



INNOVATIONS CATEGORY:
Advanced Technologies and Practices
Building Science Solutions
Optimized Comfort Solutions

INNOVATOR:
CARB and ARBI

California Energy Standards Recognize the Importance of Filter Selection

Correct filter sizing is an issue that applies to all new and existing homes that use ducted HVAC systems. About 68% of existing homes (77.1 out of 114 million) have ducted central heating systems, as do most of the homes currently under construction. The vast majority of these systems have filter boxes or grilles that are undersized for bigger, thicker, high-MERV-rated filters.

Building America research on HVAC air filter sizing prompted a change in the California "Title 24" Energy Code requiring filter manufacturers, HVAC designers, and HERS raters to make changes that will encourage the use of higher MERV filters without degrading HVAC performance.

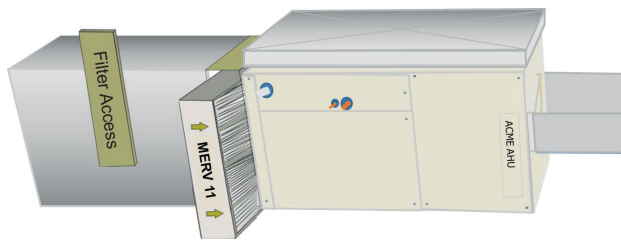
In an effort to provide cleaner indoor air, homeowners and contractors will sometimes replace the spun fiberglass filter typically installed in their furnace with a high MERV filter. MERV, or Minimum Efficiency Reporting Value, is a measure of how well the filter removes small particles; the higher the MERV, the smaller the particles that can be trapped. In new construction, many energy-efficiency programs and standards require higher MERV filters. ASHRAE Standard 62.2 calls for a minimum MERV filter rating of 6 while the U.S. Department of Energy's Zero Energy Ready Home program, U.S. Environmental Protection Agency's Indoor airPLUS program, and the LEED for Homes program all require filters to be at least MERV 8.



BUILDING AMERICA TOP INNOVATIONS

Recognizing Top Innovations in Building Science - The U.S. Department of Energy's Building America program was started in 1995 to provide research and development to the residential new construction and remodeling industry. As a national center for world-class research, Building America funds integrated research in market-ready technology solutions through collaborative partnerships between building and remodeling industry leaders, nationally recognized building scientists, and the national laboratories. Building America Top Innovation Awards recognize those projects that have had a profound or transforming impact on the new and retrofit housing industries on the road to high-performance homes.

Unfortunately, in the vast majority of central HVAC systems operating in homes today, the filter box was sized for a standard 1-inch spun-fiberglass air filter (which has a MERV rating of about 2), not for a larger, high-MERV filter. Air filters cause resistance to air flow, and higher MERV filters impose much more resistance than low-MERV filters. Other HVAC components like undersized ducts and bends in ducts also cause resistance. This resistance is called a pressure drop and is measured in inches of water column (in. WC). Most residential HVAC systems operate efficiently when the total pressure drop across the system (including the filter and all the components) is no higher than 0.4 or 0.5 in. WC static pressure. If a filter with a pressure drop of 0.25 is used in an air handler or furnace, the filter alone can account for half of the system's allotted 0.5 in. WC static pressure (DOE 2014b). Dirt in the filter increases pressure drop and high-MERV filters, which trap more particles, are likely to clog faster. A standard air handler or furnace with a permanent split capacitor (PSC) motor will continue delivering air if the pressure drop increases above 0.5 in. WC, but the airflow rate will fall below the desired 400 cfm per ton of capacity, degrading system efficiency. Air handlers and furnaces equipped with an electrically commutated (ECM) fan motor are more efficient and can maintain airflow at much higher static pressures than PSC type motors. However, if filters and ducting are improperly sized, ECMs could use over 50% more energy than if they are properly sized.



The filter box must be correctly sized for the appropriate filter, according to ACCA Manual D, taking into account pressure drop across the system. (Figure source: DOE 2014b)

If a high-MERV filter is installed in a system that is not designed for it and the static pressure is increased to an amount that is higher than the optimum (about 0.1 in. WC across the filter), several negative consequences can result. It will increase air leakage at cabinets, return ducts, and plenums as the system attempts to pull air through paths of least resistance. In systems with PSC-powered fans, the reduced airflow causes air conditioner or heat pump efficiency to decline and can cause air conditioner coils to freeze, completely blocking airflow. In systems equipped with ECM fan motors, fan energy use will increase with static pressure, and undersized filters can be deformed or drawn into the duct as the fan attempts to maintain airflow.

The DOE Building America research team Alliance for Residential Building Innovation (ARBI), led by Davis Energy Group (formerly with the Consortium for Advanced Residential Buildings [CARB]), tested 13 filters from different manufacturers, comparing the performance of filters with MERV ratings ranging from 6 to 13 to the performance of one MERV 2 fiberglass filter. Pressure drop was measured at multiple face velocities with both PSC and ECM motors to develop performance curves. The effect of filter pressure drop on power draw and airflow rate was also measured. ARBI found that new MERV 8 filters had 2.7 to 4.7 times the pressure drop of the MERV 2 fiberglass filter. All of the commonly available MERV 12 filters tested had over four times the pressure drop of the MERV 2 filter. For PSC motors, the clean MERV 8 filters reduced the airflow rate by about 7%. For regulated-airflow ECM motors, the fan power increased about 9% on average compared to that of the fiberglass filter.

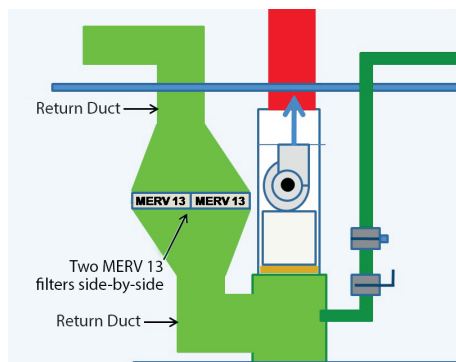
Filter pressure drop can be reduced by increasing the filter surface area by installing a filter with bigger dimensions or deeper pleats (a filter with 4-in. pleats has twice the surface area of one with a 2-in. pleats), or by providing multiple return air ducts and filter grilles. If a higher MERV filter is desired in an HVAC system designed for a 1-inch filter, an HVAC technician will have to modify the filter slot to accept the larger or deeper filter.

Although ASHRAE Standard 52.2 provides for measurement of pressure drop as well as MERV, it is uncommon to find filters in retail stores labeled with a MERV number and none list pressure drop. Because of this lack of label information, homeowners and contractors may be unaware of the possibility of reduced airflow.

The Building America research on filter sizing supported a change in California’s “Title 24” Energy Code that, effective July 2014, requires HVAC designers to design duct systems for a filter pressure drop of less than 0.05 in. WC, or allows the HERS rater to verify airflow of 350 cfm per ton or greater and fan watt draw of 0.58 W/cfm or less. The standards also call for the installer to place a label on equipment that shows the allowable maximum resistance at the airflow rate closest to the design airflow for that filter location. The California Energy Commission also issued a staff report for a future change to the Title 20 Appliance Standards that would require air filter manufacturers to label their products with the MERV rating and pressure drop.

MERV = Minimum Efficiency Reporting Value
(as defined by ASHRAE Standard 52.2-2007) A measure of how well an HVAC air filter removes small particles.

MERV	Filters out	MERV	Filters out
1	carpet fibers	11	lead dust
2	spray paint dust	12	Legionella, 1-3 µm particles
3	dust mites	13	sneezes
4	pollen, >10 µm particles	14	tobacco smoke
5	cement dust	15	all bacteria
6	fabric protector	16	.30-1.0 µm particles
7	mold spores	17	combustion smoke
8	3-10 µm particles	18	carbon dust
9	welding fumes	19	viruses
10	auto emissions	20	<0.30 µm particles



To increase surface area and reduce pressure drop for high-MERV filters, the return duct can be constructed to permit the installation of two furnace filters side by side, or deeper pleated filters can be used (Figure source: DOE 2014b.)

REFERENCES

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