Public Health England

An Evaluation of an Air Disinfection Device Against Microbial Aerosols

Report No. 15/046 A

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About Public Health England

We work with national and local government, industry and the NHS to protect and improve the nation's health and support healthier choices. We address inequalities by focusing on removing barriers to good health.

We were established on 1 April 2013 to bring together public health specialists from more than 70 organisations into a single public health service.

About Biosafety Investigation Unit

The Biosafety Investigation Unit at Porton Down has been carrying out independent evaluations of infection control interventions in laboratories, health care, containment, workplace and domestic settings for over twenty years. Our expertise is in air and water microbiology applied to nosocomial, pharmaceutical and containment situations. We have developed and offer standard techniques for the determination of the efficacy of filters and air disinfection units, the performance of safety cabinets, sealed centrifuges rotors and air samplers. We are also able to assess liquid and gaseous disinfectants and the microbial air quality of healthcare facilities, workplaces and other environments.

The Biosafety Investigation Unit provides specialist bespoke research, testing and evaluation services for commercial customers that delivers independent analysis and reports. However as a public sector body we are not able to endorse any particular products or recommend them for use by the NHS or others.

Contents

Executive summary

The effectiveness of the air purification technology built into the Sterillo hand dryer, supplied by Heat Outdoors Ltd was evaluated against aerosols of *Staphylococcus epidermidis* (NCTC 11047). *Staph. epidermidis*, a Gram positive bacteria that makes up part of our normal skin flora, is a common restroom contaminant. The experimental conditions measured the aerosol concentration of the test micro-organism in a 1 cubic meter chamber with both the air purification technology operating (the hand drying element was switched off) and the unit switched off, over a period of 3 hours. Triplicate tests with the air purification technology operating and triplicate tests with the unit switched off were performed to ensure repeatability in the test method.

The results show that when the air purification technology in the Sterillo Hand Dryer is operating it was able to reduce the airborne concentration of *Staph. epidermidis* (NCTC 11047) to near zero in 2 hours (see Table 1.). There is a natural reduction of *Staph. epidermidis* in the air due to deposition and natural death but even taking this into consideration the air purification technology showed a 99.96% efficiency for removing *Staph. epidermidis* from the air within 2 hours.

Table 1. Average percentage efficiencies

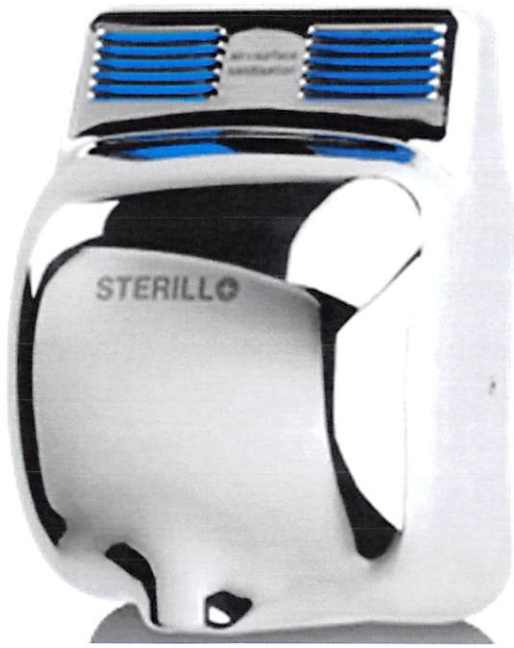
Time (Minutes)	Percentage Efficiency
30	58.84
60	98.63
120	99.96

Introduction

The air purification technology built into the Sterillo hand dryer (see Figure 1.), supplied by Heat Outdoors Ltd. operates by drawing air, using convection, through a compartment containing a UV light. The air that has passed through the UV chamber exits the top of the hand dryer via vents. The antimicrobial effectiveness of the unit was tested in a 1 cubic meter chamber against microbial aerosols of *Staphylococcus epidermidis* (NCTC 11047). This is a Gram positive bacteria that makes up part of our normal skin flora and as such *Staphylococci* species are common restroom contaminants[1]. It is normally used as a surrogate for Methicillin Resistant *Staphylococcus aureus* (MRSA) which is a common cause of hospital acquired infections.

A Collison nebuliser[2] was used to generate an aerosol of *Staph. epidermidis* and six All Glass Impingers[3] (AGIs) were used to measure the concentration of airborne micro-organisms at designated time points over a three hour period. The testing was carried out in triplicate with the air purification technology turned on and in triplicate with the unit turned off.

Figure 1. Sterillo Hand Dryer supplied by Heat Outdoors Ltd



Materials and Method

Test organisms

Staphylococcus epidermidis NCTC 11047

The test suspensions were prepared by inoculating a 500ml flask containing 100ml of Tryptone Soya Broth. A full (generous) 10µl loop of *S. epidermidis* was taken from a stock plate previously stored at 4°C±2°C and added to the flask. The culture suspension was mixed thoroughly by shaking then placed in a dry shaking incubator at 37± 2°C for a minimum of 20 hours.

The suspensions were assayed by plating out 0.1 ml of a tenfold serial dilution in duplicate onto Tryptone Soya Agar (TSA) plates and incubating the plates at 37°C±2°C for 48 hours. The colonies were counted after incubation to determine the concentration of the bacteria (colony forming units (cfu) per millilitre of suspension.

A fresh suspension was prepared for each test.

Test Chamber

A 1 cubic meter Class III microbiological safety cabinet was used for the study. The cabinet is fitted with HEPA filters on both the inlet and outlet which allows rapid dilution of any aerosols generated in the chamber. During experiments the ventilation system is not operated. The cabinet is fitted with vacuum lines, electrical supplies and high pressure air lines which enable air samplers and aerosol generators to be operated remotely and so prevent operator exposure to aerosolised microbial agents.

Aerosol Generation

An appropriate volume (approx. 30ml) of the microbial test suspension was added to a 3-jet Collison nebuliser. A fan was situated below the nebuliser (see Figure 2.). In each experiment the nebulisation of the micro-organism was achieved by operating the Collison at a pressure of 180 KPa for two minutes with the fan running during the same time period.

Aerosol Sampling

The microbial aerosol was sampled using 6 all glass impingers (AGIs), operating at ca 11 l/min, containing 20mls of PBMA (phosphate buffer with manucol and antifoam). Each sampler was set to sample for two minutes at the times stated in the test design (see Figure 2.).

Figure 2. Layout of the test equipment.

Experimental Design and Device Operation

In the test experiments the air purification technology was operating but the hand drying element was switched off. Prior to running the test study the device was turned on for 15 minutes before the sampling was started.

Test 1, 2 and 3 – Air purification technology turned on
Control Test 1, 2 and 3 – Unit turned OFF

0- 2 minutes	Microbial suspension aerosolised with mixing fan operating
2-4 minutes	Operate AGI 1
10-12 minutes	Operate AGI 2
30-32 minutes	Operate AGI 3
60-62 minutes	Operate AGI 4
120-122 minutes	Operate AGI 5
180-182 minutes	Operate AGI 6

Assay of *S. epidermidis* in collecting fluids

The collecting fluids from each of the impingers were assayed by spreading suitable dilutions in duplicate onto Soya agar (TSA) plates. The remaining collecting fluids from the impingers were concentrated by filtration onto 0.2 μm polycarbonate membrane filters (Whatman). These membrane filters were placed onto TSA plates. All the TSA plates were incubated at 30 ± 2°C for 48 hours and any colonies were counted.

Calculations

$$\textit{Concentration per ml of collection fluid} = \textit{Average cfu in } 100\mu l \textit{ x dilution factor x } 10$$

$$\textit{Total concentration In impinger} = \textit{Concentration per ml x } 20$$

Graphs

Graph 1 and 2 - Total concentration of *S. epidermidis* in impinger over time for each test run and Average total concentration of *S. epidermidis* in impingers over time, respectively

Results

Test 1 – Air Purification Technology Turned ON

Date	29th January 2016	Operator	Helen Hookway

Test Organism	*S. epidermidis* (NCTC 11047)	Batch No.	Se2801/16
		Concentration	4.95×10^9 cfu/ml

AGI	Time (mins)	Number of colonies counted						Total cfu# in impinger
		Rest	5ml	1ml	Neat (100µl)	-1 (100µl)	-2 (100µl)	
1	2	-	-	-	*TNTC TNTC	TNTC, TNTC	182, 192	3.74×10^6
2	10	-	-	-	TNTC, TNTC	TNTC, TNTC	34,33	6.70×10^5
3	30	-	-	-	TNTC, TNTC	38, 29	1, 2	6.70×10^4
4	60	-	-	89	15, 8	3, 1	-	1.78×10^3
5	120	0	0	0	0 , 0	-	-	<1
6	180	1	0	0	0 , 0	-	-	1

AGI 1 – 2 mins; 2 – 10 mins; 3 – 30 mins; 4 – 60 mins; 5 – 120 mins; 6 – 180 mins
*TNTC – Too Numerous To Count #cfu – colony forming units

Time (minutes)	Relative Humidity (%)	Temperature (°C)
2	39.4	24.2
10	39.7	24.0
30	39.4	24.2
60	39.9	24.1
120	40.2	24.3
180	40.9	24.1

Test 2 – Air Purification Technology Turned ON

Date	3rd February 2016	Operator	Helen Hookway

Test Organism	*S. epidermidis* (NCTC 11047)	Batch No.	Se0202/16
		Concentration	3.35 x 10^9 cfu/ml

AGI	Time (mins)	Number of colonies counted						Total cfu# in impinger
		Rest	5ml	1ml	Neat (100µl)	-1 (100µl)	-2 (100µl)	
1	2	-	-	-	*TNTC TNTC	TNTC, TNTC	144, 133	2.77 x 10^6
2	10	-	-	-	TNTC, TNTC	185, 198	17, 21	3.83 x 10^5
3	30	-	-	-	244, 266	15, 20	2, 4	5.10 x 10^4
4	60	-	-	91	10, 14	0, 1	-	1.82 x 10^3
5	120	4	1	0	0 , 0	-	-	5
6	180	0	0	0	0 , 0	-	-	<1

AGI 1 – 2 mins; 2 – 10 mins; 3 – 30 mins; 4 – 60 mins; 5 – 120 mins; 6 – 180 mins

Time (minutes)	Relative Humidity (%)	Temperature (°C)
2	37.6	19.4
10	37.5	19.5
30	37.5	19.7
60	37.5	20.2
120	38.1	20.8
180	38.0	20.7

Test 3 – Air Purification Technology Turned ON

Date	5th February 2016	Operator	Helen Hookway

Test Organism	*S. epidermidis* (NCTC 11047)	Batch No.	Se0402/16
		Concentration	4.20 x 10^9 cfu/ml

AGI	Time (mins)	Number of colonies counted							Total cfu in impinger
		Rest	5ml	1ml	Neat (100µl)	-1 (100µl)	-2 (100µl)	-3 (100µl)	
1	2	-	-	-	TNTC, TNTC	TNTC, TNTC	TNTC, TNTC	28, 33	6.10 x 10^6
2	10	-	-	-	TNTC, TNTC	TNTC, TNTC	221, 227	19, 21	4.00 x 10^6
3	30	-	-	-	TNTC, TNTC	TNTC, TNTC	35, 30	-	6.50 x 10^5
4	60	-	-	112	7, 9	1, 1	-	-	2.24 x 10^3
5	120	2	0	0	0, 0	-	-	-	2
6	180	0	2	0	0, 0	-	-	-	2

AGI 1 – 2 mins; 2 – 10 mins; 3 – 30 mins; 4 – 60 mins; 5 – 120 mins; 6 – 180 mins

Time (minutes)	Relative Humidity (%)	Temperature (°C)
2	61.0	18.6
10	61.4	18.4
30	61.5	18.5
60	62.0	18.5
120	61.6	19.0
180	60.9	19.4

Control Test 1 – Unit Turned OFF

Date	28th January 2016	Operator	Anna Moy

Test Organism	*S. epidermidis* (NCTC 11047)	Batch No.	Se2701/16
		Concentration	4.95×10^9 cfu/ml

AGI	Time (mins)	Number of colonies counted						Total cfu in impinger
		5ml	1ml	Neat (100µl)	-1 (100µl)	-2 (100µl)	-3 (100µl)	
1	2	-	-	TNTC, TNTC	TNTC, TNTC	213, 198	21, 20	4.10×10^6
2	10	-	-	TNTC, TNTC	TNTC, TNTC	47, 35	4 , 1	8.20×10^5
3	30	-	-	TNTC, TNTC	93, 109	17, 9	2 , 0	2.02×10^5
4	60	-	-	205, 199	16, 19	1 , 0	0 , 0	4.07×10^4
5	120	-	123	18, 17	1, 3	1 , 0	1 , 0	2.46×10^3
6	180	64	10	2, 1	0 , 0	0 , 0	0 , 0	2.56×10^2

AGI 1 – 2 mins; 2 – 10 mins; 3 – 30 mins; 4 – 60 mins; 5 – 120 mins; 6 – 180 mins

Time (minutes)	Relative Humidity (%)	Temperature (°C)
2	ND*	ND
10	ND	ND
30	ND	ND
60	ND	ND
120	ND	ND
180	ND	ND

*ND – Not Done

Control Test 2 – Unit Turned OFF

Date	2nd February 2016	Operator	Helen Hookway

Test Organism	*S. epidermidis* (NCTC 11047)	Batch No.	Se0102/16
		Concentration	3.05×10^9 cfu/ml

AGI	Time (mins)	Number of colonies counted						Total cfu in impinger
		5ml	1ml	Neat (100µl)	-1 (100µl)	-2 (100µl)	-3 (100µl)	
1	2	-	-	TNTC, TNTC	TNTC, TNTC	245, 222	27, 22	4.90×10^6
2	10	-	-	TNTC, TNTC	TNTC, TNTC	76, 80	11, 12	1.56×10^6
3	30	-	-	TNTC, TNTC	195, 190	18, 10	-	3.85×10^5
4	60	-	-	TNTC, TNTC	55, 56	6, 4	-	1.11×10^5
5	120	TNTC	TNTC	43, 44	3, 4	-	-	8.70×10^3
6	180	54	9	0, 1	0 , 0	-	-	2.16×10^2

AGI 1 – 2 mins; 2 – 10 mins; 3 – 30 mins; 4 – 60 mins; 5 – 120 mins; 6 – 180 mins

Time (minutes)	Relative Humidity (%)	Temperature (°C)
2	40.4	19.0
10	40.3	19.2
30	40.5	19.5
60	40.9	19.8
120	41.4	20.2
180	41.3	20.1

Control Test 3 – Unit Turned OFF

Date	4th February 2016	Operator	Helen Hookway

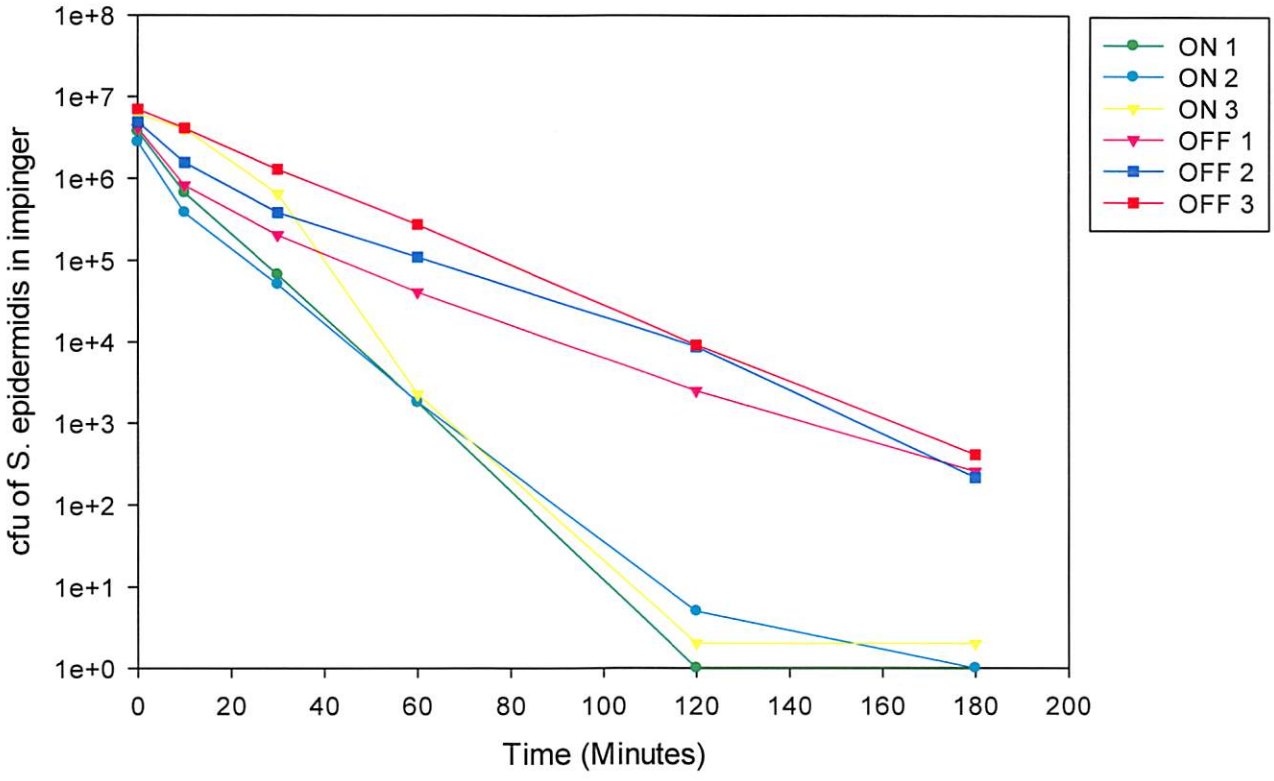
Test Organism	*S. epidermidis* (NCTC 11047)	Batch No.	Se0302/16
		Concentration	4.05 x 10^9 cfu/ml

AGI	Time (mins)	Number of colonies counted						Total cfu in impinger
		5ml	1ml	Neat (100µl)	-1 (100µl)	-2 (100µl)	-3 (100µl)	
1	2	-	-	TNTC, TNTC	TNTC, TNTC	TNTC, TNTC	32, 38	7.00 x 10^6
2	10	-	-	TNTC, TNTC	TNTC, TNTC	196, 222	21, 20	4.10 x 10^6
3	30	-	-	TNTC, TNTC	TNTC, TNTC	66, 62	-	1.28 x 10^6
4	60	-	-	TNTC, TNTC	139, 135	17, 16	-	2.74 x 10^5
5	120	-	TNTC	37, 54	6, 4	-	-	9.10 x 10^3
6	180	103	19	2, 3	0 , 0	-	-	4.12 x 10^2

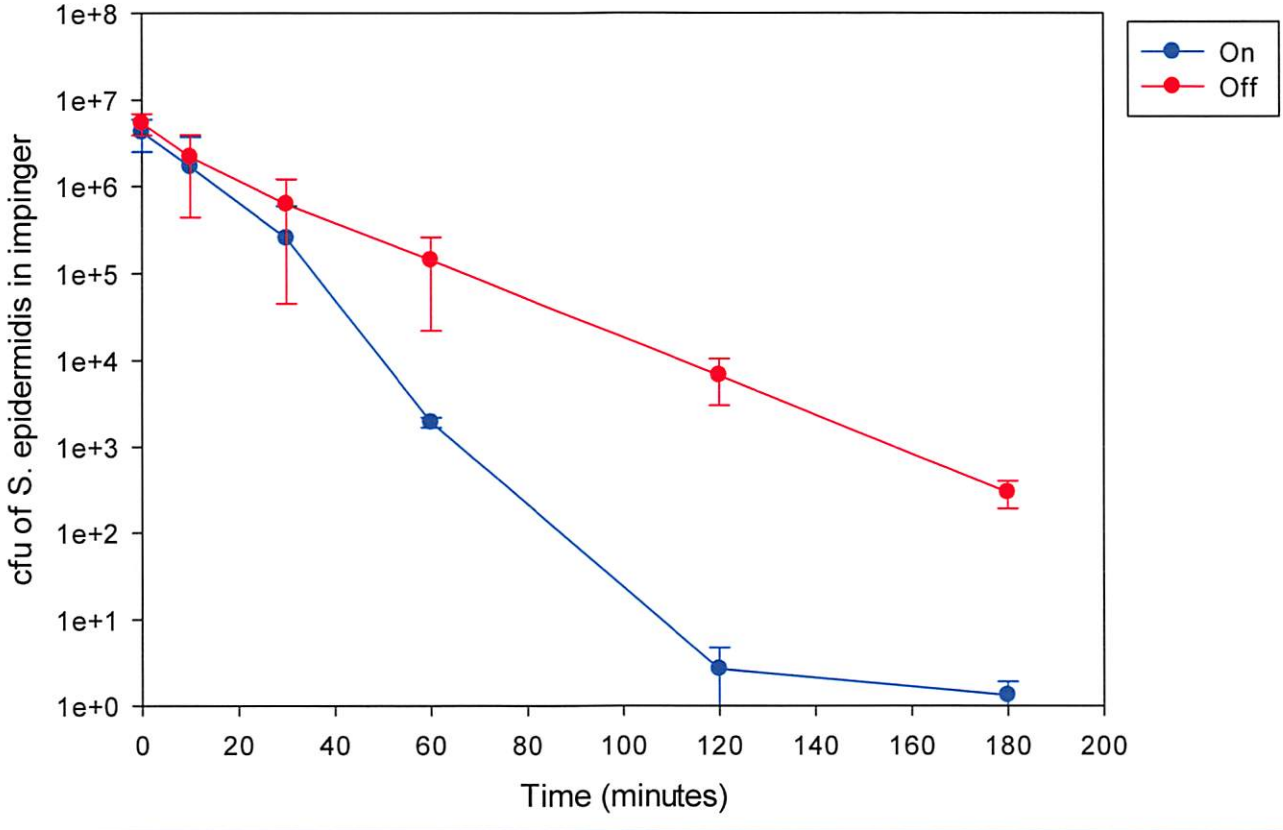
AGI 1 – 2 mins; 2 – 10 mins; 3 – 30 mins; 4 – 60 mins; 5 – 120 mins; 6 – 180 mins

Time (minutes)	Relative Humidity (%)	Temperature (°C)
2	56.5	20.1
10	56.2	20.1
30	56.1	20.2
60	56.1	20.3
120	55.2	20.8
180	55.0	21.0

Graph 1. Total concentration of *S. epidermidis* in impinger over time for each of the three test runs and three controls.



Graph 2. Average total concentration of *S. epidermidis* in impingers over time.



Conclusions

The effectiveness of the air purification technology built into the Sterillo hand dryer, supplied by Heat Outdoors Ltd, when evaluated against aerosols of *Staphylococcus epidermidis* (NCTC 11047) showed that it was able to reduce the airborne concentration of *Staph. epidermidis* (NCTC 11047) to near zero in 2 hours. There is a natural reduction of micro-organisms in the air due to deposition and natural death but even taking this into consideration the air purification technology showed a 99.96% efficiency for removing *Staph. epidermidis* from the air within 2 hours.

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