MERV 13 vs. NanoMax filtration technology

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Established by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), the Minimum Efficiency Reporting Value (MERV) system is a common shorthand for assessing how effectively air filters can capture airborne particles.

Minimum Efficiency Reporting Value (MERV) is a common shorthand to assess how effective an air filter is at capturing airborne particles.

MERV ratings have become central to the conversation around how to make shared public spaces like schools and shared offices safer for students, employees, and others from dangerous indoor air pollutants and airborne infections.

ASHRAE recommends MERV 13 as the *minimum* to help mitigate the transmission of infectious aerosols. There is evidence that shows MERV 13 cannot filter enough dangerous infectious airborne pollutants, including viruses and other ultrafine particulates.

NanoMax filtration technology is a much more efficient alternative to MERV 13 for the implementation of integrated HVAC filtration. NanoMax outperforms even MERV 16 air filters in terms of filtration efficiency but with low pressure drops comparable to MERV 8 filters, making NanoMax compatible with many HVAC systems. Additionally, NanoMax offers many other benefits like increased energy efficiency and reduced filter replacement intervals.

How MERV ratings work

The MERV system rates air filters on a scale of 1-20 on their ability to capture airborne pollutant particles.[1] The higher the MERV rating, the higher the filtration efficiency. The ASHRAE MERV standard assesses filtration efficiency for three distinct air pollutant size ranges. Each MERV rating implies the total efficiency of a filter in capturing particles that fall into each size range.

	Coarse Particles	**Fine Particles**	
Size Range (diameter)	3-10 microns	1-3 microns	0.3-1 microns
Examples	PM10, pollen, dust, mold spores, pet dander	PM2.5, PM1, bacteria, viruses, soot, combustion particles, vehicle exhaust, wildfire smoke, tobacco smoke	
Health Effects	short-term irritation, such as coughing, sneezing, watery eyes	can penetrate lungs and enter bloodstream, increasing risk of heart disease, lung disease, and premature death	

A filter is then assigned a MERV rating from 1-20 based on that filter's total efficiency in filtering these airborne particles (see Figure 1 for filtration efficiencies of MERV filters from 1-16).

Composite Average Particle Size Efficiency, % in Size Range, µm				
Standard 52.2 Minimum Efficiency Reporting Value (MERV)	**Range 1 0.30 to 1.0**	**Range 2 1.0 to 3.0**	**Range 3 3.0 to 10.0**	**Average Arrestance, %**
1	N/A	N/A	$E_3 < 20$	$A_{avg} < 65$
2	N/A	N/A	$E_3 < 20$	$65 \leq A_{avg}$
3	N/A	N/A	$E_3 < 20$	$70 \leq A_{avg}$

4	N/A	N/A	$E_3 < 20$	$75 \leq A_{avg}$
5	N/A	N/A	$20 \leq E_3$	N/A
6	N/A	N/A	$35 \leq E_3$	N/A
7	N/A	N/A	$50 \leq E_3$	N/A
8	N/A	$20 \leq E_2$	$70 \leq E_3$	N/A
9	N/A	$35 \leq E_2$	$75 \leq E_3$	N/A
10	N/A	$50 \leq E_2$	$80 \leq E_3$	N/A
11	$20 \leq E_1$	$65 \leq E_2$	$85 \leq E_3$	N/A
12	$35 \leq E_1$	$80 \leq E_2$	$90 \leq E_3$	N/A
13	$50 \leq E_1$	$85 \leq E_2$	$90 \leq E_3$	N/A
14	$75 \leq E_1$	$90 \leq E_2$	$95 \leq E_3$	N/A
15	$85 \leq E_1$	$90 \leq E_2$	$95 \leq E_3$	N/A
16	$95 \leq E_1$	$95 \leq E_2$	$95 \leq E_3$	N/A

Figure 1: MERV rating efficiency chart for three particle size categories – ASHRAE Standard 52.2-2017.

Each MERV rating is also associated with a pressure drop. This refers to the change in air pressure that happens when air passes through a filter to the other side of the duct, measured using inches of water (in H_2O) or pascals (Pa).

Pressure drop is used to assess how much airflow is restricted as air passes through the filter. MERV 13 air filters can introduce high air resistance into HVAC systems, which makes them unfit for use in many HVAC systems.

NanoMax air filters outperform MERV 16 filters in terms of filtration efficiency and achieve pressure drops similar to MERV 8 filters. This means that an HVAC system compatible with MERV 8 will also be compatible with NanoMax, ensuring low pressure drop along with high filtration performance.

The smaller the particle, the more dangerous it can be. Higher MERV ratings provide increasingly better protection from small particles.

Particle size is critical to understanding how dangerous a particle is – the smaller the particle, the more dangerous it can be.[2,3] Higher MERV ratings provide increasingly better protection from small particles.

MERV 1-7: Captures coarse particles from 3-10 microns

Coarse particles are the least dangerous airborne particles. Particles in this range are sometimes called PM10 because they're smaller than 10 microns in diameter. Common examples of coarse particles include:

- **pollen** from trees, plants, and grasses that can trigger allergies and asthma
- **dust** composed of soil, sand, and dead skin cells
- **mold spores** released by toxic molds for reproduction
- **pet dander** shed by cats, dogs, rodents, and other household animals that can carry allergy-inducing proteins from urine and saliva
- **particles released by solid antiperspirants** and other household hygiene products

Filters rated MERV 1-7 are primarily designed to capture coarse particles. Filters rated MERV 1-4 capture less than 20% of coarse particles, while filters rated 5-7 capture 20-50% of these particles.

MERV 8-11: Captures coarse and fine particles from 1 to 10 microns

Filters rated MERV 8-11 can capture coarse particles from 3 to 10 microns as well as fine particles from 1 to 3 microns, with low pressure drops that most HVAC systems can handle without issue.

This category of fine particles includes PM2.5 – airborne particulate matter smaller than 2.5 microns in diameter that's considered especially dangerous.
Coarse and fine particles in this range commonly come from the following sources:

- **household dust** comprising clothing fibers, bacteria, microplastics, and other microscopic airborne particles
- **dung and shed skin** from common household insects like dust mites
- **fine dust** blown by wind from construction sites, factories, and industrial plants
- **coal or oil dust** released when burned for fuel
- **particles from vehicle engine combustion** and exhaust

Filters rated MERV 8-11 capture approximately 70-85% of coarse particles and 20-50% of fine particles from 1-3 microns. MERV 11 filters can also capture about 20% of particles smaller than 1 micron.

MERV 12-16: Captures coarse and fine particles from 0.3-10 microns

Filters rated MERV 12 and above can filter the fine particles from 0.3 to 1 microns in size.

Some examples of fine particles smaller than 1 micron (sometimes called PM1) include:[4]

- **industrial combustion processes** at factories and power plants
- **wood smoke** from wildfires or indoor heating
- **tobacco smoke** from cigarette or cigar use
- **airborne heavy metals** from combustion of coal and other energy sources, such as copper, chromium, and iron
- **inorganic water-soluble ions (WSIs)** that chemically react with airborne particles, including SO_4, NO_3, and NH_4
- **atmospheric chemical reactions of particulate matter with airborne chemicals**, such as nitrogen oxides and sulfur dioxide
- **a variety of aerosolized bacteria and viruses**, including some COVID-19 aerosols

Filters rated MERV 12-16 capture:

- 35-95% of particles 0.3 to 1 microns
- 65-95% of particles 1-3 microns
- 85-95% of coarse particles 3-10 microns

MERV 13 filters capture about 35-50% of fine particles smaller than 1 micron. MERV 16 filters can capture up to 95% of particles from 10 microns down to 0.3 microns, but may be challenging to use in many HVAC systems without upgrades.

MERV 17-20: Measured by ISO standards

Beyond MERV 16, ISO 16890 is the preferred standard to adequately assess the performance of a high-efficiency filter.[5]

While MERV 16 filters can be retrofitted into standard HVAC systems for practical specified pressure drops, filters rated MERV 17-20 involve a high degree of mechanical engineering and fabrication to be incorporated into an HVAC system. This makes them largely untenable for use in many commercial HVAC systems.

ISO 16890 takes this into account with extensive specifications for filtration efficiency that can account for more robust systems, including:[6]

- **a simplified classification system** for PM10, PM2.5, and PM1, taking into account both average and minimum efficiencies
- **uses a finer dust for testing** than used in the MERV rating system that accounts for a wide variety of conditions that filters face in the field
- **advanced procedures to discharge filters** to ensure high accuracy of filtration measurements
- **considers urban vs. rural particle pollution distributions**, as smaller particles tend to be more common in urban areas

NanoMax technology filters ultrafine particles (UFPs)

Ultrafine particles (UFPs) are the smallest airborne particles that exist, ranging in size from 0.1 microns down to 0.003 microns. They're also typically found in much higher

concentrations (in particle count) in the air than PM10, PM2.5, and PM1, commonly originating from:[7]

- diesel soot
- vehicle exhaust
- smoke from wildfires and smoking
- industrial emissions

The MERV and ISO rating systems for air filters do not test for UFPs at this range. However, NanoMax filters have been tested to filter at least 90% of UFPs.[8]
The tiny size of UFPs allows them to enter the lungs and cross into the bloodstream through alveoli, resulting in lung tissue inflammation and damage as well as arterial plaque buildup that can lead to heart disease.

UFPs can also enter the brain from the bloodstream through the blood-brain barrier.[9] As a result, long-term exposure to UFPs can also cause:

- brain tumors
- memory loss
- confusion
- cognitive decline
- permanent learning disabilities in children and young adults
- dementia
- Alzheimer's

Much airborne infectious matter also falls into the UFP category. For example, airborne SARS-CoV-2 coronavirus virions responsible for COVID-19 infections range from 0.05 to 0.13 microns in diameter.[10,11]
These particles come from respiratory aerosols that spread through breathing, talking, whispering, laughing, and singing, entering the respiratory tract through mucous membranes in the airways and often causing COVID-19. SARS-CoV-2 coronavirus aerosols can remain airborne for hours in the absence of filtration or ventilation.

Even MERV 13 filtration, which has efficiencies of 35-45% for UFPs, is substantially lower in efficiency than NanoMax technology.

MERV 13 vs. NanoMax technology

MERV 13 filters have some key benefits that make them advantageous for a wide variety of applications:

- **widely available commodity** supplied by many vendors
- **highly familiar to most facility and HVAC professionals**, able to be installed and maintained with a minimal learning curve
- **come in 1-inch sizes** that fit into most HVAC systems

However, MERV 13 filters also have several major disadvantages:

- **low filtration efficiency of ≤ 50%** for the smallest, most dangerous particles such as UFPs and viruses
- **high pressure drops** that can increase air resistance, wear out HVAC components, and reduce efficiency as filtration material loads with particles
- **need for longer operation and more outdoor air ventilation** to disperse indoor concentrations of airborne particles by opening windows or doors, reducing building energy efficiency
- **frequent filter replacement intervals** (usually every 3 months) that result in expensive maintenance over time

NanoMax filters offer several advantages over MERV 13 filtration, including:

- **much higher efficiency than MERV 13 for all ranges of particles** – up to 100% for coarse particles (3-10 microns), 99% for 1-3 microns, and 96% for 0.3-1 microns
- **tested to filter UFPs with up to 90% efficiency**, while MERV 13 filters are not tested for UFPs
- **achieves comparatively low pressure drops despite high efficiency** (typically associated with prohibitively high pressure drops)

- **more energy-efficient** – doesn't require longer HVAC operation or more mechanical ventilation than building code requires
- **reduced filter replacement intervals**, as filters can be replaced about once every 12 months

Some disadvantages of NanoMax filters include:

- **only available as 2-inch filters** that may require HVAC system filter rack upgrades before installation
- **requires expert installation** that HVAC or facilities professionals may not be able to provide
- **higher initial cost** (approx. $100 per filter) than MERV 13 filters ($10-40 each)
- **high-demand filter type** not widely available

Filtration efficiency

MERV 13 filters become increasingly less effective as particles get smaller, filtering as little as 35% of ultrafine airborne particles. NanoMax typically filters between 96% and 100% of all particles ranging from 10 microns all the way down to 0.3 microns and smaller.

Here's a side-by-side comparison of how well MERV 13 and NanoMax filters can capture these different types of airborne pollutants.

	MERV 13	NanoMax	Estimated Improvement with NanoMax
3-10 microns	up to 90%	up to 100%	~11%
1-3 microns	80-85%	up to 99%	Up to 24%
0.3-1 micron	≤ 50%	up to 96%	Up to 174%
< 0.1 micron	Not tested	90%	Substantial

MERV 13 filters 35-45% of the smallest particles, including airborne bacteria and viruses that are the biggest concerns in classrooms and shared workspaces.
With MERV 13, over half of the airborne contaminants in the space can be left unfiltered, exposing occupants to dangerous airborne contaminants. Furthermore, HVAC filters often allow up to 30% of air to leak through the filter around unsealed edges, meaning that even less of the air is actually passing through filtration material. MERV 13 filter efficiency also drops dramatically over time, with efficiencies sometimes even lower than 35% as the filtration media becomes loaded with particulate matter.

NanoMax HVAC air filters outperform MERV 13 and even MERV 16 filters for fine and ultrafine particles like PM2.5 and viruses, with filtration efficiencies as high as 96% down to 0.3 microns and 90% of UFPs. This is accomplished through a combination of:

- up to 60 square feet of surface area of filtration material
- pleated filter designs that maximize airflow even as filters load with particulate matter
- advanced micro-fiber (AMF) material design that uses fibers 10 times thinner than typically used in standard HVAC air filters
- WedgeSeal leakage protection that ensures no polluted air passes around the filter, ensuring that all air passing through the HVAC system is filtered

Pressure Drop

The high pressure drop associated with MERV 13 filters causes HVAC motors to work harder to push air through dense, highly resistant MERV 13 filtration material.

Initial pressure drops of MERV 13 filters range from 0.25 to 0.5 in H_2O (62 to 124 Pa), and must usually be replaced before reaching 1.0 in H_2O (249 Pa). These pressure drops also may require HVAC system upgrades, such as:

- increased air duct size to allow HVAC system to operate at higher airflows
- upgraded motor to accommodate increased pressure in the HVAC system

NanoMax air filters achieve low pressure drops comparable to MERV 8 filters while still performing at higher filtration efficiencies than typical MERV 16 filters.

NanoMax filters achieve low pressure drops comparable to MERV 8 filters while still outperforming MERV 16 filters.

On average, NanoMax filters have initial pressure drops as low as 0.38 in H_2O (95 Pa) when first installed and can reach pressure drops of 1.0 in H_2O (249 Pa) before needing replacement while losing very little filtration efficiency.
This low pressure drop often allows NanoMax filters to be used even in HVAC systems compatible with MERV 8. This can make NanoMax easier to integrate into HVAC systems where high-performance air filters may otherwise require costly upgrades or incur wear or damage from high pressure drops.

Nanomax filter pleats are also arranged so that air can continue to pass through largely unrestricted even as filtration material loads up with particles over time, helping maintain a low pressure drop (see Figure 2 for a close-up).

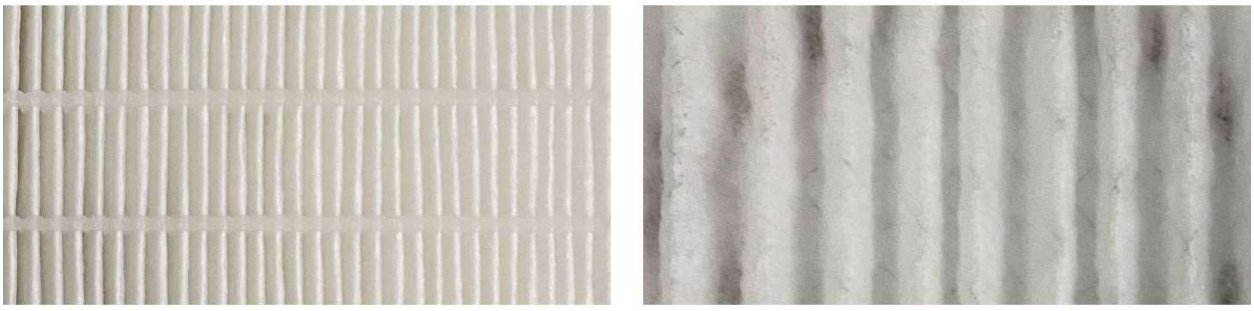

Figure 2: close up of NanoMax and MERV 13 filter pleats. This is a comparable square area of 5" x 2.75" (inches).

Ventilation

MERV 13 filters typically remove less than 50% of the smallest airborne particles ranging from 0.3 to 1 microns. This means that they must often be used along with outdoor air ventilation, done by opening doors and windows, to significantly reduce the concentration of airborne contaminants.

The use of outdoor air ventilation along with MERV 13 air filtration has several major disadvantages:

- **increasing indoor pollution from outdoor air**: opening doors and windows can introduce outdoor air pollution into indoor spaces
- **exposing occupants to outdoor temperatures**: in much of the world, temperatures can reach extreme highs or lows that make outdoor ventilation unfeasible
- **reducing energy efficiency**: due to lower filtration efficiency, HVAC systems with MERV 13 filtration require more mechanical ventilation, putting a heavy strain on HVAC systems and generating carbon emissions from power usage

NanoMax filters help reduce the need for outdoor air ventilation in the following ways:

- **Facilities need to meet building code requirements for mechanical ventilation.** However, additional mechanical ventilation is not required with NanoMax air filters. NanoMax filters capture a significant amount of the smallest, most dangerous particles.
- **HVAC systems with NanoMax filters only require operation when the indoor space is occupied** due to the high filtration efficiencies associated with NanoMax.
- **Reduced operation and outdoor air ventilation saves energy and extends filter life.** This lessens environmental impacts from HVAC operation due to reduced usage and helped reduce the cost of filter replacement and maintenance.

Filter Replacement

Manufacturers of MERV 13 air filters typically suggest filter replacement every 3 months. As a result, replacing MERV 13 air filters in an entire school or office building can become prohibitively time-consuming and costly.

NanoMax air filters need to be replaced about once every 12 months on average, containing about 60 square feet of filter media. This saves time otherwise spent on extensive installation procedures and reduces the high costs associated with frequent filter replacement across all sizes of building sites.
Refer to the table below for an illustration of estimated filter replacements, annual maintenance costs, and filter costs for a facility using, for example, 50 filters.

	Annual Filter Replacement *	**Annual Maintenance Hours (15 min./filter)**	**Annual Filter Cost**
MERV 13	4 times per year	50 hours	$2,000-$8,000
NanoMax	1 time per year	12.5 hours	$5,000

** based on usage of 8 hours per day (2,920 operation hours).*

Though NanoMax filters may cost more than typical MERV 13 filters at initial purchase, MERV 13 filters requires 400% more labor related to annual replacements and maintenance hours for each filter.

The takeaway

NanoMax air filters are superior to MERV 13 filters when it comes to filtration efficiency of airborne contaminants.

Indoor air quality improvement programs, such as the IQAir Clean Air Facility program, can help navigate the installation, maintenance, and replacement of high-efficiency NanoMax air filters.

ABOUT IQAIR

IQAir is a Swiss-based air quality technology company empowering individuals, organizations and communities to breathe clean air through information and collaboration. Since its founding in 1963, IQAir has been a global leader and operates in more than 100 countries worldwide.