Understanding MERV

TRION Indoor Air Quality

In 1999, the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) released its 52.2-1999 standard, *Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size*. This standard provides details on testing and how to report those test results, commonly referred to as MERV, or Minimum Efficiency Reporting Value. Although residential, commercial, and industrial filters are tested per the standard with the results published in literature and often on the filters themselves, there are misconceptions and misunderstandings throughout the filtration industry and to consumers about what the MERV number actually tells us.

History of Filter Efficiency

In the 1990s and into the early 2000s, filters were commonly tested per ASHRAE 52.2-1992, *Gravimetric and Dust Spot Procedures for Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter*. In residential, light commercial, and industrial dust and mist applications, the gravimetric procedures were commonly followed and reported on the filter. This gave us filters commonly rated with a range of arrestance values, i.e. 30-35%, 60-65%, or 90-95%.

Testing was done by placing and sealing a filter in a test duct, turning a fan on to a specific airflow, placing a known amount of test dust on the upstream side of the filter, and capturing whatever dust penetrated through the test filter on the downstream side. Whatever percentage of dust by weight was not collected downstream of the filter was the arrestance value. Although this was a useful value to those who understood the test standard, the average person did not know what the rating on the filter meant, nor what the term “arrestance” means.

It was common for someone who purchased a 95% ASHRAE filter (95% arrestance) to assume they were filtering out 95% of all the dust going to the filter. Unfortunately, those with extremely fine dust or even smoke quickly realized that 95% ASHRAE did not equate to 95% efficiency on smoke.

Current ASHRAE 52.2-2012 standard, *Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size*, was originally started in the 1980s, first released in 1999, and amended in 2007 and then again in 2012. This standard attempts to be more readily understood and allows for the purchasing of filters that are appropriate for the dust one wants to filter out of an airstream. This is done through evaluating the filters’ efficiencies over 12 specific particle size ranges, using a specific type of test dust, followed by a mathematical average to reduce the 12 specific particle size ranges down to three (E1, E2, and E3). See Table 1. The three size ranges are then compared to a table with minimum requirements to determine a MERV number. See Table 2.

Table 1: MERV Efficiency Groups

Range	Particle Size Range	Efficiency Group
1	0.30 - 0.40 µm	E1 (0.3 - 1.0 µm)
2	0.40 - 0.55 µm	
3	0.55 - 0.70 µm	
4	0.70 - 1.0 µm	
5	1.0 - 1.3 µm	E2 (1.0 - 3.0 µm)
6	1.3 - 1.6 µm	
7	1.6 - 2.2 µm	
8	2.2 - 3.0 µm	
9	3.0 - 4.0 µm	E3 (3.0 - 10.0 µm)
10	4.0 - 5.5 µm	
11	5.5 - 7.0 µm	
12	7.0 - 10.0 µm	

Note: Efficiency for each Group (E1, E2, or E3) is calculated by adding the measured values from the four ranges per Efficiency Group and dividing by four.

What is MERV?

MERV is a number assigned to a filter based on its minimum tested efficiency data at a known test condition.

Table 2: MERV Number

MERV No.	E1	E2	E3
1	N/A	N/A	< 20%
2	N/A	N/A	< 20%
3	N/A	N/A	< 20%
4	N/A	N/A	< 20%
5	N/A	N/A	> 20%
6	N/A	N/A	> 35%
7	N/A	N/A	> 50%
8	N/A	> 20%	> 70%
9	N/A	> 35%	> 75%
10	N/A	> 50%	> 80%
11	> 20%	> 65%	> 85%
12	> 35%	> 80%	> 90%
13	> 50%	> 85%	> 90%
14	> 75%	> 90%	> 95%
15	> 85%	> 90%	> 95%
16	> 95%	> 95%	> 95%

Note: MERV 1-4 are filters with an efficiency less than 20% on particles 3-10 microns in size. These filters also require additional testing per 52.2-2007 Appendix A, following a test procedure that mirrors 52.1-1992 (dust arrestance), as previously discussed. The low cost, 1- and 2-inch fibrous furance filters and disposable commercial/industrial filters commonly have a MERV 1-4 number. With a number this low, most manufacturers have elected not to advertise it and alternatively use the arrestance percentage instead.

Table 2 shows the minimum efficiency required for each Efficiency Group for MERV numbers 1-16. Although MERV numbers go up to 20, filters with a MERV 17 or higher number fall under a classification of HEPA or DOP filters, are typically rated/tested differently, and are beyond the scope of this literature. The remainder of this literature will focus primarily on filters with a MERV 5-MERV 16 number.

Testing for MERV

Many filter manufacturers and distributors do not have the ability to determine their filter's MERV number or prefer independent third party verification. This requires that a filter be sent to a company specializing in filter testing. Before testing begins, there are a few decisions regarding testing that need to be made:

1. How much testing to do?
2. What will the test conditions be?

Due to the numerous filters that a company may have, doing a complete 52.2-2012 test on each filter size and type offered is costly. Most companies will pick their most common filter size from each product line or filter type and run what is called an "initial test", meaning testing the efficiency of a "new" filter. The complete 52.2-2012 test requires that six separate tests are done on the filter, and the lowest efficiency from all tests run is used to determine the MERV number. However, with years of testing knowledge and historical results, almost all test filters, when tested using the standard, show their lowest efficiency to be that of a new filter. This is because, as dust is loaded onto a filter, the dust becomes part of the filtration mechanism, leading to higher efficiency filters per the design of the test. Therefore, many companies save cost on testing by only running an initial test and reporting those results in their literature and/or on the filter.

Next, companies must determine which test conditions they will put their filters under. As the test setup and test dust parameters are set specifically by the standard, the air velocity at which a filter is tested is not. 52.2-2012 states to test the filter at one of seven air velocities. See Table 3.

Table 3: MERV Test Velocities

118 FPM (0.60 m/s)
246 FPM (1.25 m/s)
295 FPM (1.50 m/s)
374 FPM (1.90 m/s)
492 FPM (2.50 m/s)
630 FPM (3.20 m/s)
748 FPM (3.80 m/s)

It is expected that the velocity that best matches the actual conditions the filter will see, or which condition will provide the lowest efficiency, will be chosen. Some companies choose a velocity that provides the results that best fit their marketing message and one that may minimize the number of different filters their company needs to stock.

For example, let's take a common filter size of 24x24x4 inches, which has a maximum rated airflow of 2000 CFM. To calculate the closest test velocity, divide 2000 CFM by four square feet (the face area of the filter). This would equal 500 FPM, so it would make sense to test the filter at 492 FPM. What is commonly seen is a company will test at 295 FPM because it has been shown over years of testing that, the slower the air velocity is through a filter, the higher the efficiency will be. By testing this filter at 295 FPM (1180 CFM for a 24x24 inch filter), a filter may test to a MERV 11 number, but when tested at 492 FPM (1968 CFM), it only has a MERV 8 number. Since a MERV 11 filter is perceived as a higher cost filter, a company can sell a low performing filter for a higher cost because the consumer expects to pay more for a higher efficiency filter.

Although 52.2-2012 requires that the test condition or velocity at which the filter was tested be included with the MERV number, very few companies publish that data, or it is hidden in the fine print of a data sheet or brochure instead of on the filter itself. When comparing two filters side by side, look for the velocity at which the filter is tested, not just the MERV number. If it is not listed, contact the supplier and request the test velocity. Only in this way can one be certain that they are truly using a filter that matches their expectations.

Mechanical vs. Electrically-Enhanced Media

One of the latest innovations in media is to add a charge to the media or Electrically Enhance the performance of the media. For example, adding a charge to a MERV 7 media that allows it to attract and retain dust would turn it into a MERV 11. That may sound like great news, but is it?

One of the challenges filter laboratory testing faces is how to best simulate what happens under real world conditions. Since it is expected that most filters will last between one month and one year, testing a filter for this timeframe is not only impractical, but it would make testing very costly. Therefore, laboratory testing can only provide a benchmark for how a filter may perform. The MERV number is a good predictor of filter performance, but in the case of electrically enhanced filter media, it is not the entire story.

The writers and commitee members responsible for 52.2-2007 added an additional test known as Appendix J. The additional test, which is infrequently run and even less reported, removes the charge of an electrically enhanced filter media, and then a test for a MERV number is run. The results are known as a MERV-A number. Therefore, the proper notation for an electrically enhanced filter may be something like MERV 11, MERV-A 7 at 492 FPM.

In most filter applications, however, the charge on the filter media will be reduced and will not provide the higher efficiency expected. What is not known nor well understood is how fast this happens and what mechanism is most responsible for the loss of charge. Research conducted by academia suggests an electrical charge on a filter media starts being reduced from the first day a filter is installed and, depending on several factors, may not reach its lowest efficiency point for up to 75% of its useful life.

Using the MERV 11, MERV-A 7 example above, if it is expected that this filter will last six months, it is likely that after four months of service, the filter will have a MERV 7 or MERV 8 rating with the loss of its electrical charge and not return to a MERV 11 efficiency before it is replaced. Therefore, in some applications, such as residential filtration, it may be best to purchase a lower efficiency mechanical media (MERV 8) and pay less for it, than pay a higher price for an electrically enhanced MERV 11 filter that over time will capture and hold less airborne dust.

Conclusion

Before purchasing the next filter, know all the facts about what is being purchased and what the filter needs to do to be successful. Here is a list of questions to help:

1. What is the MERV's filter number?
2. At what velocity was the MERV number tested, and how close is that to your need?
3. Is the filter media a mechanical media or electrically enhanced media?