

What Is This Thing?

COMMERCIAL HVAC SYSTEMS AND EQUIPMENT AND 2021 WSEC-C REQUIREMENTS



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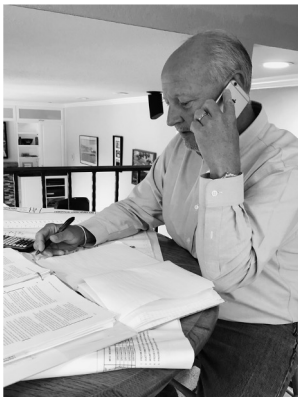
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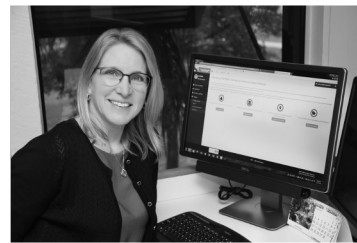
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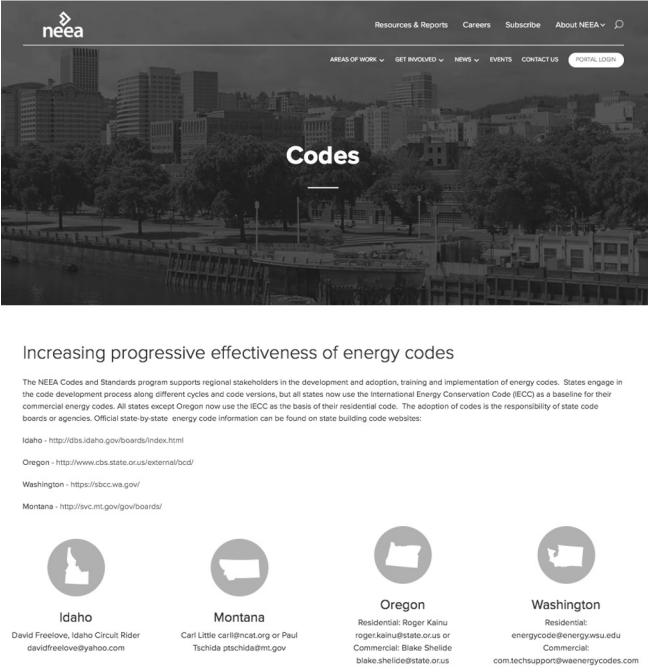


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Codes

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://lvc.mt.gov/gov/boards/>

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Today's Presentation

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



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Current Status of the 2021 WSEC-C

Effective date of all 2021 WA State Codes is March 15, 2024

- ▶ The Washington State Building Code Council (SBCC) conducted the rulemaking process to modify the 2021 WSEC-C and 2021 WSEC-R to address legal uncertainty stemming from the decision in California Restaurant Association v. City of Berkeley, issued by the Ninth Circuit Court of Appeals.
- ▶ The updated 2021 WSEC-C 2nd Edition has been posted on the SBCC website under "State Codes, Regulations & Guidelines." January 2024
- ▶ Follow the Washington State Building Council <https://www.sbcc.wa.gov/> for the latest news or to participate in the code development process.

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Topics we'll discuss today ~

1. **Prescriptive and fossil fuel space heating compliance pathways**
2. **Semi-heated buildings and spaces**
3. **Small commercial buildings and spaces**
4. **Large commercial buildings**
5. **Multifamily buildings**
6. **Shell and core buildings**
7. **Existing building mechanical alterations**
8. **Q&A Roundtable**

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2021 WSEC-C Prescriptive Space Heating Compliance Path

C403.1.4 – Use of electric resistance and fossil fuel-fired HVAC heating equipment

- ▶ **Prescriptive Space Heating Baseline = Heat Pumps**
- ▶ *“HVAC heating energy shall not be provided by electric resistance or fossil fuel combustion appliances.”*
- ▶ Electric resistance heating equipment – Includes baseboards, wall heaters, fan coils, VAV terminal reheat units, warm-air unit heaters, infrared heaters, furnaces, boilers, etc
- ▶ Fossil fuel heating equipment – Includes warm-air furnaces, duct furnaces, unit heaters, infrared heaters, boilers, etc

C403.1.4

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2021 WSEC-C Prescriptive Space Heating Compliance Path

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

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

C403.1.4

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2021 WSEC-C Prescriptive Space Heating Compliance Path

EXCEPTIONS that allow electric resistance (ER) and/or fossil fuel (FF) heating

- ▶ **Low heating capacity** – ER heating is permitted in buildings or discrete areas with total installed HVAC heating capacity less than **2.5 watt/SF** (Low energy building = 1 watt/SF; Semi-heated = 2.34 watts/SF)
- ▶ **Freeze protection** – Spaces with $\leq 45^{\circ}\text{F}$ (7°C) indoor design temperature are permitted to have ER heating for the purpose of freeze protection
- ▶ **Small systems** – ER and/or FF heating is permitted if the 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** – Future tenant spaces that are unfinished and unoccupied may be temporarily semi-heated with ER equipment

C403.1.4

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2021 WSEC-C Prescriptive Space Heating Compliance Path

EXCEPTIONS that allow electric resistance (ER) and/or fossil fuel (FF) heating

- ▶ **Tempered kitchen make-up air** – 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 are permitted for supply water temperature reset for hydronic systems serving a pasteurization cycle
- ▶ **Heat tape (trace)** – Water-filled equipment and piping located outside the building thermal envelope can be protected with ER heat tape

C403.1.4

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2021 WSEC-C Prescriptive Space Heating Compliance Path

EXCEPTIONS that allow electric resistance (ER) and/or fossil fuel (FF) heating

▶ **DOAS ERV auxiliary/supplemental heating**

- ER auxiliary/supplemental in Climate Zones 4/5 and FF in Climate Zone 5 are permitted
- DOAS auxiliary heating to preheat OSA for defrost
- DOAS supplemental heating to temper supply air to 55°F
- Only allowed in buildings without hydronic heating systems

▶ **Heat pump supplemental heating** – Heat pump compressor shall be configured as the first stage of heating; various other eligibility conditions apply

- 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

▶ **Heat pump defrost cycle** – ER heating is permitted

C403.1.4

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2021 WSEC-C Prescriptive Space Heating Compliance Path

Other allowed ALTERNATIVE sources of space heating energy

- ▶ **Pre-existing district energy** – 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

C403.1.4

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2021 WSEC-C Fossil Fuel Space Heating 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 efficiency credits required** – The number of energy efficiency credits required by Table C406.1 shall be increased by the number of additional credits required in Table C401.3.3.
- ▶ C401.3.3.1 HVAC Credit Modification – For mixed fuel buildings, the number of Additional Credits Required 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.

C401.3
C401.3.3.1

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2021 WSEC-C Fossil Fuel Space Heating Compliance Path

C401.3.6 Electrification readiness

- ▶ Purpose: Provide necessary electrical system infrastructure to support an upgrade to heat pump space heating in the future.
- ▶ Electrical accommodations shall include:
 - Spare electrical branch circuit conduit to the location of a future replacement heat pump appliance, sized for an equivalent heating capacity as the fossil fuel equipment
 - Spare electrical service entrance conduits for the purpose of upgrading the main electrical service to support all heat pump appliances throughout the building
 - Ensure main electrical room has sufficient space to accommodate increasing the electrical service size to support all heat pump appliances throughout the building
 - Additional necessary accommodations to support a future electrical service upgrade (transformers, adequate space on site, etc)

C401.3.6

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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

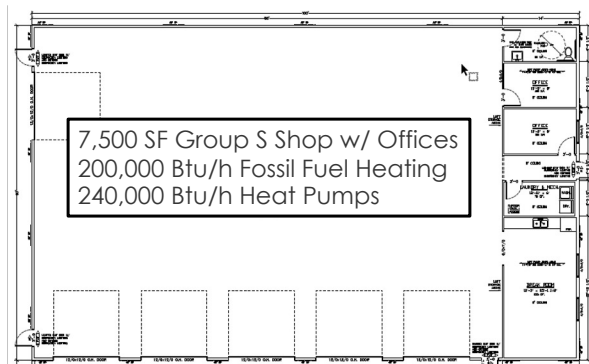
(C-B) = Total fossil fuel space heating capacity minus the total capacity of all equipment eligible for a C403.1.4 exception

D = Total capacity of all space heating equipment

C401.3.3

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Mixed Fuel Building Additional Efficiency Measure Credits



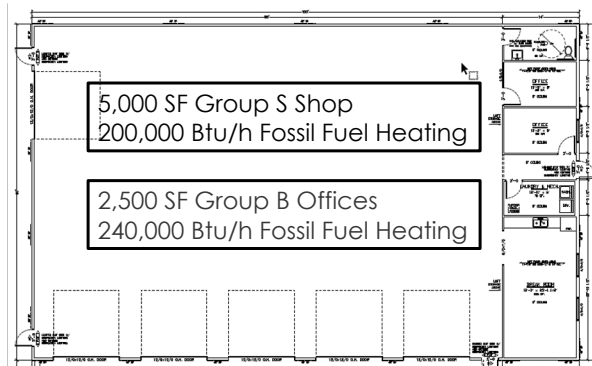
EXAMPLE – New Building

- ▶ 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 x 45.5% = 25.5 Additional Efficiency Measure Credits**

C401.3.3

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Fossil Fuel Building Additional Efficiency Measure Credits – Discrete Area Weighted



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**

C401.3.5

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Prescriptive and Fossil Fuel Space Heating Q&A

1. Is fossil fuel space heating allowed in Washington State?
2. Can DOAS systems use electric resistance for supplemental heating?
3. Can kitchen makeup air systems use fossil fuels in Climate Zone 5 without having to comply with the alternate Fossil Fuel Compliance Path?
4. Can heat pumps with natural gas auxiliary heating be used without having to comply with the Fossil Fuel Compliance Path?

C403.2.2

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Semi Heated Spaces Definition

An enclosed space within a building, including adjacent connected spaces separated by an uninsulated component (e.g., basements, utility rooms, garages, corridors), which:

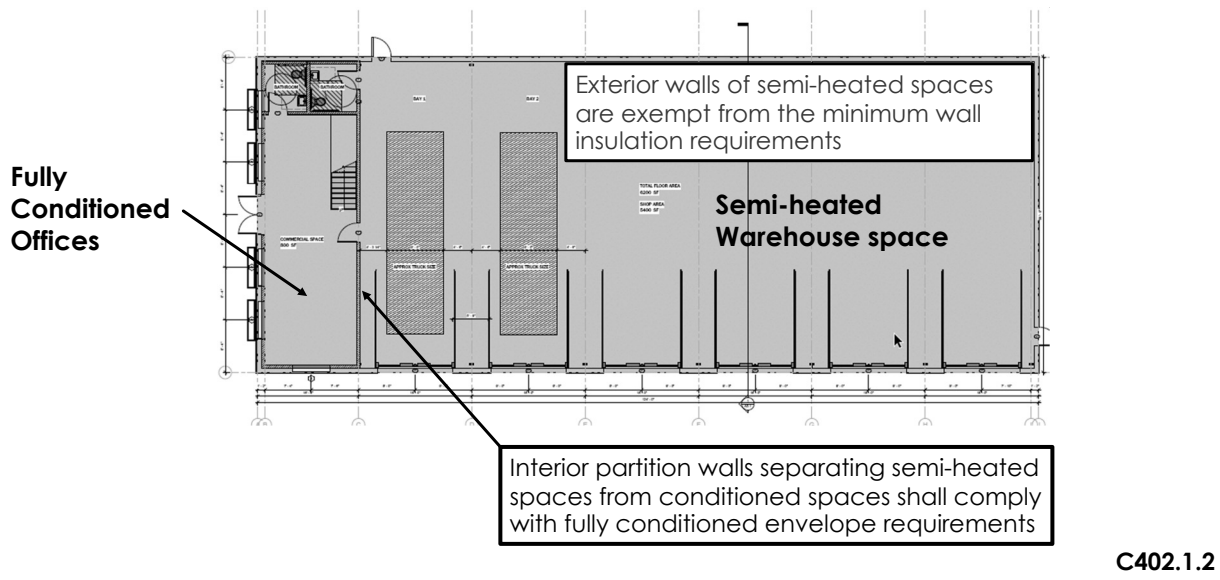
- 1. Is heated but not cooled, and has an installed heating system output capacity greater than or equal to 3.4 Btu/(h-SF) but not greater than 8 Btu/(h-SF)*;*
- 2. Is not a walk-in cooler, walk-in freezer, refrigerated warehouse cooler or refrigerated warehouse freezer space.*

* Equivalent – 1 watt/SF but not greater than 2.34 watts/SF

Chapter 2

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Example: Semi-Heated Space



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Heating Systems for Semi-Heated Spaces

NEW – Electric resistance heating equipment is permitted in semi-heated spaces

- ▶ **C403.1.4 Freeze protection** – Heating systems sized for spaces with $\leq 45^{\circ}\text{F}$ (7°C) indoor design temperature are permitted to be served by electric resistance heating equipment for the sole purpose of **freeze protection**
- ▶ **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
 - Heat trace system capacity not included in total space conditioning capacity calcs

C403.1.4
C402.1.1.2

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Heating Systems for 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 are permitted in semi-heated spaces

- ▶ Triggers Fossil Fuel Compliance Path requirements per Section C401.3
- ▶ Additional fossil fuel efficiency credits required
- ▶ Electrification readiness provisions apply

C401.3.3
C401.3.5
C402.1.1.2

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Electric Heating Systems for Semi-heated Spaces

Electric resistance tubular infrared heater

Electric resistance unit heater



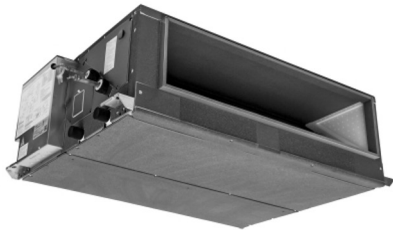
Images courtesy of King Electric

C403.1.4

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Electric Heating Systems for Semi-heated Spaces

Low temperature indoor heat pump fan-coil



Images courtesy of Mitsubishi

Low temperature outdoor heat pump



Heat pumps are allowed, provided they meet the 8 Btu/(h-SF) limit at $\leq 45^{\circ}\text{F}$ (7°C) indoor design temperature and are controlled by a heating only thermostat

C402.1.1.2

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Fossil Fuel Heating Systems for Semi-heated Spaces

Separated combustion gas-fired unit heater

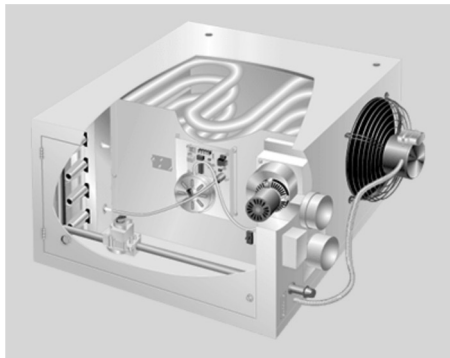


Image courtesy of Lennox

Fuel oil or waste oil unit heater



Image courtesy of Doenback

C401.3/C402.1.2

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Fossil Fuel Heating Systems for Semi-heated Spaces

Gas-fired tubular infrared heater



Image courtesy of Solaronics

Gas-fired infrared spot heater

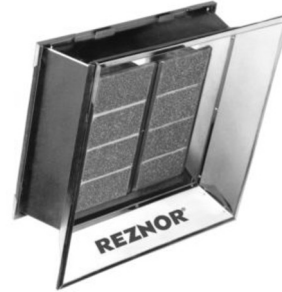


Image courtesy of Reznor

C401.3/C402.1.2

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Mechanical Ventilation for Semi-heated Spaces

2021 IMC Chapter 4

TABLE 403.3.1.1 MINIMUM VENTILATION RATES

| OCCUPANCY CLASSIFICATION | OCCUPANT DENSITY #/1000 FT ² a | PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _p CFM/PERSON | AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _a CFM/FT ² a | EXHAUST AIRFLOW RATE CFM/FT ² a |
|---|--|---|--|--|
| Storage | | | | |
| Refrigerated warehouses/freezers | — | 10 | — | 0.75 |
| Repair garages, enclosed parking garages ^{b,d} | — | — | — | 0.75 |
| Warehouses | — | 10 | 0.06 | — |

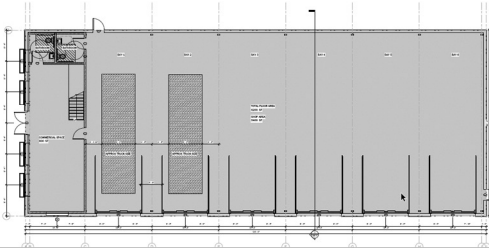
EXAMPLE – Warehouse Space:
 $5,000 \text{ SF} \times 0.06 \text{ cfm/SF} = 225 \text{ CFM}$ mechanical ventilation

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Natural Ventilation for Semi-heated Spaces

Minimum Criteria

- ▶ Openable area to the outdoors shall be $\geq 4\%$ of the floor area being ventilated
- ▶ Shall provide required ventilation rates during all occupied periods in all climate conditions



EXAMPLE – Naturally ventilated warehouse

100' x 50' = 5,000 SF

IMC minimum required operable area:

5,000 SF x 4% = 200 SF

Operable opening areas provided:

Garage Doors – (6) 12'x14' = 1,680 SF

Include 225 CFM back-up mechanical ventilation system for use during inclement weather

IMC Chapter 4

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Plan Review of Semi-heated Spaces

- ✓ Semi-heated spaces are identified on the drawings
- ✓ Regardless of heating equipment type, load calculations indicate the equipment output capacity does not exceed 8 Btu/(h-SF)
- ✓ Ventilation method (natural or mechanical) is identified on the drawings
- ✓ Ventilation calculations document compliance with natural or mechanical ventilation requirements per the IMC
- ✓ If electric resistant heating equipment is provided for freeze protection only, load calculations indicate equipment is sized for $\leq 45^{\circ}\text{F}$ (7°C) indoor design conditions

C403.2.2

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Plan Review of Semi-heated Spaces

- ✓ If fossil fuel equipment is included in the project, additional efficiency credits are included in C406 documentation and electrification readiness measures are included in the electrical documents
- ✓ Fossil fuel equipment complies with minimum efficiency requirements for equipment types listed in the efficiency tables
- ✓ If heat pumps are included in the project, indicate this equipment complies with the minimum heating efficiency requirements (HSPF2 or COP) listed in the efficiency tables
- ✓ Heat pumps are controlled by heating only thermostats set to $\leq 45^{\circ}\text{F}$ (7°C) indoor design conditions

C403.2.2

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Semi-heated Spaces Q&A

1. What is the maximum allowed output heating capacity for semi-heated spaces?
2. Is electric resistance heating allowed in semi-heated spaces?
3. Is mechanical cooling via a heat pump allowed in semi-heated spaces?
4. Are semi-heated spaces required to meet the ventilation requirements of the IMC Chapter 4?
5. What is the minimum exterior wall insulation requirement in a semi-heated space?

C403.2.2

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Small Commercial Buildings – Common Single Zone HVAC Systems

- ▶ Electric resistance wall, cove and baseboard heaters
- ▶ Wall and ceiling mounted ductless heat pumps
- ▶ Multiple head ductless and ducted variable refrigerant flow (VRF) fan coils connected to outdoor condensing unit
- ▶ Packaged rooftop and exterior wall-mounted heat pumps
- ▶ Ducted split system heat pump air handlers
- ▶ Ducted fuel-fired furnace air handler with split system air conditioner
- ▶ Packaged rooftop fuel-fired furnace air handler with air conditioner
- ▶ Single zone variable air volume – Exception to DOAS for Group A1, A2 and A3

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Electric Resistance Heating Appliances

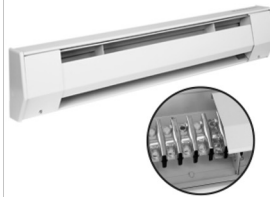
Electric resistance wall, cove and baseboard heaters

- ▶ Small buildings and spaces < 2,500 SF – Permitted via exception under the Prescriptive Compliance Path
- ▶ Buildings and spaces ≥ 2,500 SF – Shall comply under the Fossil Fuel Compliance Path

Electric resistance wall heater



Electric resistance baseboard



Electric resistance cove heater



Images courtesy of King Electric

C403.1.4

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Ductless Heat Pumps

Wall mount ductless



Ceiling mount ductless



Outdoor unit for each zone



Images courtesy of Mitsubishi

NOTE – Economizer not required if paired with dedicated outdoor air system (DOAS)

C403.5

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Multiple Head VRF Heat Pump System

Ducted fan-coils



Image courtesy of Mitsubishi

Ductless fan-coils

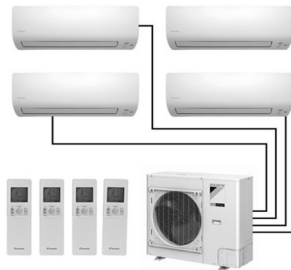


Image courtesy of Daikin

- ▶ 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

NOTE – Economizer not required if paired with a dedicated outdoor air system (DOAS)

C403.5

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Packaged Heat Pump Air Handler

Packaged rooftop heat pump



Image courtesy of Trane

Packaged vertical heat pump, exterior wall-mounted



Image courtesy of Bard

Electric resistance supplemental heating

- ▶ Allowed for packaged heat pumps under the Prescriptive Compliance Path
- ▶ Controls shall prevent supplemental heating operation when the heating load can be met by the heat pump alone

NOTE – Economizer required for all cooling equipment installed outdoors

C403.1.4
C403.5

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Ducted Split System Heat Pump Air Handlers

Ducted split system heat pumps



Image courtesy of Trane

Electric resistance supplemental heating

- ▶ Allowed for split system heat pumps under the Prescriptive Compliance Path
- ▶ Controls shall prevent supplemental heating operation when the heating load can be met by the heat pump alone

NOTE – Economizer is required if air handler is installed within a mechanical room adjacent to the outdoors

C403.1.4
C403.5

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Ducted Furnace Air Handler with Split System Air Conditioner

Fuel-fired furnace with split AC



Image courtesy of Trane

Fuel-fired HVAC equipment

- ▶ Shall comply with the Fossil Fuel Compliance Path, unless eligible for an exception to Section C403.1.4

NOTE – Economizer is required if air handler is installed within a mechanical room adjacent to the outdoors

C401.3
C403.1.4
C403.5

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Packaged Rooftop Furnace Air Handler with Air Conditioner

Packaged rooftop "Gas Pack"



Fuel-fired HVAC equipment

- ▶ Shall comply with the Fossil Fuel Compliance Path, unless eligible for an exception to Section C403.1.4

NOTE – Economizer is required for all cooling equipment installed outdoors

C401.3
C403.1.4
C403.5

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High Efficiency Single Zone VAV



Alternative to DOAS

- ▶ Allowed for Group A-1, A-2, A-3 only
- ▶ Serves a single temperature zone
- ▶ Economizer required
- ▶ Demand controlled ventilation required
- ▶ Variable volume supply based on heating/cooling demand
- ▶ High efficiency heating and cooling
- ▶ Direct digital controls (DDC) required

NOTE - High efficiency single zone VAV systems are exempt from the DOAS provisions per Section C403.3.5 Exception 2

C403.12
C403.3.5

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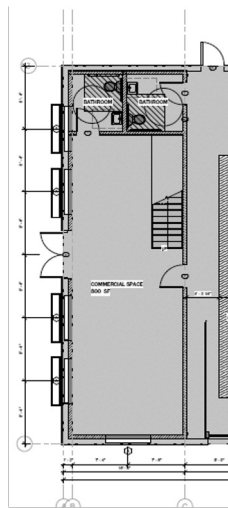
Ventilation in Small Commercial Buildings and Spaces

- ▶ Natural or mechanical ventilation shall be provided in accordance with Chapter 4 of the International Mechanical Code (IMC)
- ▶ Where mechanical ventilation is provided, the system shall be sized to provide **not more than 150%** of the minimum outdoor air required by Chapter 4 of the IMC or other applicable code or standard (whichever is greater)
- ▶ A few exceptions apply for the 150% limit:
 - Ventilation in dwelling/sleeping units in Group R-1, R-2 & I-2 occupancies
 - Specific systems that include energy recovery (refer to C403.2.2.1 for system types)
 - Ventilation used for particulate or VOC dilution, economizing or night flushing, dehumidification, pressurization, exhaust make-up, or other process air delivery

IMC Chapter 4
C403.2.2.1

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Natural Ventilation



EXAMPLE – Naturally ventilated commercial space in mixed use building

IMC minimum required operable area:
1,000 SF x 4% = 40 SF

Operable opening areas provided:
Entry Door – 7'x6' = 42 SF

NOTE – If space is air-conditioned, economizer cooling is required or comply with exception for high efficiency cooling per C403.5

IMC Chapter 4
C403.5

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Mechanical Ventilation

**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 | |

a. Occupancy classification from the *International Building Code* Chapter 3.

Dedicated Outdoor Air Systems

- ▶ No changes to the occupancy classifications from the 2018 WSEC-C
- ▶ DOAS shall be sized to meet the mechanical ventilation requirements of IMC Chapter 4

C403.3.5

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Decoupled Ventilation Supply Air

- ▶ Space conditioning equipment shall cycle off when there is no call for heating or cooling
- ▶ The DOAS supply air shall be delivered directly to the occupied space, or downstream of the terminal heating and/or cooling coils

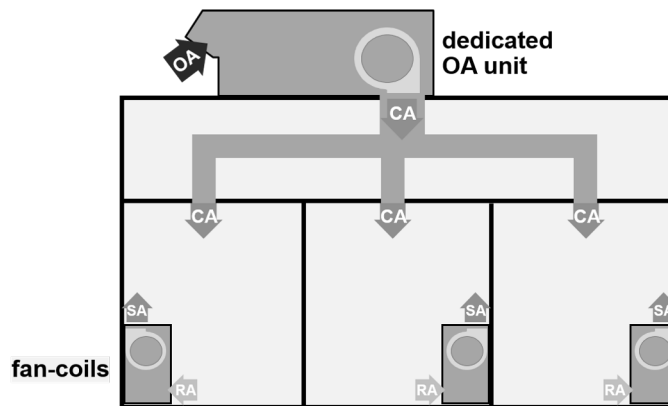


Diagram courtesy of Trane

**C403.3.5.3
C403.3.5.4**

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Mechanical Ventilation with DOAS

2021 IMC Chapter 4

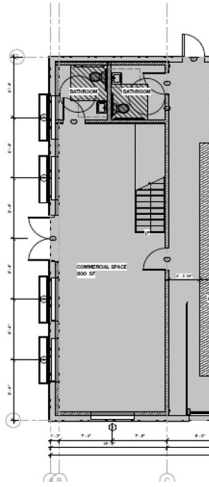


TABLE 403.3.1.1 MINIMUM VENTILATION RATES

| OCCUPANCY CLASSIFICATION | OCCUPANT DENSITY #/1000 FT ² ^a | PEOPLE OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _p , CFM/PERSON | AREA OUTDOOR AIRFLOW RATE IN BREATHING ZONE, R _a CFM/FT ² ^a | EXHAUST AIRFLOW RATE CFM/FT ² ^a |
|--------------------------|---|---|---|---|
| Offices | | | | |
| Conference rooms | 50 | 5 | 0.06 | — |
| Main entry lobbies | 10 | 5 | 0.06 | — |
| Office spaces | 5 | 5 | 0.06 | — |
| Reception areas | 30 | 5 | 0.06 | — |
| Telephone/data entry | 60 | 5 | 0.06 | — |

EXAMPLE – DOAS sizing for minimum required fresh air
 1,000 SF Office:
 $(5 \text{ people} \times 5 \text{ cfm/person}) + (1,000 \text{ SF} \times 0.06 \text{ CFM/SF}) = 85 \text{ CFM}$
 WSEC-C allows up to 150% of design – $85 \times 150\% = 128 \text{ CFM}$

IMC Chapter 4
C403.2.2.1

47

DOAS Energy Recovery Effectiveness

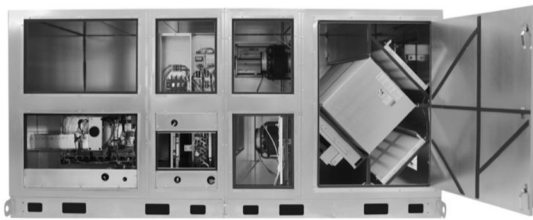
- ▶ **ENERGY RECOVERY VENTILATION SYSTEM.** Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to supplying the air to a space, either directly or as part of an HVAC system.
- ▶ Heat Recovery Ventilator (HRV) – **Sensible only** (i.e. temperature) energy recovery
- ▶ Energy Recovery Ventilator (ERV) – **Enthalpy includes sensible plus latent** (i.e. temperature and humidity) energy recovery
- ▶ **REVISED** – DOAS minimum energy recovery performance shall be at least:
 - **68% sensible** recovery effectiveness (calculated per C403.3.5.1 Equation 4-9)
 - **60% enthalpy** recovery ratio, calculated at design conditions

C403.3.5.1

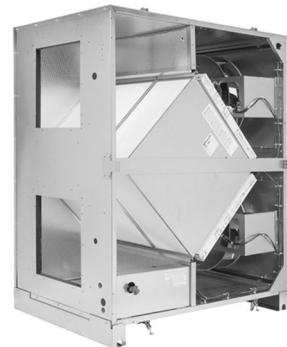
48

DOAS with Energy Recovery

Outdoor counterflow ERV



Indoor counterflow ERV



Images courtesy of RenewAir

C403.3.5

49

Small Commercial Building Example

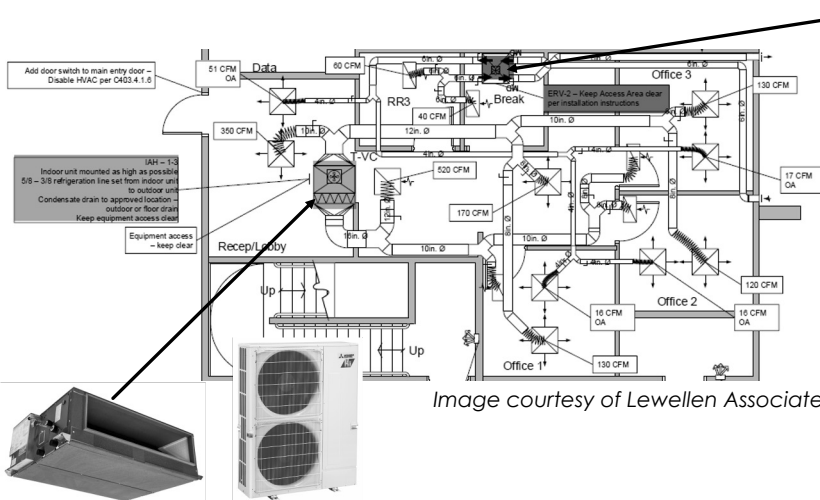


Image courtesy of Lewellen Associates



Image courtesy of Fantech

Images courtesy of Mitsubishi

C403.3.5.1

50

Plan Review of Small Commercial Spaces and Buildings

- ✓ Heating and cooling equipment sizing calculations submitted
- ✓ DOAS equipment ventilation sizing calculations on drawings
- ✓ Heating and cooling equipment efficiencies listed in equipment schedules on drawings (SEER2, EER/IEER, HSPF2, AFUE/Et/Ec, etc)
- ✓ Verify DOAS energy recovery effectiveness ratings on the drawings
- ✓ Fan power calculations for HVAC systems and DOAS are included on the drawings
- ✓ For air conditioning systems, verify economizer is provided if single package rooftop equipment or air handler(s) located in mechanical room adjacent to exterior

51

Plan Review of Small Commercial Spaces and Buildings

- ✓ Ventilation calculations document compliance with natural or mechanical ventilation requirements per the IMC Chapter 4
- ✓ For small commercial buildings > 5,000 SF that are required to have DOAS – Total System Performance Ratio (TSPR) report is submitted for cooling systems serving office (including medical office), retail, library and education occupancies
- ✓ Heating systems in vestibules have controls to turn off heating above 45°F outdoor temperature
- ✓ **REVISED** – HVAC interlock controls are provided for spaces with doors > **48 SF** that open directly to the exterior

52

Plan Review of Small Commercial Spaces and Buildings

- ✓ If project includes fossil fuel and/or electric resistance space heating equipment, provide calculations that identify the number of additional energy efficiency credits that are required to comply under the Fossil Fuel Compliance Path
- ✓ **Commissioning is included in the project scope** if cooling capacity is $\geq 180,000$ Btu/h (15 tons), heating capacity is $\geq 240,000$ Btu/h and energy recovery ventilation capacity is ≥ 300 cfm

53

Small Commercial Buildings Q&A

1. Is electric resistance space heating allowed as the primary heating source in small commercial buildings?
2. Can small commercial buildings use operable windows and doors for ventilation?
3. Are economizers required for Group B office buildings using DOAS energy recovery for ventilation?
4. Can Group M retail spaces use gas-fired heating packaged rooftop air handling units with air conditioning?
5. When is commissioning of the mechanical systems required for small commercial buildings?

54



55

Large Commercial Building HVAC Systems and Equipment

- ▶ Multiple zone variable refrigerant flow (VRF) heat pump system
- ▶ Water source heat pump system (WSHP)
- ▶ Ground source heat pump system (GSHP)
- ▶ Multiple zone variable air volume system (VAV)
- ▶ Multiple zone DOAS with energy recovery
- ▶ Hydronic Systems – Central Plant Equipment
 - Air-cooled and water-cooled chillers
 - Heat pump chillers
 - Heat recovery chillers
 - Cooling towers
 - Evaporative condensers
 - Fuel-fired and electric boilers
 - Heat pump water heaters (HPWH)

C403.1.4

56

Multiple Zone VRF Heat Pump System With Energy Recovery

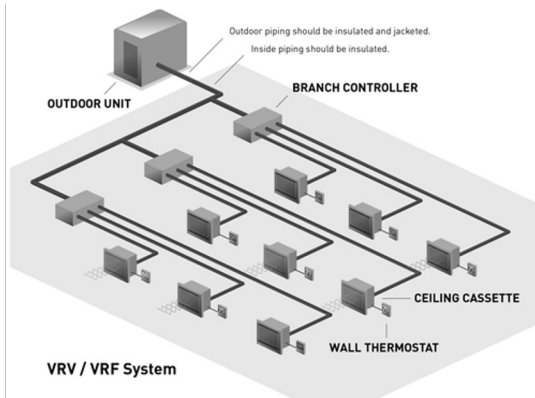


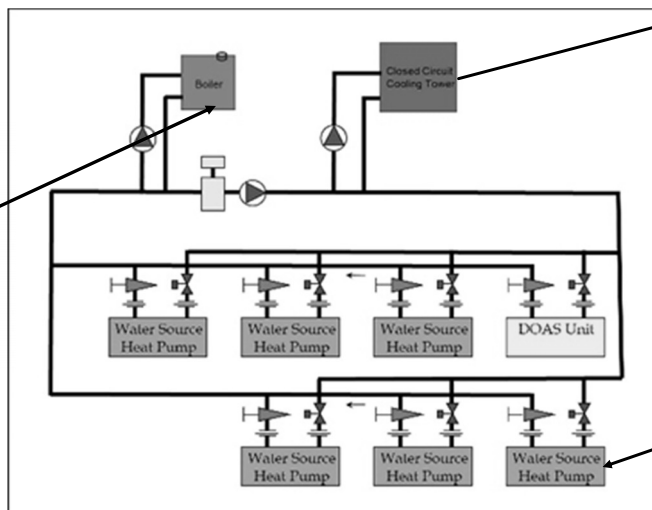
Image courtesy of Mitsubishi



Image courtesy of Daikin

57

Water Source Heat Pumps



Cooling tower

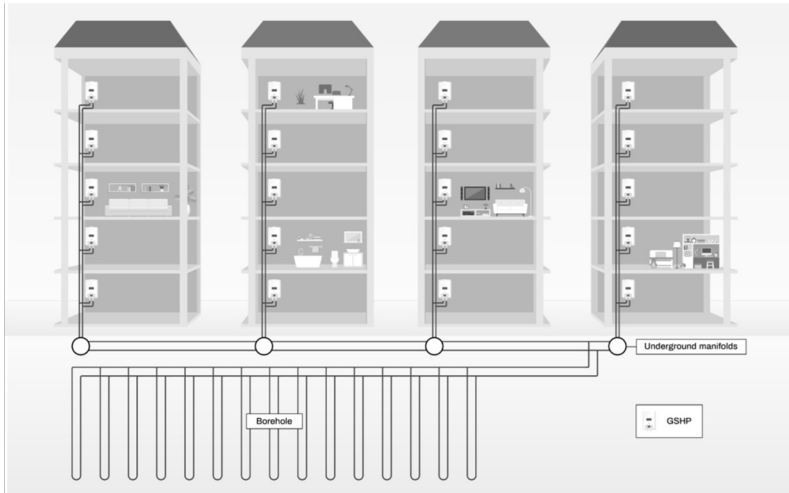


Hydronic heat pumps



58

Ground Source Heat Pumps



Hydronic System

- Circulation loop temperature is maintained by the earth temperature

59

Multiple-Zone Variable Air Volume (VAV)

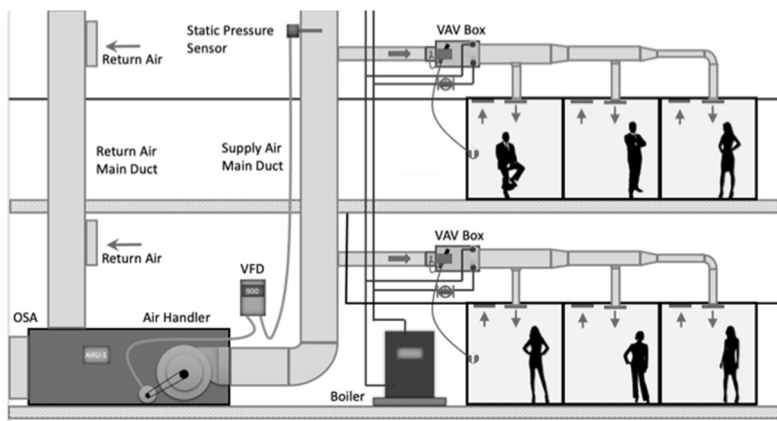


Diagram courtesy of MEP Academy

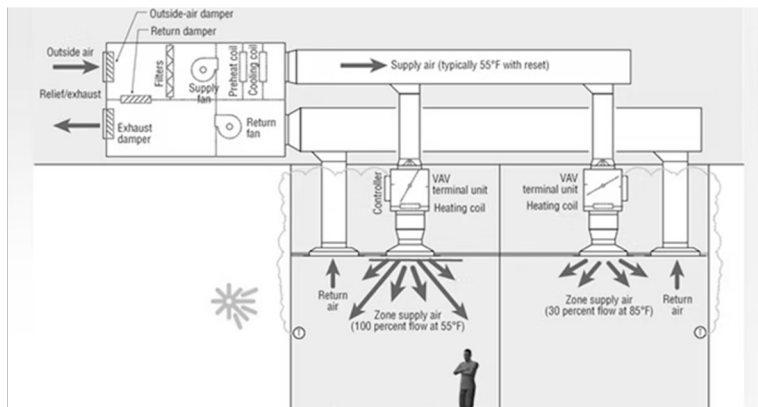
Alternative to DOAS

- High efficiency VAV systems are exempt from the DOAS provisions per Section C403.3.5 Exception 2

C403.6.1
C403.6.10

60

Multiple-Zone DOAS With Energy Recovery



- ▶ Ventilation air delivered to each space can be constant volume OR variable volume depending on occupancy
- ▶ Supplemental heating is permitted under the Prescriptive Compliance Path; can be **ER** in Climate Zones 4/5 and **FF** in Climate Zone 5

61

Central Plant - Chillers

Air-cooled chiller



Image courtesy of Daikin

Water-cooled chiller



Image courtesy of Carrier

Air-cooled and water-cooled chillers supply chilled water (40-50°F) for cooling

62

Central Plant - Heat Pump Chillers

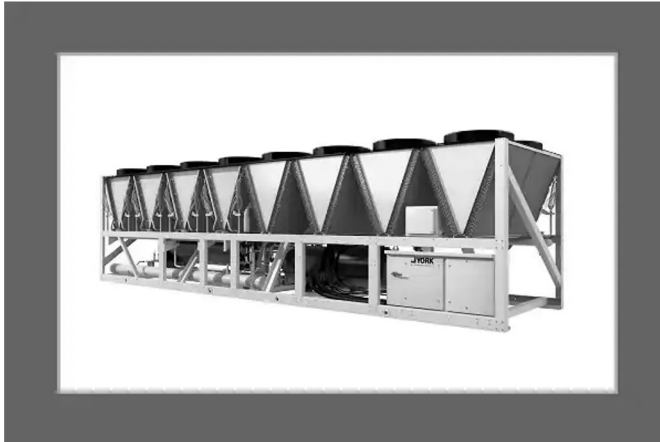


Image courtesy of Johnson Controls

- ▶ **NEW** – Minimum efficiency table has been added in the 2021 WSEC-C for this equipment type
- ▶ Heat pump chillers deliver chilled water in the summer for cooling and hot water in the winter for heating

63

Central Plant - Heat Recovery Chillers



Image courtesy of Multistack



Image courtesy of Motivair

- ▶ **NEW** – Minimum efficiency table has been added in the 2021 WSEC-C for this equipment type
- ▶ Heat recovery chillers deliver chilled water for cooling and hot water for heating at the same time

64

Central Plant - Cooling Towers

Indirect cooling tower



Image courtesy of BAC

Open cooling tower

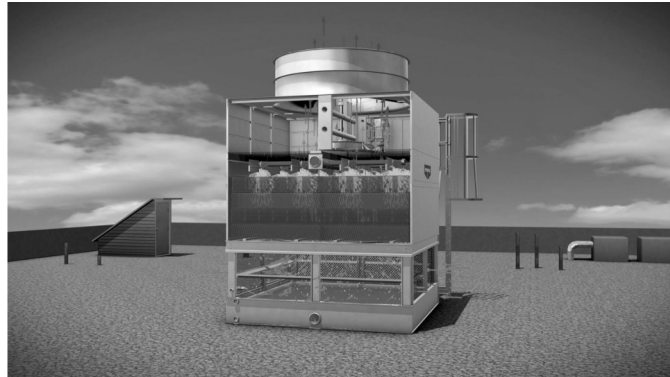


Image courtesy of Evapco

65

Central Plant – Condensers

Air-cooled condensers (refrigerant to air heat exchanger)

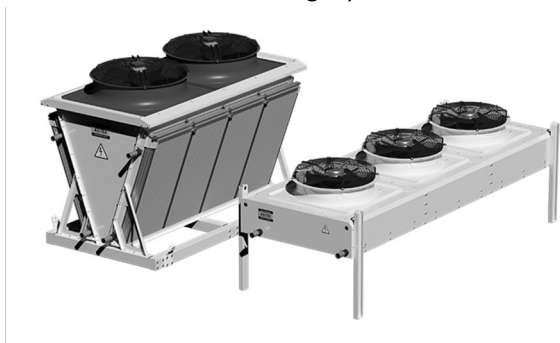


Image courtesy of Kaltra

Water-cooled condenser (refrigerant to water heat exchanger)



Image courtesy of Kendall

66

Central Plant – Dry Coolers



Water to air heat exchanger

Image courtesy of Excaliber Energy

67

Central Plant - Boilers

High efficiency gas-fired boiler



Image courtesy of Lockinvar

Electric resistance boiler



Image courtesy of Laars

- ▶ Projects with fuel-fired boilers shall comply with the Fossil Fuel Compliance Path
- ▶ Electric resistance boilers provided as an auxiliary heating source for heat pump systems are permitted under the Prescriptive Compliance Path

68

Central Plant - Heat Pump Water Heaters

Air-to-water heat pump water heater



Image courtesy of Multistack

Water-to-water heat pump water heater



Image courtesy of Multistack

- ▶ Minimum efficiency values for HPWHs with input capacity ≤ 12 kW are defined in Table C404.2
- ▶ There are no minimum efficiency requirements in the WSEC-C for electric HPWHs with input capacity > 12 kW or for gas heat pump water heaters

69

Plan Review of Large Commercial Buildings

- ✓ Heating and cooling equipment sizing calculations submitted
- ✓ Ventilation sizing calculations for DOAS and VAV systems on drawings
- ✓ Heating and cooling equipment efficiencies listed in equipment schedules on drawings (EER/IEER, IPLV, kW/Ton, COP, AFUE/Et/Ec, etc)
- ✓ Verify DOAS energy recovery effectiveness ratings on the drawings
- ✓ Fan power calculations for HVAC systems and DOAS are included on the drawings
- ✓ Heating systems in vestibules have controls to turn off heating above 45°F outdoor temperature

70

Plan Review of Large Commercial Buildings

- ✓ Ventilation calculations document compliance with natural or mechanical ventilation requirements per the IMC Chapter 4 or ASHRAE Standard 62.1
- ✓ For large commercial buildings that are required to have DOAS – Total System Performance Ratio (TSPR) report is submitted for cooling systems serving office (including medical office), retail, library and education occupancies
- ✓ For air conditioning systems, verify economizer is provided if air handlers are located on the roof or within a mechanical room adjacent to exterior

71

Plan Review of Large Commercial Buildings

- ✓ If project includes fossil fuel boiler systems >1,000,000 Btu/h capacity:
 - Verify controls are configured to comply with minimum turndown ratio
 - Verify minimum rated combustion efficiency is 90%
- ✓ If project includes fossil fuel and/or electric resistance space heating equipment, provide calculations that identify the number of additional energy efficiency credits that are required to comply under the Fossil Fuel Compliance Path
- ✓ **Commissioning is included in the project scope**

72

Large Commercial Buildings Q&A

1. Do ALL large commercial buildings require DOAS?
2. Do large commercial buildings with water source heat pumps require economizer cooling?
3. Are fan power calculations required to be submitted for large commercial buildings?
4. Do new large commercial buildings require commissioning of the mechanical systems and equipment?

73



74

Dwelling Units - Electric Resistance Heating Appliances

Electric resistance space heating is permitted as long as the installed heating capacity **in any separate space** does not exceed the following:

1. **Spaces with fenestration:** Not more than 750 watts in Climate Zone 4 and 1,000 watts in Climate Zone 5
2. **Spaces with fenestration facing two cardinal orientations:** 1,000 watts in Climate Zone 4, and 1,300 watts in Climate Zone 5
3. Spaces with exterior walls and no fenestration: 250 watts

Buildings in locations with lower than 4°F winter outdoor design temperature for heating are permitted to add an additional 250 watts above the base wattage allowed for Climate Zone 5.

Reference Appendix C for outdoor design temperatures for locations in WA State

C403.1.4

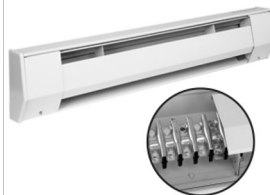
75

Dwelling Units - Electric Resistance Heating Appliances

Electric resistance wall heater



Electric resistance baseboard



Electric resistance cove heater



Images courtesy of King Electric

76

Dwelling Units – Ductless Heat Pumps

Single-zone ductless heat pump



Multiple-zone ductless heat pump



NOTE – For Group R-2, cooling equipment shall comply with an economizer exception; options include high efficiency or HVAC equipment paired with DOAS

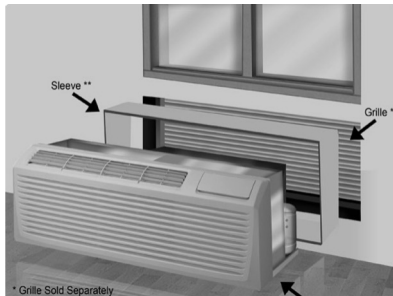
Images courtesy of LG

C403.5

77

Dwelling Units – Packaged Terminal Heat Pumps (PTHP)

Packaged terminal heat pump



High efficiency packaged terminal heat pump



NOTE – For Group R-2, cooling equipment shall comply with an economizer exception; options include high efficiency or HVAC equipment paired with DOAS

Image courtesy of Epocha

78

VPTHP & Split System Heat Pump Air Handlers

Ducted split system heat pump



Image courtesy of Trane

Vertical packaged terminal heat pump



Image courtesy of AMANA

NOTE – For Group R-2, cooling equipment with indoor supply fans and < 54,000 Btu/h capacity are exempt from economizer controls provided cooling efficiency exceeds code minimum by 15%



79

Mechanical Equipment with Through-Wall Penetrations

- ▶ **INTENT** – Reduce the impact of mechanical equipment through wall penetrations on overall building envelope thermal performance
- ▶ If total area of penetrations **exceeds 1%** of above-grade wall area ~
 - Mechanical equipment penetrations area shall be assigned a default U-factor of U-0.5
 - Penetration area U-factor shall be area-weighted with the opaque above-grade wall area
 - Calculate the resulting overall effective wall U-factor for prescriptive or component performance compliance



Table C402.1.4, Footnote k
C402.1.4.3

80

Water Source & Ground Source Heat Pump Systems

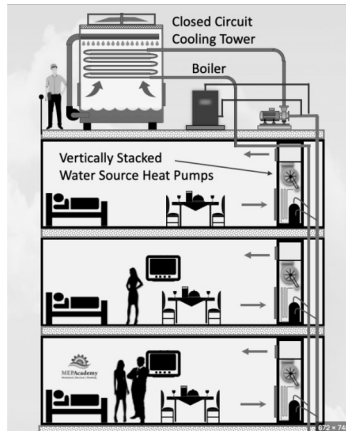
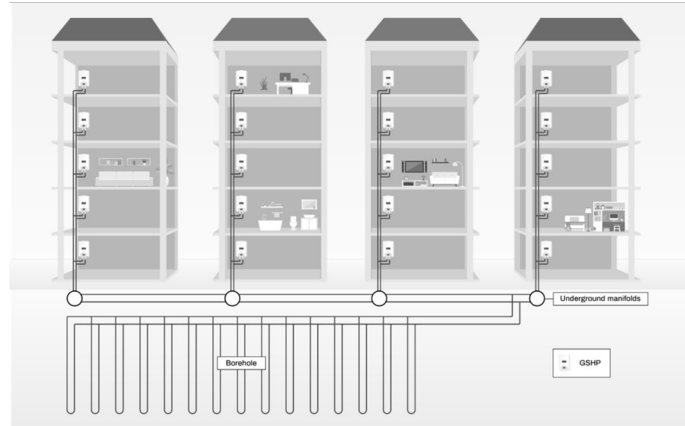


Diagram courtesy of MEP Academy



81

Dwelling Units Ventilation

Whole house (or dwelling unit) energy recovery ventilators (ERV)



Image courtesy of Greenheck

Ceiling mounted, low CFM spot ERVs



Image courtesy of Panasonic

Balanced Flow Ventilation

- ▶ Outdoor air shall be provided directly to each habitable space via a balanced ventilation system with heat recovery
- ▶ Delivered outdoor air CFM shall comply with the 2021 IMC
- ▶ HRV/ERV sensible energy recovery effectiveness shall be $\geq 60\%$
- ▶ System shall be configured so the ventilation airflow rate in each habitable space can be commissioned (Cx)
- ▶ Rated efficiency per HVI 920 based on adjusted sensible recovery effectiveness (ASRE) is permitted

C403.7.6.1

82

Corridors & Common Areas

Space Heating & Cooling Equipment Types

- ▶ Electric resistance space heating is allowed in small areas such as vestibules, stairwells and storage rooms provided the capacity does not exceed 5% of total space heating capacity of the project
- ▶ Heat pumps (single-zone, multiple-zone, multiple-zone VRF, packaged rooftop, package terminals)
- ▶ Fuel-fired furnaces and fuel-fired package rooftop units (must comply with Fossil Fuel Compliance Path)
- ▶ Central hydronic heating & cooling systems (applicable space heating Compliance Path depends on equipment type)

NOTE – Where mechanical cooling is provided, system shall comply with economizer or qualify for an exception (i.e. DOAS or high efficiency system)

83

Corridors & Common Areas

Ventilation

- ▶ Ventilation system shall be sized to provide **not more than 150%** of the minimum outdoor air required by Chapter 4 of the IMC or other applicable code or standard (whichever is greater)
- ▶ For ventilation air systems serving spaces other than dwelling units, energy recovery **may be** required depending on the total required outdoor air CFM (refer to Tables C403.7.6 (1) & (2))
- ▶ Ventilation air systems that are required to have energy recovery shall provide \geq **68%** sensible recovery effectiveness or **60%** enthalpy recovery ratio

C403.2.2.1
C403.3.5
C403.7.6.2

84

Corridors & Common Areas – DX-DOAS Heat Pump

Rooftop DX-DOAS heat pump with energy recovery

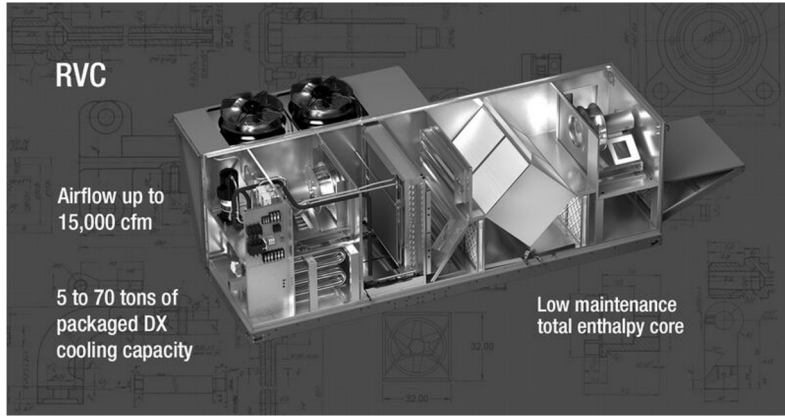


Image courtesy of Greenheck

If provided to comply with the DOAS provisions, DX-DOAS heating & cooling capacity shall not exceed what is required for outside air tempering and dehumidification

Economizer is required for all rooftop mechanical cooling equipment

85

Corridors & Common Areas – DX-DOAS with Fossil Fuel Heating

Rooftop DOAS with ERV and Gas Heating/DX Cooling

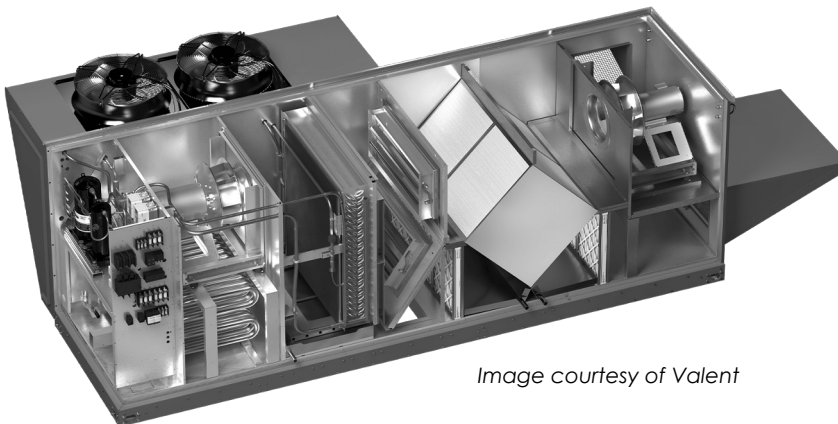


Image courtesy of Valent

Areas served by fuel-fired air handling equipment shall comply with the Fossil Fuel Compliance Path

Economizer is required for all rooftop mechanical cooling equipment

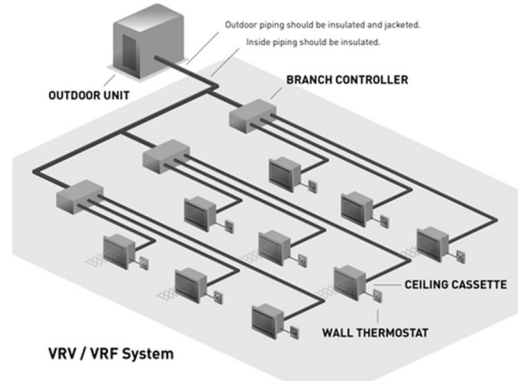
86

Corridors & Common Areas – High Efficiency DOAS with VRF

High efficiency DOAS with
energy recovery (ERV)



Multiple zone VRF heat pump system
with ductless ceiling cassettes



Images courtesy of Ventacity

87

Multifamily Buildings Q&A

1. Are heat pumps required for space heating in the main living area of the dwelling units?
2. Can dwelling units use operable windows and doors to meet the ventilation requirements of the IMC?
3. What is a balanced flow ventilation system with energy recovery?
4. Is energy recovery required for 100% outside air corridor ventilation systems operating 24 hours per day?
5. Is commissioning of the dwelling unit heating and/or cooling and ventilation systems required?

88



89

Shell & Core Buildings Space Heating

- ▶ Future tenant spaces that are unfinished and unoccupied may be temporarily heated to $\leq 40^{\circ}\text{F}$ with electric resistance equipment
- ▶ Heating & cooling systems installed prior to the initial tenant improvement will be subject to all applicable provisions when the initial tenant improvement is permitted, including:
 - Prescriptive or Fossil Fuel Compliance Path
 - Additional energy efficiency measure credits based on the occupancy group of the initial tenant improvement, including additional credits required for the Fossil Fuel Compliance Path if application
- ▶ Finished core spaces such as entrance lobbies, elevator lobbies and stairwells shall comply with all applicable provisions as occupied spaces

Initial tenant improvement = Tenant space first build out

C401.2
C403.1.4

90

Existing Building Mechanical Alterations



91

Mechanical Alterations – Cooling Equipment

There are four alteration scope options that subsequently define the requirements for the installation of new cooling equipment, or the alteration or replacement of existing cooling equipment

- ▶ Option A – Any mechanical alteration with new or replacement equipment
- ▶ Option B – Replacement unit is the same equipment type as the equipment being replaced, with the **same or smaller output capacity**
- ▶ Option C – Replacement unit is the same equipment type as the equipment being replaced, with a **larger output capacity**
- ▶ Option D – New equipment added to an existing system, or the replacement unit is a **different equipment type** than the equipment being replaced

C503.4.3

92

Mechanical Alterations – Cooling Equipment

Options A and D

- ▶ In general, equipment minimum required efficiency and economizer requirements are **the same as for new construction**
- ▶ For Option D, alternative compliance options are available (by footnote) for the alteration of existing hydronic air handling units, fan coil units and water source heat pumps, if served by older unaltered chillers

Options B and C – Compliance alternatives vary by equipment type

- ▶ Comply with the same equipment minimum required efficiency and economizer requirements as for new construction
- ▶ Maintain existing economizer capability (not all equip types allow this alternative)
- ▶ Comply with better than code cooling equipment efficiency criteria

C503.4.3

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**TABLE C503.4.3
ECONOMIZER COMPLIANCE OPTIONS FOR MECHANICAL ALTERATIONS**

| Unit Type | Option A Any alteration with new or replacement equipment | Option B (alternate to A) Replacement unit of the same type with the same or smaller output capacity | Option C (alternate to A) Replacement unit of the same type with a larger output capacity | Option D (alternate to A) New equipment added to existing system or replacement unit of a different type |
|--|--|---|---|--|
| 1. Packaged Units | Efficiency: min. ^a Economizer: C403.5 ^b | Efficiency: min. ^a Economizer: C403.5 ^b | Efficiency: min. ^a Economizer: CC403.5 ^b | Efficiency: min. ^a Economizer: C403.5 ^b |
| 2. Split Systems | Efficiency: min. ^a Economizer: C403.5 ^b | For units ≤ 60,000 Btuh, comply with two of two measures: 1. Efficiency: + 10% ^a 2. Economizer: shall not decrease existing economizer capability For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b | For units ≤ 60,000 Btuh replacing unit installed prior to 1991, comply with at least one of two measures: 1. Efficiency: + 10% ^a For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b | Efficiency: min. ^a Economizer: C403.5 ^b |
| 3. Water Source Heat Pump | Efficiency: min. ^a Economizer: C403.5 ^b | For units ≤ 72,000 Btuh, comply with at least two of three measures: 1. Efficiency: + 10% ^a 2. Flow control valve ^d 3. Economizer: 50% ^f For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b | For units ≤ 72,000 Btuh, comply with at least two of three measures: 1. Efficiency: + 10% ^a 2. Flow control valve ^d 3. Economizer: 50% ^f (except for certain pre-1991 systems ^h) For all other capacities: Efficiency: min. ^a Economizer: C403.5 ^b | Efficiency: min. ^a Economizer: C403.5 ^b (except for certain pre-1991 systems ^h) |
| 4. Water Economizer using Air-Cooled Heat Rejection Equipment (Dry Cooler) | Efficiency: min. ^a Economizer: C403.5 ^b | Efficiency: +5% ^e Economizer: shall not decrease existing economizer capacity | Efficiency: min. ^a Economizer: C403.5 ^b | Efficiency: min. ^a Economizer: C403.5 ^b |

Equipment minimum required efficiency and economizer requirements (including available exceptions) are **the same as for new construction**

Comply with **better than code** cooling efficiency criteria, AND

Maintain existing economizer capability

94

Mechanical Alterations – Heating Equipment

NEW – Addition or Replacement of Existing Heating Appliances

- ▶ Defines the requirements for the installation of new heating equipment, or the alteration or replacement of existing heating equipment
- ▶ **NOTE** – Mechanical alterations do not require compliance with C406 Additional Energy Efficiency Measures or C401.3 Prescriptive or Fossil Fuel Compliance Path
- ▶ **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
- ▶ For **building additions** where heat pump equipment for space heating is required, compliance via the Fossil Fuel Compliance Path is permitted

C503.4.6

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**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) | 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 2. Compliance with C403.1.4, except electric resistance mixed air preheat is permissible ^e |
| 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**, provided it complies with **better than code** heating efficiency criteria

**C403.1.4
C503.4.6**

96

Mechanical Alterations – Heating Equipment

Equipment not subject to the requirements in Section C503.4.6

- ▶ Terminal unit heating equipment served by an unaltered central plant – hydronic & electric resistance 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

C503.4.6

97

Mechanical Alterations – Heating Equipment

Equipment not subject to the requirements in Section C503.4.6

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

**C403.1.4
C503.4.6**

98

Shell & Core and Existing Building Mechanical Alterations Q&A

1. Can shell & core buildings use electric resistant heating in unfinished spaces?
2. In shell & core buildings, does the initial tenant improvement need to comply with the additional energy efficiency measure requirements?
3. What are the economizer requirements when adding cooling to spaces that were not previously cooled?
4. What are the requirements when replacing existing fossil fuel appliances?

99

What Is This Thing?

COMMERCIAL HVAC SYSTEMS AND EQUIPMENT AND 2021 WSEC-C REQUIREMENTS



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Duane Lewellen – Lewellen Associates, LLC

Lisa Rosenow - Evergreen Technology Consulting (ETC)

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Q&A Roundtable Discussion

COMMERCIAL HVAC SYSTEMS AND EQUIPMENT AND 2021 WSEC-C REQUIREMENTS



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