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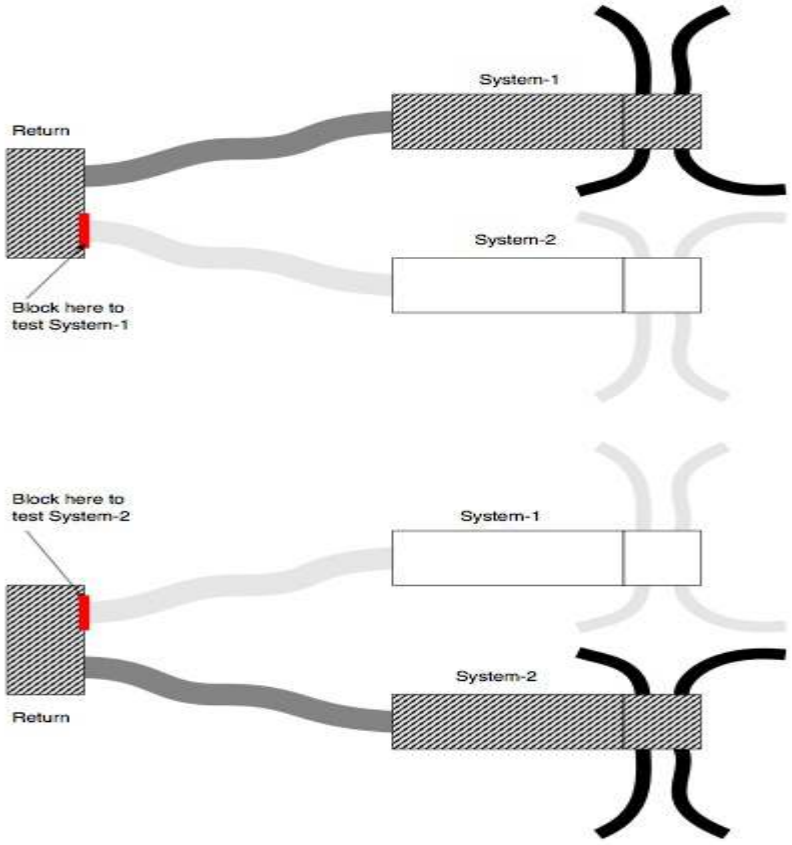
Jeff Miller, PE comment attachment 01

Additional submitted attachment is included below.

Figure 4-3: Two Duct Systems with a Common Return Duct



Source: California Energy Commission

4.4.1.14 **Air Filtration**

§150.0(m)12

Air filtration is used in forced air systems to protect the equipment from dust accumulation that could reduce the capacity or efficiency of the system. Preventing dust buildup may also prevent the system from becoming a host to biological contaminants such as mold, especially if dust is deposited on cooling coils that become wet from water condensation during comfort cooling operation. Air filter efficiencies of Minimum Efficiency Reporting Value (MERV) 6 to MERV 8 are sufficient for protection from these large airborne dust particles. Air filter efficiencies of at least MERV 13 are needed to protect occupants from exposure to the smaller airborne particles that are known to adversely affect respiratory health. These smaller particles are often referred to as PM 2.5 which refers to particulate matter of 2.5 microns. PM2.5 is produced from combustion such as that resulting from cooking in the kitchen and from exhaust from motor vehicles that enters a dwelling through ventilation openings and infiltration.

4.4.1.14.1 **Air Filter Pressure Drop**

Energy Code Section 150.0(m)12Bii requires all systems to be designed to accommodate the clean-filter pressure drop imposed by the system air filter device(s). This applies to space-conditioning systems and to the ventilation system types described in Section 4.4.1.14.2 below. 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 and posted on a sticker or label by the installer inside the filter grille or near the filter rack, according to Section 4.4.1.14.5 below.

Designers of space-conditioning systems must determine the total of the system external static pressure losses from filters, coils, ducts, and grilles, such that the sum is not greater than the available static pressure of the air handling unit at the design airflow rate. Therefore, air filters should be sized to minimize static pressure drop across the filter during system operation.

The air filter pressure drop can be reduced by increasing the amount of air filter media surface area available to the system airflow. Increased media surface area can be accomplished by adjusting one, two, or all three of the following factors:

a. *The number of pleats of media per inch inside the air filter frame.* The number of pleats per inch inside the filter frame is determined by the manufacturer's filter model design and is held constant for all filter sizes of the same manufacturer's model. For example, all 3M Filtrete™ 1900 filters will have the same media type, the same MERV rating, and the same number of pleats of media per inch inside the filter frame regardless of whether the nominal filter size is 20" X 30" or 24" X 24", and so forth. Generally, as the number of pleats per inch is increased, the pressure drop is reduced if all other factors remain constant. The pressure drop characteristics of air filters vary widely between air filter manufacturers and between air filter models, largely because of the number of pleats per inch in the manufacturer's air filter model design. System designers and system owners cannot change the manufacturer's filter model characteristics, but they can select a superior air filter model from a manufacturer that provides greater airflow at a lower pressure drop by comparing the filter pressure drop performance shown on the air filter manufacturer's product label (see example label in Figure 4-5).

b. *The face area of the air filter and filter grille.* Face area is the nominal cross-sectional area of the air filter, perpendicular to the direction of the airflow through the filter. Face area is also the area of the filter grille opening in the ceiling or wall. The face area is determined by multiplying the length times width of the filter face (or filter grille opening). The nominal face area for a filter corresponds to the nominal face area of the filter grille in which the filter is installed. For example, a nominal 20" X 30" filter has a face area of 600 in^2 and would be installed in a nominal 20" X 30" filter grille. Generally, as the

total system air filter face area increases, the pressure drop is reduced if all other factors remain constant. Total system air filter face area can be increased by specifying a larger area filter/grille, or by using multiple return filters/grilles and summing the face areas. The filter face area is specified by the system designer or installer.

c. *The depth of the filter and filter grille.* Air filter depth is the nominal filter dimension parallel to the direction of the airflow through the filter. Nominal filter depths readily available for purchase include one, two, four, and six inches. Generally, as the system air filter depth increases, the pressure drop is reduced if all other factors remain constant. For example, increasing filter depth from one inch to two inches nominally doubles the filter media surface area without increasing the filter face area. The filter depth is specified by the system designer or installer.

4.4.1.14.2 Air Filter Particle Removal Efficiency Requirements – MERV 13

An air filter with a particle removal efficiency equal to or greater than MERV 13, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30-1.0 micrometer (µm) range, and equal to or greater than 85 percent in the 1.0-3.0 µm range is required for the following systems:

a. Mechanical space conditioning (heating or cooling) systems with a total of more than 10 feet of duct. The total is determined by summing the lengths of all the supply and return ducts for the forced-air system.

b. Mechanical supply-only ventilation systems that provide outside air to an occupiable space.

c. The supply side of mechanical balanced ventilation systems, including heat recovery ventilation systems and energy recovery ventilation systems that provide outside air to an occupiable space.

Evaporative coolers are exempt from the air filtration requirements

4.4.1.14.3 Air Filter Requirements for Space-Conditioning Systems:

Space-conditioning systems may use any of the three following compliance approaches:

a. Install a filter grille or accessible filter rack that accommodates a minimum 2-inch depth filter and install the appropriate filter.

b. Install a filter grille or accessible filter rack that accommodates a minimum 1” depth filter and install the appropriate filter. The filter/grille must be sized for a velocity of ≤ 150 ft per minute. The installed filter must be

labeled to indicate the pressure drop across the filter at the design airflow rate for that return is ≤ 0.1 inch water column (w.c. [25 PA]).

Use the following method to calculate the 1" depth filter face area required. Divide the design airflow rate (ft^3/min) for the filter grille/rack by the maximum allowed face velocity 150 ft/min. This yields a value for the face area in ft^2. Since air filters are sold using nominal sizes in terms of inches, convert the face area to in^2 by multiplying the face area (ft^2) by a conversion factor of 144 in^2/ft^2. Summarizing:

$$\text{Filter Nominal Face Area (in2)} = \text{airflow (CFM)} \div 150 \times 144 \qquad \text{Equation 4.4-1}$$

c. Comply with Energy Code Tables 150.0-B and C (Table 4-10 and Table 4-11), which prescribe the minimum total system nominal filter face area and return duct size(s). The installed filter must be labeled to indicate the pressure drop across the filter at the design airflow rate for that return is ≤ 0.1 inch w.c. (25 PA). This option is an alternative to the Section 150.0(m)13 requirement for HERS-verified fan efficacy and airflow rate but requires instead a HERS verification of the return duct design.

4.4.1.14.4 Air Filter Requirements for Ventilation Systems

a. Filters with a depth of 1" or greater are allowed.

b. The design airflow rate, and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter device must be determined by the system designer or installer and that information must be posted on a sticker by the installer inside or near the filter grille/rack according to Section 4.4.1.14.5 below.

c. Ventilation systems must deliver the volume of air specified by §150.0(o) with filters in place.

4.4.1.14.5 Filter Access and Filter Grille Sticker – Design Airflow and Pressure Drop

All filters used in all system types must be accessible to facilitate replacement.

a. **Air filter grille sticker.** The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter grille/rack must be determined by the designer/installer and posted on a sticker placed by the installer inside or near the filter grille/rack. The design airflow and initial resistance posted on this sticker should correspond to the conditions used in the system design calculations. This requirement applies to space conditioning systems

and to the ventilation system types described in Section 4.4.1.14.2 above.

An example of an air filter grille sticker showing the design airflow and pressure drop for the filter grille/rack is shown in Figure 4-4.

b. **Air filter manufacturer label.** Space-conditioning system filters are required to be labeled by the manufacturer to indicate the pressure drop across the filter at several airflow rates. For the system to comply, and to ensure adequate airflow for efficient heating and cooling equipment operation, the manufacturer's air filter label (Figure 4-5) must display information that indicates the filter can meet the design airflow rate for that return grille/rack at a pressure drop ≤ the value shown on the installer's filter grille sticker (Figure 4-4). This requirement does not apply to the ventilation system types described in Section 4.4.1.14.2.

Figure 4-4: Example of Installer's Filter Grille Sticker

Air Filter Performance Requirement	Air Filter Performance Requirement	Maintenance Instructions
Airflow Rate (CFM) Must be greater than or equal to the value shown	**Initial Resistance (IWC)** Must be less than or equal to the value shown	Use only replacement filters that are rated to simultaneously meet both of the performance requirements specified on this sticker:
750	0.1	Left blank

Source: California Energy Commission

Figure 4-5: Example Manufacturer's Filter Label

MERV	(µm)	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM)	615	925	1230	1540	2085*	*Max Rated Airflow
13	PSE (%)	62	87	95	Initial Resistance (IWC)	0.07	0.13	0.18	0.25	0.38	

Source: California Energy Commission

4.4.1.14.6 Air Filter Selection

For a filter to meet the system specifications for airflow and pressure drop, it must be rated by the manufacturer to provide more than the specified airflow at less than the specified pressure drop. It is unlikely that a filter will be available that is rated to have the exact airflow and pressure drop ratings specified, so filters should be selected that are rated to have less than the specified pressure drop at the specified airflow rate, otherwise select filters that are rated to have greater

than the specified airflow rate at the specified pressure drop. See Figure 4-4 for an example of an installer's filter grille sticker that provides an air filter rating specification for minimum airflow of 750 CFM at maximum pressure drop 0.1 inch w.c.

Manufacturers of air filters may make supplementary product information available to consumers that will assist with selecting the proper replacement filters. This product information may provide more detailed information about the filter model airflow and pressure drop performance – details such as airflow and pressure drop values that are intermediate values that lie between the values shown on their product label. The information may be published in tables, graphs, or presented in software applications available on the internet or at the point of sale.

Figure 4-6 below shows a graphical representation of the initial resistance (pressure drop) and airflow rate ordered pairs given on the example air filter manufacturer's label shown in Figure 4-5 above. The graph in Figure 4-6 makes it possible to visually determine the airflow at 0.1 inch w.c. pressure drop for which the values are not shown on the manufacturer's filter label.

If there is no supplementary manufacturer information available, and it is necessary to determine the performance of a filter model at an airflow rate or pressure drop between two values shown on a manufacturer's label, linear interpolation may be used. Linear interpolation apps are readily available on the internet, and formulas for linear interpolation are shown below.

The linear interpolation method may be used to determine an unknown pressure drop corresponding to a known airflow rate by use of Equation 4-1a, or it may also be used to determine an unknown airflow rate corresponding to a known pressure drop by use of Equation 4-1b.

$$\mathbf{p} = \mathbf{p1} + [(\mathbf{f} - \mathbf{f1}) \div (\mathbf{f2} - \mathbf{f1})] \mathbf{x} (\mathbf{p2} - \mathbf{p1}) \qquad \text{Equation 4-1a}$$

where:

f = a known flow value between f_1 and f_2

p = the unknown pressure drop value corresponding to f.

p_1 and p_2 = known values that are less than and greater than p respectively.

f_1 and f_2 are the known values corresponding to p_1 and p_2.

$$f = f_1 + [(p-p_1) \div (p_2-p_1)] \times (f_2 - f_1)$$ Equation 4-1b

where:

p = a known pressure drop value between p_1 and p_2

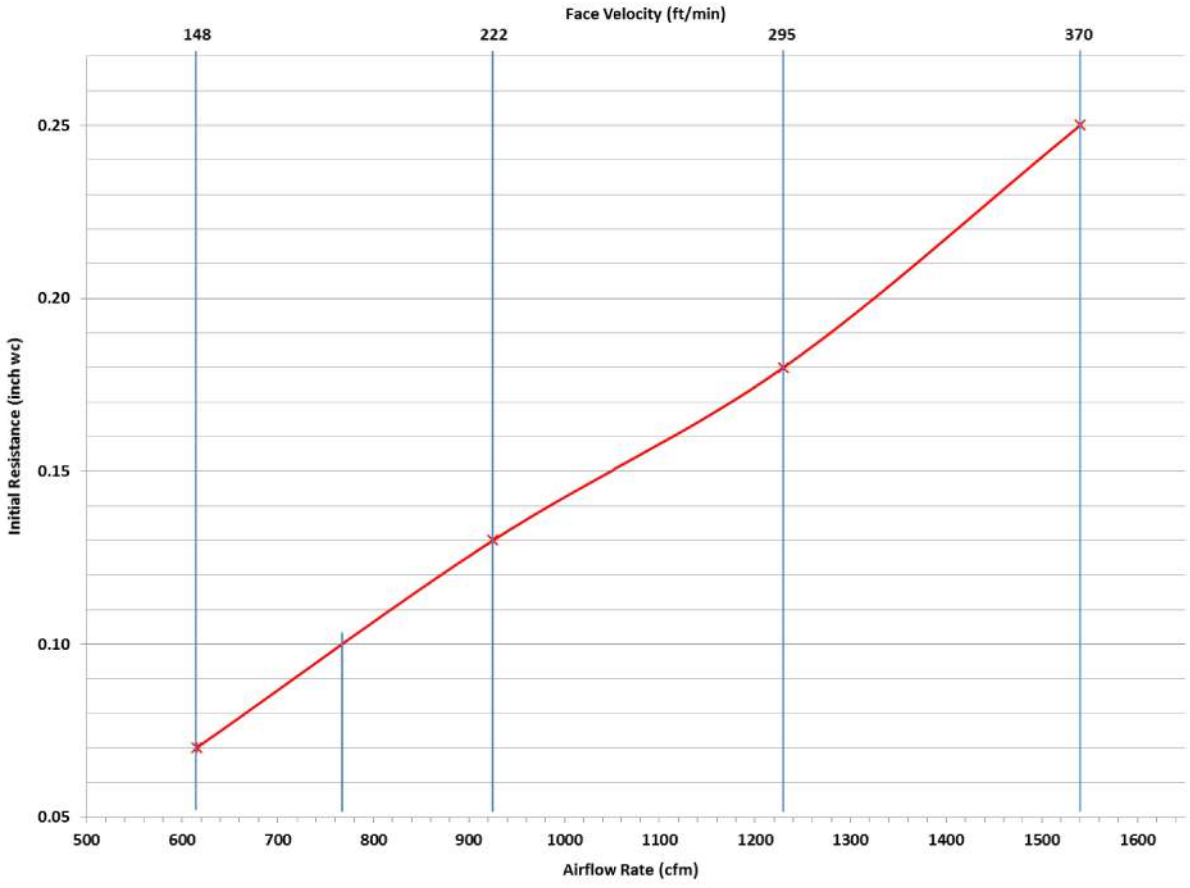
f = the unknown flow value corresponding to p.

f_1 and f_2 = known values that are less than and greater than f respectively.

p_1 and p_2 are the known values corresponding to f_1 and f_2.

See Example 4-1 for sample calculations that determine the rated airflow of the filter corresponding to a known pressure drop specification (0.1 inch w.c.).

Figure 4-6. Plot of Pressure drop vs. Airflow for a 20" X 30" X 1" Depth Air Filter
From Manufacturer Label Information



Source: California Energy Commission

4.4.1.14.7 Preventing Bypass

Any gaps around an air filter allows air to bypass the filter. The Energy Code requires that filter racks and grilles use gaskets, sealing, or other means to close gaps around inserted filters and prevent air from

bypassing the filter. Filter racks and grilles include any device that houses the air filter used to satisfy the air filtration requirements.

Example 4-1– Filter Selection Using Linear Interpolation

Question:

Does the air filter label in Figure 4-5 indicate the filter would meet the airflow (750 CFM) and pressure drop (0.1 inch w.c.) requirements shown on the installer filter grille sticker in Figure 4-4? How can I determine the filter's airflow rate at 0.1 inch w.c. for the manufacturer's filter label shown in Figure 4-5?

Answer:

The filter must be rated to provide greater than 750 CFM at the specified 0.1 inch w.c. pressure drop, or equivalently: the filter must be rated to provide a pressure drop less than 0.1 inch w.c. at the specified 750 CFM.

Referring to Equation 4-1b, we calculate the unknown value "f" in CFM that corresponds to the known value "p" of 0.1 inch w.c.

Referring to Figure 4-5: p_1=0.07, p_2=0.13, f_1=615, f_2=925, and applying Equation 4-1b:

615 + [(0.1-0.07) ÷(0.13-0.07)] x (925-615) yields 770 CFM.

Therefore, since the filter is rated for greater than 750 CFM at 0.1 inch w.c., the filter complies.

Example 4-2– Filter Sizing

Question:

I am installing a 1,200 CFM furnace in a new house. It has a 20" x 20" x 1” inch filter rack furnished with a 1" depth filter installed in the unit. Is this filter in compliance?

Answer:

The nominal face area of the filter rack is 20" x 20" = 400 in^2, and since it is a 1” filter, the face area may not be less than 1,200 (CFM)/150 (ft/min) x144 (in^2 / ft^2) = 1,152 in^2. Therefore, this filter installation does not comply.

Example 4-3

Question:

For the same 1,200 CFM furnace, what other options do I have?

Answer:

Option 1: The filter will comply if it has a depth of 2 inches or more and is properly sized by the system designer such that the duct system as a whole will be capable of meeting the HERS verification for fan efficacy specified in Section 150.0(m)13.

Otherwise, the required total system filter face area of 1,152 in^2 must be met using multiple remote wall or ceiling filter grilles for which the sum of the face areas is equal to or greater than 1152 in^2, and the filters must be rated for pressure drop of 0.1 inch w.c. or less at the design airflow rates of each filter grille.

Option 2: Table 150.0-B may be used for compliance. If the air conditioner is rated at 3 tons and two return ducts sized at 16" and 14" or larger are provided, the total filter/grille nominal area may be reduced to 900 in^2, or 450 in^2 per filter grille. However, the filters still must have a pressure drop of 0.1 inch or less at 600 CFM (based on filter manufacturer label data).

For any filter, the pressure drop, efficiency, and length of time the filter can remain in operation without becoming fully loaded with dust, can all be improved by using filters that are deeper than 1". As the depth of the filter is increased, the pressure drop across the filter at the same face area will be greatly reduced.

Example 4-4

Question:

I am installing a ductless split system in a space that is being added on to the house. Must I use the designated MERV 13 filter?

Answer:

No. The filtration requirements do not apply unless there is at least 10 feet of duct attached to the unit.

Example 4-5

Question:

My customer has allergies and wants a MERV 16 or better filter. Is this in compliance?

Answer:

Yes. MERV rated filtration greater than MERV 13 meets (exceeds) the minimum particle removal efficiency requirement; thus, it may be used provided all other applicable requirements in Section 150.0(m)12 are complied with.

4.4.1.15 **Forced-Air System Duct Sizing, Airflow Rate, and Fan Efficacy**

§150.0(m)13

Adequate airflow is critical for cooling equipment efficiency. Further, it is important to maintain adequate airflow without expending excessive fan power. Section150.0(m)13 requires system airflow and watt draw to be HERS-verified. See RA3.3 for the applicable HERS verification procedures.