

Institute of Environmental Sciences and Technology

IENT-RP-CC007.3

Contamination Control Division
Recommended Practice 007.3

Testing ULPA Filters



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1 SCOPE AND LIMITATIONS

1.1 Scope

This Recommended Practice (RP) describes the equipment, aerosol properties, processes, and calculations for determining the efficiency of ULPA and super ULPA filters in the factory, using particle counters. The procedure may be applied to production applications. This RP provides guidelines for constructing a suitable test duct and sampling system. Also provided are test criteria for quantifying penetration in the range of 0.0010% to 0.00010%, using test aerosol particles in the size range of 0.1 to 0.2 μm .

1.2 Limitations

Filters tested per IEST-RP-CC007 are typically factory-tested with uniform airflow across the filter. Ducted filters, fan filter units (FFUs), and poorly designed inlet housings for in-line filters may result in non-uniform media air velocity that can possibly reduce the *in-situ* filter efficiency.

1.3 Application of method

Application of this RP is by mutual agreement between the customer and the supplier. To apply this RP, the agreement should also include:

- a) acceptance criteria for penetration and pressure drop;
- b) the test aerosol;
- c) the test volume flow rate.

Prior to testing filters according to this RP, the most penetrating particle size (MPPS) should be determined. The determination can be made for the filter medium in flat sheet form, provided that the test is conducted with an aerosol as defined in section 4.2.9.

The test is performed at the same velocity as the average velocity through the medium in the assembled filter at the test volume flow rate.

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

The methodology described in this RP may be applied for particle-counter testing of filters outside the efficiency and particle size range covered in the document.

2 REFERENCES

The following documents are incorporated into this RP to the extent specified herein. Users should apply the most recent editions of the references.

2.1 Reference documents

ANSI/ASHRAE Standard 52.2-2012: Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size

Fluid Meters: Their Theory and Application (ASME)

ASME-N510: Testing of Nuclear Air-Treatment Systems

IEST-RP-CC001: HEPA and ULPA Filters

IEST-RP-CC014: Calibration and Characterization of Optical Airborne Particle Counters

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

IEST-RP-CC031: Method for Characterizing Outgassed Organic Compounds from Cleanroom Materials and Components

TAPPI-T1205: Dealing with Suspect (Outlying) Test Determinations

2.5 Sources and Addresses

ASHRAE

American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
1791 Tullie Circle, NE
Atlanta, Georgia 30329, USA
Phone: 404-636-8400
Fax: 404-321-5478
www.ashrae.org

ASME International

American Society of Mechanical Engineers
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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.

airflow

Airflow refers to volumetric flow rather than mass flow. Tests are run at the manufacturer-rated airflow or other airflow as agreed upon by the customer and supplier.

challenge aerosol

An aerosol derived from the selected aerosol source material and used as the leak-test challenge for a filter 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.

correlation ratio

The ratio of downstream counts to upstream counts with no filter in the test system.

For *sequential* counting systems, the correlation ratio represents the differences in the upstream and downstream sampling systems, such as:

- particle losses in sample lines and test duct
- diluter (if used)
- sample times

For *simultaneous* counting systems, the correlation ratio represents the same factors as for sequential counting systems, as well as the differences between the different particle counting instruments used upstream and downstream, such as:

- sample flow rate
- counting efficiency

DOP or DEHP

Diethyl phthalate (DOP) or di(2-ethylhexyl) phthalate (DEHP); CAS# 117-81-7.

DOS or DEHS

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

electret filter media

Media made of fibers that carry electrical charge on their surfaces.

HEPA (high-efficiency particulate air) filter

An extended-medium, dry-type filter in a rigid frame when tested at rated airflow having a minimum particle collection efficiency of 99.97% for 0.3- μ m mass median diameter particles of DOP when tested 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.

microspheres (or PSL)

Monodisperse or polydisperse sized particles usually made of polystyrene latex (PSL). Monodisperse particle size is traceable to the National Institute of Standards and Technology (NIST) or other national standards bodies with respect to the diameter.

NOTE: PSL refers to a common type of highly uniform spheres, or a suspension thereof, used to generate a solid aerosol. PSL is useful for leak testing filters where other aerosols may contaminate the filters in an unacceptable manner. The term latex refers to an emulsion in water of finely divided particles of synthetic rubber, plastic, or other elastomer, and is not to be confused with natural rubber latex.

monodisperse aerosol

An aerosol with a narrow particle size distribution that has a geometric standard deviation less than 1.10. For the procedures in this document, any aerosol with at least 90% of the particles between 0.1 and 0.2 μm is considered a monodisperse aerosol.

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, 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.

national metrology institute (NMI)

An organization providing national or international primary test standards used in the unbroken chain of traceability of test equipment. **NOTE:** Traceability to national metrology institute standards does not always require the use of the NMI of the country in which a calibration laboratory is located.

PAO (4 cSt poly-alpha-olefin)

A grade of PAO with a viscosity of 4 centistokes at 100 °C. With reference to filter testing, PAO also refers to a polydisperse aerosol of the described material.

particle count

The number of particles detected in a given volume of air (or in a given time period for a stable instrument sample flow rate). The number may be determined by counting discrete particles using a particle counter, or it may be deduced by calibration of a monotonic response (such as the photometric calibration of a condensation nucleus counter) of the instrument to a known concentration standard.

particle counter

An instrument capable of resolving responses from individual particles (e.g., an optical particle counter or condensation particle counter).

particle size

The apparent maximum linear dimension of a particle in the plane of observation as observed with an optical microscope, or the equivalent diameter of a particle detected by automatic instrumentation. The equivalent diameter is the diameter of a reference sphere having known properties and producing the same response in the sensing instrument as the particle being measured.

penetration

The ratio of the number of particles exiting the filter to the number of particles entering the filter, per unit time, expressed as a percentage for a stated particle size range.

observed penetration

The penetration calculated from observed counts.

true mean penetration

The penetration that would be calculated from the average observed counts, if the tests were repeated indefinitely.

UCL and LCL penetration

The 95% upper confidence limit (UCL) penetration and 95% lower confidence limit (LCL) penetration are values statistically calculated from the observed counts. There is a 95% confidence that the true mean penetration is between the UCL and LCL penetrations.

polydisperse aerosol

An aerosol that does not meet the definition of a monodisperse aerosol. For the procedures outlined in this document, the statistical mode of a polydisperse aerosol distribution should be between 0.1–0.2 μm .

polystyrene microspheres (PSL) (see microspheres)**sequential counting systems**

Test systems in which particles are counted by the same counter or counters both upstream and downstream of the filter. The counters are sequentially connected to either side of the filter, once or several times. Sequential counting systems are characterized by the need for stable aerosol and by reduced problems in correlating counters.

simultaneous counting systems

Test systems in which particles are counted simultaneously upstream of the filter, with a counter or counters dedicated to upstream counting, and downstream of the filter, with a counter or counters dedicated to downstream counting. Simultaneous counting systems are characterized by reduced need for stable challenge aerosol concentration and by difficulty in correlating counters.

super ULPA (ultralow-penetration air) filter

A throwaway, extended-medium, dry-type filter in a rigid frame, made with 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.

ULPA (ultralow-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. ULPA filters are defined and described in IEST-RP-CC001.

4 TEST SYSTEM

4.1 General

The basic components of a typical test system are shown in Figure 1. The configuration of components shown provides a test system that operates above ambient pressure. This configuration helps prevent system leaks from affecting the measurement. If the test system is below ambient pressure, small leaks can introduce sufficient particles to interfere with the measurements. In Figure 1, item 13 is a restriction or valve used to regulate the system pressure.

In designing systems, it should be recognized that large volumes, low velocities, and recirculating regions in the flow path lead to long system response times (see section 5.16).

4.2 Components

4.2.1 Inlet filter (Figure 1, item 1)

Prior to mixing with test aerosol, the test air should be cleaned to a level of less than 1% of the challenge aerosol concentration. Filtration with high-efficiency particulate air (HEPA) filters is recommended.

4.2.2 Relative humidity measurement and control (Figure 1, items 3 and 10; section A17)

Provisions should be included to maintain the relative humidity of the test airflow in the range of 30% to 70%.

4.2.3 Temperature measurement and control (Figure 1, items 3 and 10; section A16)

Temperature control is not required if the temperature remains in the range of 10 to 38 °C (50 to 100 °F). However, if the temperature is other than 21 °C (70 °F), appropriate corrections for the flow measurement device should be used to maintain the actual volumetric test flow. In addition, corrections to the measured pressure drop of the filter should be made as per section 7.6. Care should be taken to minimize temperature gradients.

4.2.4 Blower (Figure 1, item 2)

A blower of sufficient capacity to provide steady airflow at the test conditions should be used.

4.2.5 Flow measurement and control (Figure 1, item 4; sections A3, A16, A17, A18)

Equipment used for flow measurement and control should be capable of measuring actual volumetric flow at test conditions within $\pm 3\%$.

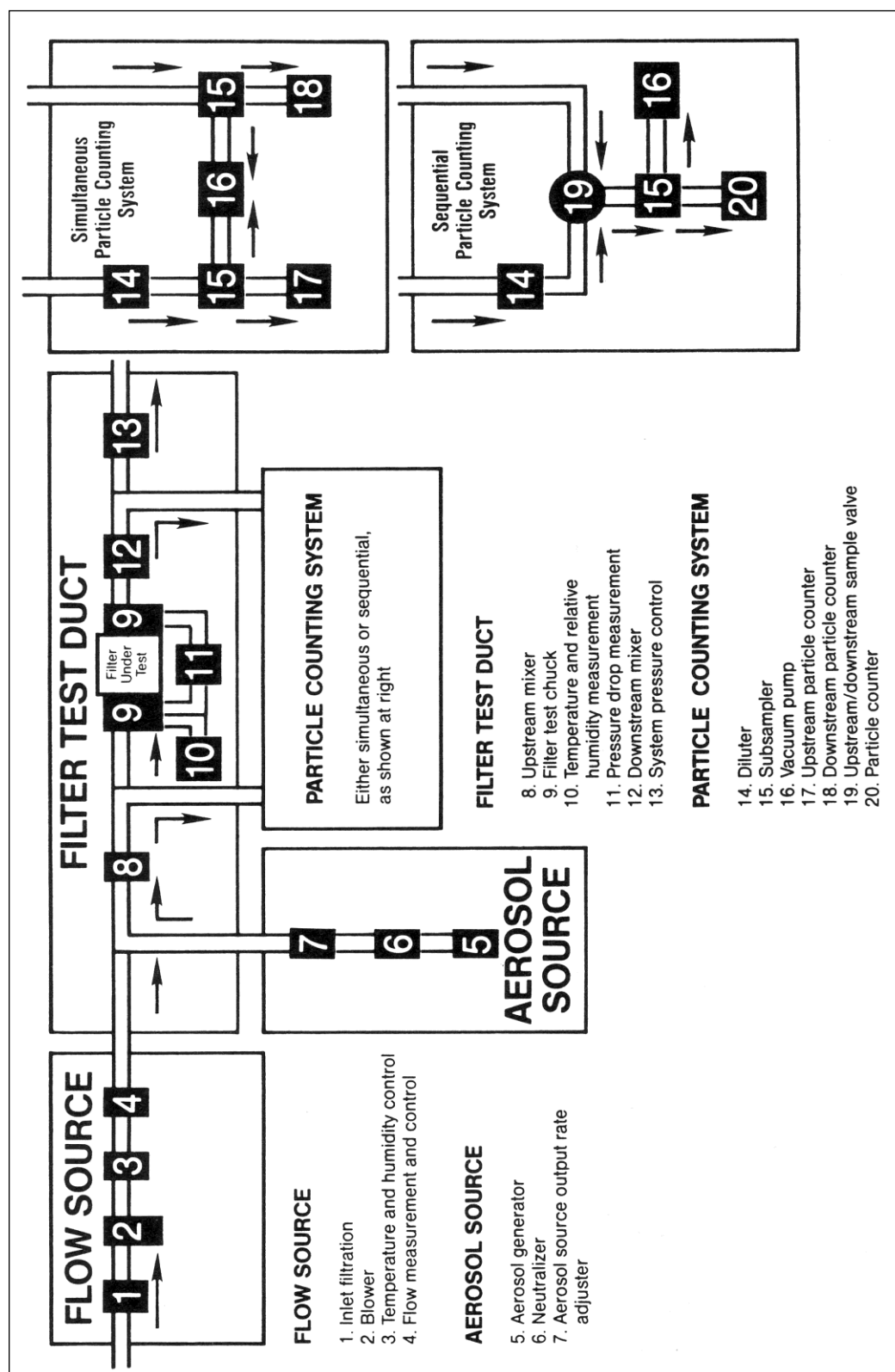


Figure 1—Block diagram of an ULPA filter test system.