

2021 WSEC-C MECHANICAL NAVIGATING THE NEW REQUIREMENTS FOR SPACE HEATING SYSTEMS



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- ▶ Classroom and webinar training
- ▶ We administer the technical support and compliance documentation webtool



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Codes

Increasing progressive effectiveness of energy codes

The NEEA Codes and Standards program supports regional stakeholders in the development and adoption, training and implementation of energy codes. States engage in the code development process along different cycles and code versions, but all states now use the International Energy Conservation Code (IECC) as a baseline for their commercial energy codes. All states except Oregon now use the IECC as the basis of their residential code. The adoption of codes is the responsibility of state code boards or agencies. Official state-by-state energy code information can be found on state building code websites:

Idaho - <http://dbs.idaho.gov/boards/index.html>

Oregon - <http://www.cbs.state.or.us/external/bcd/>

Washington - <https://sbcc.wa.gov/>

Montana - <http://svc.mt.gov/gov/boards/>



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WSEC technical support services are made possible thanks to the generous support of the Northwest Energy Efficiency Alliance

www.neea.org

Today's Presentation

- ▶ This presentation represents ETC's **unofficial** interpretation of code intent.
- ▶ Our technical support team is not an affiliate, nor do we speak for the Washington State Building Code Council (SBCC).
- ▶ The technical support we provide is advisory only and non-binding.



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Topics we'll discuss today ~

1. Heat pump requirement for prescriptive space heating compliance
2. Exceptions allowing electric resistance and fossil fuel heating equipment
3. Heat pump supplemental heating
4. Fossil fuel space heating alternate compliance path
5. Space heating in semi-heated spaces
6. Space heating in shell & core projects
7. Alterations to space heating systems in existing buildings
8. DOAS requirements for energy recovery performance, fan power limits and supplemental heating & cooling (tempering)
9. Q&A

2021 WSEC-C Prescriptive Space Heating Compliance Path

“HVAC heating energy shall NOT be provided by electric resistance or fossil fuel combustion appliances.”

PRESCRIPTIVE SPACE HEATING = HEAT PUMP

Examples of space heating equipment that do not comply prescriptively:

- ▶ Electric resistance equipment – baseboards, wall heaters, fan coils, VAV terminal reheat units, unit heaters, infrared heaters, furnaces, boilers, etc.
- ▶ Fossil fuel equipment – Warm-air furnaces, duct furnaces, unit heaters, infrared heaters, boilers, etc.

Equipment Efficiency Comparison

	COP
FOSSIL FUEL SPACE HEATING	0.80 - 0.90
ELECTRIC RESISTANCE SPACE HEATING	1.0
ELECTRIC HEAT PUMP SPACE HEATING	2.0 - 5.0

COP = Energy Output/Energy Input

Ductless Single Zone Heat Pumps

Wall mount ductless



Ceiling mount ductless



Outdoor unit for each zone



Images courtesy of Mitsubishi

Split System Heat Pumps

Ducted split system heat pumps



Image courtesy of Trane

Split system heat pump outdoor unit



Image courtesy of Carrier

VRF Heat Pump Systems

Ducted fan-coils



Image courtesy of Mitsubishi

Ductless fan-coils

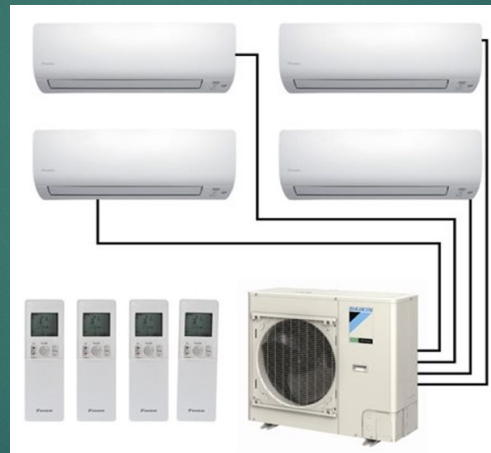


Image courtesy of Daikin

- ▶ Multiple fan coils can serve a single zone without simultaneous heating and cooling
- ▶ For spaces with multiple zones, system can deliver cooling energy to one zone and heating energy to another

Packaged Heat Pump Air Handlers

Packaged rooftop heat pump



Image courtesy of Trane

Packaged vertical heat pump, exterior wall-mounted



Image courtesy of Bard

Water Source Heat Pumps

Water Source Heat Pump System

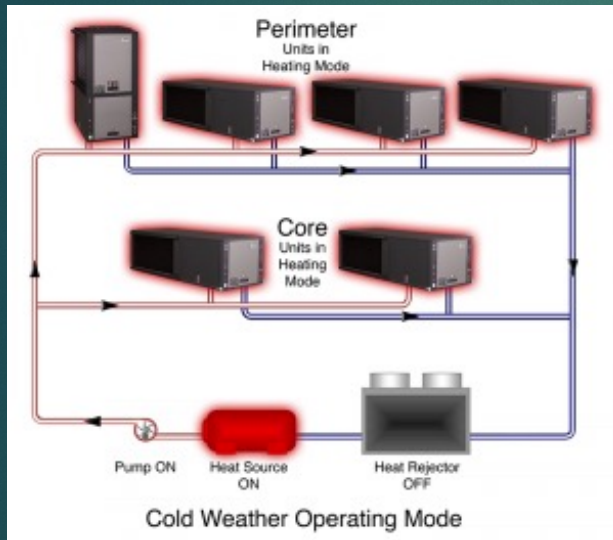


Image courtesy of ClimateMaster

Air to Water Heat Pumps



Image courtesy of Apricus

Central Plant Heat Pump Systems

6-pipe water-to-water heat pumps

CWU GEO ECO Plant

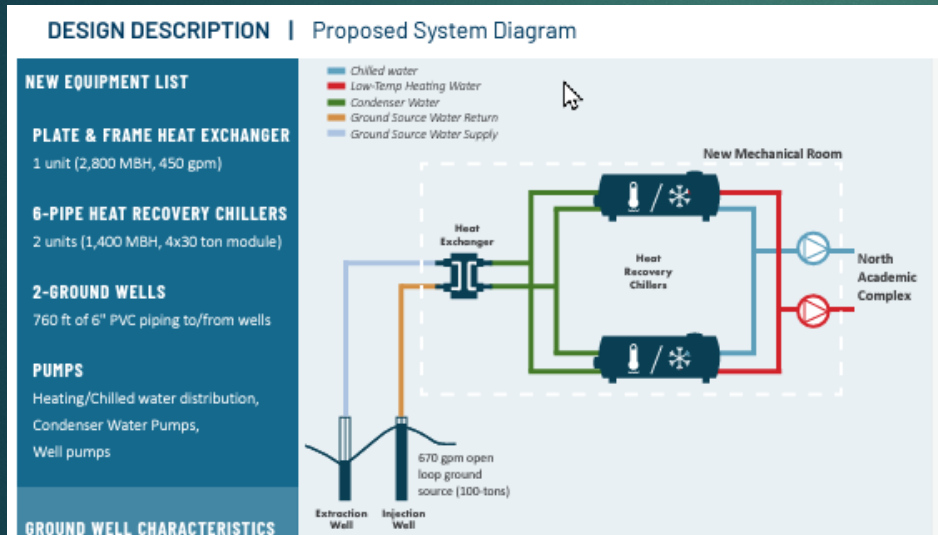


Image courtesy of Central Washington University

Image courtesy of McKinstry

Which project types does the new space heating compliance path apply to?

- ▶ Space heating systems in new buildings and additions
- ▶ New space heating systems added to an existing building
- ▶ Spaces where there is a change of occupancy per C505.3:
 - Group F, S or U converted to another occupancy
 - Commercial use converted to Group R dwelling unit
 - Group R dwelling unit converted to a commercial use or occupancy
- ▶ Buildings when there is a change in space conditioning from low-energy or semi-heated to fully conditioned

When is Electric Resistance or Fossil Fuel Space Heating Allowed?

Heat pumps are required, however, there are **EXCEPTIONS** that allow electric resistance (ER) and/or fossil fuel (FF) heating equipment

- ▶ **Dwelling & sleeping units (ER)** – Wattage limitations based on Climate Zone
- ▶ **Small conditioned buildings < 2,500 SF (ER)**
- ▶ **Essential facilities (ER and/or FF)** – Groups I-2 and I-3 occupancies that by regulation are required to have redundant emergency backup systems
- ▶ **Specific condition areas (ER and/or FF)** – Discrete areas of buildings used specifically for research, health care, process applications or other specific conditions if heat pumps cannot practicably serve the space heating needs (requires AHJ pre-approval)

Exceptions allowing ER and/or FF heating equipment

- ▶ **Low heating capacity (ER)** – Buildings or discrete areas with total installed HVAC heating capacity < **2.5 watt/SF**
- ▶ **Freeze protection systems (ER)** – Allowed for specifically freeze protection in spaces with $\leq 45^{\circ}\text{F}$ (7°C) indoor design temperature
- ▶ **Small systems (ER and/or FF)** – Where total combined capacity of all small ER and FF equipment is < 5% of total building heating capacity, or serves < 5% of the total conditioned floor area (includes decorative appliances)
- ▶ **Temporary systems (ER)** – Future tenant spaces that are unfinished and unoccupied may be temporarily semi-heated with ER equipment

Exceptions allowing ER and/or FF heating equipment

- ▶ **Tempered kitchen make-up air (ER and/or FF)** – Kitchen exhaust systems are permitted to use **ER** heating equipment in Climate Zones 4/5 and **FF** heating equipment in Climate Zone 5
- ▶ **Pasteurization systems (ER)** – Heat controls for supply water temperature reset for hydronic systems serving a pasteurization cycle
- ▶ **Heat tape (ER heat trace)** – Freeze protection for water-filled equipment and piping located outside the building thermal envelope
- ▶ **Heat pump defrost cycle (ER)**

Exceptions allowing ER and/or FF heating equipment

Heat pump supplemental heating

- ▶ Exceptions are based on heat pump type:
 - Air-to-air heat pumps – **ER** supplemental heating is permitted
 - Air-to-water heat pumps – **ER** in Climate Zones 4/5 and **FF** in Climate Zone 5 are permitted
 - Ground source heat pumps – **ER** supplemental heating is permitted
 - **There is NO exception allowing ER or FF for water-to-air (WSHP) systems**
- ▶ Heat pump compressor shall be configured as the first stage of heating
- ▶ Controls shall be configured to prevent supplemental heater operation when the heating load can be met by the heat pump alone
- ▶ Various other eligibility conditions apply, including maximum allowed heat pump capacity relative to supplemental heating capacity

C403.1.4
C403.4.1.1

Exceptions allowing ER and/or FF heating equipment

DOAS ERV auxiliary/supplemental heating

- ▶ Allowances for DOAS serving buildings or portions of buildings that do not have hydronic heating systems:
 - **ER** auxiliary/supplemental in Climate Zones 4/5
 - **FF** in Climate Zone 5
- ▶ Ventilation supply air heating allowances
 - Supplemental heating to temper supply air to up to 55°F (13°C)
 - Auxiliary heating to preheat OSA when the outdoor temperature is 35°F (2°C) or below to prevent frost/damage to the unit

C403.1.4
C403.3.5.5
C403.7.3

Exceptions allowing ER and/or FF heating equipment

ALTERNATIVE sources of space heating energy

- ▶ **Pre-existing district energy (FF)** – Steam or hot water district energy systems that serve multiple buildings, that utilize **FF** equipment as the primary source of heat energy. Must be pre-existing to the effective date of the 2021 WSEC-C.
- ▶ **Low carbon district energy** – Complies with the 2021 WSEC-C definition for *low-carbon district energy exchange system, OR low-carbon district cooling and heating or heating only systems*
- ▶ **On-site & off-site renewable energy** – Heat energy derived from renewable energy sources

Fossil Fuel Space Heating Alternate Compliance Path

C401.3 Allows fossil fuel equipment as the primary source of space heating

- ▶ C403.1.4 Modification – “HVAC heating energy shall not be provided by electric resistance ~~or fossil fuel combustion~~ appliances.”
- ▶ **Additional energy credits are required per Table C401.3.3, which is in addition to the number of Additional Energy Efficiency Measure credits that are required based on occupancy group per Section C406.1.**
- ▶ For mixed fuel buildings, the number of additional credits is adjusted based on the total fossil fuel space heating output capacity, relative to the overall output capacity of all space heating systems in the project.

2021 WSEC-C Fossil Fuel Space Heating Compliance Path

**TABLE C401.3.3
ADDITIONAL CREDITS REQUIRED**

Measure Title	Applicable Section	Occupancy Group					
		Group R-1	Group R-2	Group B	Group E	Group M	All Other
New building - Additional efficiency credits required for space heating systems using the fossil fuel pathway	C401.3.3.1	7	24	101	38	111	56
New building - Additional efficiency credits required for service water heating systems using the fossil fuel pathway	C401.3.3.2	198	212	27	17	79	107
Building additions - Additional efficiency credits required for space heating systems using the fossil fuel pathway	C401.3.3.1	4	12	51	19	56	28
Building additions - Additional efficiency credits required for service water heating systems using the fossil fuel pathway	C402.3.3.2	99	106	14	9	40	54

For mixed fuel buildings –
CR = A x (C-B)/D

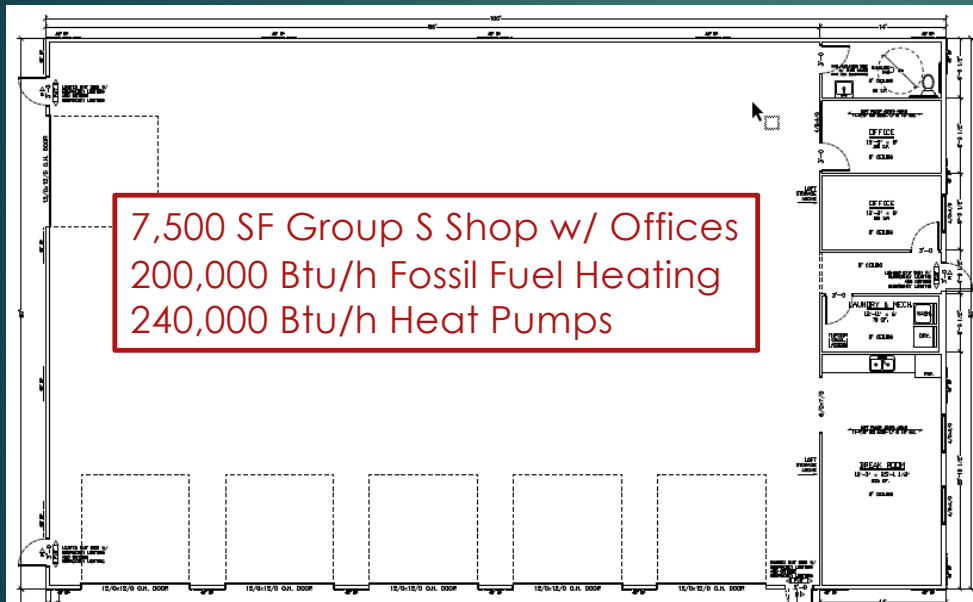
CR = Additional Credits Required

A = Baseline additional credits required

(C-B) = Total fossil fuel space heating capacity minus the total capacity of all equipment eligible for a C403.1.4 exception

D = Total capacity of all space heating equipment

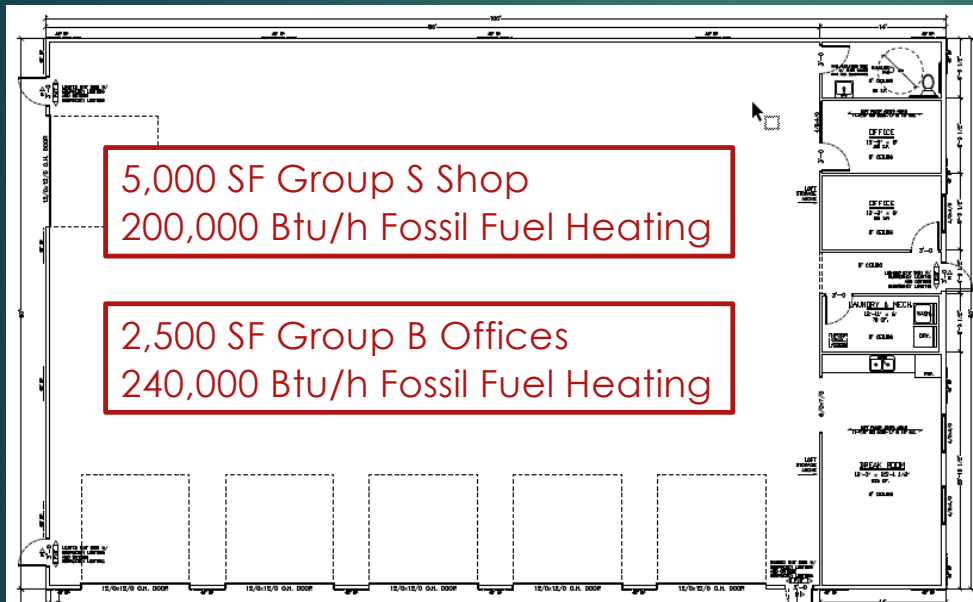
Mixed Fuel Building Example



EXAMPLE – New Building

- ▶ 440,000 Btu/h Total Output Heating Capacity
- ▶ Fossil Fuel Capacity:
 $200,000 / 440,000 = 45.5\%$
- ▶ “All Other” Occupancies
Additional Credits Required = **56**
- ▶ $56 \times 45.5\% = 25.5$ Additional Efficiency Measure Credits

Mixed Occupancy Building Example



EXAMPLE – New Building

- ▶ 440,000 Btu/h Total Fossil Fuel Output Heating Capacity
- ▶ Additional Credits Required
 - Group B Occupancy = **101**
 - 2,500 SF / 7,500 SF = 33.3%
 - All Other Occupancies = **56**
 - 5,000 SF / 7,500 SF = 66.7%
 - $(101 \times 33.3\%) + (56 \times 66.7\%) = 71$
- ▶ **71 Additional Efficiency Measure Credits**

Semi-Heated Spaces

NEW – Electric resistance (ER) heating equipment is now permitted in semi-heated spaces

- ▶ Heating system capacity in semi-heated space is limited to 8 Btuh/sf (2.3 watts/sf)
- ▶ **C403.1.4 Freeze protection (Exception #15)** – Allowed for freeze protection in spaces with $\leq 45^{\circ}\text{F}$ (7°C) indoor design temperature.
- ▶ **C402.1.1.2 Heat trace** (No change from 2018 WSEC-C)
 - Temperature maintenance systems (Section C404.7.2) provided for freeze protection of piping and equipment **only** within the semi-heated space
 - Note - Heat trace system capacity is not included in total space conditioning capacity calcs

C403.1.4
C402.1.1.2
C404.7.2

Semi-Heated Spaces

REVISED – Heat pumps are permitted in semi-heated spaces

- ▶ **C402.1.1.2 Heat pumps** – Semi-heated building or space is permitted to be served by heat pumps that do not have electric resistance back up, and are controlled by a heating only thermostat

REVISED – Fossil fuel fired equipment is permitted in semi-heated spaces provided it complies with the Fossil Fuel Compliance Path



Image courtesy of King Electric



Image courtesy of Carrier

C401.3.3
C401.3.5
C402.1.1.2

Shell & Core Buildings



Shell & Core Buildings

- ▶ HVAC systems installed in a Shell & Core project
 - Shall comply with either the Prescriptive or Fossil Fuel Compliance Path
 - The required number of Additional Energy Efficiency Measure credits are based on the occupancy group of the future initial tenant improvement, including additional energy credits required for the Fossil Fuel Compliance Path, if applicable
- ▶ Finished core spaces such as entrance lobbies, elevator lobbies and stairwells shall comply with all applicable provisions as occupied spaces
- ▶ **C403.1.4 Temporary systems (Exception #13)** – Spaces that are unfinished and unoccupied may be temporarily heated to $\leq 40^{\circ}\text{F}$ with **ER** equipment

Initial tenant improvement = Tenant space first build out

C401.2
C403.1.4

Existing Buildings – Space Heating Alterations

REVISED – Addition or Replacement of Existing Heating Appliances

- ▶ Section C503.4.6 applies to the installation of a new or replacement heating appliance connected to an existing distribution system
- ▶ 5 compliance options depending on the scope of the alteration:
 - 1) Comply as required for new construction per the prescriptive space heating compliance path (ie heat pumps) per Section C403.1.4
 - 2) Qualify for an exception to the prescriptive space heating compliance path
 - 3) Comply with the Fossil Fuel Alternate Compliance Path and achieve the required number of additional energy efficiency credits for **additions**
 - 4) **Comply with an alternate compliance option per Table C503.4.6**
 - 5) **Qualify for an exception to Section C503.4.6**

C503.4.6
C403.1.4
C401.3

Existing Buildings – Space Heating Alterations

Table C503.4.6 provides alternate compliance options for:

- ▶ Replacement unit is the same equipment type as the equipment being replaced, with a ***larger output capacity***
- ▶ Replacement unit is a ***different equipment type*** than the equipment being replaced

**TABLE C503.4.6
COMPLIANCE OPTIONS FOR MECHANICAL HEATING EQUIPMENT ALTERATIONS**

Proposed Heating Equipment Type ^a	Heating Efficiency Table Reference	Alternate Compliance Options to Section C403.1.4
1 Air-Cooled Unitary Heat Pumps	Table C403.3.2(2)	<p>1. Compliance with C403.1.4, except heat pump rated capacity in accordance with Section C403.1.4 exception 5d is permitted to be sized equal to the supplemental internal resistance heating capacity in Climate Zone 4 or 5^e</p> <p>2. Compliance with C403.1.4, except electric resistance mixed air preheat is permissible^e</p>
2 Packaged terminal, single-package vertical, and room air-conditioner heat pumps	Table C403.3.2(4)	1. Compliance with C403.1.4, except heat pump rated capacity in accordance with Section C403.1.4 Exception 5d is permitted to be sized equal to the supplemental internal resistance heating capacity in Climate Zone 4 or 5
3 Furnaces, duct furnaces, and unit heaters	Table C403.3.2(5)	1. Efficiency: +5% ^b
4 Gas-fired hot water boilers with fewer than 80% of served coils replaced	Table C403.3.2(6)	1. Efficiency: +5% ^b
5 Variable refrigerant flow air-to-air and applied heat pumps	Table C403.3.2(9)	No alternate compliance option
6 DX-DOAS equipment	Table C403.3.2(12) and Table C403.3.2(13)	1. DX-DOAS is provided with heat recovery if not required by C403.3.5.1.
7 Water-source heat pumps	Table C403.3.2(14)	No alternate compliance option

All heat pump requirements are **the same as for new construction**, except electric resistance supplemental heating capacity limitations are less stringent

Existing fuel-fired heating equipment **can be replaced with like-for-like equipment with larger capacity than the equipment being replaced**, provided new equipment complies with **better than code** heating efficiency criteria

Existing Buildings – Space Heating Alterations

EXCEPTIONS to Section C503.4.6

- ▶ Replacement unit is the same equipment type as the equipment being replaced, with the **same or smaller output capacity**

For example, like-for-like replacement of a gas rooftop unit is OK provided the heating output capacity of the new equipment is \leq the capacity of the equipment being replaced

- ▶ Where compliance with the prescriptive space heating requirements of Section C403.1.4 would trigger an unplanned utility electrical service upgrade, based on the NEC 220.87 method for determining existing loads

Existing Buildings – Space Heating Alterations

Additional EXCEPTIONS to Section C503.4.6

- ▶ Heating equipment served by an unaltered central plant – VAV terminals; hydronic & VRF fan coils; electric duct heaters, water source heat pumps
- ▶ Air handling equipment with hydronic coils served by an unaltered heating water central plant
- ▶ Air handling equipment designed for 100% OSA that's not subject to the DOAS provisions (make-up air for kitchen hoods, for example)
- ▶ Replacement of existing oil-fired boilers
- ▶ Replacement of existing steam boilers with steam distribution terminals

Existing Buildings – New Space Heating Systems

- ▶ Section C503.4.1 applies to the installation of a new space heating system that includes new heating appliance(s) and associated distribution system components
- ▶ 3 compliance options available:
 - 1) Comply as required for new construction per the prescriptive space heating compliance path (ie heat pumps) per Section C403.1.4
 - 2) Qualify for an exception to the prescriptive space heating compliance path
 - 3) Comply with the Fossil Fuel Alternate Compliance Path and achieve the required number of additional energy efficiency credits for **new construction**

C503.4.1
C403.1.4
C401.3

Occupancies Requiring DOAS

**Table C403.3.5
Occupancy Classifications Requiring DOAS**

Occupancy Classification^a	Inclusions	Exempted
A-1	All occupancies not specifically exempted	Television and radio studios
A-2	Casinos (gaming area)	All other A-2 occupancies
A-3	Lecture halls, community halls, exhibition halls, gymnasiums, courtrooms, libraries, places of religious worship	All other A-3 occupancies
A-4, A-5		All occupancies excluded
B	All occupancies not specifically exempted	Food processing establishments including commercial kitchens, restaurants, cafeterias; laboratories for testing and research; data processing facilities and telephone exchanges; air traffic control towers; animal hospitals, kennels, pounds; ambulatory care facilities
F, H, I, R, S, U		All occupancies excluded
E, M	All occupancies included	

No scope changes in the 2021 WSEC-C

DOAS Energy Recovery

- ▶ DOAS equipment energy recovery performance shall be at least:
 - **68% sensible recovery effectiveness, calculated per Equation 4-9**

(Equation 4-9)

$$\text{Sensible Recovery Effectiveness} = \frac{T_{OA} - T_{SA}}{T_{OA} - T_{RA}}$$

Where:

- T_{OA} = Design outdoor air dry bulb temperature entering the energy recovery device
- T_{SA} = Supply air dry bulb temperature leaving the energy recovery device at design temperatures and airflow conditions, as selected for the proposed DOAS unit(s)
- T_{RA} = Design return air dry bulb temperature

- **60% enthalpy recovery ratio, calculated at design conditions**
- ▶ Exceptions
 - Systems exclusively used for makeup air for systems exhausting toxic air
 - Heat recovery and energy recovery ventilators (rated and listed in accordance with HVI 920) can demonstrate compliance using the adjusted sensible recovery effectiveness (ASRE) rating of the equipment at 32°F test conditions.

Tempering of DOAS Supply Air

▶ Supplemental Heating

- C403.7.3 Ventilation air heating control – **Ventilation supply air supplemental heating**, that operates in conjunction with zone heating & cooling systems, to **temper supply air to up to 55°F (13°C)**
- Refer to Section C403.1.4 for additional information regarding DOAS auxiliary/supplemental heating equipment type allowances

▶ Supplemental Cooling

- **Ventilation supply air cooling is permitted only for the purpose of maintaining supply air relative humidity or zone relative humidity**
- Cooling coil shall be sized for peak dehumidification at design outdoor temperatures, and no larger

C403.3.5.5

C403.7.3

C403.1.4

DOAS Fan Power Allowance

DOAS fans less than < 1 kW (~1.5 Hp)

- ▶ Fan power shall not exceed 1 watt/cfm, calculated per Equation 4-10

(Equation 4-10)

$$\text{DOAS Total Combined Fan Power } \left(\frac{\text{Watts}}{\text{CFM}} \right) = \sum \left(\frac{\text{Fan bhp}}{\eta_m} \right) \times \frac{746}{\text{CFM}_{\text{supply}}}$$

Where:

Fan bhp	=	Brake horsepower for each supply, exhaust and other fan in the system at design maximum airflow rate
η_m	=	Fan motor efficiency including all motor, drive and other losses for each fan in the system
$\text{CFM}_{\text{supply}}$	=	Design maximum airflow rate of outdoor (supply) air

DOAS with at least one fan \geq 1 kW

- ▶ DOAS shall comply with the general fan power limitations per C403.8.1

Fan Power Allowance Criteria

NEW Criteria – C403.8 Fan and Fan Controls

- ▶ Fan power budget calculation is required for each fan system with **fan electrical input power $\geq 1\text{kW}$ ($\sim 1.5\text{ HP}$)**

$$\text{Design input power (Fan kW}_{\text{design}}) \leq \text{Fan power budget (Fan kW}_{\text{budget}})$$

- ▶ Low-capacity fans with motors $< 1/12\text{ hp}$ (62 watts) shall meet fan efficacy requirements per Table C403.8.4.
- ▶ *Large diameter ceiling fans* (commonly used for destratification, air mixing, etc) shall be labeled in accordance with AMCA 230

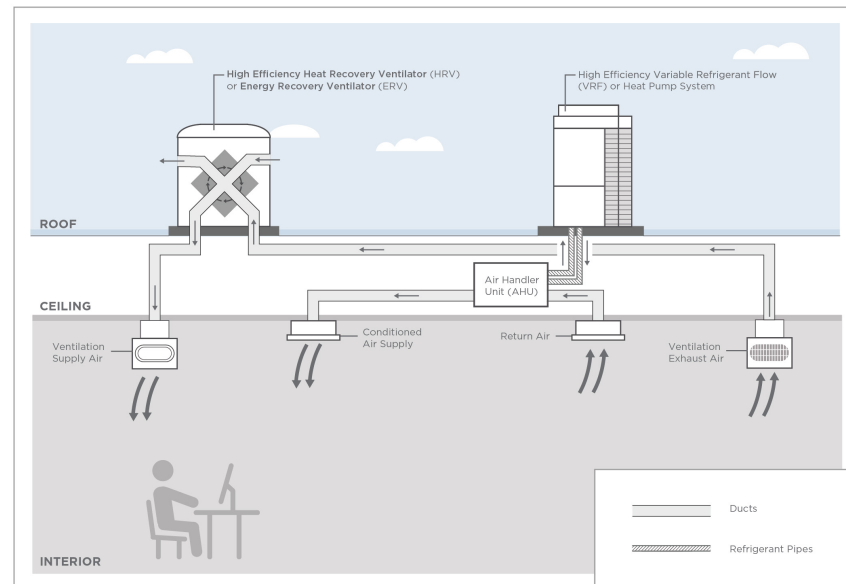
Very High Efficiency DOAS

What is it?

A DOAS approach that maximizes system performance by pairing a high efficiency (>82% sensible effectiveness) ERV/HRV with a high efficiency heating/cooling system, along with key design elements, including:

- Fully decoupling ventilation air from primary heating and cooling air
- Downsizing heating/cooling equipment
- Minimizing fan power by minimizing duct pressure drop and operating ventilation fans at optimal conditions

► How it works:



► Learn more:

For additional information, pilot demonstration project results, case studies, and system requirements, visit: betterbricks.com/solutions/hvac.

DOAS Additional Energy Efficiency Measure

**TABLE C406.2(1)
EFFICIENCY MEASURE CREDITS**

Measure Title	Applicable Section	Prorating Flag	Occupancy Group					
			Group R-1	Group R-2	Group B	Group E	Group M	All Other
7. High performance DOAS	C406.2.2.6	Heat	31	31	21	39	40	21/ (A) 40 ^c

High performance DOAS serves at least 90% of the conditioned floor area:

- ▶ 80% or higher sensible energy recovery effectiveness
- ▶ For all DOAS fans < 1 kW (~1.5 Hp) – Total combined fan power < 0.769 w/cfm
- ▶ For all DOAS with at least one fan ≥ 1 kW – Total combined fan power is ≤ 80% of allowable fan power per Section C403.8.1

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