



## Codes and Standards Enhancement (CASE) Initiative

### 2019 California Building Energy Efficiency Standards

# Residential Indoor Air Quality – Results Report

Measure Number: 2019-RES-IAQ-F

Residential IAQ

August 2018



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## Table of Contents

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<b>1. Introduction .....</b>	<b>1</b>
<b>2. Measure Description .....</b>	<b>1</b>
<b>3. Statewide Energy Impacts of Adopted Requirements .....</b>	<b>4</b>
<b>4. Evolution of Code Requirements .....</b>	<b>5</b>
4.1 Requirement for MERV 13 Filtration in All Supply Ventilation Systems .....	6
4.2 Requirement for Two-inch Depth Filters.....	6
4.3 Adoption of ASHRAE 62.2-2016 Addendum S.....	7
4.4 Makeup Air in Multifamily Exhaust Ventilation Systems .....	8
4.5 Requirements for Shaft Leakage and Balancing in HRMF Buildings.....	9
4.6 Credit for Balanced Systems in HRMF Buildings.....	9
4.7 Continuously Operating Variable Speed Central Fan Ventilation Systems in HRMF Buildings	10
4.8 Combustion Air .....	10
4.9 Summary of Changes Proposed in the Final CASE Report and Adopted Language .....	11
<b>5. Adopted Code Language.....</b>	<b>12</b>
5.1 Building Energy Efficiency Standards .....	12
<b>2. Field Verification and Diagnostic Testing.....</b>	<b>22</b>
5.2 Reference Appendices .....	22
<b>6. Bibliography.....</b>	<b>23</b>
<b>Attachment 1: Final CASE Report .....</b>	<b>25</b>
<b>Attachment 2: Public Comments Submitted by the Statewide CASE Team.....</b>	<b>111</b>
<b>Attachment 3: Docket Postings Relating to 2” Filter Depth Requirement .....</b>	<b>139</b>

## List of Tables

---

Table 1: Scope of Code Change Proposal.....	4
Table 2: Estimated Statewide First Year <sup>a</sup> Energy and Water Savings.....	5

# 1. INTRODUCTION

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The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The Statewide CASE Team consists of the four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison, and SoCalGas® – and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District – which sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission evaluates proposals submitted by the Statewide CASE Team and other stakeholders and may revise or reject proposals.

In September 2017 the Statewide CASE Team submitted the CASE Report to recommend code changes related to residential indoor air quality (IAQ). A subsequent version was submitted in February 2018 that includes results of filter testing, which is presented in Attachment 1 and is referred to in this document as the "Final CASE Report." This document explains the revisions that occurred to the proposed code changes between the submittal of the Final CASE Report to the Energy Commission and the Energy Commission's adoption of the 2019 Title 24, Part 6 Standards on May 9, 2018. The document begins with a concise description of the adopted code language, followed by the estimated energy savings of the adopted requirements, with the remainder of the document outlining the evolution of the code changes and the final adopted language.

## 2. MEASURE DESCRIPTION

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The primary objective of the residential IAQ CASE effort was to protect public health by ensuring residential buildings maintain a high level of IAQ while other Title 24, Part 6 requirements call for homes to be built with improved insulation and decreased air leakage. This was achieved by adopting requirements, with amendments, of the 2016 version of ASHRAE Standard 62.2 Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings (ASHRAE 62.2-2016) into Title 24, Part 6. The 2016 version of ASHRAE 62.2 replaced the California version of ASHRAE 62.2-2010 (which includes Addenda b, c, e, g, h, i, j, l, and n), that the Energy Commission adopted by reference for the 2016 Title 24, Part 6 Standards. ASHRAE 62.2-2016 includes requirements for high-rise multifamily (HRMF) buildings, which were formerly covered by the commercial ventilation standard, ASHRAE Standard 62.1. The Final CASE Report summarizes the key updates included in the 2016 version of ASHRAE 62.2, most of which were carried through to Title 24, Part 6 with the adoption of the 2019 Standards.

The specific changes to Title 24, Part 6 that were adopted as a result of the residential IAQ proposal are summarized below. Table 1 identifies sections of the Standards and Reference Appendices that were modified as a result of advocacy activities and in coordination with Energy Commission staff. The table also indicates that the compliance software will be updated. In accordance with Section 150.2(a), the code changes apply to additions and alterations greater than 1,000 square feet (ft<sup>2</sup>), but there were no language changes in Section 150.2.

Differences between the proposed changes presented in the Final CASE Report and the changes that were adopted for the 2019 Standards are described in more detail Section 4.

**Modified Methodology to Calculate Minimum Ventilation Rates:** ASHRAE 62.2-2016 modified the equations used to calculate minimum ventilation rates for single family and HRMF buildings, which the Energy Commission adopted for the 2019 Title 24, Part 6 Standards. For single family buildings, the changes increased the base (or total) ventilation rate while providing a credit for infiltration that varies by building height and climate zone. For HRMF buildings, the changes reduced the minimum ventilation rate. Equations are provided in this section to illustrate these changes.<sup>1</sup> The ventilation rate for low-rise multifamily (LRMF) buildings was not modified for the 2019 Title 24, Part 6 Standards. The ventilation equations covering LRMF buildings in ASHRAE 62.2-2010 and referenced by the 2016 Title 24, Part 6 Standards are the same as those in ASHRAE 62.2-2016 and were not changed in the 2019 Standards for these building types.

***Changes to minimum ventilation rate equations for single family buildings:***

The minimum mechanical ventilation rate for single family units was effectively changed from Equation 1 to Equation 2. This revision resulted in ventilation rates increasing by 45 percent on average.

**Equation 1**                       $Q_{fan} = 0.01 \times (CFA) + 7.5 \times (BR + 1)$

**Equation 2**                       $Q_{fan} = Q_{tot} - Q_{inf}$

Where:

$Q_{fan}$  = minimum mechanical ventilation rate

$Q_{tot} = 0.03 \times (CFA) + 7.5 \times (BR + 1)$ , or the total ventilation rate (cubic foot per minute (cfm));

$Q_{infil}$  = rate of infiltration, a function of building height and climate zone (cfm);

CFA = conditioned floor area (ft<sup>2</sup>); and

BR = number of bedrooms.

The calculation of  $Q_{infil}$  is complex and is provided in ASHRAE 62.2-2016 as Equation 4.3 and in the adopted 2019 Title 24, Part 6 code language as Equations 150.0-C, D, and E.

A 2017 supplement to ASHRAE 62.2-2016 pertaining to single family and horizontally attached units added Addendum S, which replaced Equation 3. Equation 3 was incorporated in the adopted requirements, but due to timing was not included in the Final CASE Report, which referred only to Equation 2.

**Equation 3**                       $Q_{fan} = Q_{tot} - \Phi (Q_{inf} \times A_{est})$  where:

$Q_{fan}$ ,  $Q_{inf}$ , as defined above;

$Q_{tot}$  = Total ventilation rate (mechanical plus infiltration) as calculated by Equation 5 below;

$A_{est} = 1$  for single family detached homes, or the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to total envelope surface area for single family attached homes;

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<sup>1</sup> Equations are numbered to facilitate referencing in this document. Equation numbers do not correspond to those in the adopted code language for the 2019 Standards or in ASHRAE Standard 62.2-2016. The form of the equations was also changed slightly to provide clarity.

$\Phi=1$  for balanced ventilation systems and  $Q_{inf}/Q_{tot}$  otherwise

***Changes to minimum ventilation rate equations for HRMF buildings:***

The minimum ventilation rate for HRMF units was changed from Equation 4 to Equation 5. This revision resulted in ventilation rates decreasing by about 30 percent.:

**Equation 4**                       $Q_{fan} = 5 \text{ cfm} \times (BR + 1) + 0.06 \text{ cfm/ft}^2 \times CFA$

**Equation 5**                       $Q_{fan} = 0.03 \times (CFA) + 7.5 \times (BR + 1)$

$Q_{fan}$ , BR, CFA as defined above.

No infiltration credit is allowed for multifamily buildings, and  $Q_{fan}$  equals  $Q_{tot}$  for these building types.

***Amendments to ASHRAE 62.2-2016 in the Adopted Language***

**Infiltration Credit Requirements for Single Family Buildings:** ASHRAE 62.2 requires a blower door test to be conducted to determine the air change that is used to calculate the infiltration credit. To eliminate the need to conduct blower door tests on all buildings, the Energy Commission proposed an approach that would allow compliance using an assumed air change rate of two air changes per hour at fifty Pascals (2 ACH50). However, if the builder chooses to take credit for tighter construction that would result in a lower air change rate than 2 ACH50, the measured air change rate would be required to be used to calculate the infiltration credit and the amount of mechanical ventilation required. To encourage tight construction, the 2019 Alternative Calculation Method will continue to allow a performance credit if the verified leakage is below 5 ACH50<sup>2</sup>. All the above provisions were included in the proposed changes described in the Final CASE Report.

**Air Filter Efficiency:** Filter efficiency for air supplied by systems with thermal conditioning components (e.g., furnaces and heat pumps) was increased from the MERV 6 required by ASHRAE 62.2-2016 to MERV 13. MERV is the Minimum Efficiency Reporting Value as determined from testing using ANSI/ASHRAE Standard 52.2-2017 (ASHRAE, Method of Testing Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size 2017). MERV 13 filters are effective at removing particulate matter in the size of 2.5 micrometers (PM2.5).

**Air Sealing of Attached (Multifamily) Dwelling Units:** ASHRAE 62.2-2016 requires that a maximum leakage rate of 0.3 cfm/ ft<sup>2</sup> be verified using a blower door test. Title 24, Part 6 Section 150.0(o)1Eii does not require verification using blower door tests if a balanced ventilation system is installed.

**Balancing of Exhaust Ventilation in Multifamily Buildings:** Balancing of central exhaust systems can be challenging in HRMF buildings. ASHRAE 62.2 only requires that the ventilation rate must be not less than the calculated value and does not specify an upper limit. The adopted language allows up to a 20 percent greater ventilation rate than the calculated value.

**Kitchen Hood Air Volume and Sound Rating Verification:** ASHRAE 62.2-2016 includes no requirements to verify that the airflow or sound ratings meet the standard. The adopted language requires Home Energy Rating System (HERS) verification that kitchen hoods in all dwelling unit types are Home Ventilating Institute (HVI) certified to meet ASHRAE 62.2-2016 requirements for air volume and sound ratings and that they be externally vented.

Table 1 identifies sections of the Standards and Reference Appendices that were modified as a result of advocacy activities. The table also identifies if the compliance software will be updated. Differences

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<sup>2</sup> The calculation used to determine the required mechanical ventilation rate is effectively decoupled from the calculation used by the compliance model to determine building performance.

between measures described in the Final CASE Report and those adopted in 15-Day Language are described in more detail Section 4.

**Table 1: Scope of Code Change Proposal**

Measure Name	Type of Requirement	Modified Sections of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Will Compliance Software Be Modified
Adoption of ASHRAE Standard 62.2-2016	Mandatory	120.1(a) & 120.1(b) 150.0(m) 150.0(o)	JA1, RA2, RA3	Yes

### 3.STATEWIDE ENERGY IMPACTS OF ADOPTED REQUIREMENTS

Table 2 shows the estimated energy savings of the adopted requirement over the first twelve months that the standards are in effect. The first-year savings have changed since submitting the Final CASE Report. Several factors are responsible for differences between the first-year savings listed in Table 10 of the Final CASE Report and listed here in Table 2:

- Analysis completed for the Final CASE Report estimated about a 45 percent increase in ventilation rate relative to 2016 Title 24, Part 6 Standards regardless of ventilation system type. Changes to ASHRAE 62.2-2016 during 2017 (Addendum S) significantly decreased the infiltration credit for unbalanced systems, which will result in about a 75 percent increase in ventilation rate for commonly used exhaust ventilation systems. Given the lack of data on current or projected relative installation quantities of balanced versus unbalanced systems, the ventilation rates used to develop the negative energy savings for Table 2 are based on unbalanced ventilation, which results in higher fan electricity use and different thermal loads.
- Correcting the assumption for furnace Annual Fuel Utilization Efficiency (AFUE) from 0.78 to 0.80 changed the impact on natural gas use slightly.
- Modifications to the whole house fan efficacy from 0.10 to 0.14 watts per cubic foot per minute (W/cfm) that were adopted for the 2019 Standards affected electricity savings in single family homes in Climate Zones 8 through 14.

The Statewide CASE Team used a multiplier of 1.28 times the single family new construction volume to estimate the number of dwelling units subject to alterations and additions. Lacking other data, it was assumed that additions 1,000 square ft<sup>2</sup> or greater that would trigger compliance with ASHRAE 62.2-2016 requirements represent five percent of all additions and alterations. Adoption of ASHRAE 62.6-2016 does not change ventilation requirements for LRMF buildings and reduces ventilation rates for HRMF buildings resulting in positive savings.

**Table 2: Estimated Statewide First Year<sup>a</sup> Energy and Water Savings**

Measure	First Year Electricity Savings (GWh/yr)	First Year Peak Electrical Demand Reduction (MW)	First Year Water Savings (million gallons/yr)	First Year Natural Gas Savings (million therms/yr)
<b>Measure (Total)</b>	<b>-15.58</b>	<b>-6.99</b>	n/a	<b>-2.36</b>
New Construction				
Single Family	-16.45	-6.90	n/a	-2.52
Low-rise Multifamily	0	0	n/a	0
High-rise Multifamily	1.11	n/a	n/a	0.20
Additions & Alterations	-0.23	-0.10	n/a	-0.04

a. First year savings from all buildings completed statewide in 2020.

## 4. EVOLUTION OF CODE REQUIREMENTS

The Statewide CASE Team submitted the final version of the CASE Report to the Energy Commission during February 2018 which includes Appendix E: HVAC System Filter Testing for Pressure Loss. The Final CASE Report addresses input that was received during utility-sponsored stakeholder meetings held on September 27, 2016, and March 16, 2017, and during the Energy Commission's pre-rulemaking workshop that was held on June 1, 2017. The Final CASE Report was posted to the docket in September 2017. A revised version of the Final CASE Report that included a report detailing results of air filter testing was posted in February 2018. Though it was abnormal to release a version of the CASE Report after the 45-Day Language was released, this was done to provide scientific data to identify the necessity for two-inch depth filters, and the addition of the filter test data was the only change from the September 2017 CASE Report. This section describes how the code change proposal evolved between the time the February 2018 CASE Report was submitted to the Energy Commission and the time the standards were adopted.

To identify industry standard practice for HRMF ventilation systems, interviews of multiple stakeholders were conducted. Results of these interviews guided most of the changes proposed in the Final CASE Report related to HRMF buildings.

Changes to proposed requirements that occurred between the date the Final CASE Report was submitted, and the adoption of the 2019 Title 24, Part 6 Standards included the following:

- Requirement for MERV 13 filtration of all supply ventilation systems.
- Requirement for two-inch thick filters or one-inch thick filters having a maximum pressure drop of 0.1-inches water column (w.c.) and maximum velocity of 150 feet per minute (fpm).
- Adoption of ASHRAE 62.2-2016 Addendum S, which reduced the infiltration credit for single family dwellings.
- Elimination of the requirement for makeup air in multifamily exhaust ventilation systems.
- Changes to requirements for shaft leakage and balancing in HRMF buildings.
- Elimination of the credit for balanced systems in HRMF buildings.
- Prohibition of continuously operating variable speed central fan ventilation systems in HRMF buildings.
- No prohibition of the use of indoor combustion air for indoor furnaces and gas water heaters as recommended by the CASE Report.



Details on these changes, including how the measures were initiated and evolved, the process used to address the issues, the Statewide CASE Team’s involvement in the process, and the final outcomes are provided in the following sections.

## **4.1 Requirement for MERV 13 Filtration in All Supply Ventilation Systems**

The California Air Resources Board (CARB) was a strong advocate for requiring filtration that would reduce exposure to PM<sub>2.5</sub> particles. Energy Commission and CARB staff also advocated for universal application of MERV 13 filtration to mechanical systems supplying outdoor air. As represented in the Final CASE Report, the Statewide CASE Team took the position that MERV 13 filtration of outside air should only be required within 500 feet (ft) of roadways with at least 100,000 annual average daily traffic (all motor vehicle types). A full discussion of this issue is provided in Appendix B of the Final CASE Report. Many California cities and counties meet current United States Environmental Protection Agency (EPA) standards for PM<sub>2.5</sub>. There is a substantial cost premium for balanced systems that can be equipped with MERV 13 filters (over \$1,000 per unit). The Statewide CASE Team concluded that requiring MERV 13 filtration in all locations would drive builders toward lower cost exhaust ventilation systems that would exacerbate the problem of compartmentalization. The Energy Commission opted to retain the requirement for universal application of MERV 13 filtration of all outdoor air supply ventilation systems, including balanced systems.

## **4.2 Requirement for Two-inch Depth Filters**

ASHRAE 62.2-2016 requires MERV 6 filters for “Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length and through a thermal conditioning component.” With support from CARB and the Lawrence Berkeley National Laboratory (LBNL) based on human health benefits, the Energy Commission initially proposed to increase the requirement to MERV 11, and then proposed that it be increased to MERV 13 as documented in Draft Code Language on Indoor Air Quality (California Energy Commission 2017). The Express Terms, which the Energy Commission released for public review on September 20, 2017, included no requirements for filter depth, but the 45-Day Language issued in January 2018 stipulated that ducted HVAC systems be required to be equipped with either two-inch minimum depth filters, or one-inch filters having a pressure drop not to exceed 0.1 inches w.c. and a velocity not to exceed 150 fpm. The two-inch deep filter requirement was based on the opinion by Energy Commission staff that the deeper pleats would reduce pressure drop.

Due to the delay in the effective date of the filter labeling requirements in the California Appliance Efficiency Standards (i.e., Title 20), there was very limited data on filter pressure drop to support the proposed requirements in the 45-Day Language. Also, stakeholders had expressed concerns about availability of equipment that can accommodate two-inch thick filters. Responding to these issues, the Statewide CASE Team decided to test a representative sample of filters, and in February 2018 fourteen filters were tested at PG&E’s Applied Technology Services (ATS) lab to identify the relationship between MERV rating, air velocity, and pressure drop. Test results included as Appendix E of the February update of the Final CASE Report had the following key findings:

- With sizing of furnaces and air handlers, ducts, and grilles done in accordance with Air Conditioning Contractors of America (ACCA) Manual D (as required by CALGreen code), a filter pressure drop of up to 0.15 inches w.c. and as high as 0.20 inches w.c. can be acceptable.

- All but one of the MERV 13 filters tested maintained a pressure drop below 0.20 inches w.c. at a velocity of 200 fpm, and all but one had a pressure drop higher than 0.15 inches w.c. at a velocity of 150 fpm.
- One common one-inch MERV 13 filter had a significantly lower pressure drop than one of the two-inch filters, and only a slightly higher pressure drop than another of the two-inch filters tested. One of the MERV 13 filters with a depth of two-inch outperformed all other filters, but three one-inch deep filters outperformed one of the two-inch deep filters.

In a docketed comments dated February 20, 2018, the Statewide CASE Team made the following recommendations:

- Eliminate all mandatory requirements related to filter pressure drop and size and rely on the verification of fan efficacy to ensure that all system components, not just filters, are properly designed and installed.
- In Section 150.0(m)12Bii, recommend a design maximum filter pressure drop of 0.15 inches w.c. instead of 0.10 inches w.c. and a maximum velocity of 225 fpm instead of 150 fpm.
- Reference the CALGreen mandatory measure for ACCA Manual D sizing in Title 24, Part 6 Section 150(m)12 to reinforce the requirement.

Test results were added to the CASE Report as Appendix E. No other changes were made to the report.

In docket comments dated April 23, 2018, the Energy Commission continued to support the two-inch filter requirement and alternative requirements for one-inch filters as included in the adopted 2019 Standards. A complete list of docket postings related to the two-inch filter depth requirement is provided in Attachment 3. Under the 15-Day Language Express Terms, practitioners desiring to use one-inch deep filters may apply Tables 150.0-B or 150.0-C which, in addition to avoiding the requirement for fan efficacy verification, allows for more lenient air velocity requirements than 150 fpm.

## 4.3 Adoption of ASHRAE 62.2-2016 Addendum S

ASHRAE 62.2-2016 is under continuous maintenance and subject to ongoing updates. One change that will have a significant impact on the required ventilation rates for single family dwellings using exhaust ventilation is the adoption of Addendum S. This change was announced late in 2017 in an ASHRAE supplement (ASHRAE, 2017 Supplement - Ventilaitn and Acceptable Indoor Air Quality in Residential Buildings 2017) that was obtained by the Statewide CASE Team in January 2018. Addendum S added the equation listed in Section 2 of this report as Equation 3. The impact this change has on mandatory ventilation rates is as follows: The ventilation rate for the blended 2,100 ft<sup>2</sup> and 2,700 ft<sup>2</sup> prototype houses under the 2016 Title 24, Part 6 Standards is 58 cfm. As described in the Final CASE Report, this would increase to 83 cfm using the calculation methods described in ASHRAE 62.2-2016 before applying Addendum S. Applying Addendum S, the blended prototype using exhaust ventilation would require 102 cfm. For balanced systems, the ventilation rate would remain at 83 cfm.

The Final CASE Report originally issued in September 2017 utilized the version of ASHRAE Standard 62.2-2016 that predated the supplement that adopted Addendum S. The 45-Day Language was released for public review January 18, 2018, and did not include any of the ASHRAE 62.2-2016 equations. Rather, the 45-Day Language referenced ASHRAE 62.2 without reprinting the equations.

The first public notification that the Energy Commission had picked up the Addendum S revisions was on April 20, 2018, when the Energy Commission released the 15-Day Language for public review.

Therefore, there was little opportunity for a reaction from the Statewide CASE Team or stakeholders in advance of the adoption hearing.

## 4.4 Makeup Air in Multifamily Exhaust Ventilation Systems

Section 150.0(m)12E in the adopted code language provides two pathways for ventilation compliance in all multifamily buildings:

- Either balanced ventilation with MERV 13 filtration or,
- Continuously operating supply (with MERV 13 filter) or exhaust ventilation with the units sealed in accordance with ASHRAE 62.2

Exceptions to ASHRAE 62.2 proposed in this section include elimination of the requirement for sealing when balanced ventilation is used, the requirement for continuously operating exhaust or supply ventilation, and the requirement for MERV 13 filtration of supplied air (instead of MERV 6).

For comparison, the Final CASE Report proposed the following:

- Sealing of all HRMF units as required by ASHRAE 62.2
- In locations with low ambient PM<sub>2.5</sub> levels only, exhaust ventilation with a source of makeup air (e.g., passive vents) provided or,
- Balanced or supply ventilation with MERV 8 filtration (MERV 13 filters in locations with high PM<sub>2.5</sub>)

Exceptions to ASHRAE 62.2 in the Statewide CASE Team's proposal include higher efficiency filters, a required source of makeup air for exhaust systems, and the disallowance of exhaust systems in locations with high PM<sub>2.5</sub>.

The Statewide CASE Team's concern about the adopted code language is that exhaust ventilation of units that are well sealed and that lack a source of makeup air would increase depressurization and would not reduce the volume of ventilation air that is sourced from adjacent units as a function of total ventilation air. Operation of kitchen hood and other bathroom exhaust fans would further aggravate the problem. As noted in Section 4.1 of this report, the higher cost of balanced systems may encourage the use of exhaust ventilation and fail to address the lack of compartmentalization.

The Stateside CASE Team reviewed its proposal to require makeup air when exhaust ventilation is used in communications with staff in April 2017 and provided further support in an email exchange in September 2017. This requirement was not included in the 45-Day Language (January 2018) or the 15-Day Language (April 2018). In its staff supplement on IAQ of January 19, 2018 (Docket TN #222282), Energy Commission staff expressed disagreement with the proposed requirement for makeup air for exhaust ventilation systems. Staff contended that airflow between units will be minimal if every unit is negatively pressurized. However, kitchen hood exhaust fans, stack effect, and other factors can disrupt the pressure equivalence between units. Staff also cited research showing that passive vents are not effective unless the dwelling unit is very tight (CARB 2016). In effect, the CARB study cited by staff concluded that an indoor-outdoor pressure differential enabled by tight construction is critical for proper operation of passive vents. The study concludes that the size and number of vents must be properly specified.

Although the Statewide CASE Team maintains its approach would yield better compartmentalization and IAQ in HRMF units, it was evident that the position taken by Energy Commission staff could not be altered.

## **4.5 Requirements for Shaft Leakage and Balancing in HRMF Buildings**

One strategy for providing exhaust ventilation in HRMF buildings is to connect each unit to a central ventilation shaft. Sealing of shafts and proper balancing is important to ensure that each unit receives its proper share of ventilation. In addition to requiring makeup air for each unit, the Final CASE Report proposed to require that shafts be sealed to restrict leakage to not more than ten percent of total exhaust airflow. In recognition that providing perfect exhaust air balancing is exceedingly difficult, and that oversizing of central fans has energy consequences, the Final CASE Report also recommended that ventilation provided to each unit be within ten percent (plus or minus) of the required ventilation rate.

The adopted 2019 Standards (Sections 120.1(b)2Av and 150.0(o)1F2v) require that ventilation to individual units served by central ventilation systems be balanced to provide, at a minimum, the required ventilation rate, but not to exceed 20 percent greater than the required rate. Shaft sealing or airtightness verification is not addressed in either Section 120.1(b) or 150.0(o) of the adopted code language. The adopted language will result in greater fan energy use than the language proposed in the Final CASE Report, but since it ensures that each unit will receive at a minimum the required ventilation under ASHRAE 62.2, the Statewide CASE Team did not oppose the adopted language.

The recommendation in the Final CASE Report to restrict leakage of ventilation shafts to ten percent or less of total exhaust leakage was supported by a prior code change proposal completed for the 2016 code cycle, which proposed a limit of five percent leakage, listing the cost per unit at \$85 per unit or less (Western Cooling Efficiency Center and Benningfield Group 2014). In discussions with Energy Commission staff there was uncertainty as to whether this measure would fall under the residential or nonresidential code.

In its January 19, 2018, Staff Supplement, the Energy Commission determined that it would not include the proposed change for the reason that it “was not viable in the absence of the appropriate method of test” and should be reconsidered as an update to the 2022 Standards after the adoption of ASHRAE Standard 215P, Method of Test to Determine Leakage of Operating HVAC Distribution Systems. The IAQ CASE Report proposed applying the test protocol in Nonresidential Appendix 2.1.4.2 (Diagnostic Duct Leakage), but concedes that the ASHRAE Standard method may provide a more accurate assessment of shaft leakage under operating conditions.

## **4.6 Credit for Balanced Systems in HRMF Buildings**

ASHRAE 62.2-2016 does not allow an infiltration credit to be applied when calculating required ventilation rates for multifamily units. To encourage the use of balanced systems in LRMF units and to improve compartmentalization, the Final CASE Report proposed providing a 15 percent ventilation rate credit for balanced systems. For example, the required ventilation rate for an 800 ft<sup>2</sup> two-bedroom unit could be reduced from 47 cfm to 40 cfm if a balanced system instead of an exhaust system were used. The adopted code language does not include a credit for balanced systems but does eliminate the requirement for sealing of units when they are used.

In its January 19, 2018, Staff Supplement, the Energy Commission determined that the reduction in ventilation rate and corresponding reduction in electrical requirements would not be sufficiently significant to justify the added complexity of factoring the ASHRAE 62.2 ventilation rate by 0.85 and would not be in alignment with ASHRAE 62.2. The Statewide CASE Team viewed other topics as more pressing and did not pursue this measure further.

## 4.7 Continuously Operating Variable Speed Central Fan Ventilation Systems in HRMF Buildings

The residential standards have prohibited the use of continuously operating central fan systems for the past several code cycles. When a furnace or heat pump air handler is continuously running and only a small fraction of the air that is circulated is drawn from outdoors, the W/cfm of outdoor air can be several times higher than would be used by an exhaust fan, or heat or energy recovery ventilator. With the application of residential ventilation requirements to HRMF buildings, the adopted 2019 Standards extend this prohibition to high-rise units.

One HRMF designer interviewed pointed out that he routinely designs systems that use variable speed air handlers that operate continuously to draw in and distribute outside ventilation air in conjunction with continuously operating exhaust fans, thereby providing balanced ventilation. The air handler operates efficiency at low speed when ventilating and shifts to a higher speed when there is a demand for heating or cooling.

In recognition of the value of this design approach for HRMF units, the Statewide CASE Team proposed the following exception be added to Sections 120.1(b)2Aii and 150.0(o)1B:

“High rise multifamily units may use continuous operation of central forced air system air handlers in central fan integrated ventilation systems for meeting the whole-unit ventilation requirement, if they have variable speed fans and controls that vary the airflow rate as a function of load. These systems can be central to the dwelling unit or to the building.” This exception was not included in the adopted code language.

The Statewide CASE Team had several communications with Energy Commission staff on this topic. In a September 28, 2017, email message Jeff Miller expressed concern about the system’s ability to deliver the volume of outside air required by ASHRAE 62.2, which was reaffirmed in the January 19, 2018, Staff Supplement. Despite that measurement of ventilation airflow, in accordance with procedures specified in Reference Residential Appendix RA3.7, is required, the lack of data on the efficacy of this ventilation approach relative to other ventilation system types ultimately led the Statewide CASE Team to stop supporting it. With the increased rate of ventilation required by ASHRAE 62.2-2016 there is a greater need for setting limits to ventilation system efficacy such as are now in place for furnaces and air handlers.

## 4.8 Combustion Air

With the knowledge that homes are being constructed more tightly and that required ventilation rates will be increasing and causing greater negative pressurization when exhaust ventilation is being used, the Statewide CASE Team investigated how current code makes allowance for combustion appliances, such as furnaces and water heaters, to use indoor air as a source of combustion air. The risk of back drafting and introduction of carbon monoxide to indoor space is a particular concern with natural draft gas storage water heaters. The prescriptive requirement for whole house fans in Climate Zone 8 through 15 accentuates this concern. The Statewide CASE Team proposed aligning with International Energy Conservation Code (IECC) Standard R402.4.4, which effectively prohibits drawing combustion air from occupied spaces as an indoor air quality measure. The Final CASE Report includes additions to Sections 150.0(h) covering space conditioning equipment and 150.0(n) covering water heating systems. These additions were not included in the adopted code language.

ASHRAE 62.2-2016 Section 6.4.1 states that when atmospherically vented appliances are installed inside the pressure boundary, the total net exhaust flow of the two largest fans (excluding whole house fans) shall not exceed 15 cfm per 100 ft<sup>2</sup> of occupied space. Although ASHRAE 62.2-2016 is referenced

in Title 24, Part 6 Section 150.0, the adopted code language does not include any direct reference to this requirement.

The reason given in the January 19, 2018, Staff Supplement for excluding this topic from the adopted language is that the proposal was submitted to Staff for consideration very late in the pre-rulemaking process, after the stakeholder and pre-rulemaking workshops were concluded. The issue of unvented gas appliances was raised in the first stakeholder meeting, but was not on the agenda for the second stakeholder meeting.

Between October and December 2016 there were several email exchanges between the Statewide CASE Team and Energy Commission staff, mainly on the topic of prohibiting gas appliances from drawing combustion air from inside the thermal envelope. The Statewide CASE Team indicated it was considering including a related measure that would align with the IECC code. An email from Energy Commission staff on December 21, 2016, indicated that this requirement was something they should consider, but expressed that if the change to Title 24, Part 6 would conflict with other codes it would not be allowed.

A follow-up message from Energy Commission staff on May 24, 2017, asked whether the Statewide CASE Team was proposing changes. The Statewide CASE Team responded with code citations that effectively prohibit unvented gas appliances effectively, putting that issue aside, but pointed out that the use of air inside the thermal envelope as a source of combustion air is still at issue. The Statewide CASE Team determined that this practice is still allowed by Chapter 7 of the California Mechanical Code. Jon McHugh suggested a change to Title 24, Part 4, Chapter 7, Section 701.1 that would prohibit the use of indoor combustion air in new construction and additions. On July 7, 2017, staff responded that the Energy Commission does not have authority to revise Title 24, Part 4, but that it does have authority to revise Title 24, Part 6 since ASHRAE 62.2 addresses this topic.

Through additional correspondence between the Statewide CASE Team and Jon McHugh that continued into October 2017 it was concluded that the risk for new homes is low because of the prevalence of direct-vent appliances, and that code modifications would require an appeal to the International Association of Plumbing and Mechanical Officials (i.e., IAPMO) and a fiscal impact analysis by California Housing and Community Development.

The Statewide CASE Team continues to have concerns about the potential safety risk, and advocates for including a reference to ASHRAE 62.2-2016 Section 6.4.2 in Title 24, Part 6 Sections 150.0 and 150.2. Section 6.4.2 of ASHRAE 62.2 states that where atmospherically vented combustion appliances are located inside the pressure boundary, the total net exhaust flow (excluding whole house fans) shall not exceed 15 cfm per 100 ft<sup>2</sup>. This requirement would apply to new construction and additions greater than 1,000 ft<sup>2</sup>. This requirement does not remove the risk of installing a whole house fan in an existing home with indoor gas appliances, but this is an issue that should be taken up by the appropriate building code bodies.

## **4.9 Summary of Changes Proposed in the Final CASE Report and Adopted Language**

- Based on the initial version of ASHRAE 62.2-2016, the Final CASE Report proposed an increase in single family residential ventilation rates averaging about 45 percent relative to the 2016 Standards. In response to a 2017 change in ASHRAE 62.2-2016 (Addendum S), an increase averaging about 75 percent was adopted.
- In accordance with ASHRAE 62.2-2016, HRMF ventilation rates decrease about 30 percent – adopted.

- Filtration of air supplied by thermal conditioning systems with more than ten feet of duct attached using filters with a minimum efficiency of MERV 13 (MERV 6 is required by ASHRAE 62.2-2016) – adopted.
- Filtration of outside air supplied by ventilation systems and use of MERV 13 (or better) filters in areas of high outdoor PM2.5 exposure – MERV 13 filtration of outside air in all locations was adopted.
- Improved compliance with ASHRAE 62.2 requirements related to kitchen hoods by requiring HERS inspections – adopted.
- Requirement for either balanced ventilation or sealing of multifamily units and providing passive vents to improve compartmentalization – passive vents not required in adopted language.
- Verification that kitchen hoods meet ASHRAE 62.2 requirements – adopted.
- Limitation of leakage from central ventilation shafts to less than ten percent – not adopted.
- Balancing of ventilation of individual units to within ten percent of required ventilation airflow – adopted language allows balancing up to 20 percent above the required minimum instead of  $\pm$ ten percent of the required minimum.
- Requirement that open combustion fuel burning appliances (water heaters and furnaces) be installed outside the conditioned building envelope – not adopted, but covered by reference to ASHRAE 62.2-2016 Section 6.4.2. for new construction and additions 1,000 ft<sup>2</sup> and greater.

## 5.ADOPTED CODE LANGUAGE

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The adopted code language for the Standards and Reference Appendices are presented in the following sections. Additions to the 2016 Title 24, Part 6 code language are underlined and deletions are ~~struck~~.

### 5.1 Building Energy Efficiency Standards

#### 5.1.1 Section 120.1(m) – Air-Distribution and Ventilation System Ducts, Plenums, and Fans

~~Nonresidential, high-rise residential, and hotel/motel buildings shall comply with the requirements of Section 120.1(a) through 120.1(e).~~

##### (a) General Requirements.

1. All occupiable spaces in high-rise residential buildings, hotel/motel buildings, and nonresidential buildings other than healthcare facilities shall comply with the applicable requirements of Section 120.1(a) through 120.1(g). Healthcare facilities shall be ventilated in accordance with Chapter 4 of the California Mechanical Code.

~~All enclosed spaces in a building shall be ventilated in accordance with the requirements of this section and the California Building Code.~~

**EXCEPTION to Section 120.1(a)1:** ~~Refrigerated warehouses and other spaces or buildings~~  
The required outdoor air-ventilation rate and the air-distribution system design assumptions made in the design of the ventilating system shall be clearly identified on the plans in accordance with required by Section 10-103 of Title 24, Part 1.

##### (b) High-rise Residential Buildings.

Attached dwellings units shall comply with the requirements of subsections 1 and 2 below. Occupiable spaces other than attached dwelling units shall comply with the requirements of

Section 120.1(c).

**1. Air Filtration.**

- A. System types specified in subsections i, ii, and iii shall be provided with air filters in accordance with Sections 120.1(b)1B through 1DE. System types specified in subsection i shall also comply with Section 120.1(b)1E.
- i. Mechanical space conditioning systems that utilize forced air ducts to supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length
  - ii. Mechanical supply-only ventilation systems that provide outside air to an occupiable space.
  - iii. 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.

**B. System Design and Installation.**

- i. The system shall be designed to ensure that all recirculated air or outdoor air supplied to the occupiable space is filtered before passing through any system thermal conditioning components.

**EXCEPTION to Section 120.1(b)1Bi:** For heat recovery ventilators and energy recovery ventilators the location of the filters required by Section 120.1(b) may be downstream of a system thermal conditioning component, provided the system is equipped with ancillary filtration upstream of the system's thermal conditioning component.

- ii. All systems shall be designed to accommodate the clean-filter pressure drop imposed by the system air filter (s). The design airflow rate, and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter shall be determined and reported on labels according to subsection iv below.

Systems specified in Section 120.1(b)1Ai shall be equipped with air filters that meet either subsection a or b below:

- a. Nominal two-inch minimum depth filter(s) shall be sized by the system designer; or
- b. Nominal one-inch minimum depth filters(s) shall be allowed if the filter(s) are sized according to Equation 120.1-A, based on a maximum face velocity of 150 ft per minute and according to the maximum allowable clean filter pressure drop specified in Section 120.1(b)1Dii

$$A_{\text{face}} = Q_{\text{filter}} / V_{\text{face}} \quad (\text{Equation 120.1-A})$$

Where,

$A_{\text{face}}$  = air filter face area, the product of air filter nominal length x nominal width, ft<sup>2</sup>

$Q_{\text{filter}}$  = design airflow rate for the air filter, ft<sup>3</sup>/min

$V_{\text{face}}$  = air filter face velocity ≤ 150, ft/min

- iii. All system air filters shall be located and installed in such a manner as to be accessible for regular service by the system owner.



- iv. All system air filter installation locations shall be labeled to disclose the applicable design airflow rate and the maximum allowable clean-filter pressure drop. The labels shall be permanently affixed to the air filter installation location, readily legible, and visible to a person replacing the air filter.
- C. Air Filter Efficiency. The system shall be provided with air filter(s) having a designated efficiency equal to or greater than MERV 13 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30-1.0  $\mu\text{m}$  range and equal to or greater than 85 percent in the 1.0-3.0  $\mu\text{m}$  range, when tested in accordance with AHRI Standard 680.
- D. Air Filter Pressure Drop. All-systems shall be provided with air filter(s) that conform to the maximum allowable clean-filter pressure drop specified by i, ii or iii below, when tested using ASHRAE Standard 52.2, or as rated using AHRI Standard 680, for the applicable design airflow rate(s) for the system air filter (s).
  - i. The maximum allowable clean-filter pressure drop determined by the system design for the nominal two inch minimum depth air filter required by Section 120.1(b)1Biia; or
  - ii. A maximum of 25 PA (0.1 in. of-water) clean-filter pressure drop shall be allowed for a nominal one-inch depth air filter sized according to Section 120.1(b)1Biib; or
  - iii. For system specified in 120.1(b)1Aii, and 120.1(b)1Aiii, the maximum allowable clean filter pressure drop determined by the system design.
- E. Air Filter Product Labeling. Systems described in 120.1(b)1Ai shall be equipped with air filters that have been labeled by the manufacturer to disclose the efficiency and pressure drop ratings that demonstrate conformance with Sections 120.1(b).

**EXCEPTION 4 to Section 120.1(b)1:** Evaporative coolers are not subject to the air filtration requirements of Section 120.1(b)1.

- 2. **Attached dwelling units.** All dwelling units shall meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Residential Buildings, subject to the amendments specified in subsection A below. All dwelling units shall comply with the Acceptance requirements specified in subsection B below.
  - A. Amendments to ASHRAE 62.2 requirements.
    - i. Window operation is not a permissible method of providing the dwelling unit ventilation airflow specified in subsections iv or v below.
    - ii. Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the dwelling unit ventilation airflow required in Section 4 of ASHRAE Standard 62.2.

**EXCEPTION to Section 120.1(b)2Aii:** The Energy Commission may approve continuous operation of central fan integrated ventilation systems pursuant to Section 10-109(h).
    - iii. Air filtration shall conform to the specifications in Section 120.1(b)1. Compliance with ASHRAE 62.2 Sections 6.7 (Minimum Filtration) and 6.7.1 (Filter Pressure Drop) shall not be required.
    - iv. Multifamily attached dwelling units shall comply with subsections a and b.

- a. Mechanical ventilation airflow shall be provided at rates determined in accordance with equation 120.1-B.

Total Required Ventilation Rate [ASHRAE 62.2.4.1.1]

$$Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1) \quad \text{(Equation 120.1-B)}$$

Where,

$Q_{tot}$  = total required ventilation rate, cfm

$A_{floor}$  = dwelling-unit floor area, ft<sup>2</sup>

$N_{br}$  = number of bedrooms (not to be less than 1)

- b. The mechanical ventilation system shall comply with the following subsections 1 or 2 below. When subsection 2 is utilized for compliance, all dwelling units in the multifamily building shall use the same ventilation system type.

1. A balanced mechanical ventilation system shall provide the required dwelling-unit ventilation airflow.
2. Continuously operating supply ventilation systems or a continuous operating exhaust ventilation systems shall be allowed to be used to provide the required dwelling unit ventilation airflow if the dwelling-unit envelope leakage is less than or equal to 0.3 cubic feet per minute at 50 Pa (0.2 in. of water) per ft<sup>2</sup> of dwelling unit envelope surface area as confirmed by field verification and diagnostic testing in accordance with Reference Nonresidential Appendix NA7.18.2.

- = vi. Multifamily building central ventilation systems that serve multiple dwelling-units shall be balanced to provide ventilation airflow to each dwelling-unit served at a rate equal to or greater than the rate specified by Equation 120.1, but not more than twenty percent greater than the specified rate. These systems shall utilize balancing means to ensure the dwelling unit airflows can be adjusted to meet this balancing requirement. These system balancing means may include but not be limited to constant air regulation devices, orifice plates, and variable speed central fans.
- = vii. Kitchen range hoods shall be rated for sound in accordance with Section 7.2 of ASHRAE 62.2.

**EXCEPTION to Section 120.1(b)2Avii:** Kitchen range hoods may be rated for sound at a static pressure determined at working speed as specified in HVI 916 Section 7.2.

- vii. Compliance with ASHRAE 62.2 Section 6.5.2 (Space Conditioning System Ducts) shall not be required.
- viii. Compliance with ASHRAE 62.2 Section 4.4 (Control and Operation) shall require manual switches associated with dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "This switch controls the indoor air quality ventilation for the home. Leave it on unless the outdoor air quality is very poor."

#### B. High-Rise Residential Dwelling Unit Acceptance.

- i. Airflow Performance. The dwelling- unit ventilation airflow required by Section 120.1(b)2Aiv or 120.1(b)-shall be confirmed through field verification and

diagnostic testing in accordance with Reference Nonresidential Appendix NA7.18.1.

- ii. Kitchen Range Hoods. The installed kitchen range hood shall be field verified in accordance with Reference Nonresidential Appendix NA7.18.1 to confirm the model is rated by HVI to comply with the following requirements:
  - a. The minimum ventilation airflow rate as specified in Section 5 of ASHRAE 62.2.
  - b. The maximum sound rating as specified in Section 120.1(b)2Avi.

### **5.1.2 Section 150.0(m) – Air-Distribution and Ventilation System Ducts, Plenums, and Fans**

**12. Air Filtration.** ~~Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) 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 types specified in subsections i, ii, and iii shall be provided with air filters in accordance with Sections 150.0(m)12B, 150.0(m)12C, and 150.0(m)12D. System types specified in subsection i shall also comply with Section 150.0(m)12E.
  - i. Mechanical space conditioning systems that utilize forced air ducts to supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length.
  - ii. Mechanical supply-only ventilation systems that provide outside air to an occupiable space.
  - iii. 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.

**EXCEPTION 1 to Section 150.0(m)12A:** Evaporative coolers are exempt from the air filtration requirements in Section 150.0(m)12.

#### **A.B. System Design and Installation**

- i. The system shall be designed to ensure that all recirculated air ~~and all~~ or outdoor air supplied to the occupiable space is filtered before passing through ~~the~~ any system's thermal conditioning components.

**EXCEPTION 1 to Section 150.0(m)12Bi:** For heat recovery ventilators and energy recovery ventilators the location of the filters required by Section 150.0(m)12 may be downstream of a system thermal conditioning component, provided the system is equipped with ancillary filtration upstream of the system's thermal conditioning component.

- ii. ~~The~~ All systems 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 and reported on labels according to subsection iv below.

Systems specified in Section 150.0(m)12Ai shall be equipped with air filters that meet either subsection a or b below.

- a. Nominal two-inch minimum depth filter(s) shall be used sized by the system designer, or
- b. Nominal one-inch minimum depth filter(s) shall be allowed if the filter(s) are sized according to Equation 150.0-A, based on a maximum face velocity of 150 ft per minute and according to the maximum allowable clean-filter pressure drop specified in Section 150.0(m)12Dii.

$$A_{\text{face}} = Q_{\text{filter}} / V_{\text{face}} \quad \text{(Equation 150.0-A)}$$

where

$A_{\text{face}}$  = air filter face area, the product of air filter nominal length x nominal width, ft<sup>2</sup>

$Q_{\text{filter}}$  = design airflow rate for the air filter, ft<sup>3</sup>/min

$V_{\text{face}}$  = air filter face velocity  $\leq 150$ , ft/min

- iii. All system air filter ~~devices~~ shall be located and installed in such a manner as to ~~be readily accessible for~~ allow access and regular service by the system owner.
- iv. All system air filter ~~device~~ installation 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~~ installation location, readily legible, and visible to a person replacing the air filter ~~media~~.

**BC. Air Filter Media Efficiency.** The system shall be provided with air filter(s) ~~media~~ having a designated efficiency equal to or greater than MERV ~~6-13~~ when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50 percent in the 0.30-1.0  $\mu\text{m}$  range, and equal to or greater than 85 percent in the 1.0-3.0  $\mu\text{m}$  range ~~3.0-10  $\mu\text{m}$  range~~ when tested in accordance with AHRI Standard 680.

**CD. Air Filter Media Pressure Drop.** ~~The~~ All systems shall be provided with air filter(s) ~~media~~ that conforms to the applicable maximum allowable clean-filter pressure drop specified in subsections i, ii, or iii, or iv below ~~determined according to Section 150.0(m)12ABii~~, when tested using ASHRAE Standard 52.2, or 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.(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-B or 150.0-C.~~

- i. The maximum allowable clean-filter pressure drop determined by the system design for the nominal two-inch minimum depth air filter required by Section 150.0(m)12Biia, or
- ii. A maximum of 25 PA (0.1 inches water) clean-filter pressure drop shall be allowed for a nominal one-inch depth air filter sized according to Section 150.0(m)12Biib, or
- iii. For systems specified in 150.0(m)12Aii, and 150.0(m)12Aiii, the maximum allowable clean filter pressure drop determined by the system design.
- iv. If EXCEPTION 1 to Section 150.0(m)13B or D is utilized for compliance with cooling system airflow rate and fan efficacy requirements, the clean-filter pressure drop for the system air filter shall conform to the requirements given in TABLE 150.0-B or 150.0-C.

**DE. Air Filter Media Product Labeling.** ~~The system~~ Systems described in 150.0(m)12)Ai shall be ~~equipped~~ provided with air filter(s) ~~media~~ that ~~have~~ has been labeled by the manufacturer to disclose the efficiency and pressure drop ratings that demonstrate conformance with Sections 150.0(m)12CB and 150.0(m)12DE.

**13. Duct Space Conditioning System Sizing and Airflow Rate and Fan Efficacy Filter Grille**

**Sizing.** Space conditioning systems that utilize forced air ducts to supply cooling to an occupiable space shall:

- A. **Static Pressure Probe.** Have a hole for the placement of a static pressure probe (HSPP), or a permanently installed static pressure probe (PSPP) in the supply plenum downstream of

the air conditioning evaporator coil. The size, location, and labeling of the HSPP or PSPP shall conform to the requirements specified in Reference Residential Appendix RA3.3.1.1 as confirmed by field verification and diagnostic testing; and

**EXCEPTION to 150.0(m)13A:** Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.3-1 shall not be required to provide holes as described in Figure RA3.3-1.

- B. **Single Zone Central Forced Air Systems.** Demonstrate, in every control mode, airflow greater than or equal to 350 CFM per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to the maximum W/CFM specified in subsections i or ii below. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.:

- i. 0.580.45 W/CFM for gas furnace air-handling units.
- ii. 0.58 W/CFM for air-handling units that are not gas furnaces.

~~as The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.~~

- C. **Zonally Controlled Central Forced Air Systems.** Zonally controlled central forced air cooling systems shall be capable of simultaneously delivering, in every zonal control mode, an airflow from the dwelling, through the air handler fan and delivered to the dwelling, of greater than or equal to 350 CFM per ton of nominal cooling capacity, and operating at an air-handling unit fan efficacy of less than or equal to the maximum W/CFM specified in subsections i or ii below. The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.3.:

- i. 0.45 W/CFM for gas furnace air-handling units.
- ii. 0.58 W/CFM for air-handling units that are not gas furnaces.

~~as The airflow rate and fan efficacy requirements in this section shall be confirmed by field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.3.~~

- D. **Small Duct High Velocity Forced Air Systems.** Demonstrate, in every control mode, airflow greater than or equal to 250 CFM per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to 0.62 W/CFM as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3

**EXCEPTION 1 to Section 150.0(m)13B and D:** Standard ducted systems without zoning dampers may comply by meeting the applicable requirements in TABLE 150.0-B or 150.0-C as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements ~~specified in by~~ of Section 150.0(m)12DiviiiC for the system air filter ~~device~~(s) shall conform to the requirements given in TABLES 150.0-B and 150.0-C.

**EXCEPTION 2 to Section 150.0(m)13B and D:** Multispeed compressor systems or variable speed compressor systems shall verify air flow (cfm/ton) and fan efficacy (Watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

**EXCEPTION 3 to Section 150.0(m)13B:** Gas furnace air-handling units manufactured prior to July 3, 2019 shall comply with a fan efficacy value less than or equal to 0.58 w/cfm as

confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

**EXCEPTION 3 to Section 150.0(m)13B:** ~~The Executive Director may approve alternate airflow and fan efficacy requirements for small duct high velocity systems.~~

**EXCEPTION 1 to Section 150.0(m)13C:** Multispeed or variable speed compressor systems, or single speed compressor systems that utilize the performance compliance approach, shall demonstrate compliance with the airflow (cfm/ton) and fan efficacy (Watt/cfm) requirements of Section 150.0(m)13C by operating the system at maximum compressor capacity and system fan speed with all zones calling for conditioning, rather than in every zonal control mode.

**EXCEPTION 2 to Section 150.0(m)13C:** Gas furnace air-handling units manufactured prior to July 3, 2019 shall comply with a fan efficacy value less than or equal to 0.58 w/cfm as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.

### 5.1.3 Section 150.0(o) – Requirements for Ventilation and Indoor Air Quality

- (o) **Requirements for Ventilation for and Indoor Air Quality.** All dwelling units shall meet the requirements of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in ~~Low-Rise Residential Buildings;~~ subject to the amendments specified in Section 150.0(o)1 below. ~~Window operation is not a permissible method of providing the whole building ventilation airflow required in Section 4 of ASHRAE Standard 62.2. Additionally, a~~ All dwelling units shall meet the following requirements: comply with Section 150.0(o)2 below.

a. ~~Field Verification and Diagnostic Testing.~~

~~A. Airflow Performance. The Whole Building Ventilation airflow required by Section 4 of ASHRAE Standard 62.2 shall be confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.7.~~

1. Amendments to ASHRAE 62.2 requirements.

A. Window operation is not a permissible method of providing the dwelling unit Whole-Building ventilation airflow required in Section 4 of ASHRAE Standard 62.2 specified in subsections C, E, or F below.

B. Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the whole-building dwelling unit ventilation airflow required in Section 4 of ASHRAE Standard 62.2.

- C. Single family detached dwelling units, and horizontally attached single family dwelling units not sharing ceilings or floors with other dwelling units, occupiable spaces, public garages, or commercial spaces shall have mechanical ventilation airflow provided at rates determined in accordance with ASHRAE 62.2 Sections 4.1.1 and 4.1.2 as specified in subsections i, ii, and iii below.

i. Total Required Ventilation Rate [ASHRAE 62.2:4.1.1].

The total required ventilation rate shall be calculated using Equation 150.0-B

$$Q_{tot} = 0.03A_{floor} + 7.5(N_{br} + 1) \quad \text{(Equation 150.0-B)}$$

where

$Q_{tot}$  = total required ventilation rate, cfm

$A_{floor}$  = dwelling-unit floor area, ft<sup>2</sup>

$N_{br}$  = number of bedrooms (not to be less than 1)

ii. Effective Annual Average Infiltration Rate. The effective annual average infiltration rate shall be determined in accordance with subsections a and b:

a. The infiltration credit shall be calculated according to ASHRAE 62.2 Section 4.1.2.1 using a value for an enclosure leakage rate in cubic feet per minute at 50 Pa (0.2 inch water) ( $Q_{50}$ ) shall be determined by either subsection a1, or subsection b2 below.

1.  $Q_{50}$  shall be calculated based on the conditioned volume of the dwelling unit and a default value for dwelling unit envelope leakage of 2 air changes per hour at 50 Pa (0.2 inch water) (2 ACH<sub>50</sub>) as specified by described in the equation 150.0-CA below.

$$Q_{50} = [(dwelling\ unit\ conditioned\ volume\ in\ ft^3) V_{du} \times (2\ ACH_{50})] / (60\ min) \quad (Equation\ 150.0-A)$$

where

$Q_{50}$  = leakage rate at 50 Pa

$V_{du}$  = dwelling unit conditioned volume, ft<sup>3</sup>

$ACH_{50}$  = air changes per hour at 50 Pa (0.2 inch water)

2. If dwelling unit envelope leakage less than 2 ACH<sub>50</sub> is confirmed by field verification and diagnostic testing,  $Q_{50}$  shall be calculated according to Equation 150.0-D below, using the value for dwelling unit envelope leakage less than 2 ACH<sub>50</sub> verified by the procedures specified in Reference Residential Appendix RA3.8.

$$Q_{50} = V_{du} \times Verified\ ACH_{50} / 60\ min \quad (Equation\ 150.0-D)$$

where

$Q_{50}$  = leakage rate at 50 Pa

$V_{du}$  = dwelling unit conditioned volume, ft<sup>3</sup>

$ACH_{50}$  = air changes per hour at 50 Pa (0.2 inch water)

b. The Effective Annual Average Infiltration Rate ( $Q_{inf}$ ) shall be calculated using Equation 150.0-E [ASHRAE 62.2:4.1.2.1].

$$Q_{inf} = 0.052 \times Q_{50} \times wsf \times [H/H_r]^z \quad (Equation\ 150.0-E)$$

where

$Q_{inf}$  = effective annual infiltration rate, cfm (L/s)

$Q_{50}$  = leakage rate at 50 Pa from equation 150.0-C, or equation 150.0-D

$wsf$  = weather and shielding factor from Table 150.0-D

$H$  = vertical distance between the lowest and highest above-grade points within the pressure boundary, ft (m)

$H_r$  = reference height, 8.2 ft (2.5 m)

$z = 0.4$  for the purpose of calculating the Effective Annual Average

Infiltration Rate

iii. Required Mechanical Ventilation Rate [ASHRAE 62.2:4.1.2]

The Required Mechanical Ventilation Rate ( $Q_{fan}$ ) shall be calculated using Equation 150.0-F

$$Q_{fan} = Q_{tot} - \Phi (Q_{inf} \times A_{ext}) \quad \text{(Equation 150.0-F)}$$

where

$Q_{fan}$  = required mechanical ventilation rate, cfm (L/s)

$Q_{tot}$  = total required ventilation rate, cfm (L/s) from Equation 150.0-B.

$Q_{inf}$  = effective annual average infiltration rate, cfm (L/s) from Equation 150.0-E

$A_{ext} = 1$  for single-family detached homes, or the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to total envelope surface area for attached dwelling units not sharing ceilings or floors with other dwelling units, occupiable spaces, public garages, or commercial spaces.

$\Phi = 1$  for balanced ventilation systems and  $Q_{inf}/Q_{tot}$  otherwise

- D. Air filtration shall conform to the specifications in Section 150.0(m)12. Compliance with ASHRAE 62.2 Sections 6.7 (Minimum Filtration) and 6.7.1 (Filter Pressure Drop) shall not be required.
- E. Multifamily attached dwelling units shall have mechanical ventilation airflow provided at rates in accordance with Equation 150.0-B [ASHRAE 62.2:4.1.1] ASHRAE 62.2 Section 4.1.1 and comply with one of the following subsections i or ii below. When subsection ii below is utilized for compliance, all dwellings units in the multifamily building shall use the same ventilation system type.
- i. A balanced ventilation system shall provide the required dwelling-unit ventilation airflow, or
- ii. Continuously operating supply ventilation systems, or continuously operating exhaust ventilation systems shall be allowed to be used to provide the required dwelling unit ventilation airflow if the dwelling-unit envelope leakage is less than or equal to 0.3 cubic feet per minute at 50 Pa (0.2 inch water) per ft<sup>2</sup> of dwelling unit envelope surface area as confirmed by field verification and diagnostic testing in accordance with the procedures specified in Reference Residential Appendix RA3.8.
- F. Multifamily building central ventilation systems that serve multiple dwelling units shall be balanced to provide ventilation airflow for each dwelling-unit served at a rate equal to or greater than the rate specified by Equation 150.0-B [ASHRAE 62.2:4.1.1] but no more than twenty percent greater than the specified rate. These systems shall utilize balancing means to ensure the dwelling-unit airflows can be adjusted to meet this balancing requirement. These system balancing means may include but not be limited to constant air regulation devices, orifice plates, and variable speed central fans.
- G. Kitchen range hoods shall be rated for sound in accordance with Section 7.2 of ASHRAE 62.2.
- EXCEPTION to Section 150.0(o)1G: Kitchen range hoods may be rated for sound at a



static pressure determined at working speed as specified in HVI 916 Section 7.2.

H. Compliance with ASHRAE 62.2 Section 6.5.2 (Space Conditioning System Ducts) shall not be required.

I. Compliance with ASHRAE 62.2 Section 4.4 (Control and Operation) shall require manual switches associated with dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: "This switch controls the indoor air quality ventilation for the home. Leave it on unless the outdoor air quality is very poor."

## **2. Field Verification and Diagnostic Testing.**

A. **Airflow Performance.** The ~~Whole Building Ventilation~~ dwelling unit ventilation airflow required by ~~Sections 150.0(o)1C, 150.0(o)1E, and 150.0(o)1F~~ Section 4 of ASHRAE Standard 62.2 shall be confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.7.

B. **Kitchen Range Hoods.** The installed kitchen range hood shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.7.4.3 to confirm the model is rated by HVI to comply with the following requirements:

- i. The minimum ventilation airflow rate as specified in Section 5 of ASHRAE 62.2.
- ii. The maximum sound rating as specified in Section 150.0(o)1G.

## **5.2 Reference Appendices**

### ***Joint Appendix JA1***

To date the Express Terms Appendix JA1 has not been updated to reference ASHRAE Standard 62.2-2016.

### ***Residential Appendix RA2***

To date Express Terms Table RA2-1 has not been updated to include kitchen range hood verification.

### ***5.2.1 Residential Appendix RA3***

#### **RA3.7.4.3 Kitchen Range Hood Verification**

The verification shall utilize certified rating data from the Home Ventilating Institute (HVI) Certified Home Ventilating Products Directory at <https://hvi.org/proddirectory/index.cfm> or another directory of certified product performance ratings approved by the Energy Commission for determining compliance. The verification procedure shall consist of visual inspection of the installed kitchen range hood to verify and record the following information:

- (a) The manufacturer name and model number.
- (b) The model is listed in the HVI Directory.
- (c) The rated airflow value listed in the HVI directory. complies with the airflow requirements specified in Standards Section 150.0(o)2B
- (d) The sound rating value listed in the HVI directory. complies with the sound rating requirements specified in Standards Section 150.0(o)2B.
- (e) If the value for the rated airflow given in the directory is greater than or equal to the airflow requirements specified in the Standards, and if the value for the sone rating given in the

directory is less than or equal to the sone rating requirements specified in Standards, then the kitchen range hood complies, otherwise the kitchen range hood does not comply.

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# **ATTACHMENT 1: FINAL CASE REPORT**

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The final version of the CASE Report is provided in full in Attachment 1 to this report.



## Codes and Standards Enhancement (CASE) Initiative

### 2019 California Building Energy Efficiency Standards

# Residential Indoor Air Quality – Final Report

Measure Number: 2019-RES-IAQ-F

Residential IAQ

August 2017



This report was prepared by the California Statewide Codes and Standards Enhancement (CASE) Program that is funded, in part, by California utility customers under the auspices of the California Public Utilities Commission.

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## Table of Contents

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<b>Executive Summary.....</b>	<b>v</b>
<b>1. Introduction .....</b>	<b>1</b>
<b>2. Measure Description .....</b>	<b>2</b>
2.1 Measure Overview.....	2
2.2 Measure History .....	13
2.3 Summary of Proposed Changes to Code Documents .....	19
2.4 Regulatory Context.....	23
2.5 Compliance and Enforcement.....	24
<b>3. Market Analysis.....</b>	<b>25</b>
3.1 Market Structure .....	25
3.2 Technical Feasibility, Market Availability, and Current Practices.....	26
3.3 Market Impacts and Economic Assessments.....	30
3.4 Economic Impacts .....	34
<b>4. Energy Savings.....</b>	<b>38</b>
4.1 Key Assumptions for Energy Savings Analysis .....	38
4.2 Energy Savings Methodology.....	38
4.3 Per Unit Energy Impact Results .....	39
<b>5. Lifecycle Cost and Cost-Effectiveness .....</b>	<b>41</b>
5.1 Energy Cost Savings Results .....	41
5.2 Incremental First Cost.....	41
5.3 Lifetime Incremental Maintenance Costs .....	45
5.4 Lifecycle Cost-Effectiveness .....	45
<b>6. First-Year Statewide Impacts.....</b>	<b>45</b>
6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings .....	45
6.2 Statewide Water Use Impacts .....	46
6.3 Statewide Material Impacts .....	46
6.4 Other Non-Energy Impacts.....	46
<b>7. Proposed Revisions to Code Language.....</b>	<b>46</b>
7.1 Standards .....	47
7.2 Reference Appendices .....	53
7.3 ACM Reference Manual.....	55
7.4 Compliance Manuals .....	55
7.5 Compliance Documents.....	56
<b>8. Bibliography.....</b>	<b>56</b>
<b>Appendix A : Statewide Savings Methodology .....</b>	<b>60</b>
<b>Appendix B : Supporting Information for Multifamily Ventilation Measures .....</b>	<b>64</b>
<b>Appendix C : Discussion of Impacts of Compliance Process on Market Actors .....</b>	<b>71</b>
<b>Appendix D : Supporting Information for Combustion Air Proposal .....</b>	<b>76</b>

## List of Tables

---

Table 1: Scope of Code Change Proposal.....	vi
Table 2: Proposed Methods of Determining Mechanical Ventilation System Capacity and Ventilation Modeling for Single Family Dwellings .....	3
Table 3: Current and Proposed Ventilation Rates for Example HRMF Units .....	5
Table 4: Comparison of HRMF Ventilation Strategies.....	7
Table 5: Intra-building Blower Door Test Results, based on ENERGY STAR HRMF Program Data.....	19
Table 6: HRV and ERV Product Cost, Flow Rates, and MERV Ratings .....	29
Table 7: Filtration Requirements in Building Standards, Above Code Programs, and City Ordinances ...	30
Table 8: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) code .....	36
Table 9: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis .....	39
Table 10: First-Year Energy Impacts for Blended Single Family Prototype – New Construction.....	40
Table 11: First-Year Energy Impacts of Ventilation Rate Change for HRMF Building Type (8 units, 6,960 ft <sup>2</sup> ) – New Construction .....	41
Table 12: Summary of Estimated Incremental Costs for High Rise Multiple Family .....	43
Table 13: Estimated Incremental Costs for Proposed Measures for Each New Construction Prototype ...	45
Table 14: Projected New Residential Construction Completed in 2020 by Climate Zone <sup>a</sup> .....	61
Table 15: Translation from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BsCZ)..	62
Table 16: Converting from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ) – Example Calculation.....	63
Table 17: PM 2.5 Standards Attainment Status for California Regions .....	67
Table 18: Description of Ventilation Rates in Past, Current, and Proposed Standards for High-Rise Multifamily Units .....	69
Table 19: Ventilation Rates under Different Standards for Example HRMF Unit Configurations (cfm) ..	70
Table 20: Roles of Market Actors in the Proposed Compliance Process.....	74

## List of Figures

---

Figure 1: Change in mechanical ventilation rate resulting from the adoption of ASHRAE 62.2-2016 for the Title 24, Part 6 single family prototypes.....	4
Figure 2: Example of central supply system in HRMF buildings.....	8
Figure 3: Example of a HRMF ventilation system using a combination of exhaust and supply air .....	9
Figure 4: Sound attenuation results for three New York apartments that underwent air sealing.....	18
Figure 5: California median home values 1997 to 2017 .....	31
Figure 6: SCAQMD Ozone design values in percentages of the federal standards.....	65



# EXECUTIVE SUMMARY

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## Introduction

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas & Electric, Southern California Edison, and SoCalGas® and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process:

<http://www.energy.ca.gov/title24/2019standards/>.

## Measure Description

The most significant proposed change to the 2016 Title 24, Part 6 Residential Standards is the adoption of the 2016 version of ASHRAE Standard 62.2, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings. The 2016 ASHRAE Standard 62.2 version replaces the California version of ASHRAE Standard 62.2-2010 (which includes Addenda b, c, e, g, h, i, j, l, and n) that was adopted by the 2016 Title 24 Building Energy Efficiency Standards (BEES). The 2016 version includes high-rise multifamily (HRMF) buildings, which were formerly covered by the commercial ventilation standard, ASHRAE 62.1. The following impacts result from the adoption of ASHRAE 62.2-2016, as well as other proposed measures that are designed to enforce and complement the provisions of the ASHRAE ventilation standard:

- Increases single family residential ventilation rates by an average of 51% for the 2,100 square foot prototype and 41% for the 2,700 square foot prototype (see Figure 1)
- Moves coverage of high-rise residential from ASHRAE 62.1 to ASHRAE 62.2, which decreases HRMF building ventilation rates by approximately 30 percent, depending on unit configuration
- Provides for fine particulate matter (PM<sub>2.5</sub>) filtration of outside air in locations with high levels of fine particulate matter (PM<sub>2.5</sub>) concentrations
- Requires an increase to the filter efficiency requirement listed in Section 6.7 of ASHRAE 62.2-2016 of from MERV<sup>1</sup> 6 to MERV 13 to reduce indoor levels of PM<sub>2.5</sub><sup>2</sup>

---

<sup>1</sup> MERV is Minimum Efficiency Reporting Value

<sup>2</sup> Pertains to Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 feet in length and through a thermal conditioning component, except evaporative coolers. It is also referenced in Title 24 Part 6 Section 150(m)12.

- Requires HERS verification that kitchen hoods in all dwelling unit types are Home Ventilating Institute (HVI) certified to meet ASHRAE 62.2 requirements for air volume, and sound ratings, and that they are externally vented
- Requires sealing of multifamily units to improve compartmentalization and verification of leakage rates
- For HRMF, requires a make-up air source for all units, and prohibits the use of passive vents in areas of high ambient PM2.5
- Provides for verification that central exhaust shafts and ducts in HRMF buildings are sealed to limit air leakage.
- Limits the use of indoor air being used as combustion air for space thermal conditioning, water heating and pool heating equipment.

These measures are intended to protect public health by providing a high level of indoor air quality (IAQ) while other Title 24, Part 6 requirements call for homes to be built with improved insulation and lower air leakage.

## Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and lists which sections of the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, and compliance documents that will be modified as a result of the proposed change.

**Table 1: Scope of Code Change Proposal**

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Will Compliance Software Be Modified	Modified Compliance Document(s)
Adoption of ASHRAE Standard 62.2-2016	Mandatory	150.0(m) and 150.0(o)	JA1, RA2, RA3	Yes - Change in mechanical ventilation rate for single family and high-rise multifamily	CF2R-MCH-27 CF3R-MCH-27

In accordance with Title 24 Part 6 Section 150.2(a), the proposed code change will apply to additions and alterations greater than 1,000 square feet. This requirement includes compliance with ASHRAE Standard 62.2-2016 and adopted modifications thereto.

This proposal also impacts other requirements in Title 24, Part 6 including:

- A dedicated makeup air source will be required for all HRMF units located in areas with high exposure to particulate matter in the 2.5 micron size range (PM2.5).
- Where central exhaust systems are included in the design of multifamily dwellings, they will be required to be tightly sealed and properly balanced.

## Market Analysis and Regulatory Impact Assessment

Taken alone, the proposed measures do not reduce energy use, but they mitigate potential IAQ and moisture problems resulting from inadequate ventilation that can occur with more tightly constructed, better insulated buildings. In particular, the proposed changes meet the regulatory requirement of California Public Resources Code Section 25402.8, which requires that the Energy Commission include the impact of indoor air pollution when considering energy conservation measures. The proposed measures also respond to Title 24, Part 11 (CALGreen) goals for reducing indoor pollutants. The energy

impact of the increase in ventilation rates associated with this proposal is accounted for in the benefit-to-cost analyses completed for other 2019 CASE proposals sponsored by the Statewide CASE Team, including the following measures: high performance walls, high performance attics, quality insulation installation, and high performance windows and doors.

The change in ventilation rate will have little or no impact on outdoor air ventilation products currently required and in widespread use. Use of vented (instead of recirculating) kitchen hoods will reduce the need for frequent cleaning of filters while removing cooking odors and moisture. The proposed requirement for MERV 13 filters in ducted thermal conditioning systems will increase costs, will require larger return air grilles to minimize pressure drop, and may require more frequent replacement, but these impacts can be minimized by using thicker pleated filters that have greater surface area.

Overall this proposal, in combination with others, increases the wealth of the state of California. California consumers and businesses save more money on energy than they do for financing the efficiency measure. The proposed changes to Title 24, Part 6 Standards have a negligible impact on the complexity of the standards or the cost of enforcement. When developing this code change proposal, the Statewide CASE Team interviewed building officials, Title 24 energy analysts and others involved in the code compliance process to simplify and streamline the compliance and enforcement of this proposal.

## **Cost-Effectiveness**

No cost-effectiveness calculations are provided in this report. In general, IAQ measures are intended to protect public health, and if they reduce energy use, it is coincidental. Public Resources Code section 25402.8 states: “When assessing new building standards for residential and nonresidential buildings related to the conservation of energy, the commission shall include in its deliberations the impact that these standards would have on indoor air pollution problems.” There has been significant research over the past decade on IAQ and its health effects that supports the proposed changes.

## **Statewide Energy Impacts**

The proposed code changes will increase single family residential ventilation rates, decrease HRMF ventilation rates, and not affect low-rise multifamily rates. The net energy impact of this code change may be close to neutral. The effect of the modified ventilation rates on other energy saving measures is captured in the other 2019 envelope related CASE Reports by including the new proposed ventilation rates in the analysis used to evaluate those measures. For example, the CBECC-Res simulation model used to evaluate high performance walls in residential buildings includes the higher ventilation rates required by 62.2-2016 in both the baseline simulations (2016 prescriptive package) and the improved case.

## **Compliance and Enforcement**

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process will have on various market actors. The compliance process is described in Section 2.5. The impacts the proposed measure will have on various market actors are described in Section 3.3 and Appendix C. The key issues related to compliance and enforcement are summarized below:

- Title 24, Part 6 consultants, designers, and builders must be made aware of the change in the method of determining the required mechanical ventilation rate (to be calculated by the Alternative Calculation Method (ACM) model and reported on the CF-1R).

- Designers, builders, and Home Energy Rating System (HERS) Raters must be informed of the requirements for kitchen ventilation hoods, which although unchanged, will require HERS-verification under the new standard.
- Designers, builders, and inspectors of multifamily buildings must follow new requirements for providing ventilation makeup air, and sealing and balancing airflow where central exhaust systems are employed. Depending on current practice, these requirements may affect construction costs.

Although a needs analysis was conducted with the affected market actors while developing the code change proposal, the code requirements may change between the time the final CASE Report is submitted and the time the 2019 Title 24, Part 6 Standards are adopted. The recommended compliance process and compliance documentation may also evolve with the code language. To effectively implement the adopted code requirements, a plan should be developed that identifies both potential barriers to compliance when rolling-out the code change and approaches that should be deployed to minimize the barriers.

# 1. INTRODUCTION

---

The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison, and SoCalGas® and two Publicly Owned Utilities (POUs) – Los Angeles Department of Water and Power and Sacramento Municipal Utility District – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to energy efficiency in buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed regulations on building energy efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2019 Title 24 website for information about the rulemaking schedule and how to participate in the process:

<http://www.energy.ca.gov/title24/2019standards/>.

The overall goal of this CASE Report is to propose a code change for residential indoor air quality (IAQ) measures. This report contains pertinent information that supports adoption of the code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with several industry stakeholders including building officials, manufacturers, builders, utility incentive program managers, Title 24 energy analysts, and others involved in the code compliance process. The proposal addresses feedback received during two public stakeholder workshops that the Statewide CASE Team held on September 27, 2016 and March 16, 2017.

Section 2 of this CASE Report provides a description of the measure and its background. This section also presents a detailed description of how this change is accomplished in the various sections and documents that make up Title 24, Part 6.

Section 3 presents the market analysis, including a review of the current market structure. Section 3.2 describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflict with other portions of the building standards such as fire, seismic, and other safety standards and whether technical, compliance, or enforceability challenges exist.

Section 4 presents the per-unit energy, demand, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate energy, demand, and energy cost savings.

Section 5 presents the lifecycle cost and cost-effectiveness analysis. This includes a discussion of additional materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs. That is, equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.

Section 6 presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2019 Standards take effect. This includes the amount of energy that would be saved by California building owners and tenants, and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic. Statewide water consumption impacts are also considered.

Section 7 concludes the report with specific recommendations with ~~strikeout~~ (deletions) and underlined (additions) language for the Standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, Compliance Manual, and compliance documents.

## 2. MEASURE DESCRIPTION

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### 2.1 Measure Overview

#### 2.1.1 *Change in Ventilation Rate and Scope*

This group of measures includes the adoption of ASHRAE 62.2-2016, which will replace the currently referenced 2010 California version of ASHRAE 62.2<sup>3</sup>. The 2016 version has two primary impacts:

- Changes the calculation method of required mechanical ventilation for single family dwellings which includes raising the conditioned floor area multiplier from 0.01 to 0.03.
- Expands the scope of ASHRAE 62.2 to include HRMF units that were previously covered by ASHRAE 62.1 and the California Mechanical Code, Title 24 Part 4, and applies the same method for calculating ventilation rate as is used for low-rise multifamily units.

In accordance with Title 24 Part 6 Section 150.2(a), the proposed code change will apply to additions and alterations greater than 1,000 square feet. This requirement includes compliance with ASHRAE 62.2-2016 and adopted modifications thereto.

High-rise buildings included in this change are limited to full-time occupancy apartment buildings. All Group R-3 occupancies (California Building Code Part 2, 310.5) and apartment houses (Part 2, 310.4) are covered by this proposal. Residential building types that have transient occupancy<sup>4</sup> will continue to be covered by ASHRAE 62.1.

#### 2.1.2 *Proposed Change for Single Family Dwellings*

The provisions of ASHRAE 62.2-2010 are currently mandatory for single family and low-rise residential buildings under Title 24, Part 6. The 2016 version of the ventilation standard will replace the current 2010 version. The primary impact will be a change in the way the mechanical ventilation rate is calculated for single family, horizontally attached, and high-rise dwelling units. ASHRAE 62.2-2010 allows an infiltration credit of 0.02 cubic feet per minute (cfm) per square foot of conditioned floor area (approximately equivalent to 5 ACH50 where ACH50 is the number of air changes per hour when the building is depressurized to 50 Pascals). ASHRAE 62.2-2016 requires blower door testing and uses the ACH50 from blower door tests, height of the building, occupancy, and climate to calculate the infiltration rate ( $Q_{infil}$ ). The  $Q_{infil}$  calculated value reduces the required mechanical ventilation rate ( $Q_{fan}$ ) as shown using the following equations:

**Equation 1:**  $Q_{total} = 0.03 \times (CFA) + 7.5 \times (BR + 1)$

**Equation 2:**  $Q_{fan} = Q_{total} - Q_{infil}$

where,

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<sup>3</sup> Hereafter, references to ASHRAE Standard 62.2-2010 in this report pertain to the California version that includes Addenda b, c, e, g, h, i, j, l, and n.

<sup>4</sup> Title 24, Part 2 defines transient lodging as “hotels, motels, hostels, and other facilities providing accommodations of a short-term nature of not more than thirty days duration.”

CFA is the conditioned floor area,  
 BR is the number of bedrooms, and  
 Q is airflow in cubic feet per minute

For horizontally attached single family units, ASHRAE Standard 62.2-2016 allows an infiltration credit, but it is factored by the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to the total envelope surface area.

The Statewide CASE Team proposes to include an exception in Title 24, Part 6 to eliminate the requirement for the blower door test specified in ASHRAE 62.2-2016 by assuming a default leakage rate of 2 ACH50 for the determination of  $Q_{infil}$ . This default leakage rate (or a lower value if the proposed building envelope leakage rate is less than 2 ACH50) will then be used to calculate the required mechanical ventilation airflow rate ( $Q_{fan}$ ) as described in Equation 2. Figure 1 shows the impact of this change on mechanical ventilation rates for the 2,100 square-foot and 2,700 square-foot prototype houses commonly used in standards development activities. The horizontal lines indicate current mechanical ventilation requirements for the two prototypes, and the bars represent the mechanical ventilation rates that would be required under ASHRAE 62.2-2016.

As prescribed by ASHRAE 62.2-2016, the calculation of  $Q_{infil}$  includes a “weather and shielding factor” (wsf), which varies by climate zone, as well as house characteristics (ACH50 and building height). The equation for determining  $Q_{infil}$  is found in ASHRAE 62.2-2016 (Equation 4.3). To facilitate selection of the correct size of ventilation system, the calculated value of  $Q_{fan}$  is proposed to be listed on the Certificate of Compliance.

This change effectively increases the mechanical ventilation rate ( $Q_{fan}$ ) in the compliance software model for single family dwellings while retaining the default 5 ACH50 leakage rate. The result will be a modest increase in energy use due to both higher fan electrical energy and the thermal impact of increased ventilation. Energy impacts are listed in Section 4 of the CASE report. The leakage rate used by the compliance model (default 5 ACH50 or as measured) to compute the thermal impact of envelope infiltration will be decoupled from the 2 ACH50 leakage rate assumption used to calculate the required mechanical ventilation air volume.

The current 5 ACH50 assumption used in the standard design will continue to be used so as to continue encouraging tight construction. Compliance credit will continue to be given for lower verified leakage rates based on the measured ACH50, if the builder pursues a building envelope leakage credit. For leakage rates below 2 ACH50 the measured leakage will be used to calculate a higher mechanical ventilation rate. Table 2 summarizes this compliance approach.

**Table 2: Proposed Methods of Determining Mechanical Ventilation System Capacity and Ventilation Modeling for Single Family Dwellings**

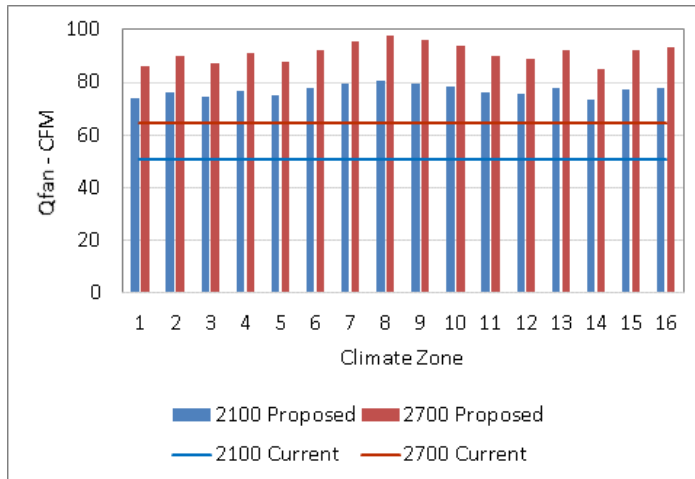
<b>Blower Door Test (ACH50)</b>	<b>Required Fan Size</b>	<b>Modeled <math>Q_{infil}</math></b>	<b>Modeled <math>Q_{fan}</math></b>
Not measured	Based on 2 ACH50	Based on 5 ACH50	Based on 2 ACH50
Less than 5, greater than 2	Based on 2 ACH50	Based on measured ACH50	Based on 2 ACH50
Less than 2	Based on measured ACH50	Based on measured ACH50	Based on measured ACH50

For single family horizontally attached<sup>5</sup> dwelling units ASHRAE 62.2-2016 requires the use of the following equation to calculate  $Q_{fan}$ :

**Equation 3:**  $Q_{fan} = Q_{total} - (Q_{infil} \times A_{ext})$

where,

$A_{ext}$  = the ratio of exterior envelope surface area that is not attached to garages or other dwelling units to the total envelope surface area.



**Figure 1: Change in mechanical ventilation rate resulting from the adoption of ASHRAE 62.2-2016 for the Title 24, Part 6 single family prototypes**

In accordance with Title 24 Part 6, Section 150.2(a), dwellings with additions greater than 1,000 square feet must comply with ASHRAE 62.2. For dwellings that have gas space heaters or water heaters that utilize indoor air as a source of combustion air, modifications must be made to these appliances so that combustion air is provided from outside. This is needed to prevent back-drafting of these appliances and associated risk of carbon monoxide exposure that could result from the proposed increased exhaust ventilation rates.

### 2.1.3 Proposed Changes Specific to Multifamily Units

#### 2.1.3.1 Compartmentalization Requirement

The Statewide CASE Team proposes that the dwelling unit envelope enclosure area (comprised of all walls, ceilings, and floors that enclose the dwelling unit) of new construction multifamily units be air sealed. Multifamily dwelling units shall demonstrate compliance through a HERS verified blower door test with maximum allowable leakage of 0.3 cfm50 per square foot of dwelling unit envelope enclosure area. The HERS Rater must conduct this test on the individual unit. Sampling may be used to meet this requirement, in accordance with Residential Appendices RA2.6.3 and 2.6.4.

The primary goal of this requirement is to reduce pollutant transfer with adjacent units which is reported to be a common complaint by tenants.

<sup>5</sup> Defined in this document as dwelling units constructed in a group of two or more attached units in which each unit extends from the foundation to roof and with open space on at least two sides. Includes duplexes, triplexes, and townhouses.



### 2.1.3.2 Proposed Changes for Low-rise Multifamily Units

Neither ASHRAE 62.2-2010 nor ASHRAE 62.2-2016 allow an infiltration credit for low-rise multifamily buildings, so there would be no change in the ventilation rate for these building types<sup>6</sup>. Where balanced ventilation systems are used including Heat Recovery Ventilators (HRVs) or Energy Recovery Ventilators (ERVs), a reduction of the required ventilation rate to 85 percent of the calculated value is proposed.

The Statewide CASE Team proposes a reduction in the ventilation rate for balanced systems, because data indicate that balanced systems should reduce air transfer between multifamily units compared with exhaust-only strategies (Consortium for Advanced Residential Buildings 2014). Appendix B of this report provides the rationale for the development of the 0.85 factor for balanced ventilation systems.

### 2.1.3.3 Proposed Changes for High-Rise Multifamily Buildings

#### *HRMF Ventilation Rates and Strategies*

Currently, HRMF units must meet the following ventilation rates in the California Mechanical Code (CMC), Section 403.2.1, which are based on rates in ASHRAE Standard 62.1-2007:

**Equation 4:**  $Q_{\text{total}} = 5 \text{ cfm} \times (\text{Number of Bedrooms} + 1) + 0.06 \text{ cfm/ft}^2 \times A$

where,

A = conditioned floor area (ft<sup>2</sup>)

The proposal to change the ventilation rate reference to ASHRAE 62.2-2016 would increase the per-person ventilation and decrease floor area ventilation with the net impact being a decrease in the ventilation rate as shown in Equation 5, which is the same as Equation 1 but written in the same form as Equation 4.

**Equation 5:**  $Q_{\text{total}} = 7.5 \text{ cfm} \times (\text{Number of Bedrooms} + 1) + 0.03 \text{ cfm/ft}^2 \times A$

The difference in ventilation rate under the current and proposed rate varies based on unit configuration (number of bedrooms and area). Table 3 presents ventilation rates for sample HRMF units. As shown, the proposed ventilation rate reduction ranges from 28 to 38 percent.

**Table 3: Current and Proposed Ventilation Rates for Example HRMF Units**

Bedrooms	Floor Area (ft <sup>2</sup> )	Current Ventilation Rate, cfm (62.1-2007)	Proposed Ventilation Rate, cfm (62.2-2016)	Percent Reduction (2016 vs. 2007)
1	800	58	39	33%
1	1,000	70	45	36%
1	1,200	82	51	38%
2	1,000	75	53	30%
2	1,200	87	59	33%
2	1,500	105	68	36%
3	1,200	92	66	28%
3	1,500	110	75	32%

The current requirement is typically met by continuous (or scheduled intermittent) mechanical exhaust in bathrooms with either no dedicated make-up air (i.e., with infiltration providing all supply air), or

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<sup>6</sup> Though it is specified in the Residential Compliance Manual, some HERS Raters that were interviewed were not aware of the ventilation rate change from one percent to three percent of floor area for low rise multiple family.

with passive vents, which rely on a pressure differential created by an exhaust system to allow outdoor air to enter the living space. According to interviewees contacted during the CASE proposal development process, the most common passive vent system in California HRMF units is a z-duct, which is shaped like a “z” with the outdoor intake separated from the indoor outlet by a vertical shaft that includes acoustic dampering. Other passive vent options include trickle vents, which are small openings in a window or other building envelope component, and air inlets such as Fresh 80 systems<sup>7</sup> installed in exterior walls. Interviewees reported it also somewhat common for designs to use packaged terminal air conditioners, which have an air inlet that remains open when they are not operating (i.e., not tempering air), thereby acting as a passive vent.

Although the current code (CBC Section 402.2) allows HRMF units to use operable windows (without continuous or scheduled intermittent mechanical exhaust) to meet the ventilation requirement, interviewees reported that almost no new HRMF projects use this approach. Under the current CASE proposal, which moves HRMF ventilation requirements to the residential sections of Title 24, HRMF units will not be allowed to use operable windows to meet the ventilation requirement. Title 24-2016 Section 150.0(o) prohibits use of operable windows for meeting the whole dwelling unit ventilation requirement, to align with the California version of ASHRAE 62.2-2010 Section 4.1, which requires “a mechanical exhaust system, supply system, or combination thereof”.

The Statewide CASE Team interviewed twenty HRMF mechanical engineers and energy analyst/ HERS Raters, five air quality specialists and public health officials, and three ASHRAE 62.2 committee members regarding whether reducing the ventilation rate will affect ventilation practices. Interviewees responded differently. Some reported that the industry will continue to use similar practices (i.e., exhaust-only strategies, sometimes with passive vents), but simply adjust fan flow rates. Others reported that reducing the ventilation rate will make the following strategies easier to implement, because of feasibility or cost reasons. Although interviewees were not able to quantify the cost reduction for reduced ventilation rates, they commented that:

- Lower ventilation flowrates (compared with 62.2-2016 rates) increases the feasibility of HRVs or ERVs, because some models of HRV or ERVs only accommodate low flows (e.g., maximum of 22 cfm). This comment was supported by the Statewide CASE Team’s product review of HRVs and ERVs, shown in Table 6 in Section 4.2.
- Lower ventilation flowrates reduce the costs of dedicated outdoor air systems (DOAS) that provide filtered, tempered air to each unit (e.g., central ducted ventilation systems) because the fans are smaller and ducts can be downsized.

Based on interviews and a literature review, the Statewide CASE Team identified four make-up air strategies used in HRMF new construction. Table 4 summarizes these strategies.

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<sup>7</sup> <http://www.positive-energy.com/product/fresh-80-air-inlet/>

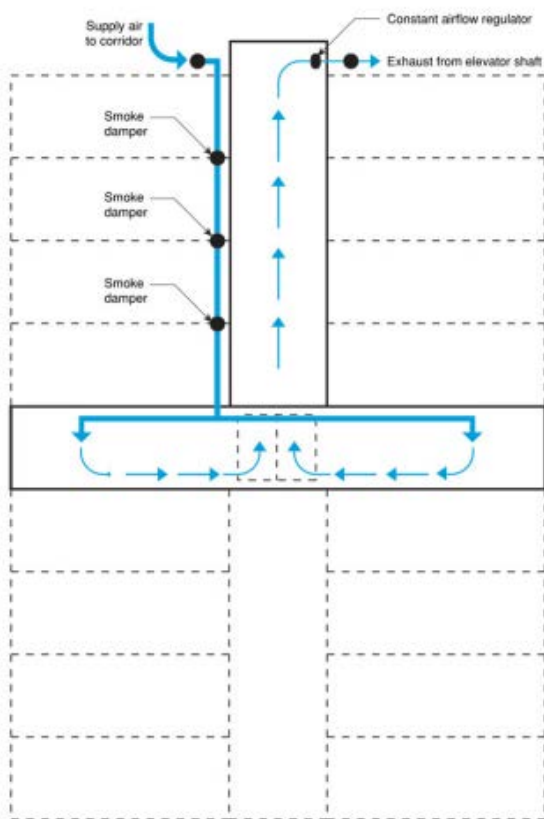
**Table 4: Comparison of HRMF Ventilation Strategies**

Method	Frequency of Use	Pros	Cons
1. Continuous exhaust with no dedicated make-up air: All make-up air comes from infiltration.	Common HRMF ventilation approach in California.	Inexpensive, simple.	Reliability concerns for providing outdoor air. Likely to result in negative pressures and bring in air from adjacent spaces.
2. Continuous exhaust with passive vents – typically z-ducts	Most common HRMF ventilation approach used, as indicated by interviewees.	Inexpensive, simple, provides somewhat more ventilation air than method 1.	Reliability concerns for providing outdoor air, occupants dislike drafts and often tape up openings. Likely to result in negative pressures and bring in air from adjacent spaces.
3. Central ducted supply air, such as dedicated outdoor air.	Occasionally used, such as when filtered air is required.	Greatest reliability and control for providing ventilation air; Capability to filter and temper incoming air.	High installation costs, potential for higher energy use.
4. HRV or ERV, usually serving individual dwelling units.	Occasionally used.	Can filter and temper incoming air. Most interviewees reported this can be less expensive than ducted supply air (method 3) due to less ductwork.	More expensive than passive vents, less control than ducted supply air, more wall penetrations. Not cost-justified for many California climates but can become cost competitive with methods 1 and 2, from downsizing of heating and cooling equipment and improved IAQ and comfort can increase marketability.

A common ventilation strategy in HRMF new construction is continuous bathroom exhaust with no dedicated make-up air. This was reported by interviewees and corroborated in the literature as a common strategy both in California and nationally. Interviewees reported they do not like this strategy – and generally do not design buildings using this approach – because of concerns regarding its reliability for providing outdoor air (note that almost all interviewees work on high performance buildings). Interviewees reported this strategy is likely to result in negative pressures and bring in air from adjacent spaces, including air from adjacent units that may have secondhand smoke or pollutants from cooking.

Interviewees reported that the other common strategy in HRMF units is continuous exhaust coupled with passive vents –typically z-ducts, as described above. None of the interviewees favored the passive vent strategy, because they questioned its reliability for providing outdoor air. However, they believed it provides somewhat more supply air than no dedicated make-up air, and it is relatively inexpensive (approximately \$100 to \$300 more expensive than no dedicated make-up air), compared with mechanically driven supply air strategies such as balanced systems (costs discussed below). Two studies conducted in the Northeast U.S. by the Consortium for Advanced Residential Buildings (CARB) supported the findings that both of these strategies (no dedicated supply air, and passive inlets) are inexpensive, but do not reliably provide the designed level of ventilation. (CARB 2014), (CARB 2016b). One of these studies found airflow from the passive vents was 13 to 36 percent of the air volume removed by the exhaust system (CARB 2016), about the same airflow as when no make-up air is provided (i.e., from infiltration).

HRMF units are occasionally served by central ducted supply air, such as dedicated outdoor air supply. Figure 2 provides an example schematic of a central supply system. This figure shows duct branches to units on one floor of the building, but it would normally be extended to serve units on all floors.



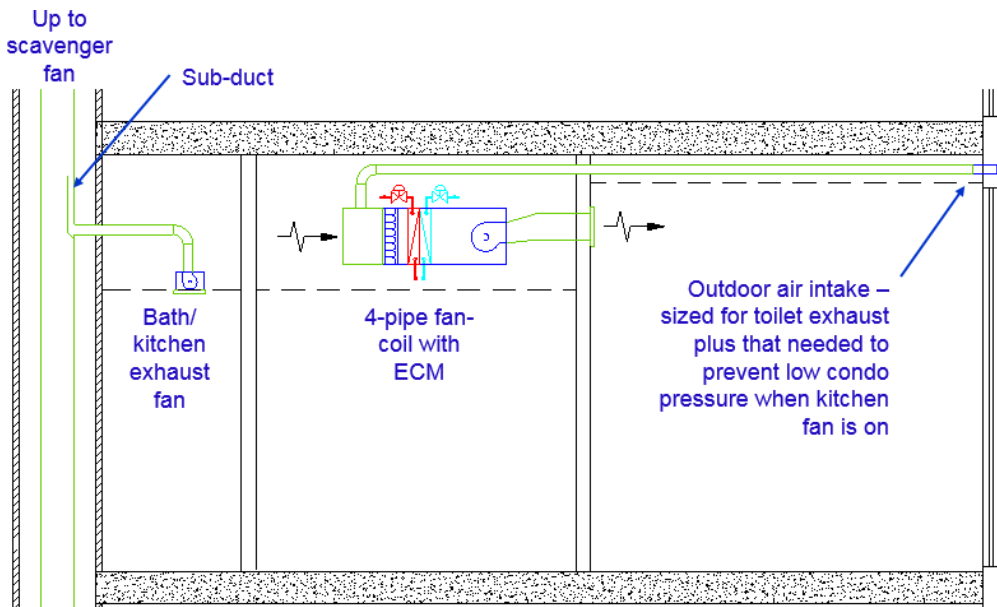
**Figure 2: Example of central supply system in HRMF buildings**

Source: Building Science Corporation 2017)

Interviewees reported this is a much more reliable strategy for providing ventilation air than the passive strategies described above, but is rarely done because of its cost. This strategy is used when filtered supply air is required, such as along freeway corridors in San Francisco under Article 38 of the San Francisco Health Code because of PM 2.5 concerns. All interviewees reported this strategy is significantly more expensive than the base case (no make-up air), although few would provide estimates of costs. Two interviewees reported the incremental cost is roughly twice that of the base case, because it requires twice the ductwork. A study done in the Northeast supported that this strategy is significantly more expensive, and found that it also results in higher energy use (Consortium for Advanced Residential Buildings 2014).

One active designer of HRMF systems that was interviewed contributed the diagram shown in Figure 3 as their preferred ventilation design. The variable speed fan coil is operated continuously at a low speed to provide a constant supply of outside air. The air supplied can be balanced by exhaust fans, and by a roof-mounted “scavenger fan” that maintains a constant flow through the central exhaust shaft. Compared to the strategies listed in Table 4, this strategy both filters and tempers outdoor air using the coil, but it is in conflict with Title 24 Part 6, Section 150.0, which states: “Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the whole-building ventilation airflow...” Interviewees reported this is a lower cost strategy than central ventilation supply. The Statewide CASE Team estimated the cost of providing stand-alone ventilation using this strategy is \$500, as described in Section 5.2. This does not include cost for the exhaust, since all units meet local exhaust requirements. Consequently, this analysis

recommends that high-rise multifamily units be allowed to use continuous operation of central forced air system air handlers used in central fan integrated ventilation systems, if they use variable speed fans (i.e., be granted an exemption).



**Figure 3: Example of a HRMF ventilation system using a combination of exhaust and supply air**

(Source: Taylor Engineering)

ERVs or HRVs are occasionally used, particularly small, through-wall ERVs and HRVs serving individual dwelling units. Compared to the base case (no dedicated make-up air), an ERV or HRV provides reliable outdoor air and also tempers air before it enters the dwelling unit, improving occupant comfort. Several interviewees reported this strategy is intermediate in cost between the base case and central ducted supply air. Although the ERV/HRVs are expensive, they require much less ductwork than the ducted outdoor air. It may also enable designers to reduce the capacity of heating and cooling equipment, which reduces cost. ERVs or HRVs installed in bathrooms can also replace bathroom fans. However, interviewees noted that ERVs and HRVs result in additional wall penetrations, which can cause challenges with design of the façade. In addition, ERVs and HRVs provide less control than central supply air. The literature review confirmed that ERVs and HRVs are used in multifamily construction when efficiency is a high priority and as permitted by the construction budget (Building Science Corporation 2017).

Almost all interviewees reported that new HRMF buildings do not use a corridor-based strategy for supplying air to units. Existing HRMF buildings often use a strategy whereby air is supplied to the corridors, and undercut doors provide air transfer to each unit. However, this strategy violates Title 24 Part 9 (California Fire Code) Sections 420 and 710.5, which limit air transfer through smoke partitions, so it is no longer allowed. As noted above, all interviewees reported that in their experiences, operable windows are rarely used as the primary ventilation strategy in new construction HRMF.

#### *Exemption for Continuous Operation of Central Fan*

Title 24-2016 Section 150.0(o) includes the following language: “Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the whole-building ventilation airflow required in Section 4 of ASHRAE Standard 62.2.” The CASE Team proposes an exemption to this language for central forced air system air handlers serving HRMF units with variable speed fans (based on requirements in Title 24 part 6 Section

140.9.a.5 for nonresidential buildings), to accommodate effective strategies currently used for HRMF buildings.

#### *Central Exhaust Shaft Sealing, Testing, and Air Balancing*

Field studies have shown that air leakage, stack effect, and lack of, or improper, balancing can prevent individual units from properly removing exhaust air (Center for Energy and Environment 2016) and increase energy use (WCEC 2014). This proposed Title 24, Part 6 code change will require that central exhaust shafts (where they are used) are sealed to limit leakage to ten percent of total airflow of the power rooftop ventilator. In addition, where central exhaust shafts are used, flowrates of the exhaust fans serving each unit must be balanced and verified, to ensure actual airflow is within ten percent of design airflow.

Interviewees reported that the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) has shaft sealing guidelines (primarily for supply air – not exhaust air), but it is uncommon to test central exhaust shaft leakage in HRMF units. Interviewees were generally supportive of this measure, because it reduces energy consumption – primarily through reduced total fan flow – and helps ensure that the exhaust shaft performs as designed. In addition, without sealing, measures such as self-balancing dampers do not function properly.

Because it is uncommon to test exhaust shaft leakage in HRMF buildings, many interviewees were hesitant to provide estimates of current shaft leakage. Those who responded estimated a 10-30 percent leakage rate. The literature supported estimates of around 25 percent (Harrington 2014).

Interviewees had different perspectives on what leakage target should be required. The originally proposed leakage rate that the Statewide CASE Team investigated was five percent, to be consistent with supply air duct leakage testing requirements. Some reported that five percent would be too stringent for a new requirement, while others reported this was attainable.

The Statewide CASE Team proposes ten percent leakage, because:

- Ten percent is stringent enough to catch major leakage issues – such as disconnected ducts in the exhaust shaft system.
- The exhaust ducts do not carry air for space conditioning. The energy penalty associated with central exhaust duct leakage comes from increased fan energy, so the proposed maximum leakage rate is less stringent than the permissible leakage for ducts carrying conditioned air (5% in residential and 6% in nonresidential buildings).
- There is currently no requirement for central exhaust shaft leakage, since limited data exists for typical leakage rates. Based on interviews and literature review, ten percent leakage represents the lower end of the range of estimates reported for shaft tightness without sealing. In the view of the Statewide CASE Team this represents a feasible goal.

The proposal leverages an existing testing protocol in Title 24: Nonresidential Appendix (NA) 2.1.4.2: Diagnostic Duct Leakage. The Statewide CASE Team also considered a testing procedure in a SMACNA manual (HVAC Air Duct Leakage Test Manual – SMACNA 016-2012), but referenced the Title 24 procedure because project teams are already familiar with the Title 24 procedure; it clearly specifies a methodology such as the test pressure (25 Pa), set-up protocols, and analysis methods; and the procedure can be applicable to central exhaust duct leakage testing.

Testing and balancing local exhaust fans in central exhaust shafts is important, particularly in buildings with a large stack effect, such as tall (over eight stories) multifamily buildings in climates with high heating or cooling loads (Markley 2014). Interviewees reported that testing and balancing is done as part of industry standard practice. However, Title 24, Part 6 does not require results to be independently verified, such as by a Home Energy Rating System rater (HERS Rater) or Acceptance Test Technician (ATT). As described below, based on findings from interviews and the literature review, the Statewide

CASE Team's findings indicate that the code proposal should require balancing but allow flexibility in how this requirement is met.

- Interviewees reported that HRMF buildings can achieve good results with other methods, including balancing with fixed edge orifice plates<sup>8</sup>. While these orifice plates do not adjust based on conditions in the building or weather, the pressure differences compared to the original conditions should be small enough that the systems are expected to perform well. Strategies such as balancing once with fixed edge orifice plates have the advantages (compared with self-balancing dampers) of requiring less ongoing maintenance and lower first costs.
- Older versions of self-balancing dampers<sup>9</sup> have demonstrated problems with clogging, based on interview findings and the literature (Center for Energy and Environment 2016), although it is unclear if newer versions have the same issue. However, many HRMF design engineers reported maintenance concerns for any type of self-balancing dampers because they are a moving part and (since they are installed within the unit) may not be accessible by maintenance staff.

The optimal strategy for a high-rise residential building will vary depending on building height, climate, and other factors. For example, in a building with a large stack effect (such as a building over eight stories in a more severe climate), or a building that will have a dedicated maintenance crew, self-balancing dampers may be a good solution. In a mid-rise (four to six story) building in a moderate climate a good strategy could be to balance the systems once using fixed edge orifice plates.

Testing and balancing exhaust rates: For HRMF buildings that use central exhaust shafts, testing and balancing local exhaust fan airflows helps ensure that each unit has adequate exhaust and also reduces fan energy of the power rooftop ventilator (WCEC 2014). The Statewide CASE Team's proposal for balancing to within ten percent of design flow aligns with industry practice for testing and balancing, which typically allows a maximum deviation of ten percent compared to the design rate. Although flow rates should ideally be no lower than design rates, only allowing ten percent above the design rate could be too narrow of a range to be feasible – e.g., 50 to 55 cfm for a bath fan with a design flow of 50 cfm. The Statewide CASE Team proposes that the requirement allow ten percent above and below the design rate, to reduce compliance challenges— between 45 and 55 cfm in the above example.

This proposal requires that exhaust airflows be compared with the design airflow. Note that the Statewide CASE Team considered requiring that exhaust airflows be compared with ASHRAE 62.2 airflow rates. However, Title 24 150.0(o) specifies that all requirements in ASHRAE 62.2 must be met, and 62.2 specifies minimum local exhaust requirements (e.g., 50 cfm for intermittent bathroom, 100 cfm for intermittent kitchen exhaust). Thus, Title 24, Part 6 already requires that the design meet ASHRAE 62.2 rates at a minimum. In some cases, designers may need to specify exhaust rates higher than the minimum values in ASHRAE 62.2 to ensure adequate removal of exhaust air. Consequently, the proposal would compare the tested flowrate with the design flowrate, which must be at least equal to the 62.2-2016 exhaust flowrate.

#### *Proposed Ventilation Requirements for HRMF Buildings*

The objective of the proposed changes for high-rise buildings is to ensure that there is a source of both supply and exhaust air. This will compensate for the reduction in ventilation rate dictated by the new

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<sup>8</sup> Orifice plates are metal insertions in the duct that are positioned to regulate airflow. They are adjusted during balancing, but are not readjusted continuously. See Figure 6 on p. 106 (PDF) of the Center for Energy and Environment, Multifamily Ventilation Assessment and Retrofit Guide, 2016.

<sup>9</sup> Self-balancing dampers are installed in a duct to regulate airflow, and continuously adjust as airflow varies. Older versions used a bladder that inflated or deflated to regulate airflow, while newer versions include dampers that lift in response to increasing static pressure. For the older self-balancing damper, see figure 3a on p. 15 (PDF) of the Center for Energy and Environment, Multifamily Ventilation Assessment and Retrofit Guide, 2016.

ASHRAE standards. In addition to meeting ASHRAE 62.2-2016 ventilation rate requirements, the following two discrete alternate methods of compliance are proposed:

- a. Where exhaust-only ventilation is used, a source of outside makeup air (passive vents) will be provided to balance exhaust air.
- b. Alternatively, the design must provide mechanically driven, filtered supply air. If a balanced ventilation system (e.g., HRV or ERV) is provided, the ventilation rate may be reduced to 85 percent of the calculated value (as for low-rise buildings).

Method (b) would be required within 500 feet of busy roadways, defined as a roadway with annual average daily traffic (AADT) equal to or greater than 100,000.

- c. Where central exhaust shafts are used, they shall be sealed to allow leakage of not more than ten percent of total exhaust airflow, and airflow at each unit shall be balanced to within ten percent of the required ventilation rate.

#### **2.1.4 Kitchen Hood Verification**

Both the 2010 and 2016 versions of ASHRAE 62.2 require that kitchen hoods have the capability to exhaust at least 100 cfm, that they not exceed a noise level of 3 sones, and that they be externally vented (not recirculating). To date, there has been no HERS verification process for kitchen range hoods. The Statewide CASE Team proposes that HERS Raters verify that installed range hoods are listed in the HVI Certified Products Directory<sup>10</sup> and that they meet the airflow and noise requirements of ASHRAE 62.2. This requirement would apply to all residential building types covered by Title 24, Part 6. The ASHRAE standard exempts range hoods that have a minimum airflow setting of greater than 400 cfm from the 3 sone at 100 cfm requirement.

#### **2.1.5 Change in Filter Efficiency Requirement**

A second proposed exception to ASHRAE 62.2-2016 increases the filter efficiency requirements for ducted forced air thermal conditioning systems from the currently required MERV 6 to MERV 13 (as determined using ASHRAE 52.2) or from the current 35 percent in the 3.0 – 10.0 micron ( $\mu\text{m}$ ) range to 85 percent in the 1.0 – 3.0  $\mu\text{m}$  range (as determined using AHRI 680). The purpose of this change is to reduce the concentration of particles in the 2.5  $\mu\text{m}$  size range (PM 2.5), which are a known carcinogen.

#### **2.1.6 Elimination of the Use of Indoor Air for Gas Appliance Combustion**

Chapter 7 of the California Mechanical Code (Title 24, Part 4) allows several methods for providing air for combustion, ventilation, and dilution of flue gases for gas appliances that are installed within buildings. One method (701.4.1) allows the use of indoor combustion air provided there are at least 50 cubic feet of interior volume per 1000 Btu per hour of appliance capacity. There are several reasons why this method should no longer be applied in new homes. Homes are much more tightly constructed than when the mechanical code was written decades ago. The increase in the mechanical ventilation rate that will occur with the adoption of ASHRAE 62.2-2016, improved compliance of kitchen hood ventilation, and prescriptive requirements for whole house fans in single family homes (Climate Zones 8 through 14) will result in periods of high negative pressurization inside the dwelling. Under these conditions, indoor gas appliances, particularly furnaces and water heaters that rely on indoor combustion air, will be more likely to backdraft, that is combustion gases containing carbon monoxide and particulates will flow backward down the flue and into the house. The downward draft on the burner could also potentially create a fire hazard. Fortunately, the practice of installing atmospherically vented gas appliances inside houses has declined with the advent of direct vent, induced draft, and power exhaust

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<sup>10</sup> Available from <http://hvi.org/proddirectory/index.cfm>. Testing for loudness is based on HVI 915 and flow is based on HVI 916.



appliances. The purpose of this code change proposal is to ensure the health and safety of homeowners by prohibiting indoor combustion air. Two options are available for furnaces, water heaters, and pool heaters that are located indoors: either requiring that they be sealed, direct vent type systems, which bring in combustion air for outside and exhaust flue gases, or requiring that they be enclosed in a closet that is isolated and sealed from the thermal envelope and provided with openings to outside air as required by California Mechanical Code Section 701.6. Additional background information on this can be found in Appendix D.

### **2.1.7 Affected Code Sections**

Revisions to Title 24, Part 6 Standards Section 120.1 will be made to shift HRMF ventilation requirements from the nonresidential (Section 120.1) to the residential section (Section 150.0). Provisions for sealing of exhaust shafts and balancing airflow will also be added to Section 120.1. Language in Sections 120.5 and 150.0(m) will be edited to increase filter efficiency for ducted thermal conditioning systems<sup>11</sup> from MERV 6 to MERV 13 (or AHRI 680-2009 particle size efficiency of greater than 80 percent in the 1.0- 3.0  $\mu\text{m}$  range), and to reference ASHRAE 62.2-2016. Subsections will be added to Section 150 to describe the proposed exceptions to 62.2-2016, including the default 2 ACH50 leakage assumption for  $Q_{\text{infil}}$  calculations, and the increase in filter efficiency. In the case of HRMF and LRMF compartmentalization is required. For HRMFa mechanically driven outdoor ventilation supply air with MERV 13 filtration is required in areas with high ambient (outdoor) PM 2.5. Section 150 will also define requirements for kitchen hood verification.

The change in the ventilation standard for high-rise multifamily will also affect other parts of Title 24, including Part 2, the California Building Code and Part 4, the California Mechanical Code. Details of the code change language are provided in Section 7.1. These changes will help correct conflicting or confusing references in Parts 2, 4, and 6.

## **2.2 Measure History**

### **2.2.1 Why These Measures are Being Proposed**

#### **2.2.1.1 Changes Pertaining to All Unit Types**

California Public Resources Code 25402.8 (new building standards for residential/nonresidential buildings) specifies that the impact of energy conservation measures on indoor air pollution be considered. This was a prescient idea to have been included in the Warren-Alquist Act. The significant improvements in building science and efficiency that have been implemented over the past several code cycles and that are proposed for the 2019 Title 24, Part 6 Standards stem from decreased building envelope leakage, improved insulation and window thermal performance, and improvements in the quality of construction, including duct sealing. As has been well documented in building science literature, tighter buildings with thicker insulation can have unintended air quality consequences. Infiltration can no longer be relied upon to maintain IAQ, and the reduced air exchange can result in higher indoor relative humidity that can cause mold growth and damage to the building structure. Thicker wall insulation means the interior surfaces of exterior cladding can become cold enough to condense moisture. In California climates, adequate ventilation can prevent these kinds of moisture problems.

The benefits of ventilation and other practices required by the ASHRAE 62.2 standard were demonstrated in a study of 81 weatherized homes (Francisco, et al. 2016). That study found higher ventilation rates, lower concentrations of volatile organic compounds (VOCs), formaldehyde and carbon

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<sup>11</sup> Consistent with the definition provided in Part 6, Section 150.0(m)<sup>12</sup>

dioxide, and improvements in health (e.g., children had fewer headaches, eczema, and skin allergies; and adults had improvements in psychological distress) after the homes met the 62.2 standard. Approximately half the homes were improved to meet the 62.2-1989 standard, and half to meet the 62.2-2010. Furthermore, there were greater reductions of some pollutants for homes that met the 62.2-2010 standard compared with the 62.2-1989 standard.

**Changes in ventilation rates:** The proposed adoption of ASHRAE Standard 62.2-2016 (to replace the 2010 California version) into Title 24, Part 6 is the primary driver for this code change proposal. Because the ASHRAE 62.2-2016 standard was only recently adopted, there are no published field studies that investigate differences in IAQ or health impacts resulting from requirements in ASHRAE 62.2-2016 compared to ASHRAE 62.2-2010. However, data suggest that ASHRAE 62.2-2016, along with the other change proposals described here, will promote improved IAQ and health. There has been extensive debate over what constitutes sufficient ventilation on the ASHRAE 62.2 Standing Standard Project Committee, with some advocating that the current 0.03 cfm/ft<sup>2</sup> basis is too high, particularly in humid climates where it introduces excessive moisture from outdoors. In California, higher ventilation rates will improve the dilution of contaminants, such as formaldehyde and PM 2.5, as well as remove excess moisture. For these reasons the Energy Commission, the Statewide CASE Team, and the California Air Resources Board are advocating adoption of the ASHRAE 62.2-2016 requirements.

- For single family houses, the mechanical ventilation rates will increase from those determined using ASHRAE 62.2-2010 as shown in Figure 1. Whereas the infiltration rate is assumed to be a fixed value under 2016 Title 24, under the proposed adoption of ASHRAE 62.2-2016 in the 2019 Title 24, it will be calculated for each climate zone and house configuration, with tighter houses requiring more mechanical ventilation.
- For horizontally attached units such as triplexes and townhomes, the assumed infiltration rate will be reduced based on the envelope surface area, resulting in higher mechanical ventilation rates than for single family dwellings of similar floor area.
- For low-rise multifamily units, 2016 Title 24, Part 6 adopted the California version of ASHRAE 62.2-2010, which included Addendum j. This Addendum requires that multifamily units provide ventilation in accordance with Equation 1, and prohibits multifamily units from using infiltration to meet this rate. The proposed code change to ASHRAE 62.2-2016 will also apply to low-rise units, but since it uses the same equation as the 2010 version, there will be no change in required ventilation rates.
- For HRMF units, ventilation rates will decrease because of the shift from ASHRAE 62.1 to ASHRAE 62.2. However, as described below, this code change proposal includes requirements that improve HRMF indoor air quality, including compartmentalization of all multifamily units to reduce pollutant transfer among units, and requirements for filtration of outside ventilation air for HRMF units in areas of high ambient PM2.5.

**Improved filtration:** Recent and ongoing studies of IAQ show that particulate matter in the PM 2.5 range is becoming a dominant health concern (Fisk 2017) (Zhao 2015). Cooking with either gas or electricity has been shown to be a predominant source of PM 2.5, as well as oxides of nitrogen (Fabian 2012) (Dacunto 2013) making indoor air filtration an important health concern.

Filtration of outside air is critical in areas with high levels of PM 2.5 which cover much of California. For exhaust-only ventilation systems, current research suggests that for single family residences, the building envelope can provide a similar level of filtration of particulates as a MERV 13 filter (Singer 2016). Based on the Statewide CASE Team's industry experience<sup>12</sup>, low-rise multifamily units typically

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<sup>12</sup> The scope of work for the Statewide CASE Team included interviews to investigate HRMF practices, because of the transition of these units into the residential portion of Title 24. Due to time limitations in interviews, low-rise multifamily practices were not investigated.

use a ventilation strategy of exhaust-only with infiltration. Low-rise multifamily units may not use passive vents as standard industry practice because, while there is still the potential for pollutant transfer among units, it is lower than in HRMF units, because:

- Stack effect increases pollutant transfer, and the risk therefore increases in taller buildings,
- Many low-rise multifamily buildings are garden-style with two or more walls exposed to the exterior, while many high-rise buildings have central corridors with one or at most two exposed walls. Corridors provide another pathway for pollutant transfer among units.
- Many units in low-rise multifamily buildings – including those in two-story buildings – have fewer surfaces adjacent to other units compared with HRMF units.

Consequently, low-rise multifamily units that use an exhaust-only strategy should have some removal of PM<sub>2.5</sub>, particularly after complying with the proposed requirement for compartmentalization. HRMF units – which (based on interviews) typically use passive vents for make-up air in an exhaust-only strategy – should use MERV 13 filters in locations with high outdoor levels of PM<sub>2.5</sub> (proposed to be defined as within 500 feet of a busy roadway; see Section 7.1.3).

The Statewide CASE Team considered proposing a requirement for MERV 13 for all outside air filtration. However, the Team did not propose this, because of concerns that it would discourage the use of balanced ventilation strategies, and encourage exhaust-only strategies. As shown in Table 12 and Table 13, balanced ventilation strategies are significantly more expensive than exhaust-only strategies, and the cost increases when MERV 13 filtration is added to the balanced system: an estimated \$322 for exhaust-only using distributed exhaust, \$1,313 for balanced with MERV 8, and \$1,968 for balanced with MERV 13. (Exhaust-only ventilation strategies do not have supply air, so are not affected by filtration requirements.) As described in this report, the Statewide CASE Team believes that balanced ventilation is preferable, at least in multifamily units, because it reduces the risk of pollutant transfer between dwelling units. In other words, builders could circumvent a requirement for MERV 13 on outside air filtration by choosing exhaust-only ventilation. The result is a trade-off: MERV 13 reduces PM<sub>2.5</sub> compared with MERV 8 for projects that use balanced ventilation, but there will be fewer balanced ventilation (and more exhaust-only) projects if MERV 13 is required compared with MERV 8. Consequently, the Statewide CASE Team limited the requirement for MERV 13 for outside air filtration only to areas that have high ambient PM<sub>2.5</sub>: near busy roadways. For the remainder of the state, the Statewide CASE Team proposes MERV 8 filtration on outside air.

**Kitchen range hood verification:** Ineffective kitchen range hoods – those that do not exhaust sufficient air, are not operated because they are too noisy, or have poor capture efficiency – contribute to the IAQ problem. The 2010 ASHRAE 62.2 ventilation standard previously adopted by Title 24, Part 6 requires that kitchen hoods meet venting, airflow, and noise standards. Performance data published by HVI can be used for verification. The proposal to increase air filter efficiency in ducted thermal conditioning systems to MERV 13 also addresses the concern about indoor sources of PM<sub>2.5</sub>.

### **2.2.1.2 Changes Specific to Multifamily Dwelling Unit Types**

#### *Ventilation Rates and Strategies*

There are additional concerns for HRMF dwelling units, which led the Statewide CASE Team to develop specific HRMF proposals. Besides exhaust-only with infiltration, another common ventilation strategy for HRMF buildings is exhaust-only ventilation coupled with passive vents installed on the exterior wall. While there is little data available on passive vent performance, the few studies conducted have found that the flowrate through passive vents is approximately one-third or less of the design rate: 15 to 40 percent (Consortium for Advanced Residential Buildings 2014) and 13 to 36 percent (Consortium for Advanced Residential Buildings 2016a). Furthermore, almost all mechanical engineers and HERS Raters interviewed by the Statewide CASE Team reported that occupants frequently cover these vents (using cardboard or tape) due to drafts, further reducing outdoor airflow. The remaining

make-up air can still come from adjacent units. Pollutant transfer from adjacent units can be further exacerbated in HRMF units because of stack effect<sup>13</sup>. In addition, whereas the building envelope provides some level of particle filtration, passive vents provide almost no PM 2.5 filtration, because a filter with a high MERV rating will create a pressure drop that cannot be overcome passively. Because of the lack of filtration (Singer 2016) (Fisk 2017), HRMF buildings constructed in areas with high levels of outdoor PM 2.5 (as described in Section 3.3.1) that use exhaust-only with passive vents could have high levels of indoor PM 2.5.

For these reasons, the proposal includes the following:

HRMF units within 500 feet of a busy roadway (with at least 100,000 annual average daily traffic [AADT]) are required to provide mechanically-driven supply air with MERV 13 filtration. The requirement for mechanically-driven supply air (i.e., supply-only or balanced) will ensure that ventilation air comes from the outdoors, rather than neighboring units, and the MERV 13 requirement will significantly reduce outdoor PM 2.5. Because of the higher cost for balanced ventilation compared with exhaust-only in HRMF units (approximately \$1,000 per unit, and \$1,600 per unit with MERV 13, described in section 5.2), the low availability of HRVs with MERV 13, and since balanced ventilation is not predicted to generate cost-effective energy savings in mild climate zones (see section 4.3), the Statewide CASE Team proposes to only require this strategy where outdoor PM 2.5 risk is greatest. As described in section 3.3.1, studies have found strong correlations between health problems and residences in homes within 500 feet of a roadway. Furthermore, a requirement for MERV 13 filtration in the forced air space conditioning system without an accompanying MERV 13 requirement for mechanically provided supply air will further encourage HRMF units to use an exhaust-only approach with passive vents. Of most concern, a requirement for MERV 13 filtration that allows exhaust-only strategies would enable HRMF units constructed close to freeways to use exhaust-only ventilation with passive vents, thereby allowing large amounts of unfiltered air to enter the units.

All multifamily units that use balanced ventilation may reduce the ASHRAE 62.2-2016 mechanical ventilation rate by 15 percent. The Statewide CASE Team proposes to encourage balanced ventilation for all multifamily buildings by allowing multifamily units that use balanced ventilation to use a reduced ventilation rate:  $0.85 \times Q_{total}$ , where  $Q_{total}$  is calculated as shown in Equation 1. This rate reduction will enable through-wall ERV systems in small multifamily units, based on ERV and HRV flowrates in Table 6 and the ventilation rate requirements in Table 18. As described in Section 2.1.2, ASHRAE 62.2-2016 does not allow for vertically attached<sup>14</sup> multifamily units to take credit for infiltration ( $Q_{infil} = 0$ ), so  $Q_{fan}$  is the same as  $Q_{total}$ . (For horizontally attached dwelling units, ASHRAE 62.2-2016 allows partial credit based on the ratio of party walls to exterior walls – see Equation 3.) The rationale for the balanced ventilation rate reduction includes:

- Based on a study comparing ventilation strategies in multifamily units, only one-third of the design ventilation rate is delivered through passive vents, while the balanced system delivered 70 percent of design flowrate (Consortium for Advanced Residential Buildings 2014). Consequently, even at 85 percent of the ASHRAE 62.2-2016 ventilation rate, a balanced system should deliver more ventilation air from the outside (since the source of ventilation air is known) than an exhaust-only system with passive vents. The Statewide CASE Team developed the 0.85 factor by reviewing a variety of current and proposed ventilation rates. The rationale for the 0.85 factor is described in Appendix B.

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<sup>13</sup>Stack effect is a natural force that generates pressure and drives vertical airflow in buildings in response to indoor-outdoor temperature differences. The stack effect increases in taller buildings.

<sup>14</sup> Defined in this document as multifamily buildings that are vertically stacked and for which a majority of units have open space on fewer than two sides.

- Several interviewees reported it is easier to provide a balanced system in HRMF units with the 15% lower ventilation rates, because some ERVs and HRVs that serve individual units have low maximum flowrates. A review of products confirmed these reports: For example, representative through-wall HRVs have a maximum flowrate ranging between 22 and 38 cfm, which is lower than the minimum ventilation rate for most HRMF unit configurations (see Table 6), without the 0.85 factor.
- Stakeholder comments indicate that builders prefer lower ventilation rates, so reducing the ventilation rate for balanced systems will encourage builders to use this strategy

HRMF units in areas of low outdoor PM 2.5 can use an exhaust-only strategy, but they must provide passive vents for make-up air and meet prescriptive compartmentalization requirements that must be verified by a HERS Rater. Although most interviewees report that passive vents may not provide a reliable ventilation rate, almost all interviewees believe that passive vents perform better than no dedicated makeup air system at all (i.e., solely relying on infiltration). The requirement for compartmentalization should reduce pollutant transfer and increase the performance of passive vents, according to a passive vent study which found that increased compartmentalization increases airflow through these vents (Consortium for Advanced Residential Buildings 2016a). The Statewide CASE Team proposes that the Residential Compliance Manual provide design guidelines for proper passive vent installation, including right-sizing these vents to increase airflow as recommended in the “Measure Guideline: Passive Vents” report (Consortium for Advanced Residential Buildings 2016b).

The requirement for mechanically driven supply air and MERV 13 filtration of outside air in high PM 2.5 areas is only for HRMF units, because low-rise units do not have as great a potential for pollutant transfer due to their reduced stack effect. In addition, low-rise units using an exhaust-only ventilation strategy generally use infiltration (as opposed to passive vents) for makeup air, so will typically have more filtration by the building envelope than HRMF units, which typically use passive vents. Particularly because few HRVs or ERVs products offer MERV 13 filtration (see Table 4), requiring MERV 13 on outside air for low-rise residential units could dissuade builders from installing a balanced ventilation system. Consequently, no MERV 13 filtration of outside ventilation air is proposed for low-rise units in areas of high PM 2.5 levels.

Through interviews, the Statewide CASE Team learned that one approach for providing mechanically driven supply air to HRMF units relies on continuous operation of forced air system air handlers. This approach uses variable speed fans to efficiently provide ventilation, and can be an effective strategy for providing balanced ventilation. Consequently, this code change proposal includes an exemption for forced air system air handlers serving HRMF units from the following requirement in Section 150.0(o), now that HRMF units will shift to following the residential requirements in Title 24, Part 6: “Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the whole-building ventilation airflow required in Section 4 of ASHRAE Standard 62.2.”

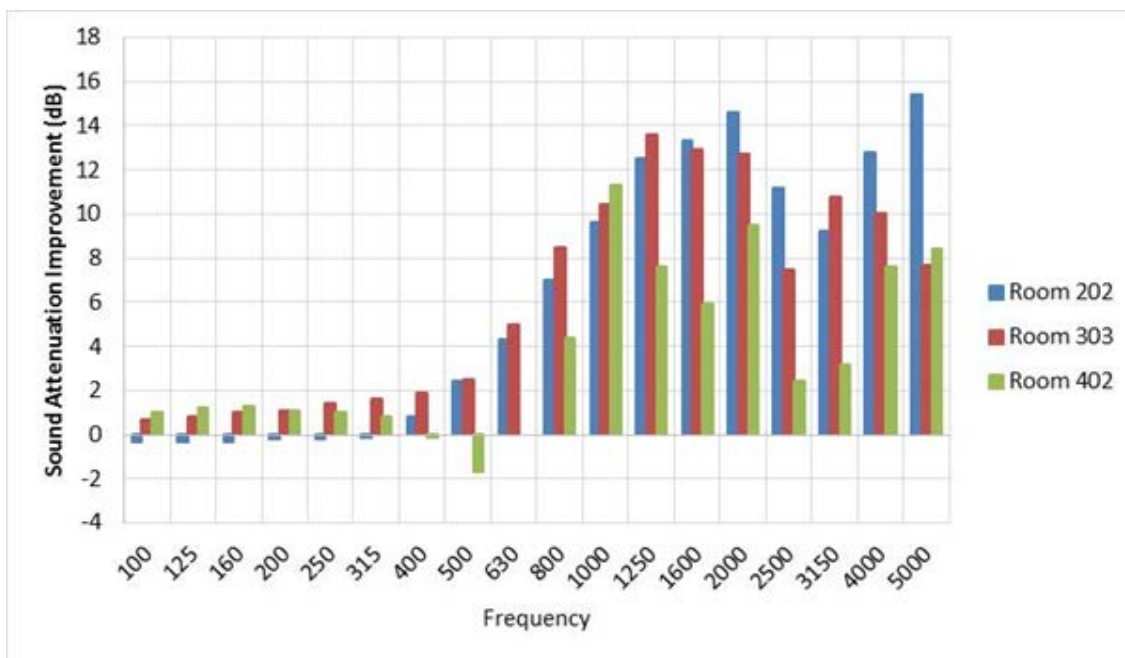
#### *Compartmentalization in Multifamily Units*

Compartmentalization reduces pollutant transfer between adjacent units, thereby improving IAQ and reducing odor and noise transfer. For multifamily units using an exhaust-only approach, compartmentalization increases the amount of ventilation drawn from the outside. Without a requirement for blower door testing, multifamily project teams may not seal between units. Studies supporting the need for compartmentalization include the following:

- In a field study of six existing multifamily buildings in Minnesota that underwent compartmentalization and ventilation upgrades (Center for Energy and Environment 2004), before the retrofit, all six buildings had at least one unit for which more than 10 percent of the air entering the unit came from another unit. The study found that the effective contaminant

transfer (ECT, which models Environmental Tobacco Smoke [ETS] transfer), was reduced by an average of 41 percent after air sealing.

- In a study that included field measurements and modeling of multifamily buildings in New York (Center for Energy and Environment and WCEC 2016), researchers found significant sound attenuation improvement for frequencies above 500 Hz due to compartmentalization via aerosol sealing. Figure 4 presents the noise reduction results. This study also included EnergyPlus airflow modeling, which considered three different leakage levels (9.5, 3 and 0.6 ACH50 or 0.50, 0.16, and 0.03 cfm50/ft<sup>2</sup>) and reported the annual average air flow rate between units for a six-story building. The study found, “for the leakiest units (9.5 ACH50), the average inter-unit airflow rate for all four ventilation strategies was 22.3 cfm, and all four values were within 4 % of the average. For the units with mechanical ventilation, the inter-unit air flow was about 25 % of the ventilation flow. This indicates that there is significant air and contaminant transfer between units with about 20% of the air that enters the units is coming from neighboring units” (p. 82). Furthermore, the 65 percent leakage reduction from 9.5 to 3.0 ACH50 resulted in an average reduction in inter-unit airflow of 86 percent. As described in Section 4.3, the proposed compartmentalization requirement of 0.3 cfm50/ft<sup>2</sup> enclosure area translates into roughly 6 to 7 ACH50. The inter-unit airflow reduction from the proposed requirement would likely be lower than what was found in the study, since final leakage was 3 ACH50. But the study results still demonstrate how air sealing between units reduces air transfer.
- A field study of a 13-story building in Canada built in 1986 that was not compartmentalized (Rickets and Straube 2014) found that pressures created by stack effect were of similar magnitude (10 to 15 Pa) as mechanical pressures. The study concluded, “there is significant potential for overwhelming of the mechanically induced pressures and consequently for alteration of airflow rates and direction.” This study illustrates the need for compartmentalization, particularly in HRMF buildings, to reduce stack effect and enable ventilation systems to operate as designed.



**Figure 4: Sound attenuation results for three New York apartments that underwent air sealing**

(Source: CEE 2016, p. 8)

The Statewide CASE Team proposes that sampling be allowed to meet the compartmentalization requirement, because data indicate that leakage varies little among units in the same multifamily building. The Statewide CASE Team analyzed blower door test results from ten buildings in the ENERGY STAR® Multifamily High-Rise program, presented in Table 5. Based on this analysis, there was little variation in results among units in the same building. Consequently, sampling can reduce the cost of compliance with little sacrifice to rigor.

**Table 5: Intra-building Blower Door Test Results, based on ENERGY STAR HRMF Program Data**

<b>Building</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>
State (if available)		MD	MD	MD	CT			NY		
Floors in Building	4	4	4	4	5	6	11	11	37	9
No. of units tested	22	13	19	22	12	16	19	36	90	17
Average blower door result (cfm50/ft <sup>2</sup> )	0.23	0.20	0.23	0.23	0.28	0.27	0.28	0.21	0.13	0.24
Minimum (cfm50/ft <sup>2</sup> )	0.16	0.17	0.19	0.14	0.22	0.17	0.23	0.13	0.07	0.16
Maximum (cfm50/ft <sup>2</sup> )	0.30	0.24	0.26	0.30	0.30	0.31	0.31	0.28	0.30	0.30
<b>Standard deviation (cfm50/ft<sup>2</sup>)</b>	<b>0.04</b>	<b>0.02</b>	<b>0.02</b>	<b>0.04</b>	<b>0.03</b>	<b>0.04</b>	<b>0.02</b>	<b>0.03</b>	<b>0.04</b>	<b>0.04</b>

#### *Central Exhaust Shaft Measures in HRMF Buildings*

Field studies have also demonstrated that air leakage, stack effect, and lack of, or improper, balancing can prevent individual units from properly removing exhaust air (Center for Energy and Environment 2016) and increased energy use (WCEC 2014). Consequently, this code change proposal includes two separate measure for HRMF buildings that use central exhaust shafts:

- The shafts must be sealed to ten percent of the power rooftop ventilator's fan flowrate,
- The exhaust fans that discharge air into the central shaft must be balanced to within ten percent of design airflow.

For further information, refer to the description of model codes located in Section 2.4. There are no preemption concerns with this measure.

## **2.3 Summary of Proposed Changes to Code Documents**

The sections below provide a summary of how each Title 24, Part 6 documents will be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

Revisions to Title 24, Part 6 Section 120.1 will be made to shift ventilation requirements for HRMF from the nonresidential to the residential standards. Alternate means of meeting HRMF ventilation requirements and requirements for sealing of exhaust shafts and balancing airflow will also be added to Section 120.1. Language in Sections 120.5 and 150 will be edited to increase filter efficiency from MERV 6 to MERV 13 (or AHRI 680-2009 particle size efficiency of 85 percent or greater in the 1.0 – 3.0 µm range), and to reference ASHRAE 62.2-2016. Subsections will be added to Section 150 to describe the proposed exceptions to 62.2-2016, including the default 2 ACH50 leakage assumption, the increase in filter efficiency, and a requirement that multifamily occupancies using exhaust fans for

outdoor air ventilation must provide a source of outside air (either passive or mechanically supplied). Section 150 will also define requirements for kitchen hood verification.

The change in the ventilation standard for HRMF buildings will also affect other parts of Title 24, including Part 2 of the California Building Code and Part 4 of the California Mechanical Code. Details of the code change language are provided in Section 7.1. These changes will help correct conflicting or confusing references in Parts 2, 4, and 6.

### **2.3.1 Standards Change Summary**

This proposal would modify the following sections of the Building Energy Efficiency Standards as shown below. See Section 7 of this report for detailed proposed revisions to code language.

#### **SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION**

**100.1(b) Definitions:** The reference to ASHRAE Standard 62.2 is updated from 62.2-2010 to 62.2-2016.

#### **SECTION 120 – REQUIREMENTS FOR VENTILATION**

**Subsection 120.1:** Simplifies references to other codes.

**Subsection 120.1(a)1:** Exception 2 will be added to indicate that all occupancies classified as R-3 and non-transient residential occupancies classified as R-2 will be covered by Section 150.0.

**Subsection 120.1(b)3:** Provides for sealing of central exhaust shafts and ducts to ten percent maximum of total ventilation air and to require balancing within ten percent of design airflow.

**Table 120.1-A:** Changes the reference for high-rise residential from the California Building Code to Section 150.0(o).

**Subsection 120.4(g):** Requires sealing of exhaust shafts and ducts in HRMF buildings to within ten percent of the measured airflow of the powered roof ventilator (added).

**Subsection 120.5(a)18:** Adds requirement specifying that filters for ducted thermal conditioning systems in HRMF buildings shall comply with 150.0(m)12B.

#### **SECTION 150 – MANDATORY FEATURES AND DEVICES**

**Exception to Subsection 150.0(e)1B:** Removes exception for outdoor combustion air for fireplaces and decorative gas appliances if located on a slab and not near a wall.

**Subsection 150.0(h)5:** Requires alternatives to indoor combustion air for open combustion space conditioning equipment similar to the requirements in IECC Section R402.4.4.

**Subsection 150.0(m)12B:** Updates MERV and AHRI 680 Particle Size Efficiency (PSE) values to match the proposed filter efficiency requirement (from MERV 6 to MERV 13), and adds language requiring that filter media be labelled by the manufacturer with efficiency and static pressure information and verified.

**Subsection 150.0(m)12B:** Inserts MERV requirements for outdoor air ventilation systems based on high-rise or low rise construction, proximity to busy roadway and type of ventilation system.

**Subsection 150.0(n)5:** Requires alternatives to indoor combustion air for open combustion water heating equipment similar to the requirements in IECC Section R402.4.4.

**Subsection 150.0(o):** Adopts the version of ASHRAE Standard 62.2 that is referenced in Section 100.1(b).

**Subsection 150.0(o)1:** Requirement that mechanical ventilation system airflow is calculated on the basis of 2 ACH50 if no blower door test is completed. Requires higher mechanical ventilation flowrates



if tested infiltration is lower than 2 ACH50 but does not reduce mechanical ventilation rate if tested infiltration rates are higher than 2 ACH50.

**Subsection 150.0(o)2** When central fan integrated ventilation systems in HRMF units use continuous operation of central forced air system air handlers for meeting the whole-unit ventilation requirement, variable speed fans that change flowrates in response to loads are required.

**Subsection 150.0(o)4A:** Prescribes methods of meeting ventilation requirements in low-rise and high-rise multifamily buildings, and allows a reduction in ventilation air if balanced systems are installed.

**Subsection 150.0(o)4B:** New section titled Kitchen Exhaust Ventilation that requires field verification of the HVI certification information for the installed kitchen range hood and references a new field verification protocol for the range hood which will be added to RA3.7.4.3.

**Subsection 150.0(o)4C:** Requires sealing of multifamily units and HERS verification of maximum total leakage of 0.3 cfm at 50 Pa per square foot of dwelling unit enclosure area (sampling allowed in accordance with RA2.6.3).

**Subsection 150.0(p)5:** Requires alternatives to indoor combustion air for open combustion pool heaters similar to the requirements in IECC Section R402.4.4.

## **SECTION 150.2 – ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS TO EXISTING LOW-RISE RESIDENTIAL BUILDINGS**

**Exception 4 to Section 150.2(b):** Indicates that the limitation on using indoor air for combustion air in Section 150.0(h)5 (space conditioning equipment), 150.0(n)5 (water heaters), and 150.0(p)5 (pool heaters) do not apply to alterations.

### **2.3.2 Reference Appendices Change Summary**

This proposal would modify the following sections of the standards appendices as shown below. See Sections 7.1.1 and 7.2.4 of this report for the detailed proposed revisions to the text of the reference appendices.

#### **JOINT APPENDICES**

**JA1 - Glossary:** The proposed regulations would update the existing ASHRAE Standard 62.2 definition to reference the 2016 version and adds definitions related to HVI labeling of kitchen hoods.

#### **RESIDENTIAL APPENDICES**

**Table RA2-1 – Summary of Measures Requiring Field Verification and Diagnostic Testing:** Adds field verifications for kitchen hood airflow and sone ratings, and blower door tests for compliance with compartmentalization of multifamily units.

**RA 2.3.1.1 Whole-Building Compliance Approach for Multifamily Buildings:** Clarify that the blower door test referenced in “(e) Building Envelope Sealing credit (blower door test)” is to determine infiltration, not for compartmentalization.

**RA2.3.1.2: Documentation registration:** Edited as follows: “For all low-rise and high-rise residential buildings...”.

**Table RA3.7-1 – Summary of Verification and Diagnostic Procedures:** Change verification procedure references and add a reference to kitchen hood verification procedures as detailed in Section 7.

**RA3.7.4 - Procedures:** Change this section to **Procedures – All Building Types**

**RA3.7.4.3 – Kitchen exhaust verification:** New section describing the procedure.

**RA3.7.4.4 – Procedures Specific to High-Rise Multifamily Buildings:** This new section describes procedures related to IAQ ventilation airflow verification for the various types of systems used in high-rise multifamily buildings, such as exhaust with passive vents, central exhaust systems, and balanced ventilation.

The proposed regulations will be required to be updated to the acceptance test protocols in the nonresidential appendices to accommodate the following measures for high-rise residential buildings:

- Path 1: Air sealing for compartmentalization and makeup air for exhaust ventilation
- Path 2: Balanced ventilation and filtration (required for non-attainment areas)
- Buildings with central-exhaust: air sealing and balancing

**RA3.8: Field Verification and Diagnostic Testing of Building Air Leakage:** Add changes to this section to describe how to alter the blower door test to assess multifamily unit compartmentalization.

## **NONRESIDENTIAL APPENDICES**

Although the common areas of HRMF buildings will continue to follow the nonresidential requirements of Title 24, Part 6, these areas affect the scope of this code change proposal – i.e., IAQ within the HRMF units. Consequently, this code change proposal includes the following revision:

**NA2.1.4.1: Diagnostic Duct Leakage:** Add a description that, for central exhaust shafts serving HRMF buildings, HERS Rater verification for 10% leakage should follow Procedure NA2.1.4.2.1.

### ***2.3.3 Alternative Calculation Method (ACM) Reference Manual Change Summary***

This proposal would modify the following sections of the Residential ACM Reference Manual. See Section 7.3 for the detailed proposed revisions to the text of the ACM Reference Manual.

## **SECTION 2 – The Proposed Design and Standard Design**

**Subsection 2.4.9:** The proposed regulations will substantially change the algorithms applied for calculating the minimum required ventilation airflow rates. This section will be revised to include the calculation method for  $Q_{total}$ ,  $Q_{inf}$ , and  $Q_{fan}$ .

### ***2.3.4 Compliance Manual Change Summary***

The proposed code change will modify the following sections of the Title 24, Part 6 Residential Compliance Manual (see Section 7 for details):

- Section 1.5 – Scope and Application
- Section 2.2.8 – Field Verification and Diagnostic Testing
- Section 3.5.8.9 – Natural Ventilation Through Fenestration
- Section 3.6.1.17 – Ventilation for Indoor Air Quality
- Section 4.1.2 – What’s New for the 2019 Energy Standards
- Section 4.6 – Indoor Air Quality and Mechanical Ventilation
- Section 9 – Additions, Alterations, and Repairs

In addition, Chapter 4.3 of the Nonresidential Compliance Manual– Ventilation Requirements, will be modified.

### ***2.3.5 Compliance Documents Change Summary***

The proposed code change will modify CF2R-MCH and CF3R-MCH to accommodate verification of HRMF ventilation and kitchen hood verification for all residential unit types. Revisions to nonresidential documents will be required to verify sealing of HRMF partition walls and air tightness of central exhaust shafts.

## 2.4 Regulatory Context

### 2.4.1 Existing Title 24, Part 6 Standards

The current Title 24, Part 6 requirements reference ASHRAE 62.1-2010.

### 2.4.2 Relationship to Other Title 24 Requirements

Title 24, Part 2 (California Building Code) and Title 24, Part 4 (California Mechanical Code) include relevant requirements. Edits to Part 2 and Part 4 are needed to make it clear that single family residential and HRMF dwellings are covered by Part 6. Updates would also clarify which R-2 occupancies are covered by 62.1 versus 62.2.

#### Title 24, Part 2

**Sections 310.4 and 310.5:** These sections define Group R-2 and R-3 residential occupancy types. The interpretation by the Statewide CASE Team is that the only R-2 occupancy type that would use the residential ventilation standard (ASHRAE 62.2) is apartment houses with non-transient occupancy. All other listed R-2 occupancies would use the Nonresidential Standard (ASHRAE 62.1).

**Section 1203.1:** This section states that “mechanical ventilation shall be provided in accordance with the California Mechanical Code (Title 24, Part 4).

#### Title 24, Part 4

**Section 402.1 Occupiable Spaces:** Quoting from this section: “Ventilation air supply requirements for occupancies regulated by the California Energy Commission are found in the California Energy Code.”

**Section 402.1.2. Dwelling:** This section specifies “Requirements for ventilation air rate for single family dwellings shall be in accordance with this chapter or ASHRAE 62.2.”

**Section 402.3: Mechanical Ventilation:** States “Where natural ventilation is not permitted by this section or the building code, mechanical ventilation systems shall be designed, constructed, and installed to provide a method of supply air and exhaust air.”

**Table 402.1. Minimum Ventilation Rates in Breathing Zone:** Designates the ventilation rate for dwelling units as 5 cfm per person plus 0.06 cfm per square foot. Footnote “g” to the table states: “Air from one residential dwelling shall not be recirculated or transferred to other spaces outside of that dwelling.”

### 2.4.3 Relationship to Federal Laws

Changes in federal standards for furnace fan efficacy that take effect in 2019 are used as the basis for revisions to Title 24, Part 6; as proposed, they would lower the current 0.58 watt/cfm efficacy to 0.4 w/cfm. A requirement for higher efficiency filters may increase the difficulty of attaining a lower fan efficacy. No other current or proposed federal regulatory changes are known to be inconsistent with or duplicative of proposed changes to Title 24, Part 6, and there are no federal regulatory requirements that address the same topic as this proposed change

### 2.4.4 Relationship to Industry Standards

This proposal includes the adoption of ASHRAE Standard 62.2-2016. To date this version has not been adopted by the International Energy Conservation Code (IECC) or local ordinances. The IECC requires similar ventilation rates as calculated using the 2010 and 2013 versions of ASHRAE 62.2, which provide for an automatic infiltration credit.

Except for ASHRAE Standard 62.2, there are no industry standards that address the same topic as this proposed change.

## 2.5 Compliance and Enforcement

The Statewide CASE Team collected input during the stakeholder outreach process on what compliance and enforcement issues may be associated with these measures. This section summarizes how the proposed code change would modify the code compliance process. Appendix C presents a detailed description of how the proposed code changes could impact various market actors. When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced.

The key steps and changes to the compliance process are summarized below:

- **Design Phase:** This measure minimally impacts the design phase process for single family dwellings. Single family home designers will need to specify slightly larger mechanical ventilation systems that meet the increased ASHRAE 62.2-2016 ventilation rates as well as kitchen hoods that are HVI certified as meeting the ventilation/sound requirements. Improved compliance with ASHRAE 62.2-2016 will eliminate recirculating kitchen hoods and combination microwave exhaust hoods that cannot meet the 100 cfm, three sone requirement<sup>15</sup>. For HRMF buildings, designers will need to be aware of the following:
  - Title 24, Part 6 – not Part 4 – will prescribe required ventilation rates, which will be lower than previously required.
  - Externally vented kitchen hoods meeting ASHRAE 62.2-2016 for air volume and sound will be verified.
  - Central exhaust systems will need to meet requirements for balanced air delivery and shaft sealing.
  - Provisions must be made for makeup air or balanced ventilation.

Single family and multifamily mechanical designers will also need to account for the pressure drop of higher efficiency filters in duct sizing calculations and ensure that either the prescriptive return grille, filter, and duct sizes are followed; or that the revised fan efficacy requirement can be met.

- **Permit Application Phase:** This measure will not have an impact on the existing permit application phase process other than minor changes to CFIR documents.
- **Construction Phase:** Provisions must be made to accommodate the new requirements for ventilation rates, kitchen hoods, and for multifamily units, makeup air and duct/shaft sealing and air balancing. The impact of changes for single family and low-rise occupancies will be very minor. The impact of changes for high-rise multifamily units will be significant in regions that are required to provide mechanically driven ventilation with MERV 13 filtration, but will be minor in all other areas of the state.
- **Inspection Phase:** For single family and low-rise multifamily units, this measure will have minimal impact on the existing building inspection phase process. There will be additional work for verifiers to inspect kitchen hoods. For high-rise buildings, inspection and verification will be required for the following:

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<sup>15</sup> Currently addressed in Residential Compliance Manual section 4.6.5.1B.

- Mandatory compartmentalization requirements required for all multifamily units with HERS verification
- Central exhaust shaft sealing to ten percent of total fan flow
- Central exhaust system balancing to within ten percent of design flow

Inspections may be completed by a HERS Rater or an ATT inspector. Verifiers will be required to have new roles where they have typically not been involved in the past, and some training will be required.

For all buildings, an additional field verification document will be needed to demonstrate kitchen exhaust hood verification. For high-rise buildings using exhaust shafts, additional testing will be required to verify proper distribution of ventilation air.

- **Compliance:** Compliance enforcement changes for new measures include the following:
  - MERV 13 filters, kitchen hoods, and proposed high-rise measure changes will increase the enforcement burden.
  - Verification of ventilation measures in high-rise projects where verification is typically not required is a significant change. Verification will include compartmentalization in HRMF units that use an exhaust-only with passive vents ventilation strategy, and verification of mechanically driven, filtered air in state regions where this is required.
  - The measures are intended to close some loopholes to compliance (for example non-compliance of kitchen hoods with ASHRAE Standard 62.2.).

No added burden on building officials will be imposed by the proposed measures for low-rise residential units. For high-rise residential buildings, building officials will need to be familiar with changes to ventilation requirements as they will no longer be responsible for verifying related mechanical code requirements, and they will need to verify the ventilation strategy.

If this code change proposal is adopted, the Statewide CASE Team recommends that information presented in this section, Section 3, and Appendix C be used to develop a plan that identifies a process to develop compliance documentation and how to minimize barriers to compliance.

## 3. MARKET ANALYSIS

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The Statewide CASE Team performed a market analysis with the goals of identifying current technology availability, current product availability, and market trends. The Statewide CASE Team considered how the proposed standard may impact the market in general and individual market actors. The Statewide CASE Team gathered information about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including Energy Commission staff, utility program staff, and a wide range of industry players who were invited to participate in utility-sponsored stakeholder meetings held on September 27, 2016 and March 16, 2017.

### 3.1 Market Structure

All products related to ventilation, including fans, kitchen hoods, heat exchange ventilators, passive vents, air control devices, and filters are commonly available from multiple suppliers. These products are manufactured both in the United States and abroad and are distributed through HVAC supply houses (e.g., Slakey Brothers and Ferguson) and by online vendors (e.g., Build.com and HVACquick.com). Large production builders may purchase commonly used products directly from manufacturers.

## 3.2 Technical Feasibility, Market Availability, and Current Practices

### 3.2.1 *Ability of the Market to Accommodate the Measure*

The construction industry is skilled in all methods used to implement the proposed measures, including; providing and installing appropriately sized and qualifying ventilation systems, kitchen range hoods, air conditioning filters, passive vents, and ventilation ducts and shafts. Training and support may be needed in some areas, for example, regarding sizing of filters and filter grilles that allow airflow and watt draw requirements to be met.

For the requirement for compartmentalizing multifamily units, no new products or strategies are needed, but education may be needed to make project teams aware that they must air seal interior partition walls as well as exterior walls to meet the requirement.

Because most HRMF units use exhaust-only strategies for supplying ventilation air, training and compliance manual guidance may be needed for designing systems that meet the requirement for mechanically driven supply air (e.g., balanced systems) and MERV 13 filtration in areas of high PM 2.5.

Builders who are accustomed to installing combination microwave exhaust fan units and recirculating range hoods will need to be educated on what products meet ASHRAE 62.2 Standards.

### 3.2.2 *Product Availability and Related Issues*

**Ventilation Fans.** There are numerous ventilation products capable of supplying ventilation in accordance with ASHRAE 62.2-2016. Most bathroom exhaust fans have the capacity to meet new ventilation requirements for any home size when used either individually (for smaller homes) or when used in combination (for larger homes). The HVI directory (HVI Publication 911) lists 4,107 different models from 46 manufacturers, with airflow ratings ranging from 14 to 620 cfm. Of these, 3,022 are ENERGY STAR® certified. HRVs, ERVs, and other available balanced exhaust systems incorporate variable speed fans with a wide range of capacities. There is also a large variety of inline fans that can be used for central ventilation systems.

**Kitchen Range Hoods.** Of the HVI listing of range hoods that meet ASHRAE 62.2 air volume and noise level requirements (100 cfm or greater and three sones or lower), there are 1,692 individual products listed by 22 manufacturers. Of these, 234 are ENERGY STAR certified. It is unknown whether there are any combination microwave-range hoods that meet the 100 cfm, three sone requirements since HVI listings for kitchen hoods do not specify whether microwaves are included.

**Filters for Ducted Thermal Conditioning Systems.** Stakeholders have expressed concern about the size and cost of MERV 13 filters relative to MERV 6 or MERV 8 filters, since the higher MERV rating is expected to require larger filter sizes to maintain equivalent pressure drop. Limited ceiling area may require additional return air grilles to be installed. In stakeholder meetings, a few HERS raters reported that they frequently see ventilation systems with inadequate airflow, because the system was not designed to overcome the pressure drop of the filter. These raters identified a training need for engineers and design-build HVAC contractors to properly design systems to increase the surface area when using higher MERV filters, and recommended that they provide more details in building plans (e.g., filter make and model).

Unfortunately, the cost impact of high MERV filters is difficult to assess because of the scarcity of filter performance data. A Title 20 Appliance Standards action was put in place that required labeling, but in an emergency rulemaking the Energy Commission extended the required date for labeling from July 1,

2016 to April 1, 2019<sup>16</sup>. As a result, Title 20 includes a category for filters, but none are listed to date. The AHRI Directory of Certified Performance does not include filters. A survey of products from big box stores and online sources show there are offerings from multiple manufacturers that provide MERV 13 or equivalent products, with the most popular brands including 3M Filtrete, American Air Filter, Honeywell, Ace, WEB, Lennox, and AprilAire. Only a few manufacturers have anticipated the Title 20 requirement by providing labeling.

Most high efficiency filters are pleated and range from one inch to four inches in thickness. Sizes up to 20 inch by 30 inch are commonly available. Larger thicknesses than 1 inch are not commonly seen in major retail stores but can be obtained from internet sources and wholesalers. The April 2019 filter labeling date will ensure that filter pressure drop data will be available for the January 1, 2020 initiation of the 2019 Standards.

The Statewide CASE Team analyzed the impact of MERV 13 filters on filter and grille sizing using data obtained from prior laboratory testing (Springer 2009), data from filter labels in stores, and information from manufacturers. Prior testing generally showed a large pressure drop penalty for MERV 13 filters relative to less efficient (MERV 7-8) filters, however the limited performance data that is currently available from manufacturers suggests there is not a clear correlation between filter pressure drop and MERV rating. For example, a 3M Filtrete MERV 7 has a higher pressure drop than a Filtrete MERV 13 (MacTavish 2017), but a 2" thick Aeolus MERV 13 filter has a 50% higher pressure drop a 2" Aeolus MERV 8 filter. Also, some 2" MERV 13 filters were found to have higher pressure drop than 1" MERV 13 filters. For costing purposes, an Aeolus SMP80 two-inch-thick MERV 13 filter was compared to a Flanders PP 40 1" MERV 8 filter<sup>17</sup>, and the relative sizes were based on maintaining a 0.15 IWC pressure drop. For these products, the 2" MERV 13 filter would have to be ten percent larger than the 1" MERV 8 to achieve comparable pressure drop.

The air velocities that underlie Title 24, Part 6 Table 150.0-B and C filter and grille sizing range from 151 to 176 feet per minute (fpm). Applying these velocities to typical filter performance curves yields pressure drops that are well below the 0.15 IWC on which the incremental filter cost estimates are based.

**Compartmentalization for Multifamily Units:** Programs for above-code new construction that target multifamily buildings include a compartmentalization requirement that is at least as stringent as this proposal: The ENERGY STAR Multifamily Highrise program requires 0.3 cfm50 / ft<sup>2</sup> enclosure area<sup>18</sup>, and the LEED for Homes Midrise program requires 0.23 cfm50/ft<sup>2</sup> enclosure area<sup>19</sup>. Consequently, project teams that have participated in these programs have met the proposed requirement. Based on the Statewide CASE Team's industry knowledge and the literature (Building Science 2015), sealing interior partitions can be achieved with the same products as are commonly used for sealing the exterior, such as caulk, foam, and gaskets, but project team must pay attention to sealing interior partitions, not just the exterior, for the unit to comply with the maximum leakage rate of 0.3 cfm50/ft<sup>2</sup> enclosure area.

**Multifamily Makeup Air Vents.** Makeup air vents that replace air removed by exhaust fans may be fabricated using sheet metal louvers and ducts, but several manufactured products are available. Some, such as Munters Z-Duct, include passive air-to-air heat exchange. There are also several manufacturers

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<sup>16</sup> Docket Number 17-AAER-02

<sup>17</sup> MERV 6 filters are required by ASHRAE 62.2, but performance data for them is more difficult to find.

<sup>18</sup> [https://www.energystar.gov/index.cfm?c=bldrs\\_lenders\\_raters.nh\\_mfhr\\_guidance](https://www.energystar.gov/index.cfm?c=bldrs_lenders_raters.nh_mfhr_guidance)

<sup>19</sup> [https://www.usgbc.org/sites/default/files/LEED%20v4%20Homes\\_10.17.16\\_current.pdf](https://www.usgbc.org/sites/default/files/LEED%20v4%20Homes_10.17.16_current.pdf)

(e.g., Panasonic, Therma-Stor, and Houzz) of low cost, passive through-the-wall vents which may include interior and exterior louvers and filters or insect screens.

**Central Shaft Air Balancing:** Most HRMF buildings with central exhaust shafts receive some type of testing and balancing for individual unit exhaust fans. Interviewees reported that this can be done through manually balancing fixed orifices, installing constant air regulation (CAR) devices, or using other methods. The manual balancing can be less expensive, and devices that provide automatically balanced ventilation are mostly used with high-rise multifamily buildings (as well as hotels). Manufacturers of the automatically balancing devices include American Aldes, Systemair, Mandik, Atlas Copco, and Smay. Title 24, Part 6 currently does not set an allowed maximum balancing result, nor does it require third party verification of central shaft balancing. However, interviewees reported that typical practice is balancing to within ten percent of the design flowrate, which is the proposed Title 24, Part 6 requirement.

**Shaft Sealing.** Exhaust shafts are typically sealed using standard drywall techniques (for gypboard shafts) and mastic and tape (for sheet metal ducts). An aerosol-based sealing method is also commercially available and has been demonstrated as being effective where there are no large openings. However, there is currently no widespread testing of exhaust shaft leakage, and consequently there is little data indicating typical leakage levels in exhaust shafts in new construction buildings. Interviewees indicated that, without attention to sealing, leakage can range from 10 to 30 percent; the literature supported an estimate of approximately 25 percent (WCEC 2014).

Table 6 provides HRV and ERV product information, based on the Statewide CASE Team web-based product review. The findings indicate that most residential HRVs and ERVs are not sold with an option for MERV 13 filtration. A few manufacturers offer products with MERV 13, including the Zehnder ComfoAir20 and Fantech VHR200R21. The Zehnder product can be installed in an exterior wall and is advertised as applicable for apartment units. Several interviewees mentioned Lunos HRVs for HRMF units, because they can be installed in a through-wall design, but Lunos products also do not currently offer MERV 13 filtration. To comply with a MERV 13 requirement manufacturers will need to provide it as an option to existing products.

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<sup>20</sup> Zehnder ComfoAir: <http://zehnderamerica.com/wp-content/uploads/2014/11/CA350-2015.03.25.pdf>

<sup>21</sup> Fantech VHR200R-EC Fresh Air Appliance: <http://www.fantech.net/products/residential-fresh-air-systems/fresh-air-appliances/vertical-appliances/vhr-r/vhr200r-ec-fresh-air-appliance/>



**Table 6: HRV and ERV Product Cost, Flow Rates, and MERV Ratings**

Manufacturer	Product Name	ERV/HRV	Cost	Flow Rate (cfm)	MERV Rating Options
Panasonic	WhisperComfort™ Spot ERV Ceiling Insert Ventilator (FV-04VE1)	ERV	\$350	40/20/10 @ 0.1 static pressure	MERV 6
Fantech	VHR200R-EC Fresh Air Appliance	HRV	\$2,163/ \$1,987	80-200	MERV 13
Broan	Broan HRV70SE Heat Recovery Ventilator, 120V Side Ports for 4" Ducts - 73 CFM	HRV	\$1,194	73	MERV 6
Broan	HRV70TE	HRV		35-70	MERV 6
Broan	HRV150TE	HRV	\$1,299	40-157	MERV 9
Broan	ERV140TE	ERV		40-140	MERV 7
Broan	ERV70T	ERV		35-70	MERV 6
Solar Palau	TR90/TR90G	ERV		40-110	MERV 8
Solar Palau	TR130	ERV	\$800	50-140	MERV 8
Solar Palau	TR200	ERV	\$1,150	100-200	MERV 8
Mitsubishi	Lossnay LGH-F300RX5-E1	ERV	\$1,687	300	MERV 6
Lennox	Healthy Climate® Heat Recovery Ventilator (HRV5-150, MERV3-300)	HRV	\$1,588	150/300	MERV 4
Zehnder	ComfoAir 70	HRV	\$1,195	up to 38	MERV 8, Optional MERV 13
Carrier	EV450IN	ERV		200-540	MERV 8
Lunos	Lunos e2	HRV	\$1,055	up to 22	MERV 5, Optional MERV 10

**Filtration Standards:** Because of the proposal to increase filtration efficiency requirements for both ducted thermal conditioning systems and outside air ventilation systems, the Statewide CASE Team developed Table 7 to compare MERV requirements. This table shows filtration requirements in buildings standards (ASHRAE 62.1-2016 and 62.2-2016), above code programs (WELL Building Standard, LEED, and EPA Indoor AirPLUS), and in two city ordinances that require filtration above Title 24, Part 6 Standards (San Francisco and Los Angeles). As shown, there is precedence for requiring higher filtration, particularly for outside air in areas with high PM 2.5 concentrations (e.g., PM 2.5 nonattainment areas, and areas close to freeways). The CEC has expressed a strong preference for MERV 13 as a statewide standard. This will equal protection to all residential occupants and will address the PM 2.5 from cooking.

**Table 7: Filtration Requirements in Building Standards, Above Code Programs, and City Ordinances**

Standard / Ordinance	Scope	Ducted Thermal Conditioning Systems	Outside Air Filtration
ASHRAE 62.1-2016	Nonresidential		MERV 11 in PM 2.5 nonattainment areas
ASHRAE 62.2-2013	Residential	MERV 6	MERV 6
WELL Building Standard	Nonresidential	Not specified	MERV 13, or demonstrate outdoor PM 2.5 and PM10 levels below WELL Air Quality Standard for 95 percent of year
LEED v. 4 and LEED for Homes	Nonresidential (v.4) and Low-rise Residential (Homes)	MERV 8	Credit (not prerequisite) for MERV 13
EPA Indoor AirPLUS	Residential	MERV 8 on “HVAC filters” does not specify if for thermal conditioning systems or outside air ventilation	
City of San Francisco (Article 38)	Residential	Ventilation systems with MERV 13 $\leq$ 500 ft of freeways and other sensitive areas. Not specified if for ducted thermal conditioning systems or outside air ventilation	
City of Los Angeles (Ordinance 184245)	Nonresidential and Residential	MERV 13 $\leq$ 1000 ft from freeways, otherwise MERV 8	MERV 13 $\leq$ 1000 ft from freeways, otherwise MERV 8

### 3.2.3 Inspection Challenges

Current Title 24, Part 6 methods and documents cover the inspection and verification process for whole house ventilation systems. New procedures that would be put in place with the proposed measures include: verification of range hoods and filters for ducted thermal conditioning systems for all occupancies, makeup air vents, air regulation and balancing, and shaft sealing for multifamily occupancies. Range hoods and filters can be verified by HERS inspectors when HVAC systems are verified for airflow and fan efficacy for single family and low-rise buildings, but a separate inspection would be required for HRMF. For multifamily buildings, verification and acceptance tests for makeup air vents as well as exhaust shaft sealing and balancing may be completed either by HERS Raters or ATTs, and HERS Raters would conduct blower door testing for the compartmentalization requirement.

### 3.2.4 Building/System Longevity, Occupant Health and Comfort, and Other Considerations

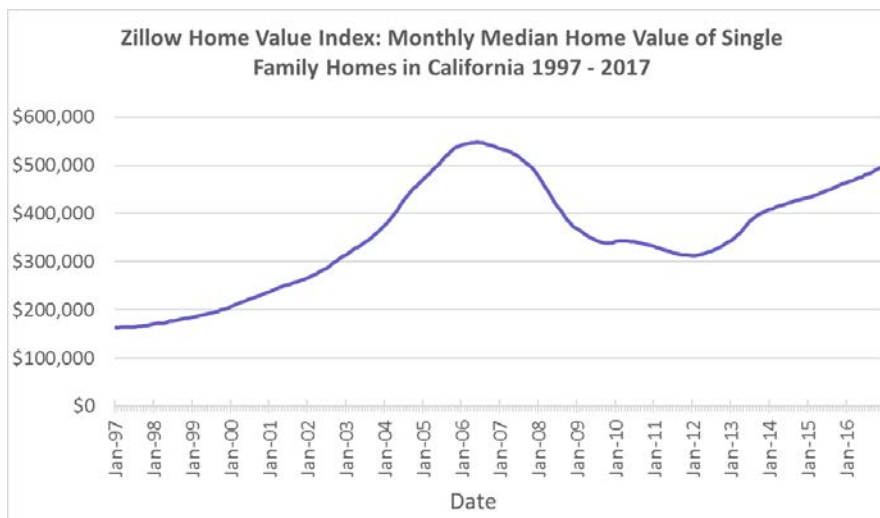
The intent of these proposed measures is to balance energy efficiency improvements proposed by other CASE Reports with the need to maintain occupant comfort and health as well as building durability. By meeting the level of ventilation recommended by the national ASHRAE Standard, indoor pollutants will be reduced by dilution and filtration, and in the dry California climate indoor humidity will be maintained at a level that will not cause damage from moisture accumulation in construction materials. None of the proposed measures are expected to add to maintenance requirements. For example, pleated higher-rated air filters have more surface area than flat filters and should require no more frequent replacement. Kitchen hoods that are more effective at venting smoke and grease to the exterior reduce the amount of grease accumulation on walls and other surfaces.

## 3.3 Market Impacts and Economic Assessments

### 3.3.1 Impact on Builders

It is expected that builders will not be impacted significantly by any one proposed code change or the collective effect of all of the proposed changes to Title 24, Part 6. Builders could be impacted for

change in demand for new buildings and by construction costs. Demand for new buildings is driven more by factors such as the overall health of the economy and population growth than the cost of construction. The cost of complying with Title 24, Part 6 requirements represents a very small portion of the total building value. Increasing the building cost by a fraction of a percent is not expected to have a significant impact on demand for new buildings or the builders' profits. Even as shown in Figure 5, California home prices have increased by about \$300,000 in the last 20 years. In the six years between the peak of the market bubble in 2006 and the bottom of the crashing in 2012, the median home price dropped by \$250,000. The current median price is about \$500,000 per single family home. The combination of all single family measures for the 2016 Title 24, Part 6 Standards was around \$2,700 (California Energy Commission 2015). This is a cost impact of approximately half of one percent of the home value. The cost impact is negligible as compared to other variables that impact the home value.



**Figure 5: California median home values 1997 to 2017**

Source: (Zillow 2017)

Market actors will need to invest in training and education to ensure the workforce, including designers and those working in construction trades, know how to comply with the proposed requirements. Workforce training is not unique to the building industry, and is common in many fields associated with the production of goods and services. Costs associated with workforce training are typically accounted for in long-term financial planning and spread out across the unit price of many units as to avoid price spikes when changes in designs and/or processes are implemented.

Review of current builder practice relative to proposed changes for single family and low-rise multifamily buildings indicates that most builders meet ventilation requirements by providing continuously operating exhaust fans. Higher-capacity fans may need to be selected for single family homes. Air sealing (and blower door testing) is rarely used to earn additional compliance credit, and tighter buildings will require larger fans.

The requirement for compartmentalization is estimated to result in an increase of approximately \$270 for air sealing, and approximately \$20 per tested unit for the HERS Rater to conduct a blower door test (assuming sampling), for a total cost of approximately \$290 per unit.

Combination microwave range hoods are in fairly common use in production homes, and the need to create space for stand-alone or combination oven-microwaves may be viewed by some builders as a marketing hardship. Research for this report was unable to identify any complying combination appliances, though one model tested by Lawrence Berkeley National Laboratory came close. HVI listings do not identify which range hoods include a microwave oven. Verification of range hoods may

increase HERS fees slightly. As indicated in ASHRAE 62.2-2016 Addendum p, products that have a minimum speed setting greater than 400 cfm are exempt from the airflow/sone requirement and therefore from HERS verification.

The requirement for mechanically driven supply air with MERV 13 filtration of outside air in HRMF units will increase costs by approximately \$1,600 per unit (Section 5.2). If MERV 13 is required statewide compliance will be simplified. At the risk of more complicated compliance, this proposal would delineate a “high ambient PM 2.5” area if it is located within 500 feet of a “busy roadway”, defined as a roadway with annual average daily traffic (AADT) equal to or greater than 100,000 vehicles per day. There is strong evidence that people living within 500 feet of a freeway are at greater risk for health problems, such as asthma, bronchitis symptoms, and lung cancer (see 0 for citations and further information). The definition of a “busy roadway” is based San Francisco Health Code Article 38, which requires MERV 13 filtration in urban locations within 500 feet of a roadway with 100,000 vehicles per day. The Statewide CASE Team estimates that roughly five percent of the population will be affected, based on an article that estimated the population within 500 feet of freeways in Southern California (Barboza 2017).

Note that the Statewide CASE Team also considered proposing MERV 13 in PM 2.5 nonattainment areas. However, this would significantly increase the scope of this requirement. The U.S. EPA Greenbook (EPA 2017) shows that approximately three-fourths of the California population currently live in an area that is listed for nonattainment with either the annual PM 2.5 standard (South Coast Air Quality Management District [SCAQMD] and San Joaquin Valley), or the 24-hour PM 2.5 standard (SCAQMD, San Joaquin Valley, Bay Area, and Sacramento). The Bay Area and Sacramento appear to have reached attainment, and need to submit re-designation requests to the EPA to be delisted for nonattainment.<sup>22</sup> PM 2.5 levels in the SCAQMD region have been declining; the region is predicted to reach attainment with the annual standard by 2023 and no later than 2025, and with the 24-hour standard by 2019 (SCAQMD 2016). PM 2.5 levels have also been declining in the San Joaquin Valley (Air Resources Board 2016), with an attainment date of 2025 for the annual PM 2.5 standard (Air Resources Board 2016). Given the trends of improving PM 2.5 in the nonattainment areas and the longevity of buildings (50-100 years<sup>23</sup>); the incremental cost for mechanically driven supply air with MERV 13 filtration; and the training that would be needed for proper design and installation of these systems, the Statewide CASE Team recommends that a minimum MERV 8 (rather than MERV 13) be required in PM 2.5 nonattainment areas. Section 0 provides further detail on the rationale for the scope of this requirement.

Requirements for sealing central exhaust shafts will place an added burden on designers and builders who choose this method of ventilation for high-rise buildings as well as verifiers, but this measure, along with proper balancing and providing a source of outside air, will provide the level of IAQ and healthy environment that is intended by the ASHRAE 62.2 Standard.

The builder is responsible for understanding the design requirements, ensuring that all subcontractors are aware of these requirements, and ultimately ensuring that all requirements are implemented per the design intent. Additional time may be required for these processes but it’s not expected to have a significant impact on project schedule.

Refer to Appendix C for additional information on how the compliance process would impact builders.

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<sup>22</sup> For the Bay Area see footnote 10: <http://www.baaqmd.gov/research-and-data/air-quality-standards-and-attainment-status>, and for Sacramento see: <https://www3.epa.gov/region9/air/actions/sacto/index.html>

<sup>23</sup> USGBC 2007: “On Green Buildings: Benefits to Health, the Environment, and the Bottom Line”. [https://www.epw.senate.gov/public/\\_cache/files/5/c/5c03f15d-1731-478a-9bfb-fe2fbbab6ab0/01AFD79733D77F24A71FEF9DAFCCB056.templeton.pdf](https://www.epw.senate.gov/public/_cache/files/5/c/5c03f15d-1731-478a-9bfb-fe2fbbab6ab0/01AFD79733D77F24A71FEF9DAFCCB056.templeton.pdf)

### ***3.3.2 Impact on Building Designers and Energy Consultants***

Adjusting design practices to comply with changing building code practices is within the normal practices of building designers. Building codes (including the California Building Code and model national building codes published by the International Code Council, the International Association of Plumbing and Mechanical Officials and ASHRAE 90.) are typically updated on a three-year revision cycles. As discussed in Section 3.3.1 all market actors, including building designers and energy consultants, should (and do) plan for training and education that may be required to adjust design practices to accommodate compliance with new building codes. As a whole, the measures the Statewide CASE Team is proposing for the 2019 Title 24, Part 6 code cycle aim to provide designers and energy consultants with opportunities to comply with code requirements in multiple ways, thereby providing flexibility in requirements can be met.

Energy consultants are responsible for identifying what measures are needed to obtain compliance, both for mandatory requirements and to meet prescriptive or performance requirements, and conveying this information to architects and builders (the design-build team). For single family dwellings, energy consultants will need to convey to the design-build team the required size of whole house ventilation fans (to be listed in the CF1R forms), and new requirements for kitchen hoods and filters for ducted thermal conditioning systems, so that these items can be properly specified. For multifamily buildings, energy consultants must also inform the design-build team (including mechanical engineers) of requirements for compartmentalization, and (where used) makeup air and design of central exhaust shafts. On high-rise projects, energy consultants can also assist mechanical engineers with identifying the relevant codes given the change in ventilation standards from 62.1 to 62.2.

Architects and engineers are responsible for developing building plans and specifications that detail mechanical equipment requirements and locations, and that comply with codes. For low-rise buildings, mechanical contractors typically have the responsibility for equipment sizing, duct design, and other installation requirements, whereas for larger multifamily projects this responsibility falls on the mechanical engineer. All design-build team participants will need to be informed of these code changes. Energy Code Ace ([energycodeace.com](http://energycodeace.com)) will be useful in providing the needed guidance.

Refer to Appendix C for additional information on how the compliance process would impact building designers and energy consultants.

### ***3.3.3 Impact on Occupational Safety and Health***

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health. All existing health and safety rules will remain in place. Complying with the proposed code change is anticipated to improve the health of occupants (see Section 6.4), and is not anticipated to have adverse impacts on the safety or health of those involved with the construction, commissioning, and maintenance of the building.

### ***3.3.4 Impact on Building Owners and Occupants (Including Homeowners and Potential First-Time Homeowners)***

Building owners and occupants will benefit from lower energy bills. For example, the Energy Commission estimates that on average the 2016 Title 24, Part 6 Standards will increase the construction cost by \$2,700 per single family home; however, the standards will also result in a savings of \$7,400 in energy and maintenance cost savings over 30 years. This is roughly equivalent to an \$11 per month increase in payments for a 30-year mortgage and a monthly energy cost savings of \$31 per month. Overall, the 2016 Title 24, Part 6 Standards are expected to save homeowners about \$240 per year relative to homeowners whose single family homes are minimally compliant with the 2013 Title 24, Part 6 requirements (California Energy Commission 2015). As discussed in Section 3.4.1, when homeowners or building occupants save on energy bills, they tend to spend it elsewhere in the economy thereby

creating jobs and economic growth for the California economy. Energy cost savings can be particularly beneficial to low income homeowners who typically spend a higher portion of their income on energy bills, often have trouble paying energy bills, and sometimes go without food or medical care to save money for energy bills (Association, National Energy Assistance Directors 2011).

This group of measures will ensure that health advantages afforded by improved ventilation and air filtration will be preserved and enhanced. Benefits include reduced exposure to volatile organic compounds (such as formaldehyde) and particulate matter, which has been linked to higher incidences of lung cancer; and for multifamily tenants, reduction of pollutants and odors from adjacent units. Section 6.4 provides further discussion of health benefits from the proposed measures, including benefits from increased filtration, and Sections 2.1.2 and 7.4 describe the need for these changes from an IAQ and health perspective.

### ***3.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)***

The proposed measure may increase demand for certain ventilation and filtration products, including whole house ventilation systems, MERV 13 filters, and may create market demand for an HVI compliant microwave-hood combinations. The measure will not impact the way products are distributed or sold. See also Section 3.4.2.

### ***3.3.6 Impact on Building Inspectors***

Building inspectors will not be significantly impacted by this measure. Where they have been responsible for inspecting HRMF ventilation systems under the California Mechanical Code (Title 24, Part 4), this burden will be shared and absorbed by HERS or ATT inspectors. See also Appendix C.

### ***3.3.7 Impact on Plans Examiners***

Plans examiners will be responsible for verifying that CF1Rs and other compliance documents match information provided on the plans.

### ***3.3.8 Impact on Statewide Employment***

Section 3.4.1 discusses statewide job creation from the energy efficiency sector in general, including updates to Title 24, Part 6. No increase in statewide job creation is likely to occur as a result of this measure.

## **3.4 Economic Impacts**

### ***3.4.1 Creation or Elimination of Jobs***

In 2015, California's building energy efficiency industry employed more than 321,000 workers who worked at least part time or a fraction of their time on activities related to building efficiency. Employment in the building energy efficiency industry grew six percent between 2014 and 2015 while the overall statewide employment grew three percent (BW Research Partnership 2016). Lawrence Berkeley National Laboratory's report *Characterizing the Energy Efficiency Services Sector: Workforce Size and Expectations for Growth* (2010) provides a detail on the types of jobs in the energy efficiency sector that are likely to be supported by revisions to building codes.

Building codes create jobs through *direct employment*, *indirect employment*, and *induced employment*.<sup>24</sup> Title 24, Part 6 creates jobs in all three categories with a significant amount attributed to induced employment, which accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees (e.g., non-industry jobs created such as teachers, grocery store clerks, and postal workers). A large portion of the induced jobs from energy efficiency are the jobs created by the energy cost savings due to the energy efficiency measures. For example, as mentioned in Section 3.3.4, the 2016 Standards are expected to save single family homeowners about \$240 per year. Money saved from hundreds of thousands of homeowners over the entire life of the building will be reinvested in local businesses. Wei, Patadia and Kammen (2010) estimate that energy efficiency creates 0.17 to 0.59 net job-years<sup>25</sup> per GWh saved. By comparison, they estimate that the coal and natural gas industries create 0.11 net job-years per GWh produced. See Section 6.1 for statewide savings estimates.

This report only addresses non-energy measures that ensure that other proposed energy-related measures do not negatively impact IAQ or building durability. Other CASE Reports describe the relationship between energy measures and job creation. Since the proposed measures herein primarily deal with substitution of one product for another and do not affect the level of effort required for procurement or installation, the impact on job creation will be very small. One exception is that sealing of exhaust shafts and provisions for makeup air in multifamily buildings will slightly increase labor needs.

### **3.4.2 Creation or Elimination of Businesses in California**

There are approximately 43,000 businesses that play a role in California's advanced energy economy (BW Research Partnership 2016). California's clean economy grew ten times more than the total state economy between 2002 and 2012 (20 percent compared to two percent). The energy efficiency industry, which is driven in part by recurrent updates to the building code, is the largest component of the core clean economy (Ettenson and Heavey 2015). Adopting cost-effective code changes for the 2019 Title 24, Part 6 code cycle will help maintain the energy efficiency industry.

The proposed code change would have very minor impact on the use of specific products, all of which are manufactured outside of California and the affected products would not alter the existing supply chains.

As proposed, implementation of the proposed measures would affect new single family and multifamily construction and additions greater than 1000 ft<sup>2</sup>.

The proposed change introduces no new products but may have an impact on the volume of sales of certain products. Few, if any, of the affected products are manufactured in California, and there is not likely to be any change in market advantage for California distribution companies. Those in the supply chain that currently handle the more specialized ventilation products for multifamily buildings may see an increase in volume. Affected products would include:

- Exhaust fans used for whole house ventilation
- Heat or energy recovery ventilators

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<sup>24</sup> The definitions of direct, indirect, and induced jobs vary widely by study. Wei et al (2010) describes the definitions and usage of these categories as follows: "*Direct employment* includes those jobs created in the design, manufacturing, delivery, construction/installation, project management and operation and maintenance of the different components of the technology, or power plant, under consideration. *Indirect employment* refers to the "supplier effect" of upstream and downstream suppliers. For example, the task of installing wind turbines is a direct job, whereas manufacturing the steel that is used to build the wind turbine is an indirect job. *Induced employment* accounts for the expenditure-induced effects in the general economy due to the economic activity and spending of direct and indirect employees, e.g., non-industry jobs created such as teachers, grocery store clerks, and postal workers."

<sup>25</sup> One job-year (or "full-time equivalent" FTE job) is full time employment for one person for a duration of one year.

- Passive through-wall vents
- Constant airflow regulators
- Filters for ducted thermal conditioning systems and outside air systems
- Kitchen range hoods

Sales and distribution of larger exhaust fans may increase to meet higher single family residential ventilation rates, but this may be countered by the reduced ventilation rates that will be required for high-rise multifamily buildings. Some increase in sales of small HRVs or ERVs, passive vents, and constant airflow regulators may occur to serve ventilation needs in high-rise buildings. Sales volume of higher-efficiency HVAC filters will increase and volume of lower-efficiency filters will decline. The market for combination microwave range hoods for new buildings will disappear unless manufacturers begin producing ASHRAE 62.2-compliant products.

These changes are not anticipated to shift market share from one manufacturer or distributor to another. For example, the same manufacturers and distributors supply range hoods with and without microwave ovens. The market for specialized ventilation products would be expected to expand, particularly if there is growth in the construction of high-rise residential buildings.

The proposed codes and standards changes will have little or no impact on construction industry jobs. The same workforce that currently provides and installs ventilation products would shift to using products that meet ASHRAE 62.2 and related requirements.

Table 8 lists industries that may benefit from the proposed code change by North American Industry Classification System (NAICS) Code.

**Table 8: Industries Receiving Energy Efficiency Related Investment, by North American Industry Classification System (NAICS) code**

Industry	NAICS Code
Residential Building Construction	2361
Manufacturing	32412

### ***3.4.3 Competitive Advantages or Disadvantages for Businesses in California***

In 2014, California's electricity statewide costs were 1.7 percent of the state's gross domestic product (GPD) while electricity costs in the rest of the United States were 2.4 percent of GDP (Thornberg, Chong and Fowler 2016). As a result of spending a smaller portion of overall GDP on electricity relative to other states, Californians and California businesses save billions of dollars in energy costs per year relative to businesses located elsewhere. Improved IAQ should reduce healthcare costs and increase productivity, and is expected to contribute to the ability of California to compete globally.

### ***3.4.4 Increase or Decrease of Investments in the State of California***

The proposed changes to the building code are not expected to impact investments in California on a macroeconomic scale, nor are they expected to affect investments by individual firms. The allocation of resources for the production of goods in California is not expected to change as a result of this code change proposal.

### ***3.4.5 Effects on the State General Fund, State Special Funds and Local Governments***

The proposed code changes are not expected to have a significant impact on California's General Fund, any state special funds, or local government funds. Revenue to these funds comes from taxes levied. The most taxes most relevant to this proposed code change are: personal income taxes, corporation taxes, sales and use taxes, and property taxes. The proposed changes for the 2019 Title 24, Part 6 Standards are not expected to result in noteworthy changes to personal or corporate income, so the revenue from personal income taxes or corporate taxes is not expected to change. As discussed, reductions in energy expenditures is expected to increase discretionary income. State and local sales tax



revenues may increase if homeowner spend their additional discretionary income on taxable items. Although logic indicates there may be changes to sales tax revenue, the impacts that are directly related to revisions to Title 24, Part 6 have not been quantified. Finally, revenue generated from property taxes is directly linked to the value of the property, which is usually linked to the purchase price of the property. The proposed changes will have a negligible impact on construction costs. As discussed in Section 3.3.1 there is no statistical evidence that Title 24, Part 6 drives construction costs or that construction costs have a significant impact on home price. Since compliance with Title 24, Part 6 does not have a clear impact on purchase price, it can follow that Title 24, Part 6 cannot be shown to impact revenues from property taxes.

#### **3.4.5.1 Cost of Enforcement**

##### *Cost to the State*

State government already has budget for code development, education, and compliance enforcement. While state government will be allocating resources to update the Title 24, Part 6 Standards, including updating education and compliance materials and responding to questions about the revised requirements, these activities are already covered by existing state budgets. The costs to state government are small when compared to the overall costs savings and policy benefits associated with the code change proposals.

The proposed residential changes will not impact state buildings.

##### *Cost to Local Governments*

All revisions to Title 24, Part 6 will result in changes to compliance determinations. Local governments will need to train building department staff on the revised Title 24, Part 6 Standards. While this re-training is an expense to local governments, it is not a new cost associated with the 2019 code change cycle. The building code is updated on a triennial basis, and local governments plan and budget for retraining every time the code is updated. There are numerous resources available to local governments to support compliance training that can help mitigate the cost of retraining, including tools, training and resources provided by the IOU codes and standards program (such as Energy Code Ace). As noted in Section 2.5 and Appendix C, the Statewide CASE Team considered how the proposed code change might impact various market actors involved in the compliance and enforcement process and aimed to minimize negative impacts on local governments.

#### **3.4.6 Impacts on Specific Persons**

The proposed changes to Title 24, Part 6 are not expected to have a differential impact on any groups relative to the state population as a whole, including migrant workers, commuters, or persons by age, race or religion. Given construction costs are not well correlated with home prices, the proposed code changes are not expected to have an impact on financing costs for business or home-buyers. Some financial institutions have progressive policies that recognize the financial implications associated with occupants of energy efficient homes saving on energy bills and therefore have more discretionary income.<sup>26</sup>

Renters will typically benefit from lower energy bills if they pay energy bills directly. These savings should more than offset any capital costs passed-through from landlords. Renters who do not pay directly for energy costs may see some of the net savings depending on if and how landlords account for energy cost when determining rent prices.

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<sup>26</sup> For example, see U.S. EPA's ENERGY STAR website for examples:  
[http://www.energystar.gov/index.cfm?fuseaction=new\\_homes\\_partners.showStateResults&s\\_code=CA](http://www.energystar.gov/index.cfm?fuseaction=new_homes_partners.showStateResults&s_code=CA).

On average, low-income families spend less on energy than higher income families, however lower income families spend a much larger portion of their incomes on energy (Association, National Energy Assistance Directors 2011). Thus, low-income families are likely to benefit more from Title 24, Part 6 Standards that reduce residential energy costs.

## **4. ENERGY SAVINGS**

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### **4.1 Key Assumptions for Energy Savings Analysis**

This group of measures is not projected to save energy. Changes in energy use resulting from increased ventilation rates in single family buildings and decreased ventilation rates in HRMF buildings are accounted for in the evaluation of energy saving measures described in other CASE Reports. For example, the analysis of energy savings for single family envelope measures used the ASHRAE 62.2-2016 ventilation rates in the modeling that evaluated those measures.

### **4.2 Energy Savings Methodology**

There is an existing Title 24, Part 6 Standard that covers the building system in question. Existing conditions assume that a building minimally complies with the 2016 Title 24, Part 6 Standards.

As noted, proposed measures are not intended to reduce energy use, but will foster healthy environments in energy-efficient buildings. In theory, higher ventilation rates will increase energy use due to increased fan energy and the thermal impact of increased delivery of outdoor air that may be either warmer or cooler than the desired indoor temperature. The impact of increased ventilation rate on energy use in new single family homes was estimated using CBECC-Res with the proposed 2019 Time Dependent Valuation (TDV) schedules.

Table 9 lists the characteristics of the buildings that were used to evaluate energy savings and costs. Low-rise multifamily buildings were not evaluated, because the ventilation rates, and consequently their energy use, will not change.

For HRMF buildings, the proposals will decrease energy use in most cases, because of the decrease in required ventilation rate in moving from ASHRAE Standard 62.1-2007 to 62.2-2016. This was modeled using the low-rise multifamily prototype. The Statewide CASE Team used the low-rise multifamily building prototype and low-rise compliance software (CBECC-Res) to model the energy savings between the current (62.1-2007) and proposed (62.2-2016) ventilation rates, because the high-rise compliance software (CBECC-Com) is unable to allow ventilation rates below the current requirements. The central exhaust shaft sealing requirement will also decrease energy use through fan energy savings. For an HRV or ERV, energy savings will vary with climate zone. Many interviewees reported that in mild climates, such as the San Francisco Bay Area, the fan energy penalty of an HRV or ERV could counteract the energy cost savings. However, central systems with ducted outside air, and ERVs/HRVs, should improve IAQ through filtered, reliable ventilation.

The two single family prototype houses used for code development (2,100 square foot one-story and 2,700 square foot two-story) were used for this analysis. Construction characteristics were based on 2016 Title 24, Part 6 prescriptive requirements. Results were weighted 45 percent for the 2,100 square foot prototype and 55 percent for the 2,700 square foot prototype, resulting in blended 2,430 square foot prototype results. Refer to other CASE Reports for a detailed description of methodologies and the net impact of changes in ventilation rates combined with energy-saving measures.

The 2016 Title 24 Part 6 compliance model (CBECC) assumes that the infiltration rate corresponds to a 5 ACH50 blower door test result, and that an additional quantity of air is delivered mechanically,

equivalent to 0.01 cfm/square foot plus 7.5 cfm per occupant. The CBECC-Res analysis for single family energy impacts also assumed an infiltration rate that corresponds to 5 ACH50, but used a mechanical ventilation rate that is calculated based on a leakage rate corresponding to 2 ACH50, such that the total ventilation rate will be approximately 0.03 cfm/square foot plus 7.5 cfm per occupant, consistent with ASHRAE 62.2-2016.

To determine the mechanical ventilation rate, it was necessary to apply the calculations in ASHRAE 62.2-2016 to estimate the infiltration rate. This was done using an open-access software tool.<sup>27</sup> Inputs to this tool included building floor area and height, number of occupants (or bedrooms + 1), and climate location. The results (i.e. required mechanical ventilation rates) were entered in CBECC-Res to develop energy use impacts for each climate zone and prototype house<sup>28</sup>.

As noted in Title 24, Part 6, Section 150.2(a), ASHRAE Standard 62.2 will apply to additions greater than 1,000 square feet. However, increasing the mechanical ventilation rate in buildings that have gas appliances that use indoor air for combustion is a potential safety risk, and such appliances must be provided with combustion air from an external source. This proposed change aligns with the IECC but is in conflict with Chapter 7 of the CMC, which allows the use of indoor combustion air. See the proposed code language changes in Section 7.

**Table 9: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis**

Prototype ID	Occupancy Type	Area (ft <sup>2</sup> )	Number of Stories	Statewide Area (million ft <sup>2</sup> )
New Construction Prototype 1	Residential single family	2,100	1	110.6
New Construction Prototype 2	Residential single family	2,700	2	173.8
New Construction Prototype 1	Residential multifamily	6,960	2	45.7

Energy savings, energy cost savings, and peak demand reductions were calculated using a TDV methodology. The latest 2019 TDV multipliers (updated February 2017) were applied in the analysis.

### 4.3 Per Unit Energy Impact Results

Energy use and peak demand impact per unit for new single family houses (using the blended 2,430 square foot home results) are presented in Table 10. Negative values indicate increases in energy use versus the current 2016 prescriptive base case. Electricity use is affected by increases in fan energy use due to larger ventilation rates, and in most climate zones by resulting increases in air conditioning loads. Furnace gas consumption is also increased as a result of higher ventilation rates during winter periods. Surprisingly, CBECC-Res shows gas energy savings in Climate Zone 14. The per unit energy impact estimates do not take naturally occurring market adoption or compliance rates into account.

<sup>27</sup> <http://www.residentialenergydynamics.com/REDCalcFree/Tools/ASHRAE6222016>

<sup>28</sup> Equation 4.3 in the version of ASHRAE Standard 62.2-2016 that includes Addenda k, l, q, and s and 11/4/2016 errata can also be used to calculate  $Q_{inf}$  from single point tests of ACH50 in accordance with ASTM E1827 or ANSI/RESNET/ICC Standard 380.

**Table 10: First-Year Energy Impacts for Blended Single Family Prototype – New Construction**

Climate Zone	Electricity Savings (kWh/yr)	Peak Electricity Demand Reductions (kW)	Natural Gas Savings (therms/yr)	TDV Energy Savings (TDV kBtu/yr)
1	-59.3	-0.01	-12.01	-4,691
2	-67.1	-0.01	-9.09	-5,127
3	-58.4	-0.01	-9.29	-3,978
4	-67.0	-0.02	-6.88	-4,034
5	-58.8	-0.01	-7.64	-3,587
6	-68.0	-0.02	-7.15	-3,990
7	-70.4	-0.01	-6.45	-3,496
8	-47.8	0.05	-5.34	-1,271
9	-52.5	0.01	-5.68	-3,092
10	-38.2	0.02	-5.12	-2,345
11	-45.9	0.02	-3.91	-2,063
12	-39.0	0.05	-3.93	-1,763
13	-58.9	0.00	-5.81	-3,864
14	-23.0	0.05	2.10	825
15	-152.3	-0.04	-2.36	-5,403
16	-67.1	-0.01	-3.16	-3,113

Table 11 shows energy use impact estimates for new high-rise residential units for the proposed requirement to reduce ventilation rates from the 62.1-2007 to the 62.2-2016 rates. These estimates are based on modeling the current (62.1-2007) and proposed (62.2-2016) ventilation rates in low-rise compliance software (CBECC-Res) using the low-rise multifamily prototype shown in Table 9. The HRMF prototype was not used because the high-rise compliance software (CBECC-Com) does not allow ventilation rate reductions below the currently required levels. These proxy results show savings at an aggregated level representing the eight unit 6,960 ft<sup>2</sup> low rise multifamily prototype building (four one-bedroom, 780 square foot units and four two-bedroom 960 square foot units). Results show that this measure will result in positive energy savings, with greater savings in climate zones with higher cooling loads.

The Statewide CASE Team did not estimate the energy savings from the proposal for compartmentalization in multifamily units, but estimates that the requirement will have no effect or may slightly increase energy savings, depending on project teams' current sealing practices. The exact translation of the compartmentalization requirement of 0.3 cfm50/square foot enclosure area to air changes per hour depends on unit geometry (e.g., ceiling height, length to width ratio of the walls), but the Statewide CASE Team estimates that the requirement represents approximately 6 to 7 ACH50<sup>29</sup>. Compliance software assumes 7 ACH50 for all multifamily dwelling units, and assumes that all infiltration air originates from the exterior. This assumption is conservative from an energy standpoint, since some air leakage comes from adjacent units which may be conditioned. Based on interview results, multifamily air sealing practices vary by project team and jurisdiction. For some HRMF buildings in urban areas, interior partitions are sealed because of acoustical requirements. In other multifamily buildings, project teams air seal exterior surfaces because of energy concerns, but do not seal interior partitions. Under the proposed compartmentalization requirement, leakage from the exterior would likely stay the same or decrease under the proposed requirement, depending on a project team's current practices with air sealing. In either case, the 7 ACH50 assumption of air leakage from the

<sup>29</sup> Assuming 8 to 9 foot ceilings, and where units ranged from square (i.e., all walls the same length) to one set of parallel walls measuring almost twice the length of the other set of walls (e.g., 20 ft by 39 ft for the 780 sf HRMF unit prototype).

exterior is an upper estimate (i.e., conservative), since a fraction of air leakage could come from adjacent, conditioned spaces.

The Statewide CASE Team did not estimate energy savings for the requirement of mechanically driven supply air with MERV 13 filtration for high-rise residential buildings in high PM 2.5 areas because it is anticipated that most units will use an ERV or HRV to meet this requirement and the current compliance software does not allow modeling of these systems.

**Table 11: First-Year Energy Impacts of Ventilation Rate Change for HRMF Building Type (8 units, 6,960 ft<sup>2</sup>) – New Construction**

<b>Climate Zone</b>	<b>Electricity Savings (kWh/yr)</b>	<b>Natural Gas Savings (therms/yr)</b>	<b>TDV Energy Savings (TDV kBtu/yr)</b>
1	59.0	24.9	6,960
2	62.1	16.6	6,265
3	46.9	12.0	4,176
4	51.3	13.4	4,872
5	39.6	11.2	3,480
6	41.0	6.3	2,088
7	36.4	2.0	1,392
8	35.0	3.6	2,088
9	54.4	6.3	4,177
10	55.6	7.4	4,176
11	91.6	15.6	6,960
12	63.9	15.9	6,264
13	93.1	14.6	6,950
14	82.8	14.6	6,264
15	169.0	1.8	6,976
16	58.5	24.2	6,960

## 5. LIFECYCLE COST AND COST-EFFECTIVENESS

### 5.1 Energy Cost Savings Results

The proposed measures in general provide no energy savings for single family buildings, have no impact on low-rise multifamily buildings, and produce modest savings in high-rise multifamily buildings. As directed by the Energy Commission, since this is a health and safety measure, lifecycle cost and cost-effectiveness has not been analyzed.

### 5.2 Incremental First Cost

The Statewide CASE Team estimated the current incremental construction costs, which represents the incremental cost of the measure if a building meeting the proposed standard were built today.

Per the Energy Commission's guidance, design costs are not included in the incremental first cost. Total costs are presented as costs to the builder. A 30 percent overhead and profit markup was applied to all material costs. Labor costs were based on a fully loaded labor rate from RSMeans of \$44/hour after applying an average California regional labor multiplier of 1.1. Labor costs for adding a return grille and duct to accommodate MERV 13 filters was obtained from a contractor and weighted 45 percent one-story and 55 percent two-story.

Incremental costs for single family whole house ventilation fans are based on Panasonic model FV-##VQ5 bathroom fans. Moving from ASHRAE 62.2-2010 to 62.2-2016 ventilation rates for the two single family prototypes requires one step up in fan capacity (e.g., 50 to 80 cfm for the 2,100 square foot prototype and 80 to 110 cfm for the 2,700 square foot prototype). No change in labor cost was assumed, because there is little change in the physical size of the larger fans. Since multiple fans could be commissioned to meet whole house ventilation requirements, the costs presented in Table 12 are conservative.

No additional labor is required to install complying range hoods. The tradeoff between material and installation costs for range hoods with microwaves and oven-microwave combinations was assumed to be even.

For the upgrade from MERV 8 to MERV 13 filters, incremental costs for both larger grille sizes and larger filters were tabulated. MERV 8 filters were used as the base cost because cost data for currently required MERV 6 filters is scarce. For one-story houses, additional labor and materials costs were included to account for the installation of a second return grille, which would be required for higher pressure drop MERV 13 filters (based on the 2,100 square foot prototype and a 3-ton cooling system). The calculation of incremental costs for two-story houses assumed that two returns were already provided and only the cost of larger grilles and filters were accounted for (based on the 2,700 square foot prototype and a 4-ton cooling system). Incremental costs for the one and two-story prototype houses were blended 45 percent and 55 percent respectively.

The larger high efficiency filter and grille is the only added expense for low-rise multifamily, which due to the lower airflow requires a smaller filter and grille than for the single family cases.

Several industry practitioners were interviewed to determine current practice and to obtain ideas on optimal ventilation strategies for HRMF building ventilation (see Appendix B). Typically, they have utilized exhaust fans, sometimes in combination with passive vents, to meet code requirements. Air is supplied through leaks in interior and exterior walls and doorways, and through passive vents (if used). This represents the lowest cost ventilation approach.

For the cost of compartmentalization, the Statewide CASE Team used the NREL Measure Database (National Renewable Energy Laboratory 2013), and assumed a reduction from 7 ACH50 (the current assumption for air leakage in multifamily units under Title 24) to 6 ACH50 (the approximate conversion of 0.3 cfm50/ft<sup>2</sup> enclosure area). The NREL database estimates the cost ranges \$0.13 - \$0.49 per square foot of conditioned area, with an average cost of \$0.31 per square foot of conditioned area. The average size of multifamily units in both the low-rise and high-rise prototypes is 870 square feet, so the average cost for sealing is estimated at \$270.

Based on interviews with five HERS Raters, each blower door test can range from \$65 to \$150 per unit, with an average cost of \$100 per tested unit. The Statewide CASE Team assumed that one in five units will be selected for blower door testing, for an average cost of \$20 per unit (after sampling). Although the sampling procedures in RA2.6 allow one in seven units to be a sample group, this analysis conservatively assumed one in five because it is not uncommon for multifamily buildings to have less than seven units.

Those interviewed generally recognize the inadequacies of the low-cost ventilation approach and appreciate the need for improved delivery of outside air. Penetrations through exterior walls are undesirable from an aesthetic perspective, but central supply ventilation systems (see Figure 2 in Section 2.1.3.3 for an example strategy) are costly. Adding filters to passive vents essentially eliminates their airflow, making balanced systems the preferred choice for high ambient PM 2.5 areas. The decision to select a particular ventilation strategy is affected by a multitude of factors besides cost. One interviewee estimated that the cost for balanced ventilation would lie somewhere between the baseline cost and the cost of central ventilation.

Table 12 lists estimated incremental costs for each measure. Table 13 summarizes costs for two baseline ventilation approaches: individual exhaust fans with no makeup air, and central supply ventilation (common exhaust ducts or shafts) with no makeup air. The cost for a third approach, balanced ventilation using an HRV, is also provided.

As another alternative for balanced ventilation, the Statewide CASE Team estimated the cost for stand-alone ventilation supplied to the individual unit (see Figure 3), using RS Means, as follows:

- \$183 for ductwork, assuming 30 feet of 6-inch flex duct. This assumes for a 29-foot x 29-foot unit, with some bends in the ductwork,
- \$152 for the soffit.
- \$100 for a smoke damper,
- \$65 for a balancing damper,

This totals to \$500 for the ventilation component of a strategy that provides stand-alone ventilation at the individual dwelling unit level. The cost for the exhaust system in this strategy is not included in this estimate, since all multifamily units must have exhaust fans to meet the 62.2-2016 local exhaust requirements.

Table 12 uses the ERV cost for balanced ventilation, because interviews and the literature indicated that ERVs are currently a more common approach for providing balanced ventilation than stand-alone ventilation. In addition, an ERV could reduce costs for an exhaust system if used as part of a local exhaust strategy.

**Table 12: Summary of Estimated Incremental Costs for High Rise Multiple Family**

Product Type	Description	Material Cost / Unit	Additional Labor Cost / Unit <sup>a</sup>	Total Cost / Unit Including Markup	Unit
Whole house ventilation fan	Based on airflow calculated in accordance with ASHRAE 62.2-2016	\$5.87 single family (blended)	\$0	\$7.63	Each single family unit
Kitchen range hoods required to meet ASHRAE 62.2-2016 requirements <sup>a</sup>	HVI listed, at least one speed setting of $\leq 400$ cfm or less having a noise level of $\leq$ three sones <sup>1</sup>	Assume no incremental cost; Ample products available that meet requirement	\$0	\$0.00	Each single family or multifamily unit
MERV 13 return air filter & grille (single family, 400 cfm/ton)	MERV 13 or better rating per ASHRAE Standard 52.2 or having a particle size efficiency of $\geq 85\%$ in the 1.0 to 3.0- $\mu\text{m}$ range per AHRI Standard 680-2009	\$70 single family blended	Additional return required in some houses \$121(blended)	\$191	Each single family unit
Makeup Air Vent <sup>b</sup>	Based on a generic passive through-wall outdoor air inlet (cost estimated by interviewee)	Included in total cost	Included in total cost	\$200	Each HRMF unit

<b>Product Type</b>	<b>Description</b>	<b>Material Cost / Unit</b>	<b>Additional Labor Cost / Unit<sup>a</sup></b>	<b>Total Cost / Unit Including Markup</b>	<b>Unit</b>
Constant airflow regulator <sup>b</sup>	Based on Aldes CAR 4" MR Modulo Adjustable Flow Regulator, 10-50 CFM	\$41	One hour	\$97	Each HRMF unit
Exhaust shaft sealing <sup>b</sup>	Sealing using typical means employed for gypboard or ducts	Nominal	Four hours more than standard practice for sealing, plus four hours for testing leakage	\$306	Each exhaust shaft (assume one per building)
Sealing of unit enclosure <sup>b</sup>	Sealing exterior and partition walls using similar techniques used for exterior walls	\$10	\$0.31 per ft <sup>2</sup> of conditioned floor area	\$270	Each multifamily unit
HERS verification of compartmentalization	Blower door test to confirm unit has been sealed to 0.3 cfm50/sf of enclosure area	Nominal	\$20/unit	\$20	Each multifamily unit
Compact HRV <sup>b</sup>	HRV for multifamily units where balanced ventilation is selected	\$507	Two hours	\$945	Each unit
Compact HRV with MERV 13 filter	HRV for HRMF units requiring balanced ventilation and MERV 13 filtration	\$1,195	Three hours	\$1,600	Each HRMF unit

- a. Addendum p to ASHRAE 62.2-2013 listed in ASHRAE 62.2-2016 clarifies that occupants that have typical sized range hoods (i.e., those with at least one speed setting 400 cfm) will have at least one speed setting rated 3 sones.
- b. Not required, but can be used as a ventilation strategy for single family homes, or for low-rise or multifamily units.



**Table 13: Estimated Incremental Costs for Proposed Measures for Each New Construction Prototype**

Measure	Single Family	Low-Rise Multifamily	High-Rise Multifamily (per unit <sup>a</sup> )		
			Exhaust Ventilation, Distributed	Exhaust Ventilation, Central	Balanced Ventilation
Exhaust Fan	\$8 <sup>b</sup>				
MERV 13 Filter & Grille for 2" Filter	\$191	\$15	\$78	\$78	\$78
Passive Makeup Air Vent			\$200	\$200	
Seal Partition Walls		\$270	\$270	\$270	\$270
HERS Verification of Compartmentalization		\$20	\$20	\$20	\$20
Constant Airflow Regulator				\$97	
Central Exhaust Sealing <sup>b</sup>				\$10	
Balanced with MERV 13					\$1,600 <sup>c</sup>
<b>TOTAL</b>	<b>\$199</b>	<b>\$305</b>	<b>\$568</b>	<b>\$675</b>	<b>\$1,968</b>

a. Per unit cost for 30 units.

b. Incremental cost for larger fan that meets 62.2-2016 ventilation rate requirement.

c. For an ERV with lower filtration, the cost is lower. For example, for a compact ERV (\$945), the total cost is \$1,313.

## 5.3 Lifetime Incremental Maintenance Costs

The incremental cost of annual filter replacement is not included in the cost estimating tables. If the frequency of filter replacement is the same for MERV 6 or 8 and MERV 13 filters, then the incremental cost of replacement (blended for the two prototypes) is estimated to be \$18.25 (not including labor or markups).

Because the proposed measures generally do not provide energy savings, lifecycle costs are not calculated and other maintenance costs are not reported. One advantage of central ventilation systems is that there are fewer fans to maintain, but as described above, there are many factors and cost tradeoffs involved in the decision of which system type to use.

## 5.4 Lifecycle Cost-Effectiveness

Individually, the proposed measures are not cost-effective, because they do not save energy; therefore, lifecycle cost-effectiveness is not reported. However, they are necessary for the maintenance of IAQ.

# 6. FIRST-YEAR STATEWIDE IMPACTS

## 6.1 Statewide Energy Savings and Lifecycle Energy Cost Savings

Statewide energy savings are not reported for this group of measures. Refer to other CASE Reports, which report on the net savings from energy-saving measures and energy costs related to increased ventilation rates.

## 6.2 Statewide Water Use Impacts

The proposed code change will not result in water savings.

## 6.3 Statewide Material Impacts

The proposed code change will not result in impacts to toxic materials or materials.

## 6.4 Other Non-Energy Impacts

Implementation of the proposed measures will result in significant improvements to IAQ for all dwelling units. In particular, indoor PM 2.5 will be reduced because of increased filtration requirements. While the Energy Commission has stated that indoor IAQ measures do not have to be cost-effective, various studies have found that reduced PM 2.5 leads to an increase in health outcomes (reduced mortality), and the resulting economic benefit of these health improvements outweigh the cost of the measures. For example, one study used modeling to estimate health benefits of different levels of filtration (including MERV 12 and MERV 14) on recirculation filters in single family homes for various U.S. cities (Zhao 2015). After accounting for the fractional runtime, for MERV 12 recirculation filters compared with MERV 5, the study estimated annual per-person benefits of \$10-\$200 for San Francisco and \$15-\$300 for Los Angeles. Recirculation filters in homes with exhaust-only systems produced lower benefits (\$10-\$25 for San Francisco, \$15-\$40 for Los Angeles), than homes with supply-only and central fan integrated systems (\$50-\$200 for San Francisco, \$75-\$300 for Los Angeles), because an exhaust-only strategy removes much of the PM 2.5 entering the home (thereby reducing PM 2.5 removal from recirculation filters). For an exhaust-only system, assuming 2.5 people per household based on census data, this translates into approximately \$25-\$63 per home for San Francisco and \$38-\$100 per home for Los Angeles. Another study (Fisk 2017) modeled the impact of using high efficiency particulate air (HEPA) filters in homes and found reduced mortality of 0.25 to 2.4 per 10,000 population, and that the economic benefits always exceeded costs (benefit to cost ratios ranging from 3.9 to 133). While this study assumed HEPA filters (essentially 100 percent efficient) and assumed a higher rate of operation (30 to 40 percent of the time) than may be found for air passing through recirculation filters in California homes, the results indicate that health outcomes could outweigh, or at least significantly offset, the additional costs of increased filtration. PM 2.5 reductions would also be seen in HRMF units that use MERV 13 filtration for outside air.

Reduction of indoor humidity due to increased ventilation will also lower the potential for mold accumulation and moisture damage to walls, and will reduce dust mite populations, which are known to cause allergic reactions.

For multifamily units, the requirement for compartmentalization will improve IAQ through reduced pollutant transfer. See section 2.2.1.2 for results of studies showing reduction of pollutant transfer after air sealing multifamily units.

## 7. PROPOSED REVISIONS TO CODE LANGUAGE

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The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2016 documents are marked with underlining (new language) and ~~striketroughs~~ (deletions).

## 7.1 Standards

### 7.1.1 Title 24, Part 2 (California Building Code)

#### SECTION 1203 – INTERIOR ENVIRONMENT

**1203.1:** Buildings shall be provided with natural ventilation in accordance with Section 1203.4, or mechanical ventilation in accordance with the California Mechanical Code. All occupancies defined as Group R-2 and R-3 under Sections 310.4 and 310.5 shall meet the ventilation requirements of Title 24, Part 6.

### 7.1.2 Title 24, Part 4 (California Mechanical Code)

#### SECTION 402 – VENTILATION AIR

**402.1.2 Dwelling.** Requirements for ventilation air rate for single family and multifamily dwellings, including high-rise, shall be in accordance with ~~this chapter or~~ the version of ASHRAE 62.2 that is referenced by Title 24, Part 6. Other provisions of Chapter 4 do not apply to these occupancy types.

#### CHAPTER 7 – COMBUSTION AIR

**701.4 Indoor Combustion Air.** The required volume of indoor air shall be determined in accordance with the method in Section 701.4.1 or Section 701.4.2, except that where the air infiltration rate is known to be less than 0.40 ACH (air change per hour), the method in Section 701.4.2 shall be used. The total required volume shall be the sum of the required volume calculated for appliances located within the space. Rooms communicating directly with the space in which the appliances are installed through openings not furnished with doors, and through combustion air openings sized and located in accordance with Section 701.5, are considered a part of the required volume. [NFPA 54:9 .3 .2] In new residential buildings or residential additions, the use of indoor air is prohibited for open combustion space conditioning, water heating and pool heating appliances.

**701.6 Outdoor Combustion Air.** Outdoor combustion air shall be provided through opening(s) to the outdoors in accordance with the methods in Section 701.6.1 or Section 701.6.2. Open combustion space conditioning, water heating and pool heating appliances in new construction residential buildings or residential additions shall be installed in accordance with the method in Section 701.6.3. The dimension of air openings shall be not less than 3 inches (76 mm). [NFPA 54:9.3.3]

...

**701.6.3 Residential New Construction and Additions – Combustion Air Separation from Conditioned Space.** Open combustion space conditioning, water heating and pool heating appliances in residential new construction and residential additions, shall be located outside the building envelope or in an enclosure that is isolated from conditioned space inside the building envelope. Such enclosures shall be sealed and insulated in accordance with the exterior envelope requirements of Title 24, Part 6. All access openings to the enclosure shall be fully gasketed. All openings to the enclosure shall be fully sealed and insulated in accordance with the requirements of Title 24, Part 6, appropriate for the building type. Combustion air ducts passing through conditioned spaces shall be insulated to a minimum of R-8.

**Exception to 701.6.3:** Direct vent appliances with both intakes and exhausts installed continuous to the outside.

## APPENDIX E – SUSTAINABLE PRACTICES

E 605.0 Indoor Air Quality for Residential Buildings.

E 605.1 General. Rooms or occupied spaces within single family homes, ~~and low-rise multifamily structures of three stories or less above grade, and high-rise multifamily structures~~ shall be designed to have ventilation (outdoor) air for occupants in accordance with ~~Section E 605.1.1 through Section E 605.1.3.2, or the applicable local code.~~ Title 24 Part 6, Section 150.0(o).

[Strike all other subsections under E 605]

### 7.1.3 Title 24, Part 6

#### SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

##### (b) Definitions.

**ASHRAE STANDARD 62.2** is the American Society of Heating, Refrigerating and Air-Conditioning Engineers document titled "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings," 2016~~0~~ (ANSI/ASHRAE Standard 62.2-2016~~0~~ with Addenda k, l, q, and s including ANSI/ASHRAE Addenda b, c, e, g, h, i and l to ANSI/ASHRAE 62.2-2010 published in the 2011 supplement, and ANSI/ASHRAE Addendum j to ANSI/ASHRAE Standard 62.2-2010 published in March, 2012, and ANSI/ASHRAE Addendum n to ANSI/ASHRAE Standard 62.2-2010 published in February, 2012 November, 2016).

#### SECTION 120.1 – REQUIREMENTS FOR VENTILATION

Nonresidential, ~~high-rise residential,~~ and hotel/motel buildings shall comply with the requirements of ~~Section 120.1(a) through 120.1(e)~~ this section and the California Building Code.

##### (a) General Requirements.

1. All enclosed spaces in a building shall be ventilated in accordance with the requirements of this section and the California Building Code.

**EXCEPTION 1 to Section 120.1(a)1:** Refrigerated warehouses and other spaces or buildings that are not normally used for human occupancy and work.

**EXCEPTION 2 to Section 120.1(a)1:** Mechanical ventilation for all residential buildings, including those defined as Group R-2 and R-3 occupancies under California Building Code Part 2, Volume 1, Sections 310.4 and 310.5 will be provided as specified by Section 150.0(o).

**EXCEPTION to Section 120.1(b)1A:** ~~Naturally ventilated spaces in high-rise residential dwelling units and hotel/motel guest rooms shall be open to and within 25 feet of operable wall or roof openings to the outdoors.~~

**120.1(b)3: Central exhaust shafts and ducts.** Central exhaust shafts and ducts in high-rise multifamily buildings shall meet the following requirements, which shall be confirmed by field verification:

A. Shaft and/or ducts and branches shall be sealed to ten percent or less of the measured fan airflow of the powered rooftop ventilator.

B. Airflow exhausted from individual units shall be balanced to within ten percent of design airflow.

**Table 120.1-A: Minimum ventilation rates:**

TYPE OF USE	CFM PER SQUARE FOOT OF CONDITIONED FLOOR AREA
Auto repair workshops	1.50
Barber shops	0.40
Bars, cocktail lounges, and casinos	0.20
Beauty shops	0.40
Coin-operated dry cleaning	0.30
Commercial dry cleaning	0.45
High-rise residential	Ventilation Rates Specified by <del>the</del> <u>CBC Section 150.0(o)</u>
Hotel guest rooms (less than 500 ft <sup>2</sup> )	30 cfm/guest room
Hotel guest rooms (500 ft <sup>2</sup> or greater)	0.15
Retail stores	0.20
All others	0.15

#### **SECTION 120.4 – REQUIREMENTS FOR AIR DISTRIBUTION SYSTEM DUCTS AND PLENUMS**

**EXCEPTION to 120.4:** Central exhaust shafts in high-rise multifamily buildings shall comply with the applicable requirements of Section 120.4, except that they must be sealed to ten percent or less leakage of measured fan airflow of the powered roof ventilator, as measured in accordance with NA2.1.4.2.

#### **SECTION 120.5 – REQUIRED NONRESIDENTIAL MECHANICAL SYSTEM ACCEPTANCE**

**120.5(a): 18.** Filters for high-rise multifamily mechanical systems shall meet the requirements of 150.0(m)12B.

#### **SECTION 150.0 – MANDATORY FEATURES AND DEVICES**

##### **(e) Installation of Fireplaces, Decorative Gas Appliances and Gas Logs**

1. If a masonry or factory-built fireplace is installed, it shall have the following:
  - A. Closeable metal or glass doors covering the entire opening of the firebox; and
  - B. A combustion air intake to draw air from the outside of the building, which is at least 6 square inches in area and is equipped with a readily accessible, operable, and tight-fitting damper or combustion-air control device; and

~~**EXCEPTION to Section 150.0(e)1B:** An outside combustion air intake is not required if the fireplace will be installed over concrete slab flooring and the fireplace will not be located on an exterior wall.~~

##### **(h) Space-Conditioning Equipment.**

...

**5. Combustion air.** Open combustion fuel burning equipment shall be located outside of the conditioned building envelope, or enclosed in an unconditioned room isolated from conditioned spaces by an envelope that meets the exterior envelope requirements of Section 150.1(c). The door into the isolated room shall be fully gasketed. The combustion air ducts shall meet the combustion air requirements of the CMC and combustion air ducts passing through conditioned spaces shall be insulated to a minimum of R-8.

**EXCEPTION to Section 150.0(h)5:** Direct vent appliances with both intakes and exhausts installed continuous to the outside.

(m) **Air-Distribution and Ventilation System Ducts, Plenums, and Fans.**

...

**12. Air Filtration.** Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length and through a thermal conditioning component, except evaporative coolers, shall be provided with air filter devices in accordance with the following:

...

**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~~ 13 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 85 percent in the ~~3.0-10~~ 1.0-3.0  $\mu\text{m}$  range when tested in accordance with AHRI Standard 680-2009. (Note: This is a modification of ASHRAE 62.2-2016 which requires MERV 6 or greater.)

...

**150.0(m)14: Air Filter Media Efficiency for Outdoor Air.** Air filter media used with outdoor air ventilation systems shall comply with the MERV ratings listed in Table 150.0-A. The AHRI Standard 680 equivalent to MERV 8 is 70 percent in the 3.0 to 10.0  $\mu\text{m}$  range. [Note that tables following Table 150.0-A must be re-numbered].

**TABLE 150.0-A FILTER MEDIA REQUIREMENTS FOR OUTDOOR AIR VENTILATION SYSTEMS**

Unit Type and Ventilation Strategy	>500 ft of Busy Roadway (AADT $\geq$ 100,000)	$\leq$ 500 ft of Busy Roadway (AADT<100,000)
<i>Single Family and Low-rise Multifamily</i>		
Exhaust-only	NR	NR
Supply only	8	13
Balanced	8	8
<i>High-rise Multifamily</i>		
Exhaust-only with passive vents	NR	NR
Supply only with relieve vent	8	13
Balanced	8	13

Note: AADT is annual average daily traffic

(n) **Water Heating System.**

...

**5. Combustion air.** Open combustion fuel burning equipment shall be located outside of the conditioned building envelope, or enclosed in an unconditioned room isolated from conditioned spaces by an envelope that meets the exterior envelope requirements of Section 150.1(c). The door into the isolated room shall be fully gasketed. The combustion air ducts shall meet the combustion air requirements of the CMC and combustion air ducts passing through conditioned spaces shall be insulated to a minimum of R-8.

**EXCEPTION to Section 150.0(n)5:** Direct vent appliances with both intakes and exhausts installed continuous to the outside.

**150.0(o): Ventilation for Indoor Air Quality.** All dwelling units shall meet the requirements of the currently referenced version of ASHRAE Standard 62.2, with the following modifications and additional requirements specified in this section. ~~Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings.~~

**150.0(o) 1. Infiltration Rate Adjustment to Ventilation Rates.** For single family dwellings, if no blower door measurement is available the required mechanical ventilation rate shall be determined by

applying the ASHRAE Standard 62.2 calculation using an infiltration rate based on 2 ACH50. If a blower door measurement is completed and leakage is less than 2 ACH50, the measured leakage shall be used to determine the mechanical ventilation rate. If a blower door measurement is completed and exceeds 2 ACH50, then the 2 ACH50 assumption will be used to calculate the mechanical ventilation rate.

**150.0(o) 2. Central Fan System Ventilation.:** High rise multifamily units may use continuous operation of central forced air system air handlers in central fan integrated ventilation systems for meeting the whole-unit ventilation requirement, if they have variable speed fans and controls that vary the airflow rate as a function of load. These systems can be central to the dwelling unit or to the building.

**150.0(o)3. Ventilation Air Rates:** In meeting the dwelling unit ventilation rate,

$Q_{total} = 0.03 \times A + 7.5 \times (\text{number of bedrooms} + 1),$

where A = conditioned floor area (square feet).

For all multifamily units (low-rise and high-rise) except townhouses, infiltration cannot be used to meet  $Q_{total}$ , and units must follow Section A or B for meeting the whole dwelling ventilation rate. High-rise multifamily dwelling units within 500 feet of a busy roadway - defined as having annual average daily traffic (AADT) greater than 100,000 must follow B:

A. Passively provided supply air.

i. For units following this pathway, the total mechanical ventilation rate equals the total ventilation rate:  $Q_{fan} = Q_{total}$ .

ii. High-rise multifamily units must meet the following additional requirements:

- a. Supply air must be delivered through a dedicated inlet and coupled with mechanical exhaust - such as continuous or scheduled intermittent exhaust.
- b. Airflow to individual units served by central exhaust shafts shall be balanced to within 10 percent of design airflow using either constant air regulation devices, manual dampers, or orifice plates.
- c. Units must meet prescriptive compartmentalization requirements

OR

B. Provide mechanically driven, filtered supply air.

i. For balanced systems, the total mechanical ventilation rate must be at least 85 percent of the total ventilation rate:  $Q_{fan} = 0.85 \times Q_{total}$  from Equation 1.

ii. For supply-only systems, the total mechanical ventilation rate shall be  $Q_{total}$  from Equation 1.

iii. Supply air shall be passed through a filter meeting the requirements of Table 150.0-A.

#### **1. 4. Field Verification and Diagnostic Testing.**

**A. Airflow Performance:** The Whole-Building Ventilation airflow required by Section 4 of ASHRAE Standard 62.2-2016 shall be confirmed through field verification and diagnostic testing in accordance with the applicable procedures specified in Reference Residential Appendix RA3.7

**B. Kitchen Exhaust Ventilation.** An HVI-Certified kitchen hood or fan with a valid HVI label shall be installed in each kitchen to provide local mechanical exhaust ventilation to meet the requirements of Sections 5 and 7 of ASHRAE Standard 62.2-2016 and shall directly exhaust to the exterior of the building, which shall be confirmed by HERS verification.

**C. Compartmentalization in Multifamily Dwelling Units:** All new construction multifamily dwelling units must air seal the dwelling unit envelope, including partitions with interior and exterior areas, to a maximum leakage of 0.3 cfm per square foot of dwelling unit enclosure area, as confirmed through field verification and diagnostic testing in accordance with Reference Residential Appendix RA3.8.

(p) **Pool Systems and Equipment Installation.** Any residential pool system or equipment installed shall comply with the applicable requirements of Section 110.4, as well as the requirements listed in this section.

...

**5. Combustion air.** Open combustion fuel burning appliances shall be located outside of the conditioned building envelope, or enclosed in an unconditioned room isolated from conditioned spaces by an envelope that meets the exterior envelope requirements of Section 150.1(c). The door into the isolated room shall be fully gasketed. The combustion air ducts shall meet the combustion air requirements of the CMC and combustion air ducts passing through conditioned spaces shall be insulated to a minimum of R-8.

**EXCEPTION to Section 150.0(p)5:** Direct vent appliances with both intakes and exhausts installed continuous to the outside.

## **SECTION 150.2 – ENERGY EFFICIENCY STANDARDS FOR ADDITIONS AND ALTERATIONS TO EXISTING LOW-RISE RESIDENTIAL BUILDINGS**

(a) **Additions.** Additions to existing low-rise residential buildings shall meet the requirements of Sections 110.0 through 110.9, Sections 150.0(a) through (q), and either Section 150.2(a)1 or 2.

...

(b) **Alterations.** Alterations to existing low-rise residential buildings or alterations in conjunction with a change in building occupancy to a low-rise residential occupancy shall meet either Item 1 or 2 below.

1. **Prescriptive approach.** The altered component and any newly installed equipment serving the alteration shall meet the applicable requirements of Sections 110.0 through 110.9 and all applicable requirements of Section 150.0(a) through (m), Section 150.0(o) through (q); and...

2. **Performance approach.** This performance approach shall only be used for projects that include tradeoffs between two or more altered components that are listed in TABLE 150.2-C.

**NOTE:** The altered components may be components of the same type, such as a tradeoff between two windows, or components of differing types, such as a tradeoff between a window and an amount of attic insulation.

A. The altered components shall meet the applicable requirements of Sections 110.0 through 110.9 and Section 150.0(a) through (q); and ...

...

**EXCEPTION 4 to Section 150.2(b): Combustion Air.** The requirements of Section 150.0(h)5, 150.0(n)5, and 150.0(p)5 are not applicable to Section 150.2(b).



## 7.2 Reference Appendices

### 7.2.1 JOINT APPENDIX 1 – GLOSSARY

**ASHRAE STANDARD 62.2** is the American Society of Heating, Refrigerating and Air-Conditioning Engineers document titled "Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings," 2016~~0~~ (ANSI/ASHRAE Standard 62.2-2016~~0~~ with Addenda k, l, q, and s ~~including~~ ANSI/ASHRAE Addenda b, c, e, g, h, i and l to ANSI/ASHRAE 62.2-2010 published in the 2011 supplement, and ANSI/ASHRAE Addendum j to ANSI/ASHRAE Standard 62.2-2010 published in March, 2012, and ANSI/ASHRAE Addendum n to ANSI/ASHRAE Standard 62.2-2010 published in February, 2012 November, 2016).

**HVI** is the Home Ventilating Institute.

**HVI-Certified product** is a home ventilation product, which has been tested and certified by HVI in accordance with HVI Publication 920, is labelled in accordance with HVI Publication 925, and is listed in HVI Publication 911.

**HVI Publication 911** is the HVI document titled "Certified Home Ventilating Products Directory", which is a directory of residential ventilation products updated monthly by HVI. All models listed in HVI Publication 911 have been tested according to HVI procedures and have been found to qualify based on the requirements of HVI Publication 920.

**HVI Publication 920** is the HVI document titled "Product Performance Certification Procedure Including Verification and Challenge," which provides product testing, certification, and challenge procedures and the use of labels for HCI-Certified home ventilating products.

**HVI Publication 925** is the HVI document titled "Label and Logo Requirements," which identifies labels and specifies appropriate uses and placements of labels for HVI-Certified home ventilating products.

### 7.2.2 RESIDENTIAL APPENDIX 2 – RESIDENTIAL HERS VERIFICATION, TESTING, AND DOCUMENTATION PROCEDURES

**Table RA2-1 - Summary of Measures Requiring Field Verification and Diagnostic Testing**

Measure Title	Description	Procedure(s)
Continuous Whole-Building Mechanical Ventilation Airflow	Measurement of whole-building mechanical ventilation is mandatory for newly constructed buildings.	RA3.7.4.1
Intermittent Whole-Building Mechanical Ventilation Airflow	Measurement of whole-building mechanical ventilation is mandatory for newly constructed buildings.	RA3.7.4.2
<u>Kitchen Exhaust Verification</u>	<u>Verifying compliance of kitchen exhaust hoods and fans with the local exhaust requirements of ASHRAE Standard 62.2.</u>	<u>RA3.7.4.3</u>
<u>Blower Door Test in Multifamily Units</u>	<u>Verifying compliance with compartmentalization requirement in multifamily dwelling units</u>	<u>RA3.8 for procedure, RA2.6.3 for sampling</u>

**RA2.3.1.2 Documentation Registration:** For all low-rise and high-rise residential buildings for which compliance requires HERS field verification, all compliance documentation (Certificate of Compliance, Certificate of Installation, and Certificate of Verification) required for the dwelling unit shall be submitted for registration and retention to a HERS Provider data registry.

### 7.2.3 RESIDENTIAL APPENDIX 3 – RESIDENTIAL FIELD VERIFICATION AND DIAGNOSTIC TEST PROTOCOLS

**Table RA3.7-1 - Summary of Verification and Diagnostic Procedures**

Diagnostic	Description	Procedure
Whole-Building Mechanical Ventilation Airflow – Continuous Operation	Verify that whole-building ventilation system complies with the airflow rate required by ASHRAE Standard 62.2.	RA3.7.4.1 <del>Continuous Operation</del>
Whole-Building Mechanical Ventilation Airflow – Intermittent Operation	Verify that whole-building ventilation system complies with the airflow rate required by ASHRAE Standard 62.2.	RA3.7.4.2. <del>Intermittent Operation</del>
<u>Blower Door Test Procedure in Multifamily</u>	<u>Procedure for conducting blower door test in multifamily units to demonstrate compliance with compartmentalization requirement</u>	<u>RA3.8 for procedure, RA2.6.3 for sampling</u>
<u>Kitchen Exhaust Verification</u>	<u>Verify that kitchen exhaust complies with the requirements of ASHRAE Standard 62.2.</u>	<u>RA3.7.4.3</u>

#### **RA3.7.4.3 Kitchen Exhaust Fan Verification:**

Visual inspection of the kitchen exhaust hood or fan used to meet the local exhaust requirements of 100 cfm shall verify the presence of a label on the exhaust hood or fan indicating that it is an HVI-Certified product. The manufacturer name and model number from the label will be used to look up the unit in HVI Publication 911. Data from this listing will be used to determine whether the fan or hood meets the minimum airflow rate of 100 cfm and maximum sound level of three (3) sones. If the listed airflow is less than required, the kitchen exhaust does not comply, and corrective action shall be taken. If the listed noise level rate is equal to or less than the value required by Section 7 of ASHRAE Standard 62.2, the kitchen exhaust ventilation complies with the requirement for kitchen exhaust ventilation airflow. If the listed noise level is greater than required, the kitchen exhaust does not comply, and corrective action shall be taken.

#### **RA3.7.4.4 Procedures for Verifying Ventilation Airflow Rates in High-rise Multifamily Buildings**

The Executive Director may approve exhaust, supply, and balanced mechanical ventilation systems, devices, or controls for use for compliance with the HERS Rater field verification and diagnostic testing requirement for mechanical ventilation airflow in high-rise multifamily buildings, subject to a manufacturer providing sufficient evidence to the Executive Director that the installed mechanical ventilation systems, devices, or controls will provide at least the minimum whole-building ventilation

airflow required by ASHRAE Standard 62.2, and subject to consideration of the manufacturer's proposed field verification and diagnostic test protocol for these ventilation system(s).

Approved systems, devices, or controls, and field verification and diagnostic test protocols for all exhaust ventilation Systems Supply Ventilation Systems shall be listed in directories published by the Energy Commission.

## **7.2.4 NONRESIDENTIAL APPENDIX 2**

### **NA2.2.1 Purpose and Scope**

1. NA2.1 contains procedures for field verification and diagnostic testing for air leakage in single zone, constant volume, nonresidential air distribution systems serving zones with 5000 ft<sup>2</sup> of conditioned floor area or less as required by Standards section 140.4(1), as well as central exhaust shaft and duct systems that exhaust air from more than one unit in high-rise multifamily buildings.

### **NA2.1.4.2.1 Diagnostic Duct Leakage from Fan Pressurization of Ducts**

- (a) 4. When testing central exhaust shafts in multifamily buildings ensure that the shaft and ducts are sealed to allow leakage of not more than ten percent of the powered rooftop ventilator airflow.

## **7.3 ACM Reference Manual**

### **7.3.1 Residential ACM Reference Manual**

**Subsection 2.4.9:** The proposed regulations will substantially change the algorithms applied for calculation requirement minimum ventilation airflow rates. This section will be revised to include the calculation method for  $Q_{total}$ ,  $Q_{infil}$ , and  $Q_{fan}$  as described in Section 2.1 of this report.

### **7.3.2 Nonresidential ACM Reference Manual**

The proposed regulations will substantially change the algorithms applied for calculation requirement minimum ventilation airflow rates for HRMF buildings. Section 2.7 of the Nonresidential ACM Reference Manual will refer to the requirements of Section 150.0(o) the BEES.

## **7.4 Compliance Manuals**

Revisions will be made to Chapters 1, 2, 3, 4, and 9 of the Residential Compliance Manual as follows:

Section 1.5: Add high-rise multifamily buildings to the list of building types covered by ventilation standards.

Section 2.2.8: Add kitchen hoods and HRMF central exhaust shafts to the list of measures requiring field verification.

Section 2.5.1: Add kitchen hoods and multifamily IAQ measures (central exhaust shaft pressure test, exhaust balancing test, and makeup air vents) to the measures list for field verification.

Section 3.5.8.9: Clarify operable windows cannot be used to meet whole house ventilation requirements.

Section 3.6.1.17: Add paragraph describing method of determining mechanical ventilation rate.

Section 4.1.2: Add changes to 62.2 requirements to “What’s New” section.

Section 4.6: Update requirement for high efficiency filters from MERV 6 to MERV 13 where required (introduction and 4.6.6.8), revise reference to ASHRAE 62.2 and discuss high-rise residential applications, describe method for selecting mechanical ventilation rate (4.6.3.1), update section on intermittent ventilation (4.6.3.2), describe verification process for kitchen hoods (4.6.5), describe

requirements for makeup air and shaft sealing (4.6.6, 4.6.6.9), add to requirements for ventilation fans, including ENERGY STAR and humidity control requirements currently in Title 24, Part 11.

Section 9: Describe what triggers requirement for kitchen hood verification (9.4.2, 9.4.3).

Section 4.3 of the Nonresidential Manual will be modified to clarify that ventilation for indoor air quality for R-2 and R-3 occupancies is covered by the Residential Manual. Documents Forms.

## 7.5 Compliance Documents

The following documents will require revisions as follows:

- CF2R & CF3R-MCH-27 – Checklist items will be added for verification of ventilation in HRMF unit types, and a new section will be added for kitchen hood verification.
- Revisions to Nonresidential forms will be required for sealing of HRMF partition walls, and sealing and testing air tightness of central exhaust shafts.

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# Appendix A: STATEWIDE SAVINGS

## METHODOLOGY

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The projected new residential construction forecast that will be impacted by the proposed code change in 2020 is presented in Table 14.

Because IAQ measures are not intended to save energy, the Statewide CASE Team did not estimate statewide impacts, but did evaluate first year energy impacts for new single family and multifamily buildings that comply with the proposed 2019 Title 24, Part 6 Standards.

The Statewide CASE Team estimated statewide impacts for the first year that new single family and multifamily buildings comply with the 2019 Title 24, Part 6 Standards by multiplying per-unit savings estimates by statewide construction forecasts that the California Energy Commission Demand Analysis Office provided. The construction forecast from the Energy Commission presented annual new construction estimates for single family and multifamily dwelling units by forecast climate zones (FCZ). The Statewide CASE Team converted estimates from FCZ, which are not used for Title 24, Part 6, to building standards climate zones (BSCZ) using a conversion factors that the Energy Commission provided. The conversion factors, which are presented in Table 15, represent the percentage of dwelling units in a FCZ that are also in a BSCZ. For example, looking at the first column of conversion factors in see Table 15, 22.5 percent of the homes in FCZ 1 are also in BSCZ 1 and 0.1 percent of homes in FCZ 4 are in BSCZ 1. To convert from FCZ to BSCZ, the total forecasted construction in each FCZ was multiplied by the conversion factors for BSCZ 1, then all homes from all FCZs that are found to be in BSCZ 1 are summed to arrive at the total construction in BSCZ 1. This process was repeated for every climate zone. See Table 16 for an example calculation to convert from FCZ to BSCZ. In this example, BSCZ 1 is made up of homes from FCZs 1, 4, and 14.

After converting the statewide construction forecast to BSCZs, the Statewide CASE Team made assumptions about the percentage of buildings in each climate zone that will be impacted by the proposed code change. Assumptions are presented in Table 14.



**Table 14: Projected New Residential Construction Completed in 2020 by Climate Zone<sup>a</sup>**

Building Climate Zone	Single family Buildings					Multifamily Dwelling Units <sup>b</sup>				
	Total Buildings Completed in 2020	Percent of Total Construction in Climate Zone	Percent of New Buildings Impacted by Proposal	Buildings Impacted by Proposal	Percent of Total Impacted by Proposal in Climate Zone	Total Dwelling Units Completed in 2020	Percent of Total Construction in Climate Zone	Percent of New Dwelling Units Impacted by Proposal	Dwelling Units Impacted by Proposal	Percent of Total Impacted by Proposal in Climate Zone
1	465	0.6%	100%	465	0.6%	111	0.2%	100%	111	0.2%
2	3,090	2.4%	100%	3,090	2.4%	1,582	2.3%	100%	1582	3.3%
3	11,496	5.7%	100%	11,496	5.7%	8,432	11.7%	100%	8432	17.4%
4	7,435	5.4%	100%	7,435	5.4%	3,848	5.6%	100%	3848	7.9%
5	1,444	1.1%	100%	1,444	1.1%	747	1.1%	100%	747	1.5%
6	6,450	4.1%	100%	6,450	4.1%	3,379	9.9%	100%	3379	7.0%
7	5,779	5.5%	100%	5,779	5.5%	3,939	7.5%	0%	0	0.0%
8	9,948	6.1%	100%	9,948	6.1%	5,153	13.7%	100%	5153	10.6%
9	12,293	5.4%	100%	12,293	5.4%	10,350	18.5%	100%	10350	21.3%
10	18,399	17.2%	100%	18,399	17.2%	4,191	10.1%	100%	4191	8.6%
11	3,947	5.9%	100%	3,947	5.9%	747	1.8%	100%	747	1.5%
12	19,414	19.3%	100%	19,414	19.3%	6,023	8.4%	100%	6023	12.4%
13	7,034	12.0%	100%	7,034	12.0%	1,375	3.0%	100%	1375	2.8%
14	3,484	3.1%	100%	3,484	3.1%	756	1.8%	100%	756	1.6%
15	3,203	3.5%	100%	3,203	3.5%	454	1.5%	100%	454	0.9%
16	3,188	2.9%	100%	3,188	2.9%	1,441	3.0%	100%	1441	3.0%
<b>Total</b>	<b>117,069</b>	<b>100%</b>		<b>117,069</b>	<b>100%</b>	<b>52,528</b>	<b>100%</b>		<b>48,589</b>	<b>100%</b>

Source: Energy Commission Demand Analysis Office

- a. Statewide savings estimates do not include savings from mobile homes.
- b. Includes high-rise and low-rise multifamily construction.

**Table 15: Translation from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BsCZ)**

		Building Standards Climate Zone (BCZ)																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Total
Forecast Climate Zone (FCZ)	1	22.5%	20.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	9.8%	33.1%	0.2%	0.0%	0.0%	13.8%	100%
	2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.0%	75.7%	0.0%	0.0%	0.0%	2.3%	100%
	3	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	20.9%	22.8%	54.5%	0.0%	0.0%	1.8%	100%
	4	0.1%	13.7%	8.4%	46.0%	8.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	22.8%	0.0%	0.0%	0.0%	0.0%	100%
	5	0.0%	4.2%	89.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	6.6%	0.0%	0.0%	0.0%	0.0%	100%
	6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	100%
	7	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	75.8%	7.1%	0.0%	17.1%	100%
	8	0.0%	0.0%	0.0%	0.0%	0.0%	40.1%	0.0%	50.8%	8.7%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.5%	100%
	9	0.0%	0.0%	0.0%	0.0%	0.0%	6.4%	0.0%	26.9%	54.8%	0.0%	0.0%	0.0%	0.0%	6.1%	0.0%	5.8%	100%
	10	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	74.9%	0.0%	0.0%	0.0%	12.3%	7.9%	4.9%	100%
	11	0.0%	0.0%	0.0%	0.0%	0.0%	27.0%	0.0%	30.6%	42.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%
	12	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	4.2%	95.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	100%
	13	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	69.6%	0.0%	0.0%	28.8%	0.0%	0.0%	0.0%	1.6%	0.1%	0.0%	100%
	14	2.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	97.1%	100%
	15	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	99.9%	0.0%	100%
	16	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100%

**Table 16: Converting from Forecast Climate Zone (FCZ) to Building Standards Climate Zone (BSCZ) – Example Calculation**

<b>Climate Zone</b>	<b>Total Statewide Single Family Homes by FCZ [A]</b>	<b>Conversion Factor FCZ to BSCZ 1 [B]</b>	<b>Single Family Homes in BSCZ 1 [C] = A x B</b>
1	1,898	22.5%	427
2	8,148	0.0%	0
3	9,396	0.0%	0
4	16,153	0.1%	23
5	11,385	0.0%	0
6	6,040	0.0%	0
7	2,520	0.0%	0
8	12,132	0.0%	0
9	9,045	0.0%	0
10	21,372	0.0%	0
11	3,741	0.0%	0
12	4,746	0.0%	0
13	8,309	0.0%	0
14	518	2.9%	15
15	1,509	0.0%	0
16	159	0.0%	0
<b>Total</b>	<b>117,069</b>		<b>465</b>

# Appendix B: SUPPORTING INFORMATION FOR MULTIFAMILY VENTILATION MEASURES

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## Rationale for Areas Requiring HRMF Balanced Ventilation and MERV 13 Filtration

In identifying areas with high ambient PM 2.5, the Statewide CASE Team considered proximity to busy roadways, and PM 2.5 nonattainment zones, as classified by the Environmental Protection Agency (EPA). This section describes the rationale for the final recommendations for mechanically driven supply air and MERV 13 filtration for high-rise residential buildings within 500 feet of roadways with at least 100,000 annual average daily traffic (AADT), and in identifying areas with high ambient PM 2.5, the Statewide CASE Team considered proximity to busy roadways, and PM 2.5 nonattainment zones, as classified by the Environmental Protection Agency (EPA). This section describes the rationale for the final recommendations for mechanically driven supply air and MERV 13 filtration for high-rise residential buildings within 500 feet of roadways with at least 100,000 AADT.

### High-rise residential buildings within 500 feet of a busy roadway ( $\geq 100,000$ AADT)

Various studies show health effects in occupants living close to freeways. The San Francisco Indicator Project reported, “Epidemiologic studies have consistently found that proximity to high traffic density or flow results in reduced lung function and increased asthma hospitalizations, asthma symptoms, bronchitis symptoms, and medical visits. Children appear to be most sensitive to adverse effects. California freeway studies show exposure levels are strongest within 300 feet, and that there is a 70 percent drop off in particulate pollution levels after 500 feet.”<sup>30</sup> A 2017 Los Angeles Times article reported that people living within 500 feet of a freeway suffer higher rates of asthma, heart attacks, strokes, lung cancer, and pre-term births, citing long-term studies to support these health claims (Barboza 2017). Air quality researchers interviewed reported that the Air Resources Board recommends no residential development within 500 feet of a freeway. Several cities (including San Francisco and Los Angeles) have a requirement for MERV 13 filtration near freeways.

Based on these findings, the Statewide CASE Team recommends that mechanically driven supply air with MERV 13 filtration be required within 500 feet of a busy roadway. To define “busy roadway”, the Statewide CASE Team used the definition from San Francisco Article 38, which requires MERV 13 for residential buildings within 500 feet of roadways with at least 100,000 AADT for urban areas, and at least 50,000 AADT in rural areas. Because the Statewide CASE Team anticipates that almost all high-rise residential buildings will be developed in urban areas, we used the urban area minimum of 100,000 AADT. The Statewide CASE Team recommends that the Residential Compliance Manual provide a link to California Department of Transportation (CalDOT) websites showing AADT data.

### High-rise residential buildings in PM 2.5 nonattainment areas

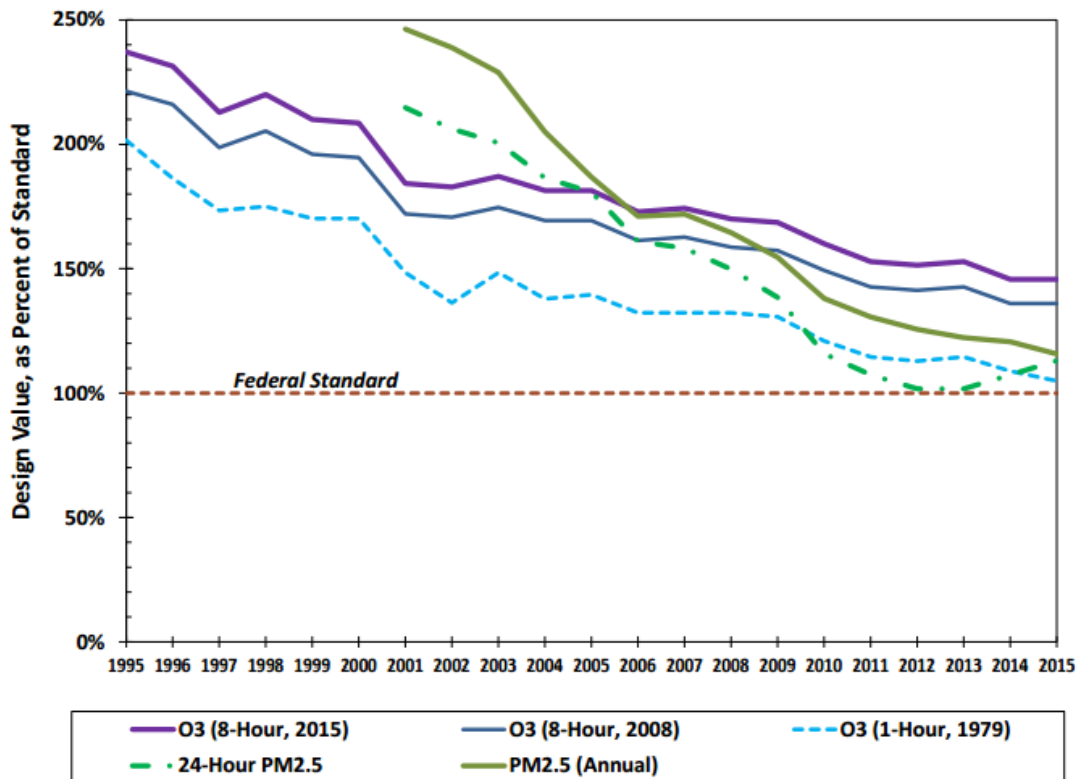
The EPA designates areas as in attainment or nonattainment with its ambient air quality standards. There are two PM 2.5 standards in effect:

1. An annual PM 2.5 standard implemented in 2012: 12  $\mu\text{g}/\text{m}^3$
2. A 24-hour PM 2.5 standard implemented in 2006: 35  $\mu\text{g}/\text{m}^3$

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<sup>30</sup> <http://www.sfindicatorproject.org/objectives/standards/55>

The SCAQMD Air Quality Management Plan predicts that the SCAQMD will be in attainment with the 24-hour standard in 2019, and with the annual standard by approximately 2023 (and no later than 2025) (SCAQMD 2016). One of the air quality specialists interviewed reported that attainment is not always reached as projected in the air quality management plans. However, as shown in Figure 6 SCAQMD measurements indicate that PM 2.5 levels are generally declining and are only slightly higher (~15-20 percent) than the PM 2.5 standards. The SCAQMD predicts that no actions will need to be taken to meet the PM 2.5 standards by the attainment years identified. The SCAQMD will need to take action to meet the ozone standards, and several of the ozone mitigation measures will also reduce PM 2.5 (SCAQMD 2016).



**Figure 6: SCAQMD Ozone design values in percentages of the federal standards**

Source: SCAQMD 2016

Table 17 shows areas of California in nonattainment with one or both of annual and 24-hour standards. This table also includes the EPA's population estimate for the nonattainment area, which the EPA provides based on 2010 populations. As shown in the table, half of the state is nonattainment with the annual standard, and approximately three-fourths of the state is listed as in nonattainment with the 24-hour standard. However, monitoring data for the Bay Area shows that it is in attainment, but the BAAQD must submit a redesignation request and maintenance plan to the EPA to be removed from the nonattainment list.<sup>31</sup> Similarly, although the EPA Greenbook lists Sacramento as a nonattainment area, Sacramento was determined in attainment with the 24-hour standard in 2013.<sup>32</sup>

<sup>31</sup> From footnote 10, on <http://www.baaqmd.gov/research-and-data/air-quality-standards-and-attainment-status>

<sup>32</sup> <https://www3.epa.gov/region9/air/actions/sacto/index.html>

PM 2.5 levels in the San Joaquin Valley have also been declining. Although the California Statewide Implementation Plan (SIP) calls out the San Joaquin Valley PM 2.5 exceedances as one of the greatest challenges for the State in meeting its EPA standards (Air Resources Board 2017), this region also has an attainment date of 2025 for the annual PM 2.5 standard. In summary, the results of Table 17, as well as the literature review indicate that PM 2.5 levels are generally in attainment for the Bay Area and Sacramento, and in nonattainment, but improving in the SCAQMD and the San Joaquin Valley.

It is important to note that requiring MERV 13 filtration on balanced and supply-only systems, while allowing exhaust-only ventilation, would likely further encourage the use of exhaust-only strategies. As shown in Table 6, there is a significant cost increase for ERVs with MERV 13 filtration (\$1,588) compared with ERVs with lower MERV (e.g., \$1,055 for Lunos, with MERV 10). The Statewide CASE Team believes that a requirement for MERV 13 filtration on outside air, without a prohibition of exhaust-only systems, will further encourage the use of exhaust-only ventilation strategies, because it is the much cheaper option. This could cause worse IAQ, because of reduced outdoor air delivery and increased pollutant transfer between units. In units with passive vents, such as many HRMF units, this could lead to significant introduction of PM2.5 in areas of high ambient PM2.5.

**Table 17: PM 2.5 Standards Attainment Status for California Regions**

	Annual (2012) PM 2.5 Std		24-hour (2006) PM 2.5 Std		
Area Description	Attainment Status	Population in Nonattainment Area (Millions)	Attainment Status	Population in Nonattainment Area (Millions)	Comment
Bay Area Air Quality Management District (BAAQMD)	Attainment	N/A	Nonattainment listing	7.0	Listed as nonattainment, but measurements show attainment.
Sacramento	Attainment	N/A	Nonattainment listing	2.2	Listed as nonattainment, but EPA determined in attainment in 2013.
South Coast Air Quality District (SCAQMD)	Nonattainment	15.7	Nonattainment	15.7	Projected to be in attainment with 24-hr std in 2019, and with annual std in 2025.
San Joaquin Valley	Nonattainment	2.9	Nonattainment	3.8	More counties in nonattainment with the 24-hour than annual standard. No attainment year found in literature reviewed.
Other Areas of CA	Generally Attainment	0.006	Generally Attainment	0.4	Part of Plumas County in nonattainment with Annual std, and parts of Chico and Imperial Counties in nonattainment with 24-hour std.
<b>Total Population in Nonattainment Area</b>		<b>18.6 (50% of CA total)</b>		<b>29.1 (78% of CA total)</b>	<b>Assumes 37 Million people in CA, based on U.S. Census data for 2010.</b>

Due to the challenges of providing mechanically driven supply air and MERV 13 filtration, including a high incremental cost, training of the building industry for proper design and construction, and the low availability of HRV products with MERV 13 filtration, the Statewide CASE Team proposes limiting the scope of this requirement to where outdoor PM 2.5 levels are most egregious.

- As described above, there is strong evidence that outdoor PM2.5 levels near busy roadways pose the greatest risk for ambient PM2.5, particularly beginning in the mid 2020's.
- While there is concern about PM2.5 penetration in low-rise multifamily units, the risk is lower for these units because the predominant ventilation strategy is exhaust-only with infiltration used as make-up air, rather than passive vents.

Consequently, the Statewide CASE Team proposes applying this requirement only to high-rise residential buildings of California within 500 feet of a busy roadway (defined above).

## **Development of 0.85 Factor for Balanced Multifamily Ventilation Rate**

This section describes the rates that were considered for developing the 0.85 factor for balanced ventilation for multifamily units.

Table 18 lists ventilation rates that are currently in use and have been proposed, as well as estimates of airflow through passive vents using an exhaust-only + passive vent strategy.

The Statewide CASE Team developed ventilation rates under different HRMF configurations (different areas and numbers of bedrooms) to develop, which compares the proposed rate for balanced ventilation systems with other rates. The 0.85 factor was designed to be significantly higher than the current and proposed rates with passive vents, and higher than the 62.2-2010 rates. Table 19 presents rates for example HRMF units under the current and proposed rates, with and without the 0.85 factor.



**Table 18: Description of Ventilation Rates in Past, Current, and Proposed Standards for High-Rise Multifamily Units**

Description of Rate	Rate Calculation
Proposed for balanced: 62.2-2016 x 0.85	Rate that is being proposed for HRMF units with balanced ventilation. This rate is higher than the estimated airflow rate through passive vents (36% of design) and higher than the previous rate for low-rise (62.2-2010), but lower than proposed rates for unbalanced systems (from 62-2016). The proposed rate for balanced of $0.85 \times [7.5 \times (BR+1) + 0.03 \text{ cfm/ft}^2 \times A]$ also results in similar rates in a proposed amendment to 62.2-2016, to change the ventilation rate for all dwelling units to $7.5 \text{ cfm} \times (BR + 1) + 0.022 \text{ cfm/ft}^2 \times A$ . The proposed amendment was supported by a majority of 62.2 members, but not the supermajority needed for publication and public review.
Current (from 62.1-2007)	Rate that HRMF units currently follow, based on 62.1-2007: $5 \text{ cfm} \times (BR + 1) + 0.06 \text{ cfm/ft}^2 \times A$ .
Proposed (62.2-2016)	Rate that is being proposed for HRMF units, to align with low-rise ventilation requirement: 62.2-2016: $7.5 \text{ cfm} \times (BR + 1) + 0.03 \text{ cfm/ft}^2 \times A$ .
Estimate of current (62.1-2007) rate through passive vents	Estimate of how much air actually enters passive vents under current rates (62.1-2007). Assumes 36% of design flowrate, based on the CARB finding that 13-36% of exhaust rates entered through the passive vents in well compartmentalized units.
Estimate of proposed (62.2-2016) rate through passive vents	Estimate of how much air actually enters passive vents under proposed rates (62.2-2016). Assumes 36% of design flowrate, based on the CARB finding that 13-36% of exhaust rates entered through the passive vents in well compartmentalized units.
62.2-2010 (previous rate for low-rise)	The old rate for low-rise multifamily units. 62.2-2010: $7.5 \text{ cfm} \times (BR + 1) + 0.01 \text{ cfm/ft}^2 \times A$ .

**Table 19: Ventilation Rates under Different Standards for Example HRMF Unit Configurations (cfm)**

<b>Bedrooms</b>	<b>Floor Area (ft<sup>2</sup>)</b>	<b>Proposed for Balanced: 62.2-2016 x 0.85</b>	<b>Current (from 62.1-2007)</b>	<b>Proposed for unbalanced (62.2-2016)</b>	<b>Estimate of Current (62.1-2007) Rate through Passive Vents</b>	<b>Estimate of Proposed (62.2-2016) Rate through Passive Vents</b>	<b>62.2-2010 (previous rate for low-rise)</b>
1	500	26	40	30	14	11	20
1	800	33	58	39	21	14	23
2	800	40	63	47	23	17	31
1	1,000	38	70	45	25	16	25
1	1,200	43	82	51	30	18	27
2	1,000	45	75	53	27	19	33
2	1,200	50	87	59	31	21	35
2	1,500	57	105	68	38	24	38
3	1,200	56	92	66	33	24	42
3	1,500	64	110	75	40	27	45

# Appendix C: DISCUSSION OF IMPACTS OF COMPLIANCE PROCESS ON MARKET ACTORS

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This section discusses how the recommended compliance process, which is described in Section 2.5, could impact various market actors. The Statewide CASE Team asked stakeholders for feedback on how the measure would impact various market actors during public stakeholder meetings that were held on September 27, 2016 and March 16, 2017. Notes from these meetings are provided at: <http://title24stakeholders.com/res-indoor-air-quality/>.

Key takeaways and questions from stakeholder meetings are detailed below. The CASE Report responds to the key issues raised.

## First Stakeholder Meeting

- Circular references in the California Mechanical Code and Title 24 need to be resolved to eliminate confusion.
- Fans designed to be used for whole house ventilation are turned off and switch labels are missing or easily removed.
- Concern about the impact of higher MERV filters on pressure drop, airflow, energy, cost, homeowner failure to replace, and minimal improvement of indoor air quality.

## Second Stakeholder Meeting

There was considerable discussion about increasing the filter MERV requirement for ducted thermal conditioning systems from 6 to 13, and strong opposition, primarily from HVAC contractors and the building industry, with comments such as:

- Filter grille sizes are already problematic with current standards. The standards must consider the cost of larger or additional return air grilles, and the cost of higher efficiency blowers, which may drive the cost beyond “cost-effective.”
- The HVAC industry is still struggling with current airflow/watt draw requirements with MERV 6 filters. What fan efficacy changes must be made to compensate for the higher static pressure of MERV 13 filters?
- People do not remember to change filters, the consequences of which will be aggravated by high MERV filters.
- Most people do not have health issues with current filtration. Allergy/asthma sufferers can use individual solutions that cost less.
- Thought the building shell was filtering outdoor air to the equivalent of MERV 13.
- If HVAC fan run time is only 6-15 percent of the year, how is filtration provided for the remainder of the time?
- Cannot MERV 6 filters be used on returns if outside air is separately filtered, and will not MERV 13 filters require more frequent replacement? Should adhere to 62.2 standards without revisions.
- If roadways are the problem let us address them, not all homes.
- Are there any studies that demonstrate the current impact 62.2-2010 has had on IAQ in residential new construction?

Representatives from the California Air Resources Board and Lawrence Berkeley National Laboratory responded with the following perspectives:

- Health impacts seen along busy roadways are cardiovascular and respiratory, leading to hospital admissions and death. Allergy problems are secondary.
- CARB does not consider the building shell to provide adequate removal of very fine particulates that are responsible for health impacts.
- Savings in health costs will likely exceed costs for better filters.
- The ongoing HENGH study led by Lawrence Berkeley National Laboratory will provide data on IAQ in newer homes.

Comments pertaining to HRMF buildings were as follows:

- How is compartmentalization verified or enforced?
- Providing a credit for balanced systems is appreciated.
- How do we know what the PM 2.5 levels are in outside air?
- Studies show that a small amount of air is admitted by passive vents. More research is needed.
- Passive air inlets have acoustic problems. Can they be used in buildings close to freeways?
- Do PM 2.5 levels change depending on the height of the building?
- Is there a method for verifying six percent leakage in large exhaust systems?
- Who tests the façade for leakage in HRMF buildings?
- For HRMF renovations, venting to the exterior is not always possible. What exceptions are there?

Comments relating to kitchen exhaust were fewer:

- At what fan speed does a kitchen exhaust fan need to meet the airflow and noise specifications (low, medium, high)?
- What about microwave exhaust hoods that do not meet the HVI sound certification?

In addition, telephone interviews were conducted with twenty-two subject matter experts including mechanical engineers, architects, energy analysts, modelers, raters, researchers, and manufacturers. A list is provided in Section 8. The results from feedback are interwoven into the report and referenced in Section 2.1.3.3.

Table 20 identifies the market actors who will play a role in complying with the proposed change, the tasks for which they will be responsible, their objectives in completing the tasks, how the proposed code change could impact their existing work flow, and ways negative impacts could be mitigated. To summarize, the proposed compliance process will affect the current compliance and enforcement process as follows:

- Assuming that there has been 100 percent compliance under current standards, the compliance process for the proposed measures will generally fit within the current work flow of market actors and, apart from new kitchen hood verification requirements and testing of exhaust shaft leakage for HRMF buildings, will not require additional tasks, but will require more attention to detail and additional time and materials for existing tasks.
- To ensure that MERV 13 filters do not result in lower HVAC performance, closer coordination between system designers and HVAC contractors will be necessary to ensure the designs are properly implemented and that “standard practice” is improved upon. Builders must also communicate to homebuyers the importance of filter maintenance.
- Depending on who is given the responsibility of HRMF verifications, (HERS Rater, ATT, or both) coordination will be required.
- Builders and subcontractors will require specialized training to acquaint them with procedures for sealing MFHR units to provide compartmentalization.
- All of the proposed measures will require additional resources, including labor and materials, to meet both existing requirements (as for kitchen hood performance) and newly proposed

measures, such as increased mechanical ventilation rates (larger fans) and higher efficiency filters.

- A new compliance document will be required to document verification of exhaust shaft sealing. Other proposed measures can probably be accommodated by changes to existing documentation.

**Table 20: Roles of Market Actors in the Proposed Compliance Process**

<b>Market Actor</b>	<b>Task(s) In Compliance Process</b>	<b>Objective(s) in Completing Compliance Tasks</b>	<b>How Proposed Code Change Could Impact Work Flow</b>	<b>Opportunities to Minimize Negative Impacts of Compliance Requirement</b>
Manufacturers & Distributors	<ul style="list-style-type: none"> <li>• Make available products that meet code requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Balance cost objectives and customer needs with code requirements</li> </ul>	<ul style="list-style-type: none"> <li>• Provides opportunities for expanding product offerings</li> </ul>	<ul style="list-style-type: none"> <li>• N/A</li> </ul>
Architect / Designer	<ul style="list-style-type: none"> <li>• Product specification (e.g., qualifying kitchen hoods)</li> <li>• Ensure design can accommodate new requirements (e.g., passive vents)</li> </ul>	<ul style="list-style-type: none"> <li>• Balances form/function to satisfy owner desires</li> <li>• Documentation prepared for permit submittal with minimal clarifications</li> <li>• Meet project budgets</li> </ul>	<ul style="list-style-type: none"> <li>• Increased detail and inclusion of code provisions in drawings</li> </ul>	<ul style="list-style-type: none"> <li>• Provide resources to designers on sizing of filter grilles, and for HRMF buildings methods for meeting makeup air requirements and information on PM 2.5 areas</li> </ul>
Title 24 Consultant	<ul style="list-style-type: none"> <li>• Provide feedback on the impact of energy measures on compliance</li> <li>• Ensure builder is aware of code requirements</li> <li>• Complete compliance documents &amp; upload to HERS registry</li> </ul>	<ul style="list-style-type: none"> <li>• Project team is aware of requirements with no surprises</li> <li>• IAQ goals are met</li> <li>• Minimal plan check comments</li> </ul>	<ul style="list-style-type: none"> <li>• No change to work flow</li> </ul>	<ul style="list-style-type: none"> <li>• Create awareness of ASHRAE 62.2-2016 impacts and leakage testing options</li> </ul>
Owner	<ul style="list-style-type: none"> <li>• Develop project goals including programming, schedules, &amp; budget</li> <li>• Little direct involvement</li> </ul>	<ul style="list-style-type: none"> <li>• Project completed to expected standards and within budget &amp; schedule</li> </ul>	<ul style="list-style-type: none"> <li>• No change to work flow</li> </ul>	<ul style="list-style-type: none"> <li>• Permanent labeling of whole house ventilation fan switches</li> <li>• Written instructions on filter maintenance</li> </ul>
Builder	<ul style="list-style-type: none"> <li>• Coordinate with design team &amp; trades</li> <li>• Ensure trades are aware of all requirements</li> <li>• Ensure proper product installation</li> <li>• Schedule inspections &amp; post forms onsite</li> </ul>	<ul style="list-style-type: none"> <li>• Owner satisfied and no warranty issues</li> <li>• Meet project budgets &amp; schedule</li> <li>• Minimal inspection failures</li> <li>• Minimal paperwork required</li> <li>• Owner satisfied and no warranty issues</li> </ul>	<ul style="list-style-type: none"> <li>• May require additional coordination time, especially for HRMF buildings</li> </ul>	<ul style="list-style-type: none"> <li>• Training for builders on proper installation and sealing techniques</li> <li>• Training on HRMF ventilation system requirements</li> </ul>

<b>Market Actor</b>	<b>Task(s) In Compliance Process</b>	<b>Objective(s) in Completing Compliance Tasks</b>	<b>How Proposed Code Change Could Impact Work Flow</b>	<b>Opportunities to Minimize Negative Impacts of Compliance Requirement</b>
Subcontractors (HVAC, drywall contractor, electrician)	<ul style="list-style-type: none"> <li>• Install products to meet requirements</li> <li>• Properly sized return air grilles</li> <li>• Properly sealed HRMF units &amp; shafts</li> </ul>	<ul style="list-style-type: none"> <li>• Meet builder's schedule</li> <li>• Finish within budget</li> <li>• Minimal inspection failures</li> <li>• Minimal paperwork required</li> </ul>	<ul style="list-style-type: none"> <li>• Account for extra time to install larger filter grilles</li> <li>• Account for time to seal for compartmentalization, and seal exhaust shafts</li> </ul>	<ul style="list-style-type: none"> <li>• Training on filter grille sizing</li> <li>• Training on sealing (HRMF)</li> </ul>
HERS/ATT Verifier	<ul style="list-style-type: none"> <li>• Review CFIR compliance documents for methods of complying with ventilation requirements</li> <li>• Complete verifications &amp; registry entries</li> </ul>	<ul style="list-style-type: none"> <li>• Verifications completed as required</li> </ul>	<ul style="list-style-type: none"> <li>• Additional time required to verify kitchen hoods</li> <li>• Additional time required to inspect sealing and test shafts (HRMF only)</li> </ul>	<ul style="list-style-type: none"> <li>• Online directory of complying kitchen hoods</li> <li>• Shaft leakage testing protocol and training</li> </ul>
Plans Examiner	<ul style="list-style-type: none"> <li>• Verify that CF-1R is consistent with building plans and meets compliance criteria for local jurisdiction</li> </ul>	<ul style="list-style-type: none"> <li>• Minimize amount of paperwork needed to review</li> </ul>	<ul style="list-style-type: none"> <li>• No change to work flow</li> </ul>	<ul style="list-style-type: none"> <li>• N/A</li> </ul>
Building Inspector	<ul style="list-style-type: none"> <li>• Verify code requirements are met</li> <li>• Verify that paperwork is complete &amp; CF documents are signed and certified</li> <li>• Sign occupancy permit</li> </ul>	<ul style="list-style-type: none"> <li>• Issue permit with minimal re-inspections</li> <li>• Minimal paperwork</li> </ul>	<ul style="list-style-type: none"> <li>• No change to work flow</li> </ul>	<ul style="list-style-type: none"> <li>• N/A</li> </ul>

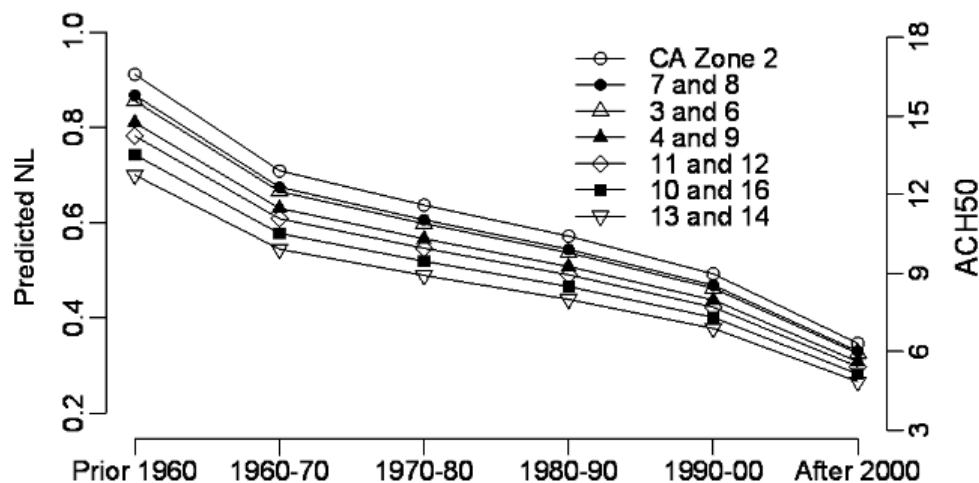
## Appendix D: SUPPORTING INFORMATION FOR COMBUSTION AIR PROPOSAL

Proposed code changes to Title 24 Part 6 for 2019 require significant increases to residential mechanical ventilation for the purposes of indoor air quality, including:

- Increase in mechanical ventilation by an average of 40%.
- Verification that kitchen hoods vent to outside and capable of exhausting at least 100 cfm.
- Under the 2016 Title 24, Part 6 cycle whole house fans became a prescriptive requirement in climate zones 8-14 – this is 69% of all projected new single family and 59% of new multifamily dwelling construction in 2020.

In addition, over time windows and doors are more airtight and with stucco being the most common form of wall construction, walls are also more airtight. Since 2005, ICAT (insulated ceiling air tight) recessed luminaires have been required when the luminaire projects into the ceiling cavity. All of these air tightening measures have resulted in more energy efficient homes. The figure below from the PIER/LBNL RESAVE study illustrates the reduced effective leakage areas in California homes over time. In comparison, the current rules for use of conditioned air for atmospheric combustion devices have been around for years and do not reflect current construction practice.

**Figure 2.1.1: Normalized Leakage (NL) of California Homes in Different Climate Zones, and as a Function of Year Built, Predicted Using the Regression Model.**



Thus, with tighter envelopes and increased ventilation, new homes have a greater potential for negative pressurization. Negative pressurization can lead to back-drafting of atmospheric combustion appliances installed within the building envelope. If back-drafting were to occur, this could pose significant risk to the health and safety of the occupants, potentially including:

- Introducing carbon monoxide and PM<sub>2.5</sub>, into the occupied space.
- Flame rollout from open combustion appliances, a fire risk.

These risks will exist so long as combustion air may be drawn from within the building envelope.

In addition to these safety considerations, having a hole in the building thermal envelope for combustion air and burning partially conditioned air (not all combustion air will come from outside, some of the air



will be drawn from the conditioned space) results in an energy penalty. The 2015 version of the IECC addressed this issue by prohibiting conditioned air from being used for combustion air as follows:

### **Residential Provisions**

**R402.4.4 Rooms containing fuel-burning appliances.** In Climate Zones 3 through 8, where open combustion air ducts provide combustion air to open combustion fuel burning appliances, the appliances and combustion air opening shall be located outside the building thermal envelope or enclosed in a room, isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table R402.1.2, where the walls, floors and ceilings shall meet not less than the basement wall *R*-value requirement. The door into the room shall be fully gasketed and any water lines and ducts in the room insulated in accordance with Section R403. The combustion air duct shall be insulated where it passes through conditioned space to a minimum of R-8.

#### **Exceptions:**

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Section R402.4.2 and Section R1006 of the *International Residential Code*.

### **Commercial Provisions**

**C402.5.3 Rooms containing fuel-burning appliances.** In *Climate Zones* 3 through 8, where open combustion air ducts provide combustion air to open combustion space conditioning fuel-burning appliances, the appliances and combustion air openings shall be located outside of the *building thermal envelope* or enclosed in a room isolated from inside the thermal envelope. Such rooms shall be sealed and insulated in accordance with the envelope requirements of Table C402.1.3 or C402.1.4, where the walls, floors and ceilings shall meet the minimum of the below-grade wall *R*-value requirement. The door into the room shall be fully gasketed, and any water lines and ducts in the room insulated in accordance with Section C403. The combustion air duct shall be insulated, where it passes through conditioned space, to a minimum of R-8.

#### **Exceptions:**

1. Direct vent appliances with both intake and exhaust pipes installed continuous to the outside.
2. Fireplaces and stoves complying with Sections 901 through 905 of the *International Mechanical Code*, and Section 2111.13 of the *International Building Code*.

A review of these requirements indicate that there are multiple configurations that make use of the full range of both direct vent and atmospheric combustion equipment while mitigating the energy and safety issues associated with using indoor air for combustion air. They include:

- Using atmospheric combustion devices outside of the conditioned envelope. This can be outdoors, in ventilated attics, or in garages.
- Using direct vented devices where outdoor air is vented directly into the sealed combustion device.
- Building a sealed and insulated "mechanical room" for atmospheric combustion devices inside conditioned space

Thus the Statewide CASE Team has recommended aligning the new construction combustion air requirements with the IECC, the national residential model energy code that is the metric of interest when states provide a determination to DOE of their progress on their energy code. This approach allows for the full range of combustion appliances being applied in a manner that is suitable for their handling of combustion air.

## ATTACHMENT 2: PUBLIC COMMENTS SUBMITTED BY THE STATEWIDE CASE TEAM

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Attachment 2 presents comments that the Statewide CASE Team submitted to the Energy Commission's docket that are relevant to this measure.

The docket posting on 2/21/2018 provides recommendations by the Statewide CASE Team based on results of filter testing:

<https://efiling.energy.ca.gov/GetDocument.aspx?tn=222628>

The docket posting on 3/5/2018 provided links to updated CASE Reports, including the February 2018 IAQ Final CASE Report containing Appendix E, which describes results of filter testing:

<https://efiling.energy.ca.gov/GetDocument.aspx?tn=222838>

The docket posting on 5/8/2018 (Section 2.4) recommended that equations referenced in ASHRAE Standard 62.2-2016 be replicated in the Title 24, Part 6:

<https://efiling.energy.ca.gov/GetDocument.aspx?tn=223381>

## DOCKETED

<b>Docket Number:</b>	17-BSTD-02
<b>Project Title:</b>	2019 Title 24, Part 6, Building Energy Efficiency Standards Rulemaking
<b>TN #:</b>	222628
<b>Document Title:</b>	Statewide Utility Codes and Standards Team Comments HVAC System Filter Requirements
<b>Description:</b>	N/A
<b>Filer:</b>	System
<b>Organization:</b>	Statewide Utility Codes and Standards Team
<b>Submitter Role:</b>	Public
<b>Submission Date:</b>	2/20/2018 10:11:13 PM
<b>Docketed Date:</b>	2/21/2018

*Comment Received From: Statewide Utility Codes and Standards Team*

*Submitted On: 2/20/2018*

*Docket Number: 17-BSTD-02*

## **HVAC System Filter Requirements**

*Additional submitted attachment is included below.*

# Comments on HVAC System Filter Requirements in 2019 Title 24, Part 6 45-Day Language

California Statewide Utility Codes and Standards Team

February 20, 2018

## 1. Introduction

The Statewide CASE Team appreciates the opportunity to participate in the rulemaking and the thoughtful feedback we have received from the California Energy Commission on the Codes and Standards Enhancement (CASE) proposals.

The CASE initiative presents recommendations to support the Energy Commission's efforts to update California's Building Energy Efficiency Standards (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. The four California Investor Owned Utilities – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and SoCalGas® – and two publicly Owned Utilities – Los Angeles Department of Water and Power, and Sacramento Municipal Utility District – sponsored this effort.

The California Statewide Utility Codes and Standards Team (Statewide CASE Team) actively supports the Energy Commission in developing revisions to Title 24, Part 6 by developing code change proposals that will result in feasible, enforceable, and cost-effective enhancements to the building energy efficiency standards. In developing these proposals, the Statewide CASE Team conducts research and market surveys, holds stakeholder meetings, and evaluates the energy savings and cost-effectiveness of considered measures. The CASE Reports, which present pertinent information that supports the code change proposals, are posted within each measure topic page on [title24stakeholders.com](http://title24stakeholders.com).

The Statewide CASE Team encourages the Energy Commission to consider the following changes to HVAC system filter requirements.

## 2. Summary

The 45-Day Language includes the mandatory requirement of MERV 13 filters. Stakeholders have expressed concerns about the pressure drop (resistance to air flow) of higher MERV filters. Tests were performed on a set of 24 inch by 24-inch filters to provide third-party verification data on the performance of filters with various MERV ratings in one and two-inch depths over a range of velocities for use by the Statewide CASE Team, the Energy Commission and stakeholders. The results show that acceptable pressure drops of less than 0.20 inch w.c. can be achieved by either one- or two-inch deep MERV 13 filters. No correlation was found between filter MERV ratings and pressure drop. One-inch and two-inch deep filters can have the same pressure drop at the same MERV rating, allowing either to be used. All filters have increasing pressure drop with increasing airflow. The full test report and results can be found in Appendix D to the Residential Indoor Air Quality CASE Report, dated February 2018, which is available here: <http://title24stakeholders.com/wp-content/uploads/2018/02/2019-T24-CASE-Report-Res-IAQ-Final-February-2018.pdf>.

### 3. Recommendations

The following modifications to the 45-Day Language are proposed:

1. Eliminate all mandatory requirements related to filter pressure drop and size, and rely on the verification of fan efficacy to ensure that all system components, not just filters, are properly designed and installed.
2. In Section 150.0(m)12Bii, prescribe a design maximum filter pressure drop of 0.15 inch w.c. and a maximum velocity of 225 feet per minute (fpm) instead of 150 fpm.
3. Reference the CALGreen mandatory measure for ACCA Manual D sizing in Part 6 Section 150(m)12 to reinforce the requirement.

### 4. Background

#### 4.1 Updates to Filter Requirements in 2019 Title 24, Part 6

To summarize the proposed 45-Day Language requirements: MERV 13 or equivalent filters must be used, and systems must include either:

- Two-inch deep filters per 150.0(m)12Biia
- One-inch deep filters with a verified face velocity of 150 fpm or less and a pressure drop less than 0.10 inch w.c. per 150.0(m)12Biib
- One-inch deep filters with a verified face velocity of not more than 151-176 fpm (depending on system size) and a pressure drop less than or equal to 0.10 inch w.c., and return ducts sized per Tables 150.0-B/C (resulting in 376 to 439 fpm duct velocity)

#### 4.2 Other Relevant Standards

Section 1607(d)(12) of the 2016 California Appliance Efficiency Regulations (Title 20) requires air filters to be labeled using the format below. The original effective date of July 1, 2016 was delayed until July 2019.

MERV	(µm) PSE	0.30-1.0	1.0-3.0	3.0-10	Airflow Rate (CFM)	[val 1]	[val 2]	[val 3]	[val 4]	[val 5]	*Max Rated Airflow
[value]	(%)	[value]	[value]	[value]	Initial Resistance (IWC)	[value]	[value]	[value]	[value]	[value]	

**Figure 1. Example of filter label in Title 20<sup>1</sup>**

The mandatory measures in the California Green Building Standards (Title 24, Part 11 or CALGreen) require that systems be sized in accordance with ACCA Manual D or equivalent methods (Division 4.5, 4.507.2). The Manual D process involves adding up the pressure losses from the cooling coil, filter, supply and return grilles, and other components, subtracting this sum from the manufacturer's listed external static pressure at the required airflow to obtain the available static pressure, and sizing the ducts so they do not exceed this available pressure. Unfortunately, this requirement is enforced by only a few building departments. A reasonably well-designed system might have the pressure drops shown in Table 1 below. As in this example, the total external pressure drop for the furnace or air handler is equal to the sum of the component pressure drops at the design airflow rate.

<sup>1</sup> 2016 Appliance Efficiency Regulations. California Energy Commission. January 2017. <http://www.energy.ca.gov/2017publications/CEC-400-2017-002/CEC-400-2017-002.pdf>

**Table 1: Typical Residential System Pressure Losses**

<b>Component</b>	<b>Pressure Drop (inch w.c.)</b>
Cooling Coil	0.25
Filter	0.15
Supply Grilles	0.03
Return Grilles	0.03
Ducts	0.24
Total PD	<b>0.70</b>
Design Furnace ESP	<b>0.70</b>

### 4.3 Stakeholder Issues

Through pre-rulemaking workshops and docket postings, stakeholders have expressed the following concerns:

- The ability of systems with MERV 13 filters to meet proposed lower efficacy requirements.<sup>2</sup>
- The challenges of installing larger filter grilles needed for MERV 13 filters due to space limitations and higher cost.<sup>3</sup>
- Filter size limitations with ceiling-mounted air handlers designed for multifamily systems, including the inability of air handlers to accommodate two-inch filters and filters with sufficient face area to meet the velocity limits.<sup>4</sup>

The CASE Team has also found that while there is an ample selection of one-inch MERV 13 filters available in retail stores, no walk-in stores currently offer two-inch filters and they must be ordered through the store, or purchased online, typically in full box quantities.

### 4.4 Goals of Testing

The Title 20 requirement for filter labeling will not become effective until July 2019. There is limited data available on filter pressure drop characteristics. The CASE Team identified only one manufacturer, 3M Filtrete, that provides labels that meet the forthcoming requirement. Testing was initiated to develop pressure drop data on un-labeled filters, and as a verification of data provided in filter labels. The results can be used to determine whether the difference in pressure drop between one and two-inch deep filters is significant enough to justify making two-inch deep filters mandatory, to verify manufacturer ratings, and to assess whether stakeholder concerns about filter pressure drop requirements are supported by test data.

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<sup>2</sup> Meeting notes. 2019 Title 24 Part 6 Code Development Cycle Utility-Sponsored Stakeholder Meeting for Residential HVAC, Residential Indoor Air Quality (IAQ) and Nonresidential IAQ Measures. September 27, 2016. [http://title24stakeholders.com/wp-content/uploads/2016/12/2019T24-Utility-Stkhldr-Mtg-Notes\\_Res-HVAC-and-All-IAQ-final.pdf](http://title24stakeholders.com/wp-content/uploads/2016/12/2019T24-Utility-Stkhldr-Mtg-Notes_Res-HVAC-and-All-IAQ-final.pdf)

<sup>3</sup> Meeting notes. 2019 Title 24 Part 6 Code Development Cycle Utility-Sponsored Stakeholder Meeting for Residential and Nonresidential Indoor Air Quality. March 16, 2017. [http://title24stakeholders.com/wp-content/uploads/2017/07/2019-Utility-Sponsored-Stakeholder-Notes\\_IAQ\\_7.12.17.pdf](http://title24stakeholders.com/wp-content/uploads/2017/07/2019-Utility-Sponsored-Stakeholder-Notes_IAQ_7.12.17.pdf)

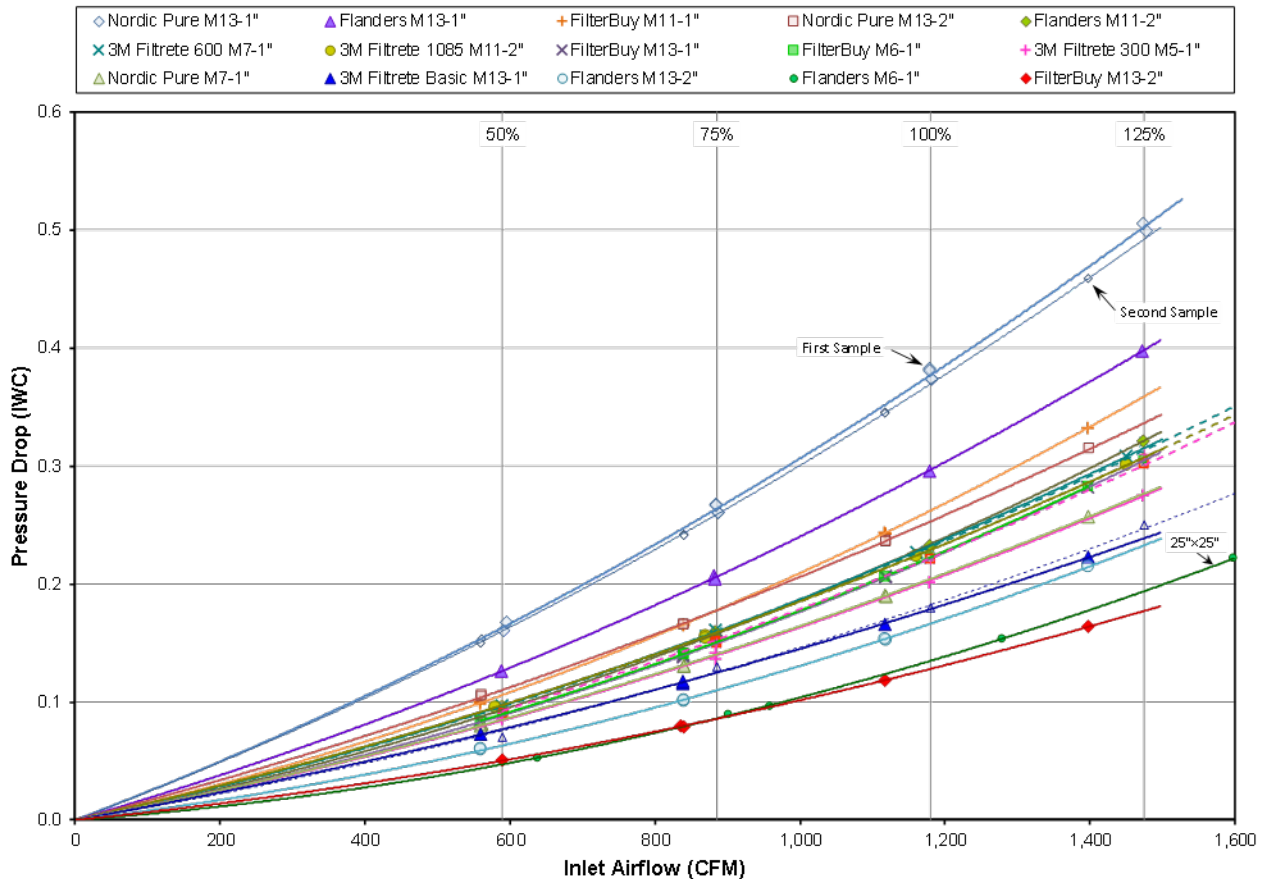
<sup>4</sup> California Building Industry Association Comments on Draft 2019 Building Energy Efficiency Standards. Docket number: 17-BSTD-01. October 13, 2017. [http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221506\\_20171013T163502\\_Robert\\_Raymer\\_PE\\_Comments\\_Draft\\_2019\\_Building\\_Energy\\_Efficiency.pdf](http://docketpublic.energy.ca.gov/PublicDocuments/17-BSTD-01/TN221506_20171013T163502_Robert_Raymer_PE_Comments_Draft_2019_Building_Energy_Efficiency.pdf)

## 5. Test Results

### 5.1 Pressure Drop vs. Airflow & Velocity

Figure 4 graphs the performance of all filters tested. The legend indicates the MERV rating and the filter depth (e.g., M13-2" is a two-inch deep MERV 13 filter).

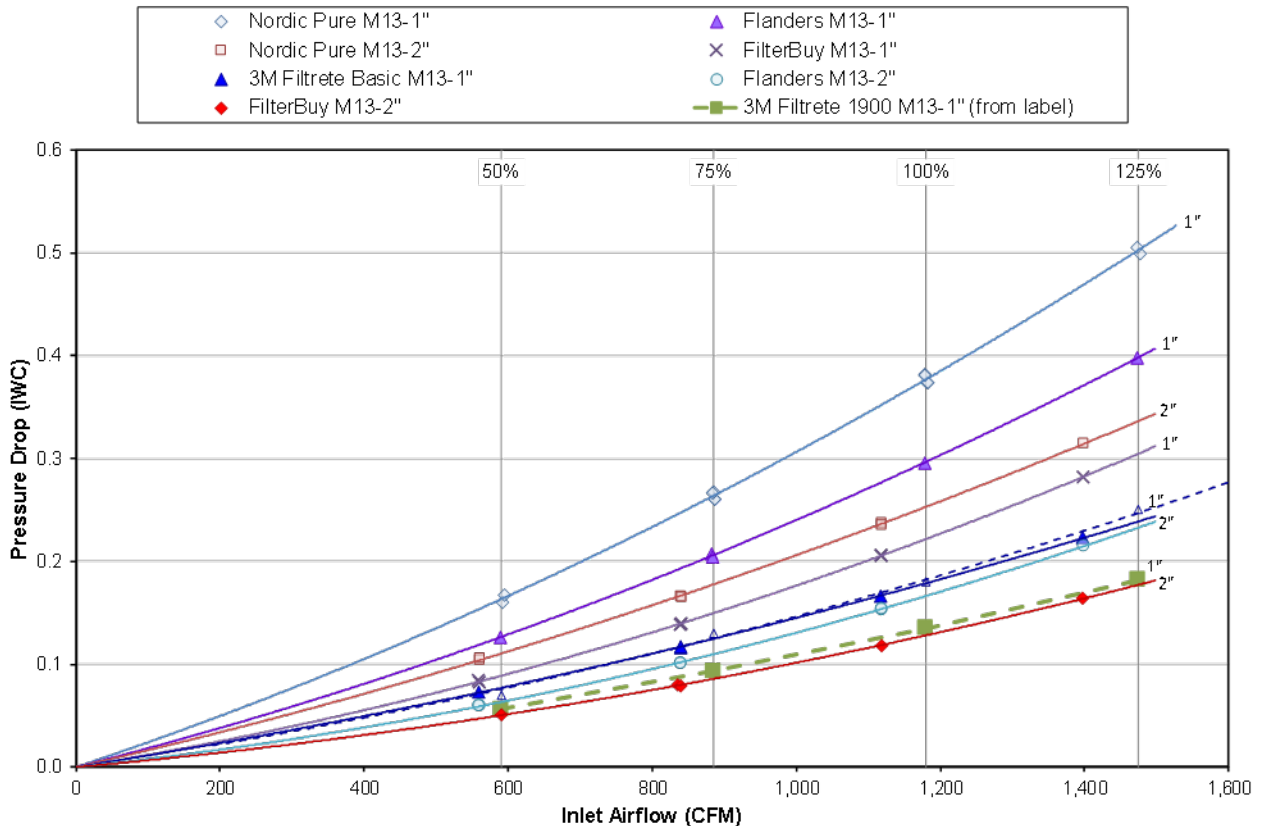
The dotted lines are plots of manufacturer performance data and show reasonably good alignment with ATS lab test results. Tests of two Nordic Pure MERV 13 filters were completed with similar results. As with Table 2, the plot shows there is no direct correlation of MERV rating to pressure drop performance. For example, the MERV 7 Filtrete 700 curve is above the MERV 13 Filtrete Basic.



**Figure 2: Pressure drop versus airflow for all filters tested**

Figure 5 shows only the curves for MERV 13 filters. The MERV 13 Filtrete Basic filter tested is not one that is commonly available in retail stores, but can be ordered and has a lower price than the commonly available Filtrete 1900. For comparison, a curve fit of the label data from a Filtrete 1900 was included in the Figure 5 plot, which appears as the green dotted line. The curves in Figure 5 are also labeled to indicate the filter depth.





**Figure 3: Pressure drop versus airflow for only the MERV 13 rated filters**

## 5.2 Relevance of Test Results to Proposed Title 24, Part 6 Standards

In response to stakeholder concerns regarding the difficulty complying with lower efficacy requirements, referring to Table 1, if filter pressure drop is kept at or below 0.15 inch w.c., then a total external static pressure of 0.7 inch w.c. should be easily achieved. Referring to Figure 3, five of the eight MERV 13 filters tested are at or below 0.15 inch w.c. at a velocity of about 225 fpm. From prior ATS testing of furnaces and heat pumps, it was learned that they can comply with a 0.45 W/cfm standard at or below external static pressures of 0.7 inches w.c.<sup>5</sup> Thus, if designers and contractors comply with the CALGreen mandatory requirement for system sizing using Manual D or other methods, then this concern can be dismissed.

Regarding the perception that larger filter grilles will be needed for MERV 13 filters, Figure 2 clearly shows that filter pressure drop does not correlate to MERV rating, and that if filters are selected carefully using labelled pressure drop data, implementers should not encounter this problem.

The 45-Day Language proposed requirements for either providing a two-inch deep filter or maintaining a filter velocity of 150 fpm or less is not necessary and could be a hardship on the HVAC industry,

<sup>5</sup> See Appendix D of the Residential Quality HVAC Measures – Final CASE Report. CASE Revised December 2017, which is available here: [http://title24stakeholders.com/wp-content/uploads/2017/12/2019-T24-CASE-Report\\_Res-Quality-HVAC\\_Final\\_December-2017.pdf](http://title24stakeholders.com/wp-content/uploads/2017/12/2019-T24-CASE-Report_Res-Quality-HVAC_Final_December-2017.pdf).

especially for ceiling-mounted air handlers used in multifamily installations. Filter slots for many of these ceiling units are not designed for filters deeper than one inch and many, to conserve space, incorporate return air grilles in the air handler box rather than using ducted returns. Again, referring to Figure 3, all but three of the MERV 13 filters would meet the requirement for a pressure drop not to exceed 0.15 inch w.c. at a velocity of 225 fpm (or 900 cfm for the 24-inch by 24-inch filter size), so if they can meet the velocity limits then they could also meet the 0.15 inch w.c. pressure drop requirement in 150.0(m)12Biib.

Of the five filters shown in Figure 5 that fall at or below 0.15 inch w.c. static pressure at 225 fpm, three are one inch deep. This result does not support the requirement for two-inch filters, or the more rigorous requirements proposed for one-inch deep filters.

## DOCKETED

<b>Docket Number:</b>	17-BSTD-02
<b>Project Title:</b>	2019 Title 24, Part 6, Building Energy Efficiency Standards Rulemaking
<b>TN #:</b>	222838
<b>Document Title:</b>	Statewide Utility Codes and Standards Team Comments Links to Updated Utility-Sponsored CASE Reports
<b>Description:</b>	N/A
<b>Filer:</b>	System
<b>Organization:</b>	Statewide Utility Codes and Standards Team
<b>Submitter Role:</b>	Public
<b>Submission Date:</b>	3/4/2018 8:30:34 PM
<b>Docketed Date:</b>	3/5/2018

*Comment Received From: Statewide Utility Codes and Standards Team*

*Submitted On: 3/4/2018*

*Docket Number: 17-BSTD-02*

## **Links to Updated Utility-Sponsored CASE Reports**

*Additional submitted attachment is included below.*

# Links to Updated Utility-Sponsored CASE Reports

## California Statewide Utility Codes and Standards Team

March 4, 2018

The California Statewide Utility Codes and Standards Enhancement Team (Statewide CASE Team) is submitting this letter to provide the most recent versions of utility-sponsored CASE Reports. The versions of the CASE Reports that the California Energy Commission (Energy Commission) posted to the rulemaking dockets (dockets number [17-BSTD-02](#) and [17-BSTD-03](#)) were working drafts. The final version of each CASE Report is available on [title24stakeholders.com](http://title24stakeholders.com). See Table 1 for links to the final reports and a summary of differences between the versions the Energy Commission posted in the docket log and the final versions.

The Statewide CASE Team actively supports the Energy Commission in developing revisions to Title 24, Part 6 by developing code change proposals that will result in feasible, enforceable, and cost-effective enhancements to the building energy efficiency standards. In developing these proposals, the Statewide CASE Team conducts research, holds stakeholder meetings, and evaluates the energy savings and cost-effectiveness of considered measures. The CASE Reports present pertinent information that supports the code change proposals. The four California Investor Owned Utilities – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and SoCalGas® – and several Publicly Owned Utilities – Los Angeles Department of Water and Power, Sacramento Municipal Utility District, and Southern California Public Power Authority – sponsored this effort.

**Table 1: Links to Updated CASE Reports and Summary of Differences Between Final Reports and Reports Posted in Docket**

Measure Name	Last Updated	Summary of Differences Between Version the Energy Commission Posted in Docket and Most Recent Version	Link to Most Recent Version of CASE Report
<b>Residential Measures</b>			
Residential Quality HVAC	December 2017	This CASE Report has not been posed in the Energy Commission's docket	<a href="http://title24stakeholders.com/wp-content/uploads/2017/12/2019-T24-CASE-Report_Res-Quality-HVAC_Final_December-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/12/2019-T24-CASE-Report_Res-Quality-HVAC_Final_December-2017.pdf</a>
Residential Indoor Air Quality	February 2018	Added Appendix E added, which discusses pressure drop in relation to filter efficiency and filter depth.	<a href="http://title24stakeholders.com/wp-content/uploads/2018/02/2019-T24-CASE-Report_Res-IAQ_Final_February-2018.pdf">http://title24stakeholders.com/wp-content/uploads/2018/02/2019-T24-CASE-Report_Res-IAQ_Final_February-2018.pdf</a>
High Performance Walls	September 2017	Incremental costs have been updated	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_HPW_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_HPW_Final_September-2017.pdf</a>
High Performance Windows and Doors	September 2017	Statewide savings have been updated	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Res-Windows-and-Doors_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Res-Windows-and-Doors_Final_September-2017.pdf</a>
High Performance Attics	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_HPA_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_HPA_Final_September-2017.pdf</a>
Quality Insulation Installation (QII)	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_ResQII_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_ResQII_Final_September-2017.pdf</a>
Compact Hot Water Distribution	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Cmpct-HW-Distbtn_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Cmpct-HW-Distbtn_Final_September-2017.pdf</a>
Drain Water Heat Recovery	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_DWHR_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_DWHR_Final_September-2017.pdf</a>
<b>Nonresidential and Cross-cutting Measures</b>			
Nonresidential Outdoor Lighting Power Allowances (LPAs)	December 2017	Includes updated recommendations for when Backlight, Uplight, and Glare (BUG) requirements apply to outdoor luminaires.	<a href="http://title24stakeholders.com/wp-content/uploads/2018/01/2019-T24-CASE-Report_NR-Outdoor-Light-Sources_With-Addendum_December-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2018/01/2019-T24-CASE-Report_NR-Outdoor-Light-Sources_With-Addendum_December-2017.pdf</a>
Indoor Lighting Power Densities	December 2017	Latest version includes updated information on models and analyses, and use-it-or-lose-it adders.	<a href="http://title24stakeholders.com/wp-content/uploads/2018/01/2019-T24-CASE-Report_NR-Indoor-Light-Sources_Final_December-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2018/01/2019-T24-CASE-Report_NR-Indoor-Light-Sources_Final_December-2017.pdf</a>
Nonresidential Outdoor Lighting Controls	September 2017	Added information on technical feasibility, proposed measures, analyses, and updated lifecycle costs and energy savings.	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Outdoor-Ltg-Controls_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Outdoor-Ltg-Controls_Final_September-2017.pdf</a>
Nonresidential Indoor Controls (Alignment with ASHRAE 90.1)	September 2017	Added information about requirements for acceptance testing for the Manual ON Time-switch measure as well as additional recommendations for improving compliance and enforcement.	<a href="http://title24stakeholders.com/wp-content/uploads/2017/10/2019-T24-CASE-Report_NR-Indoor-Controls_Final-September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/10/2019-T24-CASE-Report_NR-Indoor-Controls_Final-September-2017.pdf</a>
Nonresidential Advanced Daylighting Design	September 2017	Latest version includes minor clarifications to measures by updating code language to use the terms "clerestory windows" and "clerestory fenestration." Also included are clarifications about adjustable slats and vertical slats.	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Advanced-Daylighting-Design_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Advanced-Daylighting-Design_Final_September-2017.pdf</a>

Measure Name	Last Updated	Summary of Differences Between Version the Energy Commission Posted in Docket and Most Recent Version	Link to Most Recent Version of CASE Report
Nonresidential Indoor Lighting Alterations	September 2017	Added information about compliance and enforcement	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_NR-Indoor-Ltg-Alterations_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_NR-Indoor-Ltg-Alterations_Final_September-2017.pdf</a>
Nonresidential Indoor Air Quality (Proposal Based on ASHRAE 62.1-2016)	December 2017	Statewide savings have been updated	<a href="http://title24stakeholders.com/wp-content/uploads/2018/01/2019-T24-CASE-Report_NR-IAQ_Final_December-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2018/01/2019-T24-CASE-Report_NR-IAQ_Final_December-2017.pdf</a>
Proposals Based on ASHRAE 90.1	February 2018	Added information about interactions with other parts of Title 24	<a href="http://title24stakeholders.com/wp-content/uploads/2018/03/2019-T24-CASE-Report-Proposals-Based-on-ASHRAE-90.1_Final_February-2018.pdf">http://title24stakeholders.com/wp-content/uploads/2018/03/2019-T24-CASE-Report-Proposals-Based-on-ASHRAE-90.1_Final_February-2018.pdf</a>
Variable Exhaust Flow Control	December 2017	Statewide savings have been updated	<a href="http://title24stakeholders.com/wp-content/uploads/2017/12/2019-T24-CASE-Report_VEFC_Final_December-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/12/2019-T24-CASE-Report_VEFC_Final_December-2017.pdf</a>
Dock Seals	November 2017	Latest version includes an addendum describing revisions to analyses and recommending this measure be included into CALGreen (Title 24, Part 11) instead of Title 24, Part 6	<a href="http://title24stakeholders.com/wp-content/uploads/2017/11/2019-T24-CASE-Report_Dock-Seals_With-Addendum_11.17.2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/11/2019-T24-CASE-Report_Dock-Seals_With-Addendum_11.17.2017.pdf</a>
High Efficiency Fume Hoods in Laboratory Spaces	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Fume-Hoods_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Fume-Hoods_Final_September-2017.pdf</a>
Prescriptive Efficiency Requirements for Cooling Towers	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report-Cooling-Towers_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report-Cooling-Towers_Final_September-2017.pdf</a>
Economizer Fault Detection and Diagnostics (FDD) for Built-Up Air Handlers	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Economizer-FDD-for-Built-up-Air-Handlers_Final_September-2017.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Economizer-FDD-for-Built-up-Air-Handlers_Final_September-2017.pdf</a>
Adiabatic Condensers	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Adiabatic-Condensers_Final_September-2017-1.pdf">http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report_Adiabatic-Condensers_Final_September-2017-1.pdf</a>
Demand Response Cleanup	September 2017	No substantive changes, but made small editorial revisions	<a href="http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report-Demand-Response-Cleanup_Final_September-2017.pdf">Link to latest version: http://title24stakeholders.com/wp-content/uploads/2017/09/2019-T24-CASE-Report-Demand-Response-Cleanup_Final_September-2017.pdf</a>

## DOCKETED

<b>Docket Number:</b>	17-BSTD-02
<b>Project Title:</b>	2019 Title 24, Part 6, Building Energy Efficiency Standards Rulemaking
<b>TN #:</b>	223381
<b>Document Title:</b>	Statewide Utility Codes and Standards Team Comments Statewide Utility Codes and Standards Team - Support for Adoption
<b>Description:</b>	N/A
<b>Filer:</b>	System
<b>Organization:</b>	Statewide Utility Codes and Standards Team
<b>Submitter Role:</b>	Public
<b>Submission Date:</b>	5/7/2018 5:59:58 PM
<b>Docketed Date:</b>	5/8/2018



*Comment Received From: Statewide Utility Codes and Standards Team*

*Submitted On: 5/7/2018*

*Docket Number: 17-BSTD-02*

**Statewide Utility Codes and Standards Team - Support for Adoption**

*Additional submitted attachment is included below.*

# Support for Adoption of 2019 Title 24, Part 6 Standards

## California Statewide Utility Codes and Standards Team

May 7, 2018

The California Statewide Utility Codes and Standards Team (Statewide CASE Team) actively supports the California Energy Commission (Energy Commission) in developing revisions to the California Building Energy Efficiency Standards (Title 24, Part 6) by developing code change proposals that will result in feasible, enforceable, and cost-effective enhancements to the building energy efficiency standards. In developing these Codes and Standards Enhancement (CASE) proposals, the Statewide CASE Team conducts research and market surveys, holds stakeholder meetings, and evaluates the energy savings and cost-effectiveness of considered measures. The CASE Reports, which present pertinent information that supports the code change proposals, are posted within each measure topic page on [title24stakeholders.com](http://title24stakeholders.com).

The four California Investor Owned Utilities – Pacific Gas and Electric Company, San Diego Gas and Electric, Southern California Edison and SoCalGas® – and several publicly Owned Utilities – Los Angeles Department of Water and Power, Sacramento Municipal Utility District, and Southern California Public Power Authority – sponsored this effort.

### 1. Statewide CASE Team Supports Adoption of 15-Day Language

The Statewide CASE Team strongly supports the adoption of the 2019 Title 24, Part 6 Standards. The proposed changes to the building code, as presented in the 15-Day Language, balance many interests, are a cost-effective way to help Californians reduce energy use and greenhouse gas emissions, and represent a significant milestone in the continued effort to achieve California's long-term energy and climate goals.

Throughout this code cycle, the Statewide CASE Team has had the opportunity to work collaboratively with the Energy Commission and many other dedicated stakeholders. We commend the Energy Commission for creating and maintaining a platform for open discussion, and we appreciate all the constructive dialogue that went into developing code changes that will not only save energy, but are also cost-effective, technically feasible, and enforceable. To support the implementation of the 2019 Standards, we plan to offer tools, training, and resources through the [Energy Code Ace](#) program. [Energy Code Ace](#) works directly with market actors by providing education, outreach, technical support, tools, and resources to increase compliance with the standards. The Statewide CASE Team looks forward to working with the Energy Commission and other interested parties on the next revision of the building energy efficiency standards.

### 2. Suggestions for Continued Improvement

While the Statewide CASE Team is supportive of adopting the 2019 Title 24, Part 6 Standards, there are opportunities to improve the clarity and precision of the language which can lead to improved compliance. In the remainder of this letter, we discuss improvement opportunities, including

suggestions to remove ambiguity and clarify methods to verify compliance. We have provided some specific examples of proposed language revisions to demonstrate the value of small language improvements. We recognize that these changes are unlikely to be incorporated into the 2019 Standards. We would welcome the opportunity to work with the Energy Commission during the 2022 code cycle to make improvements that would make language less complex throughout the entire standards, including addressing the issues identified in the remainder of this letter.

The Statewide Utility Compliance Improvement (CI) Team contributed to developing the recommendations presented below. The CI Team conducts compliance improvement activities to complement and enhance advocacy work by maximizing verified savings from codes and standards that are realized and persist over time. The CI Team engages market actors throughout the compliance supply chain to ensure that advocacy and compliance improvement activities produce solutions that meet end users' needs.

The CASE Team obtained feedback on the proposed 2019 CASE measures from building departments and other subject matter experts that assist in implementing the building code. Energy Code Ace also conducted user-centered design trainings with the CASE authors to ensure recommendations presented in the CASE Reports were developed from the end-users' perspective.

To be effective in realizing sustained energy savings, code language must make it very clear exactly what features are required. This includes ensuring that outside references documents are not required to understand the Title 24, Part 6 requirements, as in the current ventilation and indoor air quality requirements. Additionally, code language in one code section must not conflict with language in another code section, and code language must not be vague, which leaves it open to misinterpretation. Current sections of the lighting alterations requirements currently fall into both categories. Based on the CI Team's experience working with a variety of end users as they implement code requirements, interpreting the code requirements for nonresidential lighting alterations has proven to be particularly challenging.

We encourage the Energy Commission to consider the changes suggested in this document. We believe addressing these issues will reduce the potential for misinterpretation and improve compliance. Recommended revisions to the 15-Day Language are included in this document in **orange**. The Statewide CASE Team's recommended language insertions are double underlined and recommended language deletions are in ~~double-strikeout~~ font.

## 2.1 High Performance Windows and Doors

**Table 110.6-A:** Section 110.6(a)2 states that the U-factor of exterior door shall be rated according to NFRC 100 or designers shall use the applicable default U-factor in Table 110.6-A. However, Table 110.6-A does not include a default U-factor for opaque doors. This will cause confusion and make compliance difficult for those who install non-rated exterior opaque doors, such as custom doors. Since the U-factor requirement is not spelled out for these door types, there is a lack of clarity on what U-factor should be used. Even with this proposed change, unrated doors cannot be used in the prescriptive approach (all the U-factors for doors in Table 110.6 including the proposed U-factor for opaque doors are higher than the prescriptive 0.2 Btu/hr-sf-°F). The door U-factor requirement is essentially enforced through the performance approach. The default proposed here (U=0.5 Btu/hr-sf-°F) is a typical value for a solid wood door. Including the default U-factor for opaque doors in the footnote to Table 110.6 will provide clarity to designers what are the default U-factors for unrated opaque doors (with less than 25 percent glass they really are no longer fenestration). Having the opaque door default U-factor in the footnote Table 110.6 will reduce the possibility of confusion and provide quick feedback to designers that using unrated doors will result in a fairly significant energy penalty when using the performance approach.

It is recommended that a default U-factor be provided for opaque exterior doors by adding footnote 5.

**TABLE 110.6-A DEFAULT FENESTRATION PRODUCT U-FACTORS**

<b>FRAME</b>	<b>PRODUCT TYPE <sup>5</sup></b>	<b>SINGLE PANE <sup>3,4</sup> U-FACTOR</b>	<b>DOUBLE PANE <sup>1, 3, 4</sup> U-FACTOR</b>	<b>GLASS BLOCK <sup>2,3</sup> U-FACTOR</b>
Metal	Operable	1.28	0.79	0.87
	Fixed	1.19	0.71	0.72
	Greenhouse/garden window	2.26	1.40	N.A.
	Doors	1.25	0.77	N.A.
	Skylight	1.98	1.30	N.A.
Metal, Thermal Break	Operable	N.A.	0.66	N.A.
	Fixed	N.A.	0.55	N.A.
	Greenhouse/garden window	N.A.	1.12	N.A.
	Doors	N.A.	0.59	N.A.
	Skylight	N.A.	1.11	N.A.
Nonmetal	Operable	0.99	0.58	0.60
	Fixed	1.04	0.55	0.57
	Doors	0.99	0.53	N.A.
	Greenhouse/garden windows	1.94	1.06	N.A.
	Skylight	1.47	0.84	N.A.
<p>1. For all dual-glazed fenestration products, adjust the listed U-factors as follows:</p> <p>a. Add 0.05 for products with dividers between panes if spacer is less than 7/16 inch wide.</p> <p>b. Add 0.05 to any product with true divided lite (dividers through the panes).</p> <p>2. Translucent or transparent panels shall use glass block values when not rated by NFRC 100.</p> <p>3. Visible Transmittance (VT) shall be calculated by using Reference Nonresidential Appendix NA6.</p> <p>4. Windows with window film applied that is not rated by NFRC 100 shall use the default values from this table.</p> <p>5. <u>Exterior doors with less than 25 percent glazing shall have a default U-factor of 0.50.</u></p>				

## 2.2 High Performance Walls

The 15-Day Language is not as clear as it could be with respect to the requirements that apply to mass walls. U-factors and R-values in Table 150.1 are not consistent with the language in 150.1(c)1.B, the values in the Reference Appendix JA4, or with the mass wall assemblies applied to the Standard Design in the Alternative Calculation Method (ACM) Reference Manual and the compliance software. It is our understanding that the U-factors were originally determined based on a concrete wall with continuous insulation applied to either the interior or exterior of the wall that meets the R-value in the table. Using the JA4 Table 4.3.6 and Equation 4-4, we are not able to replicate the U-factors in the table. We suggest verifying how these U-factors were originally determined, revising the values in the table to reflect the original intent, and adding clarifying language as necessary. This will require revisions to 150.1(c)1.B, Table 150.1-A, Table 150.1-B, and the ACM Reference Manual.

The two categories of mass walls (“Interior” and “Exterior”) do not accurately represent all types of mass walls. Certain types of walls qualify as mass walls (heat capacity greater than 7.0 Btu/h-ft<sup>2</sup>), but have insulation applied in a location other than directly to the interior or exterior of the wall (e.g., concrete sandwich panels, adobe walls, log walls) or have insulation applied to both the interior and exterior (e.g., Insulating Concrete Forms or ICF). With the current language it is unclear which prescriptive requirement in Table 150.1-A & 150.1-B should be applied to these wall types. We suggest

revising the “Exterior” designation to “All others” and providing clarifying language describing these designations. Any wall with insulation applied to the interior, and thus does not have the thermal mass of the wall directly exposed to the building, would be classified under the “Interior” designation. ICF walls would fall under this designation even though they have an additional insulation layer within the assembly. All other mass walls, including concrete sandwich panels, adobe walls, log walls, and walls with exterior applied insulation, would be classified under the “All others” designation. This will require revisions to 150.1(c)1.B, Table 150.1-A, Table 150.1-B, and the ACM Reference Manual.

#### 150.1(c)1.Bii

- ii. Mass walls above grade and below grade shall be insulated such that the wall has an assembly U- factor equal to or less than that shown in TABLE 150.1-A or B, or walls shall be insulated with continuous insulation that has an R-value equal to or greater than that shown in TABLE 150.1-A or B. “Interior” denotes ~~continuous~~ insulation installed on the inside surface of the wall, and “~~All other exterior~~” denotes all other mass walls where insulation is not applied to the inside surface of the wall~~continuous insulation installed on the outside surface of the wall.~~

**TABLE 150.1-A COMPONENT PACKAGE-A— Single Family Standard Building Design**

**And Table 150.1-B COMPONENT PACKAGE – Multi-fFamily Standard Building Design**

<b>Single Family</b>				[content from table omitted]
Building Envelope	Walls	Above Grade	Framed <sup>3</sup>	
			Mass Wall Interior <sup>4,5</sup>	
			Mass Wall <del>All Others Exterior</del> <sup>4,5</sup>	
		Below Grade <sup>4,6</sup>	Below Grade Interior <sup>6</sup>	
			Below Grade <del>All Others Exterior</del> <sup>8</sup>	

#### Footnote requirements to TABLE 150.1-A and Table 150.1-B

1. ~~Install the specified R-value with no air space present between the roofing and the roof deck.~~
  1. Install the specified R-value with an air space present between the roofing and the roof deck. Such as standard installation of concrete or clay tile.
  2. R-values shown for below roof deck insulation are for wood-frame construction with insulation installed between the framing members. Alternatives including insulation above rafters or above roof deck shall comply with the performance standards.
  3. Assembly U-factors for exterior framed walls can be met with cavity insulation alone or with continuous insulation alone, or with both cavity and continuous insulation that results in an assembly U-factor equal to or less than the U-factor shown. Use Reference Joint Appendices JA4 Table 4.3.1, 4.3.1(a), or Table 4.3.4 to determine alternative insulation products to ~~meet~~ be less than or equal to the required maximum U-factor.
  4. Mass wall has a heat capacity greater than or equal to 7.0 Btu/h-ft<sup>2</sup>. “Interior” denotes insulation installed on the inside surface of the wall.Mass walls shall be insulated such that the wall has an assembly U- factor equal to or less than that shown or walls shall be insulated with continuous insulation that has an R-value equal to or greater than that shown
  5. “Interior” denotes insulation installed on the inside surface of the wall. “~~All other Exterior~~” denotes all other mass walls where insulation is not applied to the inside surface of the wall~~insulation installed on the exterior surface of the wall.~~
  6. Below grade “interior” denotes insulation installed on the inside surface of the wall; and bBelow grade “~~All other exterior~~” denotes all other mass walls where insulation is not applied to the inside surface of the wall~~insulation installed on the outside surface of the wall.~~
  7. HSPF means “heating seasonal performance factor.”
  8. When whole house fans are required (REQ), only those whole house fans that are listed in the Appliance Efficiency Directory may be installed. Compliance requires installation of one or more WHFs whose total airflow CFM is capable of meeting or exceeding a minimum 1.5 cfm/square foot of conditioned floor area as specified by Section 150.1(c)12.
  9. A supplemental heating unit may be installed in a space served directly or indirectly by a primary heating system, provided that the unit thermal capacity does not exceed 2 kilowatts or 7,000 Btu/hr and is controlled by a time-limiting device not exceeding 30 minutes.

10. For duct and air handler location: REQ denotes location in conditioned space. When the table indicates ducts and air handlers are in conditioned space, a HERS verification is required as specified by Reference Residential Appendix RA3.1.4.3.8.

## 2.3 Healthcare Facilities

Healthcare requirements refer to “Chapter 7 of the California Administrative Code (Title 24, Part 1)” using inconsistent terminology in the following sections:

- Title 24, Part 1 10-103(a) refers to “Chapter 7,” but does not specify a resource.
- Title 24, Part 6 Section 120.8 refers to “Healthcare facilities shall instead comply with the applicable requirements of Chapter 7 of the California Administrative Code (Title 24, Part 1).”

Consistent references to requirements will make it easier for building departments to improve code compliance. In every instance of Chapter 7 throughout the standards, it is recommended to use the following language: Chapter 7 of the California Administrative Code (Title 24, Part 1)

## 2.4 Residential and Nonresidential Indoor Air Quality

During the 2019 code cycle, the Energy Commission made many valuable changes to the indoor air quality requirements for both residential and nonresidential buildings. The revisions will help ensure that the indoor air quality remains high as buildings become more efficient. While we were able to accomplish a lot, the Statewide CASE Team would like to offer recommendations to improve the language for the 2022 code cycle.

**Throughout Section 120:** The Statewide CASE Team recommends that instead of referencing sections of ASHRAE 62.1 and ASHRAE 62.2, the actual code requirements from the ASHRAE Standards be replicated in Title 24, Part 6. Specifically, the minimum ventilation airflow rates and rated sound requirements should be explicitly stated in the code language. The ASHRAE Standards are a third-party standard with a cost to access and review. Stakeholders may find this to be a barrier to compliance since a fee is required to access the code requirement. In the following are instances, the ASHRAE 62.1 and 62.2 requirements should be replicated in Title 24, Part 6.

### Section 120.1(b)2Aii

- Continuous operation of central forced air system air handlers used in central fan integrated ventilation systems is not a permissible method of providing the dwelling unit ventilation airflow required in (Section 4 of ASHRAE Standard 62.2).

### Sections 120.1(b)2Avi and 120.1(b)2Biia

- Kitchen range hoods shall be vented to outdoors and HVI rated for sound, to be less than or equal to 3 sones at the lowest speed above 100 cfm that the hood can produce in accordance with Section 7.2 of ASHRAE 62.2, 7.2, and HVI 916; 7.2.

**EXCEPTION to Section 120.1(b)2Ayii:** Kitchen range hoods may be rated for sound at a static pressure determined at working speed as specified in HVI 916 Section 7.2.

- Compliance with ASHRAE 62.2 Section 6.5.2 (Space Conditioning System Ducts) shall not be required.
- Compliance with ASHRAE 62.2 Section 4.4 (Control and Operation) shall require manual switches associated with dwelling unit ventilation systems to have a label clearly displaying the following text, or equivalent text: “This switch controls the indoor air quality ventilation for the home. Leave it on unless the outdoor air quality is very poor.”

B. High-Rise Residential Dwelling Unit Acceptance.

- i. Airflow Performance. The dwelling- unit ventilation airflow required by Section 120.1(b)2Aiv or 120.1(b)2Av~~Section 4 of ASHRAE Standard 62.2~~ shall be confirmed through field verification and diagnostic testing in accordance with Reference Nonresidential Appendix NA7.18.1.
- ii. Kitchen Range Hoods. The installed kitchen range hood shall be field verified in accordance with Reference Nonresidential Appendix NA7.18.1 to confirm the model is rated by HVI to comply with the following requirements:
  - a. The minimum ventilation airflow rate is no less than 100 cfm as specified in Section 5 of ASHRAE 62.2.
  - b. The maximum sound rating as specified in Section 120.1(b)2Avii-section 7.2.2 of ASHRAE 62.2.

**Section 120.1(b)1Biii:** Section not numbered and as a separate requirement for a separate class of equipment needs a clearer definition. This advances the numbering of subsection 120.1(b)1Biii to iv, and iv to v.

- ii. ~~The~~All systems shall be designed to accommodate the clean-filter pressure drop imposed by the system air filter(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 and reported on labels according to subsection iv below.

- iii. Ducted mechanical space conditioning Ssystems specified in Section 120.1(b)1Ai shall be equipped with air filters that meet either subsection a or b below:

**Section 120.1(c)3:** We suggest adding the phrase, “that are not naturally ventilated per item 2 above” for clarity. We also suggest striking the phrase “to the zone” to make it clear that the mechanical ventilation outdoor airflow rates are being provided at the air handler rather than the zone, as per Title 24, Part 6 (2016).

3. **Mechanical Ventilation.** Occupiable spaces that are not naturally ventilated per item 2 above shall be ventilated with a mechanical ventilation system capable of providing an outdoor airflow rate ( $V_z$ ) ~~to the zone~~ no less than the larger of A or B as described below:

**Section 120.1(c)4:** The Table reference is wrong. It should be Table 120.1-B (not D).

4. Exhaust Ventilation. The design exhaust airflow shall be determined in accordance with the requirements in Table 120.0-B ~~420.1-D~~. Exhaust makeup air shall be permitted to be any combination of outdoor air, recirculated air, or transfer air. [ASHRAE 62.1:6.5.1]

**Section 120.1(g):** The Statewide CASE Team recommends providing guidance on what the four air classifications represent, specifically adding air classification definitions as table notes in Tables 120.1-A/B/C notes since that will match how other sections of code approach defining classes in tracked changes of the 45-Day Language that we provided to the Energy Commission, we recommended providing these as a definition in Section 100.0(b), which is another viable option.

*Table 120.1-A – Minimum Ventilation Rates [Continued]*

<u>Occupancy Category</u>	<u>Area Outdoor Air Rate R<sub>a</sub></u>	<u>Min Air Rate for DCV<sup>b</sup></u>	<u>Air Class</u>	<u>Notes</u>
	cfm/ft <sup>2</sup>	cfm/ft <sup>2</sup>		
<b>Residential</b>				
Common corridors	0.15		1	F
<b>Retail</b>				



Sales (except as below)	0.25	0.20	2	
Mall common areas	0.25	0.15	1	F
Barbershop	0.40		2	<del>E</del>
Beauty and nail salons	0.40		2	
Pet shops (animal areas)	0.25	0.15	2	
Supermarket	0.25	0.20	1	F
Coin-operated laundries	0.30		2	
<b>Sports and Entertainment</b>				
Gym, sports arena (play area)	0.50	0.15	2	E
Spectator areas	0.50	0.15	1	F
Swimming (pool)	0.15		2	C
Swimming (deck)	0.50	0.15	2	C
Disco/dance floors	1.50	0.15	2	F
Health club/aerobics room	0.15		2	
Health club/weight rooms	0.15		2	
Bowling alley (seating)	1.07	0.15	1	
Gambling casinos	0.68	0.15	1	
Game arcades	0.68	0.15	1	
Stages, studios	0.50	0.15	1	D, F
<p><b>General:</b></p> <p><sup>a</sup> <sup>1</sup> Ra was determined This value assumes as being the larger of the area method and the default per person method. The occupant density used in the per person method was assumed to be one half of the maximum occupant load assumed for egress purposes in the CBC. non-fixed seating and uses the occupant density assumption in accordance with Section 120.1(c)3.</p> <p><sup>b</sup> If <sup>2</sup> If this column specifies a minimum cfm/ft<sup>2</sup> then it shall be used to comply with Section 120.1(d)4E.</p> <p><b>AIR CLASSIFICATIONS:</b></p> <p><b>CLASS 1 AIR</b> is air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.</p> <p><b>CLASS 2 AIR</b> is air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.)</p> <p><b>CLASS 3 AIR</b> is air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.</p> <p><b>CLASS 4 AIR</b> is air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered as harmful.</p> <p><b>Specific Notes:</b></p> <p>A – For high-school and college libraries, the values shown for “Public Assembly Spaces – Libraries” shall be used. B – Rate may not be sufficient where stored materials include those having potentially harmful emissions.</p> <p>C – Rate does not allow for humidity control. “Deck area” refers to the area surrounding the pool that is capable of being wetted during pool use or when the pool is occupied. Deck area that is not expected to be wetted shall be designated as an occupancy category.</p> <p>D – Rate does not include special exhaust for stage effects such as dry ice vapors and smoke.</p> <p>E – Where combustion equipment is intended to be used on the playing surface or in the space, additional dilution ventilation, source control, or both shall be provided.</p> <p>F – Ventilation air for this occupancy category shall be permitted to be reduced to zero when the space is in occupied standby mode.</p>				

*Table 120.1-B – Minimum Exhaust Rates [ASHRAE 62.1: TABLE 6.5]*

Occupancy Category	Exhaust Rete, cfm/unit	Exhaust Rate, cfm/ft <sup>2</sup>	Air Class	Notes
Arenas	-	0.50	1	B
Art classrooms	-	0.70	2	



Auto repair rooms	-	1.5	2	A
Barber shops	-	0.50	2	
Beauty and nail salons	-	0.60	2	
Cells with toilet	-	1.00	2	
Copy, printing rooms	-	0.50	2	
Darkrooms	-	1.00	2	
Educational science laboratories	-	1.00	2	
Janitor closets, trash rooms, recycling	-	1.00	3	
Kitchenettes	-	0.30	2	
Kitchens – commercial	-	0.70	2	
Locker rooms for athletic or industrial facilities	-	0.50	2	
All other locker rooms	-	0.25	2	
Shower rooms	20/50	-	2	G,H
Paint spray booths	-	-	4	F
Parking garages	-	0.75	2	C
Pet shops (animal areas)	-	0.90	2	
Refrigerating machinery rooms	-	-	3	F
Soiled laundry storage rooms	-	1.00	3	F
Storage rooms, chemical	-	1.50	4	F
Toilets – private	25/50	-	2	E
Toilets – public	50/70	-	2	D
Woodwork shop/classrooms	-	0.50	2	

**AIR CLASSIFICATIONS:**

**CLASS 1 AIR** is air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.

**CLASS 2 AIR** is air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.)

**CLASS 3 AIR** is air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.

**CLASS 4 AIR** is air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered as harmful.

**Notes:**

A – Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.

B – Where combustion equipment is intended to be used on the playing surface, additional dilution ventilation, source control, or both shall be provided.

C – Exhaust shall not be required where two or more sides comprise walls that are at least 50% open to the outside.

D – Rate is per water closet, urinal, or both. Provide the higher rate where periods of heavy use are expected to occur. The lower rate shall be permitted to be used otherwise.

E – Rate is for a toilet room intended to be occupied by one person at a time. For continuous systems operation during hours of use, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used.

F – See other applicable standards for exhaust rate.

G – For continuous system operation, the lower rate shall be permitted to be used. Otherwise the higher rate shall be used. H – Rate is per showerhead

*Table 120.1-C – Airstreams or Sources [ASHRAE 62.1:Table 5.16.1]*

Description	Air Class
Diazo printing equipment discharge	4
Commercial kitchen grease hoods	4
Commercial kitchen hoods other than grease	3
Laboratory hoods	4 <sup>a</sup>
Hydraulic elevator machine room	2

**AIR CLASSIFICATIONS:**

**CLASS 1 AIR** is air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.

**CLASS 2 AIR** is air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.)

**CLASS 3 AIR** is air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.

**CLASS 4 AIR** is air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered as harmful.

- a. Air Class 4 unless determined otherwise by the Environmental Health and Safety professional responsible to the owner or to the owner's designee.

**Section 150.0(m)12D:** Several sentences lack verbs.

- i. The maximum allowable clean-filter pressure drop shall be determined by the system design for the nominal two-inch minimum depth air filter required by Section 150.0(m)12Biia, or
- ii. A maximum of 25 PA (0.1 inches water) clean-filter pressure drop shall be allowed for a nominal one-inch depth air filter sized according to Section 150.0(m)12Biib, or
- iii. For systems specified in 150.0(m)12Aii, and 150.0(m)12Aiii, the maximum allowable clean filter pressure drop shall be determined by the system design.

**Section 150.0(o)2:** The numbering for this section should be “2” not “12”.

**12-2.** Field Verification and Diagnostic Testing.

## **2.5 Nonresidential Indoor Lighting Alterations**

**Exception 5 to 141.0(b)2I:** The Statewide CASE Team recommends that Exception 5 to 141.0(b)2I be rewritten to clarify that the intent of the exception is not to exempt simultaneous replacement of separable lamps and ballasts or separable lamps and drivers. Exception 5 is intended to exempt replacements of light sources only, control electronics only, integrated lamps only, or LED retrofit kits only. In our experience, this has been a source of confusion in the 2016 code cycle and has limited the energy savings that could be garnered from lighting alteration projects in California. Where integral lamps are replaced the intent is to treat them like any other lamp and allow these to be exempted. Note that the modified Exception 5 applies to replacing existing components of luminaires. For clarity, a separate Exception 6 describes exempting alterations that are solely control upgrades. This exception identically matches Exception 1 to Section 141.0(b)2K in the 2016 version of Title 24, Part 6.

**EXCEPTION 5 to Section 141.0(b)2I:** ~~Any alteration limited solely to adding lighting controls or replacing lamps, ballasts, or drivers~~ Alterations where the luminaire housing is retained and lighting wattage is not increased for any of the following:

1. Alterations where only the lamp or only the ballast is replaced, or
2. Alterations where only an integrated LED lamp or CFL is replaced, or
3. Alterations where only a non-integrated LED lamp or only the LED driver is replaced, or
4. Alterations where an LED light engine or LED retrofit kit is replaced.

**EXCEPTION 6 to Section 141.0(b)2I:** Alterations strictly limited to addition of lighting controls.

## 2.6 Nonresidential Outdoor Lighting Controls Alterations

**Section 141.0(b)2Lii:** This section references Section 130.2, but the references have not been updated to reflect revisions to Section 130.2 that are proposed in the 15-Day Language. The Statewide CASE Team recommends that the Energy Commission review Section 141.0(b)2Lii and update the language as appropriate so the requirements for alterations remain unchanged from the 2016 standards even though the language in Section 130.2 has been revised.

## 2.7 Nonresidential Wattage Calculation

**Section 130.0(c)2** is ambiguous and could more clearly state what is the deemed wattage of luminaires with line voltage lamp holders. The Statewide CASE Team proposes that the Energy Commission review and update the language. Specifically, the proposed 2019 code does not clearly explain the relationship between part A and B. It is unclear whether luminaire wattage is the maximum rated wattage of the luminaire, 50 watts per socket (for luminaires with screw base sockets), or the rated wattage of installed JA8 lamps. The Statewide CASE Team proposes that the Energy Commission clarify the relationship between parts A and B. The 15-Day Language as proposed by the Energy Commission is as follows:

2. For luminaires with line voltage lamp holders not containing permanently installed ballasts or transformers, the wattage of such luminaires shall be determined as follows:
  - A. The maximum rated wattage of the luminaire;
  - B. For recessed luminaires with line-voltage medium screw base sockets, wattage shall not be less than 50 watts per socket, or the rated wattage of the installed JA8 compliant lamps.

## 2.8 Residential Lighting Standards

**Section 150.0(k)1Cvi:** Reference to the "JA8" label has been removed and replaced with language that references marking requirements in Joint Appendix 8 (JA8). The 2016 Title 24 Residential Standards allowed designers, contractors, and inspectors to focus on a single metric as it applies to light emitting diode lighting: the "JA8" marking. The Statewide CASE Team believes references to the JA8 marking should be reinserted into this section to simplify compliance.

**C. Recessed Downlight Luminaires in Ceilings.** In addition to complying with 150.0(k)1A, luminaires recessed into ceilings shall meet all of the following requirements:

- i. Be listed, as defined in Section 100.1, for zero clearance insulation contact (IC) by Underwriters Laboratories or other nationally recognized testing/rating laboratory; and
- ii. Have a label that certifies the luminaire is airtight with air leakage less than 2.0 CFM at 75 Pascals when tested in accordance with ASTM E283. An exhaust fan housing shall not be required to be certified airtight; and
- iii. Be sealed with a gasket or caulk between the luminaire housing and ceiling, and ~~shall~~ have all air leak paths between conditioned and unconditioned spaces sealed with a gasket or caulk; and
- iv. For luminaires with hardwired ballasts or drivers, allow ballast or driver maintenance and replacement to be readily accessible to building occupants from below the ceiling without requiring the cutting of holes in the ceiling; and
- v. Shall not contain screw base sockets, ~~and~~ and
- ~~vi. Shall contain light sources that comply with References Joint Appendix JA8, including the elevated temperature requirements, and that are marked "JA8 2016 E" as specified in Reference Joint Appendix JA8.~~

vi. Shall contain light sources that comply with Reference Joint Appendix JA8, including the elevated temperature requirements, and that are marked “JA8-2019-E” as specified in Reference Joint Appendix JA8.

**Section 150.0(k)1G:** Language was stricken that requires screw based luminaires to be marked with “JA8-2016-E”. The Statewide CASE Team believes the intent of the language is to ensure screw based luminaires are labeled with the JA8 marking to make it easier for implementers of the residential Title 24 Standards to follow code. If this is the intent of the language, then the Statewide CASE Team proposes that the JA8 marking requirement be added back to the language. Proposed changes to language:

**G. Screw based luminaires.** Screw based luminaires shall ~~meet all of the following requirements:~~

- i. ~~The luminaires shall not be recessed downlight luminaires in ceilings; and~~
- ii. ~~The luminaires shall contain lamps that comply with Reference Joint Appendix JA8; and~~
- iii. ~~The installed lamps shall be marked with “JA8-2016” or “JA8-2016 E” as specified in Reference Joint Appendix JA8.~~ and be marked with “JA8-2019” or “JA8-2019-E”.

**EXCEPTION to Section 150.0(k)1G:** Luminaires with hard-wired ballasts for high intensity discharge lamps.

**Section 150.0(k)1H:** The Statewide CASE Team believes the Energy Commission rewrote this section for simplification. However, we believe that the language can be further clarified by stating directly that light sources installed in enclosed or recessed luminaires need to be marked with “JA8-2019-E”. The Energy Commission’s proposed language implies that the implementers of the residential Title 24 Standards need to familiarize themselves with the elevated temperature and marking requirements in JA8. Ceiling recessed luminaires are already covered by Section 150.0(k)1C.

The intent of the 2016 Title 24 Standard was to ensure that JA8 light sources are appropriate for enclosed and resources sources by requiring the “JA8-2019-E” markings, indicating elevated temperature testing had been completed. The 2016 code language included a confusing double negative. For clarity, we suggest using language similar to Section 150.0(k)1C. Proposed changes to language:

**H. ~~Light Sources in Enclosed or Recessed~~ Luminaires.** Enclosed luminaires or recessed luminaires that are not ceiling recessed luminaires, shall contain Lamps and other separable light sources that are not compliant with the JA8 elevated temperature requirements and are marked “JA8-2019-E”. ~~including marking requirements, “JA8-2016 E” shall not be installed in enclosed or recessed luminaires.~~

If it is desired to allow legacy light sources in these luminaires, then the following could be added.

**Exception to Section 150.0(k)1H:** Enclosed luminaires or recessed luminaires that are not ceiling recessed luminaires containing light sources listed as items 1-6 in the first column of table 150.0-A.

**Table 150.0-A:** The Statewide CASE Team recommends the following changes to Table 150.0-A to clarify what designers and building official should be looking for, namely the “JA8-2019” marking on all LED lamps and SSL luminaires. It also highlights that “JA8-2019-E” is suitable for enclosed and recessed luminaires.

**Table 1: Recommended changes to Table 150.0A**

High Efficacy Light Sources
<del>Luminaires installed with only the lighting technologies in this table shall be classified as high efficacy</del> Light sources shall comply with one of the columns below:

<p>Light sources in this column other than those installed in ceiling recessed downlight luminaires are classified as high efficacy and are <b>not</b> required to comply with Reference Joint Appendix JA8</p>	<p>Light sources in this column <del>shall be</del> <u>are only considered to be high efficacy if they are certified to the <a href="#">Energy</a> Commission as High Efficacy Light Sources in accordance with Reference Joint Appendix JA8 and be marked "<a href="#">JA8-2019</a>" or "<a href="#">JA8-2019-E</a>" (<a href="#">suitable for enclosed or recessed luminaires</a>) as <del>meeting</del> required by JA8.</u></p>
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## ATTACHMENT 3: DOCKET POSTINGS RELATING TO 2” FILTER DEPTH REQUIREMENT

Title	Date	By	Comment	URL
Comments HVAC System Filter Requirements	2/21/2018	Statewide Utility Codes and Standards Team	Results of filter testing were presented. Based on results that showed that acceptable filter pressure drops can be achieved using either 1" or 2" depth filters, the Statewide CASE Team proposed the following: recommend sizing based on a maximum pressure drop of 0.15 inches w.c. and maximum velocity of 225 fpm; eliminate requirements for filter pressure drop and size; reference the CALGreen requirements for ACCA Manual D sizing. This approach is consistent with the 2016 Standards, which rely on fan efficacy measurements for verification of sizing.	<a href="https://efiling.energy.ca.gov/GetDocument.aspx?tn=222628">https://efiling.energy.ca.gov/GetDocument.aspx?tn=222628</a>
CBIA Comments on 2019 Update of Residential Energy Standards	2/23/2018	Robert Raymer, California Building Industry Association (CBIA)	CBIA agrees with the Statewide CASE team recommendation that the 45-Day Language be modified to eliminate the filter pressure drop and size requirements as described in their comments submitted to the Docket on February 21, 2018.	<a href="https://efiling.energy.ca.gov/GetDocument.aspx?tn=222691">https://efiling.energy.ca.gov/GetDocument.aspx?tn=222691</a>

Comments on 2019 Residential Air Filtration Requirements	3/13/2018	Brent Stephens, Torkan Fazli, Amour College of Engineering, Illinois Institute of Technology	Found weak correlation between pressure drop and MERV when analyzing across all filter depths but found a stronger correlation ( $R^2 = 0.62$ to $0.78$ ) when analyzing 1" and 2" filters independently. No 1" filters tested had a pressure drop lower than 80 Pa (0.32") and the maximum for 2" filters was 50 Pa (0.20"). Expressed concerns that no commercially available filters can meet the target of 25 Pa (0.1") for 1" filters. Velocity used for testing was about 360 fpm (based on 16 x 25 filter size and 1,000 cfm airflow).	<a href="https://efiling.energy.ca.gov/GetDocument.aspx?tn=222953">https://efiling.energy.ca.gov/GetDocument.aspx?tn=222953</a>
Comments on HVAC System Filter Requirements in 2019 Title 24, Part 6 45-Day Language	3/13/2018	Brett Singer, Iain Walker, LBNL	Supportive of 2" filter requirement and accommodation of 1" filters (0.1" max. pressure drop). Agree that acceptable pressure drops can be achieved by either one or two-inch filters, but disagrees that there is no correlation between MERV and filter pressure drop. Cite Stephens and Fazli data.	<a href="https://efiling.energy.ca.gov/GetDocument.aspx?tn=222959">https://efiling.energy.ca.gov/GetDocument.aspx?tn=222959</a>
Staff Analysis of Air Filter Pressure Drop and Air Filter Sizing	4/23/2018	California Energy Commission	Staff contends a 2" depth filter grille and filter may allow the return grille face area to be reduced by up to 50% compared to a 1" filter grille and filter while maintaining the same airflow rate and pressure drop. A study involving numerical modeling is cited.	<a href="https://efiling.energy.ca.gov/GetDocument.aspx?tn=223260">https://efiling.energy.ca.gov/GetDocument.aspx?tn=223260</a>
Comments - 15-Day Language Express Terms for Title 24 Building Energy Efficiency Standards	5/4/2018	Mishubishi Electric	Filter requirements "can cause significant hardship and redesign of entire lines if manufacturers have few workable solutions for meeting this requirement in a way that does not also require 2" filters or significant product redesign in very compressed product development timelines."	<a href="https://efiling.energy.ca.gov/GetDocument.aspx?tn=223325">https://efiling.energy.ca.gov/GetDocument.aspx?tn=223325</a>

AHRI Comments -  
Title 24-2019  
Revised Express  
Terms

5/7/2018

Air  
Conditioning,  
Heating, and  
Refrigeration  
Institute  
(AHRI)

Concerned that PTAC/PTHP equipment used in  
HRMF buildings cannot accommodate that  
requirement.

[https://efiling.energy.ca.gov/  
GetDocument.aspx?tn=223335](https://efiling.energy.ca.gov/GetDocument.aspx?tn=223335)