Knowledge
Beyond
Measure.

Filter Testing for Air Filters and Filter Media

Trusted by Filter Manufacturers Around the Globe

The World Health Organization (WHO) has stated "In 2016, 91% of the world population was living in places where the WHO air quality guidelines were not met."* The recent pandemic has also significantly increased awareness about the health effects of inhaling higher concentrations of particles and viruses. As a result, there is a growing demand for use of respiratory masks and air filters for protection in daily life, at workplaces, in healthcare, by firefighters, etc.

In order to ensure the quality of these protective respiratory masks and filters, worldwide standards are in place to ensure reproducible test results, such as US 42 CFR 84, GB 2626, JMOL, EN 143/149, ISO 23328-1 and more.

*Source: http://www.who.int/mediacentre/factsheets/fs313/en/

TSI® provides filter testing solutions to manufacturers, researchers, and certification agencies for performance and compliance testing to many standards and regulations, such as:

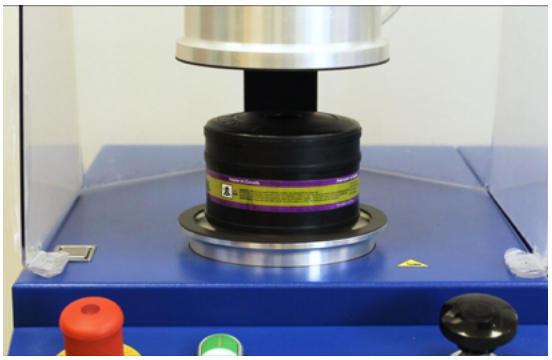
- Respiratory filter testing: US 42 CFR 84, GB 2626, EN 143/149/13274-7
- Air cleaner testing: AHAM AC-1-2020, GB/T 18801-2015
- HEPA and ULPA filter and filter media testing: EN 1822 parts 3 and 5, ISO 29463 parts 3 and 5, MIL STD 282
- Ventilation filter testing: ASHRAE 52.2, ISO 16890-2
- Others (cabin air filter testing, engine intake filter testing)

TSI® also offers various high-end components for customized systems or specific application requirements (e.g. very high efficiency filters, automated systems, unusual shapes or form factors) for:

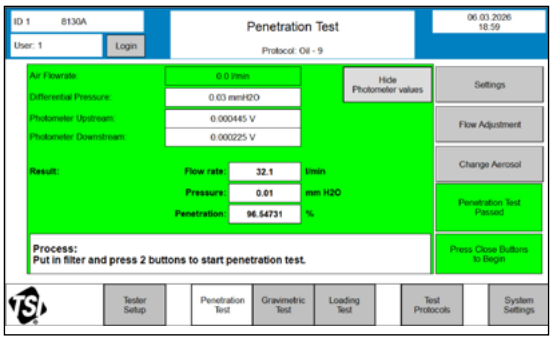
- Aerosol Generation (salt, oil, and powder/dust generators, polydisperse and monodisperse)
- Isokinetic Sampling
- Aerosol Particle Counting and Sizing (Optical Particle Sizers and Counters, Condensation Particle Counters, Photometers, Scanning Mobility Particle Sizers, etc.)
- Aerosol diluters, neutralizers, etc.

TSI's Automated Filter Testers (AFTs) for respiratory filter testing and fractional efficiency testing are designed to increase the productivity of filter testing, by increasing throughput and keeping cost of ownership to a minimum. These AFTs measure the filter or filter media resistance with highly accurate electronic pressure transducers and TSI's own mass flow meters. Simultaneous upstream and downstream detector readings provide the most accurate penetration or filter efficiency measurement results, compared to other offerings where only one detector is used.

Hundreds of Automated Filter Testers are being used worldwide. They have a proven track record of durability, reliability, and minimal maintenance. Additionally, all filter testers are backed by TSI's commitment to provide superior customer support, technical expertise, and service, anywhere across the globe.



Respiratory filter cartridge placed into the Automated Filter Tester 8130A (nonstandard custom filter holders shown)



Screen capture of the 8130A graphical user interface. A respiratory filter was tested for penetration and pressure drop and met the target requirements

Respiratory Filter Testing

Quality Control Filter Testing in the Lab

Meet your standards and achieve your goals with the Automated Filter Tester 8130A
The 8130A enables the testing of respirator filters, disposable filtering facepieces, and a wide assortment of filter media to meet the requirements of many different standards.

Benefits:
- Provides salt and oil testing in one unit
- Ergonomic design improvements for reduced operator fatigue
- Reduced cost of ownership with user-serviceable photometers

These improvements not only enable proactive scheduling of maintenance, with minimal impact to production schedules, but also increase uptime. The completely redesigned hardware and electronics, coupled with a new intuitive interface, will optimize your testing process.

The model 8130A is the successor to the model 8130, which for more than 20 years was well-known and used worldwide in quality control and manufacturing testing. Improvements made in signal processing and electronics have led to an increase in sensitivity in the 8130A compared to the 8130. It is now able to measure up to 99.9995% efficiency with oil aerosol. Overall, the data gathered with the 8130A compares excellently with the original 8130 across the penetration range.

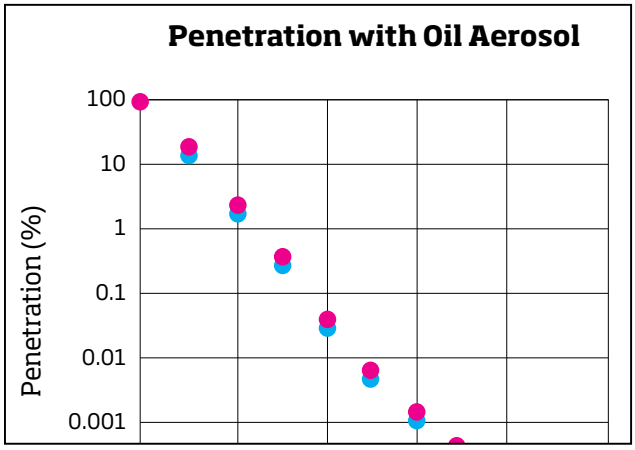
Optional Accessory:
Respirator Leak Tester 8119A
The 8119A enables you to verify the integrity of respirators with ease, giving you the confidence that your equipment is up to the task. For example, after maintenance or repairs, you need to be certain that your respirators are still providing the protection they were designed for. The 8119A allows you to conduct crucial tests to verify that your equipment is in top condition.

Maintenance and time saving benefits of the 8130A

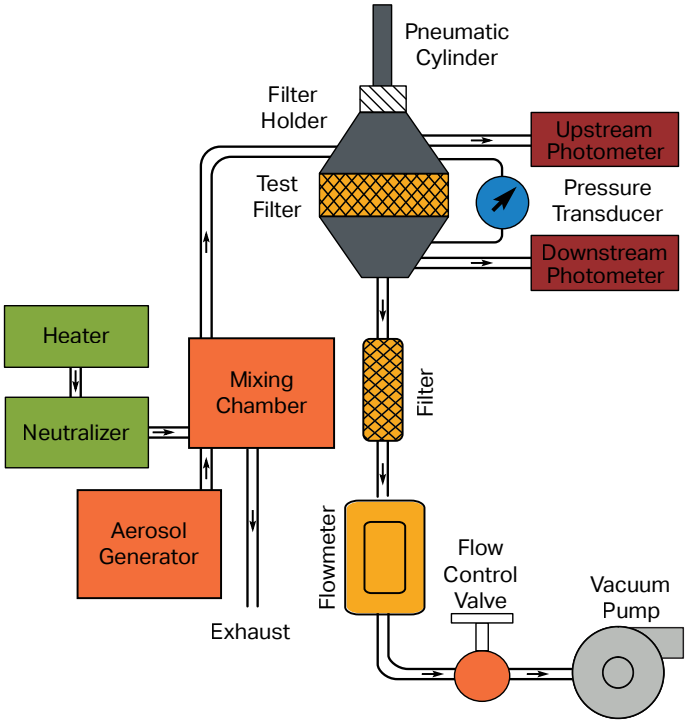
Our customers have told us that maintenance of the 8130A is not only quicker, but also easier than for the 8130. For example:

- The photometers can be cleaned on-site by the user. No tools are necessary to remove the box containing the photometers and filters
- The aerosol generator swivels out to make the refilling process easier
- Controls and gauges are installed on the inside of the front door for quick access
- Operators can change the main filter in significantly less time
- Swapping out filter holders is fast and easy. The bottom chuck is held in place by six strong magnets, for tool-free removal

Your time is important. The 8130A is designed for you to spend less time on maintenance, and more time on filter testing.



Comparison of penetration test results between model 8130A and model 8130



Operational schematic of the 8130A

Filter Quality Assurance in the Production Line

Taking high performance from the lab to the production line

The Automated Filter Tester 8150 is designed for 100% quality assurance testing of P100, FFP3/P3 and similar respiratory filters and cartridges directly on the production line to detect defects from the manufacturing process such as cracks in filter media pleats, gaps in the adhesive, or assembly defects. While optimized for high-volume throughput and round-the-clock remote operation, the 8150 also provides penetration measurement results matching those provided by the well-established 8130A used in the quality control lab. The 8150 is a highly compact automated filter tester that can easily be retrofitted into any existing production line.

Innovations that give you the edge

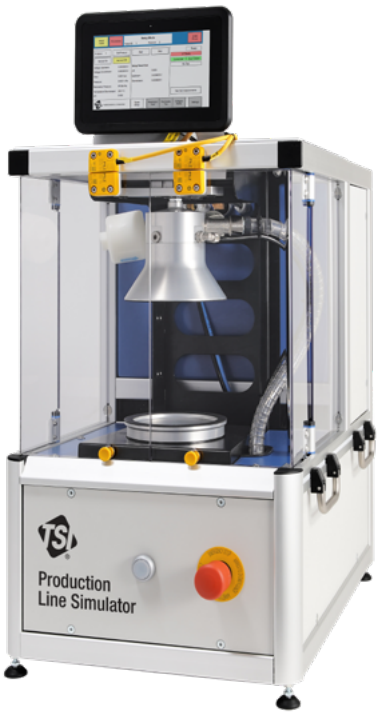
The Automated Filter Tester 8150 utilizes an innovative concept for aerosol delivery that reduces the number of valves and improves uptime. For especially tight spaces, or for applications requiring maximum speed, the photometer box can be separated from the base unit. The 8150 operates through a PLC-driven interface with extensive Modbus TCP control capabilities, and contains a comprehensive set of internal diagnostics to provide you with complete confidence in your filter efficiency measurements.

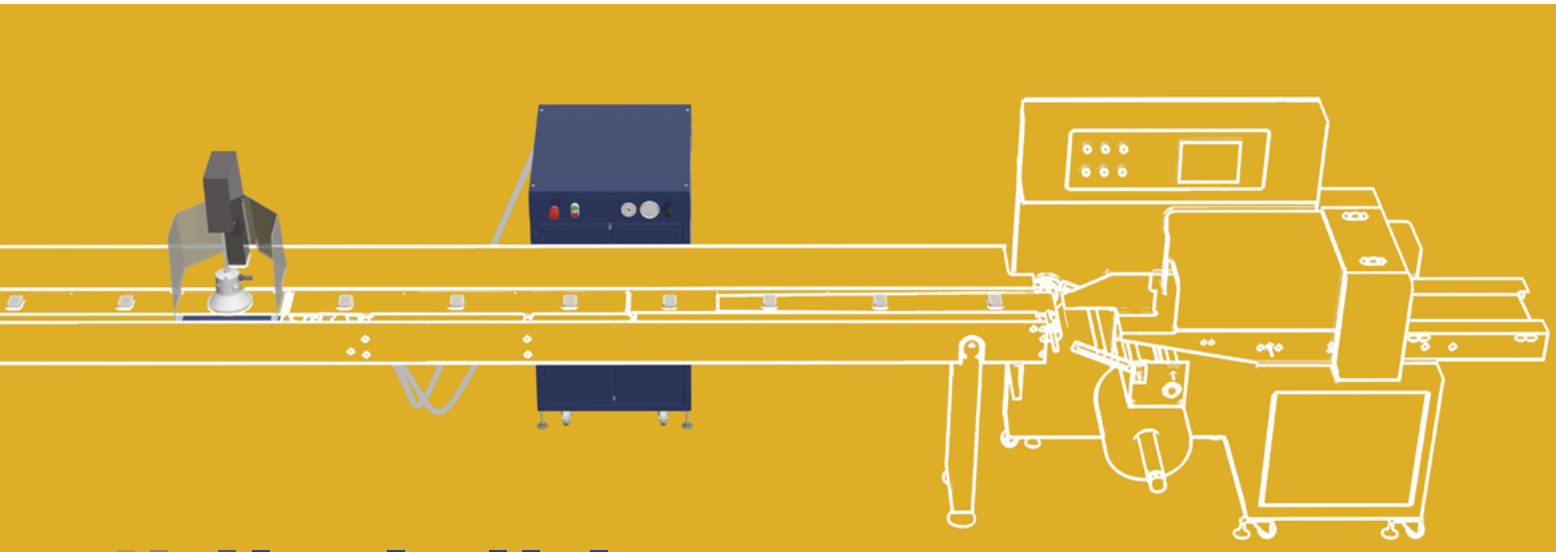
Benefits of using the 8150 in the production line

The 8150 has been optimized for demanding in-line production testing applications:

- Fast measurements down to a few seconds for high throughput
- Excellent agreement with the 8130A that is used in certification and QA/QC labs
- Compact footprint and flexible communications for ease of integration
- Two simultaneously measuring photometers for confidence in your measurements
- Supports compliance with standards such as NIOSH 42 CFR 84 and EN 143/EN 149/ EN 13274-7
- Intelligent, versatile design and diagnostics for increased uptime
- Robust design for longevity

Optional Accessory:
Production Line Simulator 8150-PLS
Operating the 8150 away from the production line enables maintenance, troubleshooting, or process characterization (i.e. determination of optimal settings). The Production line Simulator 8150-PLS is an essential accessory that enables such work.





HEPA and ULPA Filter Testing

HEPA and ULPA filters are used in hospitals, operating rooms, laboratories, clean rooms and other places that require low concentrations of particles and bacteria. Filter quality is measured by determining the fractional filter efficiency (or penetration) and the most penetrating particle size (MPPS).

Why do filters have a 'Most Penetrating Particle Size', and why would that size vary among filters?

The Most Penetrating Particle Size (MPPS) of filters is a critical concept describing their efficiency in capturing airborne particles. While a screen or sieve captures all particles larger than the pore size, and lets smaller particles through, air filters do not achieve most of their performance this way. Instead, air filters capture most particles via four major physical mechanisms: interception, impaction, diffusion, and electrostatic attraction. Each of these mechanisms is influenced by factors like particle size, air speed, and electrostatic charge (on particles and potentially on the filter media). The MPPS of a given filter results from the superposition of these four mechanisms, and represents the particle size at which a filter's efficiency is lowest, allowing the highest number of particles to penetrate.

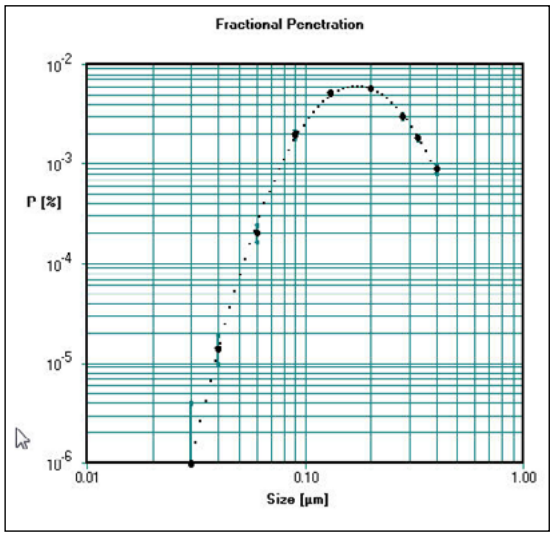
The MPPS varies among filters due to differences in design, materials, and intended applications. Factors such as pore size distribution, fiber diameter, and surface charge distribution can contribute to the variability in MPPS.

Understanding MPPS is an essential part of filter media development, and is critical for selecting filters suited to specific filtration needs.

Measure filter performance at individual particle sizes with highest sensitivity

The Automated Filter Tester 3160 determines the pressure drop and fractional filter efficiency at different particle sizes in order to obtain the MPPS of HEPA and ULPA filters and filter media. The system is designed to comply with the test requirements of EN 1822 parts 3 and 5 as well as the equivalent parts of ISO 29463. Filter tests are performed automatically following user-specific test parameters and up to 99.999999+% fractional filter efficiencies.

The 3160 uses a bank of six atomizers and the research grade TSI® Electrostatic Classifier to challenge a filter or filter media with known-size, monodisperse particles. Two new generation Condensation Particle Counters (CPCs) simultaneously count the upstream and downstream particles while the software calculates the penetration value at each size. Filters can be sequentially challenged with several different monodisperse particle sizes in the range from 10 to nearly 1,000 nm. At the end of a test, the model 3160 generates a curve of penetration vs. particle size and produces a summary of test results, including the MPPS. A quick test mode is also available, allowing for rapid, sequential quality control testing of samples at a single particle size.



MPPS and fractional penetration results measured with Automated Filter Tester 3160

Automated Filter Tester Specifications

Model	8130A	3160	8150
Measurement Application	Certification, Loading, and Quality Control Tests	Factional Efficiency, MPPS, and Single-Size QC	Quality Control in High-Speed Production
Maximum Efficiency[a]	up to at least 99.9995%	99.999999+%	99.9995%
Aerosol Type[b]	DOP, PAO, DEHS, Paraffin, and other oils, or NaCl	DOP, PAO, and other oils; NaCl; PSL	DOP, PAO, DEHS, Paraffin, and other oils
Aerosol Generation	Atomizer	Atomizer with Classifier	Atomizer
Count Median Diameter[c]	0.185 µm (Oil) or 0.075 µm (NaCl)	Monodisperse, user-selectable size	0.185 µm
Geometric Standard Deviation[c]	<1.6 (Oil) or < 1.86 (NaCl)	<1.3	<1.6
Flow Rate	10 to 110 L/min	5 to 100 L/min	10 to 120 L/min
Resistance	0-255 mm H_2O	0-150 mm H_2O (0-1470 Pa)	0-2.5 kPa
Particle Detection	Light Scattering Photometer	Condensation Particle Counter	Light Scattering Photometer
Typical Test Length	10 sec	30 sec to 20 min[c]	A few seconds
Data Reporting	Touch screen and RS-232	PC with Integrated Software	Modbus TCP/IP
Operation	Stand Alone Tester	Stand Alone Tester	Integrated in Automated Production Lines
Compliance[d]	US 42 CFR part 84, EN 143 / EN 149 / EN 13274-7, JMOL, ISO 23328-1	EN 1822- 3, -5; ISO 29463- 3, -5	US 42 CFR part 84, EN 143/ 149 / EN 13274-7

a Efficiencies higher than 99.9999% require longer than typical testing times
b Aerosol abbreviations: DOP (dioctyl phthalate), PAO (polyalpha olefin), DEHS (di-ethylhexyl sebacate)
c EN version CMD and GSD are different. See 8130A spec sheet for more information
d EN versions (for equivalent results to EN 13274-7 standard) available (8130A-EN, 8150-EN).
Example of standards only. Contact TSI® about your specific standards compliance needs

Comprehensive Testing with TSI® Automated Filter Testers: Meeting a Range of Standards

TSI® Automated Filter Testers are employed in filter testing according to a variety of standards, such as 42 CFR, EN, ASTM, IEST, SEMI, and ISO, among others. The standards named in the table below do not represent an exhaustive list; for standards-driven applications not listed here, please contact TSI® for further discussion.

Application			Standard	Automated Filter Test Solution				
				8130A		8150	3160	
				Salt	Oil	Oil	Salt[A]	Oil[A]
Personal Respiratory Protection	Respirators	N95, P100, etc.	42 CFR part 84, GB2626, JMOL/JICOSH	■	■	■		
		FFP3, P3, similar	EN 143, EN 149, EN 13274-7	■[B]	■	■		
		Surgical	42 CFR part 84	■	■			
			ASTM F2100	■				
	Medical Facemasks			■				
	Barrier Face Coverings		ASTM F3502	■				
	Medical Ventilators		ISO 23328-1[C]	■				
HEPA & ULPA	Media		EN 1822-3 and ISO 29463-3				■[D]	■
	Filter elements		EN 1822-5 and ISO 29463-5				■[D]	■

A The aerosol generators in the 3160 can be used with a variety of solutions. The salt generators can hold aqueous solutions and suspensions such as (but not limited to) NaCl or PSL in water, while the oil generators can hold alcohol solutions (such as, but not limited to, DEHS and DOP).
B EN 13274-7 formally requires that salt aerosol be analyzed via flame photometry. The photometer-based 8130A has been demonstrated to provide equivalent results.
C ISO 23328-1, in addition to using a photometer-based filter tester (such as 8130A) to assess filter efficiency, mentions use of an aerosol spectrometer to confirm the size distribution of the challenge aerosol. A Model 3938 SMPS may be used for this purpose.
D PSL aerosol may be used for leak testing only; filtration efficiency testing must be conducted with a liquid (oil) aerosol; see Part 1 of either standard for further information.

Application Spotlight: Air Cleaner Testing

People in industrialized countries spend most of the day indoors. Airborne particulates (solid particles or liquid droplets) are either transported indoors from outdoor environments, or the particles directly result from indoor sources like smoking, cooking, housework, and many more. Indoor particle concentrations can be very high, due to either the particle sources listed above, or due to air exchange with polluted outdoor air, such as in an urban environment. Inhalation of particulates has been linked to increased risk for a number of adverse health effects. Awareness of the importance of indoor air for human health continues to rise; increasing numbers of private homes, workplaces, and other public spaces are being outfitted with air cleaners.

In order to provide a quantitative performance verification for air cleaners / purifiers and to ensure the quality of their performance, the United States Association of Home Appliance Manufacturers (AHAM) has created a certification program. This is offered by independent laboratories and provides a uniform and commercially practical verification of manufacturers' Clean Air Delivery Rates (CADR) for tobacco smoke, dust and pollen. The method and requirements are specified in the most recent edition of the ANSI/AHAM AC – 1 Standard "Method for Measuring Performance of Portable Household Electric Room Air Cleaners". The International Electrotechnical Commission (IEC) has published a similar standard 63086-2-1 for international use. In addition, some countries developed additional standards that must be met when selling air cleaners within that country (e.g. GB/T 18801-215 for air cleaners sold in China).

TSI® provides components for air cleaner test systems, most of which are listed in Annex A of the AHAM standard. Some component examples include:

- Fluidized Bed Aerosol Generator 3400A
- Aerosol Neutralizer 3012
- Filtered Air Supply 3074B
- Aerodynamic Particle Sizer 3321 (optionally with model 3302A Aerosol Diluter) for dust/pollen counting
- Laser Aerosol Spectrometer 3340A for cigarette smoke detection
- Optical Particle Sizer 3330

Application Spotlight: Ventilation Filter Testing

Air filters used for general ventilation are widely used in heating, ventilation and air-conditioning (HVAC) applications in buildings. Similar filters are also used in cabin air filtration and engine air intake filtration where these filters lower the concentration of particles and improve the (indoor) air quality. Currently two main standards are used to ensure performance criteria: ASHRAE 52.2 in the United States and ISO 16890 (which replaced EN 779).

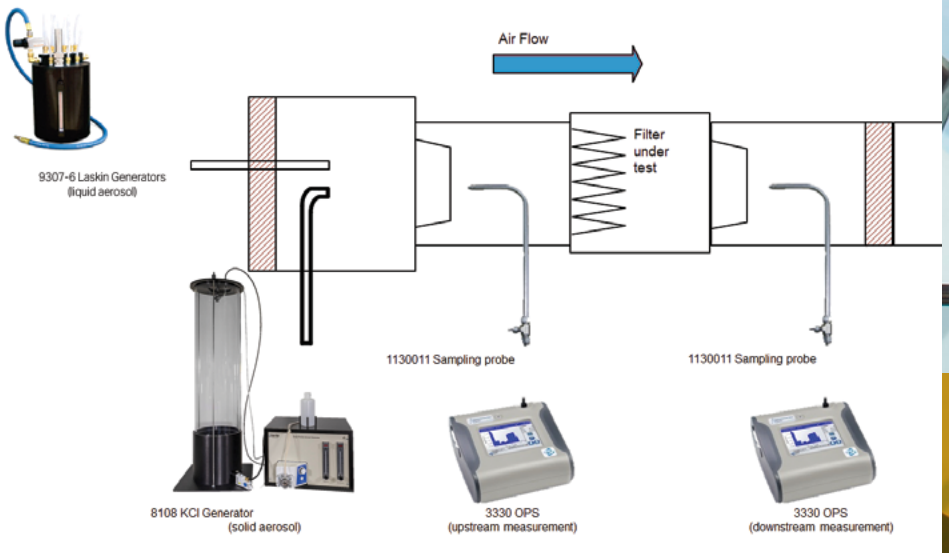
In order to work towards testing ventilation filters in a manner that reflects the nature (and terminology) of particulate matter (PM) pollution, ISO 16890 specifies that filter efficiencies will be determined by how successfully filters remove PM1, PM2.5, and PM10 particle sizes. KCl salt particles are now generated and measured in the size range from 0.3 to 10 µm using 12 size bins. For more information on how the ISO 16890 compares to EN 779 and ASHRAE 52.2 please refer to the application note on tsi.com: "ISO 16890-2 Air Filters for General Ventilation: Determining Fractional Efficiency" (AFT-005).

Standards specify requirements that the test equipment must meet to determine filter efficiency as a function of particle size. TSI® focuses on providing high-end components necessary to comply with these requirements. Filtration professionals can use the following components that comply with each of these key steps: particle generation, particle sampling, and particle measurement:

- Laskin Generator 9307-6
- Large Particle Aerosol Generator (KCl) 8108
- Isokinetic Sampling Probe and Coupler PN 1130011
- Optical Particle Sizer 3330

Depending on further requirements (whether the use case is within R&D, or Quality Assurance), the following additional instruments could be used by manufacturers:

- Aerodynamic Particle Sizer™ (APS™) 3321
- Condensation Particle Counters (CPCs) series 375x and 3789
- Scanning Mobility Particle Sizers™ (SMPS™) spectrometers series 3938
- MOUDI™ Impactors 110NR or 120R (among others)



ISO 16890-2 setup with TSI® component recommendations

Standards and Regulations

Air and gas filter testing methods are largely determined by standards and regulations. A large number of standards exist, each one appropriate for the application in which that category of filters is designed to be used. Test standards, to a large extent, define the user's filter testing needs. The table below gives examples of standards and which combinations of individual components are needed to test to the standards. If you need to test to a standard or need a component or instrument not listed here, please contact TSI® to discuss your application with a filtration expert. We are confident that we can help solve your measurement problems with our many years of filtration and aerosol leadership, and extensive product portfolio. TSI® Automated Filter Testers are employed in filter testing according to a variety of standards. Learn more on page 11.

			Component-based solution: Contact TSI® for specific guidance					
			Aerosol Generation			Detector		
Application		Standard	Monodisperse Size Distribution	Polydisperse Size Distribution	Material	CPC	Photom.	Optical
HEPA & ULPA	Media	EN 1822-3	■[A]		Oil	■		
				■				■
		ISO 29463-3	■[A]		Oil / PSL	■		
				■			■[B]	■
	Filter Elements	EN 1822-5	■[A]		Oil	■		■
				■				■
		ISO 29463-5	■[A]		Oil / PSL	■		■
				■				■
Ventilation		ASHRAE 52.2		■	KCl / Dust			■
		ISO 16890		■	Oil / KCl / Dust			■
Vehicle	Cabin Air	DIN 71460-1		■	Dust			■
		ISO TR 11155-1		■	KCl / Dust			■
	Engine Intake	ISO 19713		■	KCl / Dust			■
Misc.	Compressed Air	VDI 3926-2		■	Dust			■
	Vacuum Cleaners	ASTM F1977-04		■	KCl			■
		EN 60312 / IEC 60312		■	Dust			■
	Cleanable Filters	ISO 11057 / VCI 3926-1		■	Dust			■
	Air Cleaner	AHAM AC-1-2013		■	Dust			■

[A] Also consider the 3160 Fractional Efficiency Tester for this application.
[B] For certain classes of HEPA media, Section 13 and Annex B within ISO 29463-3 permit / recommend use of a photometric detector.

LEARN MORE
To learn more about Filter Testing, please visit tsi.com/filter-testers/

Knowledge Beyond Measure.

TSI Incorporated - Visit our website **www.tsi.com** for more information.

USA	Tel: +1 800 874 2811	**India**	Tel: +91 80 67877200
UK	Tel: +44 149 4 459200	**China**	Tel: +86 10 8219 7688
France	Tel: +33 1 41 19 21 99	**Singapore**	Tel: +65 6595 6388
Germany	Tel: +49 241 523030		

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