ADDENDA

ANSI/ASHRAE Addendum c to
ANSI/ASHRAE Standard 52.2-2017

Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

Approved by ASHRAE and the American National Standards Institute on January 21, 2022.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

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FOREWORD

The COVID-19 pandemic has demonstrated a pressing need for efficiency data for all air cleaners when used to remove or inactivate viruses and bacteria from air. ASHRAE has a bioaerosol inactivation test standard for testing ultraviolet light (UVC) devices only. Standard 185.1 is based on using a Standard 52.2 type duct and includes much of the same equipment and quality assurance. The main differences are the use of bioaerosols as the challenge instead of nonbiological particles and the use of bioaerosol samplers and subsequent counting to determine the upstream and downstream concentrations. The calculations used in Standard 185 are essentially a simplified version of those used in Standard 52.2.

Because Standard 52.2 is a particle-removal test standard, adding an option to test with different particles, in this case bioaerosols, seems logical. This addendum allows users the option of using the basic Standard 52.2 test rig and quality assurance with bioaerosols to determine the efficiency of an HVAC-mounted air cleaner for removal/inactivation of a bioaerosol. Note that the term "air cleaner" does include filters and other technologies.

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

Addendum c to Standard 52.2-2017

Add new Informative Appendix L as shown.

(This appendix 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 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.)

INFORMATIVE APPENDIX L
OPTIONAL METHOD FOR DETERMINING FILTER AND AIR-CLEANER EFFICIENCY IN REMOVING OR INACTIVATING AIRBORNE VIRUSES AND BACTERIA

L1. PURPOSE AND SCOPE OF OPTIONAL TEST

This appendix addresses the need, highlighted by the COVID19 pandemic, for efficiency data for air cleaners used to remove or inactivate airborne viruses and bacteria. ASHRAE Standard 185.1[L-1] only allows testing of ultraviolet (UV) devices. This appendix uses similar procedures, also based on using a Standard 52.2-type duct and including much of the same equipment and quality assurance (QA) as Standard 52.2, to allow testing of other air-cleaning devices. The main changes to Standard 52.2 are the use of bioaerosols as the challenge instead of nonbiological particles and the use of bioaerosol samplers and subsequent counting to determine the upstream and downstream concentrations. The calculations are changed from those of Standard 52.2 to those of Standard 185.1, which are a simplified version of those used in Standard 52.2, to be applicable to bioaerosol data.

This appendix presents a method that allows users to employ the basic Standard 52.2 test rig and QA along with procedures based on Standard 185.1 to determine the efficiency of an HVAC-mounted filter or air cleaner for removal/inactivation of a bioaerosol.

This test may be used in place of the efficiency portion of Standard 52.2 with or without the dust loads of Standard 52.2.

This test is intended for use with most air cleaners. However, for devices using UV-C, only those with the UV light completely contained within the device shall be tested. Uncontained UV devices shall be tested with Standard 185.1.

L2. DEFINITONS AND ACRONYMS

L2.1 Definitions to be used in addition to those listed in Section 3 of the standard are as follows:

air cleaner: device or system for removing contaminants from air in a ventilation system, building, or enclosed space. (***Note:*** Air cleaners include but are not limited to filters.)

bioaerosol: system of viable particles suspended in air. (***Note:*** Viable particles include fungi, bacteria, and viruses.)

contained UV device: an air cleaner that uses UV but keeps the light completely contained within the device.

uncontained UV device: an air cleaner that shines UV into the duct in which it is installed.

L2.2 Acronyms to be used in addition to those listed in Section 3 of the standard are as follows:

ATCC	American Type Culture Collection
CFU	colony-forming unit
MERV	minimum efficiency reporting value
PFU	plaque-forming unit

L3. TEST APPARATUS AND PROCEDURES

L3.1 Test Duct. The test duct shall comply with the requirements of Section 4 of the standard except as noted in this section.

L3.2 Bioaerosol Injection. Bioaerosol will be injected at the same location as the standard aerosol. The bioaerosol injection system shall produce an upstream challenge that meets the qualification criteria of Section L4.3. The injection system design is described in Section L5.2.

L3.3 Installation of Test Device. Installation of the test device shall be as designated by the manufacturer or equipment provider.

L3.4 Installation of Bioaerosol Sampler. One or more bioaerosol samplers shall be installed upstream and downstream of the test device. These samplers shall be collocated with the probes specified in the standard. If multiple samplers are used, they shall be located so that the inlet airstreams do not interfere with each other. The inlets of the bioaerosol samplers shall face into the airflow. Isokinetic sampling (to within 10% of a measured target flow velocity as measured by the instruments indicated) shall be used. Flow rate through the sampling system shall be measured with volumetric devices such as orifice plates or rotameters having an accuracy of ±5%.

L4. APPARATUS QUALIFICATION TESTING

L4.1 Apparatus Qualification Tests. Apparatus qualification tests shall verify quantitatively that the test rig and sampling procedures are capable of providing reliable bioaerosol measurements.

L4.2 Air Velocity Uniformity in the Test Duct. The velocity uniformity test shall comply with Section 5.2 of the standard.

L4.3 Duct Leakage Test. A duct leakage test shall be conducted as described in Section 5.9 of the standard.

L4.4 No-Device Correlation (Penetration) Test. This test shall be performed in the same way as the standard bioaerosol test described in Sections L5 and L6 but with no device in the rig. The no-device test must meet the specifications in Table L-1.

L5. BIOAEROSOL PREPARATION

L5.1 Test Organisms. The bioaerosol tests shall be conducted using an organism that is safe to work with when aerosolizing enough for a full-scale test. This will usually mean working with surrogates for human diseases. ASHRAE Standard 185.1[L-1] requires two organisms, covering the range of reasonable interest for UV-C device applications. The first organism to be used in Standard 185.1 is *Mycobacterium parafortuitum* (ATCC® 19686), and the second organism is *Aspergillus sydowii* (ATCC® 36542). These organisms are suitable to use for Appendix L testing.

Table L-1 System Qualification Measurement Requirements

Parameter	Control Limit
No device correlation (penetration)	Acceptable penetration: 0.80 to 1.20

This Appendix L test does not specify the organisms to be used, as the need will vary according to the device's intended use.

L5.2 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 generation system may include a six-jet Collison nebulizer that is based on air-atomizing spray nozzles in which a suspension of microorganisms is nebulized with compressed air and then dried. Other nebulizers are acceptable. The nebulizer used shall be able to generate particles of appropriate size for the challenge organism.

The six-jet nebulizer 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 shall be neutralized using a charge neutralizer.

L6. BIOAEROSOL TESTING

L6.1 Test Airflow Rate. The test shall be conducted using the airflow rate recommended by the filter or air-cleaner manufacturer. Airflow rate, temperature, and relative humidity shall be measured as indicated in Section 4.5 of the standard.

L6.2 Test Procedure. Bioaerosol sampling shall not be initiated until a steady-state bioaerosol challenge concentration has been established. Sampling shall be conducted simultaneously upstream and downstream of the test device or by alternating samples. For alternating samples, the first and last samples shall be the same location to compensate for any aerosol concentration drift.

L6.3 Bioaerosol Sampling Procedure. Sampling devices shall be the same type upstream and downstream. Impingers and impactors are acceptable samplers. Samplers shall be covered to avoid exposure to light or external contamination. At least three replicate samples shall be taken both upstream and downstream. All procedures shall be the same for processing of the upstream and downstream samples. Good lab practices appropriate for the sampler type shall be used and documented in the test report.

L6.4 Test Precision. Standard deviations of the upstream and downstream concentrations shall be calculated based on the CFU or PFU counts from the replicate plates.

L7. DETERMINATION OF REMOVAL/INACTIVATION EFFICIENCY

L7.1 Calculation of Uncorrected Removal/Inactivation Efficiency. The primary measure of performance within this test method is the single-pass bioaerosol removal/inactivation efficiency. This efficiency, η, shall be quantified by comparing the average bioaerosol concentration upstream and downstream of the device using the following general equation:

$$\eta\,(\%) = \left(1 - \frac{C_{downstream}}{C_{upstream}} \times 100\%\right) \qquad \text{(L-1)}$$

where

$C_{downstream}$ = average culturable bioaerosol concentration measured in the test duct downstream of the device

$C_{upstream}$ = average culturable bioaerosol concentration measured in the test duct upstream of the device

This general equation is corrected for system biases according to Section L7.2.

L7.2 Correction for No-Device Correlation (Penetration). The no-device correlation (penetration) ratio is calculated by measuring the numbers of culturable organisms upstream and downstream without the device in the duct (or with the device off if the device does not block much of

the cross-section of the test rig). The device-off option is allowed to aid in switching between the tests quickly and allow the possibility of using a single nebulizer solution for both tests. The same sampling methods are used as in the bioaerosol efficiency test. The equation is as follows:

$$P_{no\_device} = \frac{C_{down,\,no\_device}}{C_{up,\,no\_device}} \quad \text{(L-2)}$$

where

P_{no_device} = no-device correlation (penetration) ratio

C_{down,no_device} = downstream, no device, culturable bioaerosol concentration

C_{up,no_device} = upstream, no device, culturable bioaerosol concentration

To remove this system bias, the single-pass bioaerosol inactivation efficiency from Equation L-1 shall be corrected using the no-device correlation (penetration) ratio from Equation L-2. Thus, the final corrected value for the single-pass bioaerosol inactivation efficiency is as follows:

$$\eta_{corr}(\%) = \left(1 - \frac{C_{downstream}}{C_{upstream} \times P_{no\_device}} \times 100\%\right) \quad \text{(L-3)}$$

L8. REPORTING RESULTS

L8.1 Outline. This test yields a removal/inactivation efficiency for the test organism rather than a minimum efficiency reporting value (MERV). The summary section of the performance report shall include the following information:

a. Name and location of the test laboratory
b. Date of the test
c. Test operators' names
d. Device manufacturer's name (or name of the marketing organization if different from the manufacturer)
e. How the device was obtained
f. Description of the test device, including the following:
    1. Brand and model number
    2. Physical description of construction
    3. Photos of device as positioned in the test rig
g. Summary of test data
    1. Test air temperature and relative humidity
    2. Test airflow rate
    3. No-device test correlation (penetration) data
    4. Type of organism used for bioaerosol test
    5. Make and model number of bioaerosol sampler used for the test
    6. Name and address of the laboratory analyzing the samples
    7. Table of upstream and downstream CFU or PFU from the efficiency test
h. Calculated single-pass bioaerosol removal/inactivation efficiency
    1. Uncorrected removal/inactivation efficiency from Equation L-1
    2. Corrected removal/inactivation efficiency from Equation L-3

L8.2 Details of Test Data. Inclusion of all raw test data in the report is required. Data shall include details of the bioaerosol samples analysis.

L9. APPENDIX L REFERENCES

L1. ASHRAE. 2020. Standard 185.1 *Method of testing UVC lights for use in air handling units or air ducts to inactivate airborne microorganisms.*

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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.

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