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ADDENDA

**ANSI/ASHRAE Addendum b to
ANSI/ASHRAE Standard 185.1-2015**

Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms

Approved American National Standard
ANSI
www.ansi.org

ASHRAE Standard Project Committee 185
Cognizant TC: 2.9, Ultraviolet Air and Surface Treatment
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ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

ASHRAE Standards are prepared by a Project Committee appointed specifically for the purpose of writing the Standard. The Project Committee Chair and Vice-Chair must be members of ASHRAE; while other committee members may or may not be ASHRAE members, all must be technically qualified in the subject area of the Standard. Every effort is made to balance the concerned interests on all Project Committees.

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FOREWORD

The use of the Poisson distribution is not appropriate for this type of biological data. The degree of correction is based on total counts, so a test with thousands of counts receives a tighter confidence interval than one with hundreds. This could result in very different reported efficiencies between tests. Also, because counting plates for microorganisms requires that colonies be separate, there is an upper limit on raw counts per plate. To obtain high counts, a great number of plates must be run. In addition, the test lab must estimate the actual concentrations to determine how long to sample or how much to plate. If the level is too high, the plates are overgrown and not usable; if too low, the counts will be low. Given that the efficiency of the devices isn't known ahead of time, in order to obtain high counts repeated tests must be run. To achieve tight confidence intervals with these calculations would require great expense.

In addition, this method of calculation does not address the issue of variability at the test lab, because the total counts are used. It seems preferable to report the counts, the average, and the standard deviation to give an average efficiency and a measure of the sample count variability.

Note: *In this addendum, changes to the current standard are indicated in the text by* <u>underlining</u> *(for additions) and* ~~strikethrough~~ *(for deletions) unless the instructions specifically mention some other means of indicating the changes.*

Addendum b to Standard 185.1-2015

Modify Section 6.1.2 as shown.

6.1.2 Bioaerosol Preparation and Generation. Preparation of the test organism suspension for the aerosolization requires that the test organism be grown in the laboratory and the suspension prepared for aerosol generation in the test duct. The microbial challenge suspensions are prepared by inoculating the test organism onto solid or into liquid media, incubating the culture until mature, wiping organisms from the surface of the pure culture (if solid media), and eluting them into sterile fluid to a known concentration to serve as a stock solution. The organism preparation is then diluted into the nebulizing fluid. The nebulizing fluid is quantified on agar plates to enumerate the number of test organisms in the suspension. The number of culturable organisms shall be at least 10^6 CFU per mL.

The bioaerosol generation system shall provide a stable test bioaerosol of sufficient concentration ~~for the upstream to establish meaningful 95% confidence limits for the single pass efficiency per Section 7.2~~ <u>to allow measurement to show 99% inactivation</u>. The generation system includes a 6-jet Collison (BGI, Waltham, MA) nebulizer that is based on air atomizing spray nozzles in which a suspension of microorganisms is nebulized with compressed air and then dried. The 6-jet Collison nebulizer (BGI, Waltham, MA) generates droplets with an approximate volume mean diameter of 2 μm. The particle diameter after the water evaporates depends on the solids content of the suspension. Particle size is determined by the size of the suspended particles. The concentration in the Collison should be such that only singlets are generated. The bioaerosol generator shall be designed to ensure that the microorganisms are dry prior to being introduced into the test duct. After drying, the bioaerosol may be neutralized using a charge neutralizer. If a charge neutralizer is not used, it must be included in the report. (Kujumdzic et. al. 2007)

Modify Section 7 as shown.

7. DETERMINATION OF PERFORMANCE

The primary measure of performance within this test method is the single-pass bioaerosol inactivation efficiency. This efficiency shall be characterized in terms of the percentage of *Aspergillus sydowii* (<u>ATCC® 36542)</u> and *Mycobacterium parafortuitum* (<u>ATCC® 19686)</u> that could not be cultured after UV-C radiation exposure (Miller-Leiden et al. 1996; Hernandez et al. 1999; Xu et al. 2005; Van Osdell and Foarde, 2002). The single-pass bioaerosol inactivation

efficiency, η_{UVGI}, shall be quantified by comparing the bioaerosol concentration upstream and downstream of the UV-C device using the following general equation:

$$\eta_{UVGI}(\%) = \left(1 - \frac{C_{downstream}}{C_{upstream}}\right) \times 100\% \tag{1}$$

where

$C_{downstream}$ = average culturable bioaerosol concentration measured in the test duct downstream of the UV-C device (CFU/m^3 [CFU/f^3])

$C_{upstream}$ = average culturable bioaerosol concentration measured in the test duct upstream of the UV-C device (CFU/m^3 [CFU/f^3])

This general equation is corrected for ~~statistical sampling as well as~~ system biases according to Sections 7.1 ~~and 7.2. Both corrections shall be applied to each calculation~~.

7.1 Statistical Correction for Bioaerosol Data. ~~When calculating the single-pass bioaerosol inactivation efficiency or the no-light transmission rate on the basis of the numbers of culturable organisms, the least favorable confidence limit value of the confidence interval for each count involved shall be used as the basis for the calculation (see Informative Annex H, Table H-1 and Equation H-1, for upper and lower control limits for count data). This provides a conservative estimate of the performance of the tested device.~~

~~Thus, η_{UVGI}, the single-pass bioaerosol inactivation efficiency, shall use the 95% upper control limit of the downstream counts to calculate the concentration downstream (CFU/m^3 [CFU/f^3]) and shall use the 95% lower control limit of the upstream counts to calculate the concentration upstream (CFU/m^3 [CFU/f^3]). For each collection point, the number of CFUs shall be summed and the appropriate control limit shall be determined before averaging or concentration calculations. Equation 1 becomes~~

$$\text{Single-Pass Efficiency (\%)} = \left(1 - \frac{C_{D,\,95\%UCL}}{C_{U,\,95\%LCL}}\right) \times 100\% \tag{2}$$

~~where~~

~~$C_{D,95\%UCL}$~~ = ~~downstream culturable bioaerosol concentration using 95% upper confidence limit~~

~~$C_{U,\,95\%LCL}$~~ = ~~upstream culturable bioaerosol concentration using 95% lower confidence limit~~

7.~~2~~1 Correction for No-Light Transmission Rate. There is also a potential bias in the bioaerosol measurements if the test duct and rig cause a change in the number of culturable organisms independent of the presence of a UV-C device. For this reason a no-light transmission rate (UV-C light is not turned on in the test duct) is measured and applied as an additional correction to the single-pass bioaerosol inactivation efficiency. The no-light transmission rate is calculated by measuring the numbers of culturable organisms upstream and downstream without the UV-C light turned on. The same sampling methods are used as in the single-pass bioaerosol inactivation efficiency test, but the calculation is performed using the opposite control limit values to give the most conservative estimate. The equation is as follows:

$$TR_{no\text{-}light} = \frac{C_{DN,\,95\%LCL}}{C_{UN,\,95\%UCL}} \tag{3}$$

$$TR_{no\_light} = \frac{C_{down,\,no\_light}}{C_{up,\,no\_light}} \tag{2}$$

where

TR_{no_light} = no-light transmission rate

~~$C_{DN,95\%LCL}$~~ = ~~downstream, no light, culturable bioaerosol concentration using 95% lower confidence limit~~

~~$C_{UN,95\%UCL}$~~ = ~~upstream, no light, culturable bioaerosol concentration using 95% upper confidence limit~~

$C_{down,\,no\_light}$ = downstream, no light, culturable bioaerosol concentration, CFU/m^3 (CFU/ft^3)

$C_{up,\,no\_light}$ = upstream, no light, culturable bioaerosol concentration, CFU/m^3 (CFU/ft^3)

To remove this system bias, the single-pass bioaerosol inactivation efficiency shall be corrected by the no-light transmission rate. Thus, the final corrected form of Equation 1 becomes as follows:

$$\text{Single-Pass Efficiency (\%)} = \left(1 - \frac{C_{D,\,95\%UCL}}{C_{U,\,95\%LCL} \times \text{TR}_{No-Light}}\right) \times 100\%$$

$$\eta_{UVGI,\,corr}\,(\%) = \left(1 - \frac{c_{downstream}}{c_{upstream} \times \text{TR}_{no\_light}}\right) \times 100\% \tag{3}$$

Single-pass efficiency shall be estimated for each of the three replicate experiments. Variability of the efficiency due to plating variability shall be estimated by propagating the standard deviation of concentration from the three replicate plates. The average single-pass bioaerosol inactivation efficiency shall be calculated by averaging the efficiency from the three repeat experiments, and the experimental variability shall be estimated by propagating the standard deviation due to these three experimental runs.

Delete Informative Annex H in its entirety.

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ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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