The National Air Filtration Association (NAFA) Foundation is a 501(c)(3) organization and all contributions are tax deductible to the fullest extent of the law. Donations support industry research, technology development, member education and scholarships.

Accreditations:

NAFA Certified Air Filter Specialist (CAFS)

NAFA Certified Technician (NCT)
Level I and Level II

Publications:

Air Media

NAFA Best Practice Guidelines

NAFA Guide to Air Filtration

Installation Operation and Maintenance of Air Filtration Systems (IOM)

National Air Filtration Association Foundation®
1818 Parmenter Street, Suite 300
Middleton, WI 53562
(p) 608-310-7542
www.nafahq.org • nafa@nafahq.org

NAFA® User's Guide for

ISO 16890*

Air filters for general ventilation

**the ISO equivalent to ASHRAE 52.2*

Understanding *e*PM and ISO Coarse

Introduction

This International Organization for Standardization (ISO) 16890 "Understanding *e*PM and ISO Coarse" User Guide was created by the National Air Filtration Association (NAFA) Foundation, a NAFA nonprofit organization. NAFA is an international group of air filter distributors, manufacturers and engineers. This guide and the application of the particulate contamination removal standard ISO 16890 "*Air filters for general ventilation*" are intended to assist end-users and specifiers in their selection of appropriate air filtration products and understanding the *e*PM values in the 16890 test reporting. This guide also aims to help users understand the similarities and differences between this test and ASHRAE 52.2 and its MERV.

ISO 16890

ISO 16890 is the relatively new international standard for testing filters for particle removal. This test method is very similar, but not identical, to ANSI/ASHRAE Standard 52.2. ISO 16890 tests filter efficiency for clean and conditioned efficiency, for pressure drop and for test dust capacity. The filter ratings are based on the average of the clean and conditioned results. To get the efficiency based on mass of particles that could be removed in use (called *e*PM for particulate matter efficiency), the efficiencies for each size are weighted by the relative amount of particles of that size in a specific, chosen air distribution. These calculated mass efficiencies are rounded down to the nearest 5% level and reported for various size fractions as ePM_{10}, $ePM_{2.5}$ and ePM_{1}. Values above 95% are reported as >95%. The smaller the value in the rating name and the higher reported efficiency indicated better particle removal. Filters with ePM_{10}≤50% are grouped as ISO Coarse.

Although the efficiency tests in ISO 16890 are performed very similarly to those of ANSI/ASHRAE 52.2, the reported values (*e*PM vs MERV) do not report the same thing. ISO is a mass-based result and MERV is directly related to individual particle removal. See Table 1 for a rough comparison of the outputs of the two tests.

Why PM removal efficiency

Health effects of particulate matter (PM) vary based on the particle size. Across various organizations, including U.S. Environmental Protection Agency (EPA), the World Health Organization (WHO) and the European Union PM_{10}, $PM_{2.5}$ and PM_{1} are considered important size fractions. Use of the various levels of *e*PM gives the user a measure of how much of the PM in air will be removed by a filter.

ISO 16890 Test Procedure: how data is obtained

An air filter's performance is determined by measuring the particle counts upstream and downstream of the air-cleaning device being tested. Particle counts are taken over the range of particle sizes beginning with a clean filter and then after an IPA (isopropyl alcohol) conditioning test.

A laboratory aerosol generator, which operates much like a paint sprayer, is used to create a challenge aerosol covering the required particle sizes. The challenge aerosol is injected into the test duct and particle counts are taken for each of the size ranges. Particle counts are measured in particle size ranges defined by the test. The recommended, but not required, ranges are the same as those of ASHRAE 52.2 (See Table 2).

The filter's performance for each of the twelve particle sizes, clean and conditioned, is determined for a total of 24 efficiency calculations. The filtration efficiency is based on the ratio of the downstream-to-upstream particle counts. Since the IPA conditioning is expected to overpredict the loss in efficiency in real use for charged filters, the average of the two values in each size range is then calculated as representative of the filter's efficiency in use.

TABLE 1: Rough equivalence for ISO 16890 to ASHRAE 52.2 results

ISO 16890	MERV	Intended Particle Size Range, µm
ISO Coarse	1 - 6	>10.0
ISO Coarse >95%	7 - 8	>10.0
ePM_{10}	9 - 10	3.0 - 10.0
$ePM_{2.5}$	11 - 12	1.0 - 3.0
ePM_{1}	13 - 16	0.3 - 1.0

Table 2: ISO 16890 particle size ranges*

Range	Size	Group		
		ePM_1	$ePM_{2.5}$	ePM_{10}
1	0.30 to 0.40			
2	0.40 to 0.55			
3	0.55 to 0.70			
4	0.70 to 1.00			
5	1.00 to 1.30			
6	1.30 to 1.60			
7	1.60 to 2.20			
8	2.20 to 3.00			
9	3.00 to 4.00			
10	4.00 to 5.50			
11	5.50 to 7.00			
12	7.00 to 10.00			

*Identical to the 52.2 sizes. This is one possible way to set up the size bins. Group ISO Coarse covers these sizes and greater through the Initial Gravimetric Arrestance test.

In ISO 16890 the amount of particulate matter a filter will be exposed to in situ is represented by two different particle size distributions (psd) called rural and urban. The rural psd is used for calculating the mass removal efficiency for the ePM_{10} rated filters while the urban psd is used for the $ePM_{2.5}$ and ePM_1 rated filters. To calculate the mass removal efficiency for each particle size, the efficiency of the filter at that size is weighted by the amount of mass of that size in the psd. In practice, this means that a larger particle's removal counts for more mass removal in the PM efficiency than a smaller, less massive, particle.

To determine the PM removal efficiency for particles smaller than 10 µm, the entire data set of weighted mass removal values from 0.3-10 µm (channels 1-12) are summed up to give the ePM_{10} value. The $ePM_{2.5}$ value covers the sizes from 0.3-3 µm, and the ePM_1 value covers the sizes from 0.3-1.0 µm.

ISO Coarse are rated based only on the initial gravimetric arrestance, so the particle size dependent efficiency test data is not used.

Filters are placed into Groups based on their efficiencies. Each group consists of the acronym ISO followed by the type of class reporting value. Thus, the groups are ISO Coarse, ISO ePM_{10}, ISO $ePM_{2.5}$, and ISO ePM_1. The group is determined through the rules shown in Table 3. ISO Coarse filters are rated using only the initial gravimetric arrestance. The other groups are rated based on the efficiency testing without including the dust-loading data. Filters should only be compared using values in the same group.

Particulate matter (PM) removal efficiencies for different sizes of particles (ePM_{10}, $ePM_{2.5}$, ePM_1)

With dozens of possible ratings, ISO 16890 gives useful gradations of filter efficiency. With the values given in percent removal for given sizes, the ratings are readily understood. The reporting ranges were chosen to allow comparison to PM_{10}, $PM_{2.5}$, and PM_1 mass concentration measurements of air and to their health effects.

IPA Conditioning

After a filter is tested for clean filter efficiency, it is placed in a special chamber and exposed to alcohol vapor (IPA) for 24 hours. This exposure is designed to completely remove the electrostatic charge on filters to show how the filter would perform with only its mechanical filtration. This charging increases the removal efficiency of filters above that provided by mechanical means. In real use, as small particles are captured, the charge is masked, and filters often have reduced efficiency. Conditioning with IPA, then taking the average of the clean and conditioned efficiencies, is intended to give a useful approximation of filter performance. IPA conditioning, rather than a particle/dust exposure, is used as the exposure is straightforward and simple to perform.

Particle size distributions (psd)

Two psd were selected by the ISO committee based on published atmospheric aerosol distributions from around the world for use in the calculations of mass removal efficiency. The rural distribution has more of the mass located in larger size particles; whereas, the urban distribution has more of the mass in the smaller particles. These distributions are not intended to represent a specific location or to match anyone's actual use but are used as the standard distributions to allow for test to test (filter to filter) comparisons.

Standard test airflow rates

The filter must be tested at the air flow that it was designed for. If the manufacturer does not specify a nominal air flow rate for a 24x24" filter, it is tested at 2000 cfm.

Arrestance and test dust capacity

Dust loading is optional except for ISO Coarse filters. If done, it is run after the clean and conditioned efficiency tests. The dust loading is done in increments with ISO 15957 L2 dust (i.e., ISO Fine). The filter arrestance is determined by comparing fed and captured dust weights. The test dust capacity is the amount of dust captured by the filter.

This capacity is intended for comparison across filters and not to determine the lifetime of a filter in a specific location.

Comparison to ASHRAE 52.2

The efficiency tests are very similar between the two methods. ISO 16890 specifies an oil (DEHS) aerosol for the smaller particle size, although the same salt (KCl) aerosol as 52.2 may be used. Both methods use KCl for larger particles. Oil particles don't bounce, as dry particles may, since they stick to fibers; however, this should not make a difference to the efficiency in the smaller sizes.

ASHRAE 52.2 uses a small dust load as a conditioning step. While this was intended to reveal the drop in efficiency of charged filters, it only shows a small amount of the likely drop. ASHRAE 52.2's optional Appendix J conditioning is intended to remedy this situation and can be logically compared to ISO 16890's conditioning step. The Appendix J efficiencies may be comparable to the average efficiencies for the clean and IPA conditioning steps in ISO 16890. Thus, comparing the 52.2 MERV-A to the ISO 16890 results should make more sense for charged filters than using the MERV based on the standard 52.2 test.

The 16890 Test Dust Capacity and Gravimetric Arrestance tests are performed using a different dust from the 52.2 Dust Holding Capacity and Arrestance tests which will give different values. ASHRAE dust is essentially the dust used in 16890 with the addition of cotton linters and carbon black. 52.2 and 16890 load the dust in multiple increments. However, the value used in rating filters in 16890 is simply based on the first, small, dust-loading step which gives the initial gravimetric arrestance. In addition, 52.2 has efficiency tests after the dust loads, so the performance after dust loading when a filter may shed particles, may lower the MERV. In 16890, the dust loading does not influence the rating.

ASHRAE 52.2 has 7 allowed air velocities; filters are tested at the nearest velocity to its rated level. ISO 16890 requires that the filter be tested at its rated air flow rate or at 2000 cfm if not specified. Thus, many 24x24" filters will be tested at 1970 cfm for 52.2 and 2000 cfm for 16890. This difference is usually within the measurement error limits allowed in the tests.

TABLE 3: Groups and class reporting values

Groups	Requirement			Class Reporting Value
	ePM_1, min	$ePM_{2.5}$, min	ePM_{10}	
ISO Coarse	-	-	<50%	Initial grav. Arrestance
ePM_{10}	-	-	≥50%	ePM_{10}
ePM2.5	-	≥50%	-	$ePM_{2.5}$
ePM_1	≥50%	-	-	ePM_1

Conclusion

For further assistance, contact your local National Air Filtration Association® (NAFA) member company. Most NAFA members are staffed by NAFA Certified Air Filter Specialists (CAFS) to assist in the proper selection of filters for your application.