SARS-CoV-2の対策

換気による希釈：感染確率の低減

Wells-Riley標準モデル

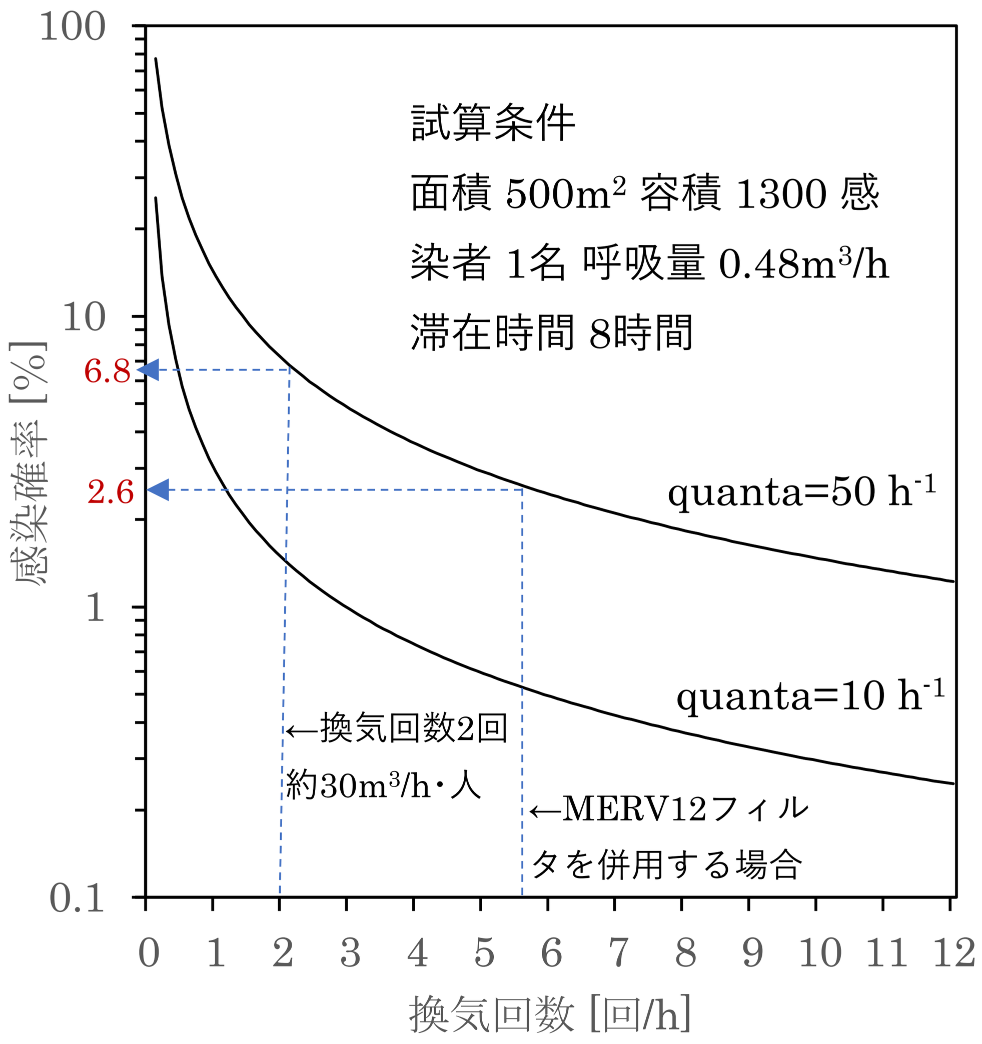
$$P_I = \frac{C}{S} = 1 - e^{-\frac{Iqpt}{Q}}$$

P_I：感染確率 [-]；C：新たな感染者数 [人]；S：感受者宿主数 [人]
I：感染者数 [人]；Q：室換気量 [m³/s]；q：発生量 [quanta/s]；
p：一人当たり呼吸量 [m³/(人･s)]；t：曝露時間 [s]

Wells-Riley拡張モデル

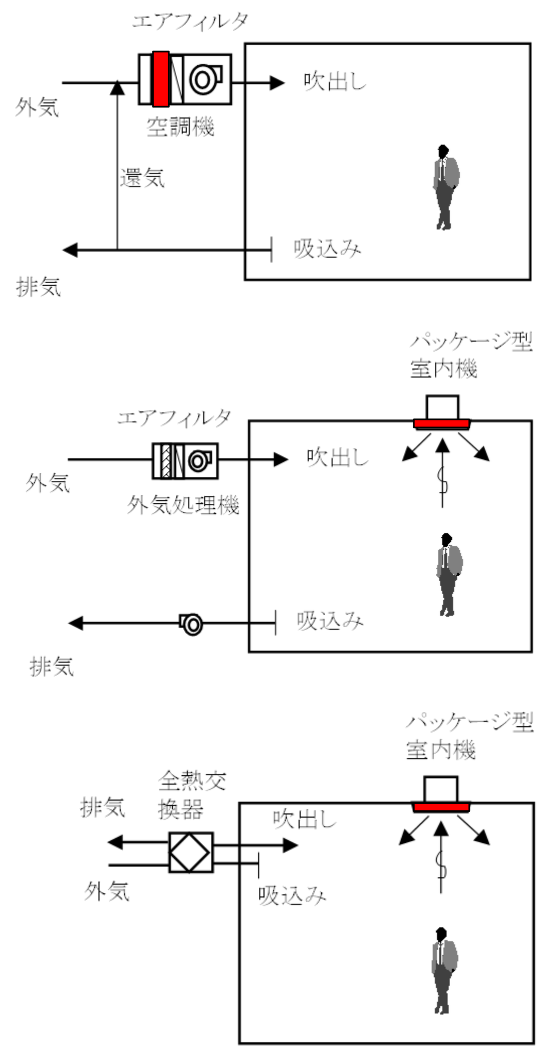
$$P_I = \frac{C}{S} = 1 - e^{-\frac{Iqpt/V}{(\lambda + K_1 + K_2)}}$$

V：室容積 [m³]
λ：循環を含めた清浄空気の量と室容積の比[1/h]
K_1：ろ過による感染性粒子の除去 [1/h]
K_2：感染性粒子の沈着量 [1/h]



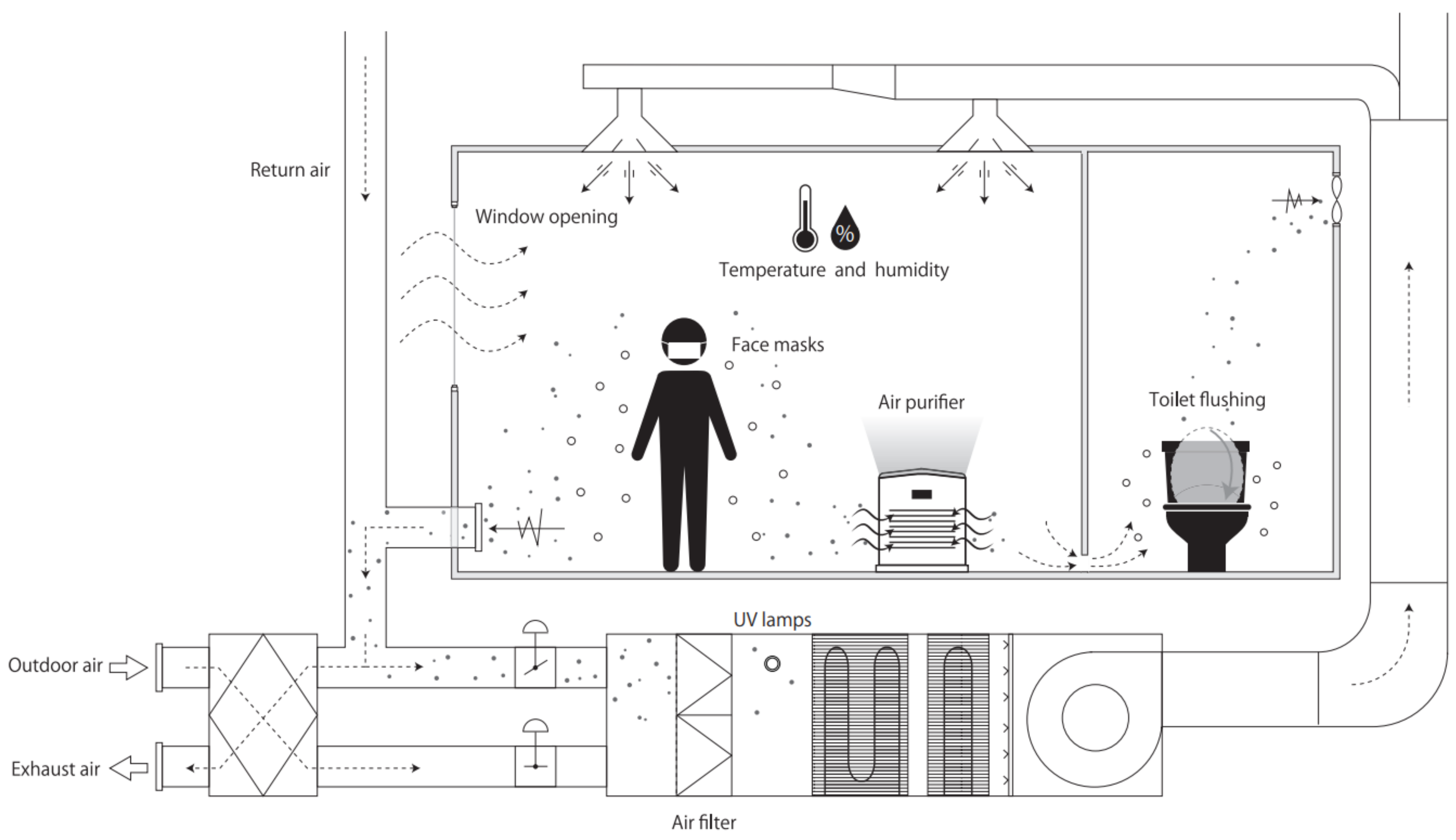
換気と感染確率

Azum K, Yanagi U, Kagi K, Kim H, Ogata M, Hayashi M, 2020. Environmental factors involved in SARS-CoV-2 transmission: effect and role of indoor environmental quality in the strategy for COVID-19 infection control. *Environmental Health and Preventive Medicine.* https://doi.org/10.1186/s12199-020-00904-2



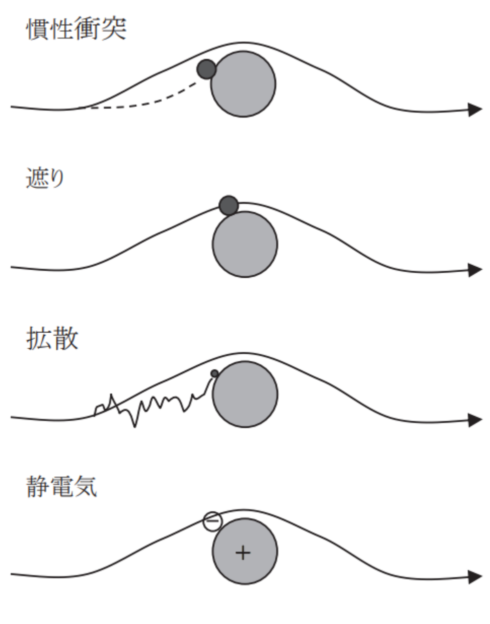
フィルタろ過後の清浄な空気の量は外気に相当する“相当換気量”になる

フィルタによるろ過

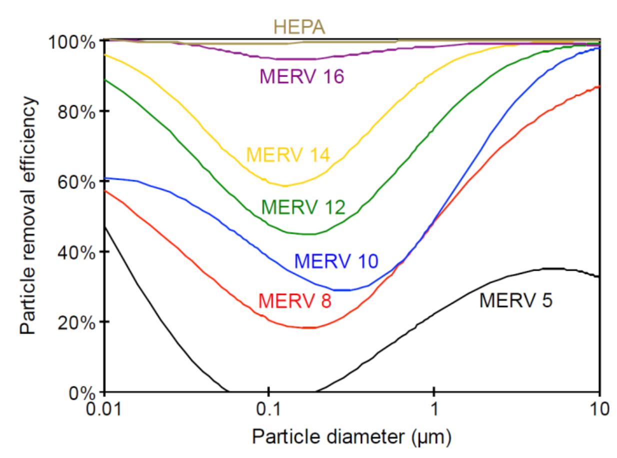


空調・換気設備にできること

Kurabuchi T, Yanagi U, Ogata M, Otsuka M, Kagi N, Yamamoto Y, Hayashi M, Tanabe S, 2021. Operation of air-conditioning and sanitary equipment for SARS-CoV-2 infectious disease control. *Japan Architectural Review.* https://doi.org/10.1002/2475-8876.12238



ろ過のメカニズム

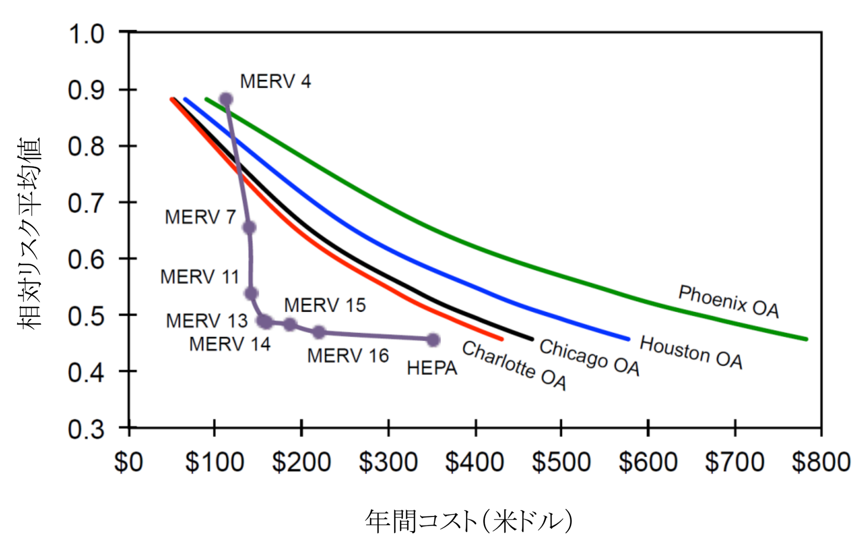


粒径別捕集特性

MERV・質量法・比色法の捕集率

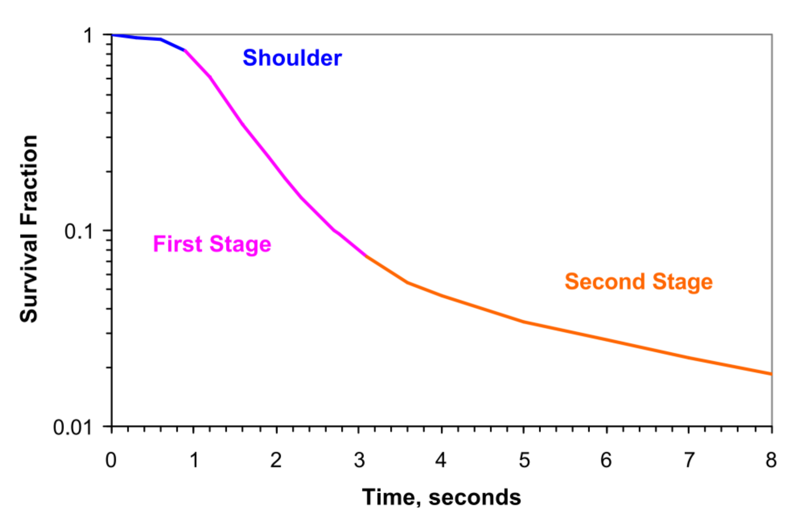
MERV	0.3-1.0 µm	1.0-3.0 µm	3.0-10 µm	質量法	比色法
1	n/a	n/a	E3<20	<65	-
2	n/a	n/a	E3<20	65	-
3	n/a	n/a	E3<20	70	-
4	n/a	n/a	E3<20	75	-
5	n/a	n/a	20≦E3	80	-
6	n/a	n/a	35≦E3	80	-
7	n/a	n/a	50≦E3	90	40
8	n/a	20≦E_2	70≦E3	90	40
9	n/a	35≦E_2	75≦E3		50
10	n/a	50≦E_2	80≦E3		50
11	20≦E_1	65≦E_2	85≦E3		60
12	35≦E_1	80≦E_2	90≦E3		75
13	50≦E_1	85≦E_2	90≦E3		90
14	75≦E_1	90≦E_2	95≦E3		95
15	85≦E_1	90≦E_2	95≦E3		98
16	95≦E_1	95≦E_2	95≦E3		-

n/a: not available,
Source: ASHRAE Standard 52.2-2017.

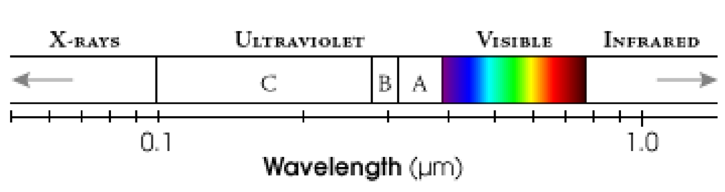


ろ過と換気による感染リスク低減効果の比較

紫外線による殺菌



Kowalski WJ, 2001. Design and Optimization of UVGI Air Disinfection Systems. A Thesis in Architectural Engineering. The Pennsylvania State University The Graduate School College of Engineering



$$SR = Fe^{-k_f It} + (1-F)\,e^{-k_s It}$$

SR：生存率（－）
k_f：1次殺菌係数（m²/J）
k_s：2次殺菌係数（m²/J）
I：紫外線強度（W/m²）
t：照射時間（s）
F：1次減衰の占める割合（－）

UV type	Virus	UV irradiance	Distance	Time	Log reduction
UV-C (254 nm)	CCoV	7.1 µW/cm²	1 m	72 h	4.8
UV LED (267 nm)	HCoV-OC43	6–7 mJ/cm²	No data	60 s	3
UV LED (297 nm)	HCoV-OC43	32 mJ/cm²	No data	60 s	3
UV LED (286 nm)	HCoV-OC43	13 mJ/cm²	No data	90 s	3
UV-C (254 nm)	MERS-CoV	–	1.22 m	5 min	5.91
UV-C (254 nm)	MERS-CoV	0.2 J/cm²	No data		>3.8
UV-C (254 nm)	MERS-CoV	0.05 J/cm²	No data		2.9
UV-A (365 nm)	SARS-CoV-1	2133 µW/cm²	3 cm	15 min	0
UV-C (254 nm)	SARS-CoV-1	134 µW/cm²	No data	15 min	5.3
UV-C (254 nm)	SARS-CoV-1	134 µW/cm²	No data	60 min	6.3
UV-C (254 nm)	SARS-CoV-1	4016 µW/cm²	3 cm	6 min	4 (below detection limit)
UV-C (260 nm)	SARS-CoV-1 (strain P9)	>90 µW/cm²	80 cm	60 min	6
UV-A (365 nm)	SARS-CoV-2	540 mW/cm²	3 cm	9 min	1
UV-C (222 nm)	SARS-CoV-2	0.1 mW/cm²	24 cm	10 s	0.94
UV-C (222 nm)	SARS-CoV-2	0.1 mW/cm²	24 cm	30 s	2.51
UV-C (222 nm)	SARS-CoV-2	0.1 mW/cm²	24 cm	60 s	2.51
UV-C (222 nm)	SARS-CoV-2	0.1 mW/cm²	24 cm	300 s	2.51
UV-C (254 nm)	SARS-CoV-2	1940 mW/cm²	3 cm	9 min	Complete virus inactivation
UV-C (254 nm)	SARS-CoV-2	3.7 mJ/cm²	220 mm	–	3
UV-C (254 nm)	SARS-CoV-2	0.849 mW/cm²	No data	0.8 s	Reduced below a detectable level
PX-UV	SARS-CoV-2	–	1 m	1 min	3.53
PX-UV	SARS-CoV-2	–	1 m	2 min	>4.52
PX-UV	SARS-CoV-2	–	1 m	5 min	>4.12
DUV LED	SARS-CoV-2	3.75 mJ/cm²	20 mm	1 s	0.9
DUV LED	SARS-CoV-2	37.5 mJ/cm²	20 mm	10 s	3.1
DUV LED	SARS-CoV-2	225 mJ/cm²	20 mm	60 s	>3.3

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