

ASHRAE Guideline Project Committee 26
Cognizant TC: TC 2.4, Particulate Air Contaminants and Particulate Contaminant Removal Equipment
SPLS Liaison: Donald L. Brandt

Donald D. Thornburg, *Chair**
Monroe A. Britt
Kyung-Ju Choi
Michael D. Corbat*
Bruce Duffy*
Joe W. Fly
James T. Hanley*
Carolyn M. Kerr*
Stephen W. Nicholas

Henri A. Manz
James E. Moulton
Ted N. Schnipper*
Michael R. Strommen
Edward J. Trocha*
Varunesh Sharma
Paolo Tronville*
R. Vijayakumar*
Forwood C. Wiser

ASHRAE STANDARDS COMMITTEE 2011–2012

Carol E. Marriott, *Chair*
Kenneth W. Cooper, *Vice-Chair*
Douglass S. Abramson
Karim Amrane
Charles S. Barnaby
Hoy R. Bohannon, Jr.
Steven F. Bruning
David R. Conover
Steven J. Emmerich

Allan B. Fraser
Krishnan Gowri
Maureen Grasso
Cecily M. Grzywacz
Richard L. Hall
Rita M. Harrold
Adam W. Hinge
Debra H. Kennoy
Jay A. Kohler
Janice C. Peterson

Douglas T. Reindl
Boggarm S. Setty
James R. Tauby
James K. Vallort
William F. Walter
Michael W. Woodford
Craig P. Wray
Eckhard A. Groll, BOD ExO
Ross D. Montgomery, CO

Stephanie C. Reiniche, *Manager of Standards*

SPECIAL NOTE

This Guideline was developed under the auspices of ASHRAE. ASHRAE Guidelines are developed under a review process, identifying a guideline for the design, testing, application, or evaluation of a specific product, concept, or practice. As a guideline it is not definitive but encompasses areas where there may be a variety of approaches, none of which must be precisely correct. ASHRAE Guidelines are written to assist professionals in the area of concern and expertise of ASHRAE's Technical Committees and Task Groups.

ASHRAE Guidelines are prepared by project committees appointed specifically for the purpose of writing Guidelines. 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 Guideline.

Development of ASHRAE Guidelines follows procedures similar to those for ASHRAE Standards except that (a) committee balance is desired but not required, (b) an effort is made to achieve consensus but consensus is not required, (c) Guidelines are not appealable, and (d) Guidelines are not submitted to ANSI for approval.

The Manager of Standards of ASHRAE should be contacted for:

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

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

ASHRAE Guideline 26-2012 Guideline for Field Testing of General Ventilation Filtration Devices and Systems for Removal Efficiency In-Situ by Particle Size and Resistance to Airflow

SECTION	PAGE
Foreword.....	2
1 Purpose	2
2 Scope	2
3 Definitions, Acronyms, and Abbreviations	3
4 Test Equipment and Setup	3
5 Site Evaluation.....	6
6 Test Procedure	6
7 Expression of Results.....	10
8 Errors and Data Analyses.....	11
9 Calculation of Results.....	11
10 Optional Enhanced Test System	13
11 References	15
Informative Appendix A: Filter Installation Pretesting Inspection Form	16
Informative Appendix B: "Approval for Testing" Form.....	18
Informative Appendix C: Example of How to Complete Testing	19
Informative Appendix D: Bibliography.....	30

NOTE

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

(This foreword is not part of this guideline. It is merely informative and does not contain recommendations or requirements necessary for conformance to the guideline.)

FOREWORD

The purpose of this guideline is to provide a test procedure for evaluating the in-situ performances of general ventilation filtration devices and systems. Although any filter with an ASHRAE Standard 52.2-2010 efficiency from MERV 1-16 could theoretically be tested using this guideline, it may be difficult to achieve statistically acceptable results for filters with performance below a typical MERV 11 value.

Supply air to the HVAC system contains viable and non-viable particles of a broad size range. Over time, these particles will cause problems for fans, heat exchangers, and other system parts, decreasing their function and increasing energy consumption and maintenance. For health issues, the fine particles ($<2.5\ \mu\text{m}$) are the most detrimental.

The method of testing measures the performance of air-cleaning devices in removing particles of specific diameters. It describes a method of counting particles of 0.3 to $5.0\ \mu\text{m}$, both upstream and downstream, in the air-cleaning devices and air-cleaning systems in order to calculate the removal efficiency by particle size. Resistance to airflow is also measured.

Particles in the size range 1.0 to $5.0\ \mu\text{m}$ are present in low numbers (less than 1% by count) in outdoor and supply air and have higher sampling-system losses. Results in the range $>1.0\ \mu\text{m}$ will therefore have lower accuracy, so the results should be interpreted with respect to this.

Particles in the 0.3 to $5.0\ \mu\text{m}$ size range are typically measured by particle counters that can determine the concentration of particles in specific size ranges. These instruments are commercially available and will determine particle size along with the concentration level by several techniques (e.g., light scattering, electrical mobility separation, or aerodynamic drag). Devices based on light scattering are currently the most convenient and commonly used instruments for this type of measurement and are, therefore, the type of device used within this guideline.

During in-situ measurement conditions, the optical properties of the particles may differ from the optical properties of the particles used for calibrating the particle counter and testing it in the laboratory. Thus, the particle counter could size the particles differently but count the overall number of particles correctly.

By adding an extra reference filter, the effect of varying measuring conditions can be reduced. Additionally, using this enhanced test method, the results can be used to correct the measured efficiencies in relation to the efficiency of the reference filter measured in laboratory using a standardized test aerosol.

The results from using the standard method or the enhanced method will give both users and manufacturers a better knowledge of actual filter and installation properties.

It is important to note that field measurements generally result in larger uncertainties in the results compared to laboratory measurements. Field measurements may produce uncertainty from temporal and spatial variability in particle

concentrations, from limitations on sampling locations due to air-handling unit configurations, and from the use of field instrumentation. These factors may result in lower accuracy and precision in the calculated fractional efficiencies as compared to laboratory measurements. It is the intent of this guideline to provide a practical method in which the accuracy and precision of the result are maximized (and the precision of the result quantified) by recommending appropriate sampling locations, sample quantities, and instrumentation. This guideline is not intended to serve as a filter performance rating method.

The guideline also describes performance specifications for the equipment and defines methods of calculating and reporting the results.

This is a revision of ASHRAE Guideline 26-2008. This guideline was prepared under the auspices of ASHRAE. It may be used, in whole or in part, by an association or government agency with due credit to ASHRAE. Adherence is strictly on a voluntary basis and merely in the interests of obtaining uniform standards throughout the industry.

The changes made for the 2012 revision were as follows:

- Updated references
- Minor editorial changes

ACKNOWLEDGMENT

The ASHRAE Guideline Project Committee would like to thank Eurovent for allowing ASHRAE to build upon the excellent work this organization published with Eurovent 4/10-2005, *In Situ Fractional Efficiency Determination of General Ventilation Filters* (see Informative Appendix D—Bibliography). Without the help of Eurovent, this project would have been more difficult and time consuming to complete.

1. PURPOSE

To establish a guideline for evaluating the removal efficiency by particle size and the resistance to airflow of an air-cleaning device as installed in a field HVAC system. The guideline includes a separate procedure for evaluating particulate filtration system efficiency for systems that meet the defined criteria.

2. SCOPE

This guideline describes a procedure for measuring the performance of general ventilation air-cleaning devices in an end-use installed configuration. The performance measurements include removal efficiency by particle size and the resistance to airflow. The procedures for test include the definition and reporting of the system airflow.

The procedure describes a method of counting ambient air particles of 0.3 to $5.0\ \mu\text{m}$ upstream and downstream of the in-place air cleaner(s) in a functioning air-handling system. The procedure describes the reduction of particle counter data to calculate removal efficiency by particle size.

Since filter installations vary dramatically in design and shape, a protocol for assessing the suitability of a site with regard to filter and system evaluation is included. When the

evaluated site conditions meet the minimum criteria established for system evaluation, the performance evaluation of the system can also be performed according to this procedure.

The procedure for testing also describes performance specifications for the testing equipment and defines procedures for calculating and reporting these results. This procedure is not intended for measuring performance of portable or movable room air cleaners. This guideline is not intended for evaluation of HEPA and ULPA filter installation(s).

3. DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

3.1 Definitions

air filter bypass: unfiltered air that passes through the air-handling unit (AHU) filter installation but remains unfiltered because it bypasses the installed air filters.

air velocity: the rate of air movement at the filter expressed in m/s (fpm) to three significant figures.

allowable measurable concentration of the particle counter: 50% of the maximum accurately measurable concentration as stated by the manufacturer of the particle counter.

coefficient of variation (CV): the standard deviation of a group of measurements divided by the mean.

diluter/dilution system: a system for reducing the sampled concentration to avoid coincidence error in the particle counter.

filter efficiency: the removal efficiency of a filter as determined by this guideline, where upstream and downstream particle count measurements are taken close to the filter being tested.

filter installation: filtration devices and systems, such as a single filter or a group of filters mounted together, with the same inlet and outlet of air. This definition covers both devices and systems.

general ventilation: the process of moving air into or about a space or removing it from the space. The source of ventilation air is either air from outside the space, recirculated air, or a combination of these.

isoxial sampling: sampling in which the flow in the sampler inlet is moving in the same direction as the flow being sampled.

isokinetic sampling: sampling in which the flow in the sampler inlet is moving in the same direction and at the same velocity as the flow being sampled.

particle counter: an instrument, such as an optical particle counter, that uses the technique of light scattering for determination of particle count by size.

particle size range: a defined particle counter channel.

reference filter: a small dry media-type filter that has been laboratory tested for removal efficiency by particle size according to ASHRAE Standard 52.2-2010.¹ It can be used in Section 10, "Optional Enhanced Test System."

removal efficiency by particle size: for a given particle-size range (particles between two diameter values), the removal efficiency is the ratio of the number of particles retained by the filter to the number of particles fed upstream of the filter.

resistance to airflow: the loss of static pressure caused by the filter and filter loading. The pressure loss is measured with the filter operating at the measured air velocity and expressed in Pa (in. wg) to two significant figures.

system efficiency: the removal efficiency of a filter system where upstream and downstream particle count measurements may be across several filter banks or other system components.

3.2 Acronyms and Initialisms

AHU	air-handling unit
CV	coefficient of variation
HEPA	high-efficiency particle air
HVAC	heating, ventilating, and air-conditioning
MERV	minimum-efficiency reporting value
OPC	optical particle counter
RH	relative humidity
ULPA	ultra low-penetration air
VAV	variable air volume
VFD	variable-frequency drive

4. TEST EQUIPMENT AND SETUP

4.1 Particle Counter. The particle counter should be capable of measuring particles in the size range 0.3 to 5.0 μm , in a minimum of four ranges, with a minimum of two ranges below 1.0 μm (e.g., 0.3–0.5, 0.5–1.0, 1.0–2.0, and 2.0–5.0 μm). For maintenance and calibration of the particle counter, see Section 4.9, "Test Equipment Maintenance and Calibration."

4.2 Diluter. A dilution system capable of diluting the aerosol concentration so the particle concentration level is within the acceptable concentration limits may be used. Choose a suitable dilution ratio so that the measured concentration of particles is well within the allowable measurable concentration limits of the particle counter in order to achieve good statistical data (see Section 9.1.2, "Minimum Upstream Concentration"). If a dilution system is used, it is to be used for both upstream and downstream sampling. The dilution system shall not change airflow to the particle counter.

4.3 Pump. A pump may be used to control the rate of the sample flow q_s through the sampling probes. A pump is not necessary when the counter flow q_{pc} to the counter or diluter is sufficient for isokinetic sampling. In this case, the sample flow q_s and the counter flow q_{pc} are the same.

4.4 Sampling System. Figure 4-1 shows the elements of a typical sampling system.

4.4.1 Sampling Probes. The sampling probe should consist of a sharp-edged nozzle connected to the sample line leading to the auxiliary pump or particle counter. The diameter of the nozzle is dependent on the sample flow q_s in order to get isokinetic sampling. The diameter should not be less than 8 mm (0.31 in.).

4.4.2 Sampling Lines. Sampling lines upstream and downstream should be of equal length and as short as possible

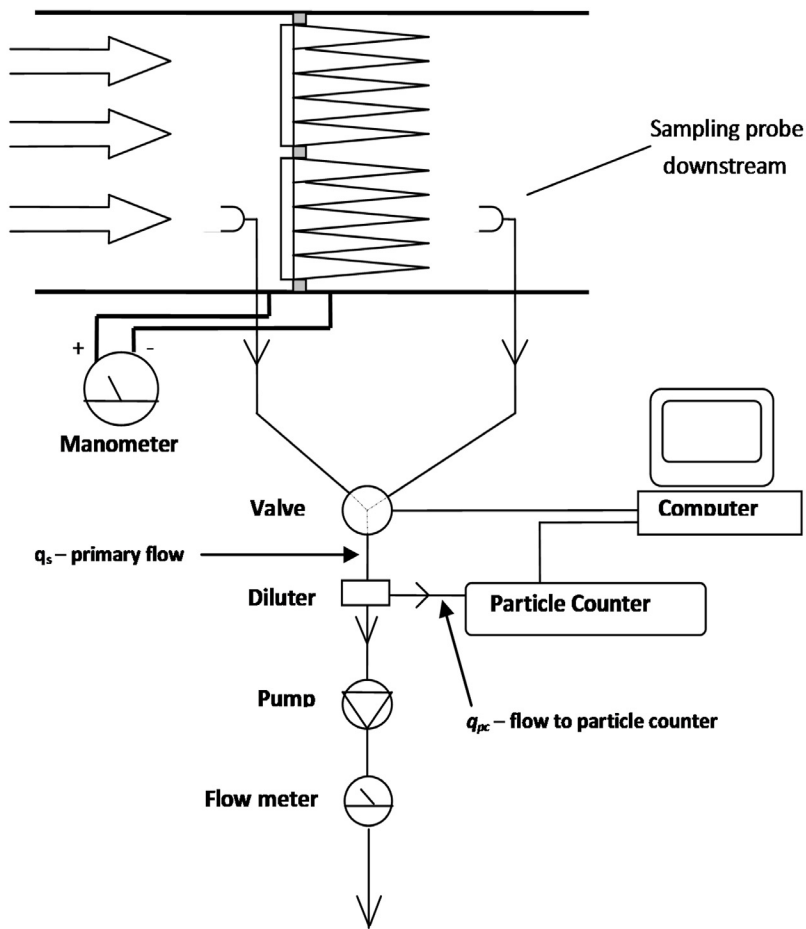


Figure 4-1 Sampling system.

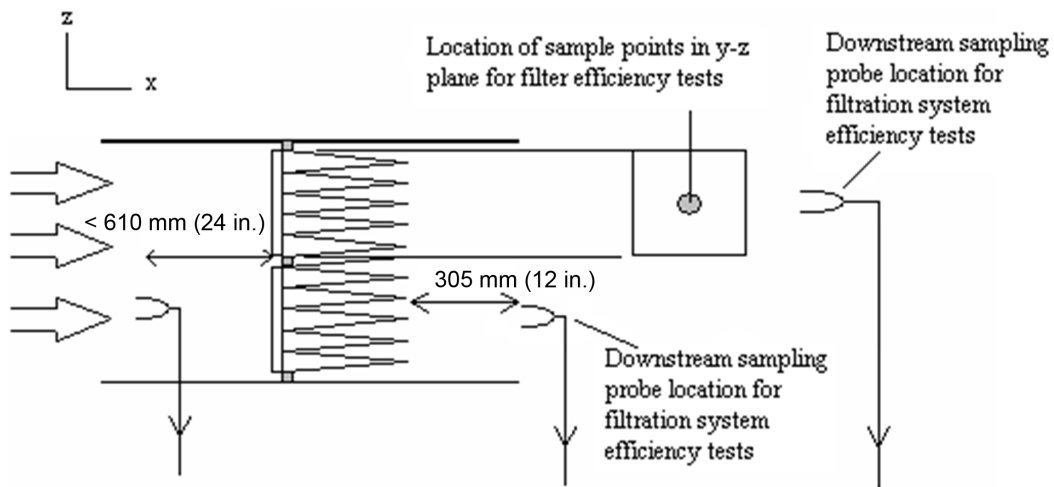


Figure 4-2 Sample locations.

to avoid losses. Material should preferably be of a type with minimum particle losses for filter installations. Software is available to calculate line losses.²

4.4.3 Sampling Locations. Sampling locations should be placed close to the filter, as shown in Figure 4-2. If the system efficiency is to be tested, the sampling locations should be further away to achieve good mixing of airflow through filters, frames, doors, etc. A measurement of system efficiency is more difficult; therefore, it is a good practice to plan the measurement carefully and describe in detail how it was made.

4.4.4 Valve (Manual or Automatic). A valve may be used to switch between upstream and downstream sample locations. The valve should be constructed so that particle losses are identical in upstream and downstream measurements. No influence on efficiency due to the valve construction is permitted (e.g., four-point ball valves of sufficient diameter may be used).

4.4.5 Isoaxial Sampling Nozzle. If a pump (Section 4.3, “Pump”) is used to obtain isokinetic sampling, the sample line should then be fitted with an isoaxial sampling nozzle directly connected to the particle counter or diluter, as shown in Figure 4-3.

4.4.6 Flowmeter. A flowmeter is necessary if a pump is part of the sampling system. The flowmeter should be located in line with the pump inlet or outlet.

4.5 Air Velocity Measurement Instrument. The instrument used to measure the air velocity should have sufficient operational limits such that the system airflow is within the limits of the instrument. The instrument should be chosen in accordance with Chapter 36, “Measurement and Instruments,” of the 2009 *ASHRAE Handbook—Fundamentals*.³ An instru-

ment that records data values and will average those values is recommended. Ideally, the instrument should have the ability to correct measurements to standard sea-level conditions.

4.6 Relative Humidity (RH) Measurement Instrument.

The instrument used to measure the RH of the system airflow should be chosen in accordance with Chapter 36, “Measurement and Instruments,” of the 2009 *ASHRAE Handbook—Fundamentals*.³ An instrument that records data values and will average those values over time is recommended.

4.7 Temperature Measurement Instrument.

The instrument used to measure the temperature of the system airflow should be chosen in accordance with Chapter 36, “Measurement and Instruments,” of the 2009 *ASHRAE Handbook—Fundamentals*.³ An instrument that records data values and will average those values over time is recommended.

4.8 Resistance to Airflow Measurement Instrument.

The instrument used to measure the resistance of the filter bank should have sufficient operational limits such that the filter bank resistance is within the limits of the instrument. The instrument should be chosen in accordance with Chapter 36, “Measurement and Instruments,” of the 2009 *ASHRAE Handbook—Fundamentals*.³ An instrument that records data values and will average those values over time is recommended.

4.9 Test Equipment Maintenance and Calibration.

Maintenance items and schedules should conform to Table 4-1, “Apparatus Maintenance Schedules.”

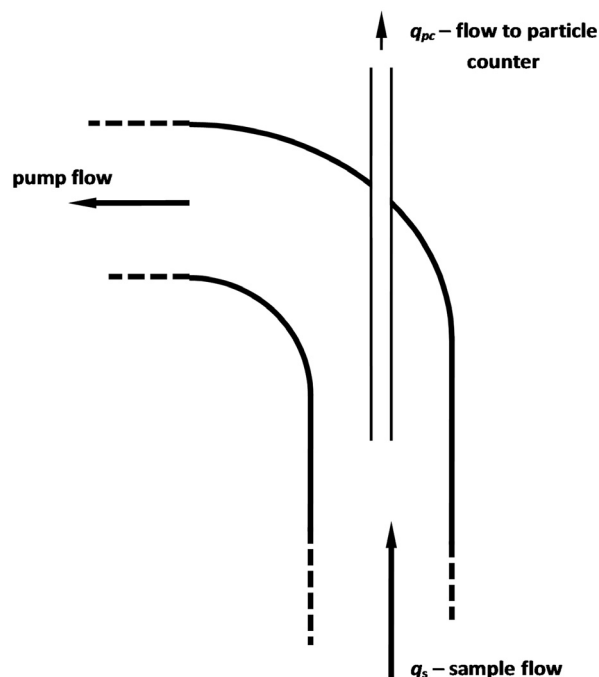


Figure 4-3 Isoaxial sampling line to particle counter.

TABLE 4-1 Apparatus Maintenance Schedules

Maintenance Item	Incorporated into Each Test	Annually	After a Change that May Alter Performance	Comment
Particle counter zero check	×			
Sampling system zero check	×			
Resistance to airflow	×			
Air velocity	×			
Temp, RH in sample airstream and at particle counter	×			
Upstream concentration test	×			
Reference filter test (field)	Optional			
Reference filter test (lab)		×	×	
Particle counter primary calibration		×	×	
Temp, RH, air velocity, resistance to airflow equipment calibration		×*	×	* or as required by equipment manufacturer
Dilution system ratio Check		×	×	
Check sample probes for damage	×			

5. SITE EVALUATION

This section identifies the recommended minimum site requirements for performing a removal efficiency test.

5.1 Filter Installation Pretesting Inspection. Pre-inspection of filters and air-handling units is necessary to determine whether a filter installation is suitable for evaluation using this guideline. It is also used to gauge whether any potentially hazardous conditions exist that would exclude or restrict access to the air-handling unit.

Items to inspect include (but are not limited to) those provided in Informative Appendix A, “Filter Installation Pretesting Inspection Form.”

5.2 Approval for Testing. Once the pretesting inspection has been completed and the filter installation determined to be suitable for testing, then the “Approval for Testing” form should be completed and signed by representatives of the building owner or manager and the company performing the testing. A suitable form is shown in Informative Appendix B, “Approval for Testing Form.”

6. TEST PROCEDURE

6.1 Air Velocity. Air velocity through the filter installation should be maintained constant for the duration of the test. This is possible if the fan speed is controllable through a variable-frequency drive (VFD) or variable air volume (VAV) boxes, and other modulating dampers are not allowed to adjust. In addition, the percentage of outside air in supply air should also be kept constant to reduce fluctuations in particle count that would influence the test results.

The air velocity at the face of the filters should be measured using the instrument identified in Section 4.5, “Air Velocity Measurement Instrument.” Air velocity measurements may be taken either upstream or downstream of the

filters, but downstream is recommended. Since air velocity can vary significantly over the area of a filter installation, sampling points should be chosen such that measurements are taken at a minimum of 25% of the filters and are distributed uniformly over the area of the filter installation. The measurement device should be extended away from turbulence caused by personnel or other obstructions. The velocity coefficient of variation (CV) (see Section 9.3, “Coefficient of Variation”) should be less than 25%.

Air velocity measurements should be conducted as close in time to resistance to airflow and removal efficiency testing as possible to ensure that the system air velocity does not change significantly between the time of the velocity measurements and the time of the resistance to airflow and removal efficiency tests. Preferably, air velocity measurements should be conducted before and after the resistance to airflow and removal efficiency testing, and the velocity measurements averaged.

Example: 1st Test: velocity measurement (average velocity = 2.0 m/s [394 fpm])
 2nd Test: resistance to airflow measurements
 3rd Test: removal efficiency testing
 4th Test: velocity measurements (average velocity = 2.2 m/s [433 fpm])

In this example, the reported average velocity would be 2.1 m/s (414 fpm).

More frequent velocity measurements may be taken in systems exhibiting a high degree of variability in velocity over time.

6.2 Relative Humidity. The instrument(s) identified in Section 4.6, “Relative Humidity (RH) Measurement Instrument,” should be used for these measurements. It is recommended that the RH of the air passing through the filter installation be within the range of the particle counter and/or