Assessment of the Air Sniper Ultra unit in removing airborne Escherichia virus MS2 in a 28.5 m^3 environmental test chamber

Testing Performed by Airmid Healthgroup ltd.
Unit 5, Trinity Enterprise Campus, Grand Canal Quay, Dublin 2, DO2 YP79, Ireland
T: +353 1 6336820 E: info@airmidhealthgroup.com W: airmidhealthgroup.com
Directors: Dr. Bruce Mitchell (Chairman and CEO),
Dr. John McKeon, Robert Jenkins, Hubert Lippe, Serge Rolle.
Co. Reg. No.: 444684 VAT Registration: IE9669332M

Report Written By: Jake Behan, BSc., Head of Operations
Report Reviewed By: Vivienne Mahon, Ph.D., Chief Scientist/Quality Director

Customer Name	AIR Alpine Innovative Research Inc
Customer Address	3855 64 Ave SE, Calgary, AB T2C 2V5, Canada
Contact	Stuart Henley
Sample Description	Air Sniper Ultra Air Purifier
Number of Samples	1
Date of Receipt	05 October 2020
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Table of Contents

1. Purpose

This report outlines the results following the assessment of the Air Sniper Ultra air purifier in removing airborne *Escherichia* virus MS2 in a 28.5 m^3 environmental test chamber.

2. Test Item Description

One Air Sniper Ultra 119-110200 air purifier was received by Airmid Healthgroup on 05 October 2020 in good condition (Figure 2.1).

Figure 2.1. Air Sniper Ultra 119-110200 air purifier

3. Materials and Methods

3.1. 28.5 m^3 Environmental Test Chamber

Testing was conducted in a state-of-the-art 28.5 m^3 test chamber purpose-built to comply with the American Society for Testing and Materials (ASTM) standard. The chamber features include HEPA filtered supply air and an ability to maintain selected temperature and humidity levels at a wide range of air change rates. The chamber was constructed using powder-coated stainless steel with all materials complying with low volatile organic compound (VOC) emission requirements.

The chamber is sealable from the exterior environment with access via an anteroom with interlocking doors and complies with cleanroom standards. The air change rate within the chamber can be controlled within a range of 0.5 to 20 air changes per hour.

3.2. Bacteriophage MS2 (MS2)

Bacteriophage MS2 (MS2) is a non-enveloped virus that infects Escherichia coli and some other closely related bacteria but has not been shown to infect eukaryotes. Like SARS-CoV-2, MS2 is a single-stranded RNA virus. However, at approximately 27 nm in diameter, MS2 is much smaller than the 120 nm diameter SARS-CoV-2 virus. Because MS2 has similar aerosol characteristics to human viruses, it is often used in air purifiers and air filtration tests as a surrogate for viruses of similar or larger dimensions [1]. For example, MS2 has been used as a surrogate for Norovirus, including studies where MS2 has been aerosolized [2] and where viral inactivation by ultraviolet light has been assessed [3, 4]. MS2 is one of the bioaerosols recommended for air filtration tests by the EPA [5]. A study of the effect of UV exposure on virus aerosols found that MS2 was more resistant than the murine hepatitis virus (MHV) coronavirus to UV air disinfection [6]. Aerosols of the MHV coronavirus were found to be 7 – 10 times more susceptible than MS2 [6]. Therefore, MS2 is a conservative surrogate for coronaviruses in this type of testing. However, as stated by the FDA: "…currently there is limited published data about the wavelength, dose, and duration of UVC radiation required to inactivate the SARS-CoV-2 virus" [7].

Based on the requirements for aerosolization, the use of ultraviolet light as the antiviral technology and its suitability as a surrogate for some human viral pathogens, MS2 was used as the challenge microorganism in this study.

4. Protocol

4.1. Environmental Conditions

Testing of the Air Sniper Ultra 119-110200 air purifier was conducted inside the environmental test chamber which was preconditioned before testing to 20°C (±3°C) and 55 % RH (±5 %). A UV-C light in the ceiling of the test chamber sterilized the surfaces for 1 hour before testing. During testing the test chamber ventilation system was turned off to minimize the ventilation rate.

4.2. Air Purifier Active Test and Inactive Control Runs

Triplicate testing was conducted in the following configurations:

- Three **inactive control runs** without the air purifier operating
- Three **active test runs** with the Air Sniper Ultra 199-110200, placed on the floor in the centre of the test chamber, operating a speed setting 2.

In each active test run or inactive control run, viable MS2 virus was aerosolized into the test chamber for up to 30 minutes. Mixing fans were operated to promote the homogenous distribution of the aerosol throughout the test chamber.

Testing was conducted in triplicate for both active test and inactive controls.

4.3. Air Sampling

Air samples were collected at a 1.0-meter height from the floor at a rate of 11.5 l/m at the following timepoints:

- -10 to 0 minutes
- 5 to 15 minutes
- 20 to 30 minutes
- 50 to 60 minutes

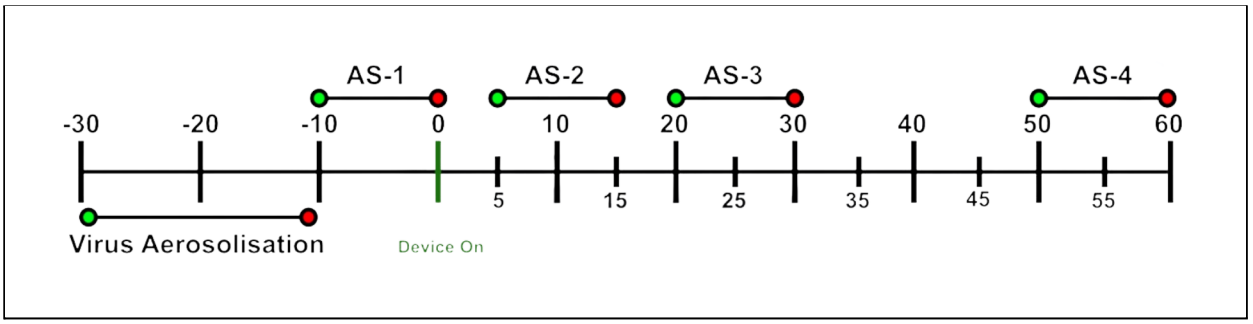

Figure 4.1. Air sampling timeline

In the active test runs, the air purifier was operated at t = 0 and remained operating for the duration of the test. All air samples collected during testing were transferred to the laboratory for analysis by plaque assay.

4.4. Sample Analysis

Samples collected from the test chamber are analyzed by plaque assay, which assesses the infectivity of the sampled virus. By applying samples to a petri plate pre-prepared with a lawn of E. coli, the concentration of viable virus in that sample can be determined by quantifying the number of plaques formed after incubation. The concentration of infective MS2 virus is denoted as the number of plaque-forming units per cubic meter of air (PFU/m^3). These values are reported logarithmically (Log10).

5. Results

Table 5.1 summarises the MS2 plaque-forming units per cubic meter of air (log PFU/m^3) measured inside the environmental test chamber at each time point. The results of three inactive control runs (no air purifier) and three active test runs (air purifier operating) are presented, the average of which is graphed in Figure 5.1. The percentage reduction is graphed in Figure 5.2.

Table 5.1. Average PFU/m^3 for Air Sniper active test and inactive control runs (Log_{10})

Time (minute)	Control				Test			
	Run 1	Run 2	Run 3	**Average (n=3)**	Run 1	Run 2	Run 3	**Average (n=3)**
-10 to 0	8.83	8.61	7.28	**8.24**	9.61	9.17	9.11	**9.29**
+ 5 to 15	8.76	8.33	7.25	**8.12**	8.64	8.23	8.40	**8.42**
+20 to 30	8.64	8.40	6.13	**8.06**	7.45	7.37	7.51	**7.44**
+50 to 60	8.49	7.89	6.88	**7.78**	6.40	5.98	5.93	**6.10**

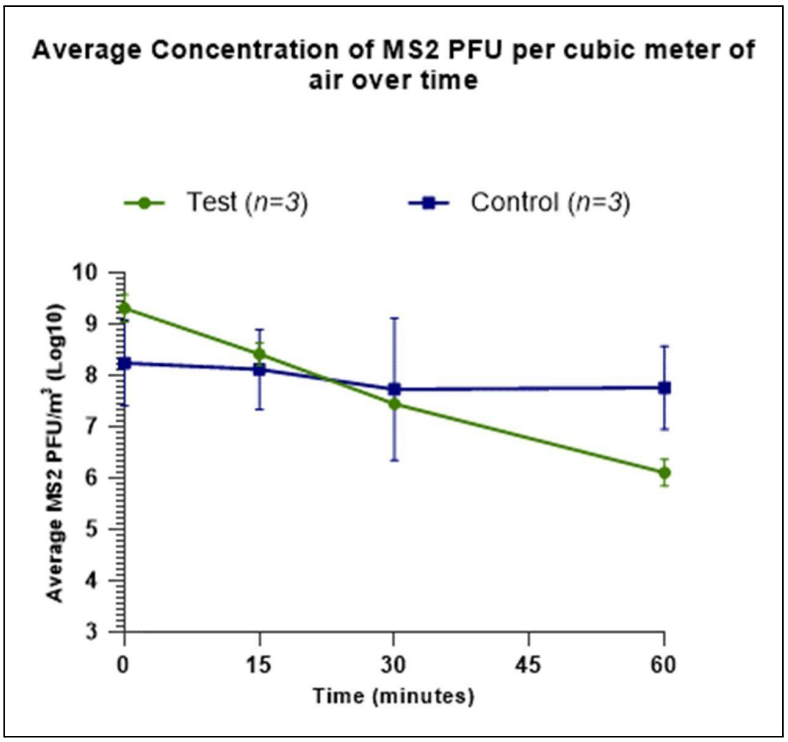

Figure 5.1. Average Log_{10} MS2 PFU/m^3 of air over time. The error bars represent standard deviation.

The measured starting concentration of MS2 was similar between each of the active test and inactive control runs. In the inactive control (no air purifier), there was a natural decay of the virus to an average of 7.78 Log_{10} MS2 PFU/m^3 after 60 minutes. In the active test runs, the average airborne concentration of MS2 recovered after the air purifier had been operating for 60 minutes was 6.10 Log_{10} MS2 PFU/m^3.

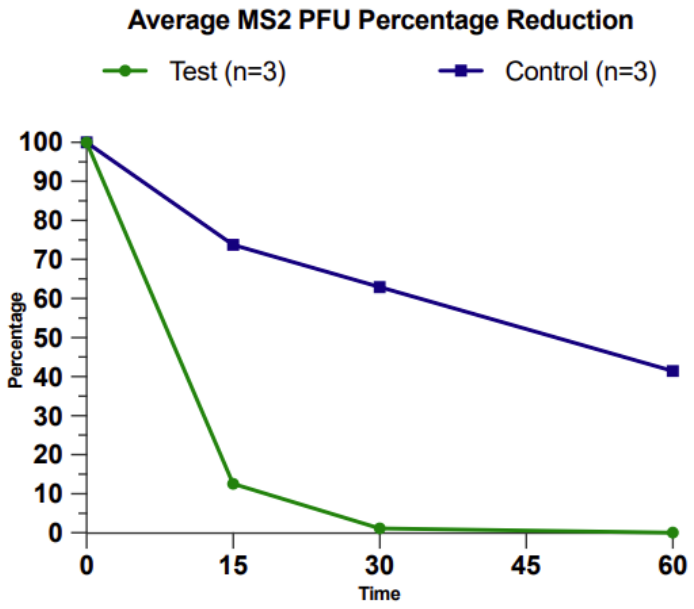

Figure 5.2. Average percentage reduction of MS2 PFU/m^3 of air over time. Graph is calculated from data points in appendix tables 8.1 and 8.2

6. Discussion

Our environmental test chamber assessment demonstrated that, when challenged with MS2, the Air Sniper Ultra 119-110200 air purifier was capable of reducing the average airborne concentration of the virus from 9.29 to 6.10 Log_{10} PFU/m^3 after 60 minutes of operation.
The triplicate inactive control runs (no air purifier) did not show the same scale of reduction, the average concentration of MS2 decreased from 8.24 to 7.78 Log_{10} PFU/m^3.

Calculating the percentage reduction based on the PFU/m^3 results there was a 99.9% reduction of airborne MS2 within 60 minutes of the air purifier operating.

7. References

[1] John Zhang, Ph.D.; Doug Huntley; Andy Fox; Bryan Gerhardt; Al Vatine; John Cherne. Study of Viral Filtration Performance of Residential HVAC Filters. ASHRAE Journal, Vol. 62, no. 8, August 2020

[2] Tung-Thompson G, Libera DA, Koch KL, de los Reyes FL III, Jaykus L-A (2015) Aerosolization of a Human Norovirus Surrogate, Bacteriophage MS2, during Simulated Vomiting. PLoS ONE 10(8): e0134277. https://doi.org/10.1371/journal.pone.0134277

[3] G.W. Park, K.G. Linden, M.D. Sobsey (2010) Inactivation of murine norovirus, feline calicivirus and echovirus 12 as surrogates for human norovirus (NoV) and coliphage (F+) MS2 by ultraviolet light (254 nm) and the effect of cell association on UV inactivation. Letters in Applied Microbiology (Volume 52, Issue 2, Pages 162-167). https://doi.org/10.1111/j.1472-765X.2010.02982.x

[4] Jung Eun Lee, GwangPo Ko (2013) Norovirus and MS2 inactivation kinetics of UV-A and UVB with and without TiO2. Water Research (Volume 47, Issue 15, Pages 5607-5613). https://doi.org/10.1016/j.watres.2013.06.035

[5] EPA. 2006. “Generic Verification Protocol for Biological and Aerosol Testing of General Ventilation Air Cleaners.” Cooperative Agreement R-83191101. U.S. Environmental Protection Agency

[6] Christopher M. Walker and GwangPyo Ko. Effect of ultraviolet germicidal irradiation on viral aerosols. Environ. Sci. Technol. 2007, 41, 5460–5465 https://doi.org/10.1021/es070056u

[7] UV Lights and Lamps: Ultraviolet-C Radiation, Disinfection, and Coronavirus https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/uv-lights-and-lamps-ultraviolet-c-radiation-disinfection-and-coronavirus

8. Appendix

Time (minute)	Table 8.1. Average PFU/m^3 recovered from test run samples				
	Test 1	Test 2	Test 3	Average	% Reduction
0	4,041,666,667	1,486,111,111	1,583,333,333	**2,370,370,370**	N/A
15	434,722,222	172,222,222	287,500,000	**298,148,148**	87.4
30	28,194,444	25,000,000	33,611,111	**28,935,185**	98.8
60	2,875,000	958,333	902,778	**1,578,704**	99.9

Time (minute)	Table 8.2. Average PFU/m^3 recovered from control run samples				
	Control 1	Control 2	Control 3	Average	% Reduction
0	693,939,394	406,060,606	19,090,909	**373,030,303**	N/A
15	590,909,091	216,666,667	18,030,303	**275,202,020**	26.2
30	436,363,636	254,545,455	13,636,364	**234,848,485**	37.0
60	324,242,424	131,515,152	8,393,939	**154,717,172**	58.5

9. Amendment History

Page	Section	Details of Amendment
4	3.2	Added additional information about MS2
9	7	Added references for additional information about MS2

This report, ASCR092438v2 supersedes previous versions

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Report Reviewed By:

Vivienne Mahon, PhD
Chief Scientist/Quality Director

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