



STANDARD

ANSI/ASHRAE Standard 145.2-2016
(Supersedes ANSI/ASHRAE Standard 145.2-2011)
Includes ANSI/ASHRAE addenda listed in Appendix G

Laboratory Test Method for Assessing the Performance of Gas-Phase Air-Cleaning Systems: Air-Cleaning Devices

See Appendix G for approval dates by ASHRAE and the American National Standards Institute.

This Standard is under continuous maintenance 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. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

© 2016 ASHRAE

ISSN 1041-2336



ASHRAE Standing Standard Project Committee 145.2

Cognizant TC: 2.3, Gaseous Air Contaminants and Gas-Contaminant Removal Equipment

SPLS Liaison: Keith I. Emerson

Matt Middlebrooks*, *Chair*

W. Brad M. Stanley*, *Vice-Chair*

Carolyn M.L. Kerr*, *Secretary*

Nick H. Agopian*

W. Peter Freeman*

Sanjeev K. Hingorani*

Kevin Kwong*

Chang-Seo Lee*

Paula J. Levasseur*

Christopher O. Muller*

Kartik Potukuchi*

David A. Schaaf, Jr.*

**Denotes members of voting status when the document was approved for publication*

ASHRAE STANDARDS COMMITTEE 2016–2017

Rita M. Harrold, *Chair*

Steven J. Emmerich, *Vice-Chair*

James D. Aswegan

Niels Bidstrup

Donald M. Brundage

Drury B. Crawley

John F. Dunlap,

James W. Earley, Jr.

Keith I. Emerson

Julie M. Ferguson

Michael W. Gallagher

Walter T. Grondzik

Vinod P. Gupta

Susanna S. Hanson

Roger L. Hedrick

Rick M. Heiden

Srinivas Katipamula

Cesar L. Lim

Arsen K. Melikov

R. Lee Millies, Jr.

Cyrus H. Nasseri

David Robin

Peter Simmonds

Dennis A. Stanke

Wayne H. Stoppelmoor, Jr.

Jack H. Zarour

William F. Walter, *BOD ExO*

Patricia Graef, *CO*

Stephanie C. Reiniche, *Senior Manager of Standards*

SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus Standard developed under the auspices of ASHRAE. *Consensus* is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this Standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this Standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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.

The Senior Manager of Standards of ASHRAE should be contacted for

- a. interpretation of the contents of this Standard,
- b. participation in the next review of the Standard,
- c. offering constructive criticism for improving the Standard, or
- d. permission to reprint portions of the Standard.

DISCLAIMER

ASHRAE uses its best efforts to promulgate Standards and Guidelines for the benefit of the public in light of available information and accepted industry practices. However, ASHRAE does not guarantee, certify, or assure the safety or performance of any products, components, or systems tested, installed, or operated in accordance with ASHRAE's Standards or Guidelines or that any tests conducted under its Standards or Guidelines will be nonhazardous or free from risk.

ASHRAE INDUSTRIAL ADVERTISING POLICY ON STANDARDS

ASHRAE Standards and Guidelines are established to assist industry and the public by offering a uniform method of testing for rating purposes, by suggesting safe practices in designing and installing equipment, by providing proper definitions of this equipment, and by providing other information that may serve to guide the industry. The creation of ASHRAE Standards and Guidelines is determined by the need for them, and conformance to them is completely voluntary.

In referring to this Standard or Guideline and in marking of equipment and in advertising, no claim shall be made, either stated or implied, that the product has been approved by ASHRAE.

CONTENTS

ANSI/ASHRAE Standard 145.2-2016 Laboratory Test Method for Assessing the Performance of Gas-Phase Air-Cleaning Systems: Air-Cleaning Devices

SECTION	PAGE
Foreword	2
1 Purpose.....	3
2 Scope.....	3
3 Definitions and Acronyms	3
4 Test Apparatus.....	5
5 Apparatus Qualification Testing	9
6 Test Conditions and Materials.....	16
7 Preparation of the Test Device.....	18
8 Test Procedures.....	18
9 Measurement of Resistance vs. Airflow	18
10 Determination of Performance	19
11 Reporting Results.....	21
12 Safety and Environmental Impact	22
13 References	22
Normative Appendix A: Large-Scale Test Duct—Leak Characterization and Control.....	26
Informative Appendix B: Commentary on the ASHRAE Standard 145.2 Test Method	33
Informative Appendix C: Gas-Phase Air-Cleaner Performance Theory	36
Informative Appendix D: How to Read a Test Report	39
Informative Appendix E: Application Guidelines.....	41
Informative Appendix F: Bibliography.....	45
Informative Appendix G: Addenda Description Information	47

NOTE

Approved addenda, errata, or interpretations for this standard can be downloaded free of charge from the ASHRAE website at www.ashrae.org/technology.

© 2016 ASHRAE

1791 Tullie Circle NE · Atlanta, GA 30329 · www.ashrae.org · All rights reserved.

ASHRAE is a registered trademark of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
ANSI is a registered trademark of the American National Standards Institute.

(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 objections on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

The air processed by building HVAC systems typically contains a variety of contaminants in gaseous form. The concentrations of these contaminants may vary from trace amounts in most cases to the toxic levels that can be encountered near a spill or other extraordinary event. Whenever gaseous contaminants reach unacceptable levels, or may be expected to reach such levels, air cleaning may be used to improve the usability of the space or to protect the building occupants, the HVAC system components, or the contents of the building. These concerns exist not only for commercial buildings but for industrial workspaces as well.

Gaseous air contaminants can be removed by various air-cleaning processes. This standard provides a performance test method both for individual filters and for complete devices designed to be used for full-scale commercial in-duct gaseous-contaminant air cleaning. Gaseous-contaminant air-cleaning devices of this type rely on sorptive active agents such as plain (untreated) or chemically impregnated activated carbons, activated aluminas, other adsorbent materials, or catalysts. They typically take the form of granular beds, supported or attached granules or powders, or fibrous mats. Other fabricated forms are possible. These gaseous-contaminant air-cleaning devices are those most often selected for use in building HVAC systems.

This standard describes a test procedure with quality-control constraints to measure percent removal efficiency and removal capacity of gaseous-contaminant removal devices when challenged under steady-state conditions. The test is designed to simulate the capture performance of commercially available HVAC filters under controlled, representative conditions. The filters to be tested using this standard are intended to remove gaseous contaminants that are present at low-to-modest levels and nuisance odors, thereby protecting building contents and processes and reducing corrosion. The test end-point is chemical breakthrough that exceeds a minimum removal efficiency. This test may be used to evaluate filters for use in a building designed and/or operated according to the ASHRAE Standard 62.1 IAQ procedure. This test method is not intended to test filters whose function is to protect against extraordinary events producing gaseous chemicals that are immediately threatening to the health of building occupants.

A companion small-scale, low-flow-rate version of this test procedure—ANSI/ASHRAE Standard 145.1, *Laboratory Test Method for Assessing the Performance of Gas-Phase Air-Cleaning Systems: Loose Granular Media*—provides comparable sorptive granular media challenges at a much lower nominal flow rate of 1.7 m³/h (28.32 L/min, or 1.0 ft³/min). This smaller scale provides a lower potential operator exposure

and, with its much smaller footprint, is much more amenable to local exhaust venting and allows relatively easy cleanup.

The test contaminants used may be hazardous, so the safety of those conducting the tests is of paramount importance. The primary personal hazard associated with the test method is inadvertent inhalation. This procedure incorporates a number of steps designed to reduce personal inhalation exposures, and these should be followed carefully. Merely following these steps does not, however, ensure safe operation. Each test organization is responsible for training, equipping, protecting, and monitoring the exposure of its personnel.

The laboratory test apparatus, equipment, test protocol, quality control guidelines, and equipment calibration recommendations provided are intended to achieve repeatability within $\pm 10\%$ of the measured value. Where possible, the method specifies the performance required of hardware and instrumentation rather than prescribing the specific characteristics of these items in detail. Considerable capital is required to establish a laboratory with the large-scale test apparatus and instrumentation described. Ideally, test data produced by the less complex and less costly companion small-scale test method (Standard 145.1) will ultimately allow prediction of large-scale results. However, actual large-scale testing requires minimal assumptions and may still be preferred for either critical applications or for contaminants for which minimal information on sorptive media characteristics exists in the literature.

While the methods presented in the standard can arguably be used to test gaseous-contaminant removal for any air-cleaning device that can be adapted to fit and operate properly in the test equipment, its stated scope is deliberately limited to sorptive active agents of the kind mentioned above. All gaseous-contaminant air-cleaning devices potentially may produce byproduct chemical species. The established sorptive air-cleaner active agents (e.g., carbon and alumina with the common impregnation systems, catalysts, and additives) have been used for many years, and the potential byproducts are in large part known. Testing to identify byproducts is thus not required.

Innovative technologies do not have the advantage of years of use-testing, and potential chemical byproducts are not known. Therefore, the standard is not suitable for testing innovative technologies because testing for byproduct chemicals is not addressed. The test method is also not intended to test technologies that inject or vaporize chemicals or sorptive materials into the airstream in that it does not require downstream measurement of unreacted reagent or material carry-over. Finally, the test method was not developed to allow accurate test chemical measurement from saturated airstreams, so water scrubbers and similar technologies cannot be tested by this method.

The testing under this methodology can be conducted by modifying (e.g., adding temperature and relative humidity control and instrumentation) some large-scale rigs designed previously for testing per ANSI/ASHRAE Standard 52.2, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size*. This adds versatility to the apparatus, allows switching back and forth between particle and gas testing, and increases the overall testing cost-

effectiveness. Thus, many of the requirements for Standard 52.2 are retained for this gas cleaner method and are cited by reference to this earlier document, rather than repeating them verbatim. Additionally, some characterization testing, such as contaminant dispersal uniformity ahead of the test substrate, if previously conducted for Standard 52.2 and found to be acceptable prior to the gas-phase testing, is accepted as sufficient for the gas testing of this standard as well.

The most useful performance data for gaseous-contaminant air-cleaning devices are those obtained at the design air-flow rate when challenged with the chemical contaminating the space and at the use conditions. The results of such a test best determine the air cleaner lifetime that can be expected. Many applications require control of mixed contaminants present at very low levels for extended periods (months), and in this case the test becomes excessively expensive. On the other hand, a test can be conducted according to this standard at a fixed flow rate, temperature, relative humidity, and at an elevated challenge concentration relative to expected use levels. Such a test is shorter, reducing testing cost, but the test results are directly useful only for ranking different air cleaners. A substantial body of theory and data supports extrapolation of breakthrough times for many physically adsorbed hydrocarbons across several orders of magnitude in concentration. Such extrapolation is not generally accepted for chemisorbed chemicals such as the acid gases.

Test challenge concentrations and conditions allowable under this method are presented in detail in the main sections of this standard.

1. PURPOSE

The purpose of this standard is to provide a standard laboratory test method for assessing the performance of sorptive media gas-phase air-cleaning devices. The results of these tests can provide information to the engineer useful for the design and selection of air-cleaning equipment and the design of air-cleaning systems for controlling indoor concentrations of gaseous air contaminants.

2. SCOPE

2.1 This standard prescribes a full-scale laboratory test method for measuring the performance of in-duct sorptive media gas-phase air-cleaning devices. In this context, "sorptive media" are defined as the active agent of the air cleaner, whether granular or sheet or pleated, that operate by adsorbing and/or chemically reacting with contaminant gases. This test is conducted under steady-state conditions at elevated gas challenge concentrations (relative to ventilation applications) and, therefore, should be used to compare devices rather than directly predict performance in any particular application.

2.2 The method of testing measures the performance of air-cleaning devices for removing one or more specified gaseous contaminants or gas mixtures intended to simulate operation during service life. This standard defines procedures for the dispersion of the gases required for conducting the test. It also provides a method for determining gas concentrations upstream and downstream of the air-cleaning device to calculate removal efficiency.

2.3 This standard establishes performance specifications for the equipment required to conduct the tests, defines methods of calculating and reporting results obtained from the test data, and establishes a results reporting system that can be applied to the gas-phase air-cleaning devices covered by this standard.

2.4 The test method defined by this standard is applied to a sample device that is assumed to be representative of other devices marketed with the same brand and model number.

2.5 This standard does not apply to stand-alone room air cleaners.

3. DEFINITIONS AND ACRONYMS

3.1 Definitions

Key terms are defined below for the purposes of this standard. For definitions not provided here, refer either to ASHRAE Terminology¹ or to ASTM's *Standard Terminology Relating to Activated Carbon*². Otherwise, common usage shall apply.

absorption: the transport and dissolution of a gaseous sorbate into an absorbent.

adsorbent: a material that collects sorbates by adsorption.

adsorption (physical): the adherence of a sorbate to the surface, both the outer surface and the inner pore surface, of a media by physical forces (Van der Waals forces). This is a reversible process. (See *desorption*).

airflow rate: the volumetric flow rate in the test duct.

airflow conditions: the temperature, pressure, and humidity of the air in the test duct.

breakthrough: a condition that occurs in a filter when, as contaminated air passes through a filter, the outlet contaminant concentration reaches a predetermined percentage of the challenge.

breakthrough curve: a plot of outlet percent penetration (contaminant outlet concentration divided by inlet concentration) versus time.

breakthrough time (t_x): the time elapsed between starting the challenge contaminant flow and the time at which the outlet contaminant concentration reaches the specified percentage penetration, $x\%$; the primary reporting breakthrough times are 5% (t_{b5}), 50% (t_{b50}), and 95% (t_{b95}) penetration.

bypass: the proportion of the challenge gas or vapor that passes around the sorptive media bed without contacting the media; significant bypass is typically attributed to improper sealing of the rim of the cross-sectional face of the media housing. (See *channeling*.)

capacity: the mass of a particular sorbate that can be contained in a sorbent device at stated conditions, including challenge gas, challenge concentration, relative humidity, and a specific breakthrough time (nominal 50%). Capacity is greatest at saturation (equilibrium) and lower at any lesser breakthrough condition. In general, capacity is a function of sorbate, sorbent, temperature, relative humidity (RH), and the presence of competitive sorbates.

capture efficiency: see *efficiency*.