typical Microbiology of HVAC Biofilm

- >50 hospitals and facilities
- 7 states
- >100 HVAC Systems
- ICU & Operating Suites
- >1,500 cultures
- >75% positive cultures

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HVAC Biofilm- Typical *Fungi* Cultured

Fungi	HAVC System Cooling Coils & Final Filters	Supply and Return Air Diffusers
Candida spp.†	•	•
Aspergillus spp	•	•
Aspergillus niger	•	
Aspergillus wentii	•	
Penicillium spp.	•	•
Fusarium spp.	•	
Cladosporium spp.	•	•
Alternaria spp.	•	•
Epicococcum spp.	•	•
Epicococcum nigrum	•	•
Cryptococcus spp.	•	
Aureobasidium spp.	•	
Aureobasidium pullulans	•	
Basidiomycetes spp.	•	
Acremonium spp.	•	
Rhodotorula spp.	•	
Chaetomium spp.	•	•
Stachybotrys spp.	•	•
Stachybotrys chartarum	•	
Ulocladium	•	
Verticillium	•	

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HVAC Biofilm - Typical *Bacteria* Cultured

Microorganisms	HAVC System Cooling Coils & Final Filters	Supply and Return Air Diffusers
Gram-negative		
(1) Pseudomonas spp†	•	•
Pseudomonas aeruginosa	•	•
Stenotrophomonas spp.	•	•
Acinetobacter spp.	•	•
Klebsiella spp.	•	•
Serratia spp.	•	•
Enterobacter spp.	•	
Enterobacter cloace	•	
Escherichia coli	•	•
Corynebacterium spp.	•	
Comamonas spp.	•	
Gram-positive		
Enterococcus spp.	•	•
(1) Staphylococcus aureus	•	•
CONS*	•	•
Micrococcus spp.	•	•
Streptococcus spp.	•	•
Bacillus spp.	•	•

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The Role of HVAC Systems and Airborne Infection Transmission

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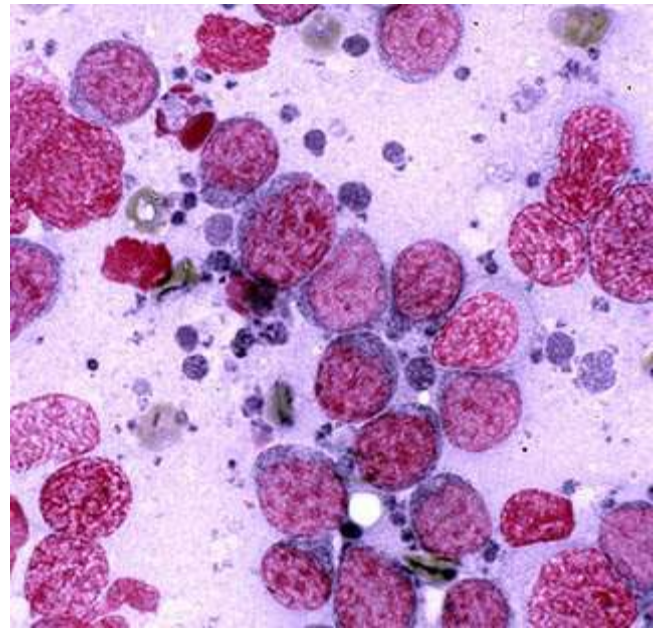
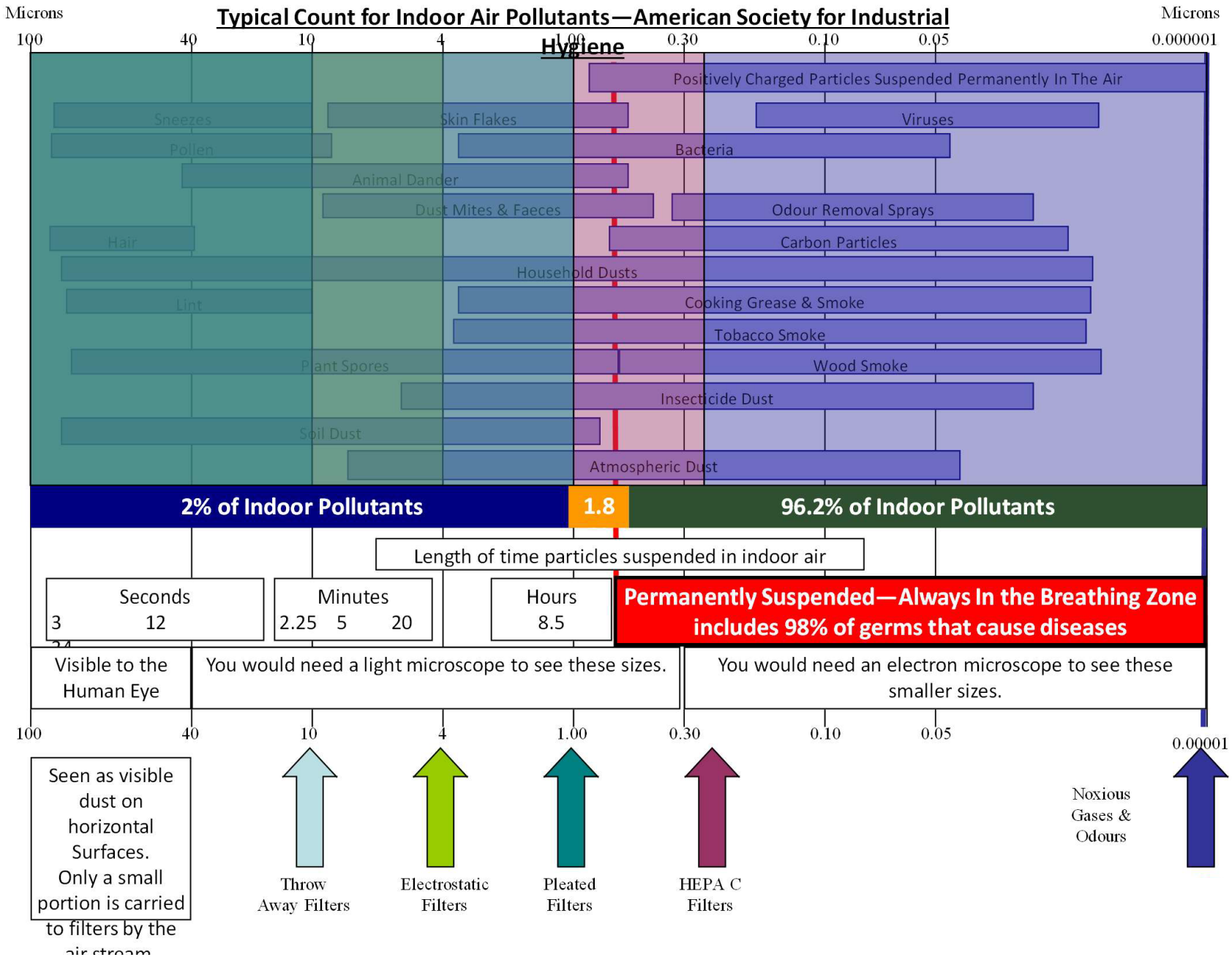
Bioaerosols

- Larger droplets fall to the ground
- Smaller droplets (1-5 micron diameter) evaporate and become droplet nuclei
- Remain suspended in air for hours or days, traveling long distances or recirculating within a building envelope



Droplet Nuclei Transfer

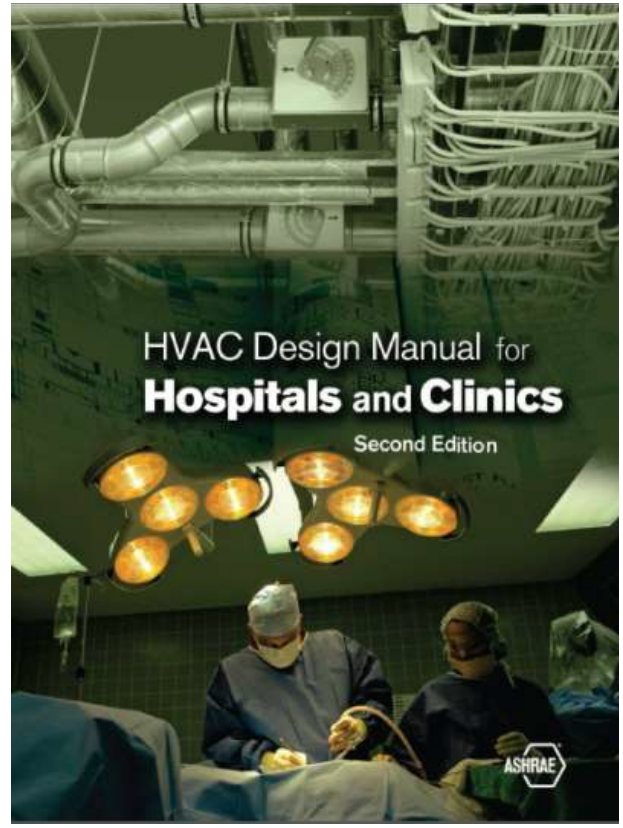
- One cough can generate 3000 droplet nuclei
- Talking for 5 minutes can generate 3000 droplet nuclei
- Singing can generate 3000 droplet nuclei in one minute
- Sneezing generates tens of thousands droplet nuclei, which can spread to individuals up to 10 feet away. Initial velocities can be up to 100 m/s


Typical Count for Indoor Air Pollutants—American Society for Industrial Hygiene
Microns
100
40
10
4
1.00
0.30
0.10
0.05
Microns
0.000001
Positively Charged Particles Suspended Permanently In The Air
Sneezes
Skin Flakes
Viruses
Pollen
Bacteria
Animal Dander
Dust Mites & Faeces
Odour Removal Sprays
Hair
Carbon Particles
Household Dusts
Lint
Cooking Grease & Smoke
Tobacco Smoke
Plant Spores
Wood Smoke
Insecticide Dust
Soil Dust
Atmospheric Dust
2% of Indoor Pollutants
1.8
96.2% of Indoor Pollutants
Length of time particles suspended in indoor air
Seconds
3
12
Minutes
2.25
5
20
Hours
8.5
Permanently Suspended—Always In the Breathing Zone includes 98% of germs that cause diseases
Visible to the Human Eye
You would need a light microscope to see these sizes.
You would need an electron microscope to see these smaller sizes.
100
40
10
4
1.00
0.30
0.10
0.05
0.00001
Seen as visible dust on horizontal Surfaces. Only a small portion is carried to filters by the
Throw Away Filters
Electrostatic Filters
Pleated Filters
HEPA C Filters
Noxious Gases & Odours

Role of HVAC in Infection Control

ASHRAE Section 2.2

- Dilution (by ventilation)
- Air quality (by filtration)
- Exposure time (by air change)
- Temperature/humidity
- Organism viability (by ultraviolet treatment)
- Airflow patterns



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How effective is a HEPA Filter

Filter load (24” x 24”)	800 CFM Avg.
particulate concentrate (CF air)	100,000
Particles/min confronting filter:	80 million
Filter efficiency rate	99.99%
Particles eluding filter:	8,000/min

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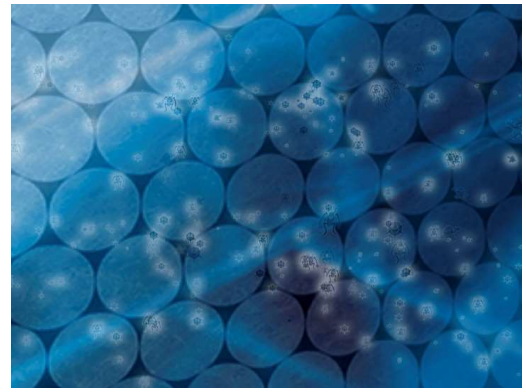
Micro-Organism Basics

How big are they?

Small enough to go through the filters!



Mold: **1 to 5+ Microns**

Bacteria: **0.5 to 4 Microns**

Viruses: **10 to 750 Millimicrons (1000th of a Micron)**

A Micron is 1 / 25,400 of an inch!

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Micro-Organism Basics

How fast do bacteria multiply?

Under ideal conditions, bacteria and viruses may double every 20 minutes.

Therefore in one day the formula becomes 2^n so that in 24 hrs we have 2^{72} or approximately 7×10^{13} or :

70 TRILLION ORGANISMS!

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Micro-Organism Basics

Doubles every
20 minutes

Every 2-6
hours

Species specific

Mold multiplies a little slower (every 6 hours)

It takes 18 days to get

70 TRILLION MOLD ORGANISMS!

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Downstream Coil - NICU HVAC

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Selected Six Tertiary Care Hospitals for Study

- (1) New York, (1) Michigan, (2) Pennsylvania & (2) Washington DC
- Total of 13 HVAC systems surfaces cultured for presence microorganisms
- All HVAC systems served critical care patient environments
- Air supply & return diffusers cultured for presence microorganisms
- Microorganism sample were collected pre-UVGI and 90 day post-UVGI installation

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Women & Children's Hospital of Buffalo (*WCHOB*)

- Neonatal Intensive Care Unit
- Ventilator Associated Pneumonia
- Highest at Risk Patient
- Infants < 30 Weeks Gestational Age
- Ventilator Support > 2 weeks
- Span of study – 2.5 years
- Presented at S.H.E.A. 2007 Conference
- Presented at PAS 2007 Conference
- Published in *Journal of Perinatology*, Spring 2011

Microorganisms Cultured from NICU Environments

WCHOB

Microorganism	Remote HVAC	NICU Environment						Outdoor Air	Infants' Tracheas
		Ceiling Diffusers	Linen Hamper	Diaper Weigh	Work Stations	Sinks	NICU Air		
Pseudomonas	❖	❖	❖	❖		❖			❖
Stenotrophomonas	❖	❖	❖	❖		❖			❖
Acinetobacter	❖	❖	❖	❖	❖	❖			❖
Klebsiella	❖	❖		❖	❖	❖			❖
Serratia	❖		❖	❖	❖	❖			❖
Staph Aureus	❖	❖	❖	❖	❖		❖	❖	❖
CONS	❖			❖		❖	❖		❖
Streptococcus	❖	❖					❖		❖
Yeast	❖	❖		❖		❖	❖		❖
Enterobacter		❖		❖	❖	❖			❖
E. Coli				❖	❖				❖
Enterococcus				❖	❖				❖
Aspergillus		❖	❖	❖	❖	❖	❖	❖	❖
Bacillus	❖	❖	❖	❖	❖	❖	❖	❖	
Flavomonas	❖	❖			❖	❖	❖		
Penicillium	❖	❖	❖	❖	❖	❖	❖	❖	
Corynebact	❖	❖	❖	❖	❖	❖	❖	❖	
Comomonas	❖			❖	❖	❖			
Cladosproridium	❖	❖				❖	❖	❖	
Alternaria	❖	❖		❖	❖		❖	❖	
Citrobacter				❖	❖				

GUH

Microorganisms	HVAC	SA Grilles	RA Grilles	Sinks	Pee Scale	Infants
Pseudomonas	X		X	X		
Stenotrophomonas						
Acinetobacter	X		X	X	X	
Klebsiella			X	X	X	
Syaphylococcus	X	X				
Bacillus	X	X	X	X		
Penicillium	X	X	X	X		
Corynebacterium	X		X	X		
Alternaria	X					
Aspergillus	X					
Cladosporium	X			X		
Yeast	X			X		
Aeomonas				X		
Enterococcus			X			
Enterobacter			X	X		
Pantoea			X	X		
Paecilomyces				X		
Fusarium				X		
Chaetomium	X					
Citrobacter				X		
Raoultella				X	X	

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Hospital Environmental Microbial Samples *Pre & Post UVC Installation*

Hospital Environment Location	Pre sample Bacteria CFU/sq. in. Mean (SD)	Pre sample Fungi CFU/sq. in. Mean (SD)	Post sample Bacteria CFU/sq. in. Mean (SD)	Post sample Fungi CFU/sq. in. Mean (SD)
HVAC Cooling Coils & Final Filters	1,255,877 (932,485.1)	85,657 (84,114.9)	125 (209.2)	1,919 (5,309.5)
Patient Care Units Supply Air & Return Diffusers	814,750 (1,149,402.1)	21,425 (30,158.1)	1,375 (1,944.5)	0 (0)

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Results - Pre & Post UVGI Installation Bacteria Reported HVAC and Air Diffusers

Sample Locations	Pre UVGI Installation Bacteria CFU/cm² Mean (SD)	90 Day Post UVGI Installation Bacteria CFU/ cm² Mean (SD)
HVAC cooling coils, condensate drain pans & final filters	1,736,396 (1,348,668)	33.3 (115.5)
Patient care area supply and return diffusers	1,092,779 (1,313,629)	28.5 (40.3)

Actual Intensive Care Unit (ICU) Costs for HAI'S

HAI Example: Ventilator Associated Pneumonia (VAP)

- Cocanour, *et al – PubMed.gov* - 2005
  $57,000 per occurrence
- Eagye, *et al – Seminars in Respiratory and Critical Care Medicine* - 2009
  $**49,000 per occurrence**
- Ryan, *et al – Journal of Perinatology*- 2011
  $65,000 per occurrence

Average Actual Cost of Infection: $57,000

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Hospital Case Study

Case study:
Women & Children's Hospital of Buffalo

Neonatal Care Unit

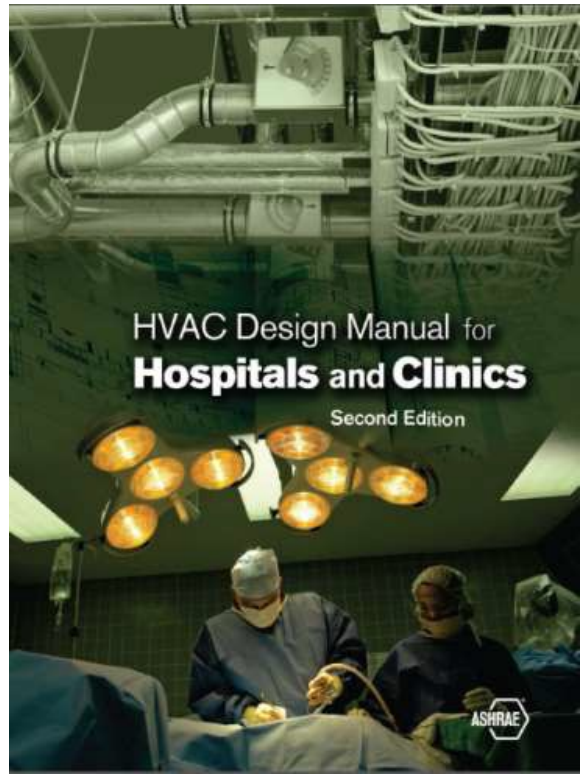
- Reduced Ventilator Associated Pneumonia (VAP)
- Reduced antimicrobial use
- Reduced antimicrobial resistance
- $800,000/year reduction in direct costs
- UVC installation costs of $25,000

2 ½ year study

ASHRAE Design Manual

- **Section 2.11: Ultraviolet Radiation**
  - UV radiation can be effective in reducing the virulence of microorganisms and, therefore, in

    attempting to reduce infection rates



ASHRAE™

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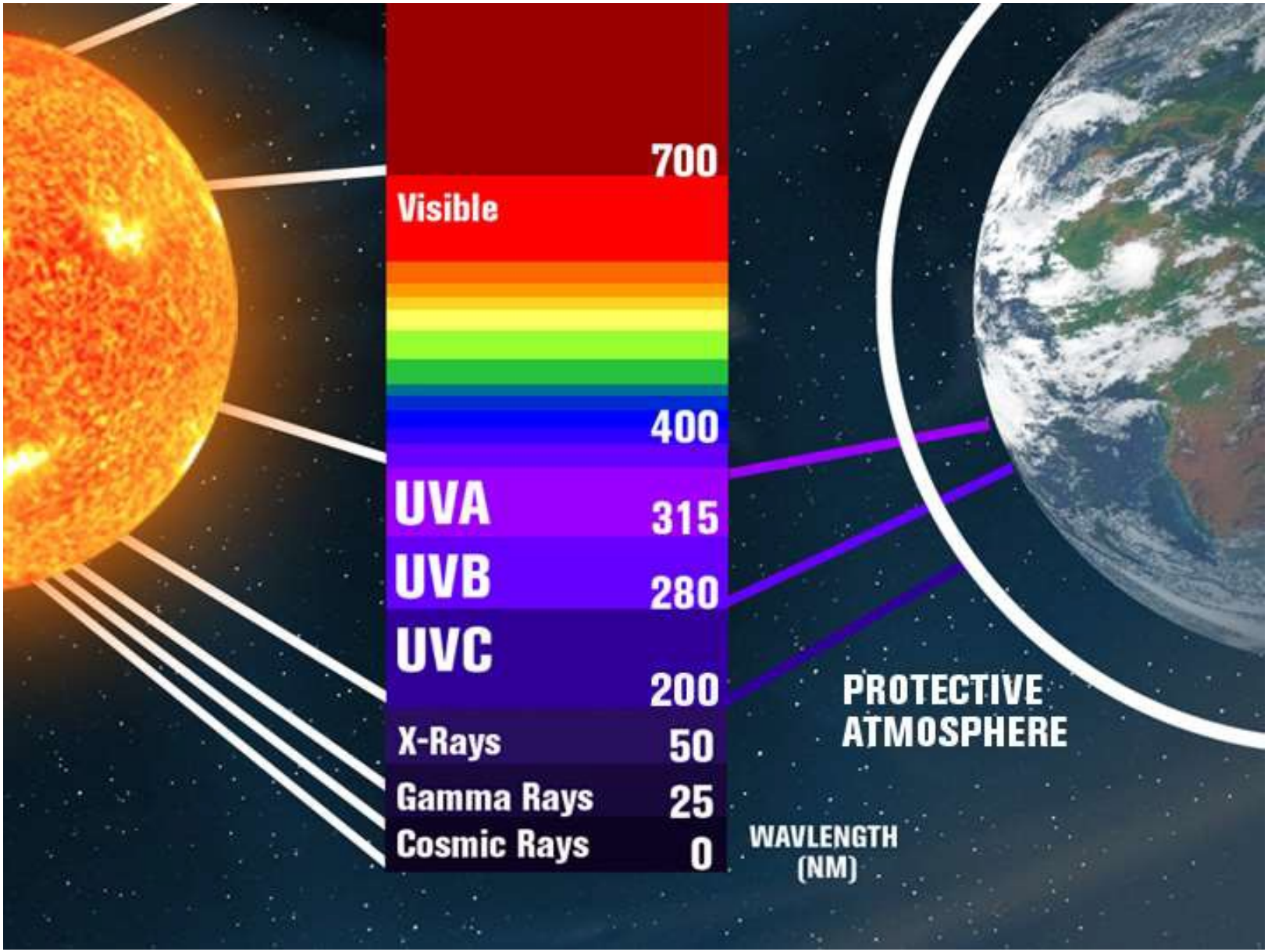
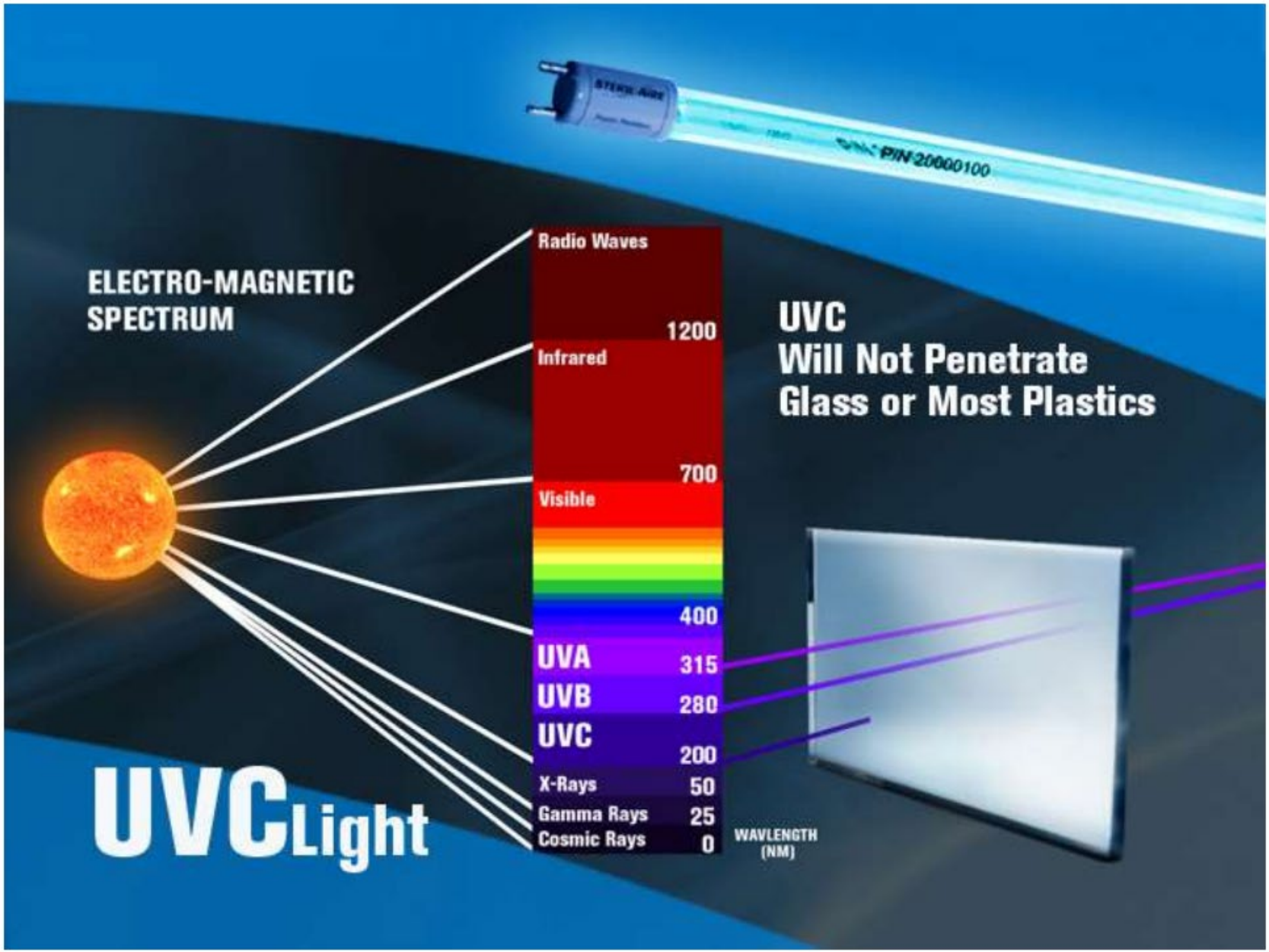
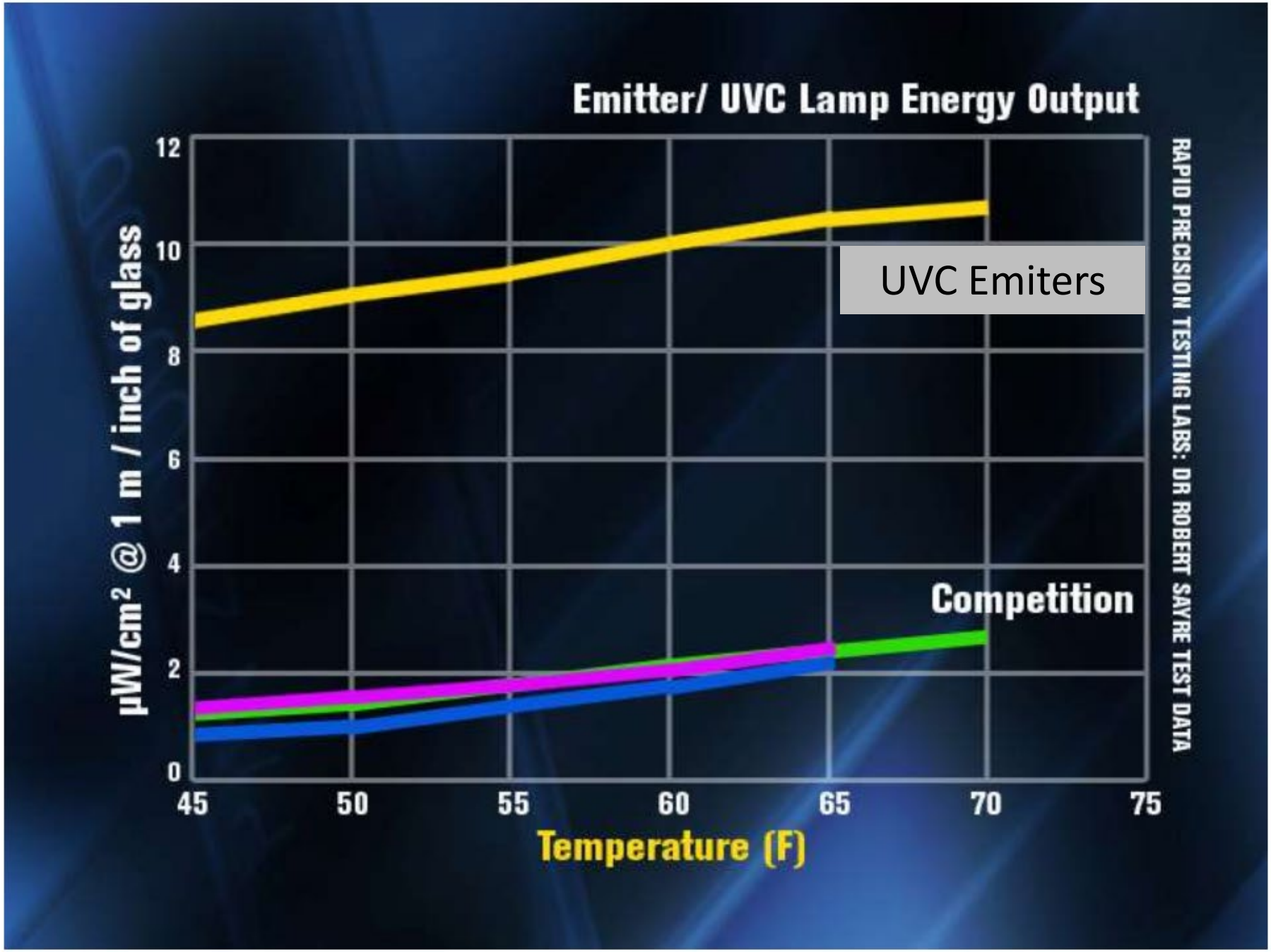

700
Visible
400
UVA
315
UVB
280
UVC
200
X-Rays
50
Gamma Rays
25
Cosmic Rays
0
WAVLENGTH
(NM)
PROTECTIVE
ATMOSPHERE


ELECTRO-MAGNETIC
SPECTRUM
Radio Waves
1200
Infrared
700
Visible
400
UVA
315
UVB
280
UVC
200
X-Rays
50
Gamma Rays
25
Cosmic Rays
0
WAVLENGTH
(NM)
UVC Will Not Penetrate
Glass or Most Plastics
UVC Light
PIN 20000100


Emitter/ UVC Lamp Energy Output
µW/cm² @ 1 m / inch of glass
12
10
8
6
4
2
0
45
50
55
60
65
70
75
Temperature (F)
UVC Emiters
Competition
RAPID PRECISION TESTING LABS: DR ROBERT SAYRE TEST DATA

UVGI System Design Parameters

- Intent was to be at 99.9% at end of lamp life
- Minimum intensity across entire irradiated surface:
  - 1,225 µW/cm² - Initial
  - 735 µW/cm² after 12 months of continuous operation
- 99.9% Inactivation rate on specified microorganisms:
  - *Aspergillus niger* in less than 10 minutes
  - *Pseudomonas aeruginosa less than 30 seconds*

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Energy Required for Microorganism Inactivation Efficiencies

MICROORGANISM	D_{90} (µj/cm²)	D_{99} (µj/cm²)	$D_{99.9}$ (µj/cm²)
Aspergillus niger Spores	135,446	270,892	406,338
Pseudomonas aeruginosa	5,495	10,984	16,486
Staphylococcus aureus	2,599	5,198	7,797
Mycobacterium tuberculosis	3,332	6,664	9,997

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Inactivation Rate Examples (99.9%) End of Lamp Efficiency

µJ = Intensity (µw/cm²) x Time

Aspergillus niger – 406,338 µJ/cm² (Required UVC dose for 99.9 inactivation) ÷ 735 µW/cm² = 552 Seconds (9.1 minutes)

Pseudomonas aeruginosa – 16,486 µJ/cm² (Required UVC dose for 99.9 inactivation) ÷ 735 µW/cm² = 22.4 Seconds

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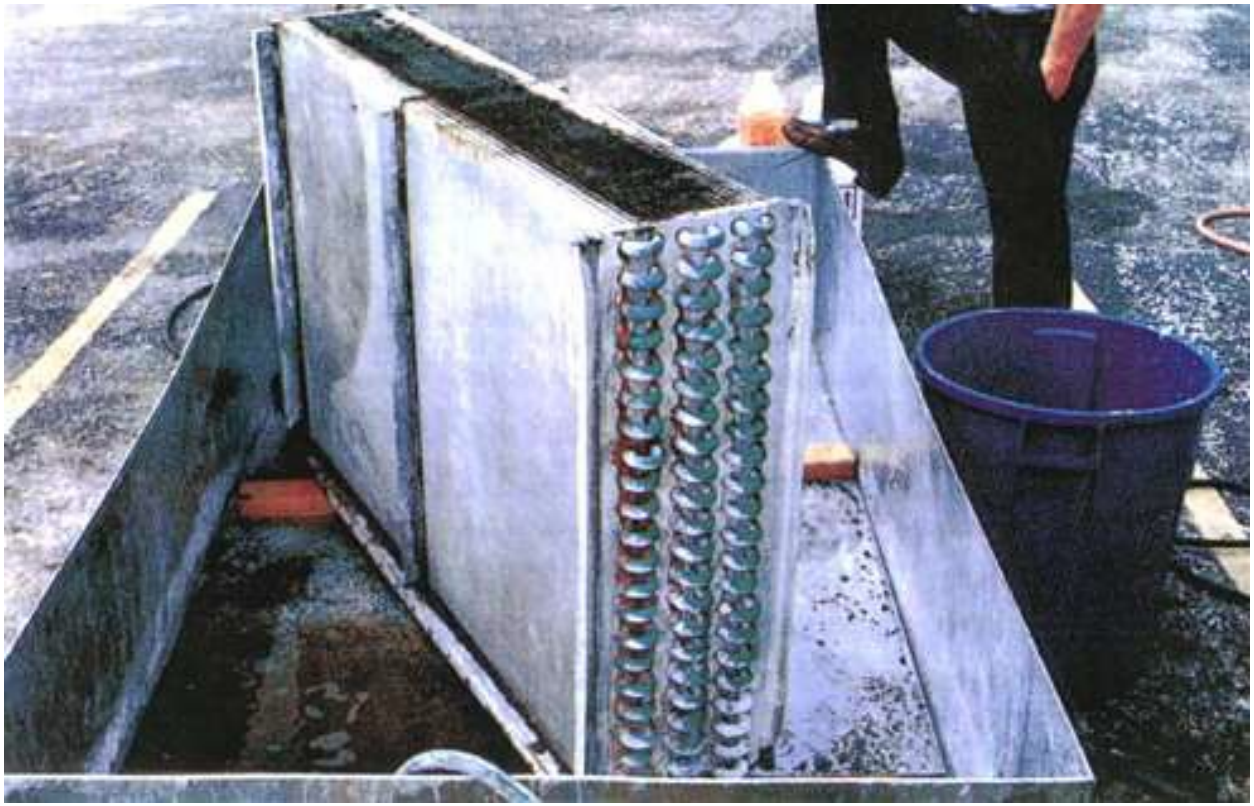
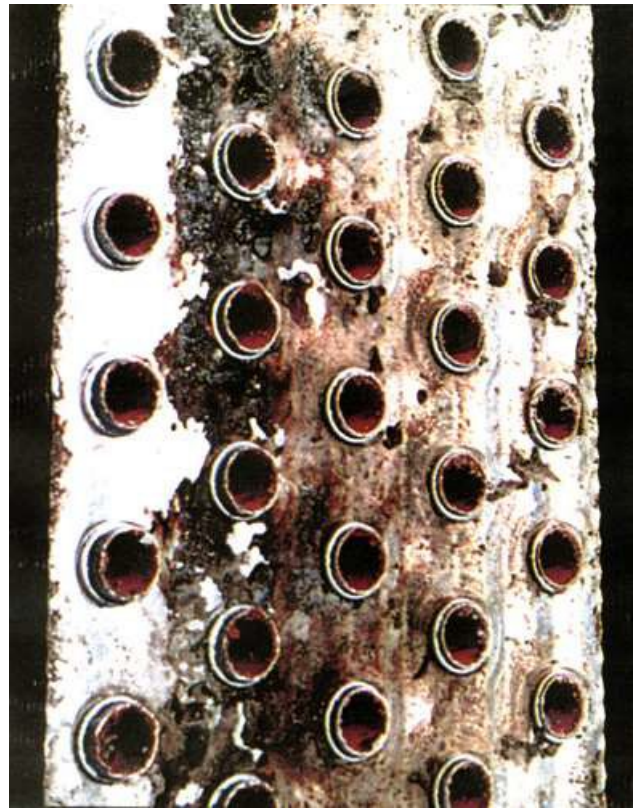
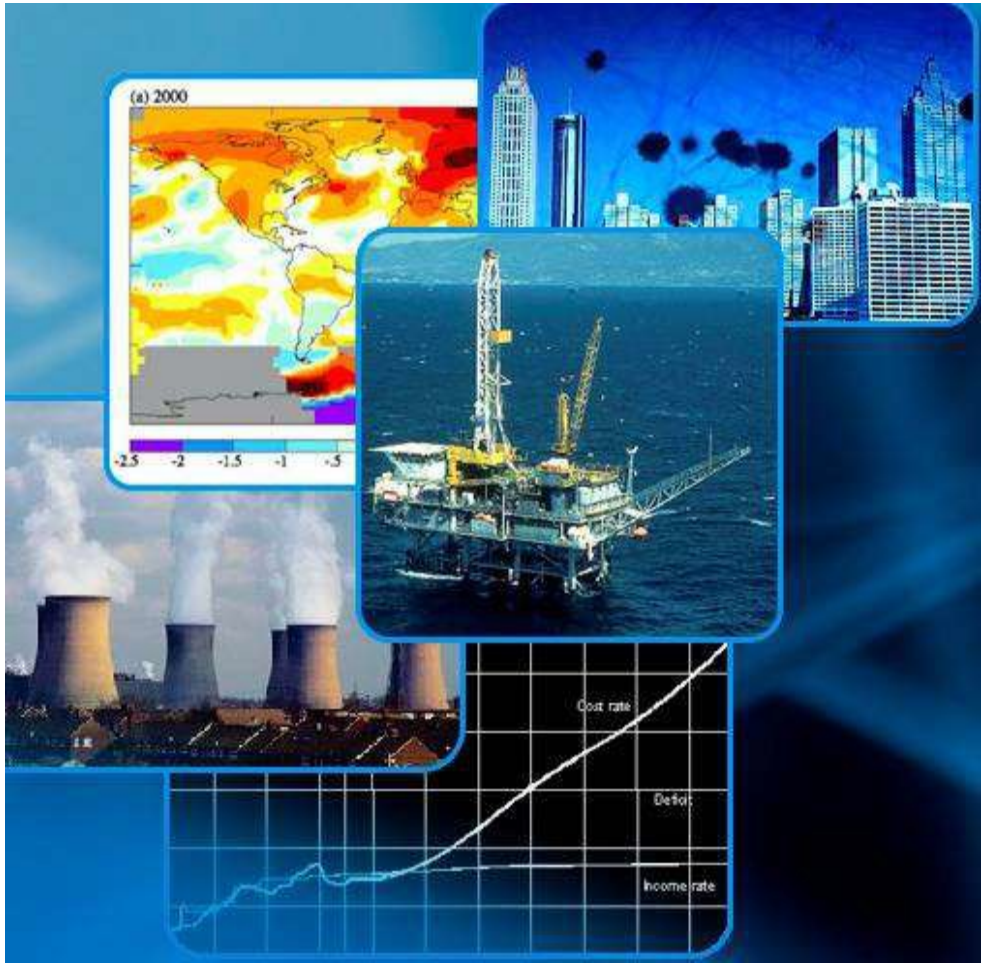
Coil Cleaning





Energy Facts



- HVAC uses 40- 60% of building energy
- Dirty coils use up to 30% more energy
- Climate Change
- Energy costs up

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UVC Emitters Energy Solutions

- Electrical energy savings up to 15%
  - Reduced fan, chiller and chiller pump use

- Clean coils improve
  - Heat transfer
  - Airflow
  - Compressor run time
  - Operational efficiency
  - Thermal comfort

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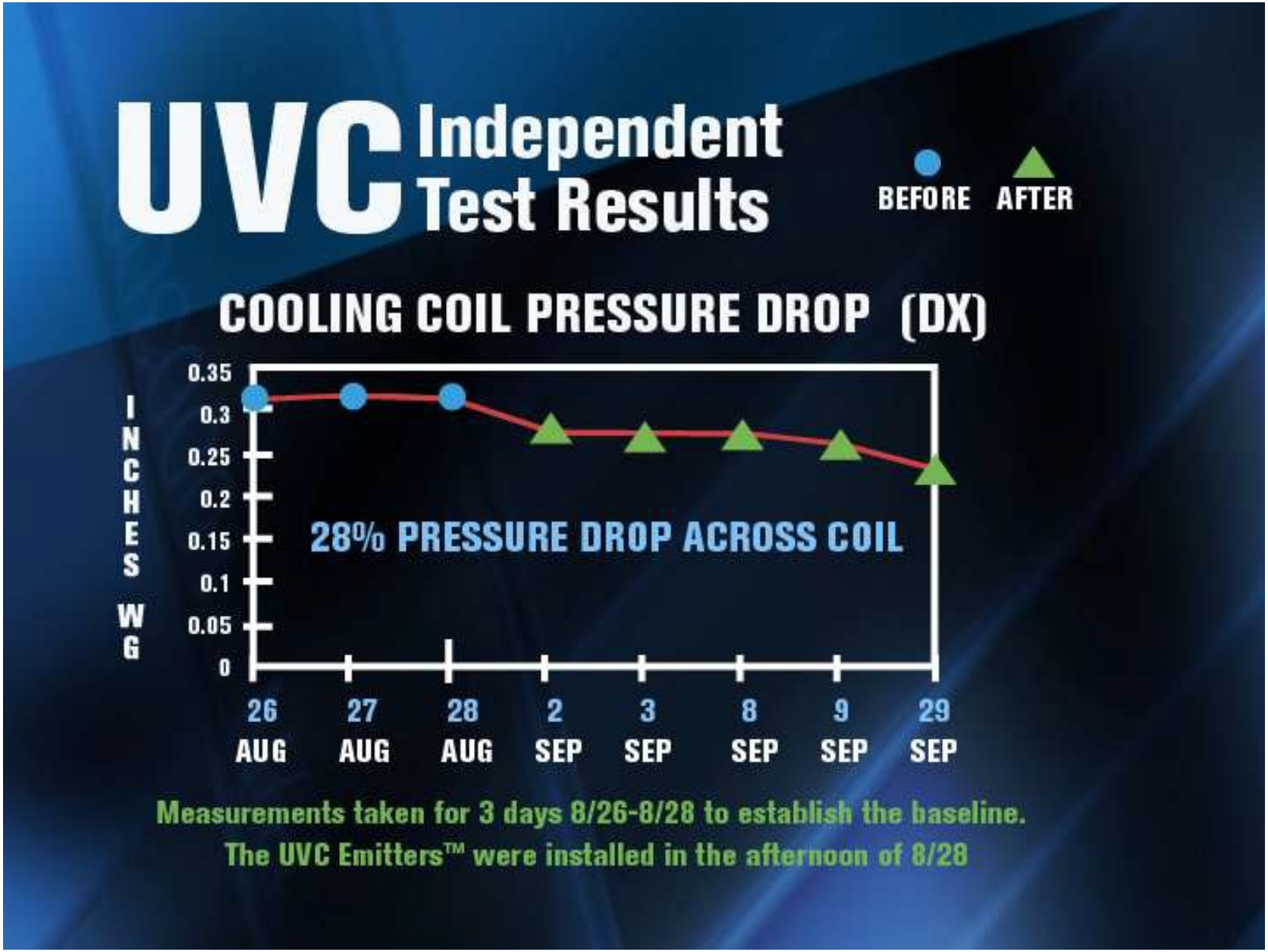
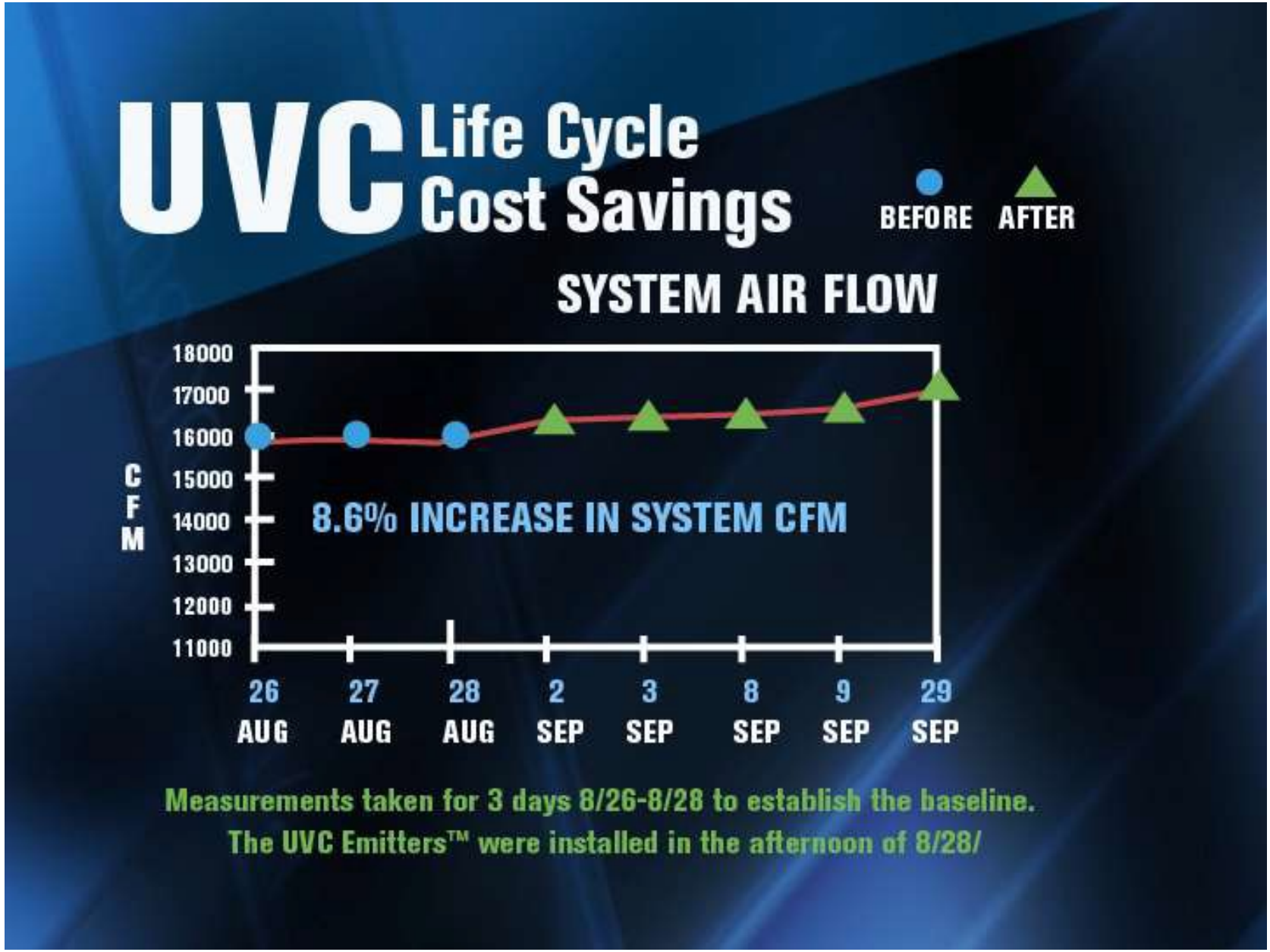
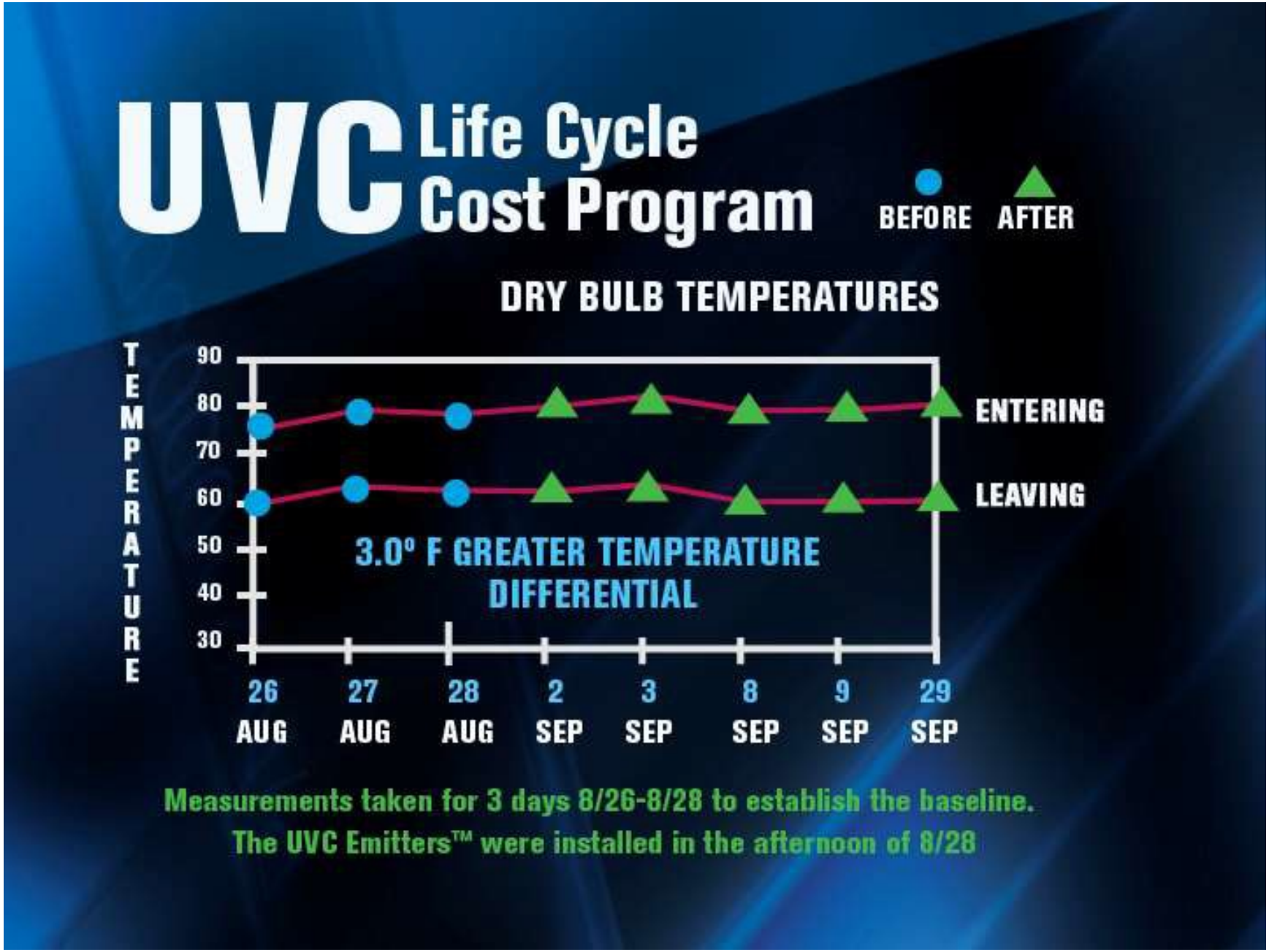
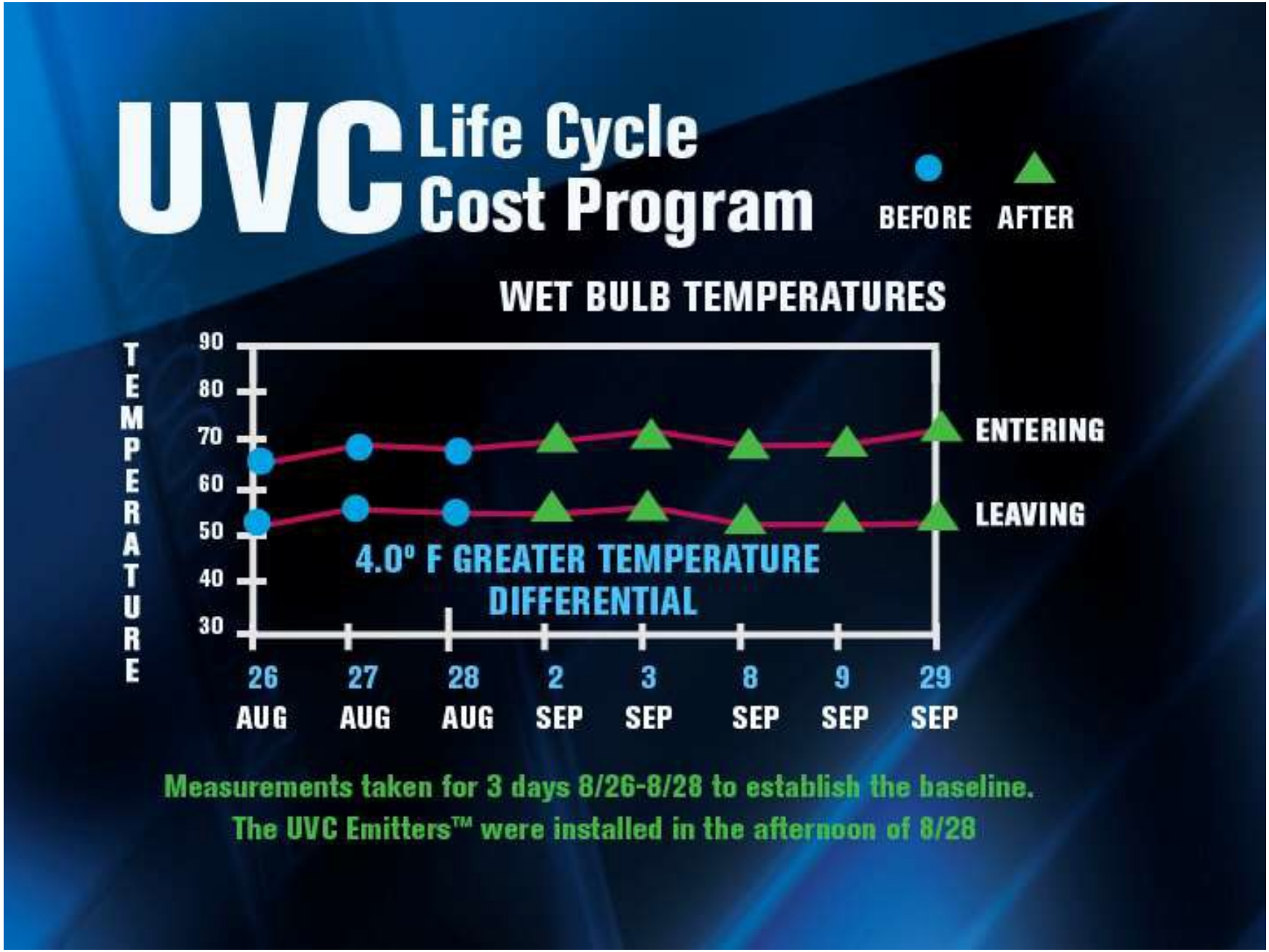

UVC Independent Test Results
BEFORE
AFTER
COOLING COIL PRESSURE DROP (DX)
INCHES WG
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
28% PRESSURE DROP ACROSS COIL
26 AUG
27 AUG
28 AUG
2 SEP
3 SEP
8 SEP
9 SEP
29 SEP
Measurements taken for 3 days 8/26-8/28 to establish the baseline.
The UVC Emitters™ were installed in the afternoon of 8/28



DVM INDUSTRIES


UVC Life Cycle Cost Program
BEFORE
AFTER
DRY BULB TEMPERATURES
TEMPERATURE
90
80
70
60
50
40
30
ENTERING
LEAVING
3.0° F GREATER TEMPERATURE DIFFERENTIAL
26 AUG
27 AUG
28 AUG
2 SEP
3 SEP
8 SEP
9 SEP
29 SEP
Measurements taken for 3 days 8/26-8/28 to establish the baseline.
The UVC Emitters™ were installed in the afternoon of 8/28


UVC Life Cycle Cost Program
BEFORE
AFTER
WET BULB TEMPERATURES
TEMPERATURE
90
80
70
60
50
40
30
ENTERING
LEAVING
4.0° F GREATER TEMPERATURE DIFFERENTIAL
26 AUG
27 AUG
28 AUG
2 SEP
3 SEP
8 SEP
9 SEP
29 SEP
Measurements taken for 3 days 8/26-8/28 to establish the baseline.
The UVC Emitters™ were installed in the afternoon of 8/28

UVC Cost Savings (Life Cycle) Estimate Sheet

Project Name: Example # 2			**Date:** 17-Aug-04	
Location:			**Contact:**	
			Engineer:	
AHU Tagging:			**Contractor:**	
UVC Installation	**Before**		**After**	
Date Sampled:	4-Jun-03		6-Aug-03	
CFM-Measured or Selected (VAV)	25,000		28,750	
Entering Air Temperature- Dry Bulb °F	80.0		79.0	
Entering Air Temperature- Dry Bulb °F	67.0		66.0	
Leaving Air Temperature- Dry Bulb °F	55.9		52.4	
Leaving Air Temperature- Dry Bulb °F	54.6		51.9	
Total Cooling capacity -Btuh	1,012,500		1,289,869	
Sensible heat- btuh	650,700		825,930	
Latent Heat - Btuh	361,800		463,939	
Net Cooling Capacity Gain - Btuh	→	277,369		

UVC Cost Savings (Life Cycle) Estimate Sheet

Pressure Drop "Across Coil"	1.25 " WG			0.79 " WG
Pressure Drop Reduction	0.46 " WG			
Pressure Drop BHP Reduction	**3.468**		EER:	7.0
Annual Operating Hours	2,500			Before
Energy Cost per kWh	$0.10		EER:	8.5
Annual Improvement (kWh cost)	**$11,068**			After
Annual Coil Cleaner & Biocide Cost	$2,000			
Annual Coil Cleaning Labor Cost	$1,500			
Annual Drain Pan Cleaner & biocide Cost	$500			
Annual Drain Pan Labor Cost				
Annual Maintenance Costs	**$4,000**			
Total Annual Improvement	**$15,068**			

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UVC Cost Savings (Life Cycle) Estimate Sheet

Installation Costs	1st Year	2nd Year	3rd Year	4th Year
Number of Fixtures	15			
Average Fixture Cost Each	500.00			
Installation Labor Cost	1,200.00			
Fixture(s) Annual Energy Cost (8760 hrs)	982.22	982.22	982.22	982.22
Emitter Replacement Cost (each)		85.00	85.00	85.00
Annual Emitter Replacement Cost		1,275.00	1,275.00	1,275.00
Total Installed & Operating Cost	$9,682.22	$2,257.22	$2,257.22	$2,257.22
Annual Improvement (Less Costs)	$5,386	$12,811	$12,811	$12,811
Estimated Return (years)	0.643			
Cumulative Improvement	$5,386	$18,197	$31,008	$43,819

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THE UNIVERSITY of NEW MEXICO

- **Installed UVC Emitters on the downstream side of Fan 67's cooling coil**
- **Performed same air handler independent tests 60 days after UVC Emitters install**

- **Results:**
  - **992 CFM Gain**
  - **0.07" WG Static Pressure Reduction**
  - **Net Cooling Capacity: 208% BTU Gain**
  - **ESTIMATED 1st YEAR NET SAVINGS: $4,639**
  - **ROI: 8 MONTHS**

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Case Studies

Florida Hospital (Orlando, FL)

- $237,500 energy savings per year

American Electric Power Dallas, TX

- 2,635,740 total kWh savings
- $139,000 annual energy savings

Rio Grande Regional Hospital McAllen, TX

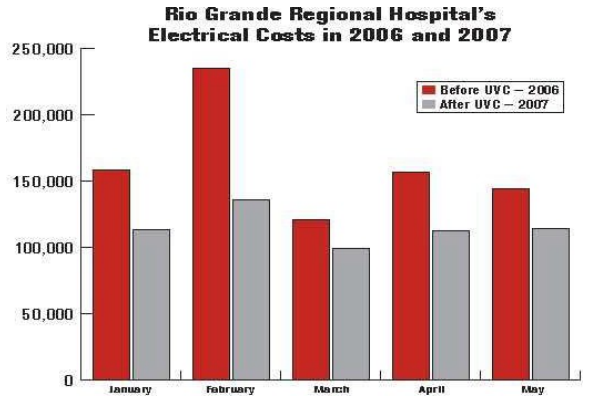
- $500,000 annual energy savings
- 2 chillers taken off-line

Pierce County Jail Tacoma, WA

- 34,102 & 39,491 therms energy reduced natural gas
- $55,000 annual savings
- Improved IAQ
- Reduced infections


UVC:
Florida Hospital Puts HVAC Maintenance Under A New Light

HVAC system downtime during coil cleaning can compromise humidity and temperature control, potentially leading to air quality or comfort problems.



Case Studies

Iolani School Honolulu, HI

- 98.8% reduction in mold growth
- Elimination of odors
- Improved IAQ
- Improved teacher & student attendance
- $8,000/yr maintenance savings
- Reduced energy costs

York Quay Toronto, Canada

- 17 story, 2000 residents
- 1200 fan coil units
- Improved IAQ
- Mold remediation

THE HVACR CONTRACTOR'S WEEKLY NEWSMAGAZINE SINCE 1926

Air Conditioning | Heating | Refrigeration

the NEWS

AUGUST 7, 2006 WWW.ACHRNEWS.COM A BNP MEDIA PUBLICATION $3.00

School Looks Ahead to Future Growth

IAQ and Sustainability are Features of the School

By B. Checket-Hanks
Of *The NEWS* Staff

HONOLULU — Iolani School may be one of the finest K-12 schools in the United States, and it's located on some prime real estate too: Oahu, Hawaii. From its academic program to its mechanical and IAQ systems, the independent school continues to challenge itself to stay on the forefront of technology and education.

In 2003, the school completed construction of the first phase of a campus master plan — the largest capital project in the school's history. The next phase is now being developed.

Teachers and administrators at Iolani School have developed a curriculum that teaches not only the basics (reading, writing, and mathematics), but is also said to teach the 1,800-plus students how to develop thinking, reasoning, and problem-solving skills; "to explore conceptual frameworks, to see the connectedness of bodies of knowledge, to hone verbal skills, and to discover individual creativity."

Class sizes are small, with an estimated student-teacher ratio of 1:12, depending on the class; Kindergarten classes tend to be among the smallest.

The school also claims to have one of the highest teacher retention rates among independent schools in the country. Part of the overall success must be due to the administration's willingness to look into technical building solutions to create a better learning environment.

Iolani School started researching the potential of UV light in 1996, by installing UVC lights in a single air-handling unit. The test unit achieved a 99.8 percent reduction in mold levels after being treated with UVC light.

The school's Weinberg Classroom/Kozuki Stadium/Multipurpose Complex project was completed in 2003, finishing the first phase in a 20-year master plan to enhance facilities on this 20-acre campus.

CAPITAL IDEAS

With the 2003 completion of the Weinberg Classroom/Kozuki Stadium/Multipurpose Complex, Iolani School finished the first phase in a 20-year master plan to enhance facilities on this 20-acre campus, said Hawaiian Electric Co. (HECO).

"Most notable improvements include 32 classrooms, four physics suites, a biology laboratory, a computer laboratory, a meeting room that comfortably seats 400 people, parking for 350 cars, office space, an athletic stadium, open space, an environmentally friendly campus-wide chilled-water loop for air conditioning, and handicap access," the school said.

One of the oldest schools in Hawaii — it was founded in 1863 — the school's aesthetic design reflects the school's roots as an Anglican school founded by English clergy during Hawaii's monarchy period. The project's goal was to implement sustainable design strategies and technology without changing the look of the school.

Sustainability and efficiency were key for the complex's main buildings: the 74,000-square-foot Weinberg Classroom building and the 174,000-square-foot Kozuki Stadium/Multipurpose Complex.

"More than 75 percent of the occupied space in this complex incorporates daylighting," said HECO. The system combines aluminum light shelves, light pipes, low-e glass, VAV, and DDC systems to enhance energy performance.

Case Studies

Airline Terminals:

- LAX – Los Angeles Airport
- George Bush Intercontinental Airport

Hotels and Casinos:

- Riviera Casino
- Four Seasons Hotel Los Angeles at Beverly Hills
- Pacific Design Center West Hollywood, CA

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GSA Specification

PBS P 100 2005 revision
Mechanical
Section 5.9
Page 143

UVC Emitters/Lamps*:* Ultraviolet light (C band) emitters/ lamps shall be incorporated downstream of all cooling coils and above all drain pans to control airborne and surface microbial growth and transfer. Applied fixtures/ lamps must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.

Can be found at http://:hydra.gsa.gov/pbs/p100/

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UVC Benefits

Immediate gains of:

- Reduced energy costs
- Reduced hospital stays
- Reduced water costs
- Reduced nosocomial infections (HAI's)
- Reduced legal liability
- Elimination of a significant microorganism reservoir
- Extended Shelf-life for Food
- Reduced Food contamination

ROI LESS THAN ONE YEAR

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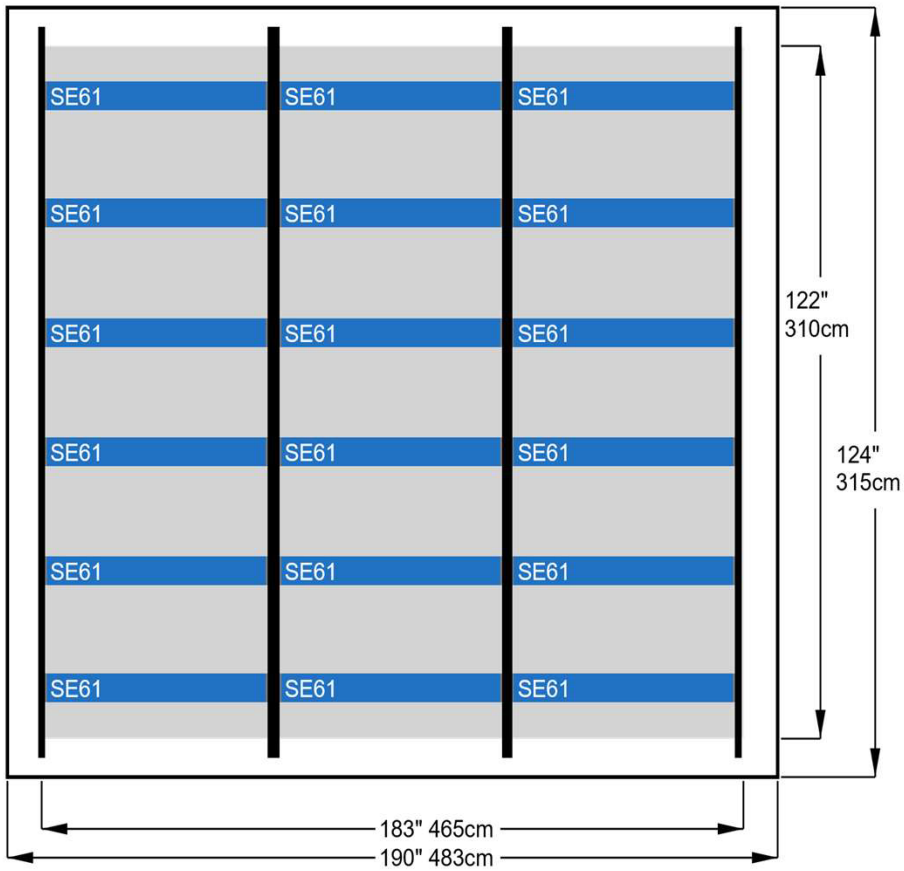
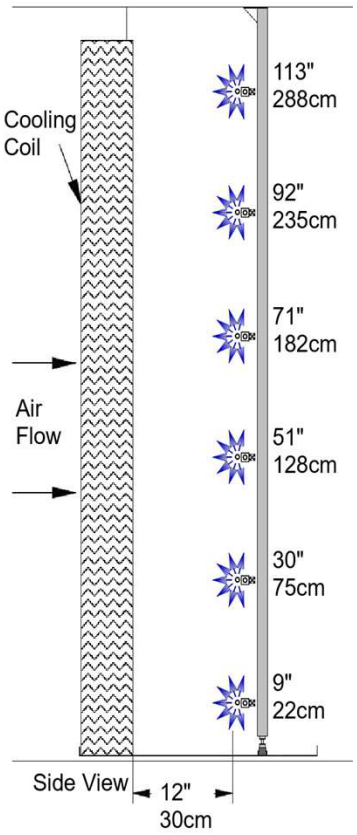
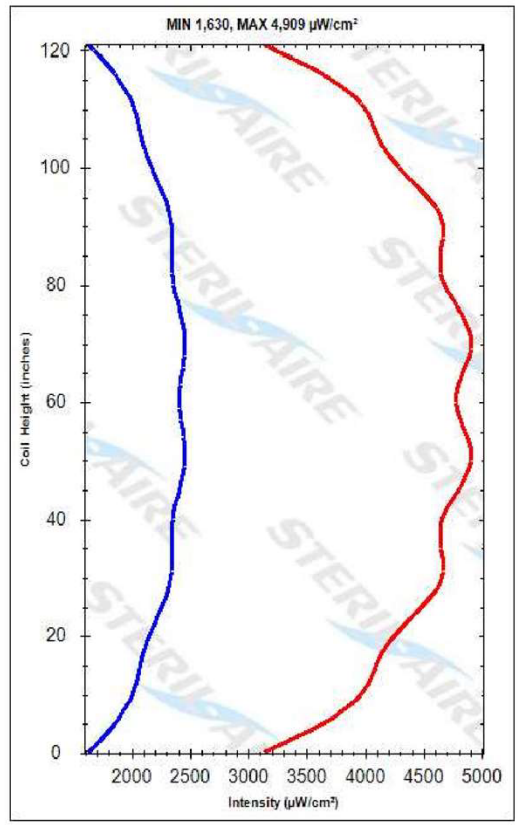
Emitter
Glass
High Quality Emitter Glass:
Crystal SiO2
Transmits UVC Light


RIK
Rapid Install Kit
Available for coils with heights from 24"(60cms) to 180" (457cm) in 1 to 8 rows and Emitter tubes
24" (60cms) to 61" (155cms) wide. For coils wider than 61" (155cms) add additional RIKs.

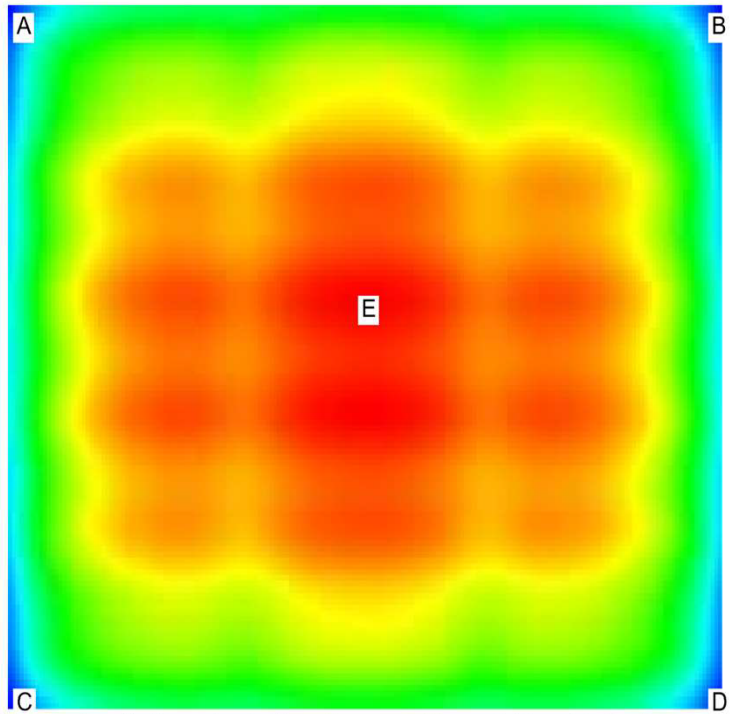
Date:	2/16/2018	Contact:		Zip Code:	
Company:		Address:		Email:	
PO#:		City:		Tele:	
Project Name:	Sodexo/Roth	State:		Rep:	Josh Oelker
Project Number:		Country:		Rep Tele:	
Notes:					







Date:	2/16/2018	Contact:		Zip Code:	
Company:		Address:		Email:	
PO#:		City:		Tele:	
Project Name:	Sodexo/Roth	State:		Rep:	Josh Oelker
Project Number:		Country:		Rep Tele:	
Notes:					



Coordinates (0, 0) are top left hand corner of the coil. Row-1 is the top row.

Item	Value/Location	Measured
Coil Distance	12" (30cm)	
Air Flow	400cfm	
Air Temp	55°F (13°C)	
ROW-1	113" (288cm)	
ROW-2	92" (235cm)	
ROW-3	71" (182cm)	
ROW-4	51" (128cm)	
ROW-5	30" (75cm)	
ROW-6	9" (22cm)	
A	1,893µW/cm² @ (2, 2")	
B	1,893µW/cm² @ (180, 2")	
C	1,893µW/cm² @ (2, 119")	
D	1,893µW/cm² @ (180, 119")	
E	4,909µW/cm² @ (90, 51")	

The following may cause measurements to be less than calculated:

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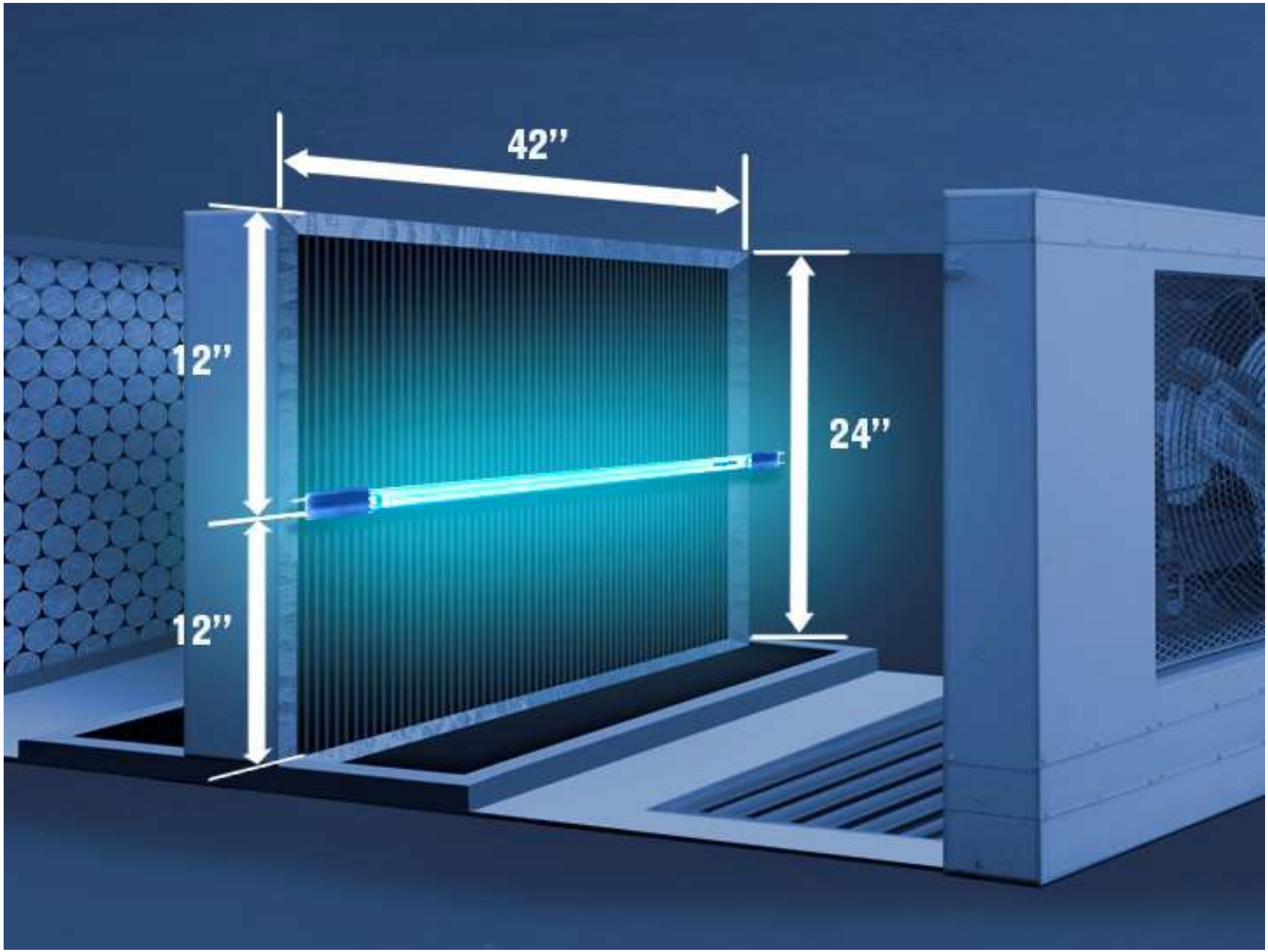
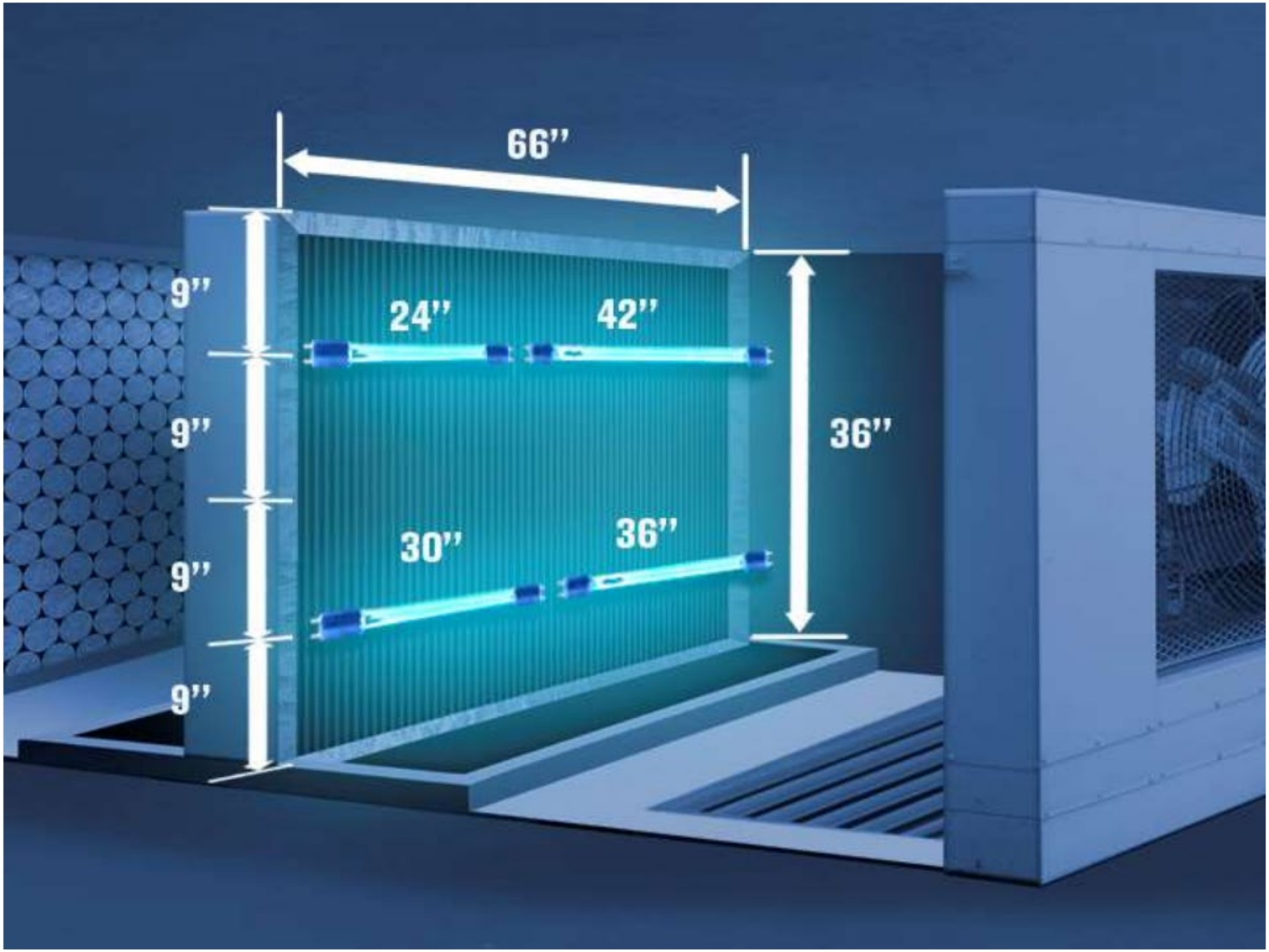
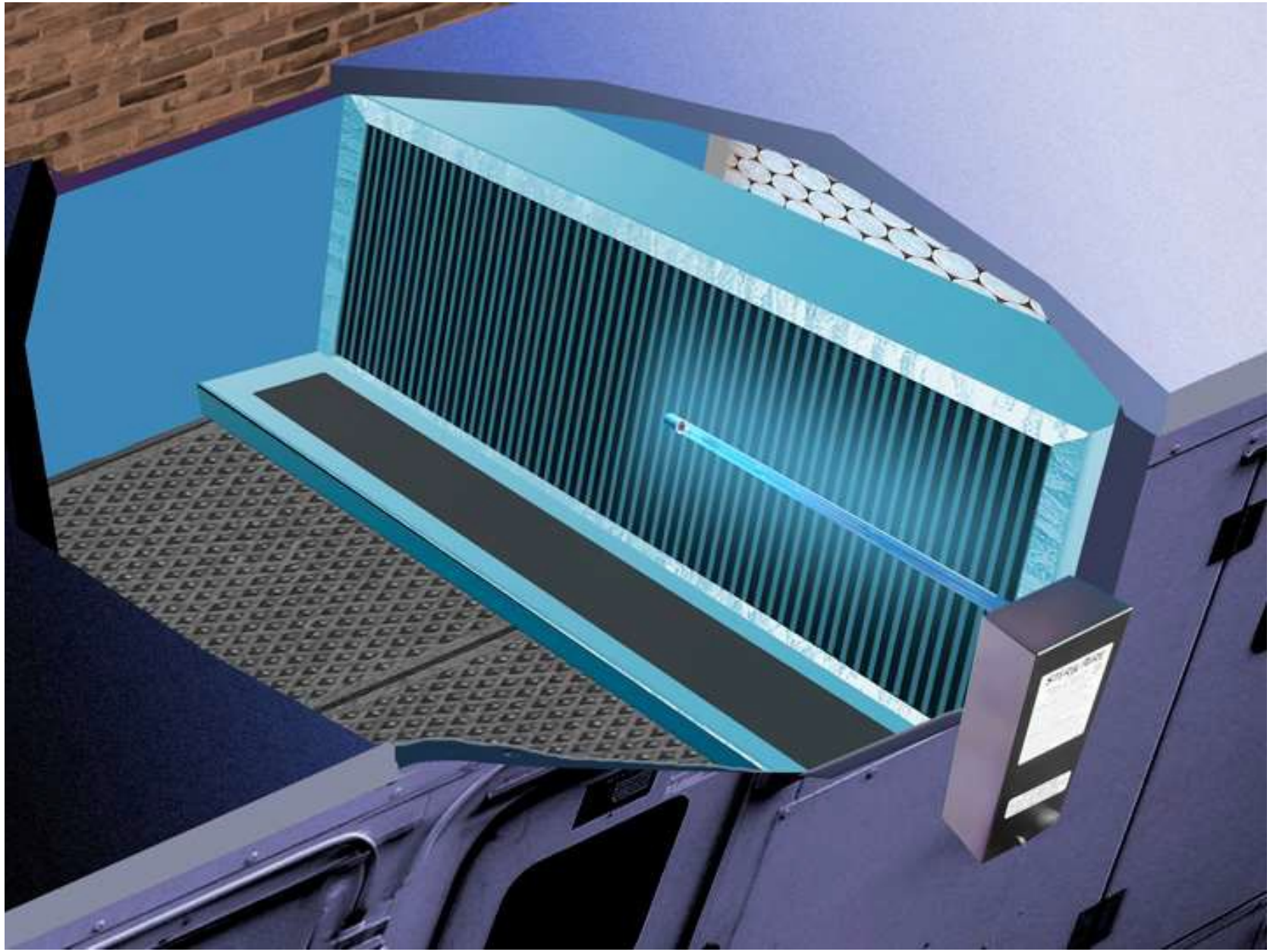

42”
12”
24”
12”


66”
9”
24”
42”
9”
36”
30”
36”
9”
9”



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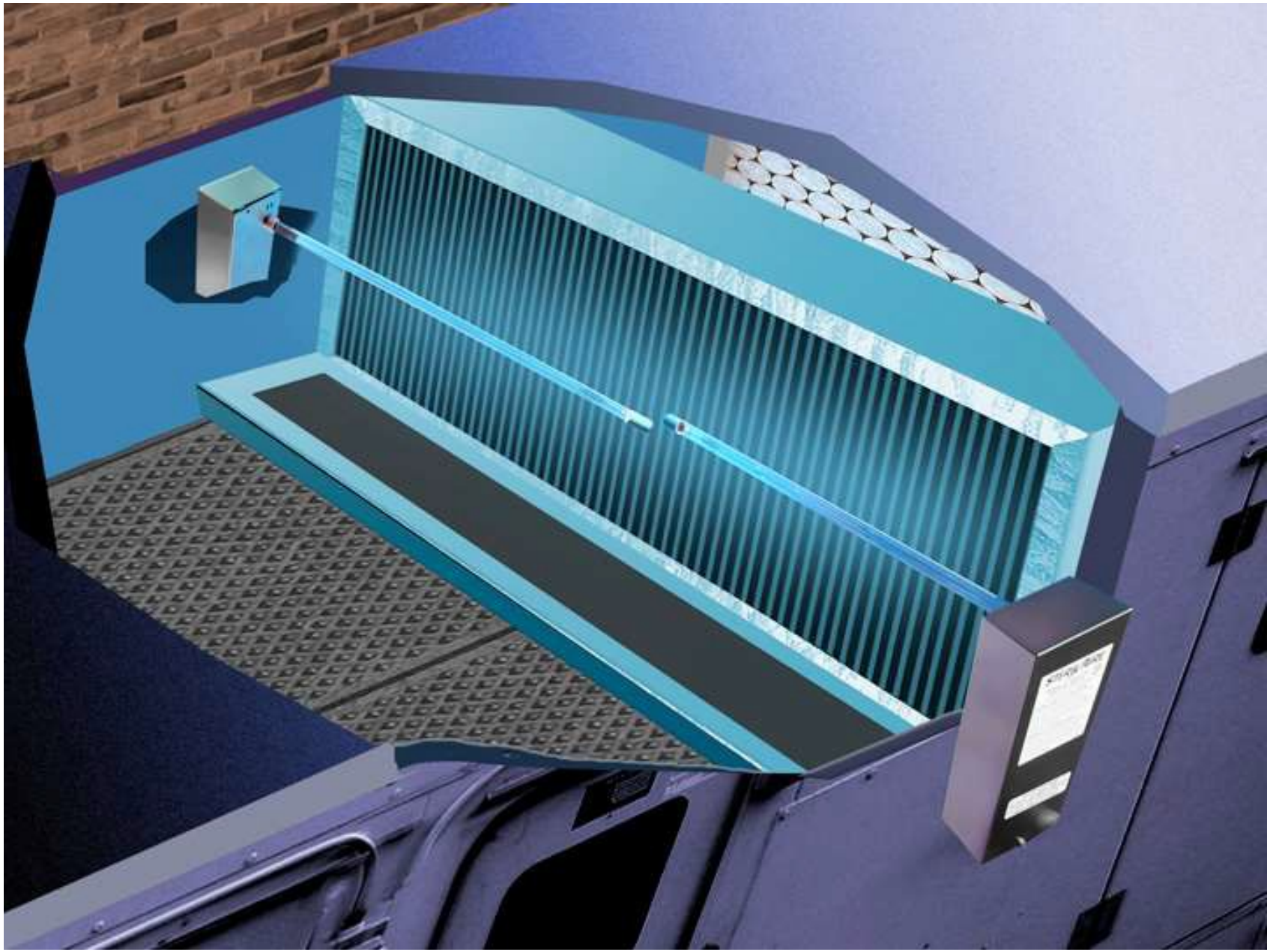

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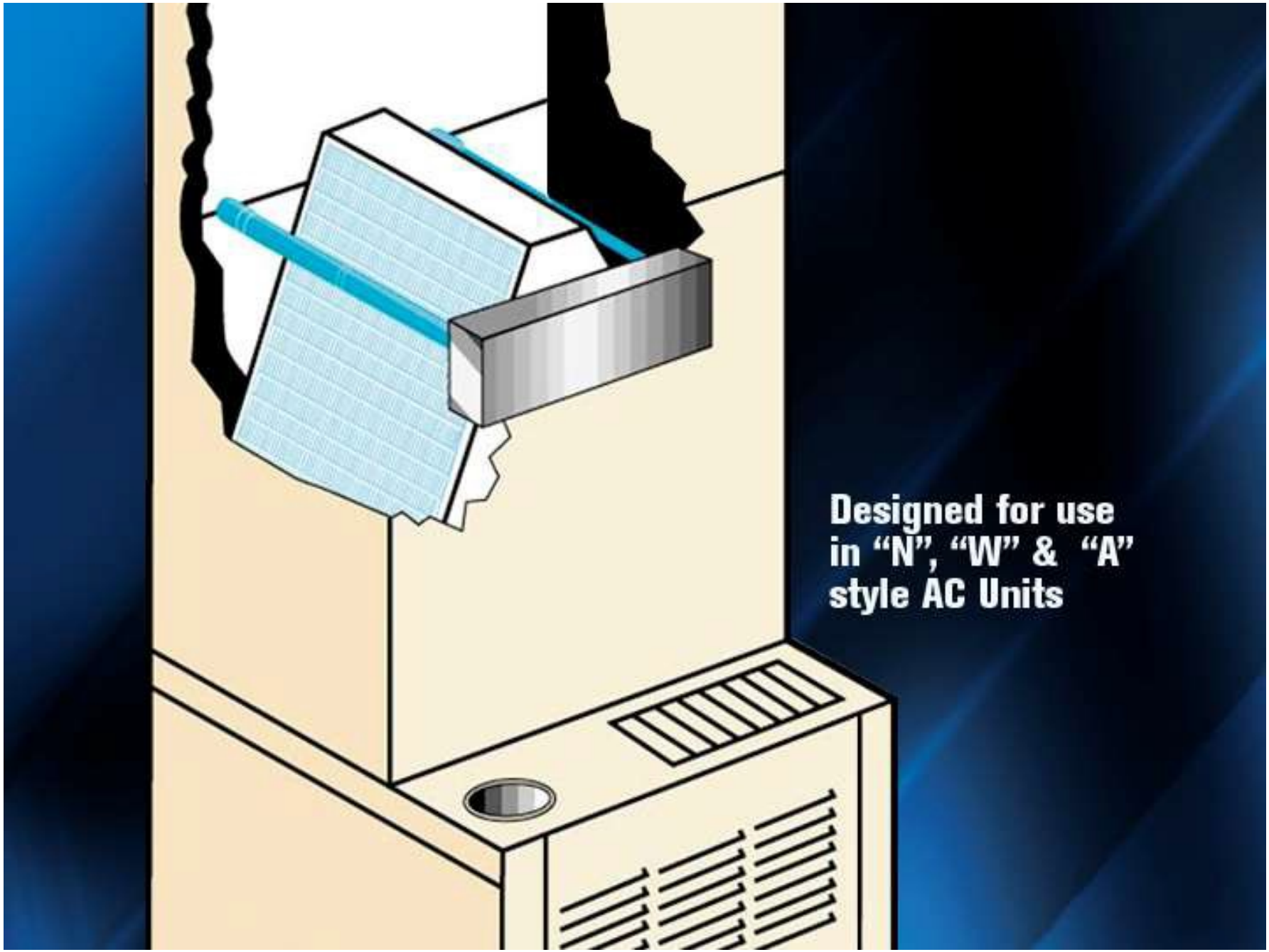
Designed for use
in “N”, “W” & “A”
style AC Units

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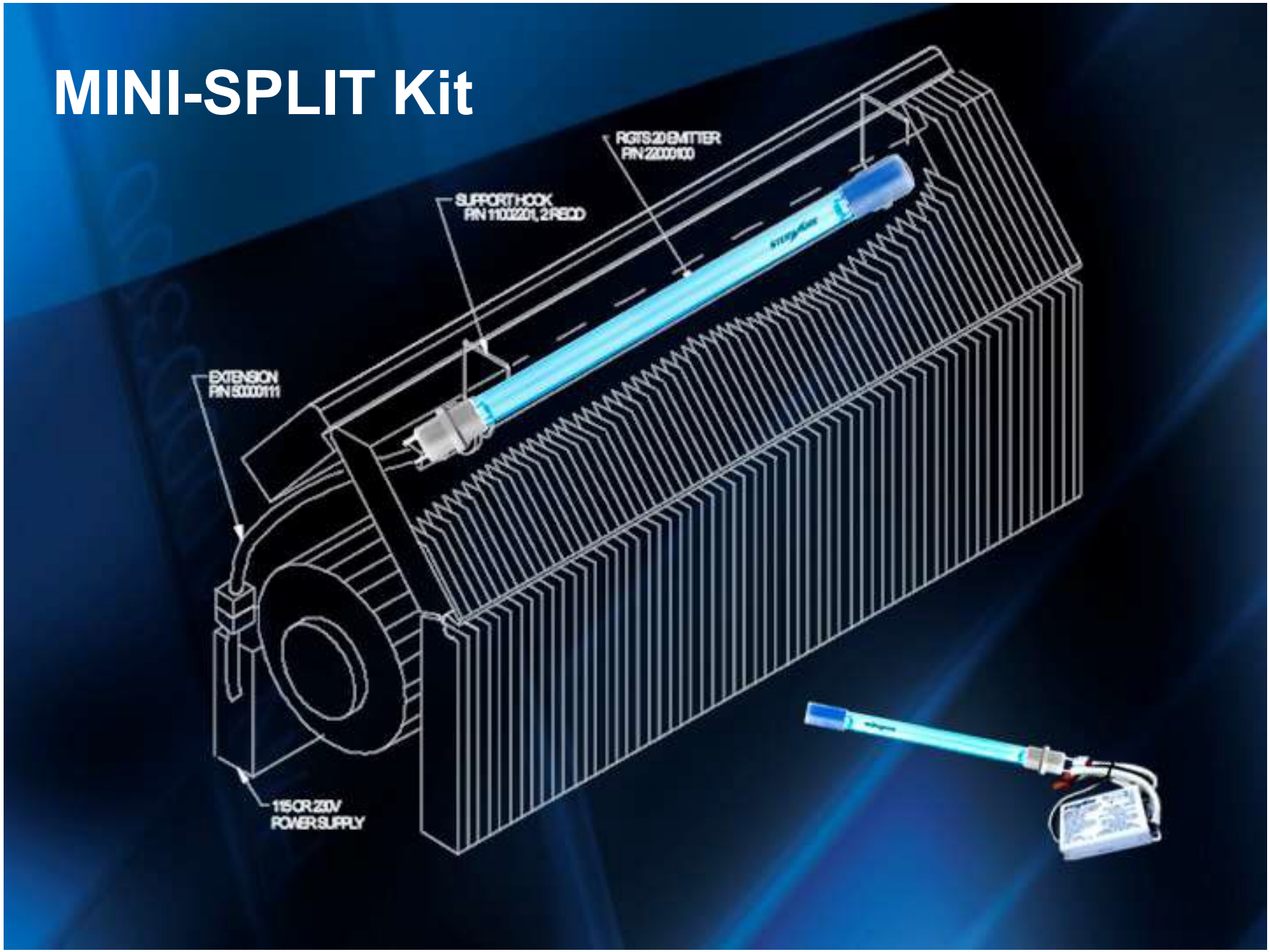
MINI-SPLIT Kit



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DVM Turnkey Facility and Energy Solutions.

Thank you!