This article is based on a paper presented at the 43rd AIVC - 11th TightVent & 9th Venticool Conference "Ventilation, IEQ and health in sustainable buildings" held on 4–5 October 2023 in Copenhagen, Denmark.
Full paper: https://www.aivc.org/resource/review-international-standards-describing-air-cleaner-test-methods

Comparison of International Test Methods for Air Cleaners



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The offer of air cleaners has increased significantly since the SARS-CoV-2 pandemic. However, up till now no consensus can be found on how to determine the performance of air cleaners. This article describes the similarities and differences between test methods for air cleaners from 13 international standards.

Keywords: Air cleaners, test methods, test standards, indoor air quality, literature overview

Overview of the investigated standards

In **Table 1**, an overview is given of the 13 investigated standards. Most of the test standards only differentiate between portable air cleaners and in-duct air cleaners and not between different technologies. However, there are some exceptions to this, e.g. tests that only apply to UV-C technology.

Test method

Test apparatus

A first characteristic of the test methods is the test apparatus used. Usually, a test chamber or a test duct is used.

The test chamber is an air-tight chamber in which the air cleaning device is placed. The size of the chamber is also defined and differs among the different standards, ranging between 1 m² and around 30 m². NF B 44-200 (2016) is an exception to the other standards, which uses a small test chamber in a test bench.

The test duct is a duct with an air inlet and outlet in which the air cleaner is placed in a manner that the airflow has to pass through the air cleaner. Most standards use a test duct for a nominal device of 610 x 610 mm, which corresponds to the dimensions of the duct. Other dimensions are also possible, if the duct is adjusted to it as described in the standards.

Standard ASHRAE 145.1 (2015) is a special case. In consequence it does not use a test chamber or test duct, but a test apparatus with a gas-phase air filtration media column, which is comparable to the test duct in terms of test set-up and test method.

Test conditions

The temperature and relative humidity of the air are prescribed and do not differ much among most of the standards. Typically, a temperature ranging between 20°C to 25°C with a deviation of 0.5 to 3°C is required.

For tests using test chambers, the air inside the test chamber has to meet these requirements prior to the test, but the air is not conditioned anymore once the test starts. For test chambers, it is also stated that the incoming air has to be clean, i.e. contain a defined maximum pollutant concentration. Filters are used to clean the air that enters the test chamber.

In the case of test ducts, the supply air should be conditioned. The background concentration of the test air is also addressed in the test standards. Examples include imposing a maximum limit for the background concentration, or filtering the supply air, measuring the background concentration during the test and taking this into account in the performance calculations.

Table 1. *Overview of the test standards.*

Test standard	Title
AHAM AC-1 (2020)	Method for Measuring Performance of Portable Household Electric Room Air Cleaners
AHAM AC-4 (2022)	Method of Assessing the Reduction Rate of Chemical Gases by a Room Air Cleaner
AHAM AC-5 (2022)	Method for Assessing the Reduction Rate of Key Bioaerosols by Portable Air Cleaners Using an Aerobiology Test Chamber
ASHRAE 52.2 (2017)	Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size
ASHRAE 145.1 (2015)	Laboratory Test Method for Assessing the Performance of Gas-Phase Air-Cleaning Systems: Loose Granular Media
ASHRAE 145.2 (2016)	Laboratory Test Method for assessing the Performance of Gas-Phase Air-Cleaning Systems: Air-Cleaning Devices
ASHRAE 185.1 (2020)	Method of Testing UV-C Lights for Use in Air-Handling Units or Air Ducts to Inactivate Airborne Microorganisms
ASHRAE 185.2 (2020)	Method of Testing Ultraviolet Lamps for Use in HVAC&R Units or Air Ducts to Inactivate Microorganisms on Irradiated Surfaces
IEC 63086-1 (2020)	Household and similar electrical air cleaning appliances – Methods for measuring the performance Part 1: General requirements
EN IS0 10121-3 (2022)	Test methods for assessing the performance of gas-phase air cleaning media and devices for general ventilation - Part 3: Classification system for GPACDs applied to treatment of outdoor air
ISO 16000-36 (2021)	Indoor air - part 36: Standard method for assessing the reduction rate of culturable airborne bacteria by air purifiers using a test chamber
EN 16846-1 (2017)	Photocatalysis — Measurement of efficiency of photocatalytic devices used for the elimination of VOC and odour in indoor air in active mode. Part 1: Batch mode test method with a closed chamber
NF B 44-200 (2016)	Independent air purification devices for tertiary sector and residential applications Test methods — Intrinsic performances

Operational mode of the air cleaner / flow rate through the air cleaner

To test the air cleaning device in a test chamber, the air cleaner has to be turned on in a specific operational mode. Depending on this, the air cleaner has a different efficiency. Most standards prescribe to test at the highest operational mode or in the automatic mode, but there are exceptions to this, e.g. to test for multiple operational modes.

If a test duct is used to test the air cleaner, an airflow rate in the test duct must be specified. The way of specifying differs among the different standards. Examples are to use the upper limit of the air cleaner's application range or to use a face velocity of 2.54 m/s.

Definition of performance

When a test chamber is used, test pollutants are usually added to the air until a certain concentration is reached. Then the supply of test pollutants stops, and the decay rate is measured. A common way of expressing the performance using this test method is the Clean Air Delivery Rate (CADR), that can be calculated by multiplying the volume (m^3) of the test chamber with the decay rate (h^{-1}) of the pollutant that is caused by the operation of the air cleaner, measured in the test chamber.

Test standards using a test duct usually have a continuous supply of pollutants for the first tests, such as measuring the removal efficiency. Afterwards, the supply of pollutants stops, and other parameters will be measured, such as the desorption. Consequently, the performance is not expressed with a CADR. Other expressions of performance that can be used are the removal efficiency at a specific time, the penetration at a specific time and the capacity for removal for a time interval, all expressed as a percentage.

Duration of the test

The duration of the test also differs among the different standards. For tests using test chambers, the test duration is mostly defined as the time from reaching and measuring the initial concentration to the end of the decay test. Some standards have a shorter measurement time, that ranges from ten minutes to an hour. The differences in measurement time are due to a faster or slower decay rate of the pollutants, characteristics of the measurement device or characteristics of the air cleaner. Other standards describe a longer test duration: e.g. to let the test run until 90% of the volatile organic compounds (VOCs) are removed, with a maximum test time up to 24 hours.

For the test methods using a test duct there is a larger difference in expressing the duration of the test. Some standards clearly specify a test duration, but often the test is allowed to stop when a certain limit is reached, such as a certain breakthrough level, which means that the test pollutant appears in the effluent air.

Test pollutants

Depending on the test, different test pollutants are used. Some standards test for a broader range of pollutants, e.g. standard NF B 44-200 (2016) uses a test gas, microorganisms, an allergen and an aerosol. Other standards have a more limited scope of test pollutants. For example, standard ISO 16000-36 (2021) only tests for two bacteria.

The test pollutants are mostly either commonly used test materials for air cleaners/filters, or they represent typical pollutants of indoor/outdoor air. Another possible selection criterion is that the used organisms cover the range of reasonable interest e.g. for UV-C device applications.

Knowledge gaps and challenges

By-products

The standards almost never prescribe a test for by-products; only two of the investigated standards explicitly address the testing of by-products and some others refer to standard UL 867 to test for ozone generation levels. However, air cleaners can introduce several unintended by-products in the air, such as ozone, but also other oxidants that can be harmful to health as well. Hence, this is an important topic to address when testing air cleaners and a proper testing method for a non-targeted analysis should be set up.

Real life performance

The tests do not predict the real-life performance of the air cleaners. The test conditions and test pollutants are pre-defined, and this does not necessarily reflect the real-life conditions in which the air cleaner will be used. This would also be hard to achieve since field conditions vary from location to location. The size of the test chambers and the fact that test pollutants are not continuously added to the test chamber is also not very realistic. As a consequence, the outcome of the test can only be used to compare the performance of different devices amongst each other, but not to predict real life performance, like the cleanliness of the space where the air cleaner is used.

Long-term performance

The tests are carried out over a limited period of time. However, breakthrough in real life conditions may take weeks or months. Therefore, the capacity test is conducted at elevated challenge concentrations to shorten the test, hence reducing the costs. As a consequence, the performance data cannot be transferred to real and long-term use conditions directly. The results can be extrapolated, but this will not always be correct, so the performance over service life cannot be predicted with the results of the test.

Conclusions

The review points out that there are many differences between the investigated test standards. One of the main differences concerns the test method that is used. Using a test chamber or a test duct imposes a different way of testing, which also influences the test duration and the definition of effectiveness. In contrast, the test conditions and the operating mode/flow rate through the air cleaner show little difference. The test pollutants used vary widely, but this is partly a consequence of the targeted type of air cleaners to be tested. If a device using UV-C technology is tested for example, only the decay of microorganisms is relevant to test.

The test standards provide a method to compare the air cleaning devices, but they do not provide results on the real use performance or the long-term performance. A non-targeted analysis to search for potentially harmful by-products is also a knowledge gap in most of the test methods.

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