RENSAIR

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October 2022

REPORT BY INDOOR SCIENCE

The following report is written by Indoor Science about Rensair's air cleaning technology. Indoor Science is a premier Indoor Air Quality (IAQ), Indoor Environmental Quality (IEQ) and Industrial Hygiene (IH) consulting firm in the United States. They have served over 15,000 residential, multi-national and government clients by testing, monitoring and recommending improvements in this space. Their core offerings also include exposure assessments, safety training and expert witness.

Indoor Science determined that the clean air delivery rate (CADR) for the Rensair Core (Model Q01B) exceeded the guideline of 300 cfm for all three particle sizes (smoke, dust, and pollen).

Indoor Science confirmed that the Rensair Core meets the criteria to be considered a high efficiency particulate air (HEPA) filter. Both the filter media and the full unit met the HEPA standard, which requires a minimum of 99.97% efficiency at removing particles at 0.3 µm in aerodynamic diameter.

Indoor Science tested the ability of the Rensair's UV light to deactivate microorganisms on the filter surface. At 30 minutes of UV exposure, all test viruses and mold spores were deactivated. Deactivating mold does not necessarily remove the allergenic proteins found on the outside of the non-viable spores. Further testing did not detect any Stachybotrys proteins on the filter surface following 60 minutes of UV light irradiation.

Kind regards

Christian Hendriksen
Co-Founder and CEO
Rensair

Air Cleaner Assessment Report: Rensair Core

Client:
Rensair LLC

Indoor Science Project ID: 4200738

Date: October 12, 2022

Prepared by:
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IndoorScience

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Executive Summary

Indoor Science determined that the clean air delivery rate (CADR) for the Rensair Core (Model Q01B) exceeded the guideline of 300 cfm for all three particle sizes (smoke, dust, and pollen). Indoor Science recommends a minimum CADR of 300 cfm for classrooms and other similarly-sized areas to mitigate COVID risks.

Indoor Science confirmed that the Rensair Core meets the criteria to be considered a high efficiency particulate air (HEPA) filter. Both the filter media and the full unit met the HEPA standard, which requires a minimum of 99.97% efficiency at removing particles at 0.3 µm in aerodynamic diameter.

Indoor Science tested the ability of the Rensair's UV light to deactivate microorganisms on the filter surface. It is our understanding that the UV light is primarily incorporated to reduce risks when changing the filter. At 30 minutes of UV exposure, all test viruses and mold spores were deactivated. Deactivating mold does not necessarily remove the allergenic proteins found on the outside of the non-viable spores. Further testing did not detect any Stachybotrys proteins on the filter surface following 60 minutes of UV light irradiation.

Background

Indoor Science was retained by Rensair to conduct an independent evaluation of the Rensair Core (Model Q01B) air cleaner. The goal was to evaluate the air cleaner for particle removal efficiency and the ability of the embedded UV light to deactivate viruses and mold on the filter surface.

The following tests were conducted:

- CADR test following AHAM methodology for all three sizes: smoke, dust and pollen
- HEPA test on the filter media to determine efficiency at 0.3 microns
- HEPA test on the full unit to determine efficiency at 0.3 microns
- MS2 surface test on filter to determine viability with UV light on vs. off
- Stachybotrys surface test on filter to determine viability with UV light on vs. off

Testing was conducted at Indoor Science's partner laboratory LMS Technologies in Bloomington, MN.

CADR – Clean Air Delivery Rates

The Rensair Core clean air delivery rate (CADR) was determined following methods adapted from the ANSI/AHAM AC-1 Standard, Method for Measuring Performance of Portable Household Electric Room Air Cleaners from the Association of Home Appliance Manufacturers (AHAM). CADR incorporates filter efficiency and fan capacity to inform customers of the total amount of clean air provided by the portable air cleaner every minute. CADR is measured in cubic feet per minute (cfm). The CADR is useful when determining the size of space to be used by an air cleaner. AHAM uses a rule of thumb which multiplies the CADR by 1.5 to determine the maximum room size for an air cleaner. For example, AHAM would recommend an air cleaner with a CADR of 300 to be used in a room no larger than 450 square feet. Indoor Science recommends air cleaners with a CADR greater than 300 for classrooms to mitigate COVID-19 risks.

The test method evaluates air cleaner performance against three different particle sizes: tobacco smoke, dust and pollen. The test method calls for particle sizes as follows:

- Tobacco smoke: 0.09 to 1.0 microns (μm)
- Dust: 0.5 to 3.0 μm
- Pollen: 0.5 to 11.0 μm

Results

The table below summarizes the Rensair Core CADRs for all three particle sizes using the fan's high setting:

Particle Size	Clean Air Delivery Rate (CADR)
Tobacco smoke	314.7
Dust	320.0
Pollen	316.2

Although CADR is generally higher for larger particle sizes (e.g. pollen), the results are within typical measurement variance.

The total flow rates of air cleaner on different settings were as follows:

- Low: 185.7 cubic feet per minute (cfm)
- Medium: 286.5 cfm
- High: 346.6 cfm

The flow rate readings were higher than the reported flowrates from the manufacturer of 180, 250, and 330 cfm respectively. These results are within typical measurement variance. Although the CADR deviated from the flow rate, the air cleaner still performed to HEPA standards, as demonstrated in the following section. The full CADR laboratory results are included in Appendix A.

HEPA tests on Filter Media and Full Unit

High efficiency particulate air (HEPA) filters are defined as those removing at least 99.97% of particles at 0.3 microns in aerodynamic diameter (other definitions use the most penetrating particle size). Both filter media and the full unit can be tested for HEPA performance. If a portable air cleaner does not have a tight seal on the HEPA filter media, bypass can reduce performance. Therefore, it is possible to have HEPA filter media without HEPA performance of the full unit.

Testing was conducted using methods adapted from the Institute of Environmental Sciences and Technology (IEST) Recommended Practice CC001: HEPA and ULPA Filters.

Results

The table below summarizes the Rensair Core HEPA performance for both the filter media and the full unit:

	Efficiency at 0.1-0.2 µm	Efficiency at 0.2-0.3 µm	Does it meet HEPA (99.97%)?
Filter media	99.989%	99.991%	Yes
Full unit	99.974%	99.976%	Yes

The full HEPA laboratory results are included in Appendix B.

UV Kill Rate for Viruses and Mold

The Rensair Core includes an ultraviolet (UV) light for the purpose of deactivating (“killing”) microorganisms that accumulate on the filter surface. The test method for evaluating the kill rate of the air cleaner utilized MS-2 virus as surrogate for SARS-CoV-2 and other similar viruses. The method used *Stachybotrys* as a surrogate for fungi/molds that grow indoors. By achieving a high kill rate, the UV can reduce risks associated with changing filters.

Organisms were grown on appropriate media, harvested, and placed on clean media test strips. The strips were attached to the inside of the air cleaner’s HEPA filter. Samples were taken at 0 time. The UV was activated, and the highest speed fan was used. The remaining test strips were timed for 5, 15, 30, and 60 minutes of exposure. Rinsates of the test strips were prepared and an aliquot was placed on agar media. Plates were incubated and counted.

An additional test was conducted on the filter media for the presence of proteins associated with *Stachybotrys*. Deactivating mold does not necessarily remove the allergenic proteins found on the outside of the non-viable spores. Indoor Science conducted a lateral flow immunoassay specific to *Stachybotrys* proteins, manufactured by Alexeter Technologies.

Results

Three test runs were conducted and the mean concentrations are reported in the summary table below:

MS2 Virus, measured in plaque-forming units (PFU)

	0 time	5 min	15 min	30 min	60 min
UV Light On	216	0	0	0	0
UV Light Off	216	170	91	63	50

Stachybotrys, measured in colony-forming units (CFU)

	0 time	5 min	15 min	30 min	60 min
UV Light On	180	4	1	0	0
UV Light Off	180	130	130	85	45

The UV light demonstrated that at 30 minutes it killed 100% of the virus and mold test organisms. The full surface kill rate laboratory results are included in Appendix C.

The lateral flow assay showed that Stachybotrys proteins were not still present on the filter surface. The results of the assay collected on 10 different locations of the filter all resulted in a negative result, as pictured below.

Conclusions and Recommendations

Indoor Science determined that the clean air delivery rate (CADR) for the Rensair Core was 314.7, 320.0, and 316.2 for tobacco smoke, dust, and pollen respectively. Indoor Science recommends a minimum CADR of 300 cfm for classrooms and other similarly-sized areas to mitigate COVID risks.

Indoor Science confirmed that the Rensair Core meets the criteria to be considered a high efficiency particulate air (HEPA) filter. Both the filter media and the full unit met the HEPA standard, which requires a minimum of 99.97% efficiency at removing particles at 0.3 μm in aerodynamic diameter. The minimum efficiency for the filter media and full unit were 99.989% and 99.974% respectively.

Indoor Science tested the ability of the Rensair's UV light to deactivate microorganisms on the filter surface. It is our understanding that the UV light is primarily incorporated to reduce risks when changing the filter. At 30 minutes of UV exposure, all test viruses and mold spores were deactivated. Deactivating mold does not necessarily remove the allergenic proteins found on the outside of the non-viable spores. Further testing did not detect any Stachybotrys proteins on the filter surface following 60 minutes of UV light irradiation.

Limitations

Indoor Science used all reasonable care to diligently assess the potential for hazardous conditions at the subject project site related to the scope of work. However, the absence of a hazardous condition being found in this assessment does not constitute a guarantee from Indoor Science that no other hazardous conditions are present, nor does the identification of hazardous conditions imply that all potentially hazardous conditions have been identified.

Indoor Science conducted this assessment following industry best practices and performed assessment protocols that are consistent with those exercised by other reputable consultants, based on current industry standards of practice for projects of similar scope and scale. No warranty, representation, or guarantee, express or implied, is included or intended in this assessment report.

As with all environmental consulting services, this assessment was limited to the defined scope and does not purport to set forth all hazards, nor indicate that other hazards do not exist.

Respectfully submitted by:

Ian Cull
Founder and Chief Science Officer
Indoor Science
Icull@indoorscience.com

Enclosed:
- Floor Plan
- Laboratory Analytical Reports

Appendix A: CADR Laboratory Results

Clean Air Delivery Rate REPORT

LMS
TECHNOLOGIES,
INC.

6423 Cecilia Circle
Bloomington, MN 55439 USA

Tel: 952-918-9060
Fax: 952-918-9061

Date: September 11, 2022
Test Requested By: Indoor Science
Test Type: CADR (Clean Air Delivery Rate)

Scope

Indoor Science provided an air purifier (Rensair, Model Q01B) for Clean Air Delivery Rate (CADR) test for dust, smoke, and pollen as challenge aerosols. Testing was performed in a large (1007 ft^3) stainless-steel chamber.

Method

Chamber test was carried out once with and once without the unit. Smoke, Dust and Pollen were fed into chamber and the reduction was measured by particle counters for one hour for both scenarios.

Microbiologists
John Cherne & Autumn Stivers-Biscuso

Testing Approval
Al Vatine, CEO

Air Cleaner Information

Manufacturer: **Rensair**

Product Name: **Model Q01B**

O


Figure 1 Rensair Q01B

Test Conditions

Environmental Conditions: 72 °F and 50% RH

Equipment

1007 ft^3 Stainless-Steel Test Chamber

TSI Model 3330 particle counter

TSI SMPS

Figure 2. Test chamber

CADR Smoke

INFORMATION FOR REPORT

These results are plotted in Figure 1. Particle decay follow the exponential decay function:

$$C_{t_i} = C_i e^{-kt_i} \qquad \text{(Equation 2)}$$

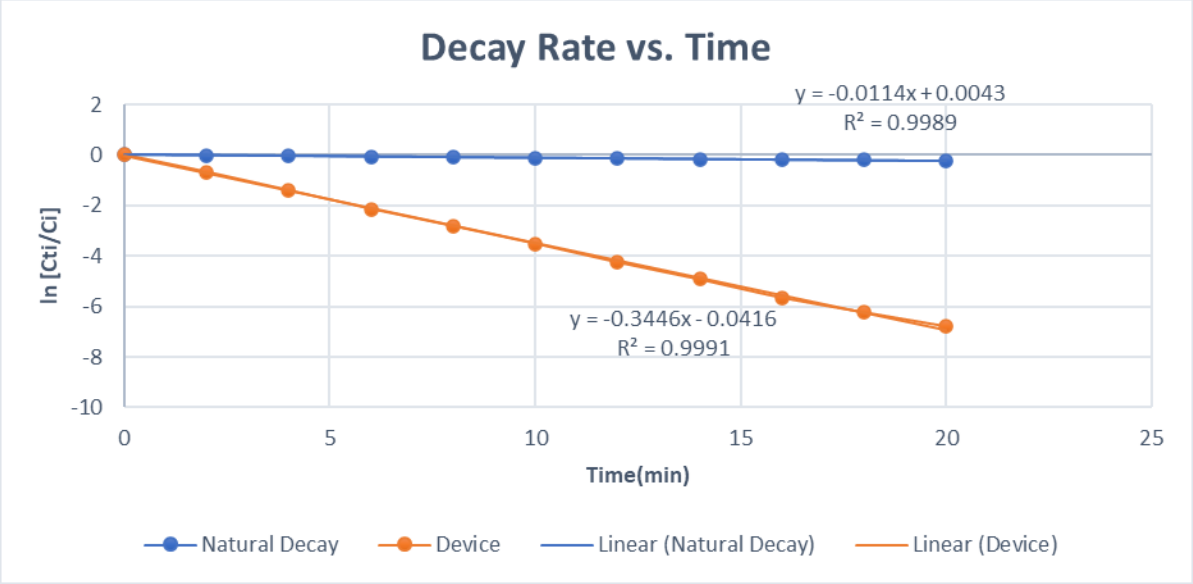
where C_{ti} is the PFU at time t_i, C_i is the PFU at time = 0 minutes, k is the decay rate constant, and t_i is the time. The decay rate constant is then found from the slope of the $\ln[C_{ti}/C_i]$ vs. t_i curve:

$$\ln\frac{C_{t_i}}{C_i} = -kt_i + b \qquad \text{(Equation 3)}$$

The following formula, modeled on the AHAM test CADR, was used to determine the $CADR_{smoke}$ of the device with a test chamber volume (V) of 944.6 ft^3:

$$CADR_{smoke} = V\left(k_{device} - k_{natural\_decay}\right) \qquad \text{(Equation 4)}$$

P-36: **EXAMPLE CALCULATION FOR EACH DEVICE IN REPORT**



k_device	k_natural decay
0.3446	0.0114
CADR=	314.7

CADR Dust

INFORMATION FOR REPORT

These results are plotted in Figure 1. Particle decay follow the exponential decay function:

$$C_{t_i} = C_i e^{-kt_i} \qquad \text{(Equation 2)}$$

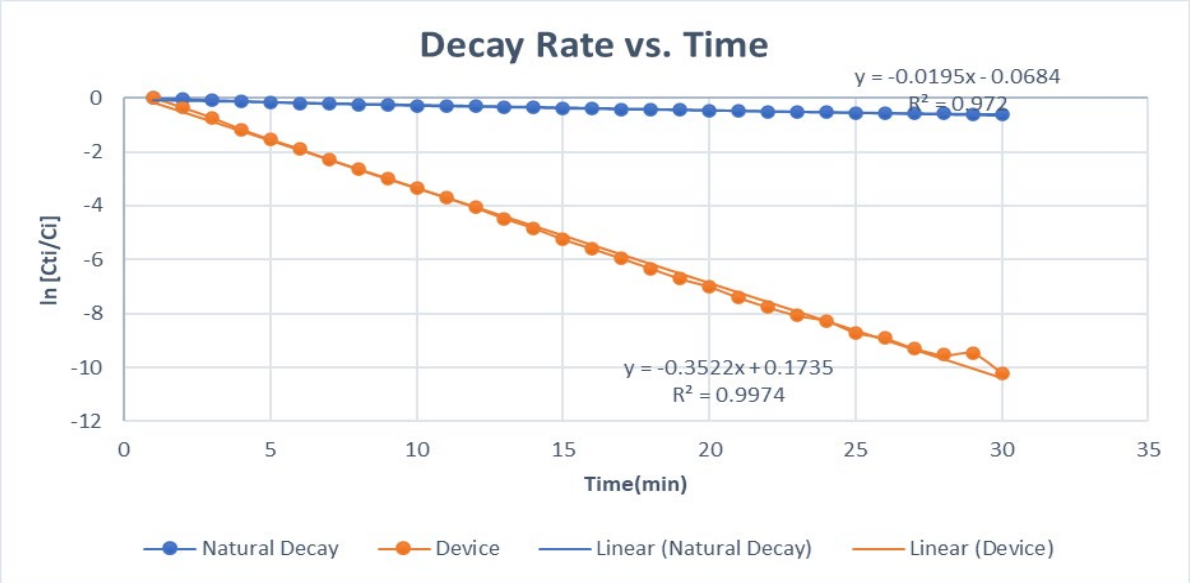
where C_{ti} is the PFU at time t_i, C_i is the PFU at time = 0 minutes, k is the decay rate constant, and t_i is the time. The decay rate constant is then found from the slope of the $\ln[C_{ti}/C_i]$ vs. t_i curve:

$$\ln \frac{C_{t_i}}{C_i} = -kt_i + b \qquad \text{(Equation 3)}$$

The following formula, modeled on the AHAM test CADR, was used to determine the $CADR_{dust}$ of the device with a test chamber volume (V) of 944.6 ft³:

$$CADR_{dust} = V\left(k_{device} - k_{natural\_decay}\right) \qquad \text{(Equation 4)}$$

P-14: **EXAMPLE CALCULATION FOR EACH DEVICE IN REPORT**



k_device	k_natural decay
0.35822	0.0195
CAR=	320.0

CADR Pollen

INFORMATION FOR REPORT

These results are plotted in Figure 1. Particle decay follow the exponential decay function:

$$C_{t_i} = C_i e^{-kt_i} \qquad \text{(Equation 2)}$$

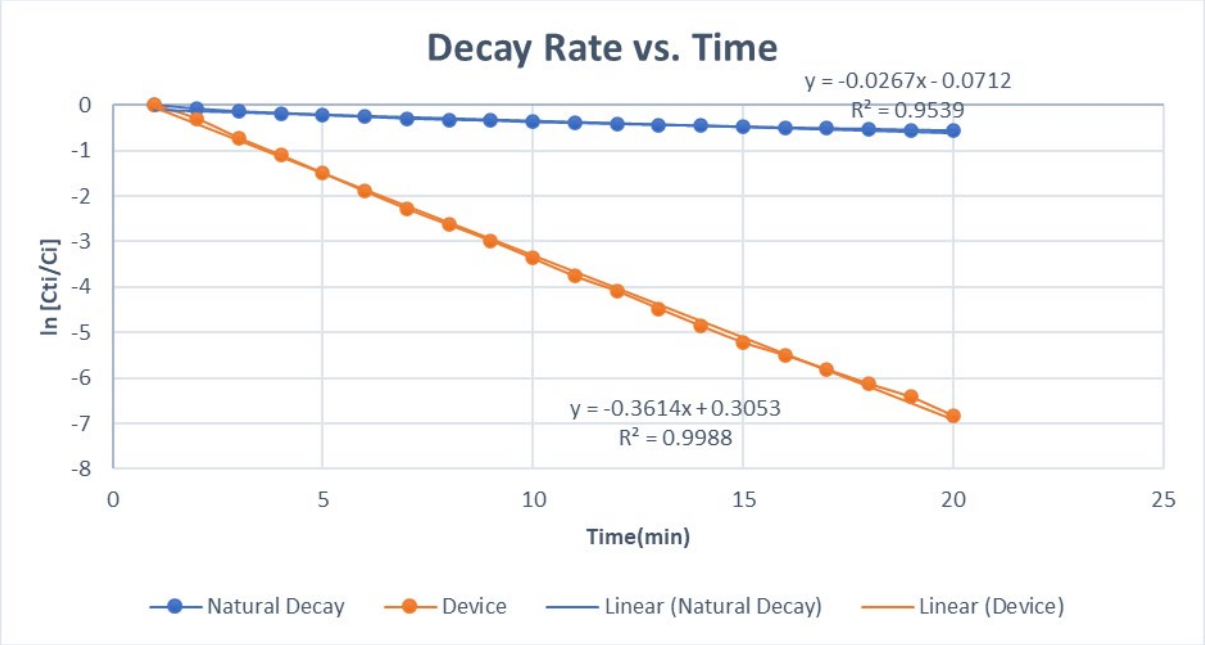
where C_{ti} is the PFU at time t_i, C_i is the PFU at time = 0 minutes, k is the decay rate constant, and t_i is the time. The decay rate constant is then found from the slope of the $\ln[C_{ti}/C_i]$ vs. t_i curve:

$$\ln \frac{C_{t_i}}{C_i} = -kt_i + b \qquad \text{(Equation 3)}$$

The following formula, modeled on the AHAM test CADR, was used to determine the $CADR_{pollen}$ of the device with a test chamber volume (V) of 944.6 ft^3:

$$CADR_{pollen} = V\left(k_{device} - k_{natural\_decay}\right) \qquad \text{(Equation 4)}$$

P-14: **EXAMPLE CALCULATION FOR EACH DEVICE IN REPORT**



k_device	k_natural decay
0.3614	0.0267
CADR=	316.2

September 28, 2022 ***LMS#7992***

Flow Rate Test Report

LMS Technologies, Inc.

6423 Cecilia Circle *Tel.: (952) 918-9060*

Bloomington, MN 55439 *Fax: (952) 918-9061*

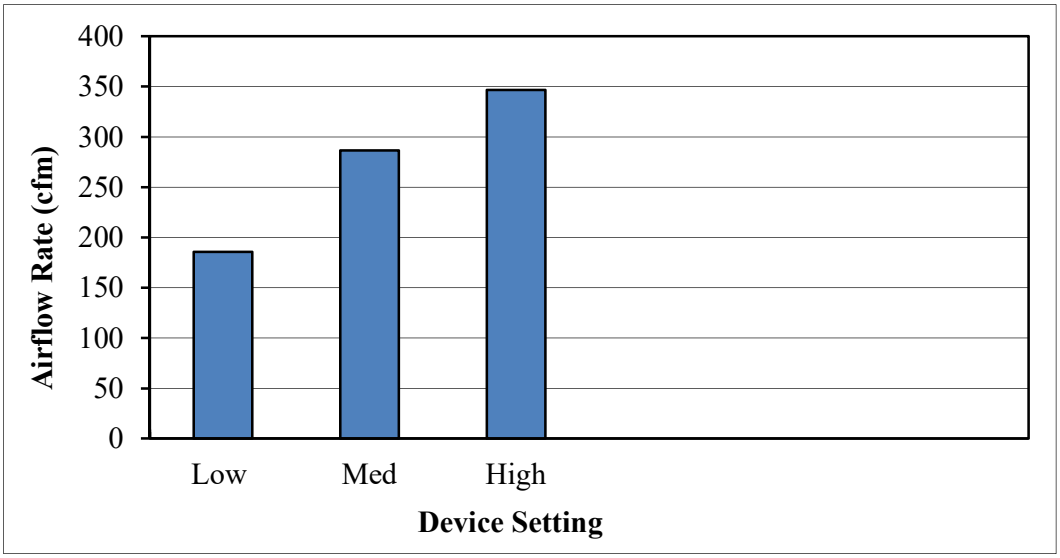
Test Type: *Flow Rate Measurement* ***Requested By:*** *Indoor Science*

Unit Model: *Q01B* ***Manufacturer:*** *Rensair*

Description: *Air Purifier Unit*

Temp and Humidity: 70°F and 35%

Device Setting	Airflow Rate (cfm)
Low	185.7
Med	286.5
High	346.6



Test Supervisor
Emile Tadros

Engineering Approval
K.C. Kwok, PH. D.

Appendix B: HEPA Laboratory Results

September 28, 2022 **LMS#7992**

IEST-RP-CC001.6 TEST REPORT

LMS Technologies, Inc.

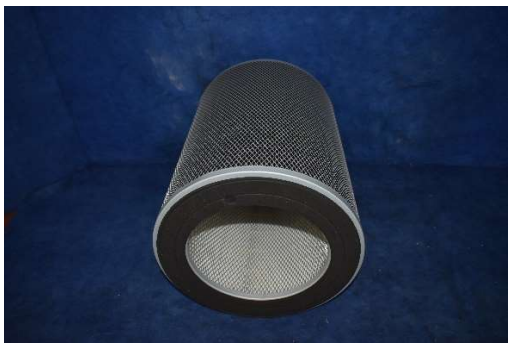
6423 Cecilia Circle
Bloomington, MN 55439
Tel.: (952) 918-9060
Fax: (952) 918-9061

Test Type :	IEST-RP-CC001.6	**Test Requested by:**	Indoor Science
Test Number:	T092822A	**Filter Manufacturer:**	Rensair
Flow Rate/Velocity:	**346.6 cfm**	**Filter ID:**	HEPA Filter
Test Aerosol:	Latex beads, Neutralized	**Description:**	Small Cylindrical Filter

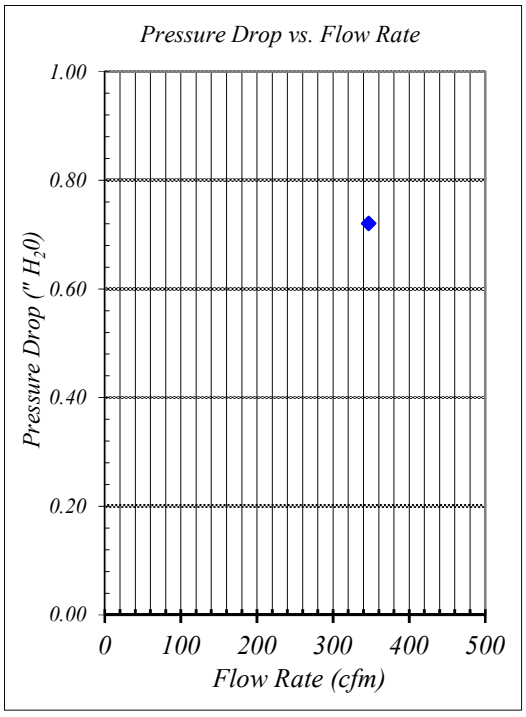
Temp and Humidity: 70 °F and 35%

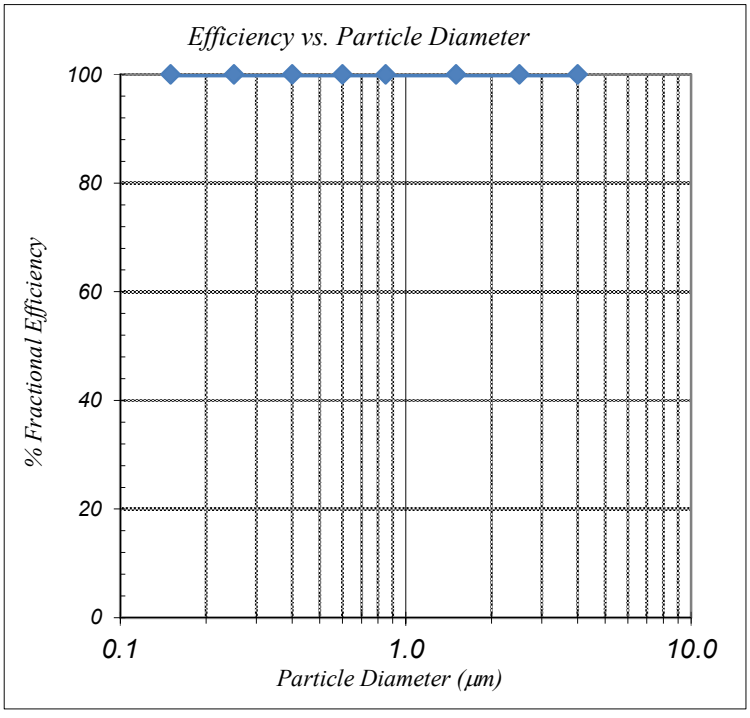
Flow Rate (cfm)	DP "H_2O
346.6	0.720

Size Range (μm)	Initial Fractional Efficiency(%)
0.1-0.2	**99.989**
0.2-0.3	**99.991**
0.3-0.5	99.997
0.5-0.7	100.000
0.7-1.0	100.000
1.0-2.0	100.000
2.0-3.0	100.000
3.0-5.0	100.000



Data verified by LMS Calibration Filter* Patent Pending





TEST SUPERVISOR
Emile Tadros_____

ENGINEERING APPROVAL
K.C. KWOK, PH.D._____

September 28, 2022 **LMS#7992**

IEST-RP-CC001.6 TEST REPORT

LMS Technologies, Inc.

6423 Cecilia Circle
Bloomington, MN 55439
Tel.: (952) 918-9060
Fax: (952) 918-9061

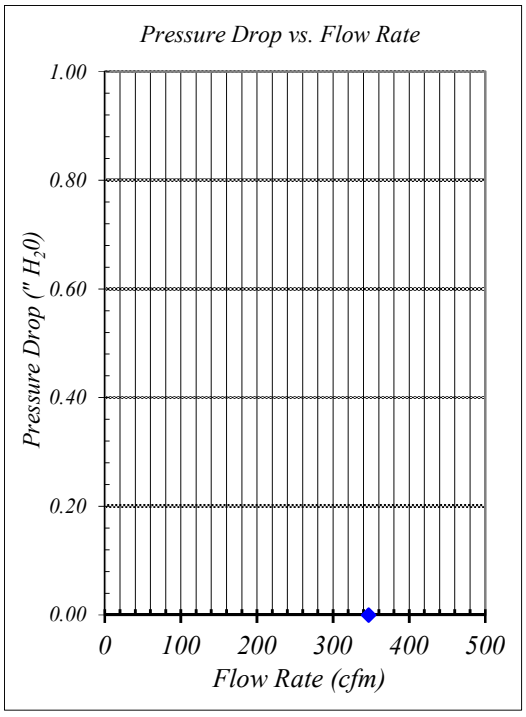
Test Type :	IEST-RP-CC001.6	**Test Requested by:**	Indoor Science
Test Number:	T092822B	**Filter Manufacturer:**	Rensair
Flow Rate/Velocity:	**In-Situ**	**Filter ID:**	Whole unit
Test Aerosol:	Latex beads, Neutralized	**Description:**	with Small Cylindrical Filter

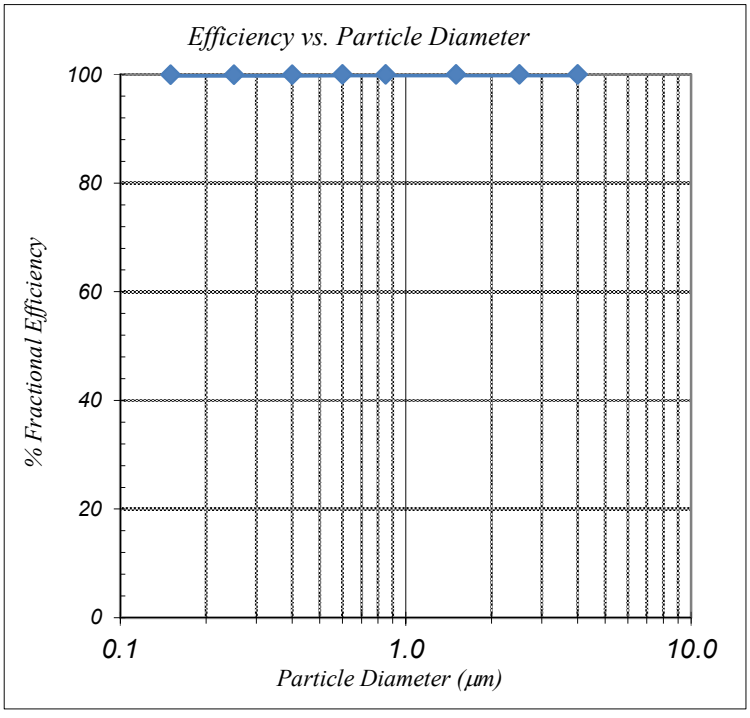
Temp and Humidity: 70°F and 35%

Flow Rate (cfm)	DP "H_2O
346.6	0.000

Size Range (μm)	Initial Fractional Efficiency(%)
0.1-0.2	***99.974***
0.2-0.3	***99.976***
0.3-0.5	99.983
0.5-0.7	99.988
0.7-1.0	99.992
1.0-2.0	99.995
2.0-3.0	99.999
3.0-5.0	100.000

Data verified by LMS Calibration Filter* Patent Pending





TEST SUPERVISOR
Emile Tadros_____

ENGINEERING APPROVAL
K.C. KWOK, PH.D._____

Appendix C: UV Kill Rate Laboratory Results

MICROBIOLOGY REPORT

LMS TECHNOLOGIES, INC.

6423 Cecilia Circle
Bloomington, MN 55439 USA

Tel: 952-918-9060
Fax: 952-918-9061

Date: October 3, 2022
Test Type: Surface Efficacy
Test Requested by: Indoor Science
LMS#7992

Scope: Test Rensair Q01B air cleaner provided by customer for surface testing with MS-2 bacteriophage (ATCC 15597-B1) and Stachybotrys Chartarum (ATCC 9182) as the challenge organisms.

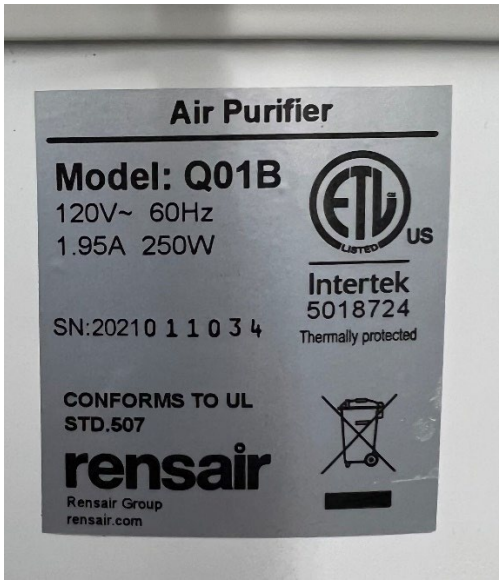
Method:
Organisms were grown on appropriate media, harvested, and placed on clean media test strips. The strips were attached to the inside of the air cleaner's heap filter. Samples were taken at 0 time. The UV was activated, and the highest speed fan was used. The remaining test strips were timed for 5, 15, 30, and 60 minutes of exposure. Rinsates of the test strips were prepared and an aliquot was placed on agar media, Plates were incubated and counted.

The collection plates were incubated for 24-48 hours. After incubation, the recovered organisms were enumerated. The efficiency was calculated using the formula:

$$\boldsymbol{Efficiency} = \mathbf{1} - \left(\frac{\boldsymbol{FilterPFU_{time=5}}min}{\boldsymbol{FilterPminFU_{time=0}}} * \frac{\boldsymbol{Control\ PFU_{time=0}}}{\boldsymbol{Control\ PFU_{time\ 5\ min}}}\right)$$

Microbiologists:
John Cherne
Autumn Stivers-Biscuso
KoKoe Noutepe

Testing Approval
Al Vatine, CEO



Microbiologists:
John Cherne
Autumn Stivers-Biscuso
KoKoe Noutepe

Testing Approval
Al Vatine, CEO

Data 1: MS-2

		MS-2 Pfu				
		0 time	5 minutes	15 minutes	30 minutes	60 minutes
Light on	Mean of 3	216	0	0	0	0
Light off	Mean of 3	216	170	91	63	50

Efficiency $\geq 99.4\%$

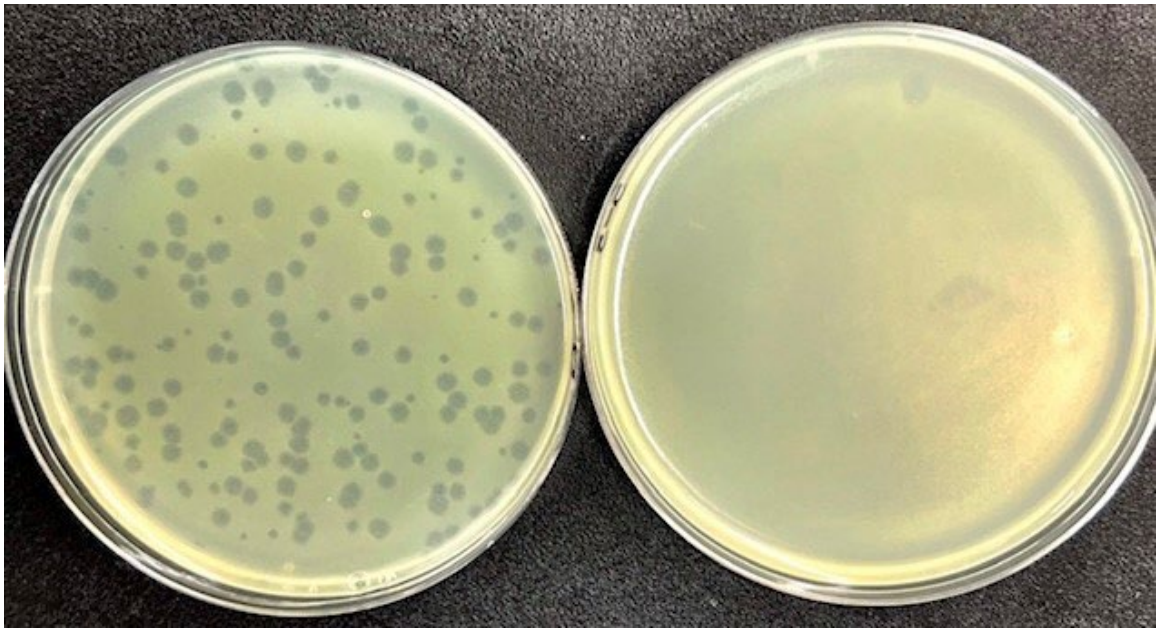


Figure 1: MS-2 Pfu at 0 min and 5 min

Data 2: Stachybotrys Chartarum

		Stachybotrys Chartarum				
		0 min	5 min	15 min	30 min	60 min
Light on	Mean of 3 runs	180	4	1	0	0
Light off	Mean of 3 runs	180	130	130	85	45
	Efficiency		96.92%	99.23%	100%	100%

Microbiologists:
John Cherne
Autumn Stivers-Biscuso
KoKoe Noutepe

Testing Approval
Al Vatine, CEO

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