2009 IECC

Commercial Mechanical Requirements

U.S. Department of Energy
Building Energy Codes Program

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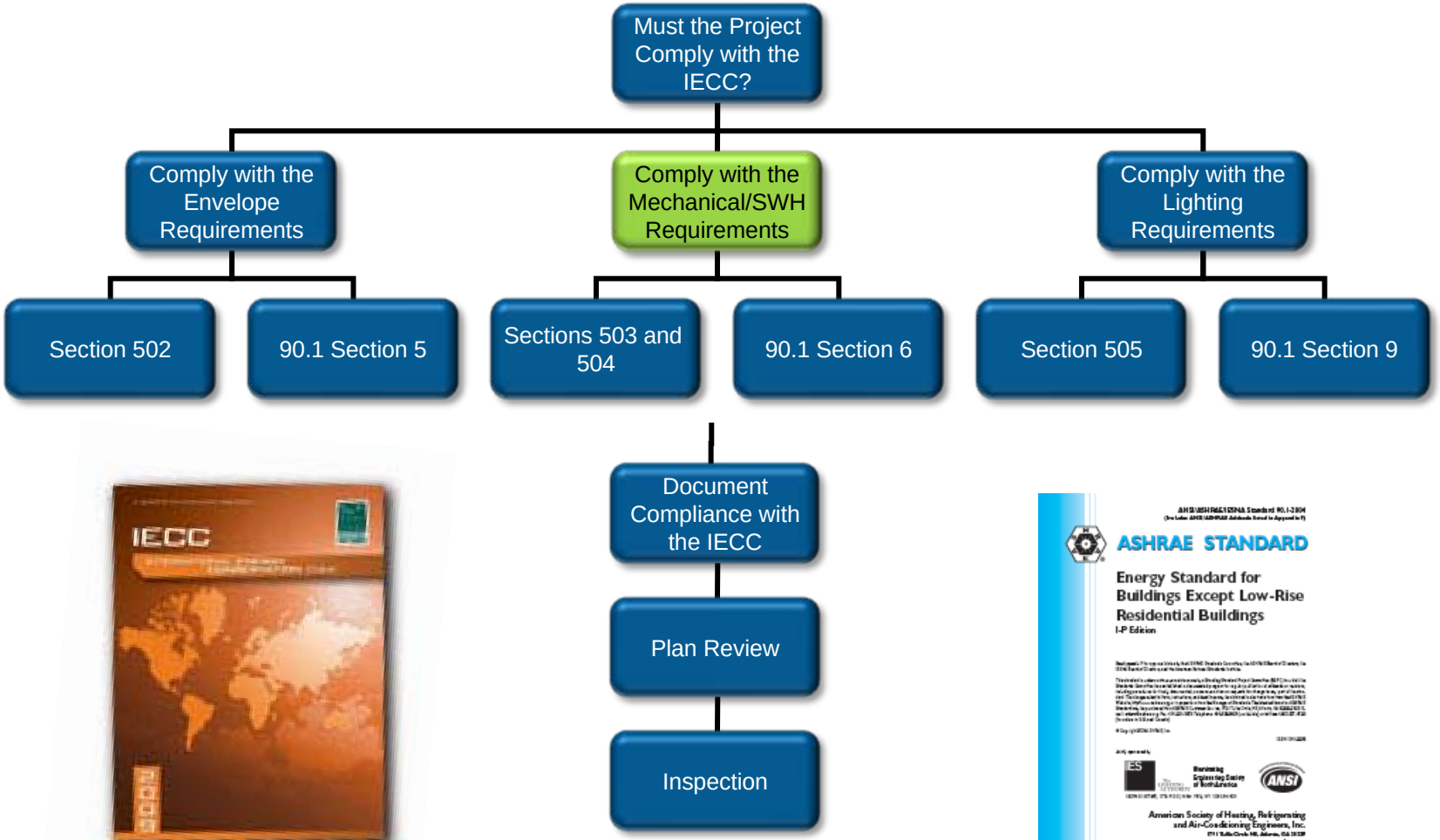
Does My Project Need to Comply with the IECC?

Non- Residential Buildings

All buildings other than:

- One- and two-family residential
- R-2, R-3, R-4 three stories or less in height

Introduction to the Energy Code Compliance Process



Section 503 Building Mechanical Systems

Simplified to Include Only Four Sections:

- General Requirements (503.1)
- Mandatory Provisions (503.2)
- Simple HVAC Systems and Equipment (503.3)
- Complex HVAC Systems and Equipment (503.4)

Mandatory Provisions *(503.2)*

Provisions Applicable to ALL Mechanical Systems

- HVAC Load Calculations
- Equipment and System Sizing
- HVAC Equipment Efficiency Requirements
- HVAC System Controls
- Ventilation
- Energy Recovery Ventilation Systems
- Duct and Plenum Insulation and Sealing
- Piping Insulation
- HVAC System Completion
- Air System Design and Control
- Fan Power Requirements
- Heating Outside a Building

HVAC Load Calculations *(503.2.1)*

Heating and cooling load sizing calculations required

- ASHRAE/ACCA Standard 183
- Other approved computation procedures
  - Exterior design conditions
    - Specified by ASHRAE
  - Interior design conditions
    - Specified by Section 302 of the IECC
      - $\leq 72^{o}$F for heating load
      - $\geq 75^{o}$F for cooling load

Equipment and System Sizing *(503.2.2)*

Output capacity SHALL NOT exceed sizing –

- Select the system which serves the greater load, heating or cooling
  - Exceptions
    - Standby Equipment with Required Controls
    - Multiple Units with Combined Capacities Exceeding Loads
      - Sequencing Controls Required

HVAC Performance (Minimum Efficiency) Requirements *(503.2.3)*

- Must comply with efficiencies listed in Tables 503.2.3(1) through 503.2.3(7)
- Applies to all equipment used in heating and cooling of buildings (chillers, boilers, air conditioners, furnaces, heat pumps, etc)
- Exception
  - Water-cooled centrifugal chillers that operate at non-standard conditions
  - Use k_{adj} to modify IPLV

Table 503.2.3(2)

TABLE 503.2.3(2)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

EQUIPMENT TYPE	SIZE CATEGORY	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
Air cooled, (Cooling mode)	< 65,000 Btu/h[d]	Split system	13.0 SEER	AHRI 210/240
		Single package	13.0 SEER	
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split system and single package	10.1 EER[c] (before Jan 1, 2010) 11.0 EER[c] (as of Jan 1, 2010)	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Split system and single package	9.3 EER[c] (before Jan 1, 2010) 10.6 EER[c] (as of Jan 1, 2010)	AHRI 340/360
	≥ 240,000 Btu/h	Split system and single package	9.0 EER[c] 9.2 IPLV[c] (before Jan 1, 2010) 9.5 EER[c] 9.2 IPLV[c] (as of Jan 1, 2010)	
Through-the-Wall (Air cooled, cooling mode)	< 30,000 Btu/h[d]	Split system	10.9 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	AHRI 210/240
		Single package	10.6 SEER (before Jan 23, 2010) 12.0 SEER (as of Jan 23, 2010)	
Water Source (Cooling mode)	< 17,000 Btu/h	86°F entering water	11.2 EER	AHRI/ASHRAE 13256-1
	≥ 17,000 Btu/h and < 135,000 Btu/h	86°F entering water	12.0 EER	AHRIASHRAE 13256-1
Groundwater Source (Cooling mode)	< 135,000 Btu/h	59°F entering water	16.2 EER	AHRI/ASHRAE 13256-1
Ground source (Cooling mode)	< 135,000 Btu/h	77°F entering water	13.4 EER	AHRI/ASHRAE 13256-1
Air cooled (Heating mode)	< 65,000 Btu/h[d] (Cooling capacity)	Split system	7.7 HSPF	AHRI 210/240
		Single package	7.7 HSPF	
	≥ 65,000 Btu/h and < 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.2 COP (before Jan 1, 2010) 3.3 COP (as of Jan 1, 2010)	
	≥ 135,000 Btu/h (Cooling capacity)	47°F db/43°F wb Outdoor air	3.1 COP (before Jan 1, 2010) 3.2 COP (as of Jan 1, 2010)	AHRI 340/360

(continued)

Table 503.2.3(3)

TABLE 503.2.3(3)
PACKAGED TERMINAL AIR CONDITIONERS AND
PACKAGED TERMINAL HEAT PUMPS

EQUIPMENT TYPE	SIZE CATEGORY (INPUT)	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY[b]	TEST PROCEDURE[a]
PTAC (Cooling mode) New construction	All capacities	95°F db outdoor air	12.5 - (0.213 · Cap/1000) EER	ARI 310/380
PTAC (Cooling mode) Replacements[c]	All capacities	95°F db outdoor air	10.9 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) New construction	All capacities	95°F db outdoor air	12.3 - (0.213 · Cap/1000) EER	
PTHP (Cooling mode) Replacements[c]	All capacities	95°F db outdoor air	10.8 - (0.213 · Cap/1000) EER	
PTHP (Heating mode) New construction	All capacities	—	3.2 - (0.026 · Cap/1000) COP	
PTHP (Heating mode) Replacements[c]	All capacities	—	2.9 - (0.026 · Cap/1000) COP	

For SI: °C - [(°F) - 32] / 1.8, 1 British thermal unit per hour - 0.2931 W
db = dry-bulb temperature, °F
wb = wet-bulb temperature, °F

a. Chapter 6 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.

b. Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7,000 Btu/h, use 7,000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.

c. Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY: NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16 inches (406 mm) high and less than 42 inches (1067 mm) wide.

System Controls *(503.2.4)*

One temperature and humidity (when applicable) controller per zone

System Controls

Heat pump systems

- Heat pump thermostat required
- Limits electric resistance heating

Demand Controlled Ventilation *(503.2.5.1)*

- *DCV* must be provided for each zone with spaces > 500 ft² and the average occupant load > 40 people/1000 ft² of floor area where the HVAC system has:
  - An air-side economizer, or
  - Automatic modulating control of the outdoor air damper, or
  - A 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.

Demand Controlled Ventilation *(503.2.5.1) - Exceptions*

- Systems with energy recovery per 503.2.6
- Multiple zone systems without direct digital control of single zones communicating with central control panel
- Systems with design outdoor airflow < 1,200 cfm
- Spaces where supply airflow rate minus any makeup or outgoing transfer air requirement < 1,200 cfm

Energy Recovery Ventilation Systems *(503.2.6)*

- Applies to individual fan systems with
  - Design supply air capacity ≥ 5,000 cfm
  - Minimum outside air supply of ≥ 70% of design supply air quantity
- Exhaust air recovery efficiency must be ≥ 50%

Energy Recovery Ventilation Systems *(503.2.6) - Exceptions*

- Where energy recovery ventilation systems prohibited by the IMC
- Lab fume hood system with at least one of the following:
  - VAV hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to ≤ 50% of design values
  - Direct makeup (auxiliary) air supply equal to at least 75% of exhaust rate, heated no warmer than 2ºF below room setpoint, cooled to no cooler than 3ºF above room setpoint, no humidification added, and no simultaneous heating and cooling use for dehumidification control
- Systems serving uncooled spaces and heated to < 60ºF
- Where > 60% of outdoor heating energy is from site-recovered or site solar energy
- Heating systems in climates < 3,600 HDD
- Cooling systems in climates with a cooling design wet-bulb temperature < 64ºF
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil

Duct and Plenum Insulation and Sealing *(503.2.7)*

Required for supply and return ducts and plenums

- Insulating ducts and plenums:
  - Located in unconditioned space – **R-5**
  - Located outside the building – **R-8**
  - Located in the conditioned space - **NR**

Low and Medium Pressure Duct Systems

- Ducts designed to operate at static pressures $\leq$ 3 in. wg
- All joints and seam (both longitudinal and transverse must be securely fastened and sealed

High Pressure Duct Systems

- Ducts designed to operate at static pressures > 3 in. wg to be leak tested in accordance with SMACNA HVAC Air Duct Leakage Test Manual
  - Air leakage rate (CL) < 6.0
  - CL = F x $P^{0.65}$
  - F = leakage rate per 100 sf of duct surface area
  - *P* = test condition static pressure
- Must test ≥ 25% of the duct area and meet the requirements

Piping Insulation *(503.2.8)*

All piping serving heating or cooling system must be insulated in accordance with Table 503.2.8

Minimum Pipe Insulation

FLUID	NOMINAL PIPE DIAMETER	
	≤ 1.5”	> 1.5”
Steam	1 ½”	3”
Hot water	1 ½”	2”
Chilled water, brine or refrigerant	1 ½”	1 ½“

(thickness in inches based on standard conductivity values (k))

Exceptions to Table 503.2.8

- Piping internal to HVAC equipment, (including fan coil units) factory installed and tested
- Piping for fluid in temperature range
  - 55 < temp < 105ºF
- Piping for fluid not heated or cooled by electricity or fossil fuels
- Runout piping ≤ 4’ in length and 1” in diameter between the control valve and HVAC coil

HVAC System Completion *(503.2.9)*

- Air System Balancing
- Hydronic System Balancing
- O & M Manual that includes:
  - Equipment Capacity and Required Maintenance
  - HVAC Controls System Maintenance and Calibration Information
    - Wiring diagrams
    - Controls sequences
    - System Setpoints
  - Written Narrative of Each System's Intended Operation

Allowable Fan Motor Horsepower *(503.2.10.1)*

- Maximum Fan Power Requirements
- Applies to HVAC systems with total fan system power > 5 hp
- Each HVAC system at design conditions can not exceed allowable fan system motor nameplate hp (Option 1) or fan system bhp (Options 2) in Table 503.2.10.1(1)

TABLE 503.2.10.1.1(1) FAN POWER LIMITATION

	LIMIT	CONSTANT VOLUME	VARIABLE VOLUME
Option 1: Fan System Motor Nameplate hp	Allowable Nameplate Motor hp	hp≤ CFMS*0.0011	hp≤ CFMS*0.0015
Option 2: Fan System bhp	Allowable Fan System bhp	bhp≤ CFMS * 0.00094 + A	bhp≤ CFMS * 0.0013 + A

Allowable Fan Motor Horsepower

BHP option includes adjustment “adders” certain devises.

DEVICE	ADJUSTMENT
Fully ducted return and/or exhaust air systems	0.5 in w.c.
Return and/or exhaust air flow control devices	0.5 in w.c
Exhaust filters, scrubbers, or other exhaust treatment.	The pressure drop of device calculated at fan system design condition.
Particulate Filtration Credit: MERV 9 thru 12	0.5 in w.c.
Particulate Filtration Credit: MERV 13 thru 15	0.9 in w.c.
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2x clean filter pressure drop at fan system design condition.
Carbon and Other gas-phase air cleaners	Clean filter pressure drop at fan system design condition.
Heat Recovery Device	Pressure drop of device at fan system design condition.
Evaporative Humidifier/Cooler in series with another cooling coil	Pressure drop of device at fan system design conditions
Sound Attenuation Section	0.15 in w.c.

Allowable Fan Motor Horsepower

- Exceptions
  - Hospital and laboratory systems using flow control devices on exhaust and/or return for health and safety or environmental control permitted to use variable fan power limitation
  - Individual exhaust fans $\leq$ 1 hp
  - Fans exhausting air from fume hoods

Motor Nameplate Horsepower

- Selected fan motor to be no larger than first available motor size greater than bhp
- Fan bhp on design documents
- Exceptions
  - Fans < 6 bhp, where first available motor larger than bhp has nameplate rating within 50% of bhp, next larger nameplate motor size may be selected
  - Fans ≥ 6 bhp, where first available motor larger than bhp has nameplate rating within 30% of bhp, next larger nameplate motor size may be selected

bhp = brake horsepower

Heating Outside a Building *(503.2.11)*

- To be radiant systems
- Controlled by an occupancy sensing device or timer switch
  - So system is automatically deenergized when no occupants are present

Simple HVAC Systems and Equipment *(503.3)*

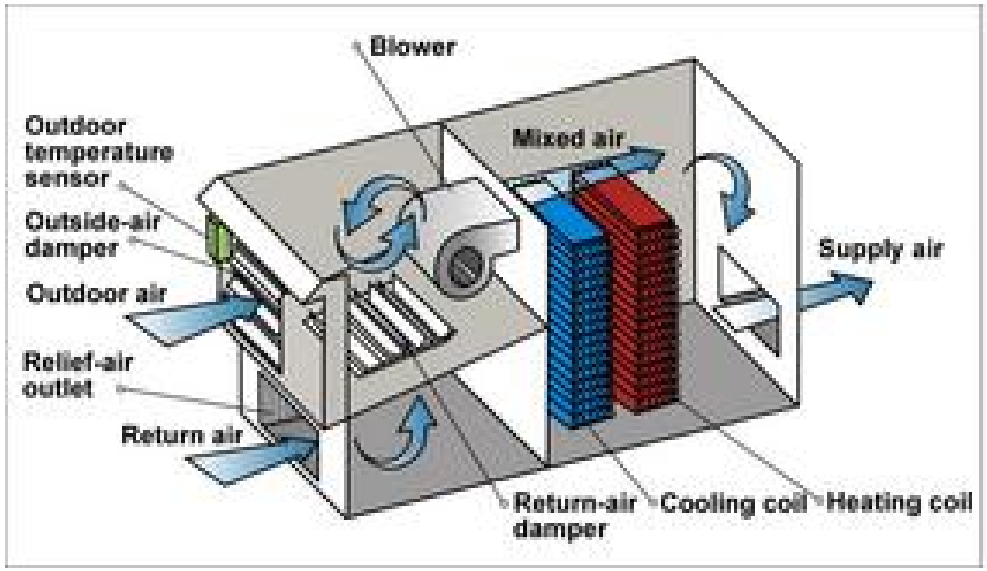
Unitary or packaged, single zone controlled by a single thermostat in the zone served. Includes:

Simple Systems

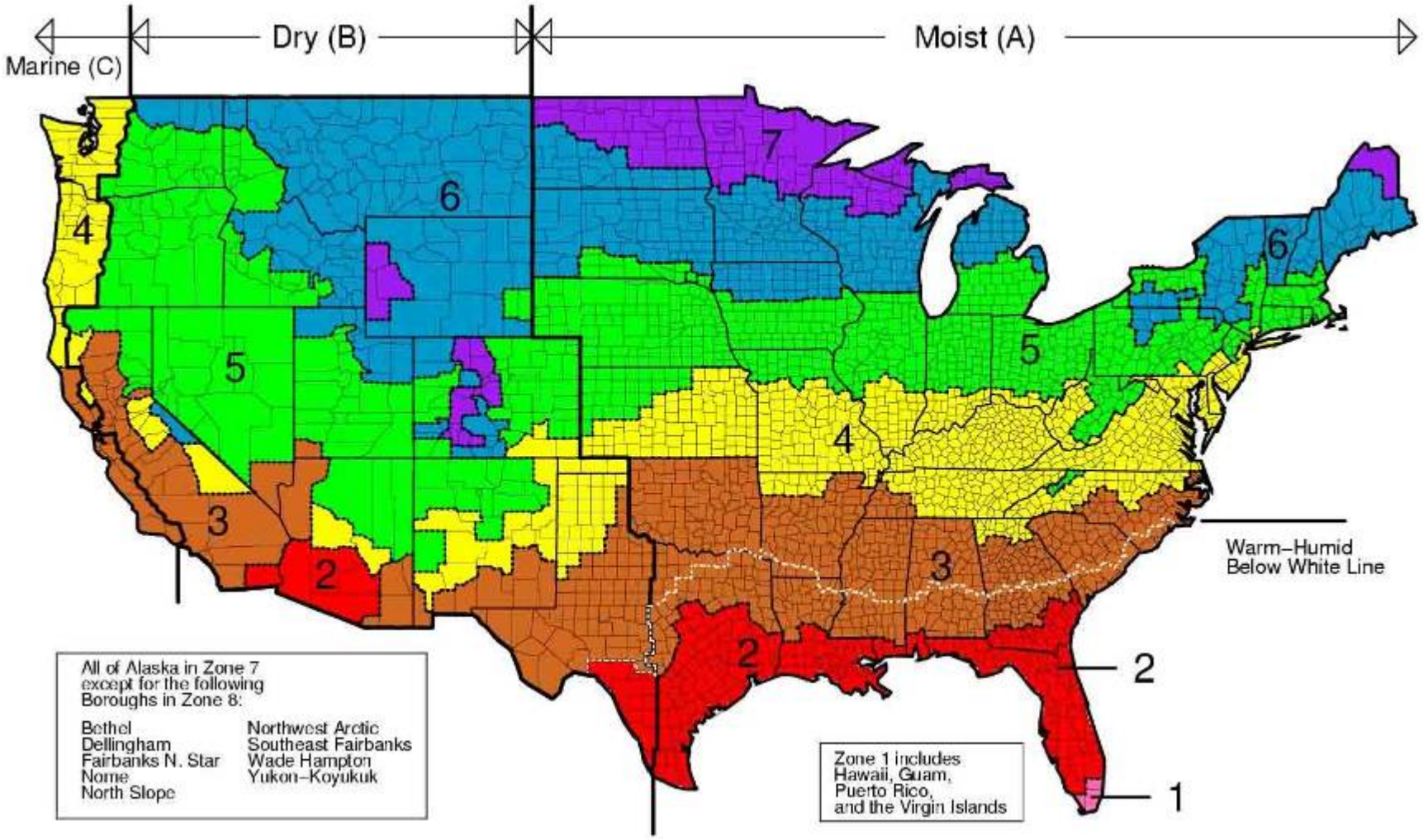
- Unitary packaged heating and cooling systems
- Split system heating and cooling systems
- Packaged terminal A/C and HPs
- Fuel-fired furnace
- Electrical resistance heating
- Two-pipe heating systems w/o cooling

Simple HVAC Systems and Equipment *(503.3)*

- Must include economizers dependent on climate zone
  - Capable of providing 100-percent outdoor air even if additional mechanical cooling is required (integrated economizer)
  - Must provide a means to relieve excess outdoor air



Climate Zones—2009 IECC



Economizers *(503.3.1)*

Table 503.3.1(1)

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B, 2A, 7, 8	No requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B	Economizers on cooling systems $\geq$ 54,000 Btu/h[a]

[a] The total capacity of all systems without economizers shall not exceed 480,000 Btu/h (40 tons) per building, or 20 percent of total cooling capacity, whichever is greater

Economizers *(503.3.1)*

Trade-off high cooling efficiency for economizer

Table 503.3.1(2)

CLIMATE ZONES	COOLING EQUIPMENT PERFORMANCE IMPROVEMENT (EER OR IPLV)
2B	10% Efficiency Improvement
3B	15% Efficiency Improvement
4B	20% Efficiency Improvement

Complex HVAC Systems and Equipment *(503.4)*

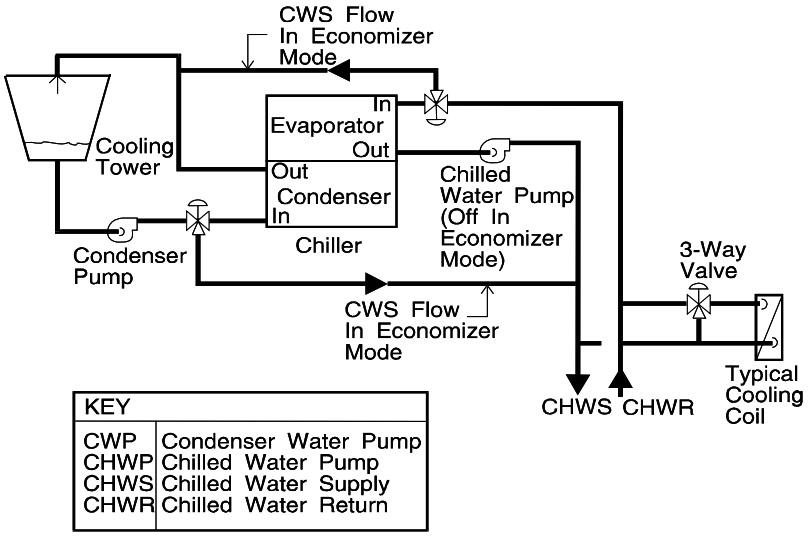
Complex Systems

- Packaged VAV reheat
- Built-up VAV reheat
- Built-up single-fan, dual-duct VAV
- Built-up or packaged dual-fan, dual-duct VAV
- Four-pipe fan coil system with central plant
- Water Source heat pump with central plant
- Any other multiple-zone system
- Hydronic space heating and cooling system

This section applies to all HVAC equipment and systems not included in Section 503.3

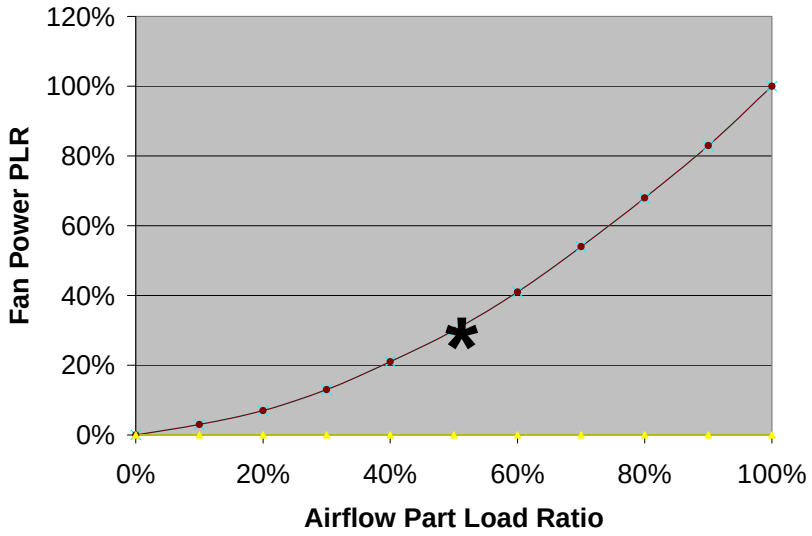
Complex System Economizers *(503.4.1)*

- Air side economizer requirements – same as simple systems (trade-off table, climate zones, size exceptions)
- Additional Exception
  - Water side economizer
  - Capable of providing 100% of the cooling system load at 50°F dry bulb / 45°F wet bulb



Variable Air Volume Fan Control *(503.4.2)*

- Individual VAV fans with motors ≥ 10hp must be:
  - Driven by a mechanical or electrical variable speed drive **OR**
  - Have controls or devices to result in fan motor demand ≤ 30% of their design wattage at 50% of design airflow (ex. vane axial fan with variable pitch blades)

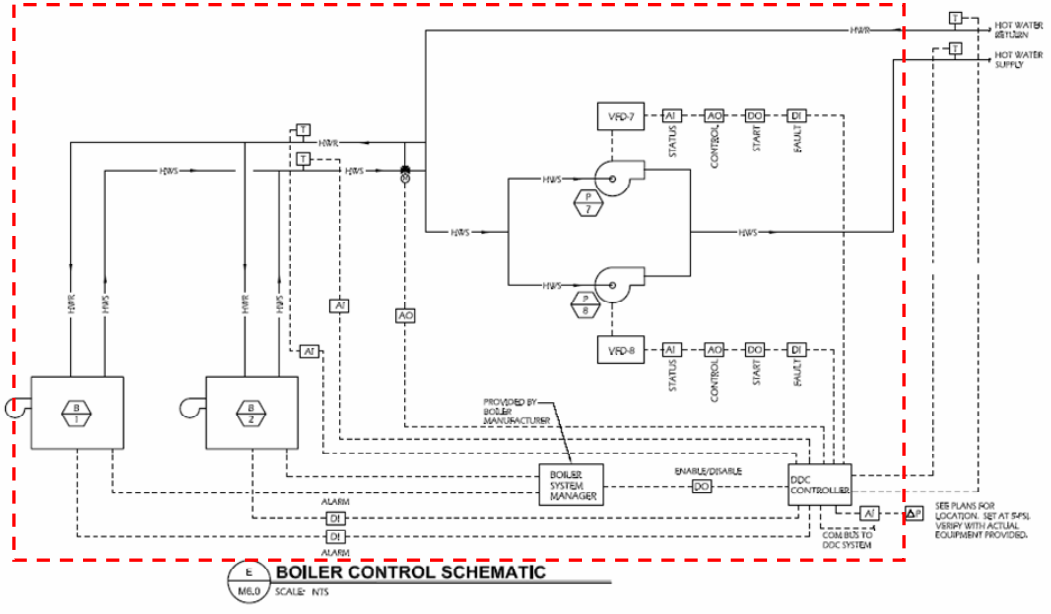


Hydronic System Controls *(503.4.3)*

- Limit reheat/recool of fluids
- Multiple boiler heating plants must include automatic controls capable of sequencing operation of the boilers
- Single boilers > 500,000 Btu/h input design capacity must include multi-staged or modulating burner

Hydronic Systems *(503.4.3)*

- 3-Pipe System – not allowed
  - Can’t use a common return
- 2-Pipe Changeover System
  - Dead band between changeover ≥ 15ºF outside temperature



Water Loop Heat Pump Systems *(503.4.3.3)*

- Temperature dead band of at least 20ºF *(503.4.3.3.1)*
  - Exception: where system loop temp optimization controller is installed and can determine the most efficient operating temp based on realtime conditions of demand and capacity
- Heat rejection equipment in Climate Zones 3 and 4 *(503.4.3.3.2)*
  - Closed-circuit cooling tower used directly in heat pump loop
    - Install either automatic valve or positive closure dampers to bypass all but a minimal flow of water around tower
  - Open-circuit tower used directly in heat pump loop
    - Install automatic valve to bypass all heat pump water flow around tower
  - Open or closed-circuit tower used in conjunction with separate heat exchanger to isolate cooling tower from heat pump loop
    - Heat loss controlled by shutting down the circulation pump on cooling tower loop

Water Loop Heat Pump Systems *(503.4.3.3)* – *cont'd*

- Heat rejection equipment in Climate Zones 5 - 8
  - Open- or closed-circuit cooling tower used
    - Must have a separate heat exchanger to isolate cooling tower from heat pump loop
    - Heat loss controlled by shutting down circulation pump on cooling tower loop and providing an automatic valve to stop flow of fluid
- Two position valve *(503.4.3.3.3)*
  - Required on each hydronic heat pump with total pump system power > 10 hp

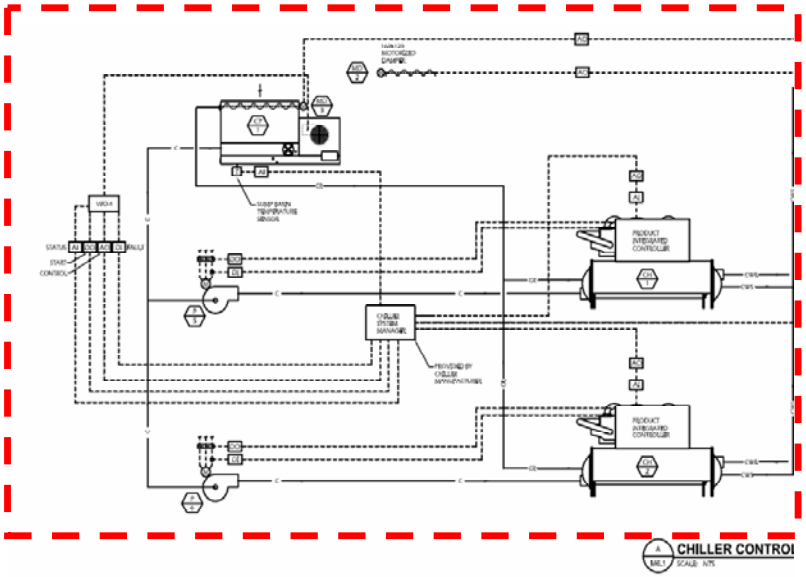
Hydronic System Part Load Control *(503.4.3.4)*

System ≥ 300,000 Btu/h must include

- Temperature reset or variable flow
  - Automatic Resets for Supply Water Temperature by at least 25% of Design Supply-to-Return Temperature Differences **or**
  - Reduce System Pump Flow by 50% of Design Flow Using
    - Multiple Staged Pumps
    - Adjustable Speed Drives
    - Control Valves that modulate as a function of load

Pump Isolation *(503.4.3.5)*

- Multiple chiller chilled water plants
  - Capability to reduce flow through the chiller automatically when chiller is shut down
  - Chillers piped in series considered one chiller
- Multiple boiler plants
  - Capability to reduce flow through the boiler automatically when boiler is shut down



Heat Rejection Equipment Fan Speed Control *(503.4.4)*

Each tower fan powered by a motor ≥ 7.5 hp must include variable speed or two speed fan

- Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device
- Exception
  - Factory-installed heat rejection devices within condensers and chillers tested and rated in accordance with Tables 503.2.3(6) and 503.2.3(7)

Multiple Zone System Airside Requirements *(503.4.5)*

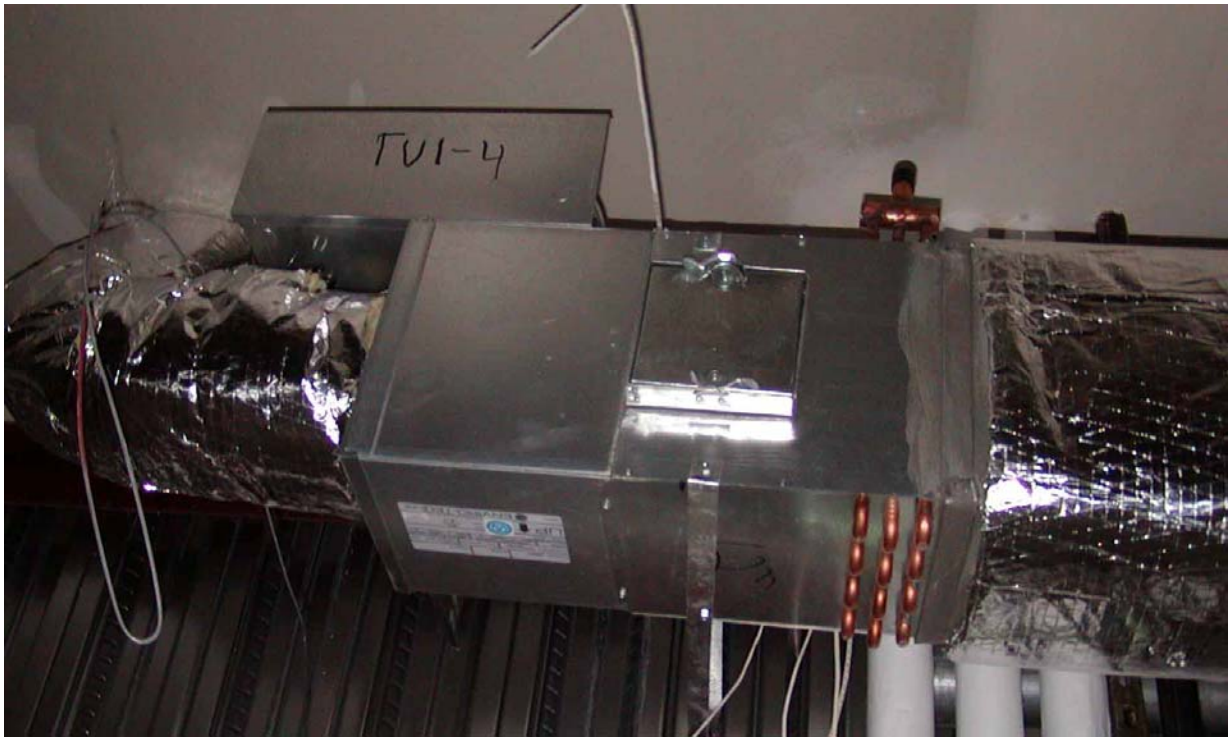
- Must be variable air volume (VAV) systems
- VAV Systems must be designed and capable of being controlled to reduce the primary air supply to each zone before reheat, recool, or mixing take place
- Maximum reheat, recool, or mixing
  - 30% of the maximum supply air to each zone
  - <300 cfm where the maximum flow rate is <10% of total fan system supply airflow rate
  - Minimum ventilation requirements from Chapter 4 of the IMC

Variable Air Volume System or Zone Exceptions

- Zones with special pressurization or cross-contamination requirements
- Where 75% of reheat energy comes from site-recovered or site-solar energy source
- Zones with special humidity requirements
- Zones with $\leq$ 300 cfm peak supply and flow rate is < 10% of total fan system supply airflow rate
- Zones where reheated, recooled or mixed air volume < minimum ventilation requirements (Chapter 4 of IMC)
- Systems with controls capable of preventing reheating, recooling, mixing or simultaneous supply of air previously heated or cooled

Single Duct VAV Systems, Terminal Devices *(503.4.5.1)*

- Single duct VAV systems must use terminal devices capable of reducing the supply of primary supply air before reheating or recooling takes place



Dual Duct and Mixing VAV Systems, Terminal Devices *(503.4.5.2)*

- Systems with one warm air duct and one cool air duct must use terminal devices capable of reducing flow from one duct to a minimum before mixing of air from the other duct takes place

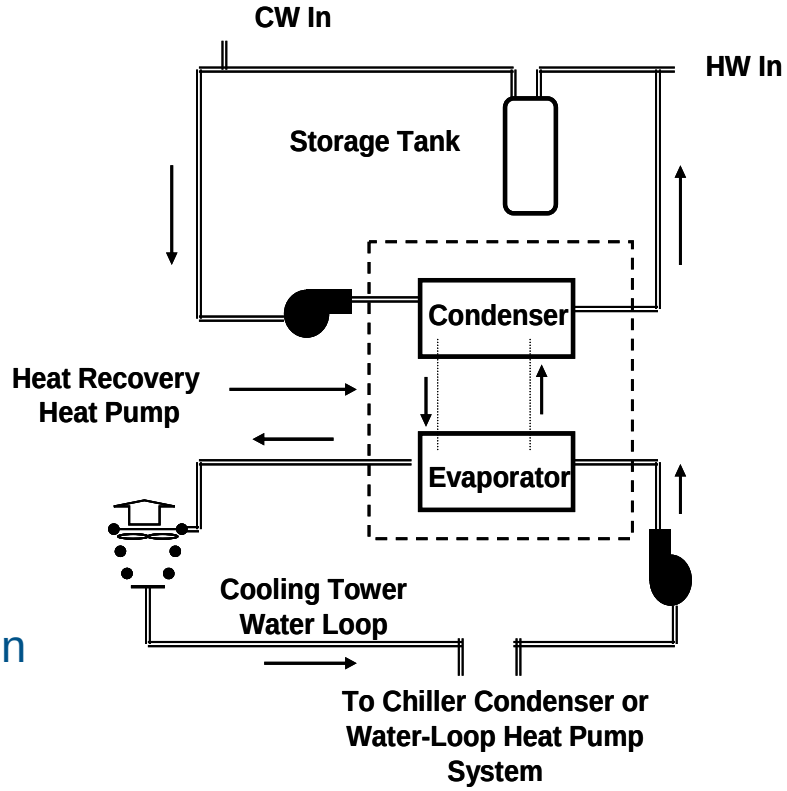
Supply-Air Temperature Reset Controls *(503.4.5.4)*

- Multiple zone HVAC systems to have controls to automatically reset supply-air temperature in response to building loads or outdoor air temperature
- Controls to be capable of resetting supply air temperature at least 25% of difference between design supply-air temperature and design room air temperature
- Exceptions
  - 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
  - Zones with peak supply air quantities of $\leq$ 300 cfm

Heat Recovery for Service Hot Water Heating *(503.4.6)*

Most effective where water heater loads are large and well distributed throughout the day

- Condenser heat recovery required for heating/reheating of SWH provided:
  - Facility operates 24 hours/day
  - Total installed heat capacity of the heat rejection of water-cooled systems >6,000,000 Btu/hr
  - Design SWH load >1,000,000 Btu/h
  - Typical applications: hotels, dorms, prisons, hospitals
- Capacity to provide the smaller of
  - 60% of peak heat rejection load at design conditions **OR**
  - Preheating to raise peak SHW to 85ºF
- Exceptions
  - Recovered heat is used for space heating or when SHW is provided by renewables or site recovered energy sources.



Section 504 Service Water Heating

- Table 504.2 Minimum Performance of Water-Heating Equipment
  - Water Heater Types Covered
    - Electric Storage
    - Gas and Oil Storage
    - Instantaneous Water Heaters – Gas and Oil
    - Hot water boilers – gas and oil
    - Pool heaters
    - Unfired storage tanks
- Temperature Controls *(504.3)*
- Heat Traps *(504.4)*

Pipe Insulation *(504.5)*

- Noncirculating system insulation requirements
  - First eight feet of outlet piping on systems with no integral heat traps - 1/2 inch of insulation required
- Circulating systems
  - 1 inch of insulation

Hot Water System Controls *(504.6)*

- Ability to turn off circulating hot water pumps and heat trace tape when the system is not in operation
  - Automatically or manually

Pool Requirements *(504.7)*

- Pool heaters *(504.7.1)*
  - Readily accessible on-off switch
  - Natural gas or LPG fired pool heaters will not have continuously burning pilot lights
- Time switches *(504.7.2)*
  - Automatic controls required to operate pool heaters and pumps on a preset schedule
  - Exceptions
    - Where public health standards require 24 hour operation
    - Where pumps are required to operate solar and waste heat recovery pool heating systems

Pool Covers *(504.7.3)*

- Heated pools required to have a pool cover
  - Pool cover must be vapor retardant
- Pools heated to over 90^{o}F
  - Minimum R-12 insulation
- Exception
  - Pools deriving > 60% energy for heating from site-recovered energy or solar source