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

Public Review Draft

Proposed Addendum *b* to Standard 185.1-2015, Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms

Second Public Review (March 2020)
(Draft shows Proposed Changes to Current Standard)

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ASHRAE, 1791 Tullie Circle, NE, Atlanta GA 30329-2305

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

The use of the Poisson distribution is not appropriate for this type of biological data. The degree of correction is based on the total counts, so that a test with thousands of counts receives a tighter confidence interval than one with hundreds. This could result in very different reports efficiencies between tests. Also, since counting plates for microorganisms requires that the spots be separate, there is an upper limit on the raw counts per plate. To get high counts, there must be a great number of plates 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, this means that there must be repeated tests if one must get high counts. To achieve tight confidence intervals with these calculations would require great expense. Also, the reported efficiency for a device depends on the number of counts, so that the same device will get a different reported efficiency if 5 plates are run instead of 3, or similar.

In addition, this method of calculation does not address the issue of variability at the test lab since 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 to Reviewers: This addendum makes proposed changes to the current standard. These changes are indicated in the text by <u>underlining</u> (for additions) and ~~strikethrough~~ (for deletions) except where the reviewer instructions specifically describe some other means of showing the changes. Only these changes to the current standard are open for review and comment at this time. Additional material is provided for context only and is not open for comment except as it relates to the proposed changes.]

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 to allow measurement to show 99% inactivation. 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)

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* (ATCC®36542)

and *Mycobacterium parafortuitum* (ATCC®19686) 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:

$$\boldsymbol{\eta_{UVGI}}\,(\%) = \left(\mathbf{1} - \frac{\boldsymbol{C_{downstream}}}{\boldsymbol{C_{upstream}}}\right) \times \mathbf{100} \qquad \textbf{Equation 1}$$

where

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

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

This general equation is corrected for system biases according Section 7.1 for final reporting.

7.1 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 done using the opposite control limit values to give the most conservative estimate. The equation is:

$$TR_{no\_light} = \frac{C_{down,\ no\_light}}{C_{up,\ no\_light}} \qquad \textbf{Equation 2}$$

where

TR_{no_light} = no-light transmission rate
$C_{down,\ no\_light}$ = 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:

~~$Single-pass\ efficiency\ (\%) = \left(1 - \frac{C_{D,95\%UCL}}{C_{D,95\%LCL} \times TR_{no\_light}}\right) \times 100\%$~~

$$\eta_{UVGI,corr}\,(\%) = \left(1 - \frac{C_{downstream}}{C_{upstream} \times TR_{no\_light}}\right) \times 100\% \qquad \textbf{Equation 3}$$

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.

INFORMATIVE ANNEX H **[Was Deleted Completely with first Public Review]**