EVALUATION OF THE INACTIVATION OF AIRBORNE MICROORGANISMS THROUGH UV-FAN-XS 40H AIR PURIFIER

Purpose of the study:
Evaluation of the inactivation % of in-duct airborne microorganisms with ultraviolet germicidal irradiation (UVGI); in this application UV-C radiation has a direct action on the airflow travelling through the unit.
The protocol used to conduct the test is outlined in the technical reference standard ISO15714:2019 *'Method of evaluating the UV dose to airborne microorganisms transiting in-duct ultraviolet germicidal irradiation devices'*.

Issued on: 12/11/2020

Client: LIGHT PROGRESS registered office and production: loc. San Lorenzo, 40
52031 Anghiari (AR)

Summary:

Attachments:

Test Report 377189 of 06/11/2020

Test Report 377190 of 06/11/2020

Test Report 377549 of 06/11/2020

Test Report 377550 of 06/11/2020

Test Report 378786 of 06/11/2020

Test Report 380760 of 06/11/2020

Test Report 378787 of 06/11/2020

Test Report 380763 of 06/11/2020

a) Laboratory that performed the test:

Tests and microbiological analysis were performed by Tecnal s.r.l. laboratory located in via Castelfranco 17d 40053 Valsamoggia loc. Bazzano (BO).

b) Date of the test:

From 09/10/2020 to 26/10/2020

c) Instrument under investigation:

UV-FAN-XS 40H AIR PURIFIER – serial N°: A08-20E; year 2020. The duct is closed in all its parts so to prevent any human exposure.

Technical data provided by the client:

- UVC lamp power: 14W

- Power supply: 230 Volt -50/60Hz -40Watt

- Maximum flow rate: 125 m^3/h

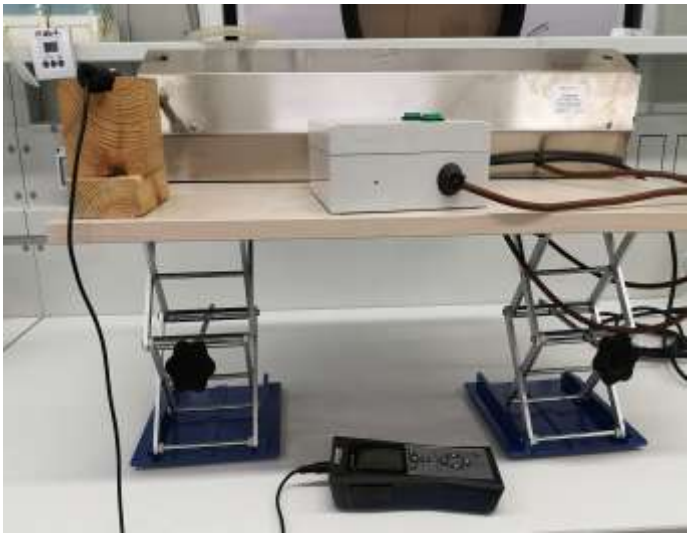
- Flow speed: 2m/sec

- Cross sectional area: 0.0166 m^2

The air transits through a turbulence-directed system so that each thread of air touches the wall of the lamp. Internally it is mirror-coated with a reflection coefficient of 85% at a wavelength of 253.7 nm.

Technical characteristics GERMICIDAL LAMPS (UV-C): Information can be found in the CHS-40WH data sheet provided by the customer.

Images of the instrument under investigation:



d) Microorganism used for the test:

Bacterial strain used for the test:

Serratia marcescens ATCC13880 - Gram-negative bacterium, member of the Enterobacteriaceae family; it has a susceptibility constant K ranging from 0.1 m^2/J to 0.9 m^2/J, representing the microorganism with high susceptibility to UV radiation.

Bacillus subtilis ATCC6633 - Gram-positive bacterium from the Bacillaceae family; has a susceptibility constant K ranging from 0.02 m^2/J to 0.07 m^2/J, representing the microorganism with low susceptibility to UV radiation.

	Cladosporium sphaerospermum ATCC11289 - A spore-forming fungus with a susceptibility constant K ranging from 0.0008 m^2/J to 0.002 m^2/J, representing the fungus with high susceptibility to UV radiation.
Preparation of the bacterial strains (point 6.2):	The bacterial strains were initially reconstituted in culture broth according to the supplier's instructions; the micro-organisms were then grown on solid culture medium plates; from the colonies obtained on the plate, after appropriate dilutions, microbial solutions were obtained at the desired cfu/ml concentration for inoculation.
Diluent for bacterial strains:	Demineralized sterile water
Culture Medium Plates (Annex A):	Nutrient Agar (Plate count agar - PCA) Potato dextrose agar (PDA)
Incubation times and temperatures of plates for microorganisms recover from the UVGI device:	*Serratia marcescens: 24 -48 hours in thermostat at 32°C+-1°C* *Bacillus subtilis: 24 -48 hours in thermostat at 32°C+-1°C* *Cladosporium sphaerospermum: 72-120 hours at 25°C+-1°C*
e) Operating procedure	The micro-organisms are introduced into the device by means of an aerosol generator; the technician sets up the Anderson impactor with the culture medium plates foreseen for the micro-organism, performs preliminary flow checks of the flow generator. The technician connects the aerosol generator in the inlet hole and the Anderson impactor in the outlet hole of the device and starts the recovery of the micro-organisms following the operating protocol as indicated in point 7.3 of the standard.
	The test is performed in triplicate with both UVC light off and on. The culture medium plates are then incubated under the above conditions.
Room conditions durign the test:	Temperature 25°C +- 2°C Humidity 50%+-10%
	The flow of air exiting the device is measured with an anemometer inserted by the client in the final part of the duct; the measurement is carried out at the beginning and end of each test. The average flow value recorded at the beginning

and end of the tests varies between 1.5 CMM and 2.2 CMM (CMM = m^3 per minute).
The test is performed at the only flow foreseen for the type of device.

Counting of the colonies:

Microbial colony counts on Anderson sampler plates are adjusted to allow for coincidence sampling, that is the increased probability that more than one microbial particle is deposited at an impact site; therefore, the provided conversion tables are used.

f) Results of microbial inactivation

Each test is carried out in triplicate; each result obtained is verified to have a relative difference of less than 50%.

The bacterial inactivation values derived from calculations using the cfu/m^3 values are shown in the following tables:

1- Serratia marcescens:

ufc/m^3 average value UVC lamp off	*ufc/m^3 average value UVC lamp on*
32.596	1

INACTIVATION RATE (point 3.1.9)	
N0/N%= (N0-N)/N0x100	Log(N0/N)
100,0	4,6

2- Bacillus subtilis:

ufc/m^3 average value UVC lamp off	*ufc/m^3 average value UVC lamp on*
32.045	2

INACTIVATION RATE (point 3.1.9)	
N0/N%= (N0-N)/N0 x100	Log(N0/N)
99,99	4,14

3- Cladosporium sphaerospermum:

ufc/m^3 average value UVC lamp off	*ufc/m^3 average value UVC lamp on*
5.583	3.124

INACTIVATION RATE (point 3.1.9)	
N0/N%= (N0-N)/N0 x100	Log(N0/N)
44,1	0,25

By applying the formula (point 3.1.10), the dose D that resulted in the microbial inactivation % found in this study can be derived:

$$ln (N0/N) = KD$$

where:
D UVC dose
K susceptibility constant (derived from Annex C list - ISO 15714:2019)
N0 micro-organisms recovered without UV-C activity
N microorganisms recovered after UV-C activity

1-Serratia marcescens:
D=11.58 J/m^2 UV dose calculated from K=0.92 (Lai, 2004)
D90 from bibliography: 3 J/m^2

2-Bacillus subtilis:
D=56.56 UV dose calculated from K=0.16858 (Nakamura, 1987)
D90 from bibliography: 14 J/m^2

3-Cladosporium sphaerospermum:
D= 276.53 UV dose calculated from K=0.0021 (VanOsdell, 2002)
D90 from bibliography: 1.439 J/m^2

g) Conclusions:

This study, carried out under the operating conditions described above and taking into account the technical details provided by the client, made it possible to obtain data useful for calculating the percentage of inactivation of airborne micro-organisms required by the technical standard; specifically, the following results were obtained:

Serratia marcescens bacterial inactivation: 100% - calculated UVC dose: D=11.58 J/m^2
Bacillus subtilis bacterial inactivation: 99.99% - calculated UVC dose: D=56.56 J/m^2
Cladosporium sphaerospermum bacterial inactivation: 44.1% - calculated UVC dose: D=276.53 J/m^2

Germicidal efficacy was demonstrated for the *Serratia marcescens* and *Bacillus subtilis* microorganisms, to a lesser extent for *Cladosporium sphaerospermum*.
The effect of ultraviolet radiation (UV-C) has been extensively studied over the years, hence a rich bibliography is available to support it; UVGI systems are now finding an increasing variety of applications aimed, above all, at countering the transmission of airborne diseases; for the sake of completeness, some bibliographic references are given below:

Bibliography:

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- Use of Ultraviolet Lights in Biological Safety Cabinets: A Contrarian View Paul J. Meechan1 and Christina Wilson Applied Biosafety, 11(4) pp. 222-227
- Far-UVC light: A new tool to control the spread of airborne-mediated microbial diseases Scientific David Welch, Manuela Buonanno, Veljko Grilj, Igor Shuryak, Connor Crickmore, Alan W. Bigelow, Gerhard Randers-Pehrson, Gary W. Johnson & David J. Brenner RePoRtS | (2018) 8:2752
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