BUILDING ENERGY CODES PROGRAM

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ANSI/ASHRAE/IES Standard 90.1-2019: HVAC

May 2020 – PNNL-SA-153210

Prepared by Pacific Northwest National Laboratory for the U.S. Department of Energy

Acknowledgements

PNNL and DOE would like to thank ASHRAE Standing Standard Project Committee 90.1 for their contributions to the development of this presentation and their technical review of the content.

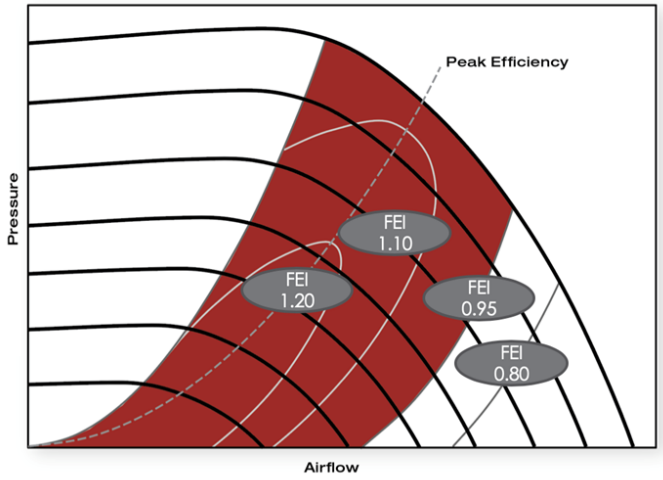
OVERVIEW OF CHANGES TO 90.1-2019

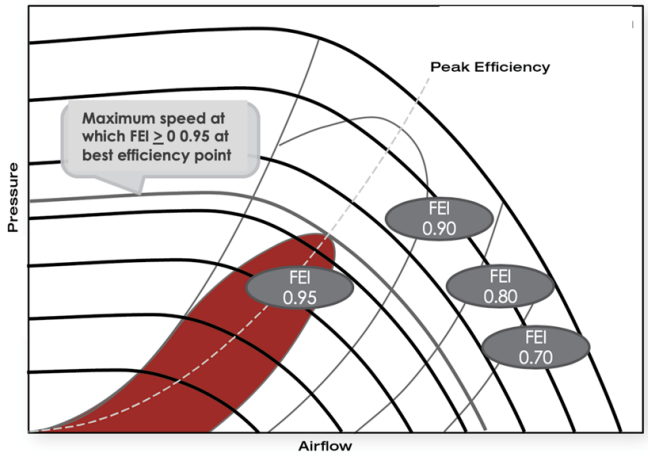
Mechanical – Computer Rooms & Data Centers

- New requirements to allow the option of using ANSI/ASHRAE Standard 90.4-2019, Energy Standard for Data Centers, instead of ASHRAE Standard 90.1 in computer rooms that have an IT equipment load larger than 10 kW
  - Took years to work out wording
  - Definition of computer room
  - Essentially big data centers follow 90.4
    - 90.4 has more electrical efficiency requirements
    - Smaller data rooms in a building follow 90.1
  - Computer Room = > 20 W/sf and ≥ 10 kW of comp load and/or IT equipment

Mechanical – Fan Energy Index (FEI)

- Replaced Fan Efficiency Grade (FEG) efficiency metric with Fan Energy Index (FEI)
- FEG mainly requires good fan peak efficiency; does not concentrate as much on good selections
- FEI mainly requires good fan selections
  - kW input must be below a calculated value AT THE SCHEDULED OPERATING POINT
  - So the fan must be fairly good too
  - Manufacturers selection software should tell you “Compliant with FEI” or NOT or just not list non-compliant products
- Exceptions for embedded fans, safety fans, ceiling fans, fans outside scope of AMCA 208
  - No exception for powered roof ventilators
- Power threshold lowered from 5 HP to 1 HP





Images courtesy of AMCA

Mechanical - FEI

- FEI is a true wire-to-air method
- Requirement:
  - Constant speed: FEI ≥ 1.0
  - VAV – FEI ≥ 0.95

$$FEI = \frac{\text{Reference Fan Electrical Input Power}}{\text{Fan Electrical Input Power}}$$

Images courtesy of AMCA

Equipment Efficiency Tables

- MANY tables were updated

- Added pump definitions, requirements, and efficiency tables to the standard for the first time
  - Match DOE Pump Energy Index (PEI)
  - Requires PEI ≤ 1.0
- PEI for pumps = similar to FEG = confusing
  - Also, lower numbers are better in FEI

Image courtesy of Grundfos

Mechanical – Ceiling Fans

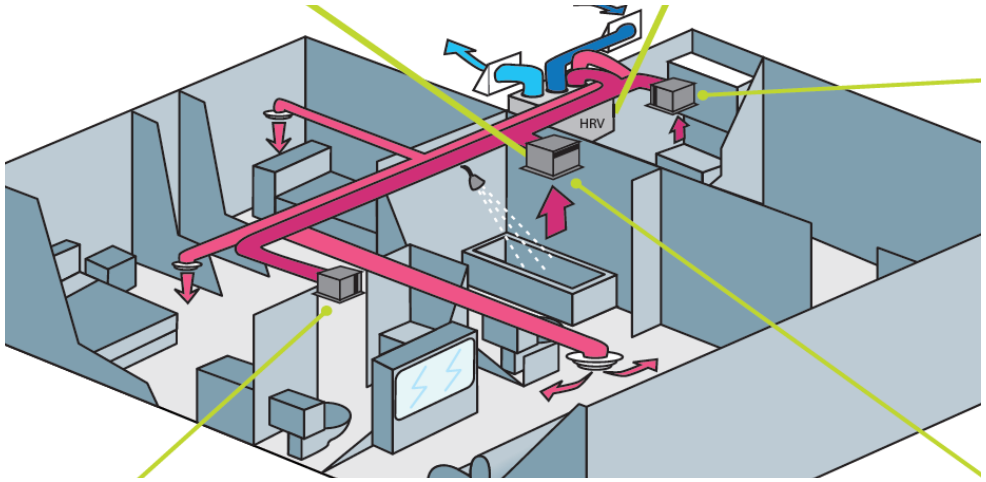
- New requirements for reporting fan power for large diameter (≥84.5”) ceiling fans
  - Rated per DOE 10 CFR 430 Appendix U or AMCA 230
  - Must report
    - Blade tip diameter
    - Rated airflow and power at max speed
  - There is not a minimum efficiency requirement
- Smaller ceiling fans are covered in the Energy Star program

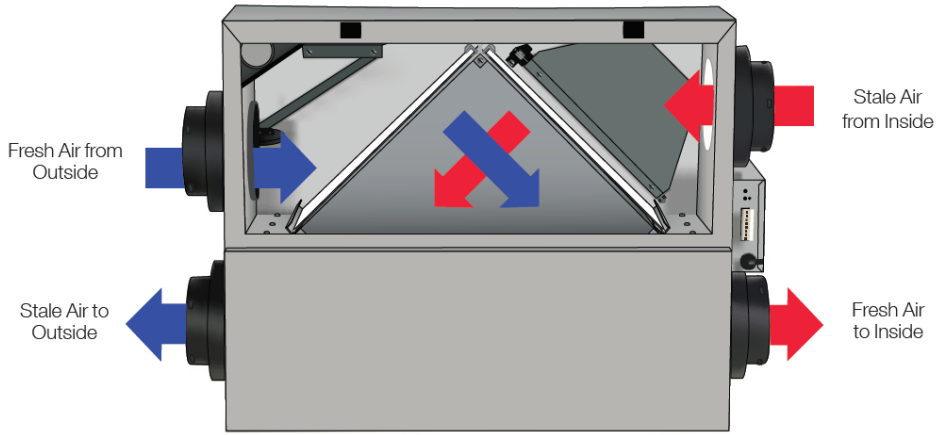
Image courtesy of Big Ass Fans

Mechanical – ERVs for Nontransient Dwelling Units

- New energy recovery requirements for *nontransient* dwelling units (apartments & condos)
  - Enthalpy recovery ratio (ERR) at design conditions
    - ≥50% ERR at cooling
    - ≥ 60% ERR at heating
    - Unless one of the modes is not required
    - ERR is different than AHRI efficiency rating
  - Exceptions based on unit floor area and CZs

Images courtesy of American Aldes



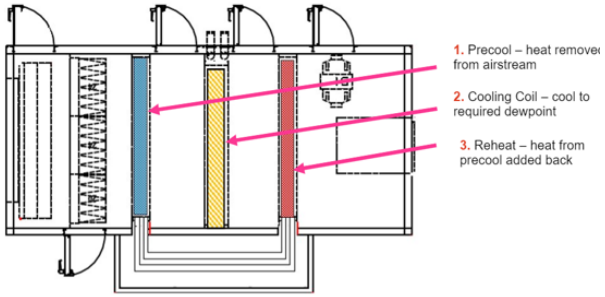


Updates to Exceptions to Exhaust Air Energy Recovery Requirements

- The language “energy recovery in series with the coil” was replaced with a definition of “series energy recovery.”
  - Added a performance requirement for series energy recovery.
  - Now limited to climate zones 0-4

Parts of the addendum were not included in the first printing of ASHRAE 90.1 (I-P). This will be corrected through the errata process.

Examples of Series Energy Recovery



Wrap-around Heat Pipes

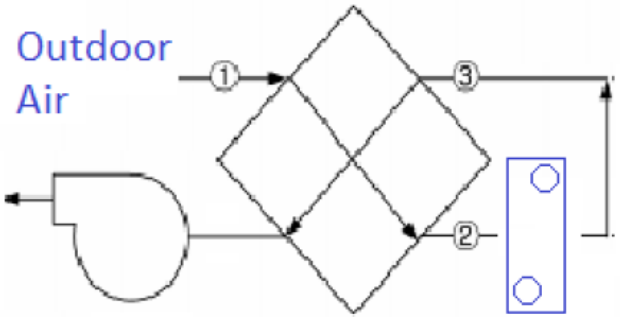


Plate Heat Exchanger

Mechanical – Occupied Standby

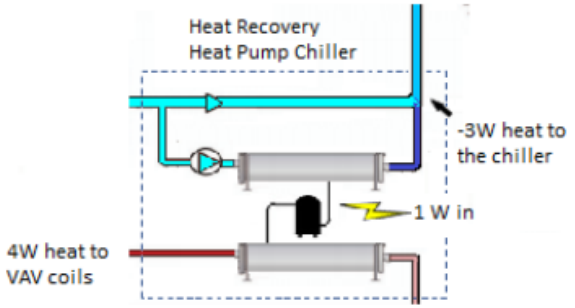
- Occupied-Standby Mode (6.5.3.8)
  - Definition: When a zone is scheduled to be occupied, and an occupant sensor indicates no occupants are within the zone
  - Applies to both single and multiple zone systems, at the zone level, where there are lighting occupancy sensors (9.4.1.1a)
  - Became important after Standard 62.1 (IAQ) allowed zero ventilation in vacant zones, even if scheduled occupied
  - Only applies to space types where 62.1 allows this mode
  - Allows standby period airflow only when zones are outside of their temperature limits

Mechanical – ER Chillers for Hospitals

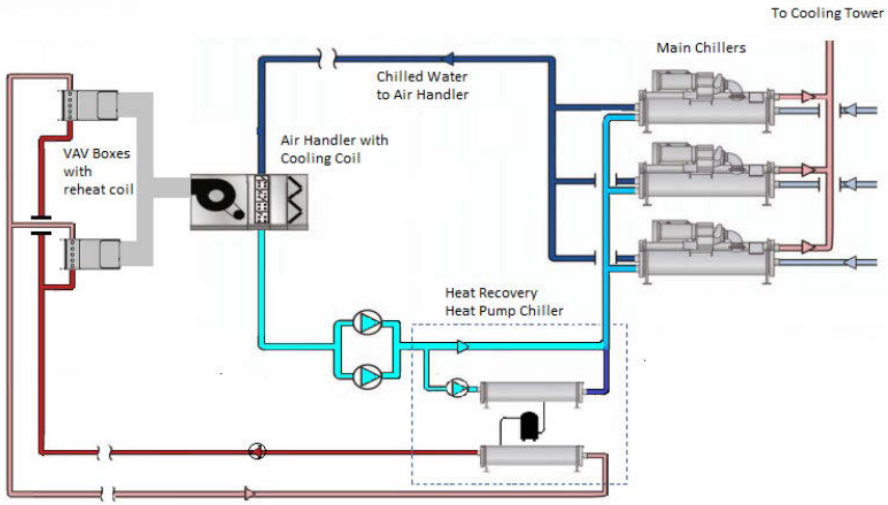
- Energy Recovery Chillers for Hospitals
  - Limited to:
    - Acute Inpatient
    - 24 hr operation
    - Chilled water capacity at design conditions >300 tons
    - Has simultaneous heat and cooling above 60F
  - Exceptions:
    - ≥60% of reheat energy from on-site renewables or site recovered energy
    - Climate Zones 5C, 6B, 7, & 8
  - Capacity of ≥7% of cooling capacity at design conditions (I.e. not standby chillers)

Image courtesy of Trane

Image courtesy of Multistack



Images courtesy of 2050 Partners



Updated Many Tables to Match Latest DOE Efficiencies

- New equipment efficiency requirement tables and changes to efficiency requirements in existing tables to match DOE requirements

Table 6.8.1-5 Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters—Minimum *Efficiency* Requirements

Equipment Type	Size Category (Input)	Subcategory or Rating Condition	Minimum *Efficiency*	Test Procedure[a]
Warm-air furnace, gas fired for application outside the U.S. [g]	<225,000 Btu/h	Maximum capacity[c]	80% *AFUE* (nonweatherized) or 81% *AFUE* (weatherized) or 80% E_t[b,d]	10 CFR 430 Appendix N or Section 2.39, Thermal *Efficiency*, ANSI Z21.47
Warm-air furnace, gas fired	≥225,000 Btu/h	Maximum capacity[c]	80% E_t[b,d] before 1/1/2023 81% E_t[d] after 1/1/2023	Section 2.39, Thermal *Efficiency*, ANSI Z21.47
Warm-air furnace, oil fired for application outside the U.S. [g]	<225,000 Btu/h	Maximum capacity[c]	83% *AFUE* (nonweatherized) or 78% *AFUE* (weatherized) or 80% E_t[b,d]	10 CFR 430 Appendix N or Section 42, Combustion, UL 727
Warm-air furnace, oil fired	≥225,000 Btu/h	Maximum capacity[c]	80% E_t[d] before 1/1/2023 82% E_t[d] after 1/1/2023	Section 42, Combustion, UL 727
Electric furnaces for applications outside the U.S. [g]	<225,000 Btu/h	All	96% *AFUE*	10 CFR 430 Appendix N
Warm-air duct furnaces, gas fired	All capacities	Maximum capacity[c]	80% E_c[c]	Section 2.10, *Efficiency*, ANSI Z83.8
Warm-air unit heaters, gas fired	All capacities	Maximum capacity[c]	80% E_c[e,f]	Section 2.10, *Efficiency*, ANSI Z83.8
Warm-air unit heaters, oil fired	All capacities	Maximum capacity[c]	80% E_c[e,f]	Section 40, Combustion, UL 731

a. Section 12 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
b. Combination units (i.e., furnaces contained within the same cabinet as an air conditioner) not covered by 10 CFR 430 (i.e., three-phase power or with cooling capacity greater than or equal to 65,000 Btu/h) may comply with either rating. All other units greater than 225,000 Btu/h sold in the U.S. must meet the *AFUE* standards for consumer products and test using USDOE's *AFUE* test procedure at 10 CFR 430, Subpart B, Appendix N.
c. Compliance of multiple firing rate units shall be at the maximum firing rate.
d. E_t = thermal *efficiency*. Units must also include an interrupted or intermittent ignition device (IID), have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a *flue damper*. A *vent damper* is an acceptable alternative to a *flue damper* for those furnaces where combustion air is drawn from the *conditioned space*.
e. E_c = combustion *efficiency* (100% less flue losses). See test procedure for detailed discussion.
f. Units must also include an interrupted or intermittent ignition device (IID) and have either power venting or an automatic flue damper.
g. For U.S. applications of federal covered greater than 225,000 Btu/h products, see Informative Appendix F, Table F-4.

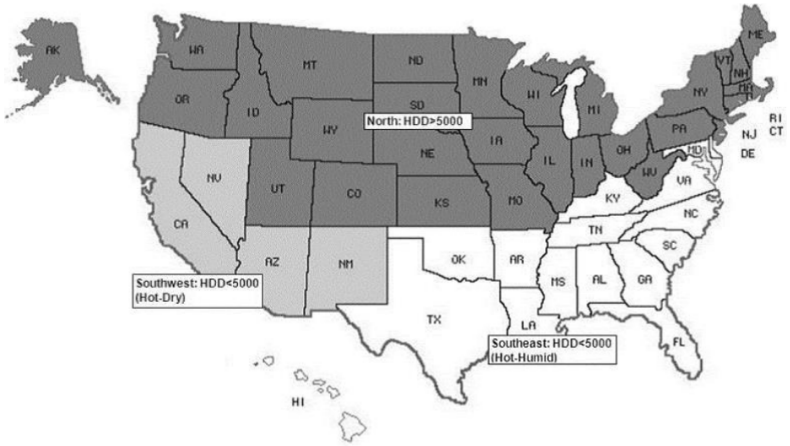


Figure F-1 Map of the regions for the analysis of central air conditioners and heat pumps.
(Source: *Federal Register* 76 FR 37431, June 7, 2018)

Table F-1 Minimum *Efficiency* Requirements for Single-Phase Central Air Conditioners and Heat Pumps for Sale in the U.S

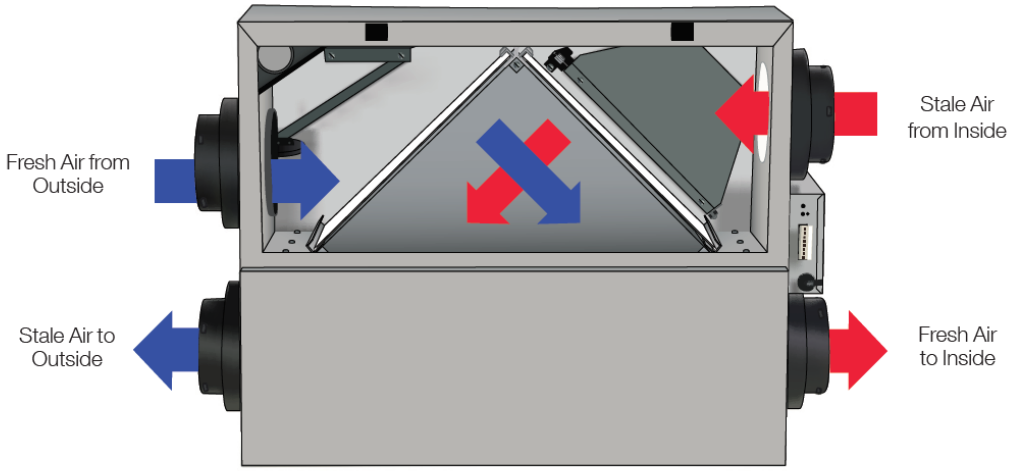
Product Class	Capacity Range	National Standards	Southeastern Region Standards[a]	Southwestern Region Standards[b]	Test Procedure[f]
Central Air Conditioners and Heat Pumps[c]					
Split-system air conditioners for U.S. applications	<45,000 Btu/h *single phase*	before 1/1/2023 *SEER* = 13.0 $P_{W,OFF}$ ≤ 30 W after 1/1/2023 *SEER2* = 13.4 $P_{W,OFF}$ ≤ 30 W	before 1/1/2023 *SEER* = 14.0 $P_{W,OFF}$ ≤ 30 W after 1/1/2023 *SEER2* = 14.3 $P_{W,OFF}$ ≤ 30 W	before 1/1/2023 *SEER* = 14.0 *EER* = 12.2 $P_{W,OFF}$ ≤ 30 W after 1/1/2023 *SEER2* = 14.3 *EER2* = 11.7/9.8[d] $P_{W,OFF}$ ≤ 30 W	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
Split-system air conditioners	≥45,000 Btu/h and <65,000 Btu/h *single phase*	before 1/1/2023 *SEER* = 13.0 $P_{W,OFF}$ ≤ 30 W after 1/1/2023 *SEER2* = 13.4 $P_{W,OFF}$ ≤ 30 W	before 1/1/2023 *SEER* = 14.0 $P_{W,OFF}$ ≤ 30 W after 1/1/2023 *SEER2* = 13.8 $P_{W,OFF}$ ≤ 30 W	before 1/1/2023 *SEER* = 14.0 *EER* = 11.7[d] $P_{W,OFF}$ ≤ 30 W after 1/1/2023 *SEER2* = 13.8 *EER2* = 11.2/9.8[e] $P_{W,OFF}$ ≤ 30 W	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023

Miscellaneous

- Removed 10 unused definitions
- Revised test conditions for pool dehumidifiers (AHRI 910) for moisture removal efficiency (MRE)
- Air barrier and leakage testing
  - ***Not mechanical*** – but very important to HVAC engineers!
  - Two major guesses in HVAC load calcs:
    - Infiltration
    - Internal Heat Gains (RP-1742 = 0.34-1.53 W/SF)
- Clarified much wording, e.g. humidification & dehumidification

Miscellaneous 2

- Added indoor pool dehumidifier energy recovery:
  - 50% EA sensible recovery, or
  - Condenser pool heating, or
  - 50% EA enthalpy recovery
- Air Curtains
  - ***NOT MECHANICAL*** – but affects MEs
- Motor selection
  - Simplified
  - Made more tolerant of motors not rated in BHP



Miscellaneous 3

- Starting to incorporate Guideline 36 recommendations, especially in reheat limitations and fan speed vs. SAT reset sequences

HVAC Compliance

Building System

- Envelope
- **HVAC**
- SWH
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

- ✓ New Buildings
- ✓ Additions to Existing Buildings
- ✓ Alterations in Existing Buildings

- Equipment
  - New equipment shall meet the minimum efficiency requirements
- Cooling systems
  - New cooling systems installed to serve previously uncooled spaces shall comply with this section
  - Alterations to existing cooling systems shall not decrease economizer capacity (unless economizer tradeoff is used)
- Ductwork
  - New and replacement ductwork shall comply with applicable requirements
- Piping
  - New and replacement piping shall comply with applicable requirements

Alterations to the building HVACR system shall comply with the requirements of Section 6

- **Exceptions** that are allowed:
  - Equipment being modified or repaired (not replaced)
    - provided such modifications will not result in an increase in the annual energy consumption
  - Equipment being replaced or altered which requires extensive revisions to other systems and such replaced or altered equipment is a like-for-like replacement
  - Refrigerant change of existing equipment
  - Relocation of existing equipment
  - Ducts and pipes where there is insufficient space or access to meet these requirements

Replacement Equipment

6.1.1.3.1 New HVACR *equipment* as a direct replacement of existing HVACR *equipment* shall comply with the following sections as applicable for the *equipment* being replaced:

a. 6.3, "Simplified Approach Option for HVAC Systems"
b. 6.4.1, "Equipment Efficiencies, Verification, and Labeling Requirements"
c. 6.4.3.1, "Zone Thermostatic Controls"
d. 6.4.3.2, "Set-Point Overlap Restrictions"
e. 6.4.3.3, "Off-Hour Controls" except for Section 6.4.3.3.4, "Zone Isolation"
f. 6.4.3.4, "Ventilation System Controls"
g. g. 6.4.3.7, "Freeze Protection and Snow/Ice Melting Systems"
h. 6.4.3.8, "Ventilation Controls for High-Occupancy Areas" only for single-zone equipment

i. 6.4.3.9, "Heated or Cooled Vestibules"
j. 6.4.5, "*Walk-In Coolers* and *Walk-In Freezers*"
k. 6.5.1.1, "*Air Economizers*" for units located outdoors
l. 6.5.1.3, "Integrated Economizer *Control*"
m. 6.5.1.4, "Economizer Heating *System* Impact"
n. 6.5.3.1.3, "Fan *Efficiency*"
o. 6.5.3.2.1, "Supply Fan Airflow *Control*"
p. 6.5.3.6, "Fractional Horsepower Fan Motors"
q. 6.5.4.1, "*Boiler* Turndown"
r. 6.5.4.3, "Chiller and *Boiler* Isolation"
s. 6.5.5.2, "Fan Speed *Control*"

- ✓ You have to follow Sections
  - 6.1 General,
  - 6.4 Mandatory Provisions,
  - 6.7 Submittals, and
  - 6.8 Minimum Equipment Efficiency
- ✓ And then you can follow either
  - Section 6.3 Simplified Approach and 6.5 Prescriptive Path

The simplified approach is an optional path for compliance when the following are met:

- Buildings with 1 or 2 stories
- Buildings with gross floor area < 25,000 ft^2
- System serving single HVAC zone
- Each system complies with 6.3.2

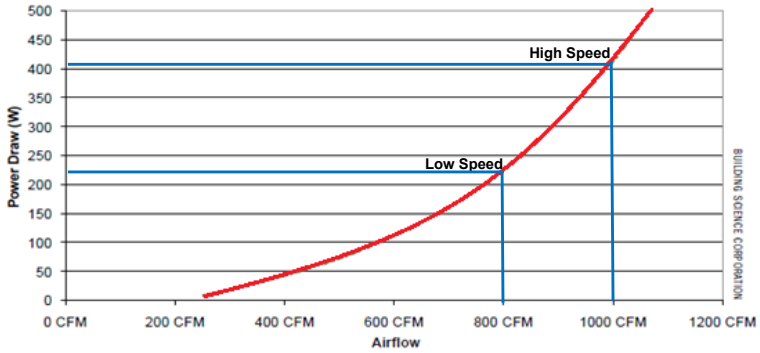
a. Single HVAC zone
b. Variable flow requirements (6.5.3.2.1)
c. Cooling equipment efficiency (6.8.1)
d. Air economizers (6.5.1 and 6.4.3.12)
e. Heating equipment efficiency (6.8.1)
f. Exhaust air energy recovery (6.5.6.1)
g. Dual setpoint thermostat or manual changeover
h. Heat pump auxiliary heat control
i. No reheat or simultaneous cooling and heating for humidity control
j. Off-hour shutoff and temperature setback/setup
k. Systems serving hotel/motel guest rooms comply with Section 6.4.3.3.5
l. Piping insulation (Tables 6.8.3-1 and 6.8.3-2)
m. Ductwork insulation and sealing (6.4.4.2.1)
n. Air balancing of ducted system
o. Outdoor air intake and exhaust systems (6.4.3.4)
p. Zone thermostatic controls to prevent simultaneous heating and cooling
q. Optimum start controls
r. Demand control ventilation (6.4.3.8, 6.5.3.8, and 6.5.3.7)
s. Door switch requirements (6.5.10)

- ✓Air-handling and fan coil unit supply fans controlled by two-speed motors or variable speed drives
  - Chilled-water cooling coils where the supply fans have motors ≥ 1/4 hp
  - Direct expansion units ≥ 65,000 Btu/h cooling capacity
  - Two speeds of fan control required during economizer operation

Temperature Control	Typical Zones	Minimum fan speed	Fan power at min speed	Fan control
Supply Air	Multiple	≤ 50% *	≤ 30%	Modulating
Room Temperature	Single	≤ 66% *	≤ 40%	Two-speed, Multi-speed or Modulating

* or volume of outdoor air required to meet Standard 62.1

Example: 1/2 HP Motor



Reference 90.1-2019 Tables:

6.8.1-1, 6.8.1-2, 6.8.1-4

The system shall either have an economizer,

Or use the economizer Trade-off Option

- Limited to unitary systems
- Requires higher minimum cooling efficiency (EER)
- Trade-off EER by
  - System size
  - Climate zone
- Eliminated separate table for computer rooms. They must follow the same thresholds as other spaces.

Reference Table 6.5.1-2 on page 99 in 90.1-2019

- Climate and size dependent *(Tables 6.5.1-1 and -2)*
- There are LOTS of exceptions
- Can use air economizers
  - 100% of design supply air
  - Sequenced with mechanical cooling equipment
  - High limit shutoff
  - Dampers
  - Relief of excess outdoor air
  - Sensor accuracy

Exceptions

- Small individual fan units: < Table 6.5.1-1
- Chilled-water cooling systems without a fan or that use induced airflow with certain capacity in certain climate zones
- Systems with nonparticulate air treatment per Standard 62.1
- Hospitals where >75% of the air must be humidified >35°Fdp
- Processes where >25% of the air must be humidified >35°Fdp
- Systems with condenser heat recovery per 6.5.6.2.2
- Residential systems <5X limits in Table 6.5.1-1
- Systems with a balance point <=60°F
- Systems expected to operate < 20hrs/wk
- Systems serving zones with open refrigerated casework
- Where comfort cooling efficiency meets or exceeds Table 6.5.1-2
- Systems serving computer rooms under certain conditions
- Dedicated systems for computer rooms where a minimum of 75% of the design load serves various conditions

Nontransient Dwelling Units

- Provided with outdoor air energy recovery ventilation systems
  - result in enthalpy recovery ratio of ≥ 50% cooling and ≥ 60% heating
  - provide required enthalpy recovery ratio at both heating and cooling design conditions, unless one mode isn't required for climate zone by exception:

Exceptions

  - Climate zone 3C
  - Units with ≤ 500 ft^2 conditioned floor area in climate zones 0, 1, 2, 3, 4C, and 5C
  - Enthalpy recovery ratio requirements at
    - heating design condition in climate zones 0, 1, and 2
    - Cooling design condition in climate zones 4, 5, 6, 7, 8

Spaces Other than Nontransient Dwelling Units

Required if:

- ✓ Supply air capacity ≥ value listed in Tables 6.5.6.1.2-1 and 6.5.6.1.2-2
  - – Values are based on climate zone and % of outdoor air flow rate at design conditions

Table 6.5.6.1.2-1 used for all ventilation systems operating < 8,000 hrs/yr

Table 6.5.6.1.2-2 used for all ventilation systems operating ≥ 8,000 hrs/yr

Recovery system effectiveness ≥ 50%

- – required thresholds have changed to account for minimum size availability of small energy recovery products

Table 6.5.6.1.2-1 Exhaust Air *Energy* Recovery Requirements for *Ventilation Systems* Operating Less than 8000 Hours per Year

Climate Zone	% *Outdoor Air* at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B,5C	NR	NR	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥28,000	≥26,500	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
0A, 1A, 2A, 3A, 4A, 5A, 6A	≥26,000	≥16,000	≥5500	≥4500	≥3500	≥2000	≥1000	≥120
7,8	≥4500	≥4000	≥2500	≥1000	≥140	≥120	≥100	≥80

NR—Not required

Table 6.5.6.1.2-2 Exhaust Air *Energy* Recovery Requirements for *Ventilation Systems* Operating Greater than or Equal to 8000 Hours per Year

Climate Zone	% *Outdoor Air* at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and < 80%	≥80%
	Design Supply Fan Airflow Rate, cfm							
3C	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 3B, 4C, 5C	NR	≥19,500	≥9000	≥5000	≥4000	≥3000	≥1500	≥120
0A, 1A, 2A, 3A, 4B, 5B	≥2500	≥2000	≥1000	≥500	≥140	≥120	≥100	≥80
4A, 5A, 6A, 6B, 7, 8	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

NR—Not required

Section 6 – 6.5.6.1 (6.3.2f)
Exhaust Air Energy Recovery Exceptions

- Lab systems meeting 6.5.7.3
- Systems serving uncooled spaces that are heated to < 60°F
- Heating energy recovery where > 60% of outdoor air heating energy is provided from site-recovered or site solar energy in climate zones 5-8
- Enthalpy recovery ratio requirements at heating design condition in climate zones 0, 1, and 2
- Enthalpy recovery ratio requirements at cooling design condition in climate zones 3C, 4C, 5B, 5D, 6B, 7, and 8
- Where sum of airflow rates exhausted and relieved within 20 ft of each other is < 75% of the design outdoor airflow, including exhaust air that is
  - Used for another energy recovery system
  - Not allowed by ASHRAE/ASHE Standard 170 for use in energy recovery systems with leakage potential, or
  - Of Class 4 as defined in ASHRAE Standard 62.1
- Heating energy recovery for systems in climate zones 0-4 requiring dehumidification during heating mode that have energy recovery and minimum SERR of 0.40
- Systems operating < 20 hrs/week at outdoor air % in Table 6.5.6.2-1
- Indoor pool dehumidifiers meeting Section 6.5.6.4

- Manual changeover or dual set-point thermostat
- Heat pump supplementary heat lockout
- No reheat or simultaneous heating and cooling for humidity control
- Time clocks *(except hotel/motel guest rooms and systems requiring continuous operation)*
- Systems serving hotel/motel guest rooms to comply with automatic control of HVAC (Section 6.4.3.3.5)

- Ductwork and plenum insulation
- Air balancing of ducted systems required
- Outdoor air intake and exhaust systems meet 6.4.3.4
- Interlocked thermostats for separate heating and cooling
- System > 10,000 cfm:
  - optimum start controls
- Demand control ventilation per 6.4.3.8, 6.5.3.8, 6.5.3.7
- Door switch requirements

Piping and ductwork/plenum insulated

Piping Insulation - Reference Tables 6.8.3-1 and 6.8.3-2 on page 150 in 90.1-2019

Duct Insulation - Reference Table 6.8.2 on page 150 in 90.1-2019

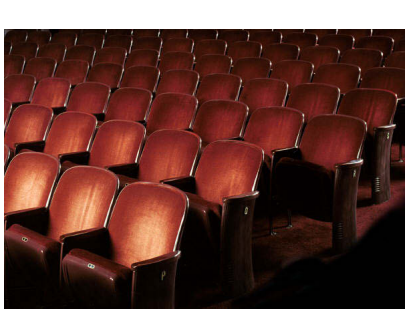
Tables 6.8.3-1 and 6.8.3-2

Exceptions

- ✓ Factory-installed
- ✓ Piping conveying fluids
  - design operating temperature range between 60°F-105°F, inclusive
  - that haven't been heated or cooled through the use of fossil fuels or electricity
- ✓ Where heat gain or loss won't increase energy use
- ✓ For piping ≤ 1 in, No insulation required for strainers, control values, and balancing values

DCV must be provided for each zone with an area > 500 ft² and the design occupancy > 25 people/1000 ft² where the HVAC system has:

- ✓ air-side economizer,
- ✓ automatic modulating control of OSA dampers
- ✓ design outdoor airflow > 3,000 cfm



Demand control ventilation (DCV): a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

Exceptions to DCV:

- Systems with exhaust air energy recovery meeting 6.5.6.1
- Multiple-zone systems without DDC of individual zones communicating with central control panel
- Systems with design outdoor air flow < 750 cfm
- Spaces where > 75% of space design outdoor airflow is required for makeup air exhausted from space or transfer air exhausted from other spaces
- Spaces with one of the following occupancy categories per ASHRAE 62.1
  - Correctional cells
  - Daycare sickrooms
  - Science labs
  - Barbers, beauty, and nail salons
  - Bowling alley seating

HVAC Compliance

Building System

- Envelope
- **HVAC**
- SWH
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

- ✓ Minimum Equipment Efficiency *(Section 6.4.1)*
- ✓ Calculations *(Section 6.4.2)*
- ✓ Controls and Diagnostics *(Section 6.4.3)*
- ✓ HVAC System Construction and Insulation *(Section 6.4.4)*
- ✓ Walk-in Coolers and Walk in Freezers *(Section 6.4.5)*
- ✓ Refrigerated Display Case *(Section 6.4.6)*
- ✓ Liquid-to-Liquid Heat Exchangers *(Section 6.4.7)*
  - ✓ *Table was removed (No prior minimum efficiency requirement)*
  - ✓ *Certified rating reporting is now required*

HVAC Equipment Covered

- ✓ Electrically operated unitary air conditioners and condensing units
- ✓ Electrically operated air-cooled unitary heat pumps
- ✓ Water-chilling packages (chillers)
- ✓ Electrically operated packaged terminal air conditioners and heat pumps, single-package vertical air conditioners, single-package heat pumps, room air conditioners, and room air conditioner heat pumps
- ✓ Warm-air furnaces, warm-air furnaces/AC units, warm-air duct furnaces and unit heaters
- ✓ Gas-and oil-fired boilers
- ✓ Performance requirements for heat rejection equipment (cooling towers)
- ✓ Electrically operated variable refrigerant flow (VRF) air conditioners
- ✓ Electrically operated VRF air-to-air and applied heat pumps
- ✓ Floor-mounted air conditioners and condensing units serving computer rooms
- ✓ Commercial refrigerators, freezers, and refrigeration
- ✓ Vapor-compression-based indoor pool dehumidifiers
- ✓ Electrically operated DX-DOAS units, single-package and remote condenser, without energy recovery
- ✓ Electrically operated DX-DOAS units, single-package and remote condenser with energy recovery
- ✓ Electrically operated water-source heat pumps
- ✓ Heat pump and heat recovery chiller packages
- ✓ Ceiling-mounted computer-room air conditioners
- ✓ Walk-in cooler and freezer display door
- ✓ Walk-in cooler and freezer nondisplay door
- ✓ Walk-in cooler and freezer refrigeration system

Equipment efficiency information from manufacturers verified by one of the following

- ✓ EPACT equipment – to comply with federal certification requirements
- ✓ If certification program exists for covered product and includes provisions for verification and challenge of equipment efficiency ratings, product listed in program
- ✓ If product not listed in program, ratings verified by an independent laboratory test report
- ✓ If no certification program exists, equipment efficiency ratings supported by data furnished by manufacturer
- ✓ Where components from different manufacturers are used, system designer specifies components whose combined efficiency meets Section 6.4.1

Mechanical equipment *(6.4.1.6.1)* – equipment not covered by NAECA to have a permanent label stating equipment complies with 90.1

Packaged terminal air conditioners *(6.4.1.6.2)* – packaged terminal air conditioners and heat pumps with sleeve sizes < 16 in. high and 42 in. wide with a cross-sectional area < 670 in^2 to be factory labeled as follows:

- ✓ *Manufactured for nonstandard size applications only: not to be installed in new construction projects*

Must calculate heating and cooling system design loads

Must determine calculations with ASHRAE/ACCA Standard 183

- When sizing pumps, head to be determined in accordance with generally accepted engineering standards/handbooks acceptable to the authority having jurisdiction
- Must calculate the pressure drop through each device and pipe segment in the critical circuit at design conditions

Thermostatic controls are required for each zone

- Perimeter can be treated differently

Dead band controls

- Thermostats must have at least a 5°F dead band

Exceptions

- Thermostats that require manual changeover between heating and cooling modes
- Special occupancy or applications where wide temperature ranges aren't acceptable (e.g., retirement homes) and approved by AHJ

If heating and cooling for the same zone are controlled by separate thermostats or sensors:

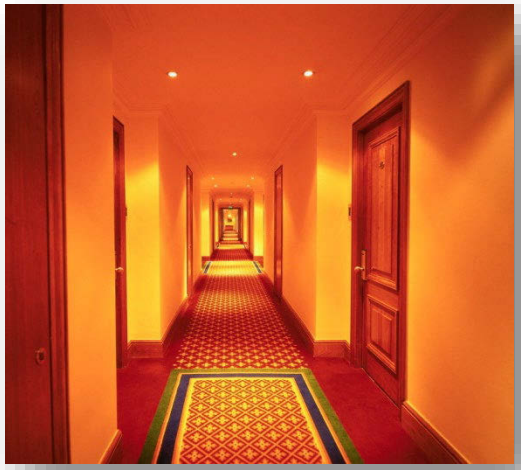
- Means will be provided to prevent the heating setpoint from exceeding the cooling setpoint minus any applicable proportional band
- Means can include limit switches, mechanical stops, or software programming for DDC systems

Temperature Control off-hour requirements

- Automatic shutdown
- Setback controls
- Optimum start
- Zone isolation
- Automatic control of HVAC in hotel/motel guest rooms

Exceptions, HVAC systems

- with heating and cooling capacity < 15,000 Btu/h
- intended to operate continuously



Each HVAC system needs one of the following:

- Automatic time clock or programmable thermostat with 7-day/week schedule and 10-hour battery backup with two-hour manual override, **OR**
- Occupant sensor, **OR**
- Manually-operated timer with maximum two hour duration, **OR**
- Security system interlock

Exception

- Residential occupancies allowed to operate with only 2 different time schedules/wk

Heating systems

- Maintain unoccupied zone temperatures at an adjustable setpoint at least 10°F below occupied heating setpoint

Cooling systems

- Temporarily operate during unoccupied periods to
  - Maintain unoccupied zone temperatures at an adjustable setpoint at least 5°F above the occupied cooling setpoint
  - May operate cooling as needed to prevent high space humidity levels

Exception

- Radiant heating systems with setback heating setpoint at least 4°F below occupied heating setpoint

Individual heating and cooling air distribution systems with setback controls and DDC

Control algorithm to be at least be a function of

- Difference between space temperature and occupied setpoint, OA temp, and amount of time prior to scheduled occupancy
- Mass radiant floor slab systems to incorporate floor temperature into the optimum start algorithm

Applies to

- Each floor in a multistory building
- Maximum 25,000 ft^2 zones

Requirements

- Central systems shall have devices and controls to ensure stable operation with only the smallest isolation zone being supplied
- Capable of separate time schedules for each isolation zone

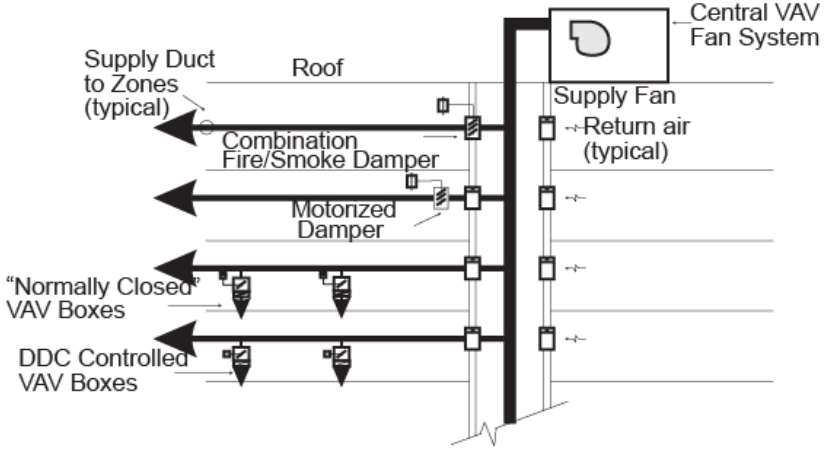


Figure 6-E

Isolation Methods for a Central VAV System

(User's Manual – 90.1.-2007)

Exceptions

- OSA and exhaust isolation when system supply air is < 5,000 cfm
- Exhaust isolation where single zone exhaust airflow less than 10% of system exhaust airflow
- Zones with continuous operation

Hotels and motels with > 50 guest rooms to have automatic HVAC controls to apply the following requirements:

Guest Room HVAC Set-point Control *(primarily clarification)*

Rented and unoccupied **(within 20 minutes of all occupants leaving)**

- Automatically raised by ≥ 4°F from the occupant set point (cooling)
- Automatically lowered ≥ 4°F from the occupant set point (heating)

Unrented and unoccupied

- Automatically reset to ≥ 80°F (cooling) and lowered ≤ 60°F (heating)
  - within 16 hours of being continuously unoccupied or
  - within 20 minutes of where a networked guest room control system indicates room is unrented

Occupied – return to occupied set points when occupancy is sensed

Guest Room Ventilation Control **(within 20 minutes of all occupants leaving)**

- Ventilation and exhaust fans automatically be turned off, or isolation devices serving each guest room shall automatically shut off the supply of outdoor air to the guest room and shut off exhaust air from the guest room.

Captive key cards are permitted to be used for compliance

There are some exceptions so see the standard for further details

Stair and Shaft Vent dampers (6.4.3.4.1)

- Motorized dampers automatically closed during normal building operation
- Interlocked to open as required by fire and smoke detection systems

Shutoff Damper Controls (6.4.3.4.2)

- All outdoor air intake and exhaust systems require motorized damper
- Outdoor air and exhaust/relief dampers capable of automatically shutting off during
  - Preoccupancy building warm-up, cool down, and setback

    (Except when outdoor air reduces energy costs or when outdoor air must be supplied due to code requirements)

Exceptions

- Nonmotorized (gravity backdraft) dampers are allowed
  - For exhaust and relief in buildings < 3 stories in height above grade
  - Of any height in climate zones 0 – 3
  - Design intake or exhaust capacity of 300 cfm or less
- Ventilation or exhaust systems serving unconditioned spaces
- Exhaust systems serving type 1 kitchen exhaust hoods
- Systems intended to operate continuously

Table 6.4.3.4.3 provides maximum leakage rates for outdoor air supply and exhaust dampers

Where OA supply and exhaust air dampers are required by Section 6.4.3.4.1

- They shall have a maximum leakage rate as indicated in Table 6.4.3.4.3

Reference Table 6.4.3.4.3 on page 91 in 90.1-2019

Fans with motors > 0.75 hp shall have automatic controls complying with Section 6.4.3.3.1 that are capable of shutting off fans when not required

Exception

- HVAC systems intended to operate continuously

Ventilation systems in enclosed parking garages

- automatically detect contaminant levels and stage fans or
- modulate fan airflow rates to ≤ 50%, provided acceptable contaminant levels are maintained

Exception

- Garages < 30,000 ft^2 with ventilation systems that do not use mechanical cooling or heating
- Garages with a garage area to ventilation system motor nameplate hp ratio > 1500 ft^2/hp and don't use mechanical cooling or heating
- Where permitted by AHJ

Controls to prevent supplemental heat when heat pump can handle the load both during operation and during setback recovery.

OK to operate supplemental heat during defrost.

Exception

- ✓ Heat pumps
  - – With minimum efficiency regulated by NAECA, AND
  - – With HSPF rating meeting Table 6.8.1-2 (*and the rating Includes all usage of internal electric resistance heating)*

6.4.3.6.1 Dehumidification

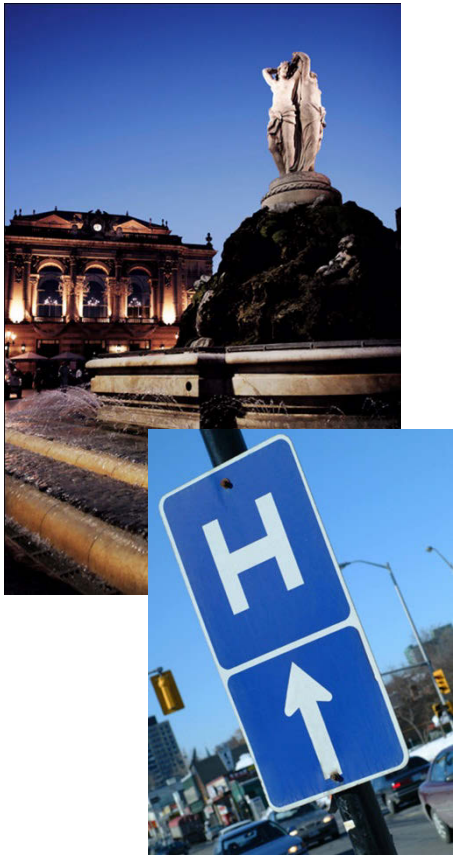
- Not use mechanical control to reduce humidity below dew point of 55°F or RH of 60% in coldest zone

6.4.3.6.2 Humidification

- Prevent use of fossil fuel or electricity to produce RH > 30% in warmest zone

6.4.3.6.3 Control Interlock

- Provide means to prevent simultaneous operation of humidification and dehumidification equipment
  - Limit switches, mechanical stops, or software programming (DDC systems)



Exceptions for 6.4.3.6.1 and 6.4.3.6.2 (requires interlock):

- Zones served by desiccant systems, used with direct evaporative cooling in series
- Systems serving zones (museums and hospitals) where
  - specific humidity levels are required by accreditation or approved by AHJ, **and**
  - configured to maintain a deadband of at least 10% RH with no active humidification or dehumidification

Exceptions for All Three Sections:

- Humidity levels are required by accreditation or approved by AHJ to be maintained with precision of not more than ± 5% RH

Automatic controls to shut off for

- ✓ Freeze protection systems
  - – outside air temperatures > 40°F or
  - – when conditions of protected fluid will prevent freezing;
    e.g, a glycol loop would have a lower shutoff setpoint
- ✓ Snow- and ice-melting systems
  - – pavement temperature > 50°F **and** no precipitation is falling
  - – **Also** shutoff if outdoor temperature > 40°F

Note that the setpoints shown are conservative upper limits, and a freeze protection system may be set to lower settings that are more energy efficient.

Include automatic controls to

- shut off heating system when
  - OA temps are > 45°F
  - Also controlled by a thermostat in the vestibule with setpoint limited to maximum of 60°F

  Note: a single heating thermostat in the vestibule limited to 45°F would meet the requirements
- shut off vestibule cooling system when
  - Controlled by a thermostat in the vestibule with setpoint limited to minimum of 85°F

Exceptions, vestibules:

- heated or cooled by site-recovered energy
- tempered with transfer air that would otherwise be exhausted

DDC provided in applications and for qualifications listed in Table 6.4.3.10.1

Where required in the table, the DDC system must be capable to provide control logic per section 6.5:

- Monitoring zone and system demand for fan pressure, pump pressure, heating, and cooling
- Transferring zone and system demand information from zones to air distribution system controllers and from air distribution systems to heating and cooling plant controllers
- Automatically detecting those zones and systems that may be excessively driving the reset logic and generate an alarm or other indication to the system operator
- Readily allowing operator removal of zone(s) from the reset algorithm

DDC Display: Where required in new buildings, DDC system to be capable of trending and graphically displaying input and output points

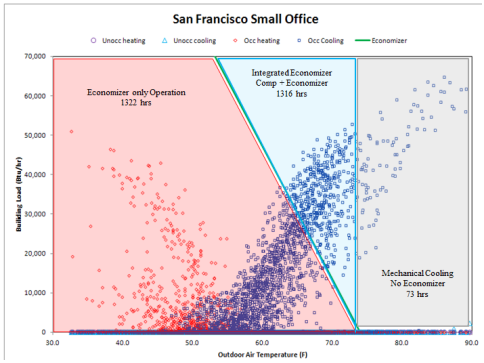
- For electric-motor-driven chilled-water plants in new buildings, or for new plants in existing buildings, measurement devices shall be installed and shall measure the electric energy use and efficiency of the chilled-water plant for:

  a. water-cooled chilled-water plants larger than 1500 tons peak cooling capacity for Climate Zones 5 through 8, 3C, and 4C, and larger than 1000 tons peak cooling capacity for all other zones; and

  b. air-cooled chilled-water plants larger than 860 tons peak cooling capacity for Climate Zones 5 through 8, 3C, and 4C, and larger than 570 tons peak cooling capacity for all other zones.

- The efficiency shall be calculated in kW/ton or COP of cooling operating efficiency

Air-cooled direct-expansion cooling units in Tables 6.8.1-1 and 6.8.1-2 (if an air economizer is installed per Section 6.5.1) to include an FDD system complying with the following:



- Outdoor air, supply air, and return temperature sensors permanently installed to monitor system operation and the control to include a means to display values
- Economizer control to provide system status indication for:
  - Free cooling available
  - Economizer enabled
  - Compressor enabled
  - Heating enabled
  - Mixed-air low-limit cycle active
- Control system capable of and configured to display the following faults:
  - Air temperature sensor failure/fault
  - Not economizing when the unit should be economizing
  - Economizing when the unit should not be economizing
  - Damper not modulating
  - Excess *outdoor air*

- ✓ Insulation installed in accordance with industry-accepted standards
- ✓ Insulation protection
- ✓ Duct and plenum insulation
- ✓ Piping insulation
- ✓ Sensible heating panel insulation
- ✓ Radiant floor heating
- ✓ Duct sealing
- ✓ Duct leakage tests

Insulation installed in accordance with industry-accepted standards

Insulation

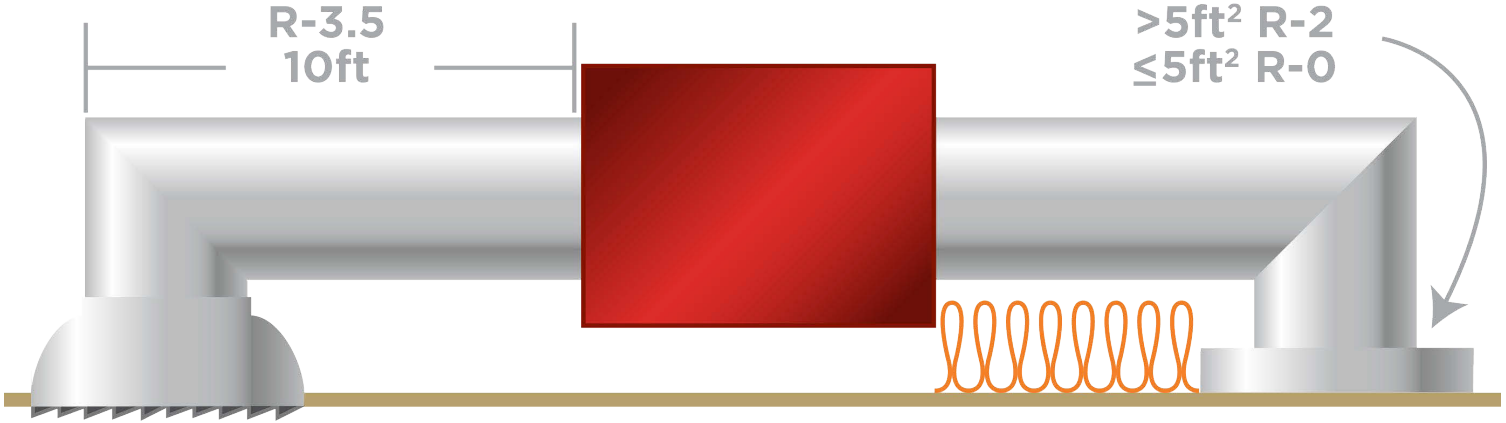
- Protected from damage due to sunlight, moisture, equipment maintenance, and wind
- Exposed to weather to be suitable for outdoor service
- Covering chilled water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space to include a vapor retardant located outside the insulation, all penetrations and joints of which to be sealed

All supply and return ducts and plenums to be insulated per Table 6.8.2

Duct insulation requirement table was simplified with some increases.

Exceptions

- Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment
- Ducts located in heated, semiheated, or cooled spaces
- For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5
- Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft^2 need not exceed R-2; those ≤ 5 ft^2 need not be insulated



Designed > 3 in. w.c.

- Leak tested
- Representative sections ≥ 25% of the total installed duct area shall be tested
- Ratings > 3 in. w.c. to be identified on drawings
- Maximum permitted duct leakage
  - $L_{max} = C_L P^{0.65}$
    - *Where L_{max} = maximum permitted leakage in cfm/100 ft^2 duct surface area*

Site assembled or site constructed walk-ins ≤ 3000 sq ft

- Automatic door closers that close doors within 1 inch of full closure for doors ≤ 3 ft 9 in. wide or ≤ 7 ft tall
- Strip doors (curtains), spring-hinged doors, or other way to minimize infiltration when doors are open
- Wall, ceiling and door insulation
  - Walk-in coolers ≥ R-25
  - Walk-in freezers ≥ R-32

  Exception: glazed portions of doors or structural members
- Floor insulation
  - Walk-in freezers ≥ R-28

- Use electronically commutated motors or three-phase motors for evaporator fan motors < 1 hp and < 460 V
- Use light sources with efficacy ≥ 40 lm/W (including any ballast losses)
  - May use light sources with efficacy < 40 lm/W in conjunction with a timer or device to turn off the lights within 15 minutes of last occupation
- transparent reach-in doors and windows in walk-in doors either filled with inert gas or heat-reflective treated glass or vacuum insulating glazing
  - freezers: triple-pane glass
  - coolers: double-pane glass
- for antisweat heaters without antisweat heater controls to have a total door rail, glass, and frame heater power draw
  - ≤7.1 W/ft^2 of door opening for walk-in freezers
  - ≤3.0 W/ft^2 of door opening for walk-in coolers
- Antisweat heater controls to reduce the energy use of the antisweat heater as a function of the RH in the air outside the door or condensation on the inner glass plane
- Use electronically commutated motors, permanent split capacitor-type motors, or three-phase motors for condenser fan motors < 1 hp
- Walk-in freezers to incorporate primary temperature-based defrost termination control with a secondary time limit
- Doors to meet Tables 6.8.1-18 and 6.8.1-19. Refrigeration systems, except for walk-in process cooling as defined in 10 CFR 431.302, to meet Table 6.1.8-20

- Meet equipment efficiency requirements
- Lighting to be controlled by one of these:
  - automatic time-switch to turn off lights during non-business hours with timed overrides to turn lights on for ≤ 1 hr
  - Motion sensors that reduce lighting power by ≥ 50% within 3 minutes after sensor area is vacated
- Low-temperature cases to have primary temperature-based defrost termination control with secondary time-limit termination.
- Antisweat heater controls to reduce energy use of antisweat heater as function of RH in air outside the door or to condensation on inner class pane

- Rated per AHRI 400 (No minimum efficiency requirement)
- See Section 12 for a complete specification of the test procedure

HVAC Compliance

Building System

- Envelope
- **HVAC**
- SWH
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

- ✓ Economizers *(Section 6.5.1)*
- ✓ Simultaneous Heating and Cooling Limitation *(Section 6.5.2)*
- ✓ Air System Design and Control *(Section 6.5.3)*
- ✓ Hydronic System Design and Control *(Section 6.5.4)*
- ✓ Heat Rejection Equipment *(Section 6.5.5)*
- ✓ Energy Recovery *(Section 6.5.6)*
- ✓ Exhaust Systems *(Section 6.5.7)*
- ✓ Radiant Heating Systems *(Section 6.5.8)*
- ✓ Hot Gas Bypass Limitation *(Section 6.5.9)*
- ✓ Door Switches *(Section 6.5.10)*
- ✓ Refrigeration Systems *(Section 6.5.11)*

Large non-fan cooling systems require a water economizer:

- Exception 2 to 6.5.1: Chilled-water cooling *systems* without a fan or that use induced airflow, where the total capacity of these *systems* is less than 1,000,000 Btu/h in Climate Zones 0, 1B, and 2 through 4; less than 1,400,000 Btu/h in Climate Zones 5 through 8; or any size in Climate Zone 1A.

Dampers capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature

This prevents the economizer from operating when heating is required or only partial cooling is required

Exception

- Systems controlled from space temperature *(such as single-zone systems)*

Single zone systems should still interlock the economizer operation with a call for cooling

- Automatically reduce outdoor air intake to minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage
- High limit control types for specific climate zones from Table 6.5.1.1.3
  - Allowed:
    - Fixed dry bulb temperature
    - Differential dry bulb temperature
    - Fixed or differential enthalpy requires dry-bulb high limit in combination
  - Not allowed:
    - Electronic hybrid enthalpy
    - Dew point and dry-bulb

Reference Table 6.5.1.1.3 on page 100 in 90.1-2019

- Exhaust/relief and outdoor air dampers to meet the requirements of Table 6.4.3.4.3
- Return dampers to meet motorized exhaust/relief damper requirements in Table 6.4.3.4.3 (clarification)

Means to relieve excess outdoor air during economizer operation to prevent over pressurizing the building

Outlet located to avoid recirculation into the building

Outdoor air, return air, mixed air, and supply sensors calibrated

Certification of factory calibration is acceptable, field calibration is not required

	Accuracy	Range
Dry-bulb and wet-bulb temperatures	± 2°F	40°F-80°F
Enthalpy and value of differential enthalpy sensors	±3 Btu/lb	20-30 Btu/lb
Relative humidity	± 5%	20%-80% RH

System capable of cooling supply air by indirect evaporation and providing up to 100% of expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below

Exceptions

- Systems primarily serving computer rooms
  - Where 100% of expected system cooling load at dry bulb and wet bulb in Table 6.5.1.2.1 is met with evaporative water economizers
  - With systems that satisfy 100% of expected system cooling load at the dry bulb in Table 6.5.1.2.1 is met with dry cooler water economizers
- If required for dehumidification, design can meet 100% of expected cooling load at 45°F dry bulb/40°F wet bulb with water-cooled fluid economizers

Precooling coils and water-to-water heat exchangers to have either

- Water-side pressure drop of <15 ft of water **OR**
- Bypassed when not in use

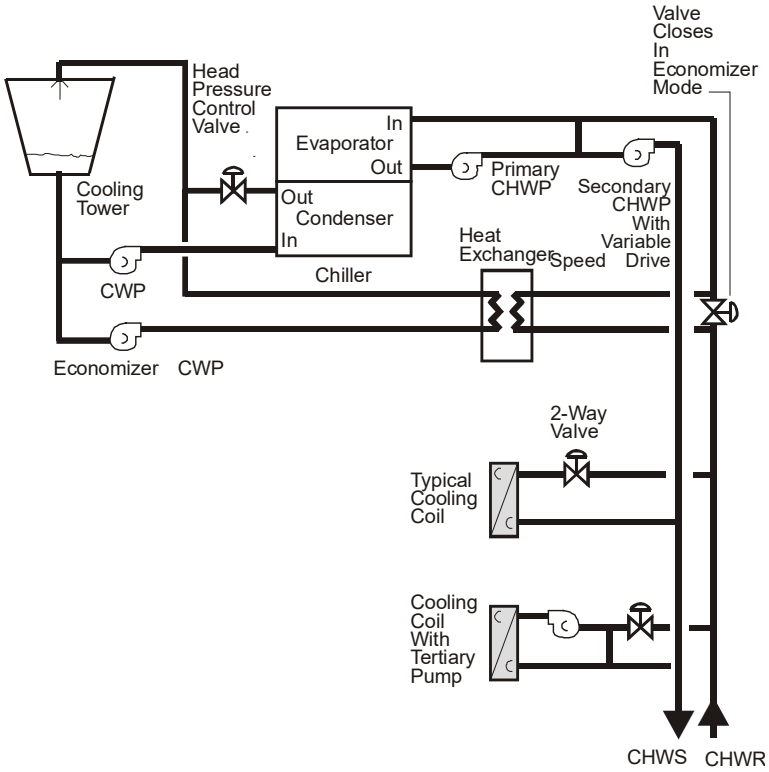


Figure 6-O from 90.1 User's Manual

Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required

Controls to not false load the mechanical cooling systems by limiting or disabling the economizer or any other means (e.g., hot gas bypass) except at lowest cooling stage

Units with air economizers

- Unit controls
  - Mechanical cooling capability interlocked with air economizer controls so outdoor air damper is at 100% open when mechanical cooling is on and outdoor air damper doesn't begin to close to prevent coil freezing due to minimum compressor run time until leaving air temperature is < 45°F
- DX units that control capacity of mechanical cooling based on occupied space temperature to have a minimum of 2 stages of mechanical cooling capacity if unit cooling capacity is ≥ 65,000 Btu/h

All other DX units, including those that control space temperature by modulating air flow to the space, to comply with Table 6.5.1.3

Rating Capacity, Btu/h	Min. # of Mechanical Cooling Stages	Min. Compressor Displacement
≥ 65,000 and < 240,000	3	≤ 35% of full load
≥ 240,000	4	≤ 25% full load

Designed so economizer operation doesn't increase the building heating energy use during normal operation

Exception

- ✓ Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature

Systems with hydronic cooling and dehumidification systems designed to maintain inside humidity at a dewpoint > 35°F to use a fluid economizer (if 6.5.1 requires an economizer)

Capable of operating in sequence the supply of heating and cooling energy to the zone

Controls prevent

- Reheating
- Recooling
- Mixing or simultaneously supplying air previously heated or cooled
- Other simultaneous operation of heating and cooling systems to the same zone

Simultaneous heating and cooling is allowed for the following 4 cases:

1. Zones for which volume of air that is reheated, recooled, or mixed is less than the larger of the following
   - 30% of zone design peak supply for systems without DDC
   - Systems with DDC, minimum primary air flow rate meets Simplified Procedure ventilation requirements of ASHRAE Standard 62.1 for zone, permitted to be average air flow rate as allowed by 62.1
   - Any higher rate that can be demonstrated to jurisdiction to reduce overall system annual energy usage
   - Air flow rate required to meet applicable codes or accreditation standards (pressure relationships or minimum air change rates)
2. Zones with DDC that comply with all of these
   - Air flow rate in dead band that doesn't exceed larger of these
     - Minimum air flow rate to meet Simplified Procedure ventilation requirements in Standard 62.1 for zone, permitted to be average air flow rate as allowed by 62.1
     - Any higher rate that can be demonstrated to jurisdiction to reduce overall system annual energy usage
     - Air flow rate required to comply with applicable codes or accreditation standards, such as pressure relationships or minimum air change rates
   - Air flow rate that's reheated, recooled, or mixed in peak heating demand < 50% of zone design peak supply
   - First stage of heating consists of modulating zone supply air temperature setpoint up to a maximum while air flow is maintained at deadband flow rate
   - Second stage of heating consists of modulating air flow rate from deadband flow rate up to heating maximum flow rate while maintaining the maximum supply air temperature
3. Lab exhaust systems complying with 6.5.7.3
4. Zones where ≥ 75% of energy for reheating or providing warm air in mixing systems is from site-recovered or site-solar source

Zones with both supply and return/exhaust air openings > 6 ft above floor to not supply heating air > 20°F above space temperature

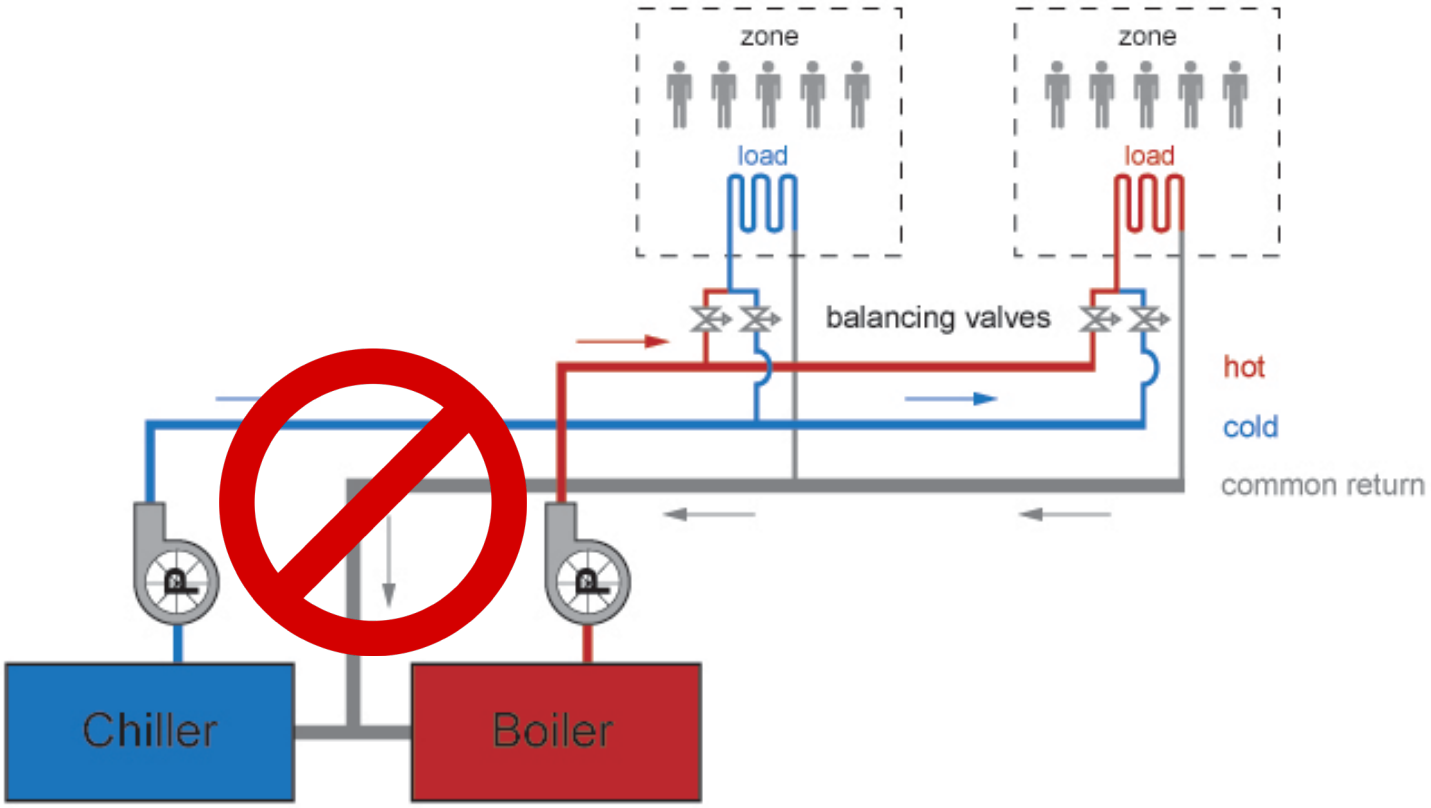
- Applies where reheating is allowed in other parts of the Standard

Exceptions

- Laboratory exhaust systems complying with 6.5.7.3
- During preoccupancy building warm-up and setback

To prevent the simultaneous heating and cooling in hydronic systems

No common return system for both hot and chilled water



Two-pipe changeover system is allowed if it meets the following requirements:

- Dead band from one mode to another is ≥ 15°F outdoor air temperature
- Controls to allow operation of ≥ 4 hours in one mode before changing to another mode
- Reset controls so heating and cooling supply temperatures at changeover point no more than 30°F apart

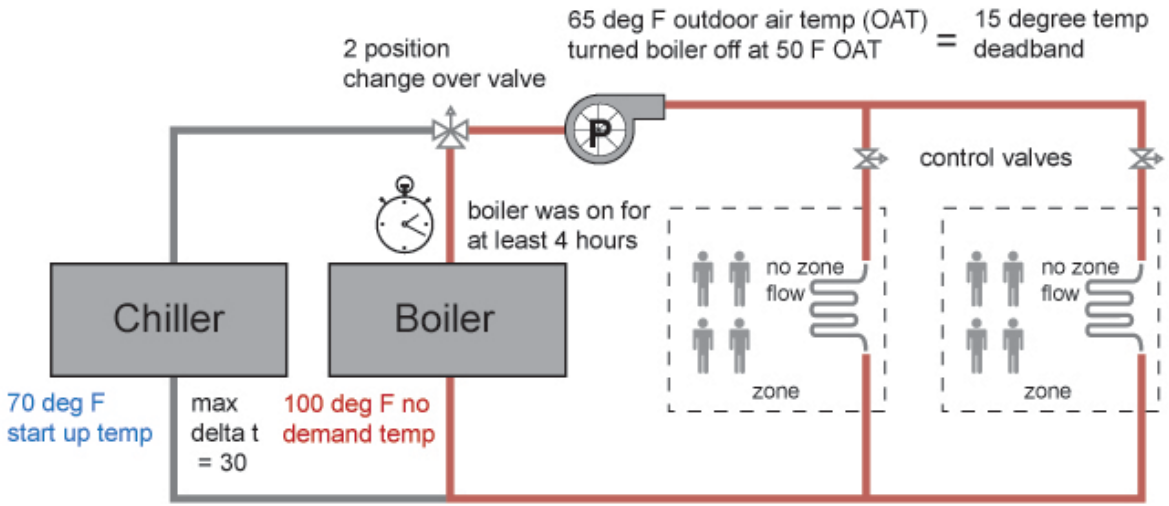


Diagram Courtesy of Ken Baker

Controls to provide heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by central devices

Exception

- If system loop temperature optimization controller is used, deadband < 20°F is allowed

A two-position valve at each hydronic heat pump for hydronic systems having a total pump system power > 10 hp

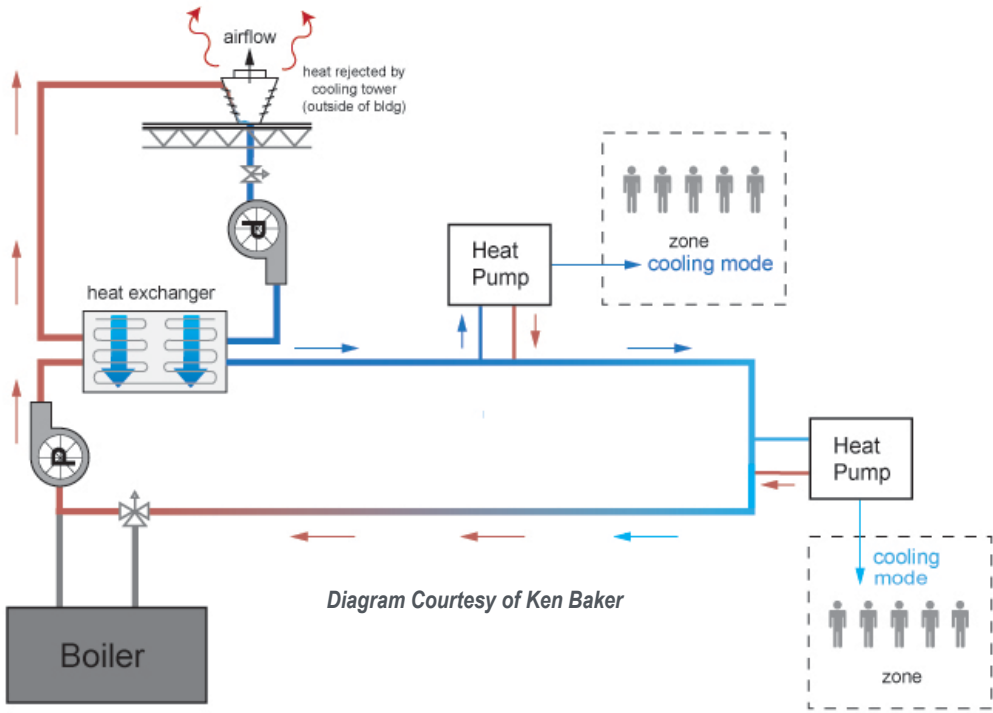


Diagram Courtesy of Ken Baker

In CZ 3-8, limit heat rejection during heating:

- Fluid cooler: provide automatic bypass or low leakage air dampers
- Open cooling tower: provide automatic bypass
- Open tower with heat exchanger (shown): automatic shutdown of tower pump

Humidistatic controls to prevent

- Reheating
- Mixing of hot and cold air streams
- Heating and cooling of same air stream

- Systems reduces supply air flow to 50%, or to minimum ventilation
- Systems ≤ 65,000 Btu/h that can unload at least 50%
- Systems smaller than 40,000 Btu/h
- Process applications where building includes site-recovered or site solar energy source that provides energy equal to ≥ 75% of annual energy for reheating or providing war air in mixing systems (exception does NOT apply to computer rooms)
- 90% of reheat or re-cool annual energy is recovered or solar
- Systems where heat added to airstream is result of use of desiccant system and 75% of heat added by desiccant system is removed by a heat exchanger (either before or after desiccant system with energy recovery)

- Automatic valve to shut off preheat in humidifiers with preheating jackets mounted in airstream
- Insulate dispersion tube hot surfaces in airstreams of ducts or AHUs ≥ R-0.5
  - Except where mechanical cooling, including economizer operation, doesn't occur simultaneously with humidification

Controls to stop heat output whenever mechanical cooling, including economizer operation, is occurring

Ventilation Air (DOAS) Heating Control

Units that provide *ventilation* air to multiple zones and operate 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

Saves energy use by taking advantage of "free cooling"

- uses cool outside air when there is a benefit to many zones in the building
- avoids mechanically cooling air that was preheated at the DOAS unit

Each HVAC system with total fan system power > 5 hp to meet 6.5.3.1

- Fan System Power and Efficiency

Appropriate fan systems to meet 6.5.3.2 through 6.5.3.7

- Fan Control
  - Fan Airflow Control
  - VAV Static Pressure Sensor location
  - VAV Set Point Reset

Table 6.5.3.1-1

Two options:

nameplate hp (Option 1)

fan system bhp (Option 2)

Exceptions

- ✓ Hospital, vivarium, and laboratory systems that utilize flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control may use variable-volume fan power limitation
- ✓ Individual exhaust fans with motor nameplate hp ≤ 1 hp

Reference Table 6.5.3.1-1 on page 106 in 90.1-2019

Reference Table 6.5.3.1-2 on page 106 in 90.1-2019

- Energy recovery credit referenced to Enthalpy Recovery Ratio
- Fully ducted return air credit now only allowed for return or exhaust systems required by code or accreditation standards to be fully ducted, or systems required to maintain air pressure differentials between adjacent rooms.

- Selected fan motors < 6hp to be no larger than first available motor size greater than 1.5 times bhp
- Fans ≥ 6 bhp, selected fan motor no larger than first available motor with nameplate rating > 1.5 times bhp

Fan bhp on design documents

Exceptions

- Motors with electronic speed control devices
- Systems complying with 6.5.3.1.1 Option 1
- Fans with motor *nameplate hp* < 1hp
- Fans with *fan nameplate electrical input power* < 0.89 kW

- Each fan and fan array to have fan efficiency index (FEI) ≥ 1.0
- Each fan and fan array in a VAV system that meets 6.5.3.2.1 to have an FEI ≥ 0.95
- FEIs calculated per AMCA 208 Annex C

Exceptions

- Fans that are not embedded with a motor nameplate hp < 1.0 hp or with a fan nameplate electrical input power < 0.89 kW
- Embedded fans and fan arrays with combined motor nameplate hp ≤ 5 hp with fan system electrical input power ≤ 4.1 kW
- Ceiling fans
- Reversible fans used for tunnel ventilation
- Fans
  - Part of equipment listed in 6.4.1.1
  - Included in equipment bearing third-party certified seal for air or energy performance of equipment package
  - Used for moving gases above 482°F
  - Used for operation in explosive atmospheres
  - Outside scope of AMCA 208
  - Intended to only operate during emergency conditions

DX cooling, chilled water, and evaporative cooling systems to be designed to vary indoor fan airflow as a function of load

- Cooling units that control capacity of mechanical cooling directly based on space temperature to have at least 2 stages of fan control
  - Low or minimum
    - Speed ≤ 66 % of full speed
    - Draw ≤ 40% of fan power at full fan speed
    - Used during periods of low cooling load and ventilation-only operation
- All other units, including DX cooling and chilled-water units that control space temperature by modulating airflow to have modulating fan control
  - Minimum speed
    - ≤ 50% of full speed
    - Draw ≤ 30% of power at full fan speed
  - Low or minimum speed
    - Used during periods of low cooling load and ventilation-only operation
- Exceptions for cycling fans without ventilation or fans that need a higher speed to meet 62.1 ventilation requirements

Located so controller set point is ≤ 1.2 in. wc

- ✓ Except for systems complying with VAV setpoint reset requirements

Install multiple sensors in each major branch if sensor would be located downstream of a major duct split

For systems with direct digital control of individual zone reporting to the central control panel

- Static pressure set point reset based on zone requiring the most pressure
- Controls to:
  - Monitor zone damper positions or other indicator of need for static pressure
  - Automatically detect zones that may be excessively driving reset logic and generate alarm
  - Readily allow operator removal of zone(s) from reset algorithm

Return and relief fans used to meet Section 6.5.1.1.5 shall comply with all of the following:

a. Relief air rate shall be controlled to maintain building pressure either directly, or indirectly through differential supply-return airflow tracking
   Systems with constant speed or multispeed supply fans shall also be allowed to control the relief system based on outdoor air damper position
b. Fans shall have variable-speed control or other devices that will result in total return/relief fan system demand of no more than 30% of total design power at 50% of total design fan flow

Exceptions

1. Return or relief fans with total motor size less than or equal to 0.5 hp
2. Staged relief fans with a minimum of four stages

In multiple-zone VAV systems with DDC of individual zone boxes reporting to central control panel

- Include means to automatically reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency as per Standard 62.1, Appendix A

Exceptions

- VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units
- Systems where total design exhaust airflow is > 70% of total outdoor air intake flow requirements
- Removed exception when there is ERV

Parallel-flow fan-powered VAV air terminals shall have automatic controls configured to:

a. turn off the terminal fan except when space heating is required or if required for ventilation;
b. turn on the terminal fan as the first stage of heating before the heating coil is activated; and
c. during heating for warmup or setback temperature control, either
    1. operate the terminal fan and heating coil without primary air or
    2. reverse the terminal damper logic and provide heating from the central air handler through primary air

This control strategy reduces fan energy use while maintaining effective comfort control for the space. It will also reduce heating energy use, by recovering heat from return air.

Multiple zone HVAC systems to have controls capable of and configured to automatically reset supply-air temperature in response to building loads or outdoor air temperature

Controls to reset supply air temperature at least 25% of difference between design supply-air temperature and design room air temperature

Controls that adjust the reset based on zone humidity are okay in Climate zones 0B, 1B, 2B, 3B, 3C, and 4-8

HVAC zones expected to experience relatively constant loads to be designed for fully reset supply temperature

Blanket SAT reset exception for climate zones 0A, 1A, 2A, and 3A removed.

Exceptions

- Climate zones 0A, 1A, and 3A with < 3000 cfm of design outdoor air
- Climate zones 2A with < 10,000 cfm of design outdoor air
- Climate zones 0A, 1A, 2A, and 3A with ≥ 80% outdoor air and employing exhaust air energy recovery per Section 6.5.6.1
- Systems that prevent reheating, recooling or mixing of heated and cooled supply air
- 75% of energy for reheating is from site-recovered or site solar energy sources

With the blanket SAT reset exception for climate zones 0A, 1A, 2A, and 3A removed, design must:

- Allow SAT reset during dehumidification
- Lock out economizers during dehumidification

Examples allowing dehumidification with less reheat:

- Separate OA cooling coil so return air can heat dehumidified OA
- Modulating return air bypass so all air does not go through cooling coil
- DOAS with parallel OA supply
- Series energy recovery

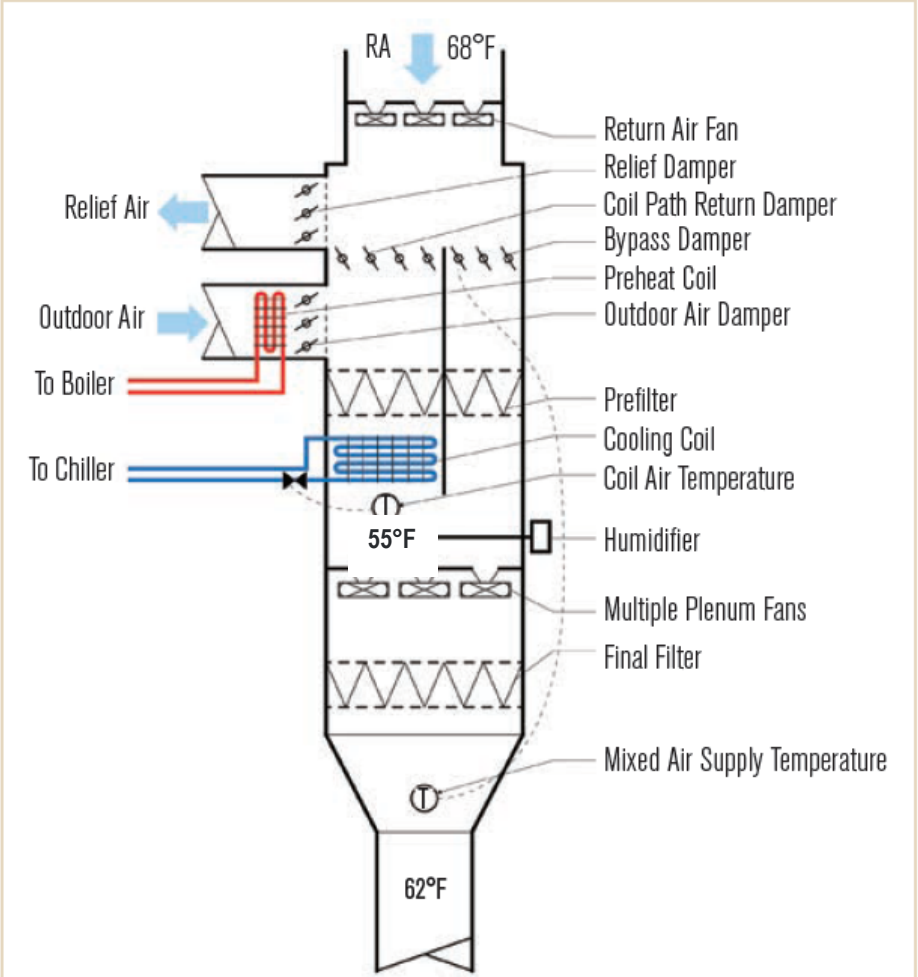


FIGURE 1 Coil bypass air-handling unit, basic configuration.

- Motors for fans ≥ 1/12 hp and < 1hp:
  - Electronically-commutate motors or have minimum motor efficiency of 70% when rated per 10 CFR 431
  - Have means to adjust motor speed for either balancing or remote control
    - Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed

Exceptions, motors

- In airstream within fan-coils and terminal units that operate only when providing heat
- Installed in space conditioning equipment certified under 6.4.1
- Covered by Table 10.8-4 or 10.8-5

The required minimum *outdoor air* rate is the larger of the minimum *outdoor air* rate or the minimum exhaust air rate required by Standard 62.1, Standard 170, or applicable codes or accreditation standards. *Outdoor air ventilation systems* shall comply with one of the following:

a. Design minimum *system outdoor air* provided shall not exceed 135% of the required minimum *outdoor air* rate

b. Dampers, *ductwork*, and *controls* shall be provided that allow the *system* to supply no more than the required minimum *outdoor air* rate with a single *set-point* adjustment

c. The *system* includes exhaust air *energy* recovery complying with Section 6.5.6.1

Zones serving rooms required to have automatic partial OFF or automatic full OFF controls per 9.4.1.1 where Standard 62.1 occupancy category permits ventilation air to be reduced to 0 when space is in *occupied-standby mode* and when using Ventilation Rate Procedure, to meet the following within 5 minutes of all rooms in that zone entering *occupied-standby mode*

a. Active heating set point setback at least 1 degree F
b. Active cooling set point setup at least 1 degree F
c. All supplied airflow to be shut off whenever space temperature is between active heating and cooling set points

Exception:

Multiple zone systems without automatic zone flow control dampers

Notes:

1. O*ccupied-standby mode* is when a space is vacant during scheduled occupancy
2. Cooling and heating setpoint adjustments in addition to required 5°F deadband

- Boiler turndown for systems with design input of ≥ 1,000,000 Btu/h per Table 6.5.4.1; requirement can be met by using:
  - multiple single-input boilers,
  - one or more modulating boilers, or a
  - combination of single-input and modulating boilers
- HVAC hydronic systems with three or more control valves to have variable flow control
- Chiller and boiler isolation
- Chilled and Hot Water Temperature Reset
- Hydronic (water-loop) Heat Pumps and Water-Cooled Unitary Air-Conditioners
- Pipe Sizing minimum limits
- Chilled-Water Coil Selection (15°F min CHW delta-T)

HVAC pumping systems with three or more control valves to be

- Designed to modulate or step open and close as a function of load
- Designed for variable fluid flow
- Capable of reducing flow rates to ≤ 25% of design flow rate

Individual pumps serving variable flow systems with a motor hp at least the power in Table 6.5.4.2

Threshold reduced in some climate zones, raised in others.

- Have controls and/or devices resulting in pump motor demand ≤ 30% of design wattage at 50% of design water flow

Differential pressure setpoint to be ≤ 110% of that required to achieve design flow through the heat exchanger

If differential pressure control and DDC controls are used

- Reset setpoint downward based on valve positions until one valve is nearly wide open

Exceptions added to clarify variable flow not required for primary pumps, preheat coils, or run around heat recovery coils

If chilled water plant has more than one chiller or boiler plant has more than one boiler

- Provide for all fluid to be automatically shut off when chiller or boiler is shut down
- Pumps
  - Number of pumps ≥ number of chillers or boilers
  - Staged on and off with chillers and boilers

Affects systems with design capacity > 300,000 Btu/h

- To include controls to automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature
- Where DDC is used to control valves, the set point shall be reset based on valve positions until one valve is nearly wide open or setpoint limits of the system equipment or application have been reached

Exceptions

- Where chilled-water supply is already cold such that blending would be required to achieve the rest chilled-water supply temperature
- Where a specific temperature is required for a process
- Water temperature reset is not required where valve position is used to comply with Section 6.5.4.2

Two-position valves at each hydronic heat pump must be provided and interlocked to shut off water flow to the heat pump when the compressor is off

Exceptions

- Units using fluid economizers

For hydronic heat pumps and water-cooled unitary ACs with total pump power > 5 hp

- Controls or devices must be provided to have pump motor demand ≤ 30% of design wattage at 50% of design water flow

Chilled-water and condenser-water piping so design flow rate in each segment doesn't exceed values in Table 6.5.4.6

This table presents the maximum allowed flow rates per section of pipe as a function of the following three criteria:

- Pipe size
- Annual hours of operation
- System flow and control

Exceptions

- Rates exceeding the Table are allowed if the specific section of pipe in question isn't in the critical circuit > 30% of operating hours
- Piping systems with equivalent or lower total pressure drop than the same system with standard weight steel pipe with piping and fittings sized per the Table

Chilled-water cooling coils provide a

- 15°F or higher temperature difference between leaving and entering water temperatures and
- minimum of 57°F leaving water temperature at design conditions

Exceptions

1. Coils with an air-side pressure drop exceeding 0.70 in. of water when rated at 500 fpm face velocity and dry conditions (no condensation).
2. Individual fan-cooling units with a design supply airflow rate 5000 cfm and less.
3. Constant-air-volume systems.
4. Coils selected at the maximum temperature difference allowed by the chiller.
5. Passive coils (no mechanically supplied airflow).
6. Coils with design entering chilled-water temperatures of 50°F and higher.
7. Coils with design entering air dry-bulb temperatures of 65°F and lower.

Energy is saved by delivering the same cooling with less water flow. In some cases chiller efficiency may be enhanced as well.

New buildings with gas hot-water boiler systems for space heating with a total system input of at least 1,000,000 Btu/h but not more than 10,000,000 Btu/h to comply with 6.5.4.8.1 and 6.5.4.8.2

Exceptions

- Where 25% of annual space heating requirement is provided by on-site renewable energy, site-recovered energy, or heat recovery chillers
- Space heating boilers installed in individual dwelling units
- Where 50% or more of design heating load is served using perimeter convective heating, radiant ceiling panels, or both
- Individual gas boilers with input capacity less than 300,000 Btu/h shall not be included in calculations of the total system input or total system efficiency

Boiler efficiency

- Gas hot-water boilers to have minimal thermal efficiency of 90% when rated per Table 6.8.1-6
  - Multiple boiler systems can meet this if space-heating input provided by equipment with thermal efficiency above and below 90% provides an input capacity-weighted average thermal efficiency of at least 90%
  - For boilers rated only for combustion efficiency, the calculation for input capacity-weighted average thermal efficiency to use combustion efficiency value

Hot-Water Distribution System Design

- Coils and other heat exchanges selected so at design conditions the hot-water return temperature entering boilers is 120°F or less
- Under all operating conditions, water temperature enter the boiler is 120°F or less, or the flow rate of supply hot water that recirculates directly into return systems, such as by three-way valves or minimum flow bypass controls, to be no greater than 20% of design flow of the operating boilers

Applies to heat rejection equipment used in comfort cooling systems such as

- Air-cooled condensers
- Dry coolers
- Open-circuit cooling towers
- Closed-circuit cooling towers
- Evaporative condensers

Exceptions

- Heat rejection devices included as an integral part of equipment listed devices whose energy usage is included in Tables 6.8.1-1 through 6.8.1-4, Tables 6.8.1-8 through 6.8.1-14, and Tables 6.8.1-16, 6.8.9-17, and 6.8.1-20

Fan Speed Control

- Each fan powered by a motor ≥ 5 hp, including the motor service factor
  - Result in fan motor demand of no more than 30% of design wattage at 50% of design airflow
  - Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device

Exceptions

- Condenser fans serving multiple refrigerant circuits or fluid cooling circuits
- Condenser fans serving flooded condensers

Multicell heat rejection equipment with variable-speed fan drives

- Operate maximum number of fans allowed that comply with manufacturer's requirements for all fan system components
- Control all fans to same fan speed required for instantaneous cooling duty, as opposed to staged (on/off) operation, minimum fan speed to comply with minimum allowable fan drive system speed per manufacturer's recommendations

- If towers have a combined rated capacity ≥ 1100 gpm at 95°F condenser water return, 85°F condenser water supply, and 75°F outdoor air wet-bulb temperature
  - Must meet requirement for axial fan open-circuit cooling towers in Table 6.8.1-7

Exceptions

- Ducted (inlet or discharge)
- Require external sound attenuation

- Open-circuit cooling towers used on water-cooled chiller systems configured with multiple- or variable-speed condenser water pumps designed so all open-circuit cooling tower cells can be run in parallel with larger of
  - Flow produced by smallest pump at its maximum expected flow rate or
  - 50% of design flow for the cell

Condenser heat recovery for SWH required if

- Facility operates 24 hrs per day **and**
- Heat rejection > 6,000,000 Btu/h **and**
- SWH load > 1,000,000 Btu/h

The required heat recovery system shall have the capacity to provide the smaller of

- 60% of the peak heat rejection load at design conditions or
- preheat of the peak service hot water draw to 85°F

Exceptions

- If condenser heat recovery is used for space heating with a heat recovery design > 30% of peak water-cooled condenser load at design conditions
- If 60% of service water heating is provided from site-solar or site-recovered energy or other sources

This new requirement is only for hospitals:

Where heating water is used for space heating, a condenser heat recovery system to be installed, provided all of these are true:

a. Building is an acute inpatient hospital, where building or portion of building is used on a 24-hour basis for inpatient medical, obstetric, or surgical care for patients
b. Total design chilled-water capacity for acute inpatient hospital, either air cooled or water cooled, required at cooling design conditions > 3,600,000 Btu/h of cooling
c. Simultaneous heating and cooling occurs above 60°F outdoor air temperature

- Total heat recovery system to have cooling capacity at least 7% of total design chilled-water capacity of acute inpatient hospital at peak design conditions

Exceptions

- Buildings that provide ≥ 60% of reheat energy from on-site renewable energy or site-recovered energy
- Buildings in climate zones 5C, 6B, 7, and 8

Indoor pool dehumidifier serving a natatorium with heated indoor pool > 500 sf to include one of the following

- Exhaust air sensible energy recovery system with sensible energy recovery ration of at least 50%
- Condenser heat recovery system capable of and configured to use 100% of heat generated through dehumidification to heat the pool water when there is a pool water heating load
- Exhaust air energy recovery system that results in an enthalpy recovery ration of at least 50%

Exception

- Natatoriums heated by on-site renewable or site recovered energy capable of and configured to provide at least 60% of annual heating energy required

Conditioned supply air delivered to any space with mechanical exhaust to not exceed the greater of

a. supply flow required to meet the space heating or cooling load;
b. ventilation rate required by the AHJ, the facility Environmental Health and Safety department, or ASHRAE Standard 62.1; or
c. mechanical exhaust flow minus the available transfer air from conditioned spaces or return air plenums on the same floor, not in different smoke or fire compartments, and that at their closest point are within 15 ft. of each other.

Available transfer air is that portion of outdoor ventilation air that

1. is not required to satisfy other exhaust needs,
2. is not required to maintain pressurization of other spaces, and
3. is transferable according to applicable codes and standards and to the class of air recirculation limitations in ASHRAE Standard 62.1.

When transfer air is used instead of supply air, it means less fan energy and less heating and cooling of supply air.

Exceptions:

1. Biosafety level classified laboratories 3 or higher.
2. Vivarium spaces.
3. Spaces required by applicable codes and standards to be maintained at positive pressure relative to adjacent spaces.
4. Spaces where demand for transfer air may exceed the available transfer airflow rate and where the spaces have a required negative pressure relationship.

NOTE: if exception 3 or 4 is used: any transferable air not directly transferred to be made available to the associated AHU and be used whenever economizer or other options do not save more energy.

- Replacement air introduced directly into hood cavity to be ≤ 10% of hood exhaust airflow rate
- If kitchen/dining facility has total kitchen hood exhaust airflow rate > 5,000 cfm, each hood's exhaust rate must not exceed the rate shown in Table 6.5.7.2.2
  - If a single hood or hood section is over appliances with different duty ratings, then the max. airflow rate for that can't exceed the Table values for highest appliance duty rating under that hood or hood section

Exception

- If at least 75% of all replacement air is transfer air that would otherwise be exhausted

- Kitchens/dining facilities with total kitchen hood exhaust airflow rate > 5,000 cfm must have one of these:
  - At least 50% of all replacement air is transfer air that would otherwise be exhausted
  - Demand ventilation systems on at least 75% of exhaust air (capable of at least 50% reduction in exhaust and replacement air system airflow rates)
  - Listed energy recovery devices with sensible heat recovery effectiveness of not less than 40% on at least 50% of the total exhaust airflow

- Performance testing of design airflow rates and proper capture and containment must be done using an approved field test method
  - If demand control ventilation systems are used, additional testing is required at minimum airflows

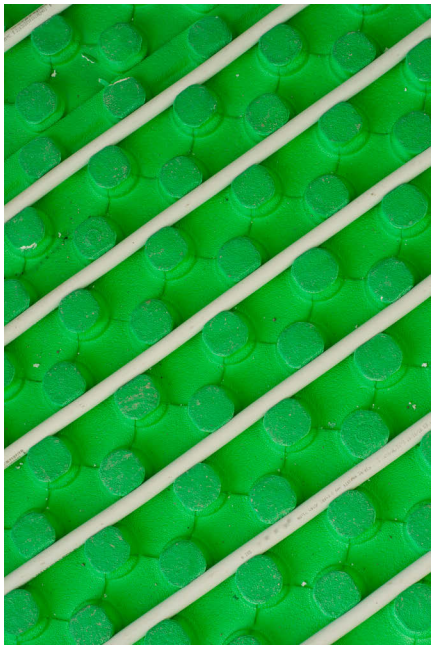
Note: see *Kitchen Exhaust Code Notes* at
http://www.energycodes.gov/kitchen-exhaust-code-notes

- Laboratory exhaust systems with total exhaust rate > 5,000 cfm to have one of the following
  - VAV lab exhaust and room supply system capable of reducing exhaust and makeup air flow rates and/or incorporate a heat recovery system
  - VAV lab exhaust and room supply systems required to have minimum circulation rates to comply with code to be capable of reducing zone exhaust and makeup air flow rates to the regulated minimum circulation values or minimum required to maintain pressurization relationship requirements
    - Non-regulated zones capable of reducing exhaust and makeup air flow rates to 50% of zone design values or minimum required to maintain pressurization relationship requirements
  - Direct makeup air supply to equal at least 75% of exhaust air flow rate, heated no warmer than 2°F below room setpoint, cooled to no cooler than 3°F above room setpoint, no humidification added, and no simultaneous heating and cooling used for dehumidification control

Required for unenclosed spaces
exception: loading docks with air curtains

Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard

- Radiant hydronic ceiling or floor panels
- Combination or hybrid systems with radiant heating (or cooling) panels
- Radiant heating (or cooling) panels used in conjunction with other systems such as VAV or thermal storage systems



Rated capacity of system	Maximum HGBP, % of total capacity
≤ 240,000 Btu/h	**15%**
> 240,000 Btu/h	**10%**

- Applied in systems with stepped or continuous unloading
- Limitation also pertains to chillers
- Hot gas bypass not to be used on constant-volume units

Doors that open to the outdoors from a conditioned space must have controls to do the following when the doors are open:

- Disable mechanical heating or reset heating setpoint to ≤ 55°F within 5 minutes of door opening
- Disable mechanical cooling or reset cooling setpoint to ≥ 90°F within 5 minutes of door opening
  - Mechanical cooling can remain if outdoor air temperature is < space temperature

Exceptions

- Building entries with automatic closing devices
- Spaces without thermostats
- Alterations to existing buildings
- Loading docks

When connected to remote compressors, condensers, or condensing units, these systems must meet 6.5.11.1 and 6.5.11.2

- Refrigerated display cases
- Walk-in coolers
- Walk-in freezers

Exception

- systems with transcritical refrigeration cycle or ammonia refrigerant

Fan-powered condensers

- Design saturated condensing temperatures for air-cooled condensers ≤ design dry bulb temperature
  - + 10°F for low-temperature systems
  - + 15°F for medium-temperature systems

  Saturated condensing temperature for blend refrigerants TBD using average of liquid and vapor temperatures as converted from condenser drain pressure
- Condenser fan motors < 1 hp to use
  - Electronically commutated motors
  - Permanent split capacitor-type motors, or
  - Three-phase motors

- Condenser fans for air-cooled, evaporatively cooled and air- or water-cooled fluid coolers or cooling towers
  - Reduce fan motor demand to ≤ 30% of design wattage at 50% of design air volume, and
  - Use either continuous variable-speed fan-control approach:
    - Air-cooled condensers – use variable setpoint control logic to reset condensing temperature setpoint in response to ambient dry-bulb temperature
    - Evaporatively-cooled condensers – use variable setpoint control logic to reset condensing temperature setpoint in response to ambient wet-bulb temperature
- Control multiple fan condensers in unison
- Minimum condensing temperature setpoint to be ≤ 70°F

- Compressors and multiple-compressor systems suction groups
  - Include control systems using floating suction pressure control logic to reset target suction pressure temperature based on temperature requirements of attached refrigeration display cases or walk-ins

Exceptions

- Single-compressor systems without variable capacity capability
- Systems serving suction groups
  - With design saturated suction temperature ≥ 30°F
  - Comprise the high stage of a two-stage or cascade system, or
  - Primarily serve chillers for secondary cooling fluids

- Liquid subcooling provided for all low-temperature compressor systems with design cooling capacity ≥ 100,000 Btu/h with design saturated suction temperature ≤ -10°F
- Subcooled liquid temperature controlled at maximum temperature setpoint of 50°F at exit of subcooler using either compressor economizer (inter stage) or as a separate compressor suction group operating at a saturated suction temperature ≥ 18°F
  - Subcooled liquid lines subject to insulation requirements in Table 6.8.3-2
- If internal or external crankcase heaters, provide a means to cycle the heaters off during compressor operation

HVAC systems serving the heating, cooling, or ventilating needs of a computer room with IT equipment load greater than 10 kW shall comply with ASHRAE Standard 90.4

HVAC Compliance

Building System

- Envelope
- **HVAC**
- SWH
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

- ✓ Record documents
- ✓ Manuals
- ✓ System balancing

Record documents of actual installation to building owner within 90 days of system acceptance and include, as a minimum

- Location and performance data on each piece of equipment
- General configuration of duct and pipe distribution system including sizes
- Terminal air or water design flow rates

Operating and maintenance manuals to building owner within 90 days of system acceptance and include several items

- Systems shall be balanced in accordance with accepted engineering standards
- Written report for conditioned spaces > 5000 ft^2
- Minimize throttling losses
- For fans with system power > 1 hp
  - Adjust fan speed to meet design flow conditions

Proportionately balanced to minimize throttling losses

Pump impeller trimmed or pump speed adjusted to meet design flow conditions

Each system to have either the ability to measure differential pressure increase across the pump or have test ports at each side of the pump

Exceptions

- Pumps with pump motors ≤ 10 hp
- When throttling results in < 5% of the nameplate hp draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed

Several changes were made to the equipment efficiency requirements defined in section 6.4.1.1 and in Tables 6.8.1-1 to 6.8.1-20

Table	Name	Change
6.8.1-1	Electrically Operated Unitary Air Conditioners and Condensing Units	Values or metrics change 1/1/2023
6.8.1-2	Electrically Operated Air-Cooled Unitary Heat Pumps	New Values 1/1/2023
6.8.1-3	Water-Chilling Packages—Minimum Efficiency Requirements	No change
6.8.1-4	Electrically Operated Packaged Terminal Air Conditioners, Packaged Terminal Heat Pumps, Single-Package Vertical Air Conditioners, Single-Package Vertical Heat Pumps, Room Air Conditioners, and Room Air Conditioner Heat Pumps	Format change for PTAC & PTHP, same requirements; some others have change
6.8.1-5	Warm-Air Furnaces and Combination Warm-Air Furnaces/Air-Conditioning Units, Warm-Air Duct Furnaces, and Unit Heaters	Some values change now or 1/1/2023; add electric furnace
6.8.1-6	Gas- and Oil-Fired Boilers	Some new values 3/2/2022
6.8.1-7	Performance Requirements for Heat Rejection Equipment	Some new values
(6.8.1-8)	Heat Transfer Equipment	Table removed

Section 6 – 6.8.1
Minimum Efficiency Requirement Listed Equipment – Standard Rating and Operating Conditions

Table	Name	Change
6.8.1-8	Electrically Operated Variable-Refrigerant-Flow Air Conditioners	No change
6.8.1-9	Electrically Operated Variable-Refrigerant-Flow and Applied Heat Pumps	No change
6.8.1-10	Air Conditioners and Condensing Units Serving Computer Rooms	Revised size ranges and some values
6.8.1-11	Commercial Refrigerator and Freezers and Refrigeration	Values change
6.8.1-12	Vapor Compression Based Indoor Pool Dehumidifiers	No change
6.8.1-13	Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery	No change
6.8.1-14	Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery	No change
6.8.1-15	Electrically Operated Water-Source Heat Pumps	New Table
6.8.1-16	Heat Pump and Heat Recovery Chiller Packages	New Table
6.8.1-17	Ceiling-Mounted Computer-Room Air Conditioners	New Table
6.8.1-18	Walk-In Cooler and Freezer Display Door	New Table
6.8.1-19	Walk-In Cooler and Freezer Nondisplay Door	New Table
6.8.1-20	Walk-In Cooler and Freezer Refrigeration System	New Table

HVAC Compliance

Building System

- Envelope
- **HVAC**
- SWH
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

HVAC controls verified and tested per 6.9.1 and provisions of 4.2.5.1

Testing to verify systems and controls are configured and operating in accordance with applicable requirements of 6.3, 6.4, and 6.5.

Verification and FTP documentation to comply with 4.2.5.1.2

Energy performance commissioned per 4.2.5.2,

Detailed instructions for *commissioning HVAC systems* shall be provided in the *construction documents,* and reporting to comply with 4.2.5.2.2

Referenced 6.9 testing and commissioning refers to 4.2.5
New in 2019: Central FPT & Commissioning requirements

4.2.5.2 Commissioning & 90.1 compliance verification	• 4.2.5.2.1 Cx Plan • 4.2.5.2.2 Cx Reporting • Any added Cx: 5.9.2 thru 10.9.2
4.2.5.1 Verification & Testing (FPT)	• 4.2.5.1.1 V&T providers • FPT provision in Const. Docs • 4.2.5.1.2 V&T Documentation
Verification & Functional Performance Testing Details	• Specific for each discipline/path • 5.9.1, 6.9.1, 7.9.1, 8.9.1, • 9.9.1, 10.9.1, 11.2(d), G1.21(c)

Referenced 6.9 testing and commissioning refers to 4.2.5

4.2.5 Verification, Testing, and Commissioning

4.2.5.1 Verification and Testing (V&T)

- V&T provider qualifications
- V&T requirements in construction documents
- Functional Performance Testing (FPT) & Verification Documentation

4.2.5.2 Commissioning (Cx) (unless Excepted)

- Cx provider qualifications
- Cx plan, design review, requirements in construction documents
- Preliminary and Final Cx report includes FPT & verification

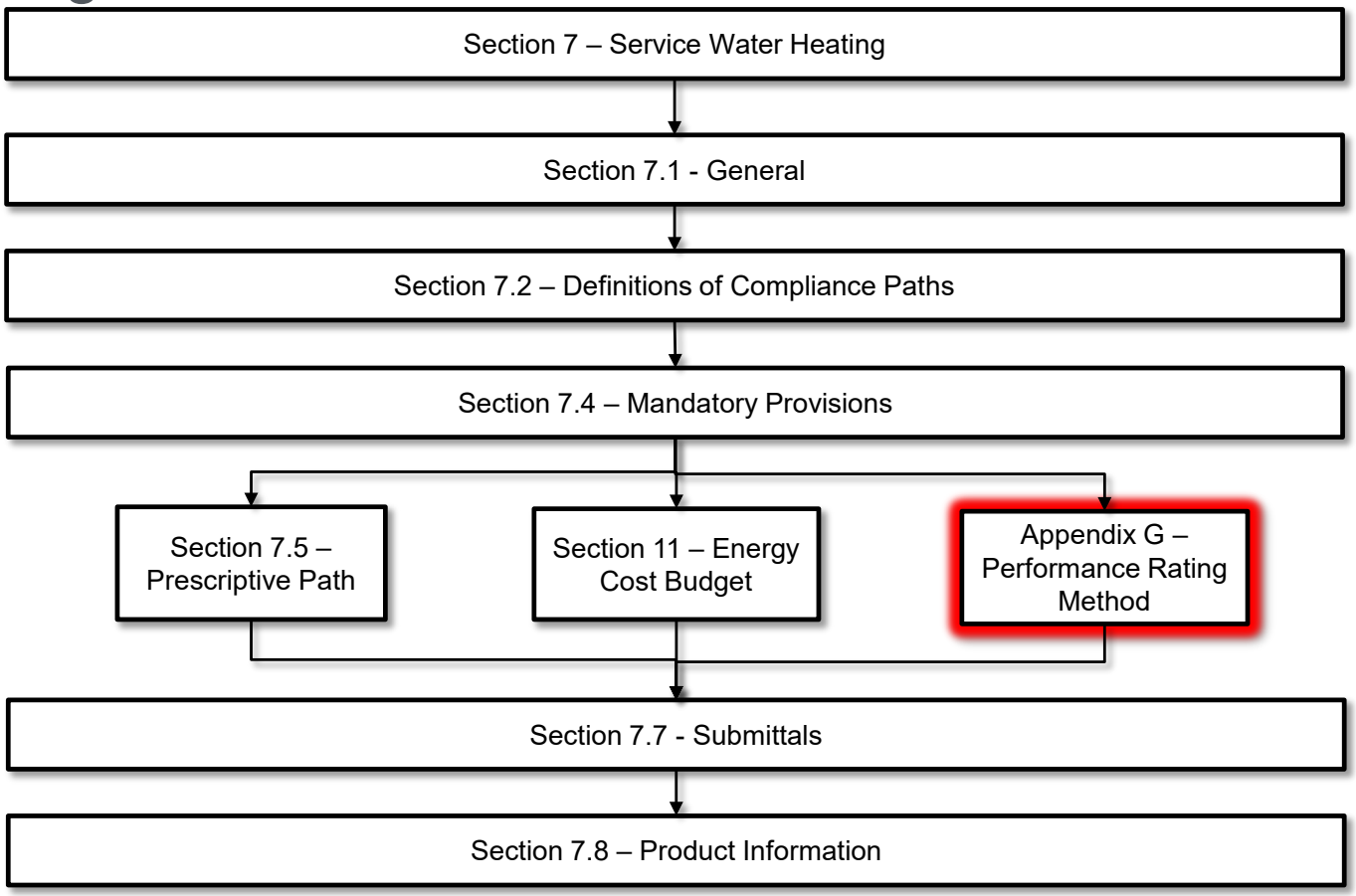
Where to FPT & Cx requirements apply

	Simple Buildings (<10k conditioned ft², warehouse, or Simple HVAC path < 25k ft²)	Complex Buildings < 25,000 ft²	All Buildings ≥ 50,000 ft² Except Warehouse
Verification, FPT	Required	Required	Required
Pre- & Design phase Cx	NR	Required	Required
Construction Phase Cx	NR	Required	Required

- 80% of US buildings are exempt from commissioning requirements
- Verification and functional performance testing (FPT) required throughout
- Pre & design phase Cx saves energy and cost by catching issues early
- 90.1 Cx requirements only apply to 90.1 standard requirements
- Verification that the design substantially meets 90.1 included

Section 7 Compliance Flowchart

Flowchart revised to clarify the compliance paths for service water heating



SWH Compliance

Building System

- Envelope
- HVAC
- **SWH**
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

Service Water Heating Changes

- Section 7.4.3 - Service hot water piping insulation
  - new requirement added to require the first 8 ft. of **branch** *piping* connecting to recirculated, heat-traced, or impedance heated *piping to be insulated*

- Table 7.8 which defines the minimum efficiency for water heating equipment the requirements for the following products was moved to an Informative Appendix and referenced to the federal requirements and applicable test procedures found in the Code of Federal Regulations 10 CFR Part 430
  - Electric table top water heaters with a storage capacity ≥ 20 gal
  - Electric water heaters < 12 kW and with a storage capacity ≥ 20 gal
  - Heat pump water heaters with ≤ 24 amps power and ≤ 250 volts power supply
  - Gas storage water heaters < 75,000 Btu/h and > 20 gallons
  - Oil storage water heaters < 105,000 Btu/h and > 20 gallons

- ✓ Section 7.2
- ✓ All compliance paths to follow Sections
  - 7.1,
  - 7.4,
  - 7.7, and
  - 7.8
- ✓ Additional requirements to comply with Section 7 = 7.5

- ✓ General *(Section 7.1)*
- ✓ Compliance Path(s) *(Section 7.2)*
- ✓ Mandatory Provisions *(Section 7.4)*
  - Load calculations
  - Equipment efficiency
  - Service hot water piping insulation
  - Service water-heating system controls
  - Pools
  - Heat traps
- ✓ Prescriptive Path *(Section 7.5)*
  - Space heating and water heating
  - Service water-heating equipment
  - Buildings with high-capacity service water-heating systems
- ✓ Submittals *(Section 7.7)*
- ✓ Product Information *(Section 7.8)*
- ✓ Verification, Testing, and Commissioning *(Section 7.9)*

- New buildings
- Additions to existing buildings
- Alterations to existing buildings

SWH equipment installed as a direct replacement shall meet these requirements

Exception

- Not sufficient space or access to meet requirements

In accordance with manufacturer's published sizing guidelines or generally accepted engineering standards and handbooks

Section 7.4.2 refers to Table 7.8 for equipment efficiencies

Equipment not listed in Table 7.8 has no minimum performance requirements, for example:

- Electric or oil water heaters < 20 gallons
- Gas instantaneous water heaters ≤ 50,000 Btu/h

Exception

- Water heaters and hot water supply boilers > 140 gal storage capacity don't have to meet standby loss requirements when
  - Tank surface is thermally insulated to R-12.5, **and**
  - A standing pilot light isn't installed, **and**
  - Gas- or oil-fired water heaters have a flue damper or fan-assisted combustion

Reference Table 7.8 on page 155 in 90.1-2019

Insulate the following per Table 6.8.3-1

- Circulating water heater
  - Recirculating system piping, including supply and return piping
- Nonrecirculating storage system
  - First 8 ft of outlet piping
  - First 8 ft of branch piping connecting to recirculated, heat-traced, or impedance heated piping
  - Inlet pipe between storage tank and heat trap
- Externally-heated pipes *(heat trace or impedance heating)*

Section 7 – Table 6.8.3-1
Piping Insulation

Reference Table 6.8.3-1 on page 150 in 90.1-2019

- ✓ Temperature Controls
- ✓ Temperature Maintenance Controls
- ✓ Outlet Temperature Controls
- ✓ Circulating Pump Controls

To allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use

Exception

- If manufacturer's installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion

Automatic time switches or other controls

- Set to switch off usage temperature maintenance system during extended periods when hot water is not required

Controls provided

- To limit maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F

To limit operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle

- Pool heaters to have readily accessible on-off switch
- Pool heaters fired by natural gas can NOT have continuously burning pilot lights
- Vapor retardant pool covers required (unless recovered or solar heat)
- Time switches required
  for both heaters and pumps

Noncirculating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)

- Either a device specifically designed for this purpose or
- Arrangement of tubing that forms a loop of 360° or piping that from the point of connection to the water heater includes a length of piping directed downward before connection to the vertical piping of the supply water or hot water distribution system, as applicable

Gas- or oil-fired space heating boiler system (complying with Section 6) is allowed to provide total space heating and water heating when ONE of the following conditions is met:

- Single boiler or component that is heating the service water has a standby loss in Btu/h not exceeding

  (13.3 x *pmd* + 400) / *n*; where *pmd* is probable maximum demand in gal/h and *n* is the fraction of the year when outdoor daily mean temperature is > 64.9°F
- Jurisdiction agrees use of a single heat source will consume less energy than separate units
- Energy input of the combined boiler and water heater system is < 150,000 Btu/h

Instructions for determining standby loss are included in this Section

Equipment used to provide the additional function of space heating as part of a combination (integrated) system shall satisfy all requirements for service water heating equipment

New buildings with total installed gas water heating input capacity ≥ 1,000,000 Btu/h

- Minimal thermal efficiency of 90%

  Multiple units are allowed to meet this requirement if water-heating input with thermal efficiency above and below 90% provides an input capacity-weighted average thermal efficiency of ≥ 90%

Exceptions

- Where 25% of annual SWH requirement is provided by site-solar or site-recovered energy
- Water heaters in individual dwelling units
- Individual gas water heaters with input capacity ≤ 100,000 Btu/h

SWH Compliance

Building System

- Envelope
- HVAC
- **SWH**
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

AHJ may require submittal of compliance documentation and supplemental information in accordance with Section 4.2.2

SWH Compliance

Building System

- Envelope
- HVAC
- **SWH**
- Power
- Lighting
- Other

Compliance Requirements

Mandatory Provisions
(required for each compliance path)

- **Prescriptive Path**
- **Simplified**
- **Trade Off Option**
- **Energy Cost Budget**
- **Performance Rating Method**

- **Submittal Requirements**
- **Information and Installation Requirements**
- **Verification, Testing, Inspection & Commissioning**

Energy Code Compliance

SHW controls verified and tested per 7.9.1 and provisions of 4.2.5.1

Testing to verify systems and controls are configured and operating in accordance with applicable requirements of

a. SWH system temperature controls (7.4.4.1 and 7.4.4.3)
b. Recirculation pump or heat trace controls (7.4.4.2) OR
c. Pool time switch controls (7.4.5.3)

Verification and FTP documentation to comply with 4.2.5.1.2

Energy performance commissioned per 4.2.5.2, and reporting to comply with 4.2.5.2.2

Referenced 7.9 testing and commissioning refers to 4.2.5
New in 2019: Central FPT & Commissioning requirements

4.2.5.2 Commissioning & 90.1 compliance verification	• 4.2.5.2.1 Cx Plan • 4.2.5.2.2 Cx Reporting • Any added Cx: 5.9.2 thru 10.9.2
4.2.5.1 Verification & Testing (FPT)	• 4.2.5.1.1 V&T providers • FPT provision in Const. Docs • 4.2.5.1.2 V&T Documentation
Verification & Functional Performance Testing Details	• Specific for each discipline/path • 5.9.1, 6.9.1, 7.9.1, 8.9.1, • 9.9.1, 10.9.1, 11.2(d), G1.21(c)

Referenced 7.9 testing and commissioning refers to 4.2.5

4.2.5 Verification, Testing, and Commissioning

4.2.5.1 Verification and Testing (V&T)

- V&T provider qualifications
- V&T requirements in construction documents
- Functional Performance Testing (FPT) & Verification Documentation

4.2.5.2 Commissioning (Cx) (unless Excepted)

- Cx provider qualifications
- Cx plan, design review, requirements in construction documents
- Preliminary and Final Cx report includes FPT & verification

Where to FPT & Cx requirements apply

	Simple buildings (<10k conditioned ft², warehouse, or Simple HVAC path < 25k ft²)	Complex Buildings < 25,000 ft²	All Buildings ≥ 50,000 ft² Except Warehouse
Verification, FPT	Required	Required	Required
Pre- & Design phase Cx	NR	Required	Required
Construction Phase Cx	NR	Required	Required

- 80% of US buildings are exempt from commissioning requirements
- Verification and functional performance testing (FPT) required throughout
- Pre- & design-phase Cx saves energy and cost by catching issues early
- 90.1 Cx requirements only apply to 90.1 standard requirements
- Verification that the design substantially meets 90.1 included