



Fresh-Aire UV® APCO Rack System Airborne & Surface Disinfection Technology & Validation Report

Objective

The goal is to reduce microbial and VOC contamination in the air stream and inside HVAC systems and to improve indoor air quality for building occupants.

Airborne & Surface Disinfection

Air stream and surface disinfection using UVGI (ultraviolet germicidal irradiation with UVC light) is a well established technology which is proven to sterilize airborne microbial contaminants including mold, bacteria, viruses, and allergens. In commercial HVAC systems UVGI is used to sterilize microbial growth on air system interior surfaces including coils. This benefits building owners by reducing the need for chemical cleanings while increasing the longevity of the air handling equipment and improving energy efficiency.

The other major threat to indoor air quality is VOC (volatile organic compound) contamination. VOCs are potentially toxic chemical vapors which are the source of nearly all odors. Fresh-Aire UV® APCO® technology reduces airborne VOCs without ozone using our unique adsorptive photocatalytic technology.

Product Description

The APCO® Rack System is designed to disinfect both the air stream and surfaces within the HVAC systems. It can be mounted at the cooling coils for combined surface/airborne treatment. This application typically uses lower output UVC lamps (150 $\mu\text{W}/\text{cm}^2$ @ 1 Meter) to minimize deterioration of plastic materials within the air system.

The APCO® Rack System can also be configured for airborne disinfection only, using high-output UVC lamps (330 $\mu\text{W}/\text{cm}^2$ @ 1 Meter). The APCO Rack System can be mounted at the cooling coils for combined surface/air stream disinfection or in the supply side duct perpendicular to, or in-line with, the airstream.

The Fresh-Aire UV® Commercial Series is a family of devices intended for use in commercial HVAC applications. The core of these devices is the Fresh-Aire UV lamp which is available in 32" or 60" length, normal or high output. All are made with high quality touch-resistant hard quartz and are powered by the heavy-duty waterproof Fresh-Aire UV electronic power supply. The modular nature of the components makes for easy assembly into custom multi-lamp configurations based on the specifics of the application.



APCO® Rack System with
Tubular Rack Mount



APCO® Rack System with
Duct Mount

TECHNOLOGY OVERVIEW

UVC Light

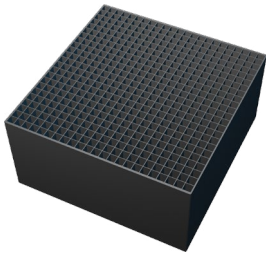
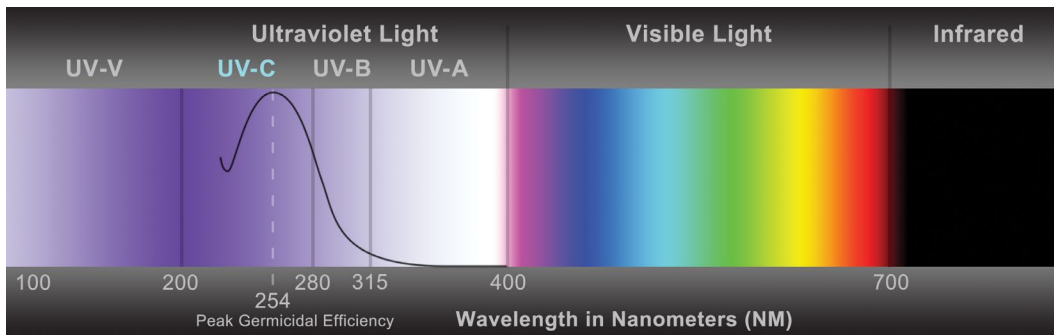
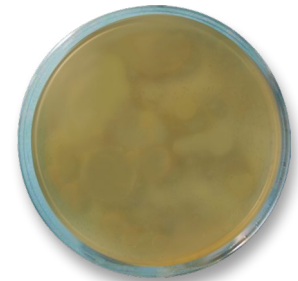
UV light disinfection is now widely used in hospitals and laboratories to sanitize instruments and work surfaces and to prevent the spread of potentially lethal airborne infectious diseases. The technology is used by the food industry to sterilize food before packaging and water treatment systems large and small now incorporate UV light as a chemical-free means of purification.

Ultraviolet (UV) light is electromagnetic radiation with a wavelength shorter than that of visible light, but longer than X-rays, in the range 10 nm to 400 nm. For over a century scientists have known about the germ-killing properties of ultraviolet light.

The UVC band ranges from 200 nm–280 nm with 254 nm being optimal for microbial disinfection. UV-C light disrupts the DNA of micro-organisms which prevents them from reproducing, thereby effectively killing them.



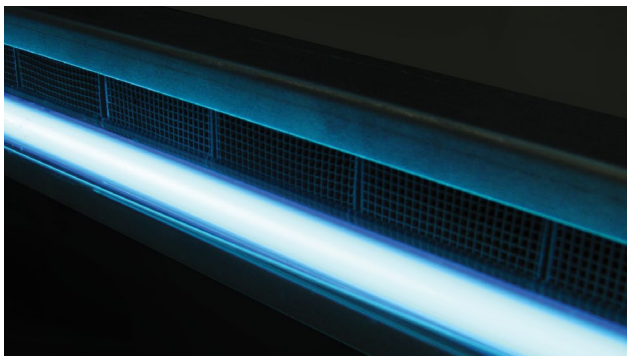
UV-C light sterilizes 99% of microbes after 1 hour of exposure



Activated carbon cell used in APCO® modules



Ultra-porous microscopic structure of activated carbon



UVC light with APCO® module

THE APCO® PHOTOCATALYTIC PROCESS

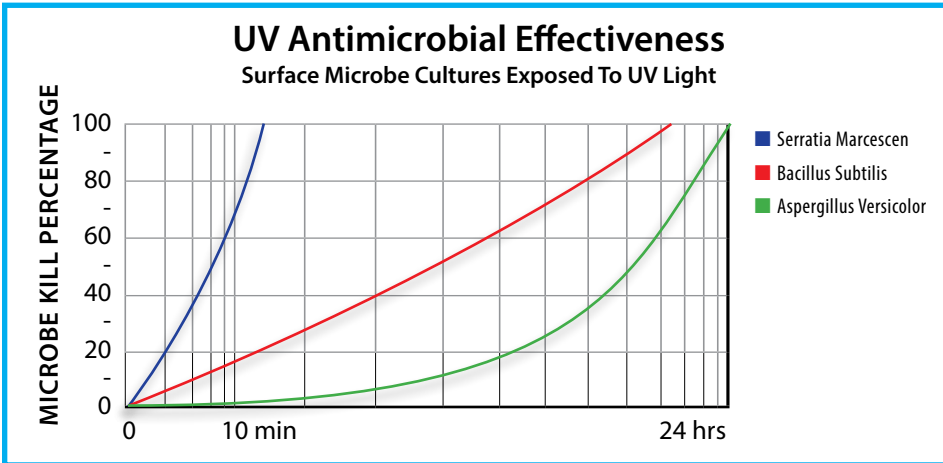
Air first passes by the UVC light which irradiates microorganisms in the air stream. Some volatile organic compounds (VOCs) are catalyzed directly by the light as they pass by. The UVC light also shines onto air system interior components providing surface disinfection.

Downstream of the UVC lamp is the APCO module which is a matrix of titanium dioxide-infused activated carbon cells. VOCs and microbes are captured and held in place by the carbon cells. UVC light shining on the titanium dioxide infused cells creates a photocatalytic zone around the cells which transforms captured VOCs in water-vapor and CO₂.

APCO® cells are effectively regenerated by continuous photocatalysis, so they never fill up or wear out. Unlike many of the older generation PCO based air purifiers the APCO® process does not produce ozone.

TEST RESULTS BIOLOGICAL

UV Effectiveness Test

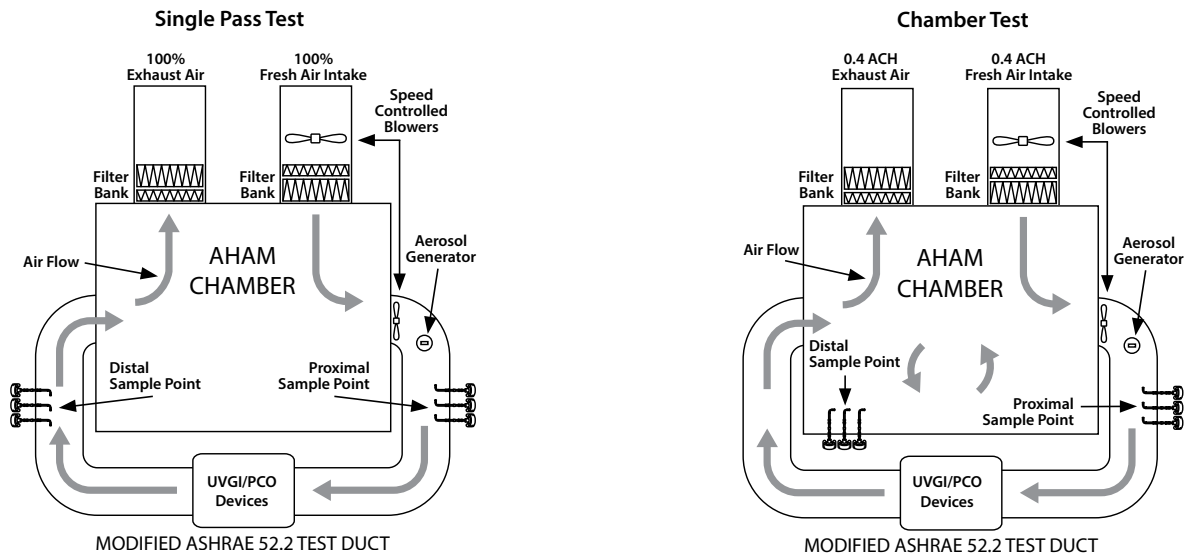


This laboratory test of microbial cultures exposed to UV-C light for a period of 24 hours resulted in a greater than 99% reduction in these common household biological contaminants when exposed to UV-C light.

Test performed by LMS Technologies

Fresh-Aire UV Commercial Series Challenge Organism Inactivation Efficiency (%)

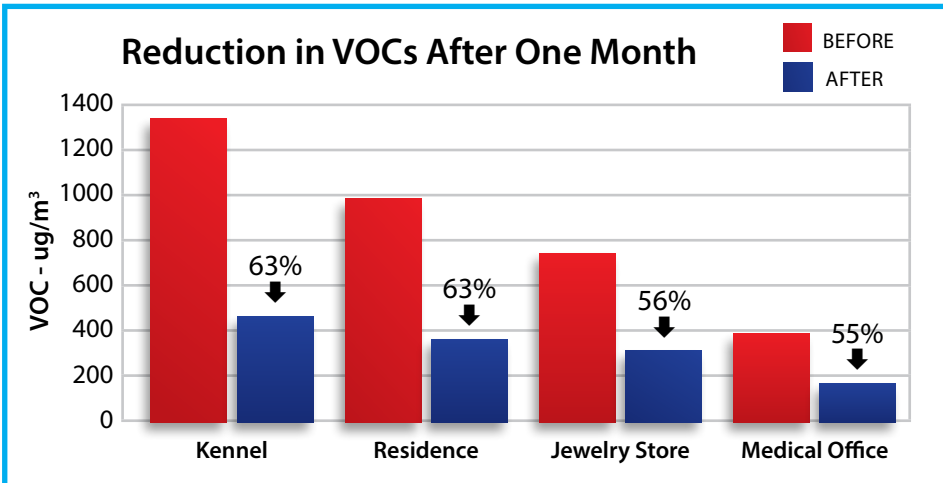
Challenge Organism Inactivation Efficiency (%) In-Duct UVC & In-Duct UVC/APCO Devices			
	<i>S.epidermidis</i>	MS2 Coliphage	<i>A.niger</i>
UVC Light Single Pass Test	99.29%	99.03%	78.80%
UVC Light Chamber Test	99.35%	99.99%	42.94%
UVC & APCO Chamber Test	93.37%	98.38%	64.21%



Test Performed by Airmid Healthgroup. The results are reported as per requirements of the EPA report Test/QA Plan for Biological and Aerosol testing of General Ventilation Air Cleaners. V1, August 17, 2006. The survival rate was corrected for the survival results obtained in the natural decay runs with the UV switched off as outline in the methods section.

TEST RESULTS VOCs

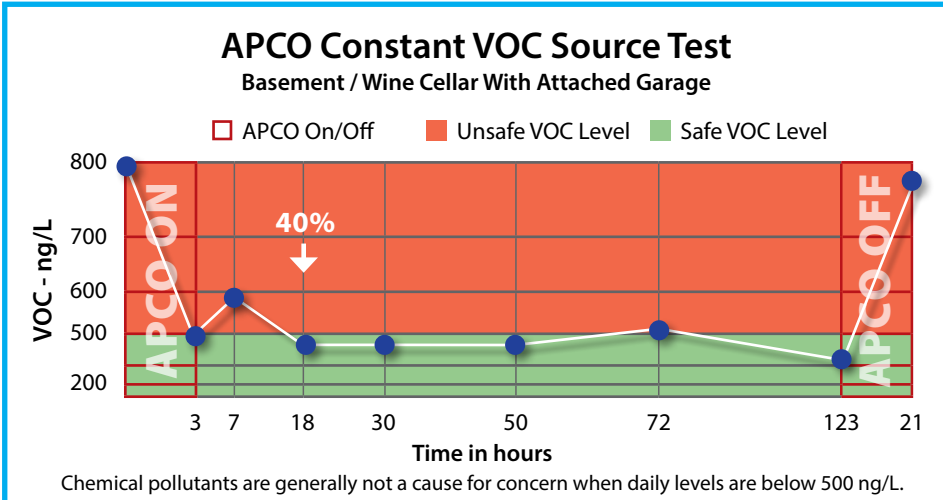
APCO® Field Tests Before & After



After one month of operation in a variety of real-world source odor applications, the Fresh-Aire UV® APCO® reduced airborne VOCs by an average of 60%.

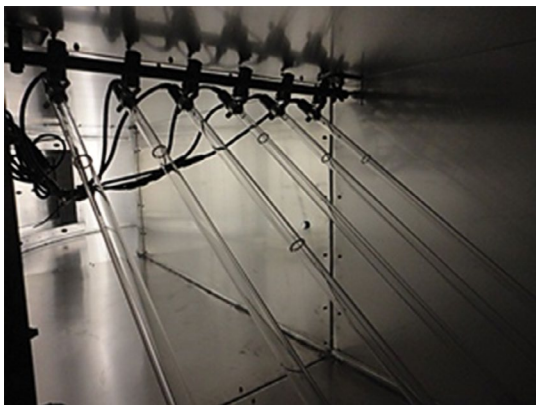
Various Field Tests Conducted by Triatomic Environmental

Sustained VOC Source Test

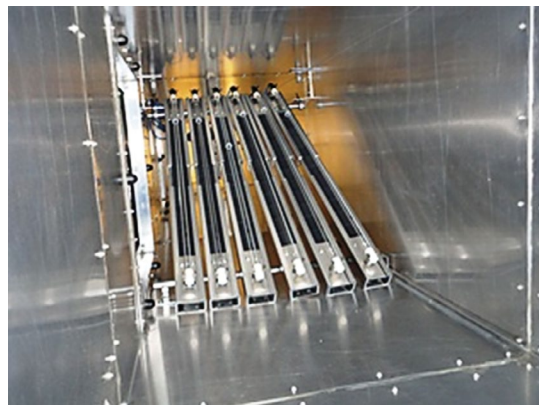


This test was conducted in a basement/wine cellar with attached garage that was known to have a constant high-level source of VOC emissions. Testing showed that APCO® significantly reduced and maintained VOCs below safe levels.

Test performed by Prism Analytical Technologies



UVC only System in modified ASHRAE test chamber



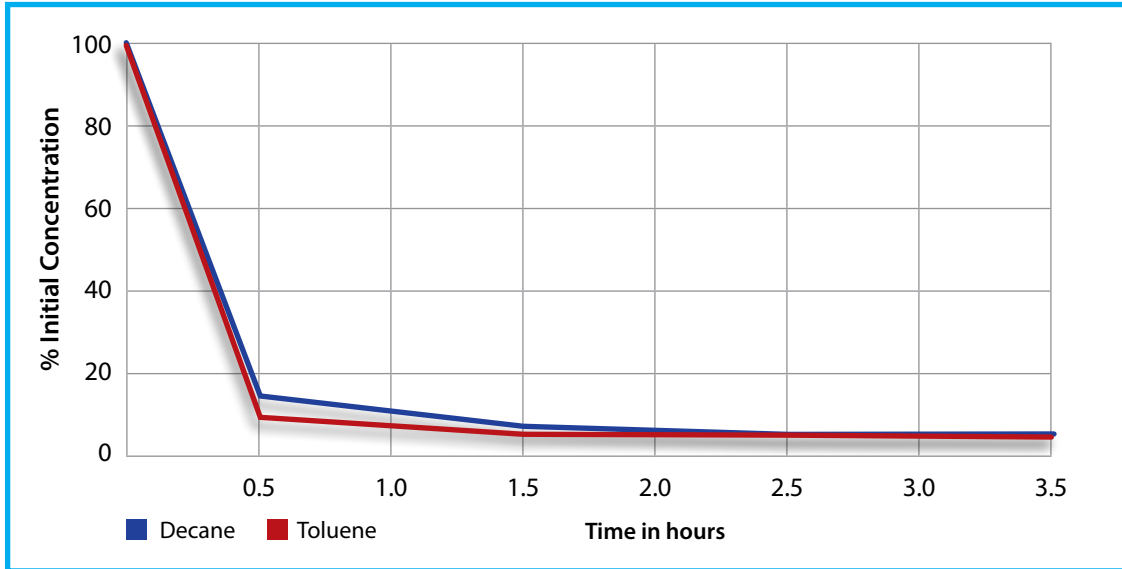
APCO Rack System in modified ASHRAE test chamber

TEST RESULTS VOCs

Constant Source VOC Reduction Tests

Testing was performed in a dynamic environmental chamber continuously dosed with decane and toluene to determine the VOC removal efficiency of the Fresh-Aire UV® APCO®. The chamber air was monitored for decane and toluene over a 5 hour period. Additionally the chamber air was continuously monitored for ozone over the same 5 hour period. After 4 hours of operation, the Fresh-Aire UV® APCO® resulted in a 93% reduction in decane, and a 95% reduction in toluene. No measurable levels of ozone were detected during the 5 hour test period.

Percentage Reduction of VOCs



Tests performed by UL Air Quality Sciences, Inc.

Environmental Chamber VOC Reduction Tests

Reduction of Decane, Toluene, And Ozone ($\mu\text{g}/\text{m}^3$)					
COMPOUND	Sample Time Interval (Hour)				
	APCO Off	APCO On			
	-1 – 0	0 – 1	1 – 2	2 – 3	3 – 4
Decane	105	17.3	8.4	7.9	7.6
Toluene	126	13.1	7.3	7.2	6.9
Ozone	0	0	0	0	0
Percent Reduction of Decane & Toluene					
Decane	-%	83%	92%	92%	93%
Toluene	-%	90%	94%	94%	95%

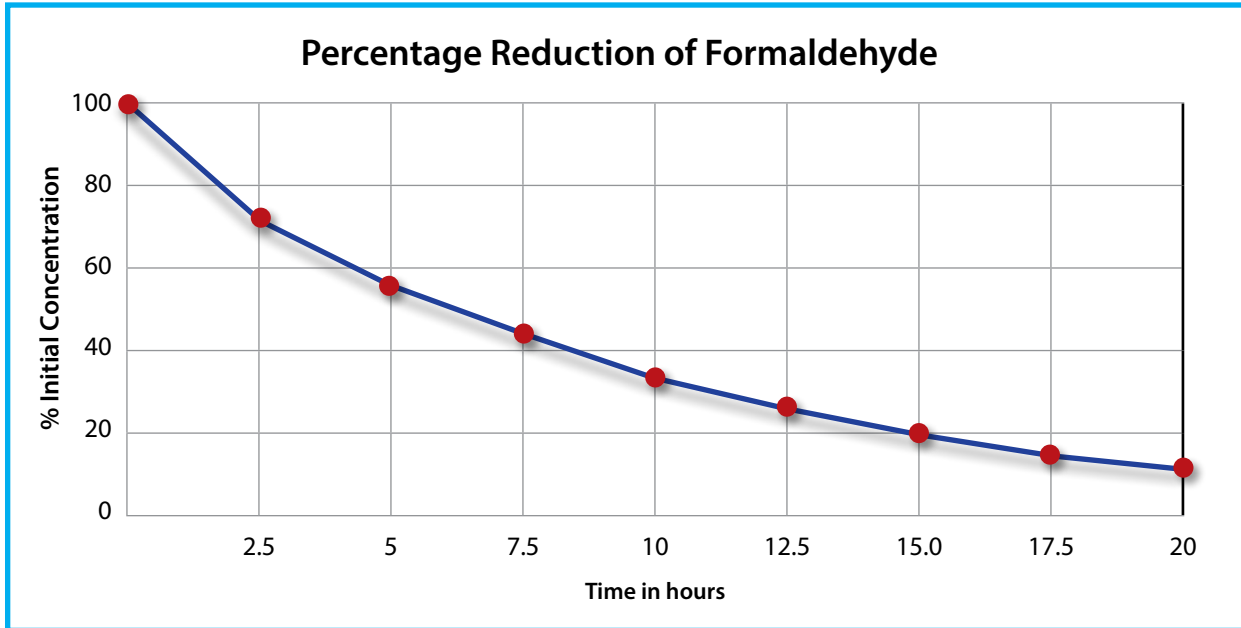
Tests performed by UL Air Quality Sciences, Inc.

TEST RESULTS VOCs

Formaldehyde Test

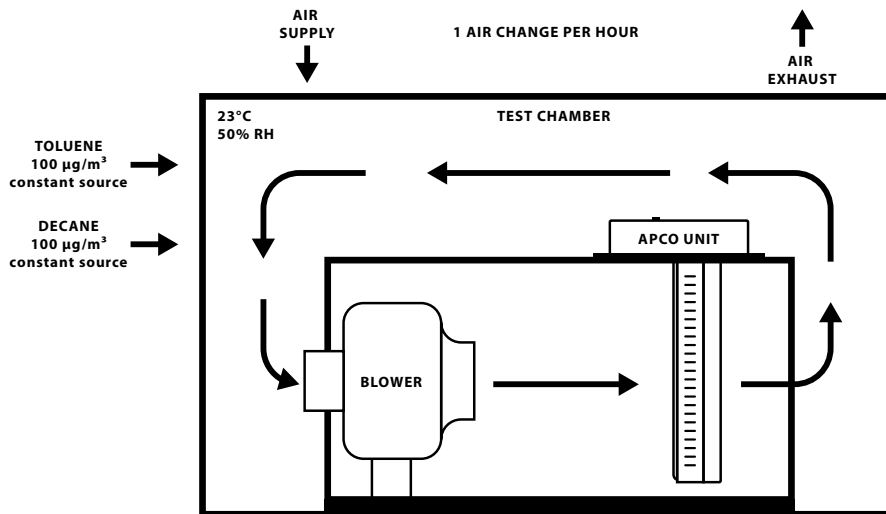
Testing was performed in a dynamic environmental chamber continuously dosed with formaldehyde to determine the VOC removal efficiency of the Fresh-Aire UV[®] APCO[®]. The chamber air was monitored for formaldehyde. After 24 hours of operation, the Fresh-Aire UV[®] APCO[®] resulted in a 88% reduction in formaldehyde.

Percentage Reduction of VOCs

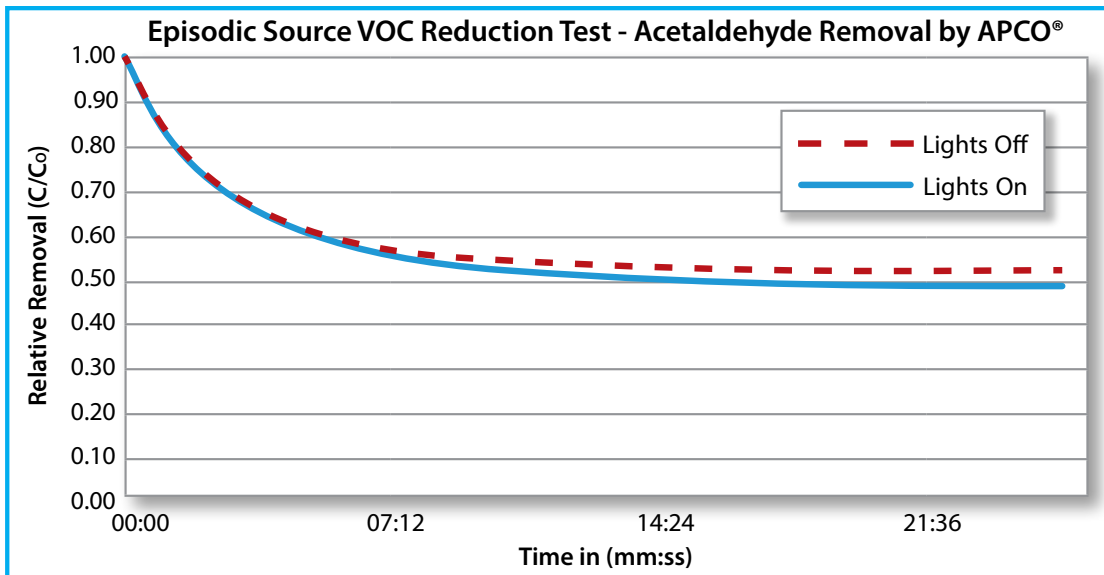


Percentage Reduction of Formaldehyde ($\mu\text{g}/\text{m}^3$)

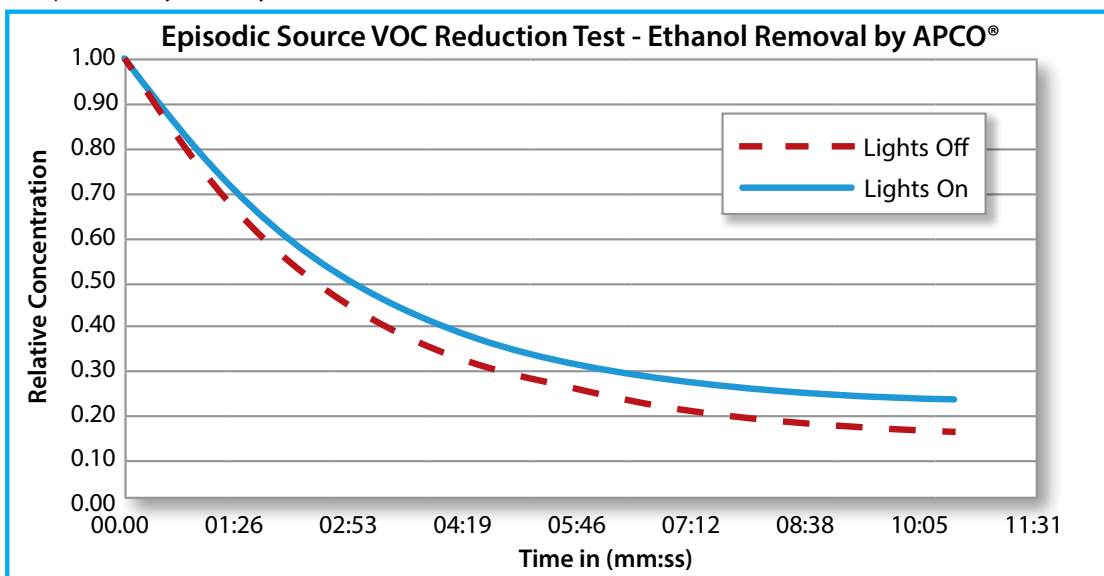
COMPOUND	SAMPLE TIME INTERVAL (HOUR)									
	0	2.5	5	7.5	10	12.5	15	17.5	20	
$\mu\text{g}/\text{m}^3$	180	138	105	81	62	47	36	28	21	
% Reduction	0	23	42	55	65	74	80	84	88	



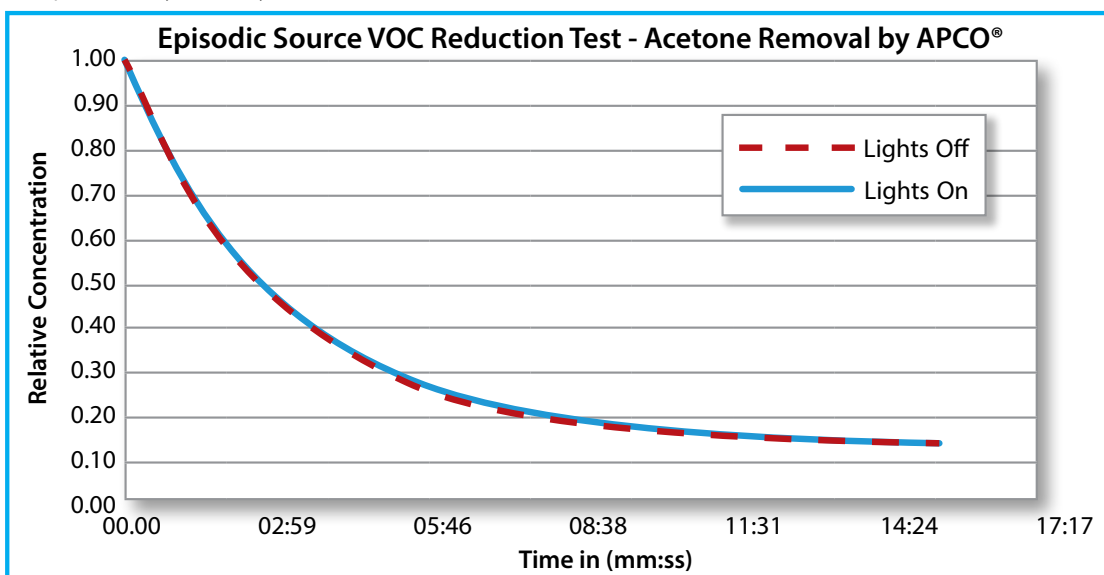
Tests performed by UL Air Quality Sciences, Inc.



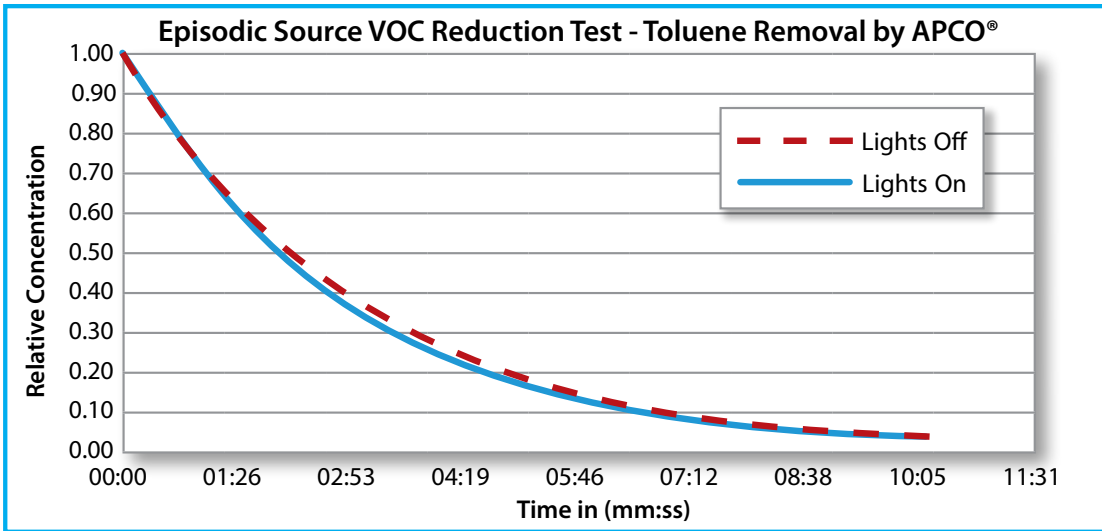
Tests performed by University of Wisconsin, Madison



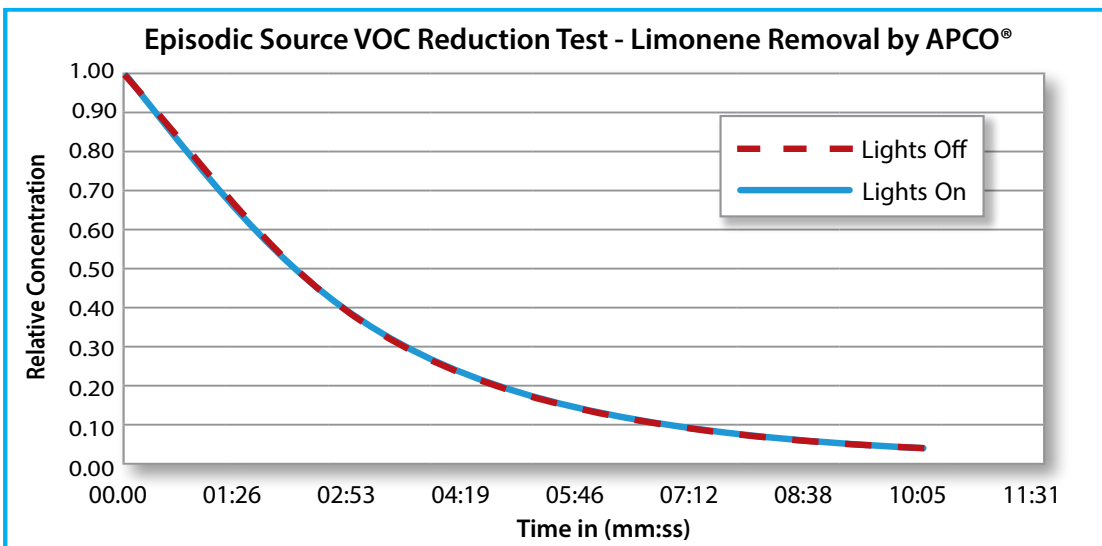
Tests performed by University of Wisconsin, Madison



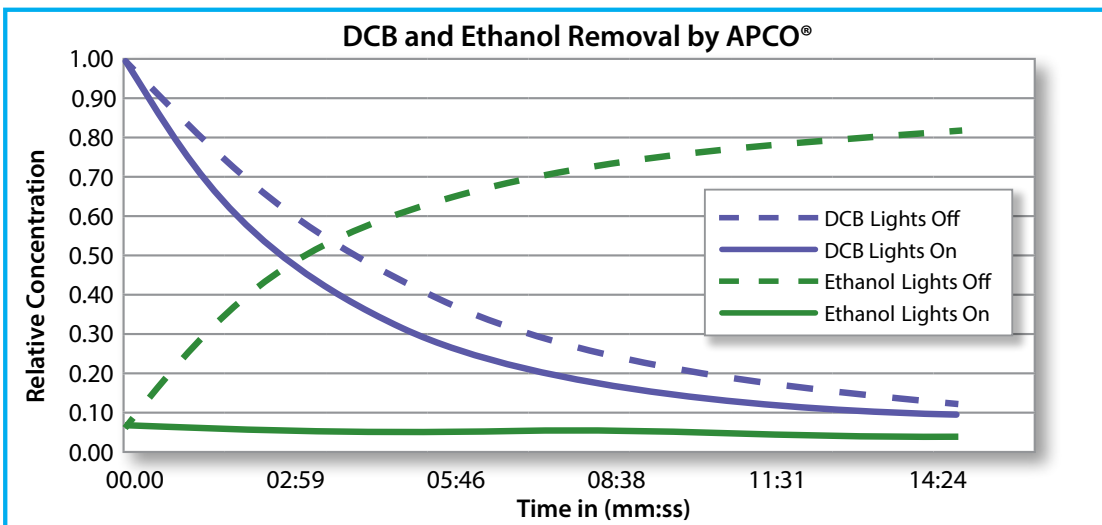
Tests performed by University of Wisconsin, Madison



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Tests performed by University of Wisconsin, Madison



Tests performed by University of Wisconsin, Madison



APCO RACK SYSTEM



APCO Rack Technical Specifications	
Dimensions	S-D Power supply: 8.75"L x 3.75"W x 2.5"H T-Q Power supply: 13"L x 3.75"W x 2.5"H 32" Lamp & APCO Module: 36" L x 4.5"H 3"D, Lamp: 32"L x 0.875 Dia. 60" Lamp & APCO Module: 64"L x 4.5"H 3"D, Lamp: 60"L x 0.875 Dia.
Electrical	32" Standard Output Lamps Auto Switching Multi-Voltage 120 - 277 VAC, 0.94-0.40 Amps Per Lamp
Electrical	60" Standard Output Lamps 120 to 277 VAC, 1.2-0.6 Amps Per Lamp
Electrical	32" High Output Lamps 120 or 230 VAC, 1.5-0.8 Amps Per Lamp
Kit includes	Remote power supply, 10' lamp cable, 6' power cord, UV lamp, mounting hardware and view port, 0.5" EMT conduit not included
32" UV Lamp	1 Year Standard Output Quartz hot filament (Teflon® coating available) 150 μW/cm ² @ 1 meter 2 Year Standard Output Shielded quartz hot filament with filament guard (Teflon® coating available) 140 μW/cm ² @ 1 meter
60" UV Lamp	1 Year Standard Output Quartz hot filament 190 μW/cm ² @ 1 meter 2 Year Standard Output Shielded quartz hot filament with filament guard 175 μW/cm ² @ 1 meter
32" UV Lamp	1 Year High Output Quartz hot filament, 300 mw/cm ² @ 1 meter, Output per 1" arc length of not less than 10 μW/cm ² at 1 meter in a 400 fpm airstream of 45° F
Warranty	1 Year & High Output Lamps - 1 Year 2 Year Lamps - 2 Years All other parts - Lifetime



800-741-1195

WWW.FRESHAIREUV.COM

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