Institute of Environmental Sciences and Technology

IEST-RP-CC034.3

Contamination Control Division
Recommended Practice 034.3

HEPA and ULPA Filter Leak Tests

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1 SCOPE AND LIMITATIONS

1.1 Scope

This Recommended Practice (RP) covers definitions, equipment, and procedures for leak-testing high-efficiency particulate air (HEPA) filters and ultralow-penetration air (ULPA) filters in the factory as they are produced, at the job site before they are installed, and after they are installed in cleanrooms and in unidirectional-flow, clean-air devices. When used in conjunction with other RPs, including IEST-RP-CC001, IEST-RP-CC002, IEST-RP-CC006, IEST-RP-CC007, IEST-RP-CC021, and IEST-RP-CC028, this RP may be used to define the basis of an agreement between customer and supplier in the specification and procurement of HEPA and ULPA filters, and in the testing of unidirectional-flow, clean-air devices and cleanrooms.

This RP also includes procedures for measuring the uniformity of the aerosol challenge approaching the filter under test.

1.2 Limitations

This document does not cover in-place testing of banks of filters in nuclear power or nuclear research applications, nor does it cover biological safety or containment cabinets except for scanning of the filters for leaks. This document does not cover leak-testing of filters in high-temperature environments. This document provides values of acceptance limits for guidance; however, it is the responsibility of the customer and supplier to specify which leak-test method is used and the acceptance criteria for each application. A brief guideline on *in situ* leak-testing based on the procedures recommended in this RP is provided in Appendix J.

CAUTION: Testing in accordance with this RP may involve hazardous materials, operations, and equipment. This RP does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use of this RP.

2 REFERENCES

The following documents are incorporated into this Recommended Practice to the extent specified herein. If no specific edition is cited, the most recent edition should be used. Where specific editions are cited, subsequent revisions of these publications do not automatically supersede the cited editions and users should investigate the applicability of revised editions.

2.1 Reference documents

IEST-RP-CC001: HEPA and ULPA Filters

IEST-RP-CC002: Unidirectional-Flow, Clean-Air Devices

IEST-RP-CC006: Testing Cleanrooms

IEST-RP-CC007: Testing ULPA Filters

IEST-RP-CC013: Calibration Procedures and Guidelines for Select Equipment Used in Testing Cleanrooms and Other Controlled Environments.

IEST-RP-CC021: Testing HEPA and ULPA Filter Media

IEST-RP-CC028: Minienvironments

ISO 14644-1:1999 Cleanrooms and associated controlled environments—Part 1: Classification of air cleanliness

MIL-STD-282: Filter Units, Protective Clothing, Gas-Mask Components, and Related Products: Performance Test Methods

NSF/ANSI 49: Biosafety Cabinetry: Design, Construction, Performance, and Field Certification

2.2 Sources and Addresses

Referenced documents may be obtained from the following sources:

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ISO (National Standards)
IEST
Arlington Place One
2340 S. Arlington Heights Road, Suite 100
Arlington Heights, IL 60005-4516, USA
Phone: 847-981-0100
Fax: 847-981-4130
www.iest.org

MIL/QQ (Military Standard)
Standardization Document Order Desk
700 Robbins Avenue
Bldg. #4, Section D
Philadelphia, PA 19111-5094, USA
http://dodssp.daps.dla.mil/

NSF
NSF International
789 N. Dixboro Road
P.O. Box 130140
Ann Arbor, MI 48113-0140, USA
Phone: 734-769-8010
Fax: 734-769-0109
Web: www.nsf.org

3 TERMS AND DEFINITIONS

The following terms have special meaning in the context of this RP.

aerosol
A gaseous suspension of fine solid or liquid particles.

aerosol photometer
An instrument that measures mass concentrations of aerosol using the forward light scattering principle. For the applications described in this RP, the instrument should be capable of measuring aerosol concentrations of up to 100 mg/m^3 and have a threshold sensitivity capable of measuring 1 µg/m^3.

calibrated equipment
Test equipment that has been calibrated in accordance with the manufacturer's recommendations or accepted industry practices.

challenge aerosol
An aerosol derived from the selected aerosol source material and used as the leak-test challenge for a filter medium leak test. Challenge aerosols may be produced by a variety of methods, with the choice determined by the aerosol type and the particle size characteristics.

clean-air device, unidirectional flow
A clean work station or other device (other than a cleanroom or clean zone) that incorporates one or more HEPA or ULPA filters and one or more motor-blowers for the purpose of supplying unidirectional-flow, clean air to a controlled work space.

clean zone
A defined space in which the concentration of airborne particles is controlled to specified limits.

coincidence loss limit
A particle concentration level, determined by the particle counter manufacturer, that represents the point where the presence of two or more particles simultaneously in the sensing volume of the instrument causes the instrument to improperly report the combined signal erroneously as resulting from one larger particle.

count or number mean diameter of aerosol
The average particle size of the number distribution of the aerosol.

count or number median diameter of aerosol (CMD)
The 50th percentile of the number distribution of the aerosol; i.e., 50% of the particles are smaller than the count median diameter and 50% are larger than the count median diameter.

designated leak
A leak that should be detectable during scanning of a filter.

NOTE: When using a photometer, a designated leak is characterized by a standard leak penetration, which is the photometer response when the sampling probe is stationary over a leak, divided by the photometer response upstream of the filter when using a 28.3-L/min (1-ft^3/min) photometer. The designated leak is represented as greater than or equal to a value, e.g., 0.010% or 0.050%. When using a discrete-particle counter, a designated leak is characterized by a standard leak penetration and by a designated number of counts chosen to establish statistical probabilities related to its detection.

diluter
A device that reduces the particle concentration by the dilution ratio of the device. These devices typically mix a known volume of sample air with a known volume of particle-free or filtered air to achieve the dilution. The ratio of the two volumes is the dilution ratio.

discrete-particle counter (DPC)
An instrument, such as an optical particle counter or condensation nucleus counter, capable of resolving responses from individual particles.

DOP or DEHP
The mineral oil dioctyl phthalate (DOP) or di(2-ethylhexyl) phthalate (DEHP); CAS# 117-81-7. With reference to filter testing, DOP also refers to a polydisperse aerosol of the described material.

DOS or DEHS
Dioctyl sebacate (DOS) or di(2-ethylhexyl) sebacate (DEHS); CAS# 122-62-3.

field bench tests
Leak tests performed on HEPA or ULPA filters after unpacking at the location of use prior to installation in the clean-air device or cleanroom. A portable test system is used.

HEPA (high-efficiency particulate air) filter
An extended-medium, dry-type filter in a rigid frame, having a minimum particle collection efficiency of 99.97% for 0.3-µm mass median diameter particles of DOP when tested at the rated airflow in accordance with MIL-STD-282.

NOTE: The foregoing is the traditional definition for the HEPA filter. Changes in the filter manufacture, end-user requirements, and testing have introduced products that vary parametrically from filters that have been considered standard according to this definition. Additional information on this topic is given in IEST-RP-CC001.

Laskin nozzle
A nozzle used as part of a system to generate a monodisperse aerosol from a liquid, such as PAO, that uses a source of compressed gas as shown in IEST-RP-CC013.

Laskin-nozzle-generated aerosol
An aerosol generated by a Laskin nozzle from liquid dioctyl phthalate or other oil. The aerosol has a light-scattering mean diameter (mass median) of approximately 0.5 µm, with a geometric standard deviation of about 1.8. Such an aerosol has an approximate count median diameter of 0.4 µm.

leak penetration
When using a photometer, measured leak penetration is the photometer response when the probe is stationary over a leak, divided by the photometer response upstream of the filter. When using a discrete-particle counter, leak penetration is the concentration of particles counted when the probe is stationary over a leak, divided by the concentration of particles that would be counted upstream of the filter in the same time if the counter could sample upstream. Measured leak penetration depends on the photometer or discrete-particle counter flow rate. The leak can be defined as the portion (percentage) of the test instrument's sample flow that passes unfiltered through a defect in the filter or filter medium.

mass mean diameter of aerosol
The particle diameter size that is the average particle size of the mass distribution of the aerosol. Typically, because the mass of a particle varies as the cube of its diameter, most of the mass of an aerosol tends to be in the larger sizes, resulting in the mass mean being larger than its count or number mean.

mass median diameter of aerosol (MMD)
The 50th percentile of the mass distribution of the aerosol; i.e., 50% of the mass of the aerosol is made up of particles smaller than the mass median diameter and 50% of the mass of the aerosol is made up of particles larger than the mass median diameter.

most-penetrating particle size (MPPS)
The particle size at which a given filter has its highest penetration (or lowest efficiency); i.e., the worst-case particle size with respect to filtration efficiency. From filtration theory, the efficiency is higher for particle sizes smaller or larger than the MPPS. In practice, the MPPS of a filter is considered to be within a measured size range typical in commercial instruments rather than at one unique particle size.

PAO (poly-alpha-olefin)
The mineral oil PAO CAS# 68649-12-7. With reference to filter testing, PAO also refers to a polydisperse aerosol of the described material.

photometer response time constant
The time it takes for the photometer reading to reach 63% of its final value when there is a step change in aerosol concentration at the probe inlet (i.e., the time constant of the exponential response of the photometer). The response time is a function of the photometer design, the photometer scale used (e.g., full scale equals 0.10%), and the sampling system.

PSL
A term abbreviating polystyrene latex, used to refer to a common type of highly uniform spheres or a suspension thereof used to generate a monodisperse solid aerosol. PSL is useful for leak-testing filters where other aerosols may contaminate the filters in an unacceptable manner.

representative upstream sample
A sample of the aerosol upstream of the filter that is being leak-tested, used to set the 100% point of a photometer or to calculate values for discrete-particle counter scanning. In factory test systems, in field bench test systems, and in unidirectional-flow, clean-air devices, a method of obtaining a representative

upstream sample should be built into the device by the device manufacturer.

sample acquisition time
The time that the particle counter accumulates counts before automatically resetting to zero and restarting counting.

scanning
A method for disclosing leaks in HEPA and ULPA filters where the inlet of the sampling probe of an aerosol photometer or discrete-particle counter is moved in a series of parallel, slightly overlapping strokes across the test area at a distance of approximately 2.5 cm (1 in.) from the filter face and at a rate based on the leak penetration to be detected and the upstream concentration of the challenge aerosol.

standard leak penetration
The leak penetration that would be measured by a photometer or particle counter with a 28.3-L/min (1-ft^3/min) sample flow rate when the sample probe is stationary over the leak.

super ULPA (ultra-low-penetration air) filter
An extended-medium, dry-type filter in a rigid frame, made with a filter medium having a minimum particle collection efficiency of > 99.9999% (i.e., a maximum particle penetration of < 0.00010%) for particles of the most-penetrating particle size (MPPS) when tested at the average medium velocity in the filter in accordance with the methods of IEST-RP-CC021.

thermal generator
A device that produces a liquid aerosol by means of an evaporation-condensation process in the absence of controlled nucleation. The particle size distribution and mass median diameter (MMD) of an aerosol produced by a thermal generator are measurably smaller than those of an aerosol from a Laskin nozzle.

thermally generated aerosol
An aerosol generated by quenching (condensing) vapor that has been evaporated from mineral oils such as DOP or PAO by heat. The aerosol has a mass median diameter (MMD) of approximately 0.3 µm, with a geometric standard deviation of about 1.4. Such an aerosol has a count median diameter (CMD) smaller than 0.2 µm. This aerosol is also often referred to as "hot" DOP or PAO.

ULPA (ultra-low-penetration air) filter
A throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle-collection efficiency of 99.999% (that is, a maximum particle penetration of 0.0010%) when tested in accordance with the methods of IEST-RP-CC007.

unidirectional airflow
Air that flows in a single pass in a single direction through an air device or clean zone with generally parallel streamlines. **NOTE:** In past cleanroom literature, this was referred to as laminar airflow.

work zone
The volume within the clean-air device or cleanroom that is designated for clean work and for which testing is required. The work zone volume is defined by an entrance plane and an exit plane (normal to the airflow where there is unidirectional airflow).

4 BACKGROUND AND PURPOSE

HEPA and ULPA filters such as those used in cleanrooms and clean benches are tested for particle removal efficiency and resistance to airflow when they are manufactured. Frequently, these filters are scanned for leaks as an additional precaution. This scanning is performed by the filter manufacturer before the filters are packaged and shipped. The scan test may be repeated as a field bench test when the filters are unpacked at the customer's location before the filters are installed. If product is exposed or located immediately downstream of the HEPA or ULPA filter(s), a scan test is often performed after the filters are installed to verify the integrity of the filter and its installation. Typically, the scanning is repeated at regular time intervals to verify the continued integrity of the filtration system. If the filters are remote to the cleanroom (clean zone), a test to determine the total leakage of the filter installation is adequate.

Leak-testing HEPA and ULPA filters is one important part of verifying their performance. Other tests, such as those described in IEST-RP-CC001, IEST-RP-CC002, IEST-RP-CC006, IEST-RP-CC007, and IEST-RP-CC028, are also important for characterizing the performance of HEPA and ULPA filters, clean-air devices, and cleanrooms.

The choice of which test procedures are required depends on the performance level of the filters, clean-air device, or cleanroom, and on the intended application. Specific test requirements are the result of an agreement between customer and supplier.

This RP provides a set of recommended procedures for testing HEPA and ULPA filters for leaks. Two methods are provided for scanning the downstream surface of HEPA and ULPA filters for leaks. One method is provided for determining if there are leaks in inaccessible HEPA and ULPA filters. Section 5 provides guidance for selecting the appropriate leak-test method.

When purchasing HEPA or ULPA filters, or a clean-air device or cleanroom containing HEPA or ULPA filters, the appropriate sections of this RP should become part of the purchase order to define the expected performance of the filters as received.