Air Filter Testing, Listing, and Labeling

Codes and Standards Enhancement (CASE) Initiative
For PY 2013: Title 20 Standards Development

Analysis of Standards Proposal for
Air Filter Testing, Listing, and Labeling

Docket #12-AAER-2E

July 29, 2013

Prepared for:

PACIFIC GAS & ELECTRIC COMPANY

SOUTHERN CALIFORNIA EDISON

SAN DIEGO GAS AND ELECTRIC

SOUTHERN CALIFORNIA GAS COMPANY

Prepared by:
Jeff Steuben, ENERGY SOLUTIONS
Greg Barker, ENERGY SOLUTIONS
Alex Chase, ENERGY SOLUTIONS
Marshall Hunt, P.E., PG&E

This report was prepared by the California Statewide Utility Codes and Standards Program and funded by the California utility customers under the auspices of the California Public Utilities Commission.

*A*cknowledgements

The CASE Team would like to thank NRDC, in particular Meg Waltner, for contributions in the development of this standards proposal.

Table *of* Contents

1 Executive Summary

The Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas (SCG), San Diego Gas & Electric (SDG&E) Codes and Standards Enhancement (CASE) Initiative Project seeks to address energy efficiency opportunities through development of new and updated Title 20 standards. Individual reports document information and data helpful to the California Energy Commission (CEC) and other stakeholders in the development of these new and updated standards. The objective of this project is to develop CASE Reports that provide comprehensive technical, economic, market, and infrastructure information on each of the potential appliance standards. This CASE report covers a standard proposal for air filter labeling (marking) and product performance disclosures to the CEC Appliance Standards database.

Language included in the most recent update to California's building code, Title 24 Part 6-2013, specifies that air filter products shall be labeled with the filter efficiency (how well the filter removes particulate matter from the air) and static pressure drop (the impact the filter has on the flow of air through the HVAC system). The code does not, however, provide specifics on these labels. A Title 20 measure is proposed by this report to provide more specific guidance and standardization of these labels to provide accurate information to HVAC designers and improve consumer understanding of their filter selection.

Residential air filters currently available for sale do not disclose the pressure drop, and do not always disclose the filter efficiency. This makes it challenging for HVAC designers to accurately gauge how the filter will impact the system pressure drop and difficult for consumers to select the most appropriate filter for their home. Without pressure drop information for filters, HVAC designers may use assumptions in Title 24 Table 150.0C or 150.0D, resulting in more expensive ductwork in new homes. Filter labeling will provide the necessary information for designers to avoid costly additions to an HVAC system while maintaining Title 24 compliance. This information will also allow consumers to match replacement filters to their original filters, ensuring that they maintain the appropriate level of filtration and pressure drop.

This proposed measure builds on language passed in Title 24 that was deemed cost effective under a collection of measure improvements. Additionally, the measure is deemed cost effective when comparing the cost of labeling to the avoided costs of additional ductwork on new HVAC systems. A labeling requirement does not require substantial engineering or manufacturing changes, and as such, the implementation costs are minimal. Additionally, these incremental costs per filter are brought down by the high volume of production.

In addition to labeling requirements, this measure recommends manufacturer reporting of product data to the CEC as described by Table X in Section 1606 to create a comprehensive database of filter product performance data as a resource for HVAC designers and specifiers.

2 Title 24 Requirements

Requirements regarding air filter labeling has been included in the most recent update to California's building code, Title 24 Part 6-2013.[1] Section 150.0(m) 12 is as follows:

12. **Air Filtration.** Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 ft (3m) in length and through a thermal conditioning component, except evaporative coolers, shall be provided with air filter devices in accordance with the following:
    - A. **System Design and Installation.**
        - i. The system shall be designed to ensure that all recirculated air and all outdoor air supplied to the occupiable space is filtered before passing through the system's thermal conditioning components.
        - ii. The system shall be designed to accommodate the clean-filter pressure drop imposed by the system air filter device(s). The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter device shall be determined.
        - iii. All system air filter devices shall be located and installed in such a manner as to allow access and regular service by the system owner.
        - iv. All system air filter device locations shall be labeled to disclose the applicable design airflow rate and the maximum allowable clean-filter pressure drop as determined according to subsection ii above. The labels shall be permanently affixed to the air filter device readily legible, and visible to a person replacing the air filter media.
    - B. **Air Filter Media Efficiency.** The system shall be provided with air filter media having a designated efficiency equal to or greater than MERV 6 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 3.0-10 μm range when tested in accordance with AHRI Standard 680.
    - C. **Air Filter Media Pressure Drop.** The system shall be provided with air filter media that conforms to the maximum allowable clean-filter pressure drop determined according to Section 150.0(m)12Aii, as rated using AHRI Standard 680, for the applicable design airflow rate(s) for the system air filter device(s). If the alternative to 150.0(m)13B is utilized for compliance, the design clean-filter pressure drop for the system air filter media shall conform to the requirements given in TABLE 150.0-C or 150.0-D.
    - D. **Air Filter Media Product Labeling.** The system shall be provided with air filter media that has been labeled by the manufacturer to disclose the efficiency and pressure drop ratings that demonstrate conformance with Sections 150.0(m)12B and 150.0(m)12C

Residential central forced air systems must have filtered air entering the heating and cooling heat exchangers. Furnace and heat pump air handers are commonly shipped with a filter. Concern for indoor air quality and the advance of standards has led to the promulgation of the MERV (minimum efficiency reporting value) rating and the filter efficiency rating of AHRI Standard 680.

---

[1] p. 215 - 216, 2013 BUILDING ENERGY EFFICIENCY STANDARDS, Title 24, Part 6, and Associated Administrative Regulations in Part 1, MAY 2012 CEC-400-2012-004-CMF http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/44_Final_Express_Terms/2013_Standards_FINAL.pdf

To meet Title 24 12Aii for a furnace system using the methodology of Air Conditioning Contractors of America (ACCA) Manual D[2] Duct Design, the following must be done:

ACCA Manual D Duct Design – Available Static Pressure Calculation			
Steps	Item	**Example**	**Source**
1	CFM required	1200	3 ton AC airflow
2	Static Pressure (IWC) delivered by selected furnace at required CFM	0.7	Manufacturer's blower performance data table
3	Pressure Drop through wet AC Evaporator Coil	-0.25	Manufacturer's coil performance data table
4	Pressure Drop through clean filter	-0.25	**Currently estimated by filter type. To meet Title 24-2013 requirements, must be derived from manufacturer's data**
5	Pressure Drop through supply register	-0.03	Manufacturer data at design velocity
6	Pressure Drop through return grille	-0.03	Manufacturer data at design velocity
7	Pressure Drop through balancing damper	-0.03	Standard value
	Available Static Pressure	**0.11**	**Duct system designed to match available static pressure, which must be greater than zero**

Figure 2.1 ACCA Manual D Static Pressure Calculation
Source: ACCA

Step 4 cannot be done without filter manufacturer data. There are a wide range of filter size options for system design, as evidenced by the large number of different size filters in stock at a local hardware store. Since MERV is established with a test at 492 feet per minute (fpm), which can be thought of as roughly equivalent to 500 fpm, the filter must be at least large enough to keep velocities below 500. In the case of the example shown above, for a 1200 cfm system, the filter area must be at least 1200/500*144 = 346 square inches, or 20x18 inches. This area requirement could be met by several filters so that filter grilles could be located in different locations for better system performance. To allow for a clean filter getting dirty and for better filtration at lower pressure drop a velocity of 300 fpm or less is recommended. Using the same calculation, the size becomes 1200/300*144 = 576 square inches, or 20x30 inches.

If data is not available or if the designer does not want to do the calculations, Table 150.0-C Return Duct Sizing for Single Return Duct Systems or Table 150.0-D[3] Return Duct Sizing for Multiple Return Duct Systems can be used. Table 150.0-D requires that the "Minimum Total Return Filter Grille Gross Area (square inches) for a 3 ton system be 900 which would require a huge 30x30 inch filter or two 20x24 inch filters. Reorganizing the equation for calculating the required area the velocity through the 900 $inch^2$ filter is calculated: 1200/900*144 = 192 fpm. Since filters work better at lower velocities, this low velocity will ensure good system performance. This low velocity, combined with the extremely large default return duct sizes is provided as a safe but expensive (hundreds of dollars) alternative to doing the design work using manufacturer's data.

[2] p. 8.2, Residential Duct Systems, Manual D, 2007, Air Conditioning Contractors of America (ACCA Manual D), www.acca.org, Arlington, VA.
[3] p. 219, Title 24

Thus it is necessary that filter manufacturers provide the following data:

MERV	Face Velocity (fpm)	Static Pressure Drop (IWC)
(reported value)	300	(reported value)
	500	(reported value)

Figure 2.2 Proposed Filter Product Label

While the ARHI 680 particle efficiency is allowed under Title 24, a MERV rating is recommended because it is customer friendly, widely used and can be calculated form AHRI 680 test data (see Appendix A). An added benefit of the recommended changes is that consumers will have readily available information they can use as the shop for replacement filters. For occupants of recently built dwellings, replacing a used filter labeled with MERV and pressure drop with one with the same or better performance will facilitate the persistence of the energy efficiency of their heating and cooling system. For occupants of older dwellings, customer education by retailers will help them buy a filter that gives them good filtration without high static pressure.

To implement the recommendation additions need to be made to Title 20[4]. The following sections need to be modified:

1601. Scope.

1602. Definitions.

1604. Test Methods for Specific Appliances.

1607. Marking of Appliances;

These edits and additions are described in Section 9.2 below.

[4] California Code of Regulations, Title 20. Public Utilities and Energy, Division 2. State Energy Resources Conservation and Development Commission, NOVEMBER 2012, CEC-140-2012-002 http://www.energy.ca.gov/2008publications/CEC-140-2008-001/CEC-140-2008-001-REV1.PDF

3 Product Description

Air filters are used in air conditioning and heating systems in residential and commercial facilities. Filters serve the purpose of removing particulates such as dust, pollen, and pet dander from the building's outdoor or recirculated air to protect equipment from degradation and to improve indoor air quality. Air filters are necessary for the proper operation of the HVAC units, to keep internal components clean and free of debris that would otherwise build up and affect the efficiency of the systems. Dust build up on an air conditioner's evaporator coil prevents the efficient transfer of heat between the air and the coil, lowering its efficiency.

Air filters are made in a range of thicknesses, materials, and styles:

- One to four inches thick
- Polyester, fiberglass, or reusable
- Flat, pleated, passive electrostatic, or electronic

Flat filters represent the baseline technology used to remove large particles from the air stream. These filters protect HVAC equipment from large particles such as dirt or animal hair, but do not capture small particles that impact indoor air quality. Pleated filters use folds of material to increase the surface area of the filter media, and have higher filter efficiency than flat filters. Passive electrostatic filters use the properties of the filter media to create a static charge as air flows through the filter. This charge helps attract small, naturally charged particles in the air flow. Active electronic filters differ from passive electrostatic filters in that they use a two-stage process to first add a static charge to particles in the air flow and then collect the particles using electrified plates with the opposite electric charge[5].

An example of a common one-inch pleated filter is shown in Figure 3.1. While most air filters for residential systems are flat fiberglass or one inch pleated filters, there is not a clear distinction between filters used in residential and commercial systems. Commercial HVAC systems may use residential style filters, or may use more sophisticated bag or box filters as shown in Figure 3.2. Because there is no distinct line between the different filter and their application, all HVAC air filter products should be considered for this measure.

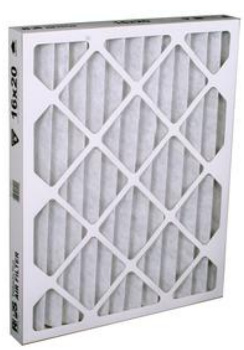

Figure 3.1 Typical pleated residential air filter
Source: Lowes

[5] p. [NAFA] National Air Filtration Association. 2007. *NAFA Guide to Air Filtration*, Fourth Edition. Virginia Beach, Va.: National Air Filtration Association.

Figure 3.2 Commercial bag and box air filters
Sources: 5 Star Filter, American Air Filter

Unlike the efficiency of an electrical product, which refers to its energy consumption, air filter efficiency refers to a filter's ability to remove particulate matter from the air. The MERV rating is determined using ASHRAE Standard 52.2 and gives a measure of the ability of the filter to capture particles ranging from 0.3 to 10.0 μm in size. MERV rating numbers correspond to different categories of performance. For common residential and commercial applications, MERV ratings range from 1 to 16, with most products rated between 6 and 11. A larger MERV rating indicates that a filter is more effective at capturing particles passing through it. Particle size efficiency, a similar metric determined using AHRI Standard 680, is reported in percentages of particles arrested across three particle size ranges measured in microns, 0.3 to 1.0; 1.0 to 3.0; and 3.0 to 10.0. The particle arrestance percentage values can be turned into a MERV rating using a reference table shown in Appendix A.

While air filters do not themselves consume electric power or heating fuel, they are an integral and necessary component of HVAC systems, and play a role in the system's energy use. Greater resistance to airflow results in higher static pressures. Fans controlled by electronically commutated motors (ECMs, also known as BPM, or brushless permanent magnet) provide a specific rate of airflow over its range of operating static pressure. An ECM will draw more wattage to overcome increased airflow resistance. Permanent split capacitor (PSC) motors, a common motor in unitary HVAC systems, experience no change or have a slight decrease in their watt draw (see Figure 3.3) and a decrease in airflow with increased duct system resistance as shown in Figure 3.4. Filters with lower pressure drops will result in more energy-efficient HVAC systems for both motor types, whether through decreased fan power demands, or through lower operating hours due to improved sensible cooling capacity.

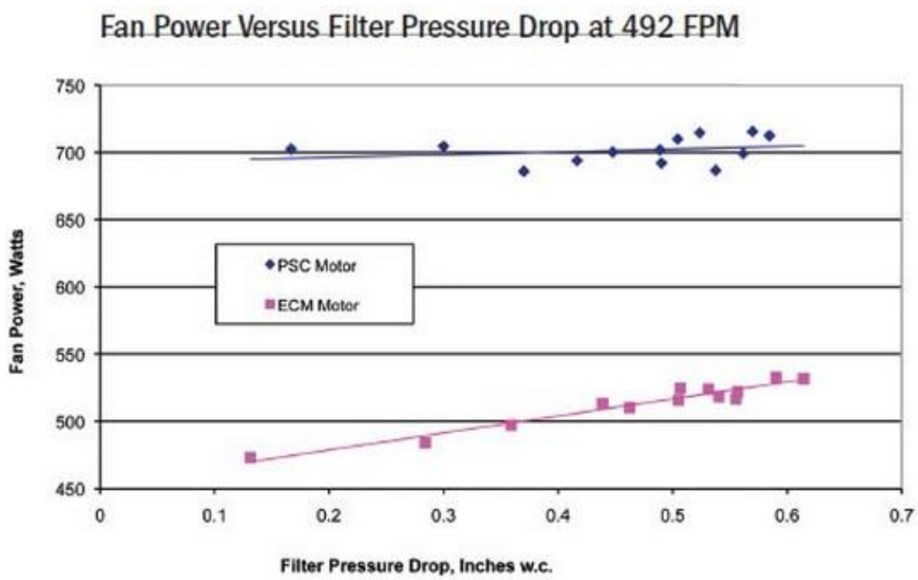

Figure 3.3 Fan Power Increases with Pressure Drop for ECM Motors
Source: [Springer 2009]

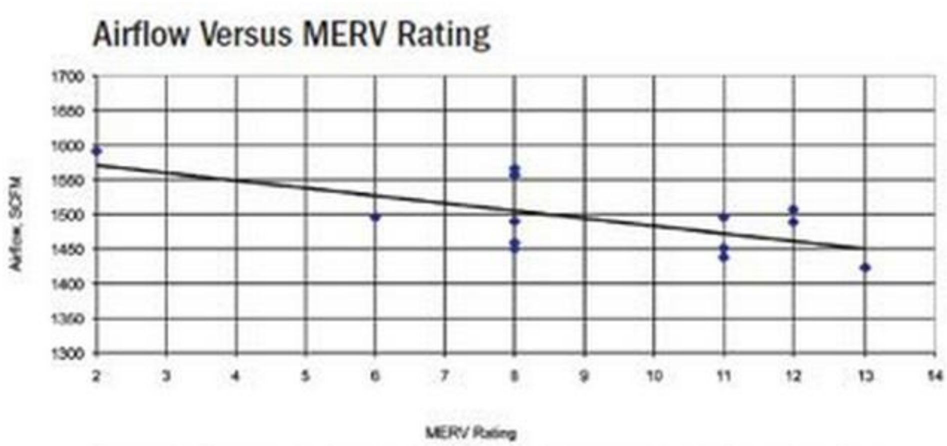

Figure 3.4 Airflow decreases with increase in MERV for PSC Motors
Source: [Springer 2009]

In general, as the MERV goes up, so does the static pressure drop. Additionally, as the airflow velocity in feet per minute (fpm) goes up, so does the static pressure drop. However, different models of filters with the same MERV rating can have substantially different pressure drops. Thus, there is a need for labeling to include MERV and pressure drop to provide essential information to consumers and HVAC specifiers.

4 Manufacturing and Market Channel Overview

A small survey of residential air filtration products available at five hardware stores and big-box home improvement stores in the San Francisco Bay Area, combined with Internet research evaluating other California markets, indicated a market dominated by two manufacturers and a single product design.

3M™ and Flanders™ products represented 72 percent of filters found on shelves in the surveyed stores, with 3M™ representing approximately 38 percent of products and Flanders™ representing 34 percent. 3M™ products were found at all five locations and Flanders products at three of five stores (Barker 2012).[6] 3M™ is a NYSE-listed, technology-focused company with $30 billion in sales in diverse markets and 84,000 employees worldwide in 65 countries. Flanders™ was purchased, and taken private in 2012 by Insight Equity, but according to 2011 filings, had $250 million in sales in air filtration, and 2,500 employees in four countries. Other companies in the market include American Air Filter International, Camfil Farr Company, Clarcor Inc., Donaldson Company, Inc., Glasfoss, and True Blue.

According to Flanders™' year-end statement for 2011, "the air filtration market is mature, with market growth driven by a gradual trend toward higher efficiency and greener filters for residential, commercial, and industrial applications"[7]. This mature market is characterized by slow product design and sales cycles to a degree that is difficult to quantify, because store sales staff did not recall any recent new product introductions. The same filing states that among recent trends there is "a greater interest in upgrading residential filtration systems as well as commercial systems to address both energy savings and better indoor air quality.[8]" Though the filing offers many examples of air quality initiatives and rating systems, it provides no examples or quantification of energy savings.

The market for residential air filters has also settled on a main incumbent technology: pleated air filters, which comprise 75 percent of products found in our survey (Barker 2012). Other represented technologies were fiberglass filters and washable filters. Fiberglass filters (13 percent of products inspected) do not offer MERV or other efficiency ratings and are priced at the extreme low end of the price range. A washable, reusable filter was found for sale at three of five locations. Average prices are $1.08 for fiberglass, $9.41 for pleated, and $20.98 for washable.

---

[6] Detailed survey results are provided in Appendix B.

[7] p.7, FLANDERS™ CORPORATION INFORMATION AND DISCLOSURE STATEMENT FOR THE YEARS ENDED DECEMBER 31, 2011 AND DECEMBER 31, 2010 www.flanderscorp.com/Newsletters/YEAREND_2011_FINAL_040612_filed.pdf

[8] ibid

5 Title 24 Compliance Strategies

5.1 Test Methods

5.1.1 Current Test Methods

Title 24, Part 6-2013 references two available test methods for air filters: **ANSI/ASHRAE Standard 52.2**, *Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size* and ANSI/**AHRI Standard 680-2009**, *Performance Rating of Residential Air Filter Equipment*. Both test methods can be used to determine the efficiency of the filter at removing particles from the air. AHRI 680 also provides the pressure drop across the filter and dust holding capacity of the tested filter.

5.1.2 Proposed Test Methods

No changes are proposed to existing test methods which are ANSI/AHRI 680 and ANSI/ASHRAE 52.2.

5.2 Compliance Enhancement through Product Labeling

5.2.1 Particle Efficiency and Pressure Drop Labeling

Under a filter labeling scenario, labels would be affixed to air filter products which disclose the filter efficiency (MERV) and pressure drop at two different face velocities. This information complements requirements specified in Title 24. Title 24, Part 6-2013 includes two labeling mandates for HVAC filters. First, the filter installation site on the equipment needs to be labeled with the design airflow rate and maximum filter pressure drop. Second, in order to show whether a filter meets the criteria listed on the equipment, the filters themselves must also be labeled with pressure drop and the MERV rating, with 6 being the minimum allowed for Title 24. Without labeling, forced air central heating and cooling system designers do not know the pressure drop through the filter at the velocity of their design, building inspectors cannot determine if the products are in compliance with Title 24 requirements, and later purchasers of air filters have no way of knowing whether the product they are buying are appropriate for their system.

The role of Title 20 is to provide specific guidance on submitting data to the Appliance Database[9], the label design, and specific metrics to be included. Without this clarification from Title 20, each manufacturer could develop different label designs with varying information that will result in poor consumer understanding. The best outcome for the public is the adoption of an industry standard rating method and consistent label design across all brands and products to allow for easy comparison between choices.

Title 20 uses the "basic model" concept to reduce the testing, listing, and labeling burden on the manufacturers while providing the public with the information needed to comply with Title 24 and Title 20. In the case of air filters, manufacturers can list the performance of the basic model that represents the performance of a model family in which all of the sizes have the same materials, construction method, and meet the same MERV rating. It is normal for a manufacturer to offer

[9] Two relevant websites are:
http://www.energy.ca.gov/2012publications/CEC-400-2012-FS/CEC-400-2012-FS-003-En.pdf
http://www.energy.ca.gov/appliances/

filters in a wide variety of sizes under one brand. Using the “basic model” method would reduce testing requirements compared to AHRI Standard 680, which rates each model and size separately, creating the need for testing of each size filter separately. It is recommended that the testing size be fixed at 20 inches by 20 inches to provide consistency during testing.

Figure 5.1 below depicts an example table for publishing test results under AHRI Standard 680[10].

Table 1. Example of Format for Published Rating						
AHRI 680 Standard Rating						
Airflow Rate (CFM)	Initial Resistance ("wc)	Final Resistance** ("wc)	Dust Holding Capacity** (g)	Particle Size Efficiency** (0.30 - 1.0 µm)%	Particle Size Efficiency** (1.0 - 3.0 µm)%	Particle Size Efficiency** (3.0 - 10 µm)%
400	0.05					
800	0.10					
1200	0.17					
1600	0.25					
2000*	0.32	0.50	45	17	53	87
* Maximum Rated Airflow Rate as published by the manufacturer.						
** Standard Rating requires that these shall be tested at Maximum Rated Airflow Rate as published by manufacturer.						

Figure 5.1 AHRI 680 Test Results
Source: AHRI

Data for the calculation of MERV is only listed for the 2000 cfm maximum airflow. Since MERV is at 492 fpm the filter size can be inferred as: 2000/492*144 = 585 square inch, or a 20x30 inch filter. A system designer meeting Title 24 requirements and following ACCA Manual D procedures would use this type of filter in a 2 or 3 ton system so that the clean filter pressure drop was low enough to allow a duct system of reasonable size to be designed. The velocity at 1200 cfm was demonstrated above as 300 fpm. Without this information the Table 150.0-D requirements for a 3 ton system would require the 900 square inches calculated above. This could be provided by having both a 20x30 inch filter grille and a 20x20 inch filter grille at a cost of more than $200 for the extra duct, connection, filter grille can, and filter grille.

A simple label design is recommended that captures the two main pieces of information needing to be disclosed, without other additions that would complicate the design and confuse the reader. A concept draft of this label is shown below in Figure 5.2. While the static pressure drop at increasing face velocity is not precisely linear, it is close enough to use two test values and the slope intercept equation to calculate values not listed. The intercept at zero velocity creates zero pressure drop. Additionally, the label discloses the filter efficiency of the filter on the MERV scale, as determined by ASHRAE 52.2 or determined from AHRI 680 test results as shown in Appendix A.

[10] p. 5, Air-Conditioning, Heating, and Refrigeration Institute. 2010. 2009 Standard for Performance Rating of Residential Air Filter Equipment, Arlington, VA

MERV	Face Velocity (fpm)	Static Pressure Drop (IWC, inches of water column)
(reported value)	300	(reported value)
	500	(reported value)

Figure 5.2 Proposed Filter Product Label

The font size used in the label needs to be readable and fit with other information, such a direction of airflow and size, already be printed on the filter. A precedent can be found in the marking requirement for televisions:

> (A) Each television shall be marked, permanently and legibly on an accessible and conspicuous place on the unit, in characters of equal size to the largest font used within the menu screen within the television's built in menu ……[11]

Title 24-2013 specifies that either ASHRAE 52.2 or AHRI 680 can be used to determine a filter's particle efficiency. A MERV rating can be determined using ASHRAE 52.2 or by comparing AHRI 680 particle efficiency results to a table of MERV values. We recommend that all air filter labels use the MERV scale to display filter efficiency. The simple integer units and limited range of values for the MERV scale improve understanding of a filter's performance relative to others. Although not entirely ubiquitous, MERV is the largest non-brand-specific efficiency metric used by air filter manufacturers, with one third of surveyed products using the metric (Barker 2012). This same survey showed that none of the 32 products inspected used a particle efficiency percentage metric, as determined by AHRI Standard 680. Thus consumers are more likely to be familiar with the MERV scale, and less likely to understand particle efficiency percentage measurements.

We recommend standardization of label style and placement so that the information is consistently accessible to the public. The label information presented on the air filter product must also consider that the packaging is discarded after the product is installed. When the consumer goes to replace their installed filter, they will not be able to reference the packaging of the installed product. With that in mind, the label must be printed on the filter product itself, not solely on the packaging. This also comes into play when building inspectors conduct an inspection. It is very likely that filter packaging will not be present in the home after the product is installed.

5.3 Compliance Enhancement through Manufacturer Data Reporting (Test and List)

Once an appliance is listed in "Section 1601. Scope."[12] it is then subject to the sections that follow. Under Sections 1603 and 1604, test standards are established. In Section 1606, testing and listing require manufacturers to submit product data to the California Energy Commission (CEC) as

[11] p. 326, California Code of Regulations, Title 20. Public Utilities and Energy, Division 2. State Energy Resources Conservation and Development Commission, NOVEMBER 2012, CEC-140-2012-002 , Section 1607.(b)(11)(A) http://www.energy.ca.gov/2008publications/CEC-140-2008-001/CEC-140-2008-001-REV1.PDF

[12] p. 134, Title 20

specified in Table X[13] Manufacturers are required to submit the data shown in Figure 5.3. Manufacturers are encouraged to disclose these reported values on their product webpages as well, but at a minimum, shall be submitted to the California Energy Commission to provide a consolidated and easily accessible resource for the entire industry. This publically available resource is necessary for Title 24 compliance by providing HVAC system designers with information regarding expected filter pressure drop when the consumer replaces their filters.

Appliance	***Required Information***	***Permissible Answers***
All Appliances	Manufacturer's Name	
	Brand Name	
	Model Number	
	Regulatory Status	Federally-regulated consumer product, federally-regulated commercial and industrial equipment, non-federally-regulated
Air Filters	MERV	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
	Initial Resistance at 300 fpm (in. W.C.)	Test results to one-hundreds of an Inch of Water Column Example: 0.25
	Initial Resistance at 500 fpm (in. W.C.)	Test results to one-hundreds of an Inch of Water Column Example: 0.41

Figure 5.3 Proposed Table X Data Submittal Requirements for Air Filter Products

[13] p. 291, Title 20

6 Market Saturation & Sales

6.1 Current Market Situation

Looking at data from the Residential Appliance Saturation Survey, one or more central air conditioners are present in 46 percent of California homes and a filtered central furnace is present in 68 percent (KEMA 2010). The 2010 census identified over 13.6 million housing units in California, which correlates to 7.1 million air conditioners and 9.3 million furnaces equipped with filters (U.S. Census Bureau 2012). For the purpose of calculating sales, the total number of filters is not the sum of air conditioners and furnaces, as houses with both systems share ducts and filters. This report uses 9.3 million filters to represent annual sales, as shown in **Error! Reference source not found.**. This report assumes a low one filter change per year, so annual sales and stock are equal.

Table 6.1 California Stock and Sales – 2012

	Annual Sales	Stock
Product Class	Units	Units
Residential air filters	9,341,710	9,341,710

Source: KEMA 2010, U.S. Census Bureau 2012

Growth in the air filter market is directly tied to the growth of the California housing market. After the burst of the U.S. credit bubble in 2007, growth in new construction in California has slowed significantly. This report assumes an average growth of 100,000 new homes per year from 2011 through 2020. Growth assumptions were determined using historic demand for building permits in California, using data from the California Department of Finance covering 1975 to 2010 (CA Department of Finance 2012). Each new home is assumed to have one filter serving a central A/C and furnace.

6.1.1 Non-Qualifying Products

There is no history of labeling requirements for air filters in California. Therefore, non-qualifying products are likely to be a large percentage of the products currently available on the market both because they are not labeled as required and are less than MERV 6. A small survey of 32 unique air filter products available locally in the San Francisco Bay Area confirmed that no air filter products specify the pressure drop, and only 34 percent of products are labeled with a MERV rating (Barker 2012).

Additionally, 13 percent of products found were flat fiberglass style filters, which, for this report, are expected to not meet Title 24's MERV 6 minimum regardless of added labels. Fiberglass filters also have a significantly lower cost than pleated filters, which may appeal to price-sensitive consumers.

6.1.2 Qualifying Products

As described in Section 6.1.1, it is expected that there are no products currently on the market that meet product labeling qualifications. Once products are labeled with their MERV rating and static pressure drop for two face velocities, it will be easy to identify filters that do not meet Title 24's MERV 6 minimum requirement and/or have unacceptably high static pressure drops.

7 Economic Analysis

7.1 Incremental Cost

As discussed above in Section 1, without test and list and filter labeling, compliance with Title 24 cannot be done without using the defaults in Tables 150.0-C and D. With an increased cost of $200 per dwelling and a production level 100,000 dwellings a year the cost to California home buyers would be $20,000,000 a year. This is in sharp contrast to a cost increase of $0.10 calculated below which for 100,000 dwellings would equal $10,000.

The costs associated with an additional labeling requirement would include an upfront cost to pay for the label design and implementation on the production line. The cost of the extra ink is minimal. The incremental cost to meet this requirement is brought down by the high product volume nature of the business. Additionally, it is typical for product manufacturers to periodically redesign packaging. If the product packaging is being redesigned, the addition of labeling information would be close to zero.

In response to the CEC's Invitation to Participate (ITP), a major filter manufacturer responded that one-time costs for labeling all filter media would be about $2,000,000, and annual costs to change existing labels would be about $500,000. These costs are assumed to correspond to all filters made by the manufacturer as they do not exclusively label filters designed for sale in California. The manufacturer did not provide sales data to determine the incremental cost per filter.

Even though the reported costs appear to be very high and cannot be independently confirmed it is instructive to explore the impacts. It is obvious that the $20 Million/year cost to meet Title 24 dwarfs the estimated cost of labeling. An estimate the incremental cost of labeling is made taking the startup cost and annual costs provided by the major filter manufacture with an estimated 10 year label design life. This total cost was compared to the total number of filters produced over that period. A rough estimate of the major manufacturer's market share was calculated using data from Barker's 2012 survey and extrapolated to all of the filter label production in the U.S. The estimate incremental manufacturer cost was calculated to be $.02 per filter per the calculations shown below. No information was provided by manufacturers in responses to the CEC ITP as to how (or if) manufacturers would pass along any incurred costs to consumers through changes in product pricing to wholesalers and retailers.

Cost estimation steps for filter labeling:

1. $2M startup + (10 years * $500,000 annual costs) = $7,000,000
2. 38% (est. major manufacturer market share) * 9.3M filters/yr in CA = 3.5M filters sold by a major manufacturer in California
3. 3.5M filters by major manufacturer sold in CA / 12% (percent of USA population in CA) = 29M filters sold by a major manufacturer in U.S.
4. $7 M cost to major manufacture / (29M * 10 years) = $0.02 per filter

This incremental cost is on filters costing around $10 retail. MERV 6 in a 1 inch filter requires the use of a pleated filter or other enhanced type of media and cannot be met using a $1 fiberglass mesh. Even if marked up by $0.10 per filter through the market chain, the incremental cost is still only a 1% increase in cost.

Manufacturers who are not currently testing their products to ASHRAE 52.2 or AHRI 680 will have to perform the required testing. However, it is expected that manufacturers are already having this testing done, and if not, the cost of testing will be spread across the millions of filters produced, resulting in an insignificant per-filter incremental cost. Using the basic model concept for testing and listing will reduce the testing burden. Without testing, no one knows how the product is performing, making any claims subject to challenge.

7.2 Benefits

Labeling requirements have already been adopted into latest version of Title 24, Part 6 (2013), a broad package of measures that was deemed necessary and cost-effective on a statewide basis as part of the Title 24 adoption process. Heating and cooling system designers will save on first costs by being able to accurately know the pressure drop of the filters they are using.

As a result of clarifying the labeling specifics in Title 20, the likelihood of an installed filter in new construction to have an appropriate pressure drop is significantly higher than for routine replacements, as building inspectors have a better understanding of Title 24 requirements than the average homeowner. Furthermore, the label, test, and list requirements can help building owners avoid filters with too high static pressure drop. High pressure drop can cause additional issues with HVAC systems by reducing air flow, which can cause stresses to the heat exchanger or result in ice formation on the evaporator coil.

A recently published report on research funded by the California Energy Commission (CEC) Public Interest Energy Research (PIER) provides an assessment of filters as applied in dwelling is California[14]. Its Executive Summary contains the following:[15]

> For the California building energy code (Title 24) and the ASHRAE residential ventilation standard it is recommended that filter-related energy use does not need to be addressed for filters of MERV 11, or less, and that MERV 16 filters should only be used with low leakage (based on the 6% level used in California Building energy Codes) duct systems. For contractors, high MERV filters should only be used if the filter area is sufficient to prevent noise issues and if the duct system has low air flow resistance and low leakage. Occupants need information on the performance of filters. Filters should be labeled for their air flow resistance, or static pressure at a particular flow rate. These rating labels would allow codes and standards to reference a particular performance specification and allow contractors and homeowners to make informed purchases.

Using the ACCA Manual D procedures addresses the need for duct systems sized to handle the impact of the higher static pressure drop of MERV 6 and higher filtration.

[14] Walker, Iain, Darryl Dickerhoff, David Faulkner and Will Turner; Energy Implications of In-Line Filtration in California, LBNL-6143E, Ernest Orlando Lawrence Berkeley Nation Laboratory, October 2012.
[15] Ibid pp. 2-3

The report summarizes the annual simulated impacts of changes in MERV in

> The result of averaging the energy penalty for all loading rates and all six climate zones but distinguishing between filter MERV rating is shown in Table 22. This table also shows the energy penalty as a fraction of the baseline HVAC energy averaged over all climates.

Table 22: Energy Penalty (kWh and fraction of baseline HVAC energy consumption) for MERV changes

MERV	PSC		BPM	
	DL = 6%	DL = 28%	DL = 6%	DL = 28%
5 → 8	-7 (0.0%)	-63 (0.3%)	75 (0.5%)	98 (0.6%)
5 → 11	18 (0.1%)	-58 (0.4%)	93 (0.6%)	139 (0.9%)
5 → 16	153 (1.1%)	104 (0.6%)	126 (0.9%)	512 (3.1%)

Figure 7.1. On January 1, 2014 the 2013 version of Title 24 will go into force. To meet the code there will be extensive use of brushless permanent magnet (BPM also known as electric commutated motor ECM) blower motors. Also the duct leakage (DL) will be 6%. Thus the impacts will be a less than 1% increase in annual kWh.

The relevant excerpt for the report is as follows[16]:

> The result of averaging the energy penalty for all loading rates and all six climate zones but distinguishing between filter MERV rating is shown in Table 22. This table also shows the energy penalty as a fraction of the baseline HVAC energy averaged over all climates.

Table 22: Energy Penalty (kWh and fraction of baseline HVAC energy consumption) for MERV changes

MERV	PSC		BPM	
	DL = 6%	DL = 28%	DL = 6%	DL = 28%
5 → 8	-7 (0.0%)	-63 (0.3%)	75 (0.5%)	98 (0.6%)
5 → 11	18 (0.1%)	-58 (0.4%)	93 (0.6%)	139 (0.9%)
5 → 16	153 (1.1%)	104 (0.6%)	126 (0.9%)	512 (3.1%)

Figure 7.1 Energy Penalty of HVAC Systems

Thus cost effectiveness is driven by the first cost of meeting Title 24 without needing to use Table 150.0C or 150.0D assumptions in the absence of filter manufacturers providing filter performance data.

The report also makes the following recommendation[17]:

> Require filter manufacturers to label filters with static pressure drop at one or more rating points (similar to European Standards)

7.3 Design Life

With the exception of a handful of products, manufacturers typically recommend replacing pleated air filters every three months. There are a few exceptions, such as the "Four Seasons" line of air filters, which are designed to last one year. This is primarily accomplished by extending the filter depth from one to four inches.

Regardless of the design life, the actual amount of time a filter is put in service can vary wildly depending on the consumer. While four filter changes per year is the best case scenario, some filters will not be replaced for a number of years.

---

[16] Ibid p. 91
[17] Ibid p. 98

8 Acceptance Issues

8.1 Infrastructure Issues

Air filter products currently sold do not disclose both filter efficiency and pressure drop versus airflow. Before products on store shelves will meet these labeling requirements, existing stock will need to be sold. This is a normal occurrence when new standards are promulgated.

Figure 8.1 Non-MERV Particle Efficiency Rating Labels
Sources: [3M™](), [Home Depot™]()

As shown in Figure 8.1, some manufacturers and retailers, such as 3M™ and The Home Depot™, have developed different scales to represent filter efficiency. The presence of non-industry standard efficiency scales makes cross-product comparisons difficult. Individual brands may keep separate metrics, but will be required to post the industry standard label.

8.2 Existing Standards

There is no existing language in Title 20 on this topic. However, Title 24, Part 6-2013 includes the following paragraph[18] .

> "The system shall be provided with air filter media that has been labeled by the manufacturer to disclose the efficiency and pressure drop ratings…"

This language is included here for the purposes of providing the requirement, but will rely on Title 20 language to clarify the specifics of the label design.

8.3 Stakeholder Comments

The following stakeholders provided responses to the CEC's Invitation to Participate data request: 3M™, ACEEE, AHRI, ASAP, NRDC, National Grid, NEEP, and Proctor Engineering. Stakeholder comment letters can be accessed here: http://www.energy.ca.gov/appliances/2013rulemaking/documents/responses/Air_Filter_Labeling_12-AAER-2E/.

[18] p. 295, Title 24

9 Recommendations

9.1 Recommended Standards Proposal

In order to establish a clear and consistent method of comparing air filter products, the CEC should require the following:

1. Specify labeling requirements for filter efficiency and pressure drop. The labeling requirements should include specifics on size, placement, and content.
2. Require manufacturers to report product performance information to the CEC so that information on all filters sold in California is consolidated and available on the CEC's Appliance Standards Database.

9.2 Proposed Changes to the Title 20 Code Language

The following is proposed language, by section, for the Title 20 2010 Appliance Efficiency Regulations.

Section 1601. Scope. (c) Central air conditioners, which are electrically-powered unitary air conditioners and electrically-powered heat pumps, except those designed to operate without a fan; and gas-fired air conditioners and gas-fired heat pumps including the air filter(s) that are installed with them.

Section 1602. Definitions.

"Air filter" means any type of media installed in a forced air heating and/or cooling system with the intention of removing particulate matter from the air flow

"Pressure drop" means the drop in an HVAC system static pressure versus air flow face velocity across air filter media as tested according to AHRI Standard 680

"MERV" means the Minimum Efficiency Reporting Value as tested by ASHRAE Standard 52.2 or derived from AHRI Standard 680 measurements.

"Particle efficiency" means the percentage of particles removed from the air by the filter media as tested according to AHRI Standard 680 or ASHRAE Standard 52.2.

Section 1604. Test Methods for Specific Appliances.

1604(c)(2)[19] The test methods for Air are shown in Table D-1[20].

Table D-1

Air Filter Test Methods

Appliance	***Appliance Performance Criteria***	***Test Method***
Air Filter	Air Filter Pressure Drop	AHRI 680-2009

[19] This will require re-numbering the rest of 1604(c). Final formatting to be confirmed in final draft.

[20] This will require re-numbering existing Tables D-1 to R. Final formatting to be confirmed in final draft.

	Air Filter Particle Efficiency and MERV	ASHRAE 52.2-2010

Section 1606. Filing by Manufacturers; Listing of Appliances in Database.

Insert a new "D" in Table X Data Submittal Requirements[21]

Appliance	***Required Information***	***Permissible Answers***
Air Filters	MERV	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16
	Initial Resistance at 300 fpm (in. W.C.)	Test results to one-hundreds of an Inch of Water Column Example: 0.25
	Initial Resistance at 500 fpm (in. W.C.)	Test results to one-hundreds of an Inch of Water Column Example: 0.40

Section 1607 Marking of Appliances

1607(e)[22]**Air Filters.** Each unit shall be marked, permanently and legibly on an accessible and conspicuous place on the filter packaging (if applicable) and the filter itself, in characters of equal size to the largest font used for other printing on the filter packaging or filter, with the following information: the unit's MERV rating as determined by ASHRAE 52.2, the static pressure drop of the unit at 300 fpm face velocity, and the static pressure of the unit at 500 fpm face velocity. The information shall be disclosed using the following format:

Minimum Efficiency Reporting Value (MERV)	Face Velocity (fpm)	Static Pressure Drop (in. W.C.)
(reported value)	300	(reported value)
	500	(reported value)

[21] p. 298, Title 20. The remaining categories in Table X need to be changed. Final formatting to be confirmed in final draft.

[22] New subsection in 1607.

10 References

[ACCA Manual D] Residential Duct Systems, Manual D, 2007, Air Conditioning Contractors of America, www.acca.org, Arlington, VA.

[AHRI] Air-Conditioning, Heating, and Refrigeration Institute. 2010. "2009 Standard for Performance Rating of Residential Air Filter Equipment." Arlington, VA: AHRI.

[ASHRAE] Standard 52.2-2012 -- Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size (ANSI Approved), Atlanta, GA.

Barker, Greg (Energy Solutions). 2012. Personal Communication. July 3. (See Appendix B: Barker 2012 Air Filter Study Results)

California Department of Finance. 2012. "California Construction Data." http://www.dof.ca.gov/html/fs_data/latestecondata/FS_Construction.htm. Sacramento, CA: Department of Finance.

California Energy Commission, 2013 BUILDING ENERGY EFFICIENCY STANDARDS, Title 24, Part 6, and Associated Administrative Regulations in Part 1, MAY 2012 CEC-400-2012-004-CMF http://www.energy.ca.gov/title24/2013standards/rulemaking/documents/final_rulemaking_documents/44_Final_Express_Terms/2013_Standards_FINAL.pdf

California Energy Commission, California Code of Regulations, Title 20. Public Utilities and Energy, Division 2. State Energy Resources Conservation and Development Commission, NOVEMBER 2012, CEC-140-2012-002
http://www.energy.ca.gov/2008publications/CEC-140-2008-001/CEC-140-2008-001-REV1.PDF

Flanders™ Corporation. 2012. *Information and Disclosure Statement for the Years Ended December 31, 2011 and December 31, 2010. www.flanderscorp.com/Newsletters/YEAREND_2011_FINAL_040612_filed.pdf*.

Heschong Mahone Group, Inc. 2011. "Residential Ducts – Duct Sealing, Cooling Coil Airflow, Fan Watt Draw and Measured Static Pressure." Prepared on behalf of the California IOUs. http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-05-31_workshop/review/2013_CASE_R_12_Ducts_Draft_052711.pdf.

KEMA, Inc. 2010. "2009 California Residential Appliance Saturation Study." California Energy Commission. Publication number: CEC-200-2010-0040-ES. Table ES-2.

[NAFA] National Air Filtration Association. 2007. *NAFA Guide to Air Filtration*, Fourth Edition. Virginia Beach, Va.: National Air Filtration Association.

Proctor, J., R. Chitwood & B. Wilcox. 2011b."Efficiency Characteristics and Opportunities for New California Homes (ECO)." California Energy Commission. Publication number: CEC-500-2012-062. http://www.energy.ca.gov/2012publications/CEC-500-2012-062/CEC-500-2012-062.pdf

Springer, D. 2009. "Is There a Downside to High-MERV Filters?." *Home Energy*. Nov/Dec 2009. http://www.homeenergy.org/show/article/page/3/id/667.

U.S. Census Bureau. 2012. “California QuickFacts.”
http://quickfacts.census.gov/qfd/states/06000.html. Washington, D.C.: U.S. Census Bureau.

Walker, Iain, Darryl Dickerhoff, David Faulkner and Will Turner; Energy Implications of In-Line Filtration in California, LBNL-6143E, Ernest Orlando Lawrence Berkeley Nation Laboratory, October 2012.

Appendix A: Particle Efficiency and MERV Ratings

Table A.1 Particle Efficiency Requirements for MERV Ratings

Standard 52.2 Minimum Efficiency Reporting Value (MERV)	Composite Average Particle Size Efficiency,% in Size Range, μm		
	Range 1 0.30–1.0	Range 2 1.0–3.0	Range 3 3.0–10.0
1	n/a	n/a	$E_3 < 20$
2	n/a	n/a	$E_3 < 20$
3	n/a	n/a	$E_3 < 20$
4	n/a	n/a	$E_3 < 20$
5	n/a	n/a	$20 \leq E_3 < 35$
6	n/a	n/a	$35 \leq E_3 < 50$
7	n/a	n/a	$50 \leq E_3 < 70$
8	n/a	n/a	$70 \leq E_3$
9	n/a	$E_2 < 50$	$85 \leq E_3$
10	n/a	$50 \leq E_2 < 65$	$85 \leq E_3$
11	n/a	$65 \leq E_2 < 80$	$85 \leq E_3$
12	n/a	$80 \leq E_2$	$90 \leq E_3$
13	$E_1 < 75$	$90 \leq E_2$	$90 \leq E_3$
14	$75 \leq E_1 < 85$	$90 \leq E_2$	$90 \leq E_3$
15	$85 \leq E_1 < 95$	$90 \leq E_2$	$90 \leq E_3$
16	$95 \leq E_1$	$95 \leq E_2$	$95 \leq E_3$

Appendix B: Barker 2012 Air Filter Study Results

MFR	Brand	Size	Filter Type	MERV	MPR rating (for 3M products)	FPR rating (for Home Depot)	Cost	Store	Store Type	Pressure drop
Flanders	PrecisionAire	01.14.24	Pleated	None			$ 2.49	True Value Eastern Supplies	Small Hardware	None
Flanders	NaturAire	01.14.25	Pleated	8			$ 3.99	True Value Eastern Supplies	Small Hardware	None
Flanders	EZ Flow II	01.16.20	Fiberglass	None			$ 1.29	True Value Eastern Supplies	Small Hardware	None
3M	Filtrete	01.16.20	Pleated	None	600		$ 8.99	True Value Eastern Supplies	Small Hardware	None
American Air Filter	ElectroKlean	01.15.20	Washable, non-adjustable	None			$21.99	True Value Eastern Supplies	Small Hardware	None
Clarcor	Purolator	01.14.25	Pleated	6			$ 4.50	Ashby Lumber	Independent Hardware	None
TrueBlue	TrueBlue	01.14.25	Pleated	7			$ 4.50	Ashby Lumber	Independent Hardware	None
3M	Filtrete	01.14.25	Pleated	None	1000		$15.99	Ashby Lumber	Independent Hardware	None
American Air Filter	DustDemon	01.16.20	Pleated	6			$ 3.99	Orchard Supply Hardware	Chain Hardware	None
3M	Filtrete	01.16.20	Pleated	6			$ 3.99	Orchard Supply Hardware	Chain Hardware	None
3M	Filtrete	01.16.20	Pleated	None	300		$ 6.29	Orchard Supply Hardware	Chain Hardware	None
3M	Filtrete	01.16.20	Pleated	None	1000		$12.99	Orchard Supply Hardware	Chain Hardware	None
3M	Filtrete	01.16.20	Pleated	None	1500		$16.99	Orchard Supply Hardware	Chain Hardware	None
3M	Filtrete	01.16.20	Pleated	None	1900		$19.99	Orchard Supply Hardware	Chain Hardware	None
WEB		variable	Adjustable, washable	None			$21.99	Orchard Supply Hardware	Chain Hardware	None
American Air Filter		01.16.20	Fiberglass	None			$ 0.99	Orchard Supply Hardware	Chain Hardware	None
Flanders		01.14.24	Fiberglass	None			$ 0.75	Home Depot	Chain Hardware	None
Flanders	NaturAire	01.12.20	Pleated	8		4	$ 3.97	Home Depot	Chain Hardware	None
Flanders	NaturAire	01.12.24	Pleated	8		4	$ 3.97	Home Depot	Chain Hardware	None
Flanders	NaturAire	01.14.24	Pleated	11		8	$ 8.97	Home Depot	Chain Hardware	None
Flanders	NaturAire	01.14.24	Pleated	8		4	$ 3.97	Home Depot	Chain Hardware	None
Flanders	PrecisionAire	variable	cut to fit	None			$ 7.97	Home Depot	Chain Hardware	None
WEB			Adjustable, washable	None		4	$19.97	Home Depot	Chain Hardware	None
3M	Filtrete	01.14.24	Pleated	None	1900	10	$19.97	Home Depot	Chain Hardware	None
3M	Filtrete	01.14.24	Pleated	None	1500	9	$16.97	Home Depot	Chain Hardware	None
3M	Filtrete	01.14.24	Pleated	None	1000	7	$10.97	Home Depot	Chain Hardware	None
ACE		01.12.24	Pleated	8			$ 4.49	ACE Grand Ave	Small Hardware	None
3M	Filtrete	01.12.24	Pleated	None	1000		$12.99	ACE Grand Ave	Small Hardware	None
ACE	30-day	01.12.24	Fiberglass	None			$ 1.29	ACE Grand Ave	Small Hardware	None
Flanders		02.16.25	Pleated	None			$ 6.99	ACE Grand Ave	Small Hardware	None
Flanders	NaturAire	01.10.30	Pleated	8				ACE Grand Ave	Small Hardware	None
3M	Allergen	01.12.24	Pleated	None	1500		$18.49	ACE Grand Ave	Small Hardware	None

Products listed with Efficiency Labels

	None	MERV	MPR	FPR	Total Products surveyed
Count	9	11	11	8	32
Percent	28%	34%	34%	25%	