Infection, Disease & Health 26 (2021) 156—159

Available online at www.sciencedirect.com

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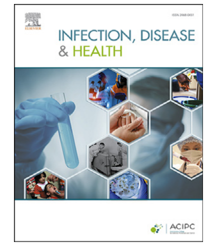

Letter to the Editor

Re-purposing of domestic steam disinfectors within the Hospital-at-Home setting: Reconciliation of steam disinfector thermal performance against SARS-CoV-2 (COVID-19), norovirus and other viruses' thermal susceptibilities

KEYWORDS
Disinfection;
SARS CoV-2;
COVID-19;
Heat inactivation;
Thermal inactivation;
Norovirus

Highlights

- Description of time/temperature thermal performance of a domestic steam-disinfector device is presented.
- Thermal susceptibility of SARS-CoV-2 (COVID-19), norovirus and other viruses is presented.
- Knowing the thermal susceptibility of viruses and performance of device can help predict fate of viruses in such devices.

Dear Editor,

Recently, our group published a paper in *Infection, Disease & Health* describing the re-purposing of domestic steam disinfectors to eradicate bacterial pathogens within the Hospital-at-Home scenario [1]. The main value of this paper is the description of time/temperature combinations within the steam disinfector device, as determined by employment of calibrated thermocouple probes, as shown in Table 1 (Thermal performance of steam disinfector using the A0 Concept according to EN ISO 15883). This table shows the duration of time (sec) that the device remains at ≥ 70 °C, ≥80 °C, ≥ 90 °C and ≥93 °C. Whilst this manuscript was solely focussed on the elimination of bacterial pathogens, subsequent interest has been expressed as to how these time/temperature data could be exploited to determine how the disinfector would eradicate non-bacterial targets, particularly respiratory and gastrointestinal viruses.

To address this, we now present an additional table (Table 2) of thermal lethality data against viral targets, compiled from previously published thermal inactivation reports.

We hope that a synthesis of both these tables will now allow the reader to predict the fate of these viruses within the steam disinfector device.

https://doi.org/10.1016/j.idh.2021.01.001

Table 1 Thermal performance of steam disinfector using the A_o Concept according to EN ISO 15883. Reprinted from [1] with permission from Elsevier.

Probe position	Maximum temperature reached (°C)	Time (sec) at (A0 equivalent)			
		≥70 °C	≥80 °C	≥90 °C	≥93 °C
Upper Layer					
(i) No Fan; 90 mls fill volume, lower layer empty					
1	100.0	800 (A_o = 60)	600 (A_o = 600)	400 (A_o = 3000)	340 (A_o = 6000)
2	100.1	820 (A_o = 60)	620 (A_o = 600)	400 (A_o = 3000)	320 (A_o = 6000)
3	100.5	800 (A_o = 60)	580 (A_o = 60)	400 (A_o = 3000)	320 (A_o = 6000)
4	99.9	780 (A_o = 60)	580 (A_o = 60)	400 (A_o = 3000)	340 (A_o = 6000)
5	100.1	800 (A_o = 60)	600 (A_o = 600)	420 (A_o = 3000)	340 (A_o = 6000)
(ii) Fan [30mins]; 90 mls fill volume, lower layer empty					
1	98.0	516 (A_o = 6)	400 (A_o = 60)	280 (A_o = 600)	200 (A_o = 3000)
2	98.4	520 (A_o = 6)	400 (A_o = 60)	280 (A_o = 600)	220 (A_o = 3000)
3	99.0	500 (A_o = 6)	400 (A_o = 60)	280 (A_o = 600)	240 (A_o = 3000)
4	98.1	500 (A_o = 6)	400 (A_o = 60)	280 (A_o = 600)	200 (A_o = 3000)
5	98.5	520 (A_o = 6)	420 (A_o = 60)	300 (A_o = 600)	220 (A_o = 3000)
(iii) No Fan; 90 mls fill volume, lower layer filled with baby bottles					
1	95.7	510 (A_o = 6)	300 (A_0 = 60)	120 (A_0 = 600)	60 (A_0 = 600)
2	96.7	510 (A_o = 6)	330 (A_0 = 60)	120 (A_0 = 600)	60 (A_0 = 600)
3	96.7	510 (A_o = 6)	330 (A_0 = 60)	150 (A_0 = 600)	90 (A_0 = 600)
4	95.3	480 (A_o = 6)	270 (A_0 = 60)	90 (A_0 = 600)	30 (A_0 = 600)
5	96.7	510 (A_o = 6)	300 (A_0 = 60)	120 (A_0 = 600)	60 (A_0 = 600)
Lower Layer					
(i) No Fan; 90 mls fill volume, lower layer empty					
6	89.9	460 (A_0 = 6)	320 (A_0 = 60)	0	0
7	88.8	360 (A_0 = 6)	200 (A_0 = 60)	0	0
8	86.1	360 (A_0 = 6)	180 (A_0 = 60)	0	0
9	93.0	480 (A_0 = 6)	400 (A_0 = 60)	160 (A_0 = 600)	1
10	89.6	480 (A_0 = 6)	240 (A_0 = 60)	0	0
(ii) Fan [30 mins]; 90 mls fill volume, lower layer empty					
6	89.3	180 (A_0 = 6)	60 (A_0 = 60)	0	0
7	88.0	260 (A_0 = 6)	160 (A_0 = 60)	0	0
8	83.5	320 (A_0 = 6)	180 (A_0 = 60)	0	0
9	90.0	260 (A_0 = 6)	140 (A_0 = 60)	0	0
10	89.0	380 (A_0 = 6)	260 (A_0 = 60)	0	0
(iii) No Fan; 90 mls fill volume, inside baby bottles					
6	95.2	560 (A_0 = 6)	380 (A_0 = 60)	220 (A_0 = 600)	100 (A_0 = 600)
7	96.5	660 (A_0 = 60)	480 (A_0 = 60)	220 (A_0 = 600)	160 (A_0 = 600)
8	95.0	640 (A_0 = 60)	400 (A_0 = 60)	161 (A_0 = 600)	79 (A_0 = 600)
9	95.3	620 (A_0 = 60)	421 (A_0 = 60)	200 (A_0 = 600)	141 (A_0 = 600)
10	97.1	719 (A_0 = 60)	559 (A_0 = 60)	320 (A_0 = 3000)	241 (A_0 = 3000)

Table 2 Thermal susceptibility of SARS CoV-2, norovirus and other viruses.

Virus	Sample	Treatment	Temp. (°C)	Time (min)	Viral Titre Before Heat	Log_{10} reduction (LRF)
SARS-CoV-2						
SARS-CoV-2 England [2]	Tissue culture fluid	Heat block	56	15	5.8 log_{10} pfu/ml	2.7
			56	30	5.8 log_{10} pfu/ml	4.9
			56	60	5.8 log_{10} pfu/ml	2.1
			80	15	5.7 log_{10} pfu/ml	3.5
			80	30	5.7 log_{10} pfu/ml	4.4
			80	30	5.6 log_{10} pfu/ml	4.1
			80	60	5.6 log_{10} pfu/ml	≥5.1
			80	90	5.6 log_{10} pfu/ml	≥5.1
			95	1	5.7 log_{10} pfu/ml	≥5.2
			95	5	5.7 log_{10} pfu/ml	≥5.2

(*continued on next page*)

Table 2 (*continued*)

Virus	Sample	Treatment	Temp. (°C)	Time (min)	Viral Titre Before Heat	Log_{10} reduction (LRF)
SKU:026V-03883 (Berlin, Germany) [3,4]	Cell culture supernatant	Heat block	56	30	3.3×10^6	>5
			60	60	3.3×10^6	>5
			92	15	3.3×10^6	>6
SKU:026V-03883 (Berlin, Germany) [4]	Nasopharyngeal swab	Heat block	60	60	3.5×10^5	>5
			56	30	3.5×10^5	>5
SKU:026V-03883 (Berlin, Germany) [4]	Blood sera	Heat block	56	30	3.5×10^5	>5
			60	60	3.5×10^5	>5
SARS-CoV-2/human/Liverpool/REMRQ0001/2020 [5]	NK	NK	80	60	1.1×10^7	None detected
NK [6]	N95 Respirators	Dry heat	70	60	7.8 log	None detected
SARS-CoV-2, strain USA_WA1/2020 [7]	Virus stock	Heating block	100	5	6.0 log	None detected
	Virus stock	Heating block	56	45	6.0 log	None detected
SARS CoV-2 (France) [8]	Cell culture supernatant	Water Bath	56	15	6.6 log	3.37
			56	30	6.6 log	None detected
			65	15	6.6 log	None detected
	Nasopharyngeal sample	Water bath	65	5	6.57 log	1.74
			65	10	6.57 log	None detected
			95	0.5	6.57 log	0.34
			95	3	6.57 log	None detected
	Sera	Water bath	56	5	6.2 log	1.33
			56	10	6.2 log	3.63
			56	15	6.2 log	None detected
SARS-CoV-2 isolates (designated hCoV-19/Cambodia/1775/2020, 1775; hCoV-19/Cambodia/2018/2020, 2018; and, hCoV-19/Cambodia/2310/2020, 2310) [9]	Virus culture	Thermo-block	56	30	4-5 log	None detected
			56	60	4-5 log	None detected
			98	2	4-5 log	None detected
Norovirus						
Norovirus (GI & GII) [10]	Cow's milk		85	1	8 log_{10}	6.6 ± 0.2 log_{10}
			85	2	8 log_{10}	8 log_{10}
			90	90s	8 log_{10}	8 log_{10}
			95	60s	8 log_{10}	8 log_{10}
			100.5	40s	8 log_{10}	8 log_{10}
Human Norovirus surrogates						
Murine norovirus [11]	PBS	Water bath	56	10	10^5 PFU/ml	None detected
Tulane virus [11]	PBS	Water bath	56	30	10^5 PFU/ml	None detected
Aichi virus [11]	PBS	Water bath	56	10	10^5 PFU/ml	None detected
Tulane virus [12]	PBS	Water bath	56	30	10^5 PFU/ml	None detected
			63	10	10^5 PFU/ml	None detected
			72	5	10^5 PFU/ml	None detected
Murine norovirus [13]	Modified Eagle's medium + PBS	Water bath	85	1	6×10^6 PFU/ml	None detected
Tulane virus [14]	M199-Earle's medium	Heating block	56	30	4×10^4 -6.4×10^5 l	None detected
			63	5		None detected
Poliovirus Sabin 1 [15]	Viral culture in stool suspension	Water bath	73	3	>4 log	Complete inactivation
Adenovirus type 5 [15]						
Influenza A (H1N1) [15]						
Mouse norovirus (MNV1) [15]						
Human NoroGII.4 [15]						

Authorship statement

Beverley C. Millar: Conceptualization; Formal analysis; Investigation; Methodology; Visualization; Roles/Writing - original draft; Writing - review & editing. **John E. Moore:** Conceptualization; Formal analysis; Investigation; Methodology; Visualization; Roles/Writing - original draft; Writing - review & editing.

Funding

This work was not supported by any external funding.

Provenance and peer review

Not commissioned; externally peer reviewed.

Ethics

This was entirely an in vitro study not involving patients, healthcare staff, any other humans nor animals and as such did not require ethical approval.

Conflict of interest

None of the authors have any conflicts to declare.

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8 January 2021
Available online 28 January 2021