DOCKETED	
Docket Number:	21-BSTD-01
Project Title:	2022 Energy Code Update Rulemaking
TN #:	238158
Document Title:	Statewide Utility Codes and Standards Enhancement Team Comments on DOAS for 45-Day
Description:	N/A
Filer:	System
Organization:	Statewide Utility Codes and Standards Enhancement Team
Submitter Role:	Public
Submission Date:	6/8/2021 3:21:35 PM
Docketed Date:	6/8/2021

Comment Received From: Statewide Utility Codes and Standards Enhancement Team
Submitted On: 6/8/2021
Docket Number: 21-BSTD-01

Statewide Utility Codes and Standards Enhancement Team Comments on DOAS for 45-Day

Additional submitted attachment is included below.

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Comment on Dedicated Outdoor Air System (DOAS) Requirements – 45-Day Language

CALIFORNIA STATEWIDE UTILITY CODES AND STANDARDS TEAM

June 8, 2021

1. Introduction

The California Statewide Utility Codes and Standards Enhancement Team (Statewide CASE Team) appreciates the opportunity to participate in the review of the May 6, 2021 Express Terms 2022 Energy Code, Title 24 Parts 1 and 6 (45-Day Express Terms)[1].

The Statewide CASE Team actively supports code-setting bodies in developing and revising building energy codes and standards. The program's objective is to achieve significant energy savings and assist in meeting other energy-related state policy goals through the development of reasonable, responsible, and cost-effective code changes. Three California Investor Owned Utilities – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison – and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The Statewide CASE Team is actively supporting the California Energy Commission (Energy Commission) in updating the California Energy Code (Title 24, Part 6) for the 2022 code update cycle. Through CASE Reports, the Statewide CASE Team has provided the Energy Commission with the technical and cost-effectiveness information required to make informed judgments on proposed standards for promising energy efficiency design practices and technologies.

The Statewide CASE Team encourages the Energy Commission to consider the recommendations presented in this document.

[1]CEC Docket #21-BSTD-01, Document #237717
https://efiling.energy.ca.gov/GetDocument.aspx?tn=237717&DocumentContentId=70942

2. Background

The Statewide CASE Team's original Dedicated Outdoor Air Systems (DOAS) proposal is described in the HVAC Controls CASE Report,[2] and was amended as described in the HVAC CASE Report Addendum.[3] However, after reviewing stakeholders' feedback from the February 22, 2021 Draft 2022 Energy Code Express Terms (February Express Terms)[4] and holding additional conversations with commenters, the Statewide CASE Team recognizes that proposed requirements need additional clarification. There remains confusion on specifics of the requirements and intent of the proposed code changes. Interested parties have also expressed concern that the code language (both the February Express Terms and 45-Day Express Terms) does not adequately describe certain system configurations. For example, the language does not describe requirements if a DOAS unit provides ventilation air directly to another unit as seen in floor-by-floor units—a design that is common in humid climates. To resolve these issues, the Statewide CASE Team worked in collaboration with the Compliance Improvement team, Energy Commission, and stakeholders to find ways to improve the clarity of the language. The recommendations presented in this document aim to provide the necessary clarifications to minimize confusion and provide code language that applies to all design scenarios.

3. Summary of Recommended Revisions

To provide clarity and resolve outstanding issues, the Statewide CASE Team has reviewed the code language and recommended a reorganized version for the following sections:

- Exception 6 to Section 140.4(e): exception to requirements for economizers for DOAS systems.
- Section 140.4(p): Dedicated Outdoor Air Systems (DOAS).

These changes included the following:

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[2] CEC Docket #19-BSTD-03, Document # 234916
https://efiling.energy.ca.gov/GetDocument.aspx?tn=234916&DocumentContentId=67779

[3] CEC Docket #21-BSTD-01, Document #237693
https://efiling.energy.ca.gov/GetDocument.aspx?tn=237693&DocumentContentId=70914

[4] CEC Docket #19-BSTD-03, Document # 234930
https://efiling.energy.ca.gov/GetDocument.aspx?tn=236876&DocumentContentId=70030

1. The DOAS pathway utilizing the economizer exception listed under Section 140.4(p)1B in the 45-Day Express Terms was consolidated into Exception 6 to 140.4(e) through the following four changes:
    - DOAS unit sizing requirements of at least 0.3 CFM/square foot (Section 140.4(p) 1Bi in 45-Day Express Terms) were moved to subsection B to Exception 6 of Section 140.4(e);
    - Exhaust air heat recovery ratio requirements (Section 140.4(p)1Bii in 45-day Express Terms) were moved to subsection A to Exception 6 of Section 140.4(e);
    - Exhaust air heat recovery bypass control requirements (Section 140.4(p)1Biii in 45-Day Express Terms) were moved to subsection A to Exception 6 of Section 140.4(e);
    - Section 140.4(p)1 in the 45-Day Express Terms was deleted through this consolidation;
    - Subsections under 140.4(p) were renumbered.
2. The DOAS requirements under Section 140.4(p)3 & 140.4(p)4 of the 45-Day Express Terms were consolidated and clarified into one subsection: Section 140.4(p)3. These changes addressed configurations such as floor-by-floor air handler designs which were unclear in the 45-Day Express Terms.
3. Minor changes were made to the Exhaust Air Heat Recovery requirements listed under Section 140.4(q) of the 45-Day Express Terms. Section 140.4(q)3 was deleted along with now outdated references in Table 140.4-G and Table 140.4-H. These changes were related to the deleted pathway from 140.4(p)1A of the 45-Day Express Terms.

These changes significantly simplified the structure of the DOAS requirements. Included below is the recommended code language for DOAS followed by mark-ups to the 45-Day Express Terms. These changes do not impact the stringency of the measure. We appreciate the opportunity to provide these recommendations to the Energy Commission.

4. Proposed Code Language

The proposed changes to the code language are provided below. Changes Revisions to the 2019 code language that the Energy Commission published in the 45-Day Express Terms are underlined in black for the additions and ~~strikethrough in black~~ for deletions.

1.1 Recommended Code Language

The recommended code language is provided below with the revised language pertaining to DOAS presented in double-underlined in blue. This language is not a full

mark-up of the 45-Day Express Terms. This version is represents how the language would read with simplified mark-ups. The full mark-up of the 45-Day Express Terms is provided in the following section

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

A building complies with this section by being designed with and having constructed and installed a space-conditioning system that meets the applicable prescriptive requirements of Subsections (a) through (~~e~~g).

… sections omitted …

(e) **Economizers.**

1. Each cooling air handler that has a design total mechanical cooling capacity over ~~54,000~~33,000 Btu/hr, or chilled-water cooling systems without a fan orthat use induced airflow that has a cooling capacity greater than the systems listed in Table 140.4-C, shall include either:

   A. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or

   B. A water economizer capable of providing 100 percent of the expected system cooling load, at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

   EXCEPTION 1 to Section 140.4(e)1: Where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants, makes compliance infeasible.

EXCEPTION 2 to Section 140.4(e)1: Where the use of outdoor air for cooling will affect other systems, such as humidification, dehumidification, orsupermarket refrigeration systems, so as to increase overall building TDV energy use.

EXCEPTION 3 to Section 140.4(e)1: Systems serving ~~high-rise residential living quarters and~~ hotel/motel guest rooms.

EXCEPTION 4 to Section 140.4(e)1: Where comfort cooling systems have the cooling efficiency that meets or exceeds the cooling efficiency improvement requirements in TABLE 140.4-D.

EXCEPTION 5 to Section 140.4(e)1: Fan systems primarily serving computer rooms. See Section 140.9(a) for computer room economizer requirements.

EXCEPTION 6 to Section 140.4(e)1: In all climate zones, each air handler that has a design total mechanical cooling capacity less than 54,000 Btu/hr where ventilation is provided by a dedicated outdoor air system (DOAS)

with exhaust air heat recovery in accordance with 140.4(p) and the following:

A. The DOAS unit shall meet the exhaust air heat recovery ratio as specified in 140.4(q)1 and includes bypass or control to disable energy recovery as specified in 140.4(q)2.

B. The DOAS unit shall provide at least the minimum ventilation air flow rate as specified in Section 120.1(c)3 and provide no less than 0.3 cfm/ft2 during economizer conditions.

EXCEPTION 7 to Section 140.4(e)1: Where the use of an air economizer in controlled environment horticulture spaces will affect carbon dioxide enrichment systems.

… sections omitted …

(p) **Dedicated Outdoor Air Systems (DOAS).** HVAC systems which utilize a dedicated outdoor air system (DOAS) to condition, temper, or filter 100 percent outdoor air separate from local or central space-conditioning systems serving the same space shall meet the following criteria:

1. DOAS unit fan systems with input power less than 1 kW shall not exceed a total combined fan power of 1.0 watts per cfm. DOAS with fan power greater than or equal to 1 kW shall meet the requirements of Section 140.4 (c).
2. The DOAS supply air shall be delivered directly to the occupied space or at the outlet of any terminal heating or cooling coils and shall cycle off any zone heating and cooling equipment fans, circulation pumps, and terminal unit fans when there is no call for heating or cooling in the zone.

   EXCEPTION 1 to Section 140.4(p)2: Active chilled beam systems.

   EXCEPTION 2 to Section 140.4(p)2: Sensible-only cooling terminal units with pressure-independent variable-airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.

   EXCEPTION 3 to Section 140.4(p)2: Any configuration where a DOAS unit provides ventilation air through a downstream fan (a terminal box, air handling unit, or other space conditioning equipment) where the total system airflow can be reduced to ventilation minimum or the downstream fan power is no greater than 0.12 watts per cfm when space temperatures are within the thermostat dead band at low speed per manufacturers literature.
3. DOAS supply and exhaust fans shall have a minimum of three speeds to facilitate system balancing.
4. DOAS with mechanical cooling providing ventilation to multiple zones and

operating in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above 60°F when representative building loads or outdoor air temperature indicate that the majority of zones require cooling.

1.2 Mark-up of 45-Day Express Terms

This section presents a marked-up version of the 45-Day Express Terms. The Statewide CASE Team's recommended revisions are marked with double-underlined in blue for additions and ~~double-strikeout in blue~~ for deletions. The proposed revision would impact the following sections: Sections 100.1, Sections 140.4(e), 140.4(p) and 140.4(q).

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

ANSI/ASHRAE 84 is the American National Standards Institute / American Society of Heating, Refrigeration, and Air- conditioning Engineers document titled "Method of Testing Air-to-Air Heat/Energy Exchanger". 2020 (ANSI/ASHRAE 84- 2020)

…

AHRI 920 is the Air-Conditioning, Heating, and Refrigeration Institute document titled "Performance Rating of ~~DX-~~Direct Expansion-Dedicated Outdoor Air System Units" 2020 (~~ANSI/~~AHRI Standard 920 (I-P)-2020).

AHRI 1060 is the Air-Conditioning, Heating, and Refrigeration Institute document titled "Performance Rating of Air-to-Air Exchangers for Energy Recovery Ventilation Equipment," 2018 (AHRI Standard 1060 (I-P)-2018).

…

DEDICATED OUTDOOR AIR SYSTEM (DOAS) – A ventilation system which delivers 100 percent outdoor air and deliversventilation supply air to each space, either directly or in conjunction with local or central space-conditioning systems serving those same spaces such as a DX-DOAS, HRV, ERV, or custom ventilation only unit.~~/s~~

…

DX-DEDICATED OUTDOOR AIR SYSTEM UNITS (DX-DOAS)- a type of air-cooled, water-cooled, or water-source DOAS unitthat dehumidifies 100 percent outdoor air and includes reheat that is capable of controlling the supply dry-bulb temperature of the dehumidified air to the designed supply air temperature. This conditioned outdoor air is then delivered directly or indirectly to the conditioned spaces. It may precondition outdoor air by containing an enthalpy wheel, sensible wheel, desiccant wheel, plate heat exchanger, heat pipes, or other heat or mass transfer apparatus.

…

ENTHALPY RECOVERY RATIO (ERR) is a ratio of the change in enthalpy of the outdoor air supply to the difference in enthalpy between the entering supply airflow and the entering exhaust airflow, with no adjustment to account for that portion of the psychometric change in the leaving supply airflow that is the result of leakage of entering exhaust airflow rather than exchange of heat or moisture between the airstreams.

…

INTEGRATED SEASONAL COEFFICIENT OF PERFORMANCE (ISCOP) A seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the two COP values for the heating season of a DX-DOAS unit water or air source heat pump, expressed in W/W.

INTEGRATED SEASONAL MOISTURE REMOVAL EFFICIENCY (ISMRE) A seasonal efficiency number that is a combined value based on the formula listed in AHRI Standard 920 of the four dehumidification moisture removal efficiency (MRE) ratings required for DX-DOAS units, expressed in lb. of moisture/kWh.

…

SENSIBLE ENERGY RECOVERY RATIO is a ratio of the change in the dry-bulb temperature of the outdoor air supply to the difference in dry-bulb temperature between the outdoor air and entering exhaust airflow, with no adjustment to accountfor that portion of the dry-bulb temperature change in the leaving supply airflow that is the result of leakage of entering exhaust airflow rather than heat exchange between the airstreams.

SECTION 140.4 – PRESCRIPTIVE REQUIREMENTS FOR SPACE CONDITIONING SYSTEMS

A building complies with this section by being designed with and having constructed and installed a space-conditioning system that meets the applicableprescriptive requirements of Subsections (a) through (~~e~~g).

(e) **Economizers.**

2. Each cooling air handler that has a design total mechanical cooling capacity over ~~54,000~~33,000 Btu/hr, or chilled-water cooling systems without a fan orthat use induced airflow that has a cooling capacity greater than the systems listed in Table 140.4-C, shall include either:

   A. An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or

   B. A water economizer capable of providing 100 percent of the expected system cooling load, at outside air temperatures of 50°F dry-bulb and 45°F wet-bulb and below.

   EXCEPTION 1 to Section 140.4(e)1: Where special outside air filtration and treatment, for the reduction and treatment of unusual outdoor contaminants,makes compliance infeasible.

   EXCEPTION 2 to Section 140.4(e)1: Where the use of outdoor air for cooling will affect other systems, such as humidification, dehumidification, orsupermarket refrigeration systems, so as to increase overall building TDV energy use.

   EXCEPTION 3 to Section 140.4(e)1: Systems serving ~~high-rise residential living quarters and~~ hotel/motel guest rooms.

   EXCEPTION 4 to Section 140.4(e)1: Where comfort cooling systems have the cooling efficiency that meets or exceeds the cooling efficiency improvementrequirements in TABLE 140.4-D.

   'EXCEPTION 5 to Section 140.4(e)1: Fan systems primarily serving computer rooms. See Section 140.9(a) for computer room economizer requirements.

   ~~**EXCEPTION 6 to Section 140.4(e)1:** Systems design to operate at 100 percent outside air at all times.~~

   ~~**EXCEPTION 6 to Section 140.4(e)1** Each air handlerthat has a design total mechanical cooling capacity less than 54,000 Btu/hr that utilizes a dedicated outdoor air system~~

~~(such as a DX-DOAS, HRV, or ERVunit) for ventilation in accordance with 140.4(p)1B and 140.4(p)2 through 140.4(p)6.~~

EXCEPTION 6 to Section 140.4(e)1: In all climate zones, each air handler that has a design total mechanical cooling capacity less than 54,000 Btu/hr where ventilation is provided by a dedicated outdoor air system (DOAS) with exhaust air heat recovery in accordance with 140.4(p) and the following:

A. The DOAS unit shall meet exhaust air heat recovery ratio as specified in 140.4(q)1 and include bypass or control to disable energy recovery as specified in 140.4(q)2.

B. The DOAS unit shall provide at least the minimum ventilation air flow rate as specified in Section 120.1(c)3 and provide no less than 0.3 cfm/ft2 during economizer conditions

EXCEPTION 7 to Section 140.4(e)1: Where the use of an air economizer in controlled environment horticulture spaces will affect carbon dioxide enrichment systems.

TABLE 140.4-C CHILLED WATER SYSTEM COOLING CAPACITY

Climate Zones	Total Building Chilled Water System Capacity, Minus Capacity of the Cooling units with Air Economizers	
	Building Water-Cooled Chilled Water System	Air-Cooled Chilled Water Systems or District Chilled Water Systems
15	≥ 960,000 Btu/h (280 kW)	≥ 1,250,000 Btu/h (365 kW)
1-14	≥720,000 Btu/h (210 kW)	≥940,000 Btu/h (275 kW)
16	≥1,320,000 Btu/h (385 kW)	≥1,720,000 Bu/h (505 kW)

TABLE 140.4-D ECONOMIZER TRADE-OFF TABLE FOR COOLING SYSTEMS

Climate Zone	Efficiency Improvement [a]
1	70%
2	65%
3	65%
4	65%
5	70%
6	30%
7	30%
8	30%
9	30%
10	30%
11	30%
12	30%

[a] If a unit is rated with an annualized or part-load metric, ~~IPLV, IEER or SEER,~~ then to eliminate the required ~~air or water~~ economizer, only the applicable minimum cooling efficiency of the ~~HVAC~~ unit must be increased by the percentage shown. If the ~~HVAC~~ unit is only rated with a full load metric, ~~such as~~ like EER or COP cooling, then that metric must be increased by the percentage shown. To determine the efficiency required to eliminate the economizer, when the unit equipment efficiency is rated with an energy-input divided by work-output metric, the metric shall first be converted to COP prior to multiplying by the efficiency improvement percentage and then converted back to the rated metric.

13	30%
14	30%
15	30%
16	70%

2. If an economizer is required by Section 140.4(e)1, and an air economizer is used to meet the requirement, then it shall be:

   A. Designed and equipped with controls so that economizer operation does not increase the building heating energy use during normal operation; and

      EXCEPTION to Section 140.4(e)2A: Systems that provide 75 percent of the annual energy used for mechanical heating from site-recovered energy or asite-solar energy source.

   B. Capable of providing partial cooling even when additional mechanical cooling is required to meet the remainder of the cooling load.

   C. Designed and equipped with a device type and high limit shut off complying with TABLE 140.4-E.

TABLE 140.4-E AIR ECONOMIZER HIGH LIMIT SHUT OFF CONTROL REQUIREMENTS

Device Type[a]	**Climate Zones**	**Required High Limit (Economizer Off When):**	
		Equation[b]	**Description**
Fixed Dry Bulb	1, 3, 5, 11-16	TOA > 75°F	Outdoor air temperature exceeds 75°F
	2, 4, 10	TOA > 73°F	Outdoor air temperature exceeds 73°F
	6, 8, 9	TOA > 71°F	Outdoor air temperature exceeds 71°F
	7	TOA > 69°F	Outdoor air temperature exceeds 69°F
Differential Dry Bulb	1, 3, 5, 11-16	TOA > TRA°F	Outdoor air temperature exceeds return air temperature
	2, 4, 10	TOA > TRA-2°F	Outdoor air temperature exceeds return air temperature minus 2°F
	6, 8, 9	TOA > TRA-4°F	Outdoor air temperature exceeds return air temperature minus 4°F
	7	TOA > TRA-6°F	Outdoor air temperature exceeds return air temperature minus 6°F
Fixed Enthalpy[c] + Fixed Drybulb	All	hOA > 28 Btu/lb[c] or TOA > 75°F	Outdoor air enthalpy exceeds 28 Btu/lb of dry air[c] or Outdoor air temperature exceeds 75°F

[a] Only the high limit control devices listed are allowed to be used and at the setpoints listed. Others such as Dew Point, Fixed Enthalpy, Electronic Enthalpy, and Differential Enthalpy Controls, may not be used in any Climate Zone for compliance with Section 140.4(e)1 unless approval for use isprovided by the Energy Commission Executive Director.

[b] Devices with selectable (rather than adjustable) setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.

[c] At altitudes substantially different than sea level, the Fixed Enthalpy limit value shall be set to the enthalpy value at 75°F and 50% relative humidity. Asan example, at approximately 6,000 foot elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

D. The air economizer and all air dampers shall have the following features:

i. **Warranty.** 5-year Manufacturer warranty of economizer assembly.

ii. **Damper reliability testing.** Suppliers of economizers shall certify that the economizer assembly, including but not limited to outdoor air damper, return air damper, drive linkage, and actuator, have been tested and are able to open and close against the rated airflow and pressure of the system for 60,000 damper opening and closing cycles.

iii. **Damper leakage.** Economizer outdoor air and return air dampers shall have a maximum leakage rate of 10 cfm/sf at 250 Pascals (1.0 in. of water) when tested in accordance with AMCA Standard 500-D. The economizer outside air and return air damper leakage rates shall be certified to the Energy Commission in accordance with Section 110.0.

iv. **Adjustable setpoint.** If the high-limit control is fixed dry-bulb or fixed enthalpy + fixed dry-bulb then the control shall have an adjustable setpoint.

v. **Sensor accuracy.** Outdoor air, return air, mixed air, and supply air sensors shall be calibrated within the following accuracies.

1. Drybulb and wetbulb temperatures accurate to ±2°F over the range of 40°F to 80°F;
2. Enthalpy accurate to ±3 Btu/lb over the range of 20 Btu/lb to 36 Btu/lb;
3. Relative humidity (RH) accurate to ±5 percent over the range of 20 percent to 80 percent RH;

vi. **Sensor calibration data.** Data used for control of the economizer shall be plotted on a sensor performance curve.

vii. **Sensor high limit control.** Sensors used for the high limit control shall be located to prevent false readings, including but not limited to being properly shielded from direct sunlight.

viii. **Relief air system.** Relief air systems shall be capable of providing 100 percent outside air without over-pressurizing the building.

E. The space conditioning system shall include the following:

~~A~~i. Unit controls shall have mechanical capacity controls interlocked with economizer controls such that the economizer is at 100 percent open position when mechanical cooling is on and does not begin to close until the leaving air temperature is less than 45°F.

~~B~~ii. Direct Expansion (DX) units greater than 65,000 Btu/hr that control the capacity of the mechanical cooling directly based on occupied space temperature shall have a minimum of two stages of mechanical cooling capacity.

~~C~~iii. DX units not within the scope of Section 140.4(e)2E,B shall (i) comply with the requirements in TABLE 140.4-F, and (ii) shall have controls that do not false load the mechanical cooling system by limiting or disabling the economizer or by any other means except at the lowest stage of mechanical cooling capacity.

TABLE 140.4-F DIRECT EXPANSION (DX) UNIT EQUIREMENTS FOR COOLING STAGES AND COMPRESSOR DISPLACEMENT

Cooling Capacity	Minimum Number of Mechanical Cooling Stages	Minimum Compressor Displacement

≥ 65,000 Btu/h and < 240,000 Btu/h	3 stages	≤ 35% full load
≥ 240,000 Btu/h	4 stages	≤ 25% full load

3. Systems that include a water economizer to meet Section 140.4(e)1 shall include the following:

   A. Maximum pressure drop. Precooling coils and water-to-water heat exchangers used as part of a water economizer shall either have a waterside pressuredrop of less than 15 feet of water, or a secondary loop shall be installed so that the coil or heat exchanger pressure drop is not contributing to pressure drop when the system is in the normal cooling (non-economizer) mode.

   B. Economizer systems shall be integrated with the mechanical cooling system so that they are capable of providing partial cooling even when additionalmechanical cooling is required to meet the remainder of the cooling load. Controls shall not false load the mechanical cooling system by limiting or disabling the economizer or by any other means, such as hot gas bypass, except at the lowest stage of mechanical cooling.

… sections omitted …

(p) **Dedicated Outdoor Air Systems (DOAS).** HVAC systems which utilize a dedicated outdoor air system (DOAS) such as a DX-DOAS, HRV or ERV unit to condition, temper, or filter 100 percent outdoor air separate from local or central space-conditioning systems serving the same space shall meet the following criteria:

~~1. Provide each space with either of the following configurations:~~

~~A. A DOAS unit and a separate independent space conditioning system in which the independent space conditioning system in accordance with the economizer requirements specified by Section 140.4(e) and the DOAS unit in accordance with the exhaust air heat recovery requirements specified in Section 140.4(q).~~

~~B. A DOAS unit which meets or exceeds the following criteria and a separate space cooling system:~~

~~i. Provides at least the minimum ventilation air flow rate as specified in Section 120.1(e)3 and provides no less than 0.3 cfm/ft² during economizer operation.~~

~~ii. Ventilation sensible energy recovery ratio of at least 60 percent or enthalpy recovery ratio of at least 50 percent at full flow cooling design conditions and heating design condition.~~

~~iii. Energy recovery bypass or control to directly economize with ventilation air based on outdoor air temperature limits specified in TABLE 140.4-E.~~

~~**EXCEPTION 1 to Section 140.4(p)1:** Systems installed for the sole purpose of providing makeup air for exhausting toxic, flammable materials, paint, corrosive fumes or dust, dryer exhaust, or commercial kitchen hoods used for collecting and removing grease vapors and smoke.~~

~~2. DOAS supply and exhaust fans shall have a minimum of 3 speeds to facilitate system balancing.~~

~~3. Heating and cooling equipment fans, heating and cooling circulation pumps, and terminal unit fans shall cycle off and terminal unit primary cooling air shallbe shut off when there is no call for heating or cooling in the zone.~~

~~**EXCEPTION to Section 140.4(p)3:** Fans used for heating and cooling using less than 0.12 watts per cfm, as certified by the manufacturer, may operatewhen space temperatures are within the thermostat deadband to provide destratification and air mixing in the space.~~

~~4. The DOAS supply air shall be delivered directly to the occupied space or downstream of the terminal heating/or cooling coils.~~

~~**EXCEPTION 1 to Section 140.4(p)4:** Active chilled beam systems.~~

~~**EXCEPTION 2 to Section 140.4(p)4:** Sensible-only cooling terminal units with pressure-independent variable-airflow regulating devices limiting the DOASsupply air to the greater of latent load or minimum ventilation requirements.~~

~~**EXCEPTION 3 to Section 140.4(p)4:** Terminal heating and/or cooling units that comply with the low fan power allowance requirements in Exception toSection 140.4(p)3.~~

~~5. DOAS with mechanical cooling providing ventilation to multiple zones and operating in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above 60°F when representative building loads or outdoor air temperature indicate that the majority of zonesrequire cooling.~~

~~6. DOAS with a total fan system input power less than 1 kW shall not exceed a total combined fan power of 1.0 W/cfm. DOAS with fan power greater than orequal to 1 kW shall meet the requirements of Section 140.4 (c).~~

1. DOAS unit fan systems with input power less than 1 kW shall not exceed a total combined fan power of 1.0 W/cfm. DOAS with fan power greater than or equal to 1 kW shall meet the requirements of Section 140.4 (c).

2. The DOAS supply air shall be delivered directly to the occupied space or at the outlet of any terminal heating or cooling coils and shall cycle off any zone heating and cooling equipment fans, circulation pumps, and terminal unit fans when there is no call for heating or cooling in the zone.

   EXCEPTION 1 to Section 140.4(p)2: Active chilled beam systems.

   EXCEPTION 2 to Section 140.4(p)2: Sensible-only cooling terminal units with pressure-independent variable-airflow regulating devices limiting the DOAS supply air to the greater of latent load or minimum ventilation requirements.

   EXCEPTION 3 to Section 140.4(p)2: Any configuration where a DOAS unit provides ventilation air to a downstream fan (a terminal box, air handling unit, or other space conditioning equipment) where the total system airflow can be reduced to ventilation minimum or the downstream fan power is no greater than 0.12 watts per cfm when space temperatures are within the thermostat dead band (at low speed per manufacturers literature).

3. DOAS supply and exhaust fans shall have a minimum of three speeds to facilitate system balancing.

4. DOAS with mechanical cooling providing ventilation to multiple zones and operating in conjunction with zone heating and cooling systems shall not use heating or heat recovery to warm supply air above 60°F when representative building loads or outdoor air temperature indicate that the majority of zones require cooling.

(g) **Exhaust Air Heat Recovery.** Fan systems designed to operate to the criteria listed in either Table 140.4-G or Table 140.4-H shall include an exhaust air heat recovery system which meets the following:

1. A sensible energy recovery ratio of at least 60 percent or an enthalpy recovery ratio of at least 50 percent for both heating and cooling design conditions.

2. Energy recovery bypass or control to disable energy recovery and to directly economize with ventilation air based on outdoor air temperature limits specified in TABLE 140.4-E. For energy recovery systems where the transfer of energy cannot be stopped, bypass shall prevent the total airflow rate of either outdoor air or exhaust air through the energy recovery exchanger from exceeding 10% of the full design airflow rate.

   EXCEPTION ~~1~~ to Section 140.4(g)2: For DOAS units with the capability to shut off when a separate ~~independent~~ space-conditioning system serving the same space meets the economizer requirements ~~specified by~~in section 140.4(e)1A ~~is economizing~~.

~~3. For a DOAS unit and a separate independent space conditioning system meeting the requirements of 140.4(p)1A the design supply fan airflow rate shall be the total airflow of only the DOAS unit.~~

EXCEPTION 1 to Section 140.4(g): Systems meeting Section 140.9(c) Prescriptive Requirements for Laboratory and Factory Exhaust Systems.

EXCEPTION 2 to Section 140.4(g): Systems serving spaces that are not cooled and that are heated to less than 60°F.

EXCEPTION 3 to Section 140.4(g): Where more than 60 percent of the outdoor air heating energy is provided from site-recovered energy inClimate Zone 16.

EXCEPTION 4 to Section 140.4(g): Sensible recovery ratio requirements at heating design conditions are exempted for Climate Zone 15.

EXCEPTION 5 to Section 140.4(g): Sensible recovery ratio requirements at cooling design conditions are exempted for Climate Zone 01.

EXCEPTION 6 to Section 140.4(g): Where the sum of the airflow rates exhausted and relieved within 20 feet of each other is less than 75 percentof the design outdoor airflow rate, excluding exhaust air that is either:

1. used for another energy recovery system,
2. not allowed by California Mechanical Code (Title 24, Part 4) (CMC)for use in energy recovery systems with leakage potential, or
3. of Class 4 as specified in Section 120.1(g).

EXCEPTION 7 to Section 140.4(g): Systems expected to operate less than 20 hours per week.

TABLE 140.4-G: ENERGY RECOVERY REQUIREMENTS BY CLIMATE ZONE AND PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW (<8,000 HOURS / YEAR)

% Outdoor Air at Full Design Airflow	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
≥10% and <20%	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
≥20% and <30%	≥15,000	≥20,000	NR	NR	NR	NR	NR	NR	NR	NR	≥18,500	≥18,500	≥18,500	≥18,500	≥18,500	≥18,500
≥30% and <40%	≥13,000	≥15,000	NR	NR	NR	NR	NR	NR	NR	NR	≥15,000	≥15,000	≥15,000	≥15,000	≥15,000	≥15,000
≥40% and <50%	≥10,000	≥12,000	NR	NR	NR	NR	NR	NR	NR	≥22,000	≥10,000	≥10,000	≥10,000	≥10,000	≥10,000	≥10,000
≥50% and <60%	≥9,000	≥10,000	NR	≥18,500	NR	NR	NR	NR	NR	≥17,000	≥8,000	≥8,000	≥8,000	≥8,000	≥8,000	≥8,000
≥60% and <70%	≥7,000	≥7,500	NR	≥16,500	NR	NR	NR	NR	≥20,000	≥15,000	≥7,000	≥7,000	≥7,000	≥7,000	≥7,000	≥7,000
≥70% and <80%	≥6,500	≥7,000	NR	≥15,000	NR	NR	NR	NR	≥17,000	≥14,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000
≥80%	≥4,500	≥6,500	NR	≥14,000	NR	NR	NR	NR	≥15,000	≥13,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

1. **Flow rates in Table 140.4-G represent the design supply fan airflow rate in CFM.**
2. **For a DOAS unit providing outdoor air to another space-conditioning system, ~~and a separate independent space-conditioning system meeting the requirements of 140.4(p)1A,~~ the full design supply airflow rate shall bethe total airflow of only the DOAS unit.**

TABLE 140.4-H: ENERGY RECOVERY REQUIREMENTS BY CLIMATE ZONE AND PERCENT OUTDOOR AIR AT FULL DESIGN AIRFLOW (≥8,000 HOURS / YEAR)

% Outdoor Air at Full Design Airflow	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
≥10% and <20%	≥10,000	≥10,000	NR	NR	NR	NR	NR	NR	NR	≥40,000	≥40,000	≥20,000	≥10,000	≥10,000	≥10,000	≥10,000
≥20% and <30%	≥2,000	≥5,000	≥13,000	≥9,000	≥9,000	NR	NR	NR	NR	≥15,000	≥15,000	≥5,000	≥5,000	≥5,000	≥5,000	≥5,000
≥30% and <40%	≥2,000	≥3,000	≥10,000	≥6,500	≥6,500	NR	NR	NR	≥15,000	≥7,500	≥7,500	≥3,000	≥3,000	≥3,000	≥3,000	≥3,000
≥40% and <50%	≥2,000	≥2,000	≥8,000	≥6,000	≥6,000	NR	NR	NR	≥12,000	≥6,000	≥6,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥50% and <60%	≥2,000	≥2,000	≥7,000	≥6,000	≥6,000	NR	NR	≥20,000	≥10,000	≥5,000	≥5,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥60% and <70%	≥2,000	≥2,000	≥6,000	≥6,000	≥6,000	NR	NR	≥18,000	≥9,000	≥4,000	≥4,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥70% and <80%	≥2,000	≥2,000	≥6,000	≥5,000	≥5,000	NR	NR	≥15,000	≥8,000	≥3,000	≥3,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000
≥80%	≥2,000	≥2,000	≥6,000	≥5,000	≥5,000	NR	NR	≥12,000	≥7,000	≥3,000	≥3,000	≥2,000	≥2,000	≥2,000	≥2,000	≥2,000

1. **Flow rates in Table 140.4-G represent the design supply fan airflow rate in CFM.**
2. **For a DOAS unit providing outdoor air to another space-conditioning system, ~~and a separate independent space-conditioning system~~**

~~**meeting the requirements of 140.4(p)1A,**~~ **the full design supply airflow rate shall bethe total airflow of only the DOAS unit.**

NOTE: Authority: Sections 25213, 25218, 25218.5, 25402 and 25402.1, Public Resources Code. Reference: Sections 25007, 25008, 25218.5, 25310, 25402, 25402.1,
25402.4, 25402.8, and 25943, Public Resources Code.