



ASHRAE STANDARD

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

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NOTE

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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 some 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 145.1-2008, *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, it is much more amenable to local exhaust venting and allows relatively easy cleanup.

The test contaminants used may be hazardous, and 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 therefore incorporates a number of steps that are 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 (ANSI/ASHRAE Standard 145.1-2008) 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 exists in the literature on sorptive media characteristics.

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 has been 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 air stream in that it does not require downstream measurement of unreacted reagent or material carryover. Finally, the test method was not developed to allow accurate test chemical measurement from saturated air streams, 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 is that 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

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 *Terminology of HVAC&R*¹ 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 also *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