Camfil Farr

Technical Services Bulletin

HEPA/ULPA Cleanroom Filter Testing

Protocols Utilized in Camfil Farr Facilities

Filter Classifications

Quite a few inaccuracies and erroneous "jargon" are commonplace in the high efficiency filtration industry. One of the key issues pertains to nomenclature (i.e., HEPA, ULPA, VLSI, SULPA, etc.). This issue involves misconceptions regarding a filters efficiency and the relationship to particle size.

CEN, the *Comite European de Normalization*, has developed a Standard, *EN 1822-1:1998*, based on particle counting at the Most Penetrating Particle Size (MPPS). This European Standard applies to High Efficiency Particulate Air (HEPA) and Ultra Low Penetration Air (ULPA) filters used in the field of ventilation and for technical processes (e.g., for clean room technology or applications in the nuclear and pharmaceutical industries).

Key definitions from this Standard include:

Penetration — The ratio of the particle count downstream of the filter to the particle count upstream.

Efficiency — The ratio of the number of particles captured by the filter to the number of the particles challenging the filter.

Overall Efficiency/Penetration — The efficiency/penetration averaged over the "superficial/useable" face area of a filter element under given operating conditions of the filter.

Superficial/Useable Face Area — The cross-sectional area of the filter element, through which the air passes.

Local Efficiency/Penetration — The efficiency/penetration at a specific point on the superficial/useable face area of the filter element under given operating conditions of the filter.

CEN Classification: HEPA/ULPA Filters EN 1822-1:1998

Filter Class	Overall Value (%)		Local Value (%)	
	Efficiency	Penetration	Efficiency	Penetration
H 10	85	15	---	---
H 11	95	5	---	---
H 12	99.5	0.5	---	---
H 13	99.95	0.05	99.75	0.25
H 14	99.995	0.005	99.975	0.025
U 15	99.9995	0.0005	99.9975	0.0025
U 16	99.99995	0.00005	99.99975	0.00025
U 17	99.999995	0.000005	99.999975	0.000025

Leak Threshold — Local penetration greater than or equal to five (5) times the filters overall penetration.

This Standard allows a classification of filters in terms of efficiency and is, therefore, useful for both buyer and seller.

Basic Test Protocols

Leak Scanning

Camfil Farr leak tests each Megalam Panel and Ducted Ceiling Module HEPA/ULPA filter. Testing is performed in Class 100 (M3.5) clean zones within a Class 10,000 (M5.5) cleanroom. All testing is conducted per the controlled and documented procedures of Camfil Farr's *ISO 9001* certified quality system.

To enhance upstream sampling capability, leak-scanning systems are equipped with dilution equipment for measuring high particle concentrations. Probe geometry has been optimized to maximize traverse rate and eliminate undetected leaks while maintaining isokinetic sampling. The entire face of the filter is scanned with overlapping strokes including the media to frame interface. Per customer requirements, Polystyrene Latex Spheres (PSL) is Camfil Farr's standard challenge aerosol.

Any leak with a penetration exceeding five (5) times the filters average rated penetration, is repaired with an alcohol based silicone sealant per industry standards or customer specifications. Polyurethane and other repair materials are available upon request.

Menu-driven, computer controlled auto-scanning is utilized for standard filter configurations. Manual scanning is performed for small quantity, custom filter designs/sizes and leak repair.

Filter Media Efficiency Testing

Per Camfil Farr raw goods supplier specifications, suppliers are required to test each master roll of Camfil Farr filtration media for efficiency utilizing Condensation Nuclei Counters (CNC) & Q127 Penetrometers. Test results are submitted to Camfil Farr for review & material acceptance prior to release authorization.

Filter Efficiency Testing

Manual Scan: Camfil Farr's computer integrated system gathers efficiency information from a fully encapsulated filter. The system features simultaneous upstream and downstream data collection. If the efficiency is lower than specified, the filter is rejected.

Auto-Scan: The discrete data points generated during the scan test are integrated to calculate the test filters global efficiency. If the efficiency is lower than specified, the filter is rejected.

Filter Media Pressure Drop Testing

Per Camfil Farr specifications, approved suppliers test each lot of media for pressure drop. Test results are submitted to Camfil Farr for review & material acceptance prior to release authorization.

Filter Pressure Drop Testing

Manual Scan: During the test, the system continuously monitors and collects filter pressure drop data. If the pressure drop is higher than specified, the filter is rejected.

Auto-Scan: During the scan test, the system continuously measures the filters pressure drop. If the pressure drop is higher than specified, the filter is rejected.

Manual Scanning Protocol

Depending on customer requirements, either Photometer or Particle Counter manual scanning techniques are utilized. Typically, depending upon the detection equipment selected, a solid aerosol (i.e., PSL - Polystyrene Latex spheres) is used. Probe geometry has been optimized to maximize traverse rate and eliminate undetected leaks while maintaining isokinetic sampling. A summary of Camfil Farr's manual scanning protocol follows:

1) Typical test aerosol concentration is:
   PSL (Polystyrene Latex) > 5 x 107 N/ft3

2) Typical scan speed is 1.5 – 2.0 inches/second.

3) Testing: The entire face of the filter is scanned with overlapping strokes with particular attention given to the media pack to frame seal.

   A. Particle Counter Scanning: If a particle count is detected, the operator checks the area for continuous counts. If continuous counts in excess of the specified leakage threshold are detected, the leak is repaired.

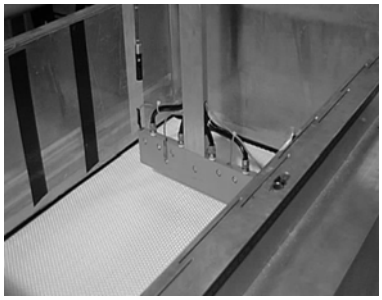
   B. Photometer Scanning: If a discernable displacement of the % Penetration indicator occurs, or the alarm sounds, the operator re-checks the area of concern. If the % Penetration indicator displacement exceeds the specified leakage threshold, the leak is repaired.

4) Leak Repairs: If a leak exceeds the specification, it is repaired with a silicone sealant. Alcohol-based silicones and polyurethane are also available for use as leak repair materials. After a repair has been made, the entire filter face is re-scanned.

Note: Photometer Scanning is generally reserved for HEPA filters, while Particle Counter Scanning is used for ULPA filters and/or for customers with stringent outgassing requirements.

Auto-Scanning Protocol

Camfil Farr Auto-Scanners have been designed to detect pinhole leaks in HEPA/ULPA filters. The test apparatus is an automated, computer-controlled system, utilizing multiple particle counters for accuracy. Polystyrene Latex (PSL) is the standard challenge aerosol. To further enhance system sensitivity, Camfil Farr uses advanced dilution equipment for



Camfil Farr's exclusive auto-scan process ensures leak free filter performance

measuring high upstream particle concentrations. The automated system eliminates the possibility of incorrect test results that can result from human error. The computer interface controls filter airflow rate, test aerosol injection, particle counting upstream and downstream of the test filter, probe traverse rate, data reduction and data storage. A description of system parameters follows:

1) System protocol includes:

a) Aerosol Concentration:
PSL concentration = 3 x 10^8 N/ft^3 (typical)

b) Particle Counter Flow =
1 CFM (cubic foot per minute)

c) Sampling = Isokinetic

d) Sample Time = Continuous

e) Size Range =
0.1 – 0.5 m (0.1 m band widths)

2) Required operator input:

a) Min./Max. and Rated Efficiency

b) Leakage factor (per customer specification

c) Dilution ratio

d) Min./Max. and Rated Pressure Drop

e) continuous upstream sampling during the scan process

f) Programmed to automatically traverse the filter with overlapping strokes. Proximity sensors (mounted in the probe) monitor the probes location with regard to the clamping frame, ensuring that the probe overlaps the media to frame interface along the filters perimeter.

g) The system utilizes the Rated Efficiency, Leakage Factor and Dilution Ratio inputs comparing downstream samples, from the entire scan, with the average upstream sample to determine if a leak exists.

h) If a leak is detected, a reject report is generated that indicates the magnitude and location of the leak.

i) Measuring pressure drop continuously across the filter. If the pressure drop is higher than specified, the filter is rejected.

j) Calculating global efficiency by integrating the discrete data points collected during the scan test. If the efficiency is less than specified, the filter is rejected.

The scan rate is calculated per IEST-RP-00001.3 Section 9.2.2:

$$S_r = C_c L_s F_s D_p/(60N_I)$$

Where:

C_c is the challenge concentration in particles/ft^3

L_s is a significant leak in terms of standard penetration

F_s is the sample flow rate in CFM

D_p is the probe dimension expressed in inches parallel to the scan direction

N_I is the number of particle counts that define the maximum leak

60 is the conversion factor from seconds to minutes.

Camfil Farr specifies that the variable N_I is to be set to twice the particle counter background level or a minimum of 25.

Camfil Farr's Cam Count Efficiency Testing Protocol

Camfil Farr's Cam Count efficiency test system is designed to test HEPA/ULPA filters per IEST-RP-CC007.1 and EN1822. All testing is performed per the controlled & documented procedures of Camfil Farr's ISO 9001 certified quality system.

Camfil Farr's Cam Count efficiency test system has been designed to measure the overall efficiency and pressure drop of HEPA/ULPA filters. The test apparatus is an automated, computer controlled system, utilizing a single laser particle counter for accuracy. Poly Alpha Olefin (PAO) is the standard challenge aerosol.

A Poly Styrene Latex Sphere (PSL) test aerosol is also available upon request and is utilized on all high temperature filters. To further enhance system sensitivity, Camfil Farr uses advanced dilution equipment for measuring high upstream particle concentrations. The automated system eliminates

the possibility of incorrect data that can result from human error. The computer interface controls the flow rate, the test aerosol injection, particle counting upstream and downstream, and data collection, reduction and storage. A description of system parameters follows:

1) System protocol includes:

a) Aerosol Concentration:

PAO concentration = 3 x 10^8 N/ft^3 (typical)

PSL concentration = 1-3 x10^8 N/ft^3

b) Particle Counter Flow = 1 CFM (cubic foot per minute)

c) Sample Time = 20 second upstream & downstream sequentially (typical)

d) Size Range = 0.1 – 0.5 mm, 0.1 – 0.2 mm, 0.2 – 0.3 mm, 0.3 – 0.5 mm, and > 0.5mm.

2) Required operator input:

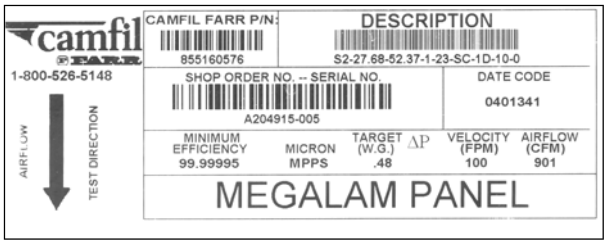
a) Minimum, maximum, & target efficiency

b) Minimum, maximum, & target pressure Drop

c) Test flow rate

3) System Operation:

The system sequentially measures the upstream & downstream particle concentration. After applying the dilution ratio to the upstream concentration, it calculates the filter efficiency, while simultaneously measuring the filter pressure drop using a calibrated pressure transducer. These values are automatically compared to the input minimum & maximum values. A filter with values outside the specified range is rejected. The system automatically generates a test label that includes the test results for each passing filter.



The system automatically generates a test label that includes the test results for each passing filter.

UL 900

Camfil Farr Megalam Panel and Ducted Ceiling Module type HEPA/ULPA filters are listed with Underwriters Laboratories per UL 900, "Standard for Test Performance of Air Filter Units" as either of the following:

> Class 1: "those that, when clean, do not contribute fuel when attacked by flame and emit only negligible amounts of smoke".
>
> Class 2: "those that, when clean, burn moderately when attacked by flame or emit moderate amounts of smoke, or both".

Please call factory for the specific rating of your product (s).

Factory Mutual

Camfil Farr's Megalam Panel and Ducted Ceiling Module type HEPA/ULPA filters meet the approval requirements of *Factory Mutual Research Corporation* (FM) for product construction of limited combustibility, when installed in an approved ceiling grid. For this approval, FM tests the filter as a component in a complete ceiling grid system.

During the ten (10) minute fire exposure test for *Factory Mutual Standard FM-4920* ceiling system approval, there was no visible ignition of the Camfil Farr filter and no flame spread. For this test, the ceiling system tested was composed of a third party ceiling grid, third party gel sealant, and Camfil Farr filter. The complete system passed all technical requirements of the standard.

References:

Printed copies of referenced documents may be purchased from the following entities:

CEN

European Committee for Standardization
36 rue de Stassart, B - 1050 Brussels
Tel: + 32 2 550 08 11; Fax: + 32 2 550 08 19

IEST

Institute of Environmental Sciences and Technology
5005 Newport Drive, Suite 506, Rolling Meadows, IL 60008
Phone: (847) 255-1561; Fax: (847) 255-1699

Factory Mutual

Factory Mutual
1301 Atwood Avenue
P.O. Box 7500
Johnston, R.I. 02919
Phone: (401) 275 3000; Fax: (401) 275 3029