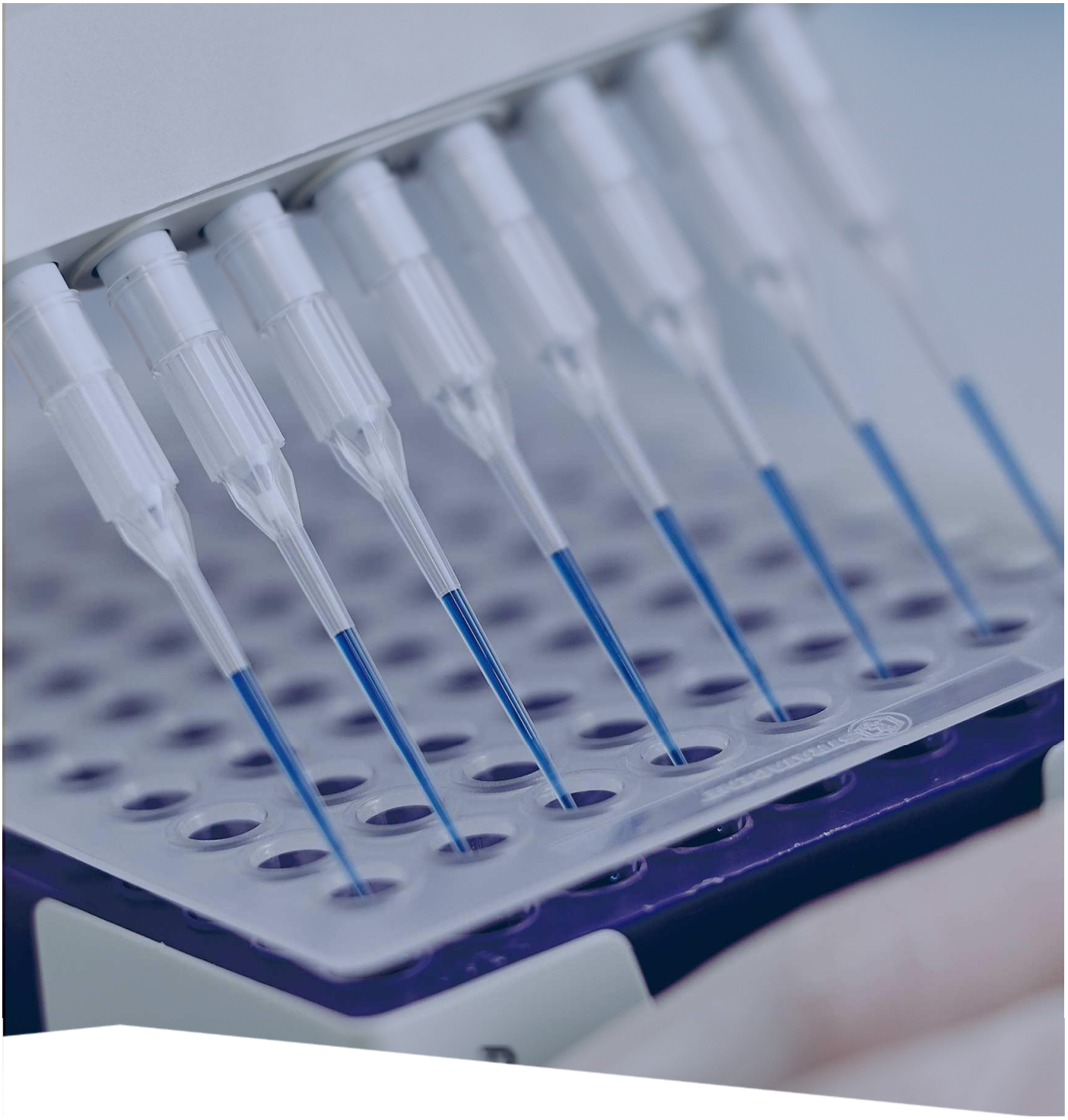

Report no. 933322

Inactivation of aerosolized vira: MS2 bacteriophages

Jimco MAC500

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Inactivation of aerosolized vira: MS2 bacteriophages

Jimco MAC500

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September 2020

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Summary

The purpose of the test is to determine the efficiency of the air purifier to reduce the concentration active of aerosolized MS2 bacteriophages using a modified ISO 16000-36:2018 method. The tested air purifier is a Jimco MAC500.

The significant and consistent difference between the Natural decay test and the Product test clearly shows a reduction of the concentration of active and airborne MS2 caused by the air purifier.

The measured decay of the concentration of active MS2 during the tests is attributed to a natural decay of the aerosol and an attribution of the air purifier. The determined attribution of the air purifier is 0.73-1.2 log-reduction (base 10) per hour in the 20 m^3 room.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus.
Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

* Kowalski W. Ultraviolet Germicidal irradiation Handbook. Springer 2009
† Walker and Ko, ENVIRONMENTAL SCIENCE & TECHNOLOGY / VOL. 41, NO. 15, 2007

Method and Materials

The purpose of this test is to determine the inactivation effect of the air purifier on MS2 bacteriophages aerosolized in a test chamber. The natural decay rate of the concentration of active aerosolized MS2 is determined by sampling the air in the chamber over a 2-hour period and the enhanced decay rate due to the air purifier is determined in a similar manner.

The volume of the used chamber is 20 m^3 and it has an inert FEP lining for chemical resistance and easy cleaning. The room is airtight, and a fan is in the room to mix the air and secure a homogenous concentration of aerosols. The aerosol is generated within the room using a nebulizer (Palas AGK 2000) and the air purifier is placed on a stainless-steel table in the middle of the room with a height of about 100cm. See the setup in Figure 1.
The room is cleaned using a 10 ppm ozone system and it is heavily ventilated using clean air for more than 48 hours before the test. The air purifier is turned on more than 24 before the test and a slight overpressure is applied to keep the room clean and reduce build-up of ozone from the device. The ozone concentration before and during the test was below the health exposure limit of 0.1 ppm.
The relative humidity adjusted to 60 +/- 5 %RH and temperature is 22.5 °C +/- 0.5 °C

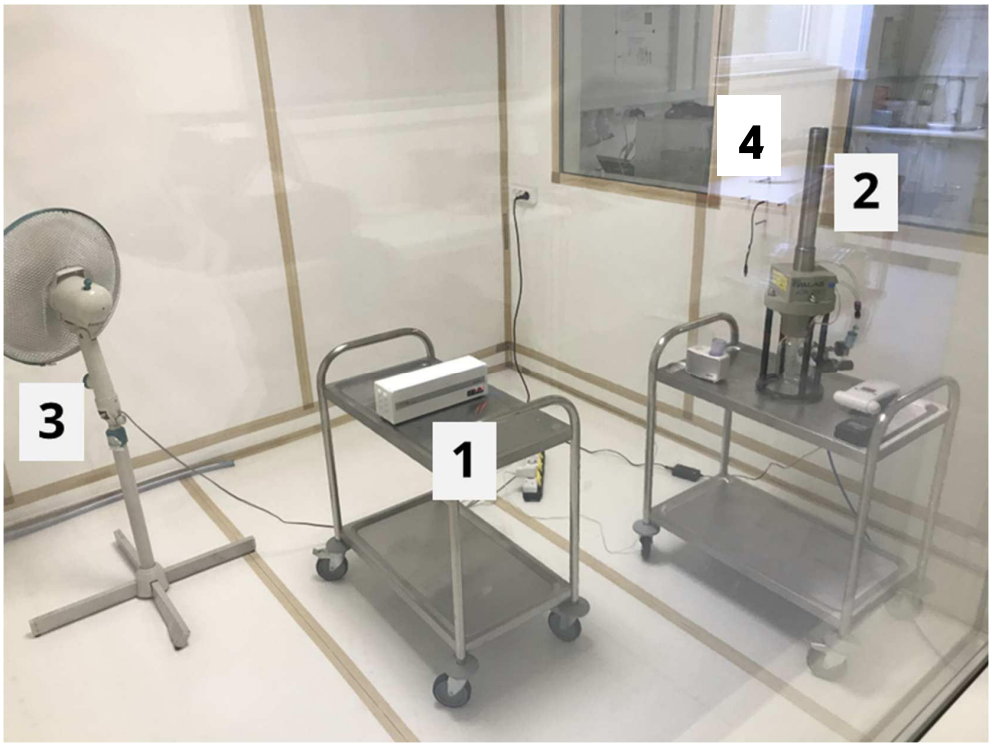

Figure 1: Test chamber. 1: Air Purifier MAC500. 2: Nebulizer (PALAS AGK 2000). 3: Mixing Fan, 4: Sampling port

The sampling of the air is done through a 6mm stainless steel tube in the sidewall of the room using GilAir plus pump at 4 L/min. A total of 20L is extracted per sample into an impinger with 60mL SM-buffer. The timing of sampling is: 0, 15, 30, 60, 120 minutes after finishing aerosolization. The start of the first sample (t = 0 minutes) is less than a minute after the nebulizer is stopped.

The procedure is the following:

1. A suspension of MS2 in SM-buffer is prepared and the concentration is determined.
2. A background sample is taken before the test and injection of aerosol.
3. The air purifier is running during injection of the MS2 containing aerosol based on a suspension of $8 \cdot 10^9$ PFU*/ml. The Palas nebulizer is working at 3.2 bar pressure for a total time of 15 minutes.
4. The sampling is carried out according to the timing plan.
5. After the 2 hours test with the air purifier on, the device is turned off and the room is flushed with clean air for 40 minutes. The particle count is checked to ensure that it is reduced to background level.
6. A reference test of the natural decay is carried out by the same procedure as the above described test but without the air purifier turned on.
7. The sampling is carried out according to the timing plan.
8. The concentration of active MS2 is evaluated for each sample by mixing dilutions series with a fresh culture of the host bacteria, cultivation, and enumeration of PFU following incubation.

The test date is the 23/9 2020 and the plates are counted 24/9 and 25/9 2020.

*PFU is Plague forming units

Microbiological Test Parameters:

Test organism:	MS2 bacteriophage, ATCC 15597-B1
Host organism:	*Escherichia coli*, ATCC 15597
Growth conditions:	Coliform top agar at 37±1°C for 48 hours
Sampling and dilution solution:	SM-buffer

Results

The concentration of active MS2 expressed as PFU/m^3 is shown in Table 1 and in graph in Figure 2. The room background is measured before the first injection of aerosols.

Time	Natural decay	Product test
Minutes	PFU/m^3	PFU/m^3
Background		0
0	6.85E+06	3.86E+06
15	4.22E+06	1.21E+06
30	5.46E+05	1.77E+05
60	9.64E+04	3.22E+03
120	6.07E+03	*

Table 1: The concentration of active MS2 (PFU/m3) for the Natural decay and the Product test. *The Product test sample at 120 minutes is below the detection limit which is determined to be 1.5E+03 PFU/m^3.

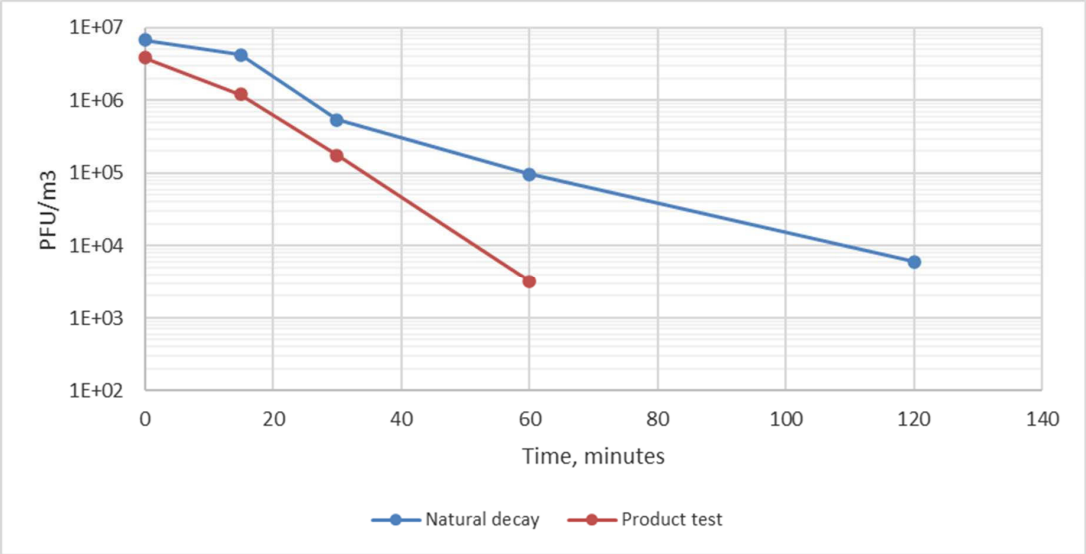

Figure 2: The concentration of active MS2 for the Natural decay and for the Product test

The air purifier's attribution to the overall decay of concentration of MS2 is calculated by the difference in decay constant (k) from the exponential fit to both the Natural decay and the Product test decay:

$$Active\ MS2\ [PFU/m^3] = a \cdot \exp[-k \cdot time]$$

The decay constants are shown in the fits in Figure 3 and summarized in Table 2. The points at 120 minutes have been removed because of larger uncertainties close to the detection limit. The Product attribution is calculated by subtracting the decay constant of the Product test and the Natural decay.

Table 2: Decay constant and corresponding half time and Log-reduction (base 10) per hour.

	Decay constant, min^-1	Half time, min	Log-reduction per hour
Natural decay	0.075	9.24	1.95
Product test	0.121	5.73	3.15
Product attribution	0.046	15.07	1.20

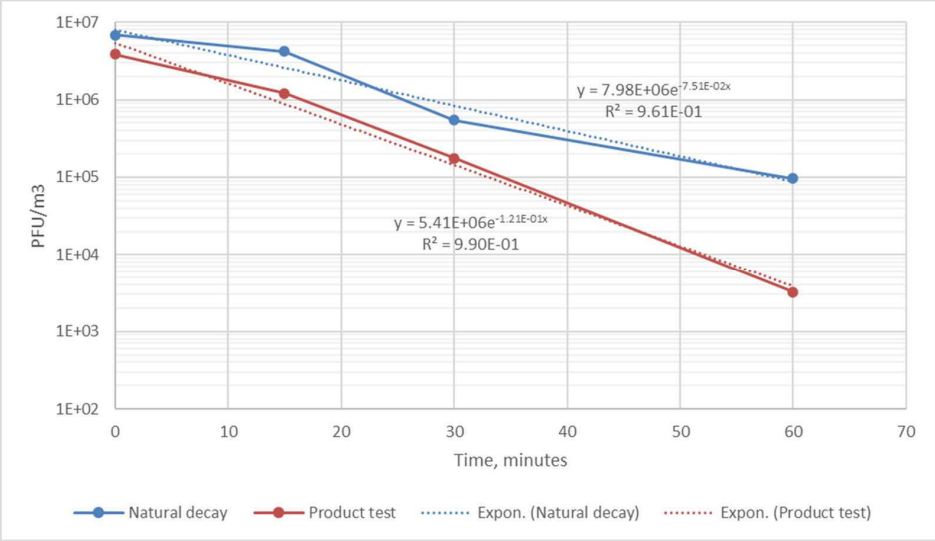

Figure 3: Fit to decay of the concentration of active MS2

Discussion

The performed test is designed to allow for direct evaluation of the effect of the air purifier on the concentration of aerosolized and active MS2 bacteriophages. The significant and consistent difference between the Natural decay test and the Product test clearly shows a reduction of the concentration of active MS2 caused by the air purifier.

A single test was performed so the uncertainty cannot be calculated.
However, the differently timed sampling point allows for an evaluation of the variability. If the sampling point at 60 minutes is removed from the dataset for the Product test (which is closest to the detection limit and thus more uncertain), the product attribution yields a 0.73 log-reduction per hour.
Therefore, the products attribution to the inactivation of MS2 likely falls in the interval of 0.73-1.2 log-reduction per hour.

It is worth mentioning that the product attribution to the reduction is due to inactivation of MS2 whereas the natural decay is mainly due to fallout of the MS2-containing aerosol to surfaces in the chamber.

The exponential reduction model and virus UV-susceptibility

The reduction rate of the concentration of aerosolized and active MS2 is found to be 0.73-1.2 log-reductions per hour and the mean value of these points yield of 0.97 log-reductions per hour (in the 20 m^3 test chamber). According to Kowalski W. (Ultraviolet Germicidal irradiation Handbook, Springer 2009), the UV-susceptibility of different type of viruses span about an order of magnitude and MS2 is among the lowest of the tested. The theoretical reduction rates of the air purifier are calculated for increasing UV-susceptibilities in Table 3 and shown in Figure 4.

Time, minutes	15	30	45	60	75	90	105	120
MS2 susceptibility: 0.97 log/hour								
Reduction, %	42.6	67.1	81.1	89.2	93.8	96.4	98.0	98.8
Log-reduction	0.24	0.48	0.72	0.97	1.21	1.45	1.69	1.93
3 times more susceptibly than MS2: 2.9 log/hour								
Reduction, %	81.1	96.4	99.3	99.9	99.976	99.995	99.999	99.9998
Log-reduction	0.72	1.45	2.17	2.90	3.62	4.34	5.07	5.79
5 times more susceptibly than MS2: 4.8 log/hour								
Reduction, %	93.8	99.6	99.976	99.999	99.9999	100	100	100
Log-reduction	1.21	2.41	3.62	4.83	6.03	7.24	8.44	9.65

Table 3: Reduction rates over time and for different UV-susceptibilities.

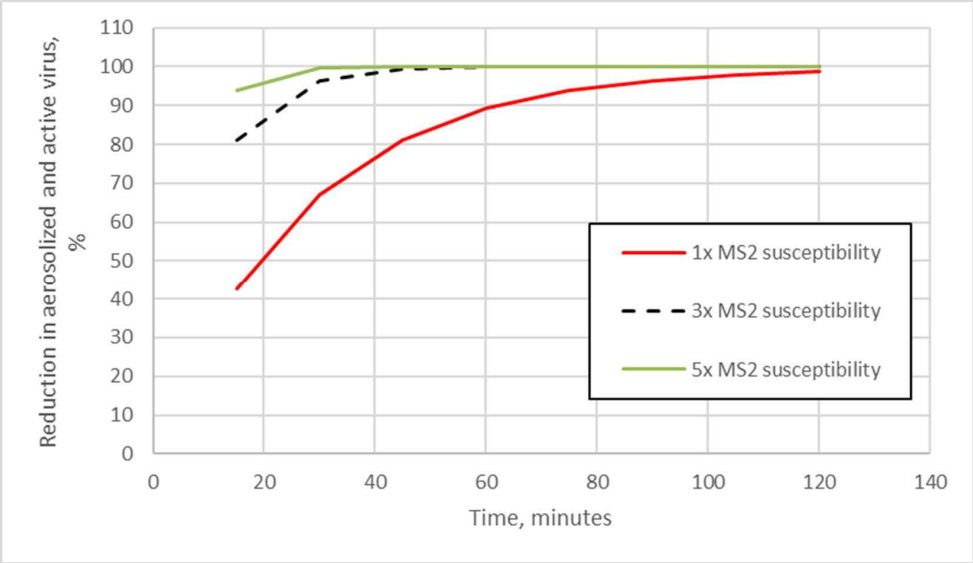

Figure 4: Reduction rate over time and for different UV-susceptibilities.

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5th of October 2020

Declaration of test and assessment

Danish Technological Institute has performed tests of the efficiency for inactivation virus of the Jimco MAC500 air purifier.

The test was conducted with the unit installed in a 20 m^3 sealed room. The efficiency of the air purifier was tested using MS2 bacteriophages (ATCC 15597-B1) on host *Escherichia coli* (ATCC 15597) as a virus surrogate. The rate of inactivation of the aerosolized MS2 was determined as the difference between the natural inactivation rate and the inactivation rate measured during the use of the Jimco MAC500 air purifier. These inactivation rates were determined by sampling of the air in the chamber over a 2-hour period. The significant and consistent difference between the Natural decay test and the Product test clearly shows a reduction of the concentration of airborne and active MS2 caused by the air purifier.

Based on the measured inactivation efficiency of the MAC500, the reductions in % and in log-reductions are calculated and are found in the table below:

Product attribution	**1 hour**	**2 hours**	**3 hours**
Reduction, %	89% ± 8%	99% ± 2.3%	99.9 ± 0.5%
Log-reduction (base 10)	0.97 ± 0.24	1.93 ± 0.47	2.9 ± 0.71

The full testing procedures and results are presented in report no. 933322.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus. Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

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† Walker and Ko, ENVIRONMENTAL SCIENCE & TECHNOLOGY / VOL. 41, NO. 15, 2007

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5. Oktober 2020

Deklaration af test og bedømmelse

Teknologisk Institut har udført en effektivitetstest af luftrensen Jimco MAC500 for inaktivering af virus.

Testen blev udført med enheden installeret i et lukket 20 m^3 testkammer. Effektiviteten af luftrenseren blev testet med en virus-surrogat bestående af MS2 bakteriofager (ATCC 15597-B1) og en E.coli værtsorganisme (ATCC 15597).
Inaktiveringsraten af den aerosoliserede MS2 blev bestemt som forskellen mellem den naturlige inaktiveringsrate og inaktiveringsraten målt under drift af Jimco MAC500 luftrenseren. Disse inaktiveringsrater blev målt ved at udtrække luftprøver fra kammeret over en periode på to timer.
Den signifikante og konsistente forskel mellem det naturlige henfald og henfaldet målt med produktet i drift viser en tydelig reduktion i koncentrationen af aktive MS2 i luften forårsaget af luftrenseren.

Baseret på den målte inaktiveringseffektivitet af luftrenseren MAC500 så er reduktionerne beregnet og vist i tabellen nedenunder – i % og i log-reduktion:

Produktets tillæg	**1 time**	**2 timer**	**3 timer**
Reduktion, %	89% ± 8%	99% ± 2,3%	99,9 ± 0,5%
Log-reduktion (base 10)	0,97 ± 0,24	1,93 ± 0,47	2,9 ± 0,71

Den fulde beskrivelse af testen er dokumenteret i rapport nr. 933322.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus. Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

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Venlig hilsen,

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5. Oktober 2020

Test- und Bewertungserklärung

Das Danish Technological Institute hat Tests durchgeführt, um die Effizienz des Jimco MAC500 Luftreinigers auf die Inaktivierung von Vira zu überprüfen.

Der Luftreiniger war während des Tests in einem 20 m3 großen versiegelten Raum installiert. Die Effizienz des Luftreinigers wurde unter Verwendung von MS2-Bakteriophagen (ATCC 15597-B1) auf Wirt-Escherichia coli (ATCC 15597) als Virussurrogat getestet. Die Inaktivierungsrate des MS2 Aerosols wurde als Differenz zwischen der natürlichen Inaktivierungsrate und der Inaktivierungsrate bestimmt, die während der Verwendung des Luftreinigers Jimco MAC500 gemessen wurde.
Diese Inaktivierungsraten wurden durch Probenahmen der Luft in der Kammer über einen Zeitraum von 2 Stunden bestimmt. Der signifikante und konsistente Unterschied zwischen dem natürlichen Inaktivierungstest ohne Luftreiniger und dem Test mit Luftreiniger zeigt deutlich eine Verringerung der Konzentration von luftgetragenem und aktivem MS2 bei Verwendung des Luftreinigers.

Basierend auf den gemessenen Werten für die Inaktivierungseffizienz des MAC500 wurde die Reduktion in % und log berechnet und in der folgenden Tabelle aufgelistet:

Produktzuordnung	**1 hour**	**2 hours**	**3 hours**
Reduktion, %	89% ± 8%	99% ± 2,3%	99,9 ± 0,5%
Log-Reduktion (Basis 10)	0,97 ± 0.24	1,93 ± 0,47	2,9 ± 0,71

Die vollständigen Testprozeduren sowie alle Ergebnisse sind im Bericht Nr. 933322 zu finden.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus. Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

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5/10/2020

Declaración y evaluación de test

El Instituto Tecnológico de Dinamarca ha realizado un test de eficiencia en la inactivación de virus del purificador de aire Jimco MAC500.

El test fue realizado con una unidad instalada en una cámara sellada de 20 m3. La eficiencia de inactivación del purificador de aire se realizó con un substituto de virus, compuesto por el bacteriófago MS2 (ATCC 15597-B1) y una bacteria huésped, E.coli (ATCC 15597).

La tasa de inactivación del MS2 en forma de aerosol se determinó como la diferencia entre la tasa de inactivación natural y la tasa de inactivación medida durante la operación del purificador de aire Jimco MAC500. Estas tasas de inactivación fueron medidas durante la extracción de las muestras de aire en un periodo de 2 horas.

La diferencia significante y consistente obtenida entre la disminución natural del MS2 y la medida en el producto bajo operación, muestra una clara reducción en la concentración de MS2 en el aire, producto del efecto del purificador de aire.

Con base en la eficiencia de inactivación medida en el purificador de aire MAC500, las reducciones se calculan y se muestran en la siguiente tabla, en % y en reducción logarítmica:

Atribuciones del producto	**1 hora**	**2 horas**	**3 horas**
Reducción %	89% ± 8%	99% ± 2,3%	99,9% ± 0,5%
Reducción logarítmica (base 10)	0,97 ± 0,24	1,93 ± 0,47	2,9 ± 0,71

La descripción completa del test está documentada en el informe Nº 933322.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus. Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

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Saludos cordiales,

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Le 5 octobre 2020

Déclaration de test et d'évaluation

L'institut technologique danois a mené des tests d'efficacité d'inactivation d'un virus sur le purificateur d'air Jimco MAC500.

Le test a été effectué sur une unité installée dans une pièce fermée de 20 m^3. L'efficacité du purificateur d'air a été testée à l'aide de bactériophages MS2 (ATCC 15597-B1) sur l'hôte *Escherichia coli* (ATCC 15597) comme substitut de virus. Le taux d'inactivation des MS2 en aérosol a été déterminé sur la base de la différence entre le taux d'inactivation naturel et le taux d'inactivation mesuré pendant l'utilisation du purificateur d'air Jimco MAC500. Ces taux d'inactivation ont été déterminés en prélevant un échantillon d'air dans la chambre sur une période de 2 heures. La différence importante et constante entre le test de décomposition naturelle et le test du produit indique clairement une réduction de la concentration de MS2 actifs dans l'air grâce au purificateur d'air.

Sur la base de l'efficacité d'inactivation mesurée du MAC500, les réductions en % et logarithmiques sont calculées et figurent dans le tableau ci-dessous :

Attribution du produit	**1 heure**	**2 heures**	**3 heures**
Réduction, %	89% ± 8%	99% ± 2,3%	99,9 ± 0,5%
Réduction logarithmique (base 10)	0,97 ± 0,24	1,93 ± 0,47	2,9 ± 0,71

Les procédures de test complètes figurent dans le rapport n° 933322.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus. Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

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Best regards,

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5 października 2020 r.

Oświadczenie dotyczące przeprowadzenia testu i oceny

Danish Technological Institute przeprowadził testy skuteczności urządzenia do oczyszczania powietrza Jimco MAC500 pod kątem inaktywacji wirusa.

Test został przeprowadzony w pomieszczeniu hermetycznym o powierzchni 20 m^3, gdzie zainstalowano jednostkę. Skuteczność urządzenia do oczyszczania powietrza przetestowano przy użyciu bakteriofagów MS2 (ATCC 15597-B1) na żywicielu *Escherichia coli* (ATCC 15597) pełniącym rolę odpowiednika wirusa. Tempo inaktywacji MS2 w postaci aerozolu przedstawiono w formie różnicy między naturalnym tempem inaktywacji a tempem inaktywacji zmierzonym podczas stosowania urządzenia do oczyszczania powietrza Jimco MAC500. Tempa inaktywacji zostały określone po pobraniu próbek powietrza z komory w ciągu 2 godzin. Istotna i logiczna różnica między testem naturalnego rozpadu a testem produktu wyraźnie wykazuje redukcję stężenia unoszącego się w powietrzu aktywnego MS2 spowodowaną użyciem urządzenia do oczyszczania powietrza.

W oparciu o zmierzoną skuteczność inaktywacji MAC500, obliczono redukcje odsetka (%) i logarytmiczne wskaźniki redukcji, które przedstawiono w poniższej tabeli:

Atrybucja produktu	**1 godz.**	**2 godz.**	**3 godz.**
Redukcja, %	89% ± 8%	99% ± 2,3%	99,9 ± 0,5%
Logarytmiczny wskaźnik redukcji (podstawa operacji potęgowania 10)	0,97 ± 0,24	1,93 ± 0,47	2,9 ± 0,71

Kompletne procedury testowe zostały przedstawione w raporcie nr 933322.

According to Kowalski* and Walker† the UV-susceptibility for bacteriophage MS2 is lower than the UV-susceptibility for the enveloped virus, vaccinia virus. Hence, the indicated efficacy of the tested MAC500 UV-C device to degrade the bacteriophage MS2 will be at least similar to the efficacy against enveloped vaccinia virus. Efficacy against vaccinia virus allows for a claim for efficacy against all enveloped viruses (e.g. MERS-CoV, SARS-CoV-1 and SARS-CoV-2) according to DS/EN 14885:2018.

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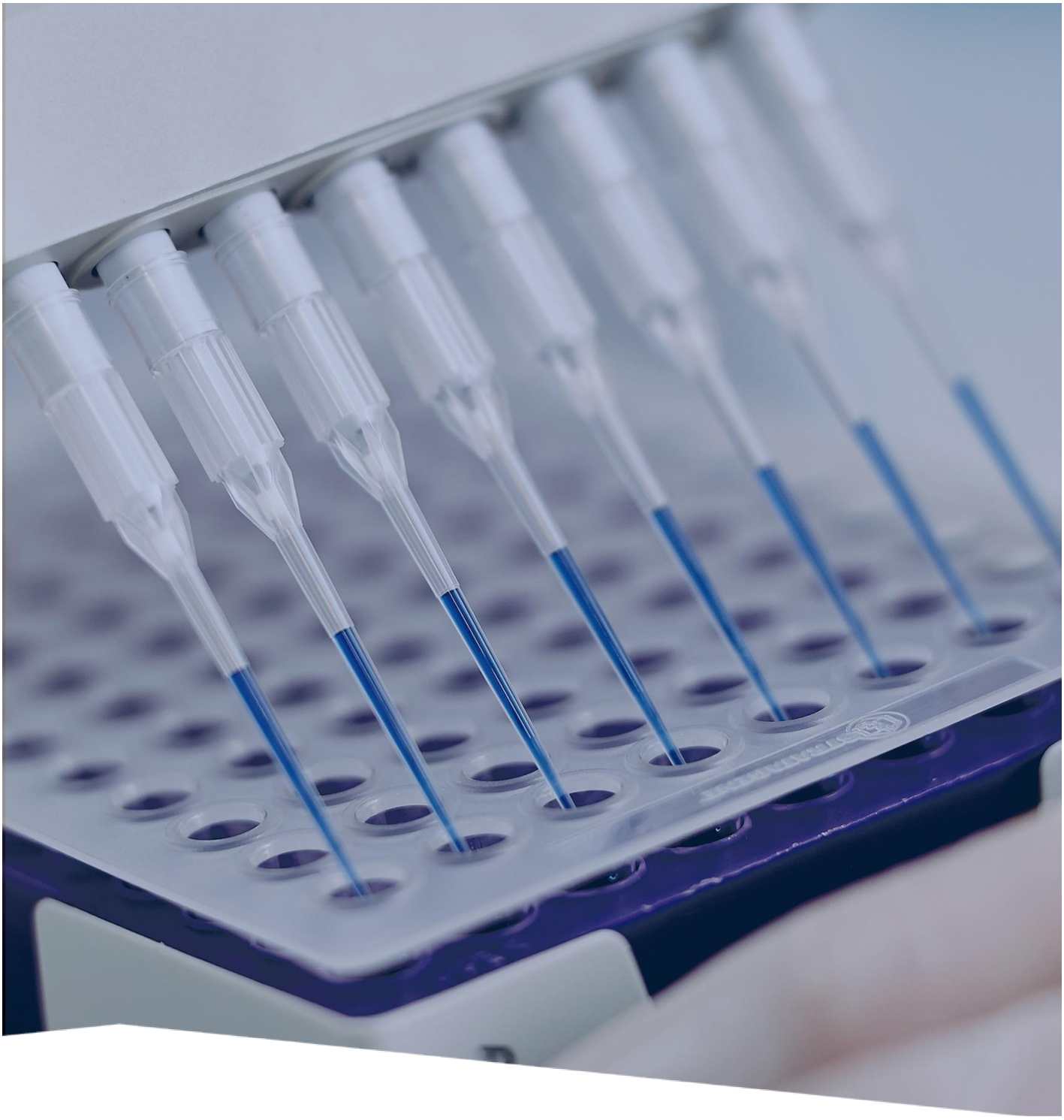

Report no. 954748

Uncertainty calculation of air purifier test

Jimco MAC500

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Uncertainty calculation of air purifier test

Jimco MAC500

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Summary

The purpose of this report is to evaluate the statistical uncertainty of the air purifier test carried out in report no. 933322. The air cleaner test determined the efficiency of the air purifier to reduce the concentration of active and aerosolized MS2 bacteriophages. The tested air purifier was a Jimco MAC500.

The statistical analysis show that it is high unlikely (a probability of <0.04%) that the difference in the natural decay and the product test is based on a coincidence. The effect of the product is statistically significant ($p<0.05$).

Calculation method and results

The total number measurements (number of PFU on agar plates), which consists of duplicates and dilution series, are used to calculate the statistical uncertainty of the determined rate constants of the two measurement series (natural decay and product test).
The statistical tool used for the evaluation is Python package Statsmodels. The tool is used to determine the confidence intervals of the rate constant at different confidence levels. By increasing the level of confidence, the confidence intervals of the two rate constants broadens.

The level of confidence of the experiment is determined to be when the confidence interval of the two rate constants overlap.
The statistical analysis is shown in the table: (the values are in units of 1/min)

	Average	Standard deviation	95% confidence interval	99.9% confidence interval	99.97% confidence interval
Natural decay	0.0600	0.0039	0.0511; 0.0689	0.0406; 0.0795	0.0366; **0.0835**
Product test	0.1207	0.0051	0.1082; 0.1332	0.0903;0.1512	**0.0827**; 0.1588

At a confidence level of 99.97% the rate constant of the natural decay and the product test overlap, which can be interpret as that the level of confidence of the experiment is at this level. It is therefore high unlikely (a probability of <0.04%) that the difference in the natural decay and the product test is based on a coincidence.

This analysis is based on a statistical analysis of the measurement data and cannot be used evaluate if systematic errors might be present in the test.

Sammenfatning

Formålet med denne rapport er at evaluere den statistiske usikkerhed af luftrensertesten udført i rapport nr. 933322. Luftrensertesten bestemte effektiviteten af luftrenseren til at reducere koncentrationen af aktive og aerosolerede MS2 bakteriofager. Den testede luftrenser var en Jimco MAC500.

Den statistiske analyse viser at det er højest usandsynligt (mindre end 0,04% sandsynlighed) at forskellen mellem det naturlige henfald og produkttesten er baseret på en tilfældighed. Effekten af produktet er statistisk signifikant ($p<0.05$).

Beregningsmetode og resultater

Det totale antal målinger (antal af PFU på agar-plader), hvilket indebærer dobbeltbestemmelser og fortyndingsrækker, er benyttet til at beregne de statistiske usikkerheder af de bestemte ratekonstanter af de to måleserier (naturligt henfald og produkttest).
The statistiske værktøj brugt i evalueringen er Python-pakken Statsmodels. Værktøjet er benyttet til at bestemme konfidensintervaller af ratekonstanterne ved forskellige konfidensniveauer. Når konfidensniveauet øges vil konfidensintervallerne af de to ratekonstanter blive bredere.

Konfidensniveauet af eksperimentet er bestemt ud fra hvornår konfidensintervaller imellem de to ratekonstanter overlapper.

Den statistiske analyse er vist i tabellen: (værdierne er in enheder af 1/min)

	Middel-værdi	Standard afvigelse	95% konfidensinterval	99,9% konfidensinterval	99,97% konfidensinterval
Naturligt henfald	0,0600	0,0039	0,0511; 0,0689	0,0406; 0,0795	0,0366; **0,0835**
Produkt test	0,1207	0,0051	0,1082; 0,1332	0,0903;0,1512	**0,0827**; 0,1588

Der er ikke overlap i konfidensintervallerne mellem naturligt henfald og produkttesten før 99,97% konfidensintervallet tages i betragtning. Det vurderes derfor at være højest usandsynligt (mindre end 0,04% sandsynlighed) at forskellen mellem det naturlige henfald og produkttesten er baseret på en tilfældighed.

Denne analyse er baseret på en statistik analyse af målingerne og kan ikke bruges til at bestemme om der måtte være systematiske fejl i testen.

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Report no. 959809

Modelled theoretical effect of virus UV-susceptibility and room size

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Modelled theoretical effect of virus UV-susceptibility and room size

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Model calculations

The purpose of this report is to evaluate the reduction rate at increased room size and UV susceptibility based on the reduction rate determined in report no. 933322. The air purifier test determined the efficiency of the air purifier to reduce the concentration of active and aerosolized MS2 bacteriophages. The tested air purifier was a Jimco MAC500.

The theoretical reduction rates of the concentration of aerosolized and active MS2 caused by the air purifier are calculated for increasing room size and UV-susceptibilities and are shown in Table 5. The calculations are based on measured log-reduction for MS2 of 0.97 log/hour/20m^3.
The log-reduction (decay constant) is assumed to decrease linearly with the increasing room size, hence the log-reduction is halved for a double size room. This is valid when the air is well-mixed in the room.
The equivalent air change per hour (ACH) is calculated under the assumption that the air is well-mixed and using the model referenced by US CDC[1].

MS2 susceptibility: 0.97 log/hour/20m3			
Room size, m3	Reduction, % 60 minutes	Log-reduction per hour	Equivalent ACH*
20	89.3	0.97	2.2
40	67.3	0.49	1.1
60	52.5	0.32	0.7
80	42.8	0.24	0.6
100	36.0	0.19	0.4
3 times more susceptibly than MS2: 2.91 log/hour/20m3			
Room size, m3	Reduction, % 60 minutes	Log-reduction per hour	Equivalent ACH*
20	99.88	2.91	6.7
40	96.5	1.46	3.4
60	89.3	0.97	2.2
80	81.3	0.73	1.7
100	73.8	0.58	1.3
5 times more susceptibly than MS2: 4.85 log/hour/20m3			
Room size, m3	Reduction, % 60 minutes	Log-reduction per hour	Equivalent ACH*
20	99.999	4.85	11.2
40	99.6	2.43	5.6
60	97.6	1.62	3.7
80	93.9	1.21	2.8
100	89.3	0.97	2.2

Table 5: Reduction after 60 minutes, log-reduction per hour and equivalent air exchange per hour for increasing room size and UV susceptibility. *The equivalent ACH is calculated based on airborne-contaminant removal efficiency using the formula from CDC in footnote 1.

[1] https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html

By using the same mathematical model as above, the maximum room size is found for equivalent ACH between 2 and 6 and for increasing UV-susceptibility. This is shown in Table 6. These values should be understood as guidelines and the actual use of the room should also be considered.

	X times more susceptibly than MS2		
Equivalent ACH*	**1**	**3**	**5**
2	22	67	112
3	15	45	74
4	11	34	56
5	9	27	45
6	7	22	37

Table 6: The maximum room size (m^3) for a given equivalent ACH and UV-susceptibility. *The equivalent ACH is calculated according to the reference in footnote 1.

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Rapport no. 959809

Modelleret teoretisk effekt af virus UV-susceptibilet and rumstørrelse

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Modelleret teoretisk effekt af virus UV-susceptibilet and rumstørrelse

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Modelberegningen

Formålet med denne rapport er at evaluere inaktiveringsraten ved øgede rumstørrelser og UV-susceptibiliteter baseret på inaktiveringsraten fundet i rapport nr. 933322. Luftrensertesten bestemte effektiviteten af luftrenseren til at reducere koncentrationen af aktive og aerosolerede MS2 bakteriofager. Den testede luftrenser var en Jimco MAC500.

Den teoretiske inaktiveringsrate af koncentrationen af aerosolerede og aktive MS2 bakteriofager forårsaget af luftrenseren er beregnet ved øgede rumstørrelser og UV-susceptibiliteter og er vist i tabel 7. Beregningerne er baseret på målingen af log-reduktionen for MS2 på 0.97 log/time/20m^3.
Log-reduktionen (henfaldskonstanten) er antaget at aftage lineært med rumstørrelsen, dvs. at log-reduktionen er halveret for et rum af dobbelt størrelse. Dette er gældende når luften er tilstrækkeligt opblandet i rummet.
Det ækvivalente luftskifte per time (ACH) er beregnet under antagelse af luften er tilstrækkeligt opblandet og ved brug af modellen henvist af USA CDC[1].

MS2 susceptibilitet: 0,97 log/time/20m^3			
Rumstørrelse, m^3	Reduktion, % 60 minutter	Log-reduktion pr. time	Ækvivalent ACH*
20	89,3	0,97	2,2
40	67,3	0,49	1,1
60	52,5	0,32	0,7
80	42,8	0,24	0,6
100	36,0	0,19	0,4
3 gange højere susceptibilitet end MS2: 2,91 log/hour/20m^3			
Rumstørrelse, m^3	Reduktion, % 60 minutter	Log-reduktion pr. time	Ækvivalent ACH*
20	99,88	2,91	6,7
40	96,5	1,46	3,4
60	89,3	0,97	2,2
80	81,3	0,73	1,7
100	73,8	0,58	1,3
5 gange højere susceptibilitet end MS2: 4,85 log/hour/20m^3			
Rumstørrelse, m^3	Reduktion, % 60 minutter	Log-reduktion pr. time	Ækvivalent ACH*
20	99,999	4,85	11,2
40	99,6	2,43	5,6
60	97,6	1,62	3,7
80	93,9	1,21	2,8
100	89,3	0,97	2,2

Tabel 7: Reduktionen efter 60 minutter, log-reduktionen per time og den ækvivalente luftskifte pr. time ved øgede rumstørrelser og UV-susceptibiliteter. *Den ækvivalente ACH er beregnet ud fra referencen i fodnote 1.

[1] https://www.cdc.gov/infectioncontrol/guidelines/environmental/appendix/air.html

Ved at anvende samme matematiske model som ovenover er den maksimale rumstørrelse fundet for en given ækvivalent ACH mellem 2 og 6 og for øget UV-susceptibilitet. Dette er vist i Tabel 8. Disse værdier skal forstås som en rettelinje og den aktuelle brug af rummet bør også tages i betragtning.

	X gange højere susceptibilitet end MS2		
Ækvivalent ACH*	**1**	**3**	**5**
2	22	67	112
3	15	45	74
4	11	34	56
5	9	27	45
6	7	22	37

Tabel 8: Den maksimale rumstørrelse (m^3) for et givent ækvivalent ACH og UV-susceptibilitet. *Den ækvivalente ACH er beregnet ud fra referencen i fodnote 1.

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