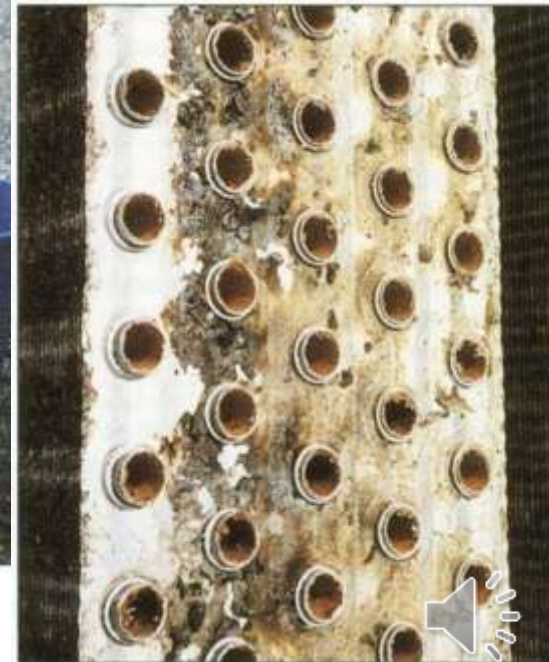




# Using UVC Energy for Surface and Air Treatment and Air Contaminant Control in HVAC & R Equipment

# Bio-Contamination



# Bio-Contamination

- Causes:
  - Higher Coil  $\Delta P$
  - Reduced:
    - Air Flow
    - Heat Exchange Efficiency
    - Drain Pan Drainage
  - Source of:
    - Mycotoxins
    - Endotoxins
    - Microbial VOC
    - Other Odor







**Various Infected Coils & Drain Pans**





# Plenums, Fans & Dampers

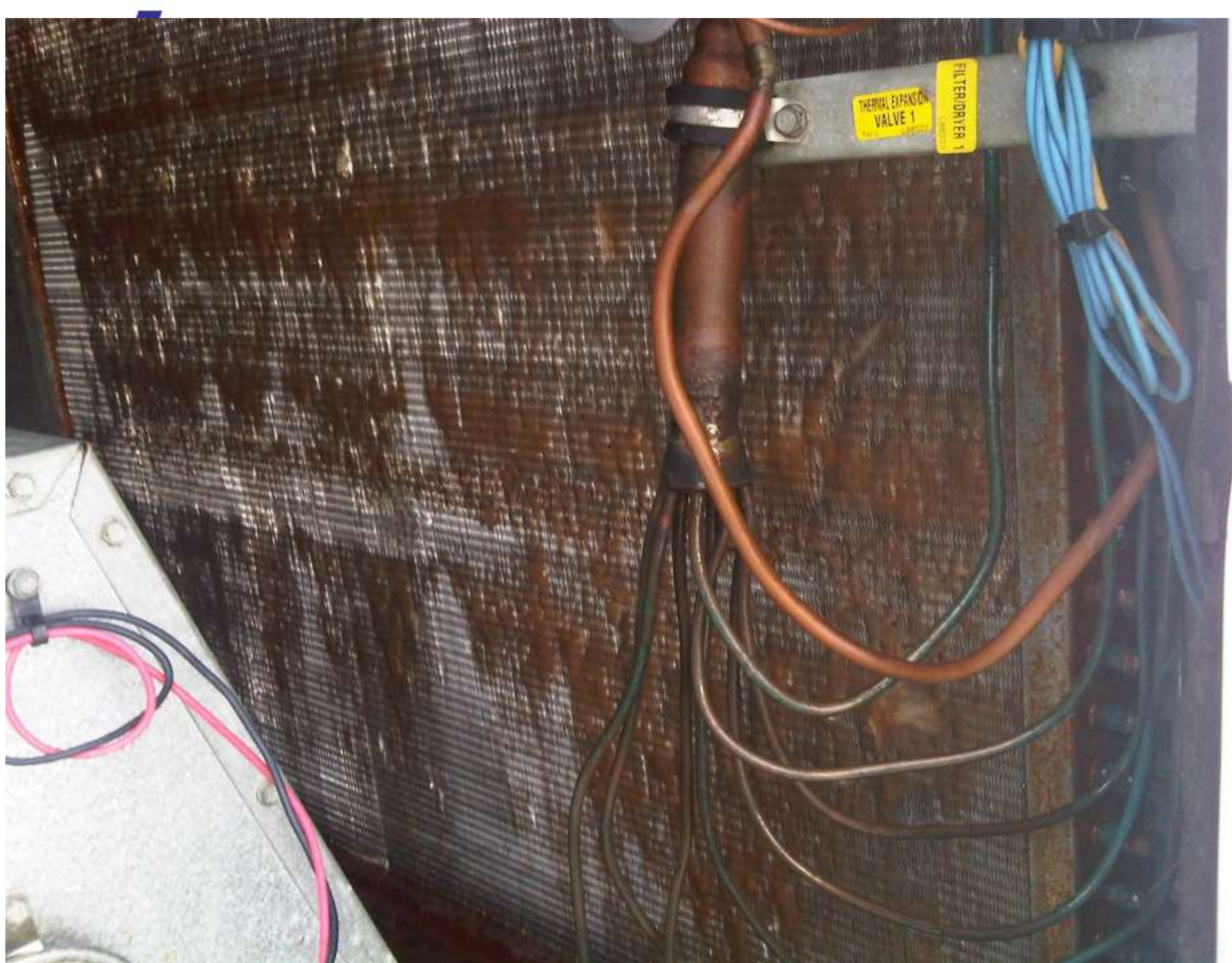




# Hospital Drain Pans







# Coil Surface Samples





# THE PROBLEM

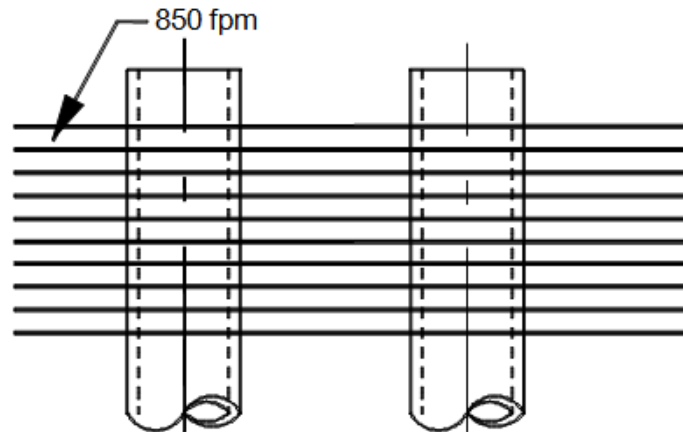


# Organic Matter Buildup Lowers Coil Efficiency / Increase in Coil Pressure

**New Clean Coil:**



500 fpm  
APPROACH



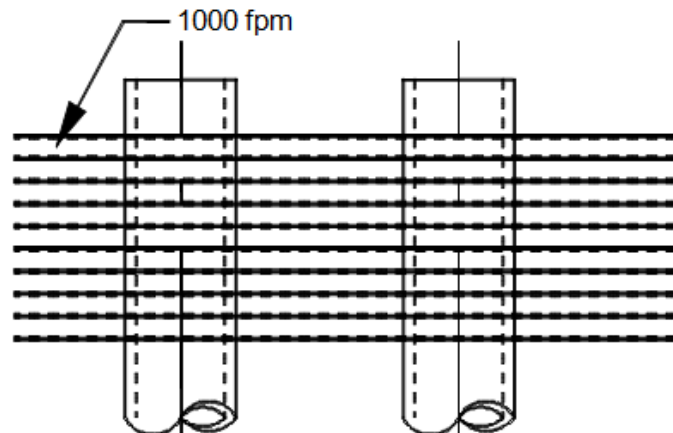
60%  
OPEN =

**Optimum  
cooling/  
Design**

**Add only .006”  
of bio film:**



500 fpm  
APPROACH



51%  
OPEN =

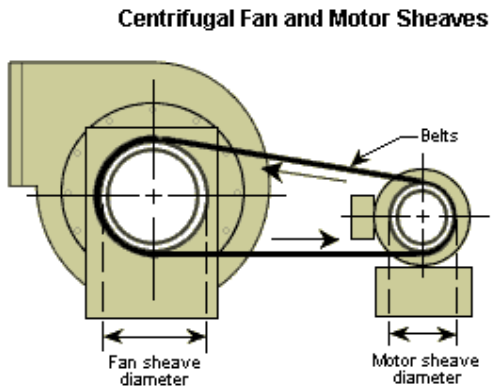
**Decreased  
efficiency**





# Typical Responses To The Problem

**Speed up Fan**



**Pump More Chilled Water**



**Lower Coil Water Temp**



**Increased kWh  
Usage on Fan  
Motors**

**Increased kWh  
Usage on Pump Motors**

**Significantly  
Increases kWh  
Usage on Chiller**

**INCREASED ENERGY COSTS**



# THE SOLUTION



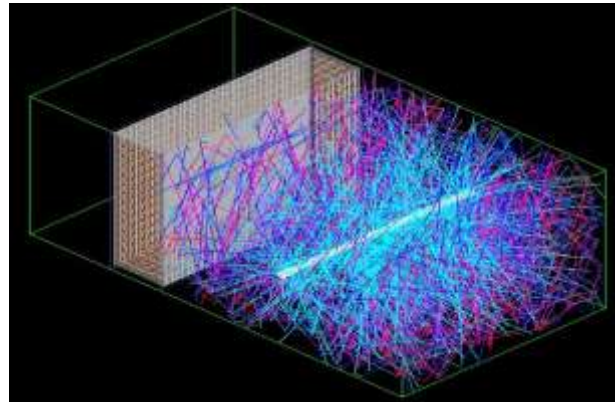


# Restore The Coil Efficiency

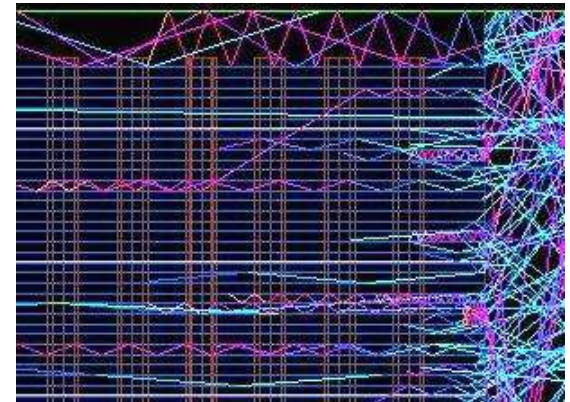
**UV-C on The Coil**



**UV-C Energy Vaporizes Organic Matter**

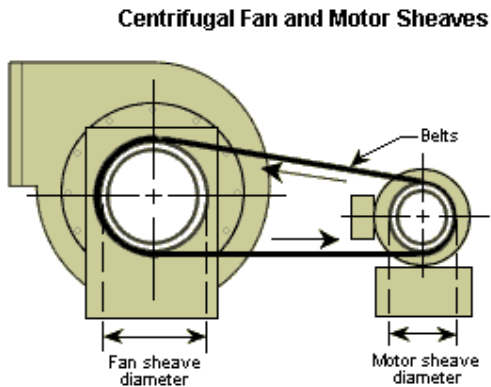


**Energy is Reflected Through The Coil**



# Harvesting Energy Savings From A Restored Cooling Coil

**Slow Down Fan**



= Restored kWh  
Usage

**Pump Less  
Chilled Water**



= Restored kWh  
Usage

**Raise Coil Water Temp**



= Restores Significant  
kWh Usage

## SUSTAINABLE ENERGY SAVINGS





# Norman Regional Health System

39 Days



SEF-N Lights On

	INSTALLED	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8
DATE	9/21/2007	9/27/2007	10/4/2007	10/12/2007	10/18/2007	10/29/2007			
AHU #	AHU-36	AHU-36	AHU-36	AHU-36	AHU-36	AHU-36			
PRE-FILTER PRESSURE DROP		0.14" WC	0.10" WC	0.08" WC	0.18" WC	.17" WC			
FILTER PRESSURE DROP		0.00" WC	0.00" WC	0.00" WC	0.00" WC	0.00" WC			
CHW COIL PRESSURE DROP	3.07" WC	3.31" WC	3.02" WC	3.12" WC	1.30" WC	.77" WC			
CHW DESIGN DROP	.7" WC	.7" WC	.7" WC	.7" WC	.7" WC	.7" WC			
CHW SUPPLY TEMP		44 DEG F	44 DEG F	44 DEG F	44 DEG F	44 DEG F			
CHW RETURN TEMP		51 DEG F	49 DEG F	49 DEG F	52 DEG F	51 DEG F			
OUTSIDE AIR TEMP		71 DEG F	85 DEG F	60 DEG F	75 DEG F	55 DEG F			
RETURN AIR TEMP		70 DEG F	76 DEG F	68 DEG F	72 DEG F	72 DEG F			
MIXED AIR TEMP		71 DEG F	78 DEG F	70 DEG F	74 DEG F	58 DEG F			
DISCHARGE AIR TEMP		62 DEG F	64 DEG F	54 DEG F	55 DEG F	56 DEG F			



# Norman Regional Health System





# UVROI

## Return on Investment

UVC Installation			
	Before	After	Net Change
Date Sampled:	2/1/2011	5/2/2011	90 DAYS
CFM - Measured or Selected (VAV)	25,000	25,000	-
Entering Air Temperature - Dry Bulb °F	71.8	71.8	-
Entering Air Temperature - Wet Bulb °F	59.7	59.7	-
Leaving Air Temperature - Dry Bulb °F	57.3	57.3	-
Leaving Air Temperature - Wet Bulb °F	47.3	46.3	(1)
Total Cooling Capacity - Btuh	840,375	900,000	59,625
Sensible Heat -Btuh	391,500	391,500	-
Latent Heat - Btuh	448,875	508,500	59,625
Net Cooling Gain/Loss - Btuh →			59,625
Pressure Drop "Across Coil" ("WG)	1.5	0.8	0.70
Pressure Drop BHP Reduction			4.589
Annual Improvement (kWh cost)			\$ 11,071.34
Total Annual Improvement			\$ 11,871.34

Installation Costs	1st Year	2nd Year	3rd Year	4th Year
Average Fixture Watts	156			
Number of Fixture(s)	4			
Total System Cost	\$ 2,000.00			
Installation Labor Cost	\$ 2,000.00			
Total Annual Energy Cost (8760 hrs)	\$ 546.62	\$ 546.62	\$ 546.62	\$ 546.62
Lamp Replacement Cost (each)	\$ 100.00	\$ 100.00	\$ 100.00	\$ 100.00
Total Lamp Replacement Cost	\$ 400.00	\$ 400.00	\$ 400.00	\$ 400.00
Total: Installation & Operating Costs	\$ 4,546.62	\$ 946.62	\$ 946.62	\$ 946.62
Annual Potential Recovery (-Costs)	\$ 7,324.72	\$ 10,924.72	\$ 10,924.72	\$ 10,924.72
Estimated Return (ROI in years)	0.38			
Cumulative Improvement	\$ 7,324.72	\$ 18,249.44	\$ 29,174.16	\$ 40,098.88

# ASHRAE

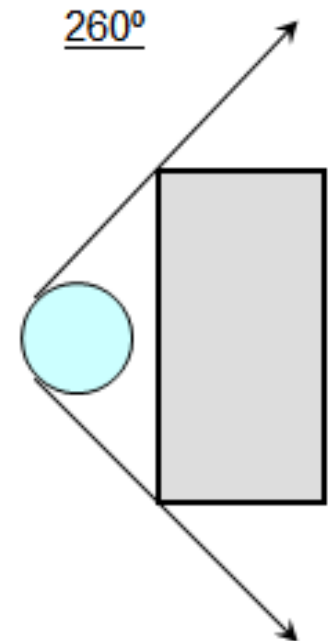
## **2011 ASHRAE Handbook HVAC Applications Chapter 60**

**“Using reflectors to focus lamp output on surfaces can reduce the power required for surface treatment, but at the expense of reducing air treatment effectiveness.”**

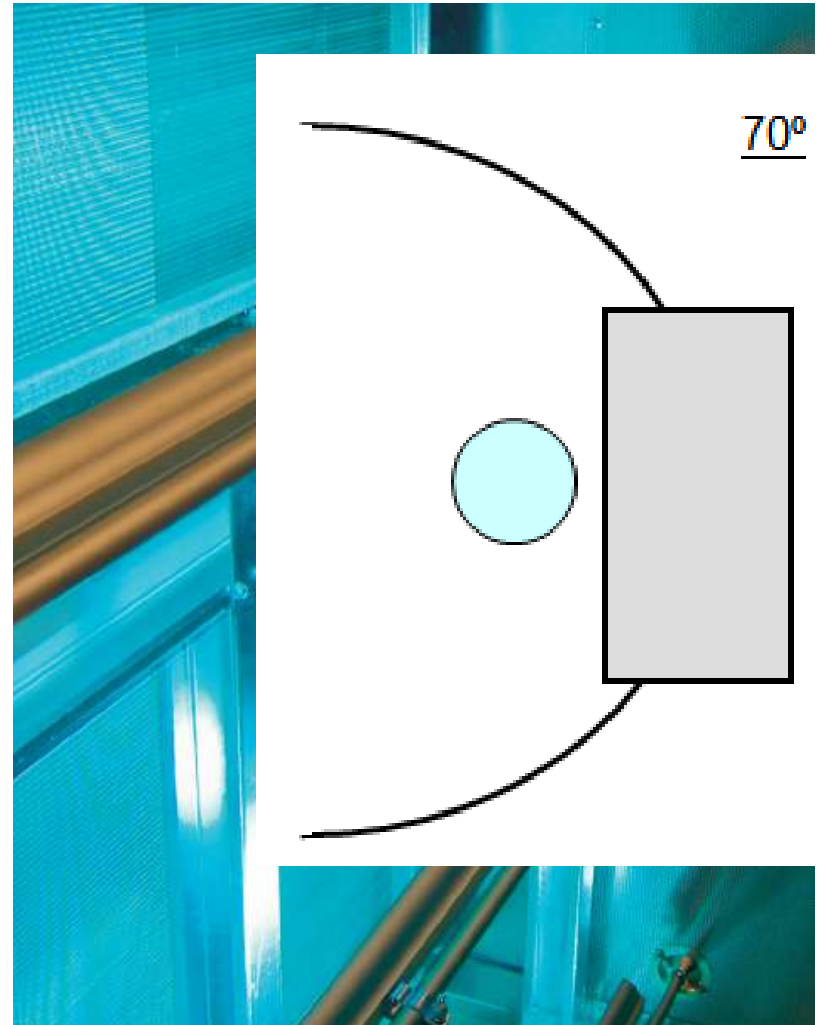


260°

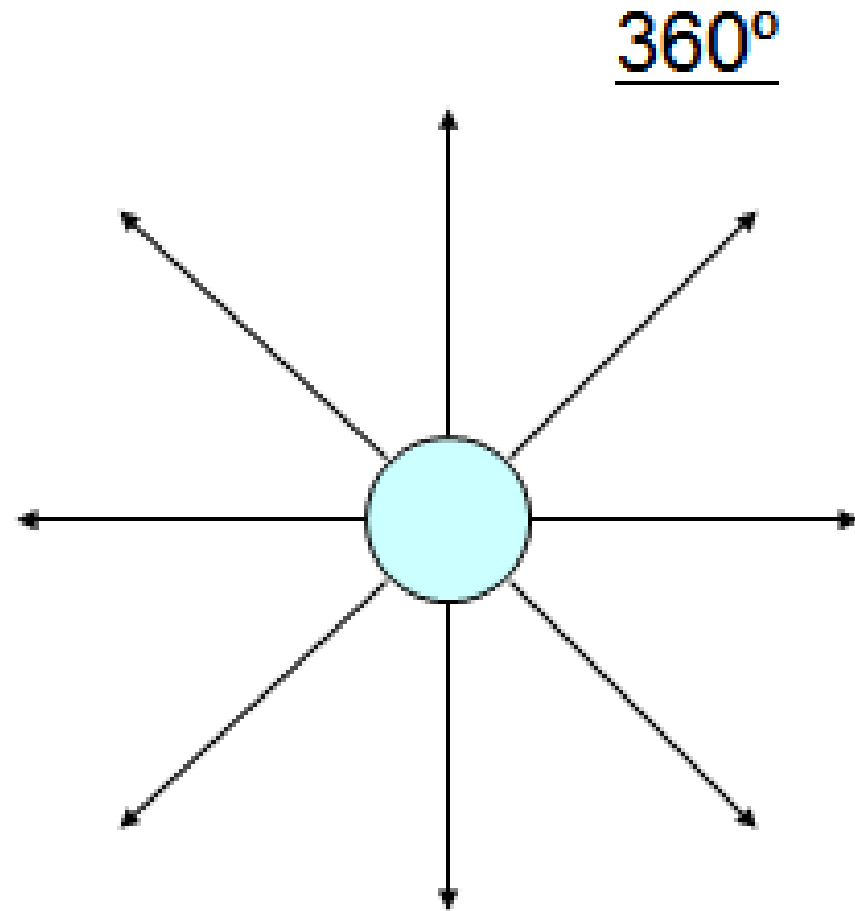
- Notice the distribution of the light.



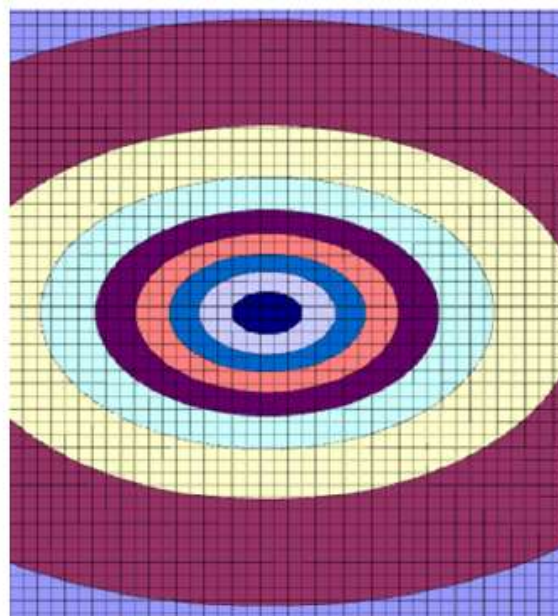
# Enhanced Reflectivity



360°





**Maximum Surface Intensity****2936  $\mu\text{W}/\text{cm}^2$** **Average Surface Intensity****1120  $\mu\text{W}/\text{cm}^2$** Target Size: **40H X 61W X 12D**CFM: **8,500**Project Name: **61" HO lamp at 52 degree Windchill**Location: **Calculated at lamp life of 85%**Tagging: **RLMX-61-HO Performance**Date: **8/20/2010**Rep: **UVResources™****UV Resources**

■ 4000-4500

□ 3500-4000

■ 3000-3500

□ 2500-3000

■ 2000-2500

□ 1500-2000

□ 1000-1500

■ 500-1000

Notes:

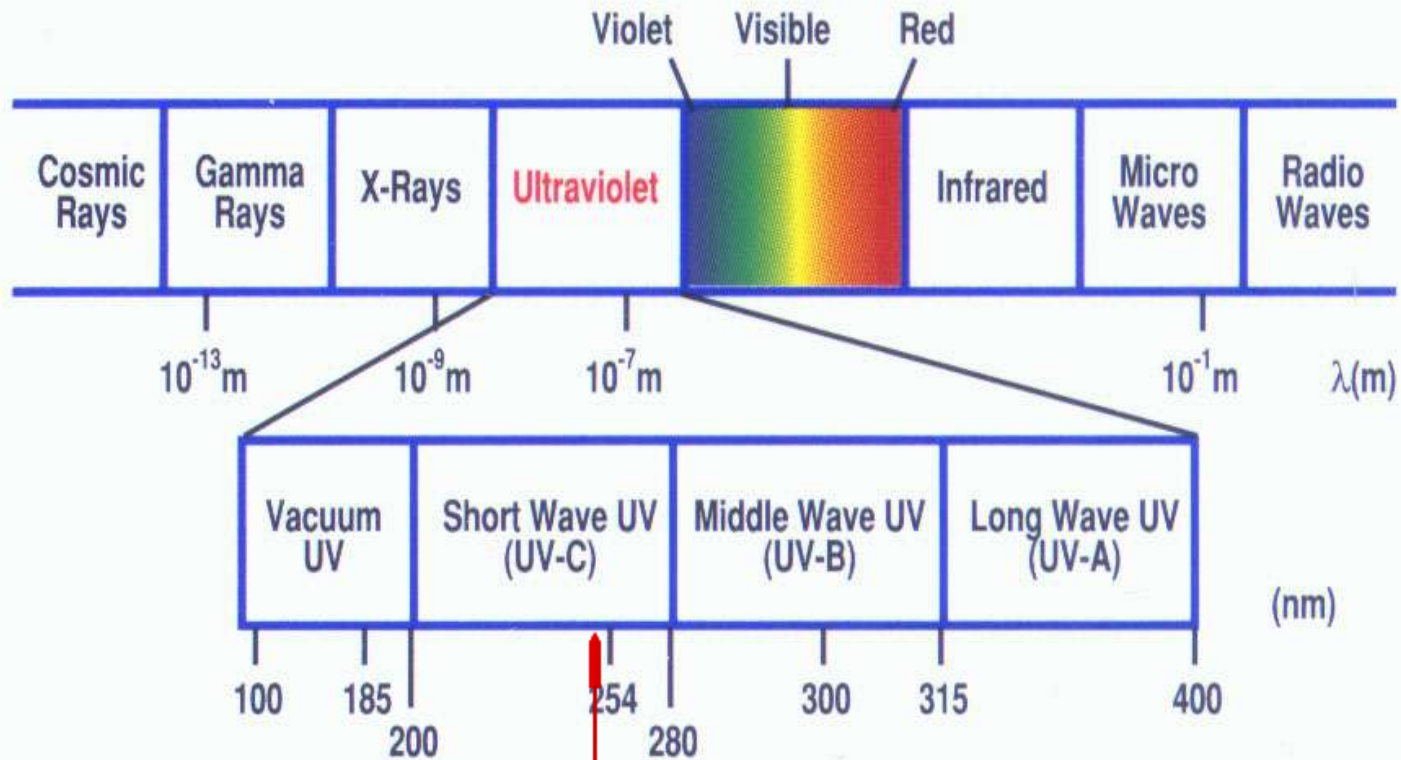
- 1.) UL/CUL Listed
- 2.) Use Inter-Lock Switch on all Accesses to lamps.
- 3.) CAUTION: Never Look at Lit Lamps - Protect both Eyes and Skin

\*Calculation of surface irradiance based on 3rd Party Software developed by Wladyslaw Jan Kowalski, PE, PhD, The Pennsylvania State University, Department of Architectural Engineering on behalf of UV Resources.

# UVC-HVAC Applications



# Light Spectrum

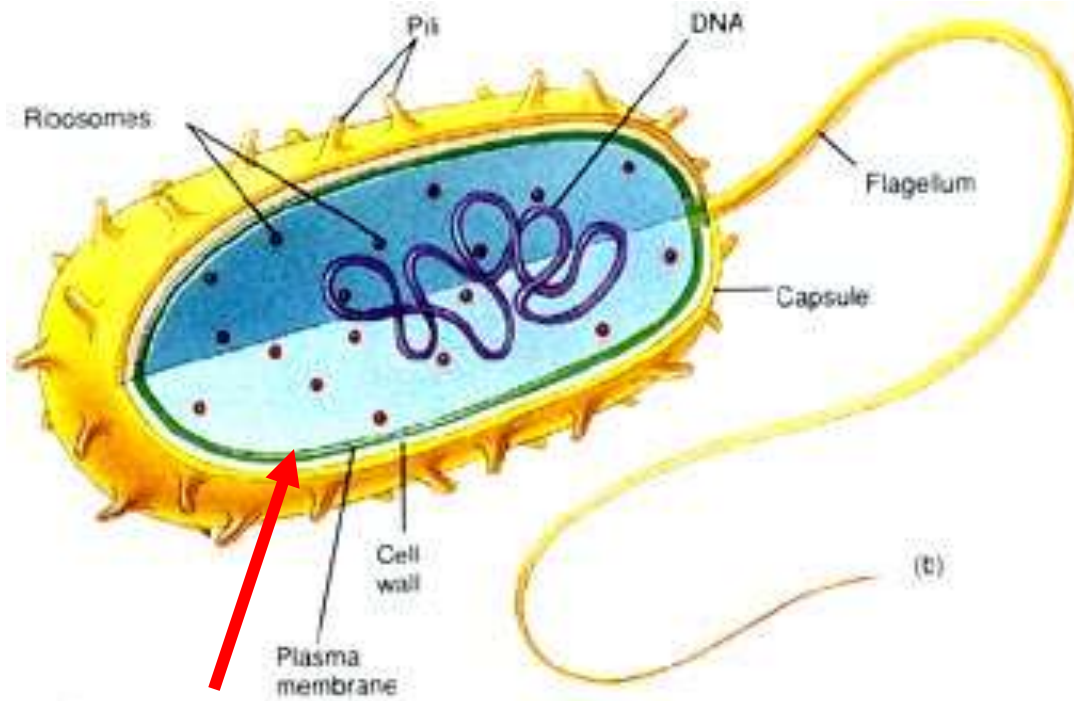


**Germicidal UV-C Lamp 253.7 nm**





# Cell Destruction



**UVC energy enters the cell**

- Electromagnetic energy breaks through cell wall
- Damages DNA
- Cannot reproduce or feed
- Cell "Dies"



# DNA Damage

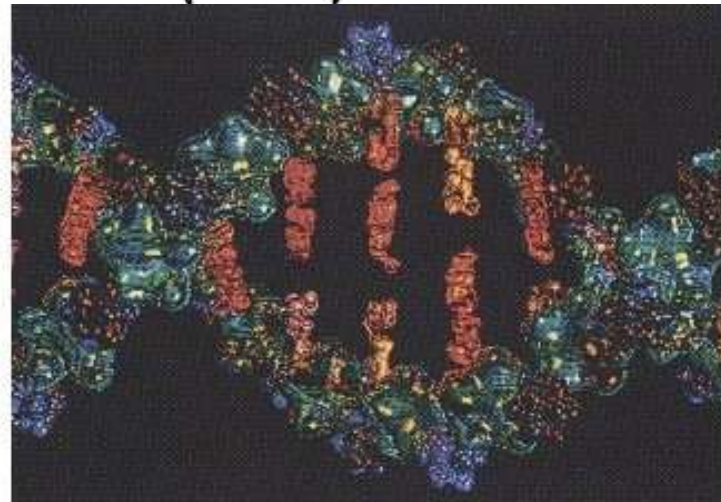
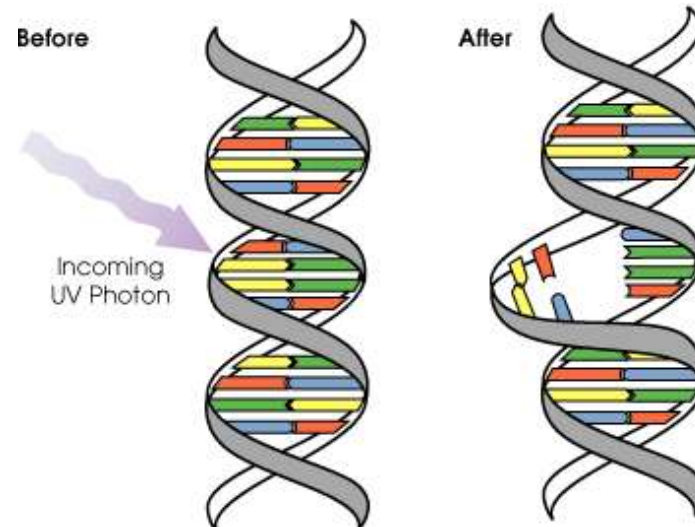
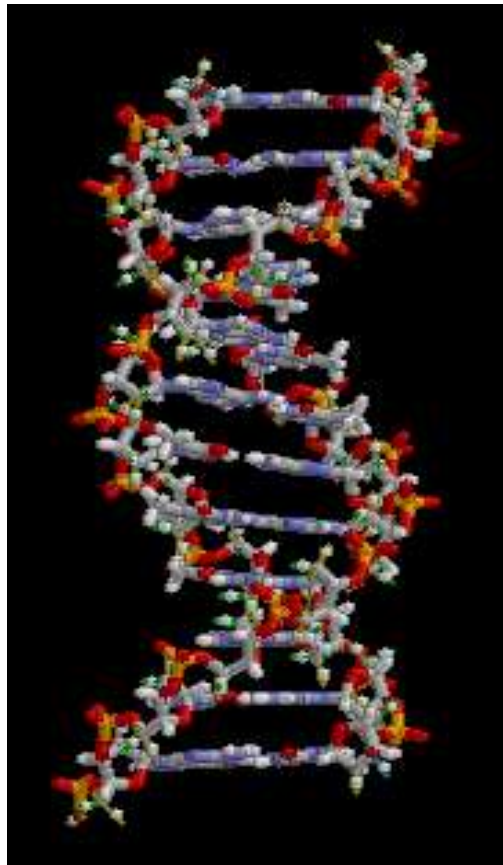


Figure 2-2. Computer Generated Image of DNA Helix Damage from UV Radiation Treatment (Aquafine Corp., 1988)



# Lamps





# Many kinds of lamps

## Black light



## UV-A



## UV-C

## Germicidal

## Fluorescent



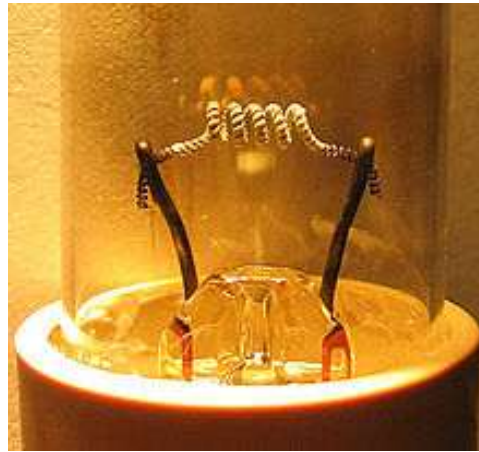
# Fluorescent



- Impure or “junk” glass; does not transmit UV-C
- Contains Mercury (Hg)
- Contains Phosphor
- Contains Noble gases



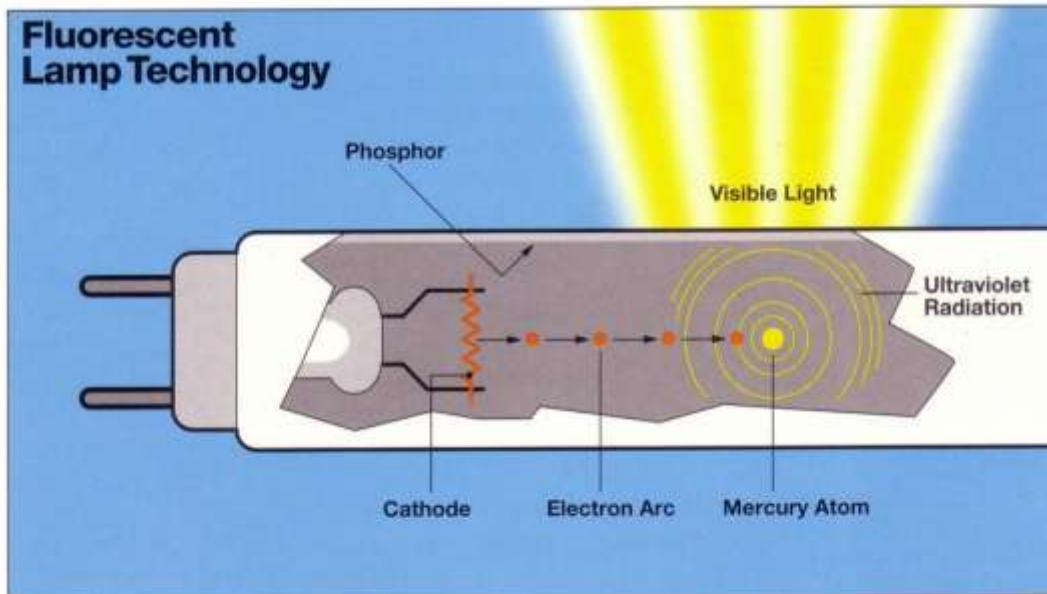
# Germicidal Lamps



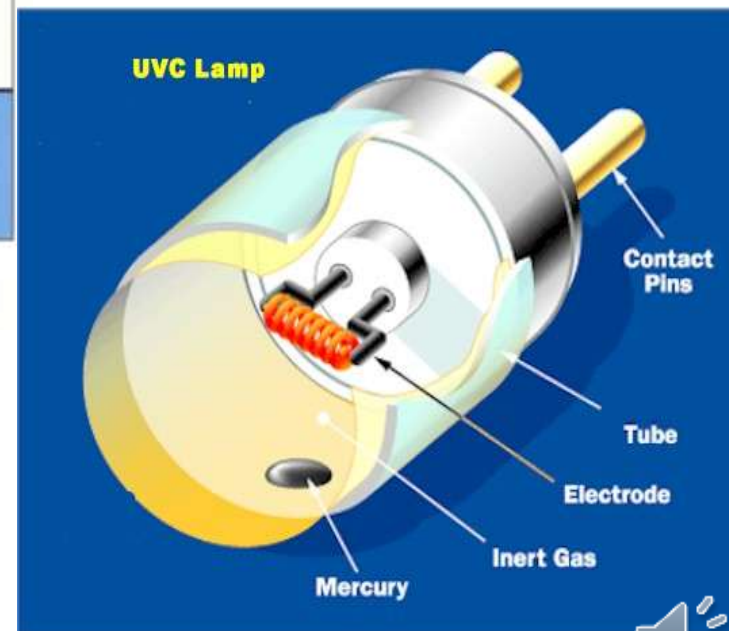
- Glass that transmits UV-C
  - Quartz
  - Soda Barium ("soft glass")
- Phosphor is removed
- Contains Mercury (Hg)
- Contains Noble gases



# Fluorescent Vs. UV-C Lamps



All fluorescent lamps generate an arc between two cathodes at opposite ends of a glass tube which excites atoms of mercury. This generates ultraviolet radiation which causes a phosphor coating to fluoresce and produce visible light.





# UV-C Exposure

3. Acute kerato-conjunctivitis is an inflammation of the cornea and conjunctiva after excessive exposure to UVB or UVC radiation. This is also known as snow blindness or welder's flash. Although the injury is extremely painful, it is usually temporary because of the recuperative powers of the epithelial layer. The latent period is usually 4-12 hours from the time of exposure and is spectral and dose dependent. There is a sensation of "sand" in the eyes, photophobia, blurred vision, lacrimation and blepharospasm (painful uncontrolled excessive blinking). Symptoms may last up to 24 hours with the corneal pain being severe. Recovery takes one to two days.



# Radiometer



# HVAC Applications for UV-C



**“On-The Fly”**

Two distinct applications for UVC

- Decontaminating surfaces
  - Coils
  - Filters “capture and kill”
- Decontaminating moving air-streams  
 (“on-the-fly”)

**Coil**



# Organism Chart and Energy need to Kill Factor

## MOLD

90%

99.9%

Aspergillus niger

132,000

330,000

Penicillium roqueforti

13,000

26,400

## ORGANISM

Bacillus anthracis

4,520

8,700

Bacillus subtilis

5,800

11,000

Mycobacterium tuberculosis

6,200

10,000

Staphylococcus aureus

2,600

6,600

## Virus

Influenza

3,400

6,600





# NICU Results

Subject: Fungal and Bacteria air sampling in NICU area of Hospital.

In June 2008 air samples were taken throughout the NICU areas that are supplied by AHU #13 & AHU #14. These areas included the waiting room, Exam room A, Bay 7, Bay 5, and Bay 1 room 12.

Total fungal levels ranged from <38 to 106 CFU/m<sup>3</sup>.

Total bacterial levels ranged from 35 to 318 CFU/m<sup>3</sup>.

During and thereafter December 2008 all air entering the NICU area through AHU #13 & AHU #14 is being treated with UVC light. This was accomplished by installing High Intensity UVC bulbs in each air handlers.

In January 2009 air samples were taken again in the same areas of NICU.

Total fungal levels ranged from <35 to 35 CFU/m<sup>3</sup>.

Total bacterial levels ranged from 35 to 71 CFU/m<sup>3</sup>.

**This is a 77% reduction in fungal organism and a 87% reduction in bacterial organism.**



# Lamp Wattage/ Output

For a variety of low pressure mercury TUV lamps, the irradiance values at 1 meter distance are expressed below.

Irradiance values		μW/cm <sup>2</sup>
Philips TUV 4W	T5	9
Philips TUV 6W	T5	15
Philips TUV 8W	T5	21
Philips TUV 10W	T8	23
Philips TUV 11W	T5	26
Philips TUV 15W	T8	48
Philips TUV 16W	T5	45
Philips TUV F17T8	T8	88
Philips TUV 25W	T5	69
Philips TUV 25W	T8	
Philips TUV 30W	T8	100
Philips TUV 36W	T8	145
Philips TUV 55W HO	T8	150
Philips TUV 75W HO	T8	220
Philips TUV 115W-R VHO	T12	610
Philips TUV 115W VHO	T12	360
Philips TUV 240W XPT	T6	800
Philips TUV 270W XPT	T10	920
Philips TUV PL-S 5W/2P		9
Philips TUV PL-S 7W/2P		15
Philips TUV PL-S 9W/2P		22
Philips TUV PL-S 11W/2P		33
Philips TUV PL-S 13W/2P		31
Philips TUV PL-L 18W/4P		51
Philips TUV PL-L 24W/4P		65
Philips TUV PL-L 35W/4P HO		105
Philips TUV PL-L 36W/4P		110
Philips TUV PL-L 55W/4P HF		156
Philips TUV PL-L 60W/4P		166
Philips TUV PL-L 95W/4P HO		250
Philips TUV 36T5		144
Philips TUV 64T5		280
Philips TUV 36T5 HO		230
Philips TUV 64T5 HO		442

**Table 6.** Irradiance values of Philips TUV lamps at a distance of 1.00 meters.

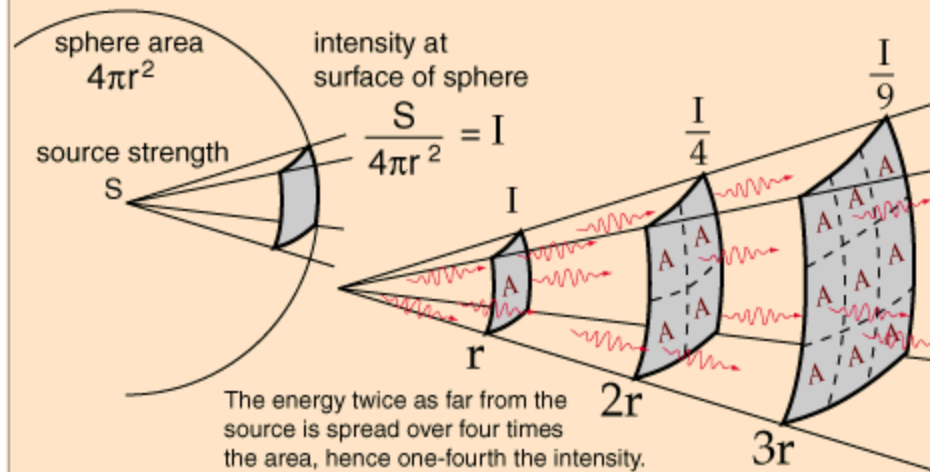
Philips Lamp Description	Lamp Wattage	Diameter	μW/CM <sup>2</sup>
Philips TUV 4W	4	T5	9
Philips TUV 6W	6	T5	15
Philips TUV 8W	8	T5	21
Philips TUV 10W	10	T8	23
Philips TUV 11W	11	T5	26
Philips TUV 15W	15	T8	48
Philips TUV 16W	16	T5	45
Philips TUV F17T8	17	T8	88
Philips TUV 25W	25	T5	69
Philips TUV 25W	25	T8	69
Philips TUV 30W	30	T8	100
Philips TUV 36W	36	T8	145
Philips TUV 55W HO	55	T8	150
Philips TUV 75W HO	75	T8	220
Philips TUV 115W-R VHO	115	T12	610
Philips TUV 115W VHO	115	T12	360
Philips TUV 240W XPT	240	T6	800
Philips TUV 270W XPT	270	T10	920
Philips TUV PL-S 5W/2P	5	PLS	9
Philips TUV PL-S 7W/2P	7	PLS	15
Philips TUV PL-S 9W/2P	9	PLS	22
Philips TUV PL-S 11 W/2P	11	PLS	33
Philips TUV PL-S 13W/2P	13	PLS	31
Philips TUV PL-L 18W/4P	18	PLL	51
Philips TUV PL-L 24W/4P	24	PLL	65
Philips TUV PL-L 35W/4P HO	35	PLL	105
Philips TUV PL-L 36W/4P	36	PLL	110
Philips TUV PL-L 55W/4P HF	55	PLL	156
Philips TUV PL-L 60W/4P	60	PLL	166
Philips TUV PL-L 95W14P HO	95	PLL	250
Philips TUV 36T5	40	T5	144
Philips TUV 64T5	75	T5	280
Philips TUV 36T5 HO	75	T5	230
Philips TUV 64T5 HO	145	T5	442

# Inverse Square Law, Light

As one of the fields which obey the general [inverse square law](#), the [light](#) from a point source can be put in the form

$$E = \frac{I}{r^2}$$

where  $E$  is called [illuminance](#) and  $I$  is called [pointance](#).



The source is described by a general "source strength"  $S$  because there are many ways to characterize a light source - by power in watts, power in the visible range, power factored by the eye's sensitivity, etc. For any such description of the source, if you have determined the amount of light per unit area reaching 1 meter, then it will be one fourth as much at 2 meters.

The fact that light from a point source obeys the inverse square law is used to advantage in measuring [astronomical distances](#). If you have a source of known intrinsic brightness, then it can be used to measure its distance from the Earth by the "[standard candle](#)" approach.

# UV-C Exposure

Lamp Intensity Factors

		Lamp	$\mu\text{W}/\text{CM}^2$
		Philips TUV 64T5 HO	442
Distance from Lamp (inches)	Intensity	$\mu\text{W}/\text{CM}^2$	
2	32.3	14277	
3	22.8	10078	
4	18.6	8221	
6	12.9	5702	
8	9.85	4354	
10	7.94	3509	
12	6.48	2864	
14	5.35	2365	
18	3.6	1591	
24	2.33	1030	
36	1.22	539	
39.37	1	442	
48	0.681	301	
60	0.452	200	
80	0.256	113	
100	0.169	75	
120	0.115	51	



# **ASHRAE Handbook**

## **UV Chapters**

**Chapter 16      2008**

**Chapter 60      2011**

**Chapter 17      2012**



# RLMXtreme



# CDC Guidelines



## **Morbidity and Mortality Weekly Report**

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Recommendations and Reports

December 30, 2005 / Vol. 54 / No. RR-17

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### **of *Mycobacterium tuberculosis* in Health-Care Settings, 2005**



# CDC

- Because of the results of numerous studies (116-120) and the experiences of TB clinicians and mycobacteriologists during the past several decades, the use of UVGI has been recommended as a supplement to other TB infection-control measures in settings where the need for **killing or inactivating tubercle bacilli** is important (2,4,121-125).
- Commercially available UV lamps used for germicidal purposes are low-pressure mercury vapor lamps (127) that emit radiant energy in the UV-C range, predominantly at a wavelength of **253.7 nm** (128).





# Correctional Facilities



## MMWR™

**Morbidity and Mortality Weekly Report**

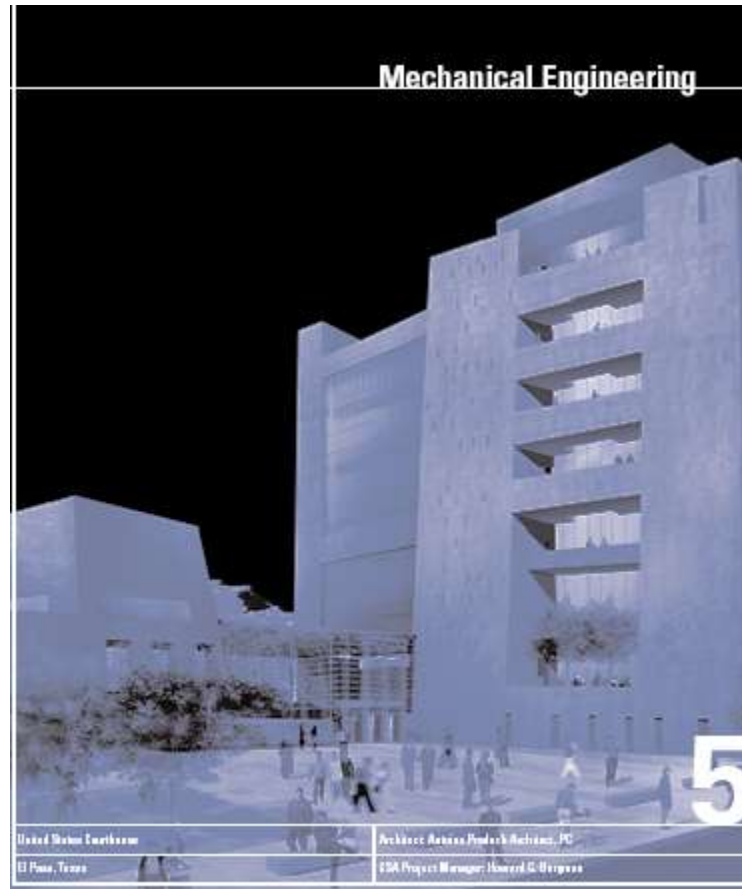
Recommendations and Reports

July 7, 2006 / Vol. 55 / No. RR-9

**Prevention and Control of Tuberculosis  
in Correctional and Detention Facilities:  
Recommendations from CDC**



# GSA Specification



# GSA Specification

Section Five, Sub-Section 5.8, Page 135

HVAC Components

Revised March 2005 – PBS-P100



# GSA Section 5.8, pg 135

*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.







Thank You

