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STUDY REPORT

Arc | Beam | Vive

Performance Validated by
Independent Laboratory Testing

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Study Report

| Viral Strains

R-Zero Arc Performance Validated by Independent Laboratory Testing

In September 2020, R-Zero engaged an independent clinical testing lab to validate the efficacy of its flagship UV-C disinfection system, Arc, against human coronavirus, feline calicivirus (FCV), MRSA and E. coli carriers.

R-Zero selected microorganisms endemic to the environments Arc will be used in, ensuring partners understand Arc's efficacy against the microorganisms most important to them. The following represents the results of that testing.

Testing Laboratory

Bioscience Laboratories, Inc is an EPA and FDA GLP-Compliant, ISO 17025 Accredited Testing Laboratory (American Association for Laboratory Accreditation, certificate number 3945.01). Tests were conducted at the Bioscience laboratory, 1755 South 19th Avenue, Bozeman, MT 59718.

Product Tested

R-Zero ARC (UV light device, 78 inches tall, with wheels, with four long-range sensors and eight maximum output bulbs)

Test Method

Testing was designed to simulate the consumer use and was based upon the procedures outlined in the American Society of Test Materials (ASTM) test methods designated:

- **ASTM E1053-20,** Standard Test Practice to Assess Virucidal Activity of Chemicals Intended for Disinfection of Inanimate, Nonporous Environmental Surface.
- **ASTM E3135-18,** Standard Practice for Determining Antimicrobial Efficacy of Ultraviolet Germicidal Irradiation Against Microorganisms on Carriers with Simulated Soil.

Study Conclusions

Completed: 9/20/2020
Evaluation: Virucidal Efficacy, 3 UV Devices vs. 2 Viral Strains
Study ID Number: 2005308-404

Under the conditions of this evaluation, R-Zero Arc reduced the microbial populations of Escherichia coli (ATCC #25922) and Staphylococcus aureus MRSA (ATCC #33591) by an average of 99.99% following a 7 minutes exposure at a distance of 8 feet.

Microorganism Species (ATCC #)	Distance (feet)	Time (min,)	Log Reduction	Percent Reductions	Average Percent Reductions
Human Coronavirus, strain 229E (ATCC #VR-740)	8	7	≥ 3.833	≥99.99	≥99.99%
			≥ 3.833	≥99.99	
			≥ 3.833	≥99.99	
Feline Calicivirus, strain F9, EPA-approved surrogate for Human Norovirus (FCV; ATCC #VR-782)	8	7	4.917	≥99.99	≥99.99%
			4.833	≥99.99	
			4.833	≥99.99	

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Study Report

| Bacterial Strains

R-Zero Arc Performance Validated by Independent Laboratory Efficacy Testing

Testing Laboratory

Bioscience Laboratories, Inc, is an EPA and FDA GLP-Compliant, ISO 17025 Accredited Testing Laboratory (American Association for Laboratory Accreditation, certificate number 3945.01). Tests were conducted at the Bioscience laboratory, 1755 South 19th Avenue, Bozeman, MT 59718.

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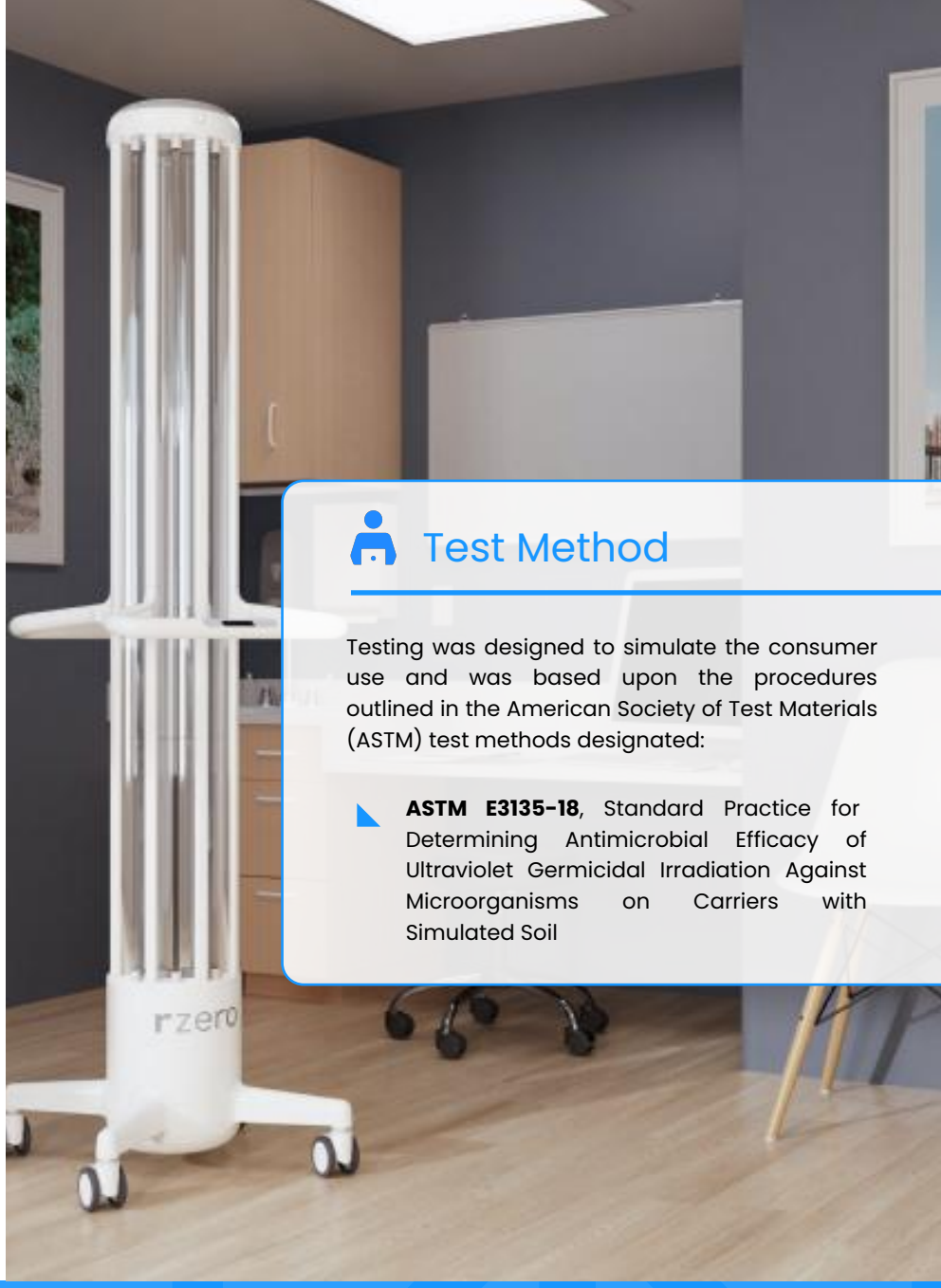
Product Tested

R-Zero ARC (UV light device, 78 inches tall, with wheels, with four long-range sensors and eight maximum output bulbs)



Test Method

Testing was designed to simulate the consumer use and was based upon the procedures outlined in the American Society of Test Materials (ASTM) test methods designated:

- **ASTM E3135-18**, Standard Practice for Determining Antimicrobial Efficacy of Ultraviolet Germicidal Irradiation Against Microorganisms on Carriers with Simulated Soil

Study Conclusions

Completed: 11/12/2020
Evaluation: Antibacterial Efficacy 3 UV Devices vs. 2 Bacterial Strains
Study ID Number: 2006455-204

Under the conditions of this evaluation, R-Zero Arc reduced the microbial populations of Escherichia coli (ATCC #25922) and Staphylococcus aureus MRSA (ATCC #33591) by an average of 99.99% following a 7 min. exposure at a distance of 8 feet.

Microorganism Species (ATCC #)	Distance (feet)	Time (min,)	Mean CFU/Carrier (C) n=3	Percent Reductions	Average Percent Reductions
Escherichia coli (ATCC #25922)	8	7	1.95×10^6	≥99.99	≥99.99%
			1.95×10^6	≥99.99	
			1.95×10^6	≥99.99	
Staphylococcus aureus MRSA (ATCC #33591)	8	7	2.03×10^6	≥99.99	≥99.99%
			2.03×10^6	≥99.99	
			1.64×10^7	≥99.99	

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Study Report

| Spore-forming microorganisms

R-Zero Arc Performance Validated by Independent Laboratory Testing

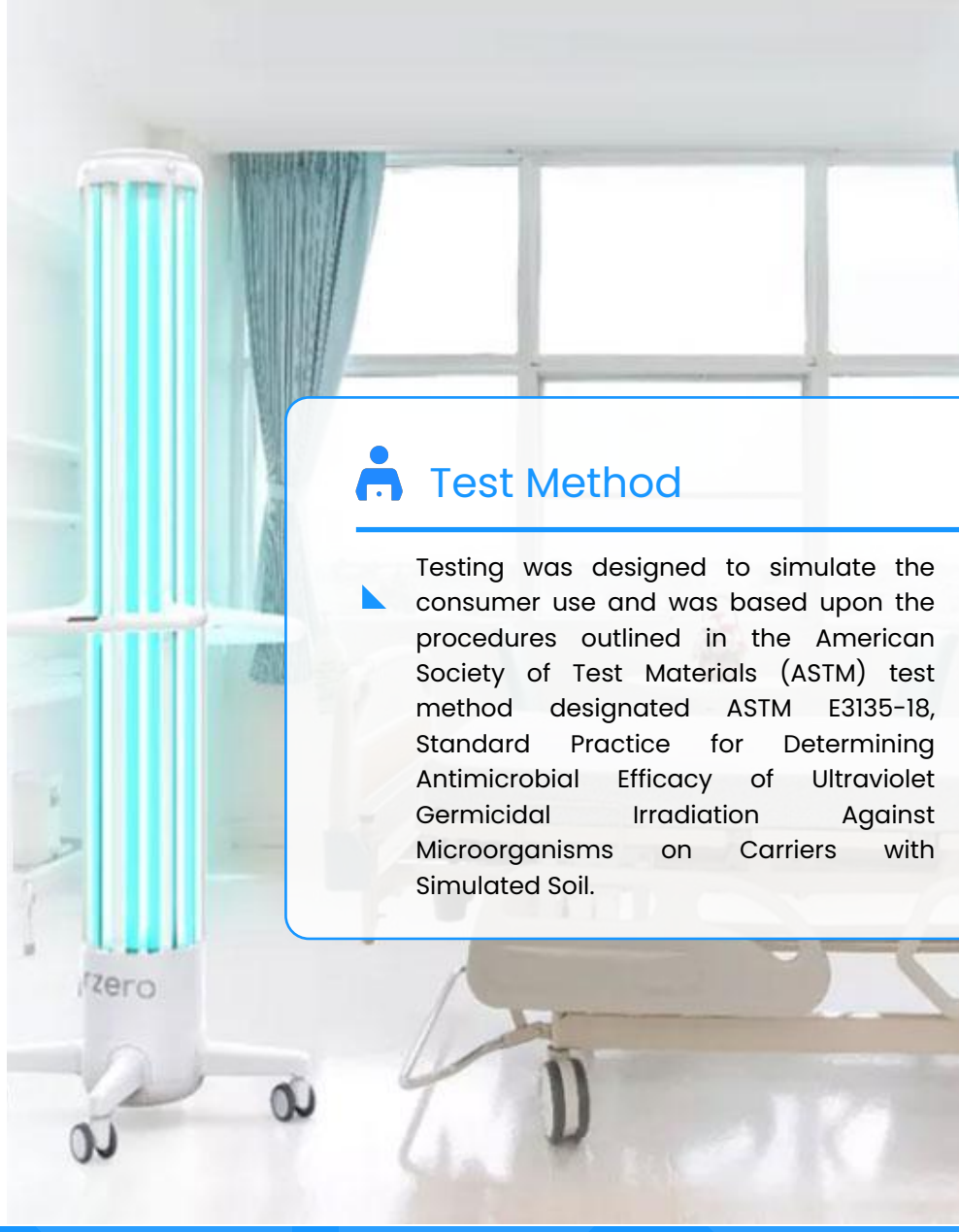
In January 2022, R-Zero engaged Microchem Laboratories to test Arc's efficacy against spore-forming bacteria and fungal microorganisms.

Testing Laboratory

Microchem Laboratories, a Texas-based independent laboratory with ISO 17025 accreditation and EPA and FDA GLP compliance. At this laboratory.

Product Tested

R-Zero ARC (UV light device, 78 inches tall, with wheels, with four long-range sensors and eight maximum output bulbs)



Test Method

Testing was designed to simulate the consumer use and was based upon the procedures outlined in the American Society of Test Materials (ASTM) test method designated ASTM E3135-18, Standard Practice for Determining Antimicrobial Efficacy of Ultraviolet Germicidal Irradiation Against Microorganisms on Carriers with Simulated Soil.

Study Conclusions

This test used organic soil load to simulate soiling agents such as saliva and oils. This additional soil makes for a more challenging test by decreasing the UV-C ability to reach the microbial sample, simulating real world conditions.

Microorganism Species (ATCC #)	R-Zero's Arc reduced the microbial populations of:	Reduction of microbial populations by percentage	Exposure Time	Exposure Distance
Bacterial spores	Clostridioides difficile spores ATCC 43598	99.9%	7 minutes	8 feet
Fungal microorganism	Candida auris CDC AR Bank #038	99.9%	7 minutes	8 feet

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Study Report

| Aerosolized Microorganisms

R-Zero Beam Performance Validated by Independent Laboratory Testing

In August 2021, R-Zero engaged an independent clinical testing lab to validate the efficacy of its Upper Room UVGI device, Beam, against human coronavirus, MRSA, MRSE, Klebsiella aerogenes, and Aspergillus brasiliensis.

R-Zero selected microorganisms endemic to the environments Beam will be used in, ensuring partners understand Beam's efficacy against the microorganisms most important to them. The following represents the results of that testing.

Testing Laboratory

Testing was performed at Aerosol Research and Engineering Laboratories, a third party lab specializing in biological aerosol testing. Tests were conducted at the ARE laboratory, 15320 S. Cornice Street, Olathe, KS 66062.

Product Tested

R-Zero Beam Upper Room UVGI light device, 77" x 16" x 4" with 40 LED lights emitting UV-C at 265nm, and 2 long range PIR sensors in the irradiance zone and a baffle under the LEDs to ensure safety.

Test Method

Each microorganism was aerosolized into a sealed 16m3 environmental bioaerosol chamber, containing the R-Zero's Beam device, using a Collison 24-Jet Nebulizer. All the bioaerosols had a mass median aerodynamic diameter (MMAD) ranging from 0.7-4.0 µm (species dependent).

Bioaerosol samples were taken at multiple time points throughout each trial, in order to quantify the reduction rate capability of the air purification device. Impinger samples were serially diluted, plated, incubated, and enumerated in triplicate to yield viable bioaerosol concentration for each sampling point. Chamber control trial data, or natural decay, was subtracted from the device trial data to yield the net LOG reduction for each of the bioaerosol challenges. Additionally viable cascades, run at 30 L/min, were used to further resolve the lower detection limits achieved by the R-Zero device.

Study Conclusions

The R-Zero Beam is extremely adept at inactivating viable bioaresols from room air. Within 45 min of operation, the R-Zero Beam had removed approximately 6.0 net log (99.9999%) of bioaerosols from the test chamber for all of the organisms. Based on the viability reduction seen with the various microorganisms tested, tentative conclusions can be made about how the device would inactivate more lethal viruses and bacteria with similar properties to the tested surrogates. The clean air delivery rate was calculated for all organisms, the device had an average CADR of 796.96 CFM.

Species	Number of trials	Total Trial Time	Data Type	Trial 1	Trial 2	Trial 3	Average Trials
Staphylococcus epidermidis	3	60	Net Log Reduction Net % Reduction	-8.06 99.9999991%	-7.19 99.9999936%	-7.47 99.9999966%	-7.57 +/-0.44 0.9999966% +/-0.00000003%
Klebsiella aerogenes	3	60	Net Log Reduction Net % Reduction	-4.98 99.9989429%	-5.53 99.9997019%	-5.45 99.9996439%	-5.32 +/- 0.3 0.999994% +/-.0.00000004%
T1 Bacteriophage	3	60	Net Log Reduction Net % Reduction	-5.60 99.9997515%	-6.03 99.9999077%	-6.21 99.9999385%	-5.95 +/- 0.31 0.999999% +/-0.000001%

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Study Report

| Aerosolized Microorganisms

R-Zero Vive Performance Validated by Independent Laboratory Testing

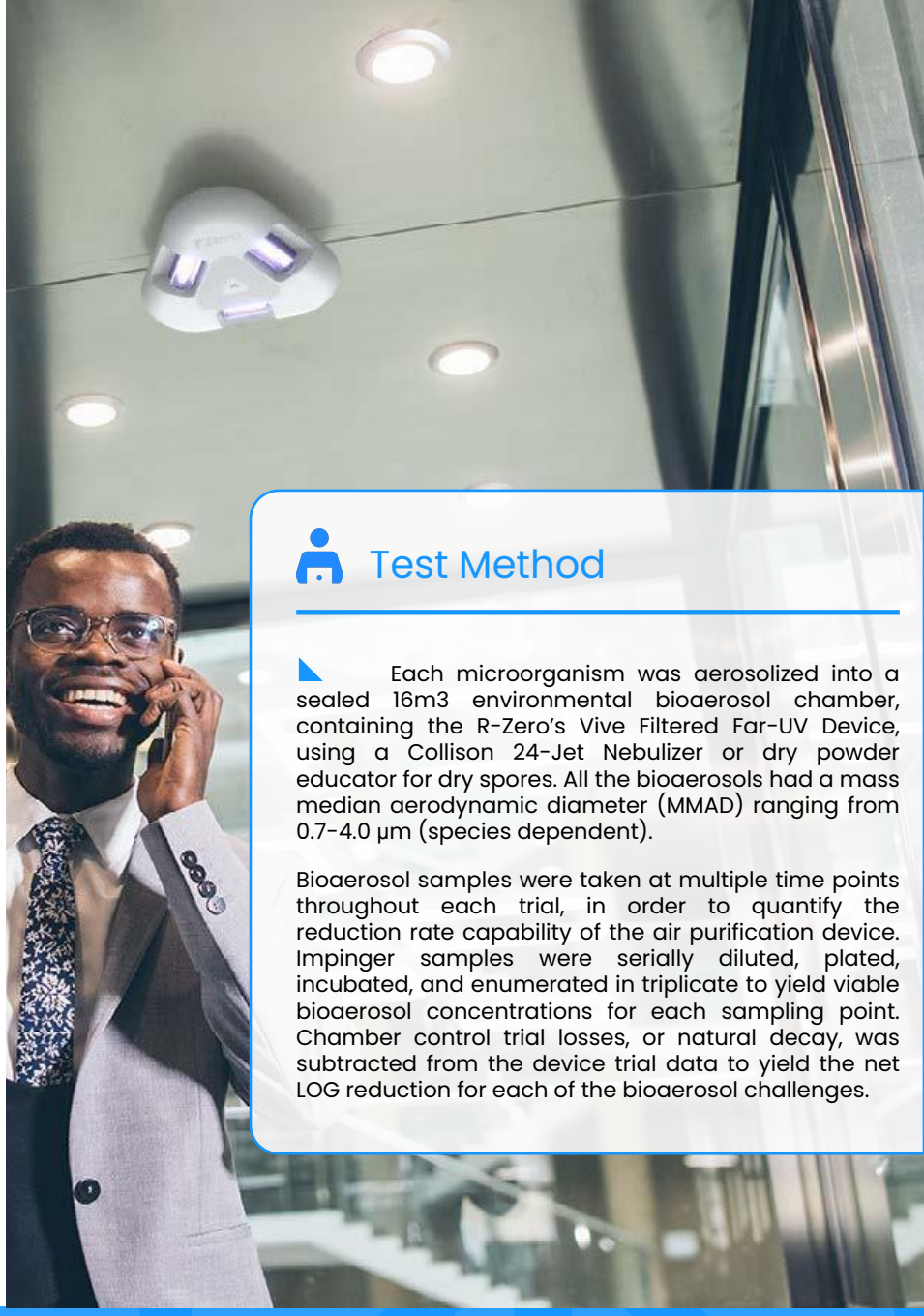
In August 2021, R-Zero engaged an independent clinical testing lab to validate the efficacy of its Far UV disinfection device, Vive, against human coronavirus, MRSA, MRSE, Klebsiella aerogenes, and Aspergillus brasiliensis. R-Zero selected microorganisms endemic to the environments Vive will be used in, ensuring partners understand Vive's efficacy against the microorganisms most important to them. The following represents the results of that testing.

Testing Laboratory

Aerosol Research and Engineering Laboratories, Inc. is an EPA and FDA GLP-Compliant, ISO 17025 Accredited Testing Laboratory (American Association for Laboratory Accreditation, certificate number 3945.01). Tests were conducted at the Bioscience laboratory, 1755 South 19th Avenue, Bozeman, MT 59718. Avenue, Bozeman, MT 59718.

Product Tested

R-Zero Vive Far UV light device, 13.5" x 12" x 4.5" with one PIR sensor and 3 KrCl bulbs with nanofilters.



Test Method

Each microorganism was aerosolized into a sealed 16m3 environmental bioaerosol chamber, containing the R-Zero's Vive Filtered Far-UV Device, using a Collison 24-Jet Nebulizer or dry powder educator for dry spores. All the bioaerosols had a mass median aerodynamic diameter (MMAD) ranging from 0.7-4.0 µm (species dependent).

Bioaerosol samples were taken at multiple time points throughout each trial, in order to quantify the reduction rate capability of the air purification device. Impinger samples were serially diluted, plated, incubated, and enumerated in triplicate to yield viable bioaerosol concentrations for each sampling point. Chamber control trial losses, or natural decay, was subtracted from the device trial data to yield the net LOG reduction for each of the bioaerosol challenges.

Study Conclusions

The R-Zero Vive Filtered Far-UV Device is effective at inactivating viable bioaerosols from room air. Within 120 minutes or less, 3 of the 4 organisms were reduced significantly from the test chamber air. The most UV resistant organism, the mold spore, was observed to have a net log reduction of 2.68 +/- 0.14 after 240 minutes. With a reduction of 99.99% the device should decrease the risk of infection due to respiratory inhalation of microorganisms.

Average % NET Reduction and NET LOG Reduction of Viable Bioaerosol

Bioaerosol Type	Species	Number of trials	Total Trial Time	Data Type	Trial 1	Trial 2	Trial 3	Average /
Virus	T1 (Non-enveloped dsDNA virus)	3	120	Net Log Reduction Net% Reduction	-4.41 99.9961%	-4.04 99.990.8%	-4.18 99.9934%	-4.21+/-0.19 99.9934%+/-+/-0.0027%
Bacterial	Staphylococcus epidermidis (+, vegetative)	3	120	Net Log Reduction Net% Reduction	-4.85 99.9986%	-4.85 99.9986%	-4.47 99.9966%	-4.72+/-0.22 99.9979%+/-+/-0.0011%
Bacterial	Klebsiella aerogenes (Gram - negative)	3	90	Net Log Reduction Net% Reduction	-4.89 99.9987%	-4.94 99.9988%	-5.14 99.9993%	-4.99+/-0.14 99.9989% +/- 0.0003%
Mold	Aspergillus brasiliensis (mold, spold forming)	3	240	Net Log Reduction Net% Reduction	-2.53 99.7018%	-2.81 99.8443%	-2.72 99.8080%	-2.68+/-0.144 99.7847%+/-+/-0.0741%

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