ANSI/ASHRAE/IESNA Standard 90.1-2007

An Overview of the Mechanical and Service Water Heating Requirements

February 28, 2008

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Your Instructor

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- Principal at Taylor Engineering, LLC in Alameda, California http://www.taylor-engineering.com
- Vice-Chair of SSPC 90.1
- Author of many of the HVAC requirements in the non-residential building energy standards for ASHRAE (90.1), California (Title 24), Vietnam and India

Acknowledgements

- Thanks to Mick Schwedler, Chair of SSPC 90.1, for his contributions to these slides.
- Many of these slides and graphics are from the Trane Company, a Division of American Standard.

Resources

- ASHRAE (http://www.ashrae.org)
  - Standard and User's Manual (bookstore)
  - Interactive compliance forms
  - SSPC 90.1 meeting schedule
  - List services
  - Public review drafts
  - Continuous maintenance proposal forms
  - Addenda
  - Errata and interpretations
  - SSPC 90.1 Website (http://sspc901.ashraepcs.org)

Resources

continued

- DOE's Building Energy Codes Program (http://www.energycodes.gov)
  - COM*check* (compliance software)
  - Training
  - Information about State Energy Codes
  - Resource Center
  - Code Notes
  - Other valuable resources

Climate Criteria
Normative Appendices B and D

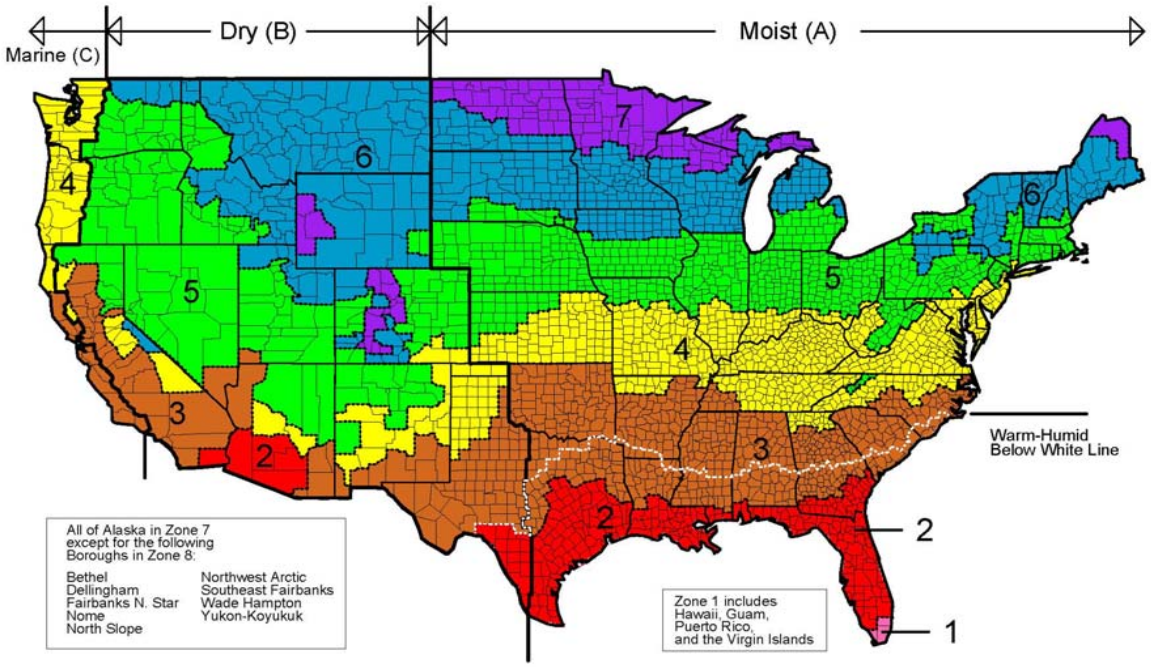


Figure B-1 and Table B-1 US Climate Zones

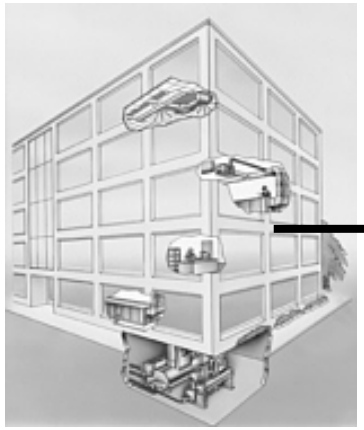
HVAC/SWH Addenda to 90.1-2004

- Summarized in Appendix F of 90.1-2007
  - 90.1b: Revisions to Table 6.8.1D (SPVAC/HP efficiencies) in response to DOE comments.
  - 90.1 f&g: Revisions to Tables 6.8.1A (AC) and 6.8.1B (HP) to reflect changes in DOE Efficiency Standards.
  - 90.1 h: Removes exemption from dead band requirements for data centers (6.4.3.1.2 and 6.4.3.7).
  - 90.1q: Removes exception for off hours controls (6.4.3.2) for hotel/motel guestrooms.
  - 90.1s: Updates references to Standard 62.1.
  - 90.1t: Updates boiler test procedure.

HVAC/SWH Addenda to 90.1-2004 (cont.)

- 90.1v: Modifications to the requirements for demand control ventilation (6.4.3.9).
- 90.1ac: Significant changes to the fan power limitations (6.5.3).
- 90.1ak: Changes to the rating procedures for cooling towers (Table 6.8.1G).
- 90.1an: Increase in boiler efficiencies (Table 6.8.1F).
- 90.1ao: Adds IID and dampers or power venting to furnaces and unit heaters (Table 6.8.1E).
- 90.1ar: Reduces the threshold to 10hp for VSDs on supply fans (6.5.3.2.1).

ASHRAE Standard 90.1-2007
Compliance Paths: HVAC



proposed HVAC design

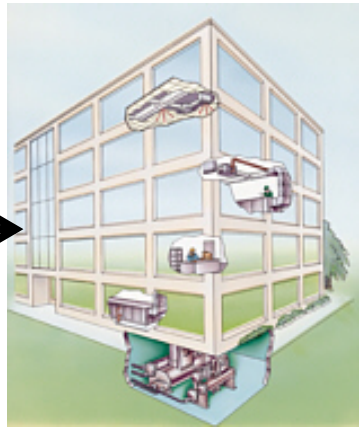
mandatory provisions (§6.4)

prescriptive requirements (§6.5)

Energy Cost Budget Method (ECB, §11)

Simplified Approach Option (§6.3)

(small buildings only)



90.1-compliant HVAC system

HVAC Compliance with Std 90.1-2007

Simplified Approach (§6.3)

- Minimal effort
- Equally stringent requirements
- Fits on two pages
- Limited to …
  - Buildings with 1 or 2 stories
  - Buildings less than 25,000 gsf
  - Single-zone systems (unitary or split)
  - Air-cooled or evaporatively cooled

Simplified Approach (§6.3)

continued

- Economizer as necessary
- Heat: Heat pump (air source), fuel-fired furnace, electric resistance, or baseboard system with boiler
- Min outdoor air: ≤ 3,000 cfm AND < 70% of SA, unless energy recovery is used
- Manual-changeover or dual-setpoint thermostat
- Controls for heat pumps with auxiliary heat
- No reheat for humidity control

HVAC Compliance with Std 90.1-2007

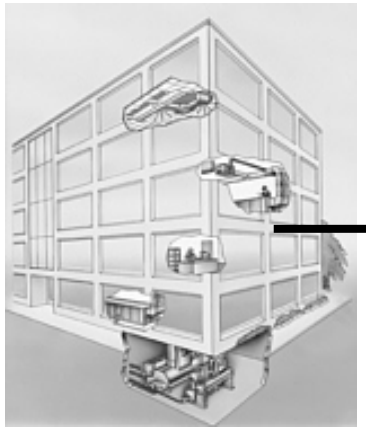
Simplified Approach (§6.3)

concluded

- Time clock and night setback controls (except hotel/motel guest rooms)
- Insulation for piping and ductwork
- Balancing of ducted systems
- Interlocked thermostats for separate heating and cooling equipment
- Exhaust > 300 cfm: Gravity or motorized dampers unless operated continuously
- System > 10,000 cfm: Optimum start

Section 6: HVAC

Mandatory Provisions (§6.4)



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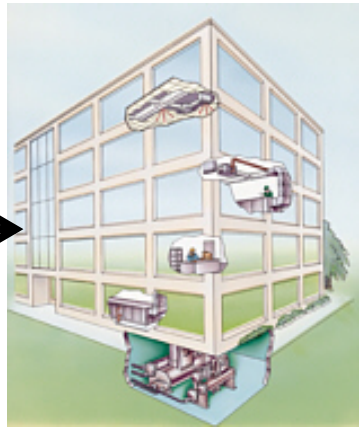


90.1-compliant HVAC system

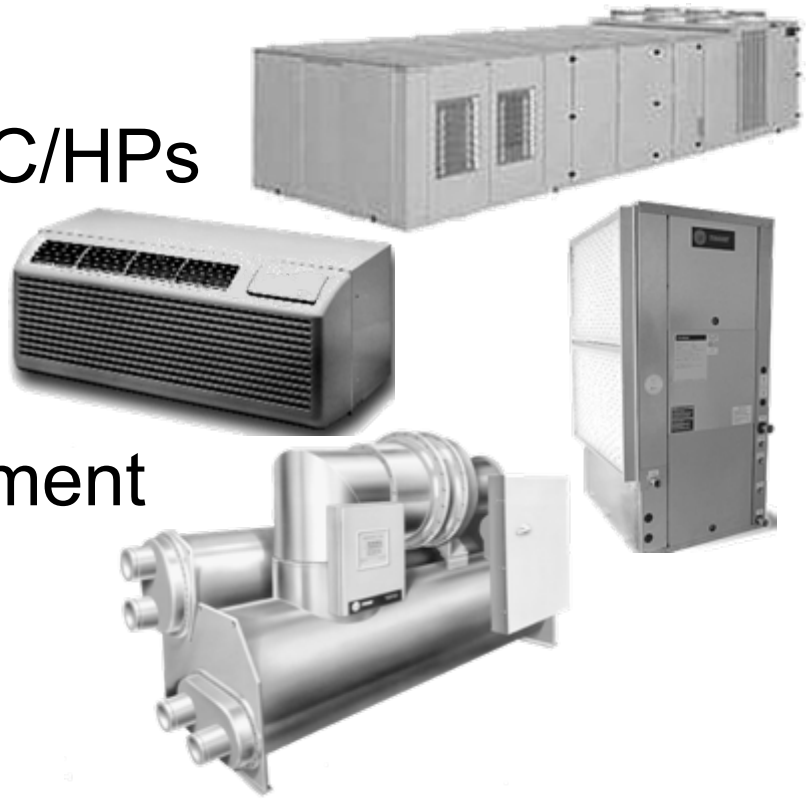
Mandatory Provisions (§6.4)

- Equipment efficiencies (§6.4.1 and §6.8)
- Load calculations (§6.4.2)
- Controls (§6.4.3)
- Construction and insulation (§6.4.4)
- Completion requirements (§6.4.5 and §6.7.2)
- **Drawings, manuals, balancing, and commissioning**

Mandatory HVAC Provisions

Equipment Efficiencies (§6.4.1 and §6.8)

- 90.1f&g Air conditioners and condensing units
- 90.1f&g Heat pumps
- Chillers
- 90.1b PTAC/HPs and SVAC/HPs
- 90.1aq Furnaces
- 90.1an Boilers
- 90.1ak Heat-rejection equipment



Equipment Efficiencies - Examples

Equipment type	Minimum efficiency
Self-contained, water-cooled w/electric resistance heat (≥20 tons)	**11.0 EER** **10.3 IPLV**
Water-source heat pump (1.5–5.25 tons)	**12.0 EER** (cooling) **4.2 COP** (heating)
Centrifugal chiller, water-cooled (≥ 300 tons)	**6.10 COP** **0.576 kW/ton** **6.40 IPLV** **0.549 IPLV** (at ARI rating conditions)

§6.4.1.1: "… Where multiple rating conditions or performance requirements are provided, the equipment shall satisfy all stated requirements …"

Mandatory HVAC Provisions

Load Calculations (§6.4.2)

- Must calculate heating and cooling system design loads
- Must base calculations on generally accepted engineering standards and handbooks

Mandatory HVAC Provisions

Controls (§6.4.3)

- Zone Thermostatic Controls (§6.4.3.1)
- Setpoint Overlap Restriction (§6.4.3.2)
- Off-Hour Controls (§6.4.3.3)
- Ventilation System Controls (§6.4.3.4)
- Heat Pump Auxiliary Heat Control (§6.4.3.45)
- Humidifier Preheat (§6.4.3.6)
- Humidification and Dehumidification (§6.4.3.7)
- Freeze Protection and Snow/Ice Melting Systems (§6.4.3.8)
- Ventilation Controls for High-Occupancy Areas (§6.4.3.9)

Mandatory HVAC Provisions
Zone Thermostatic Controls (§6.4.3.1)

90.1h

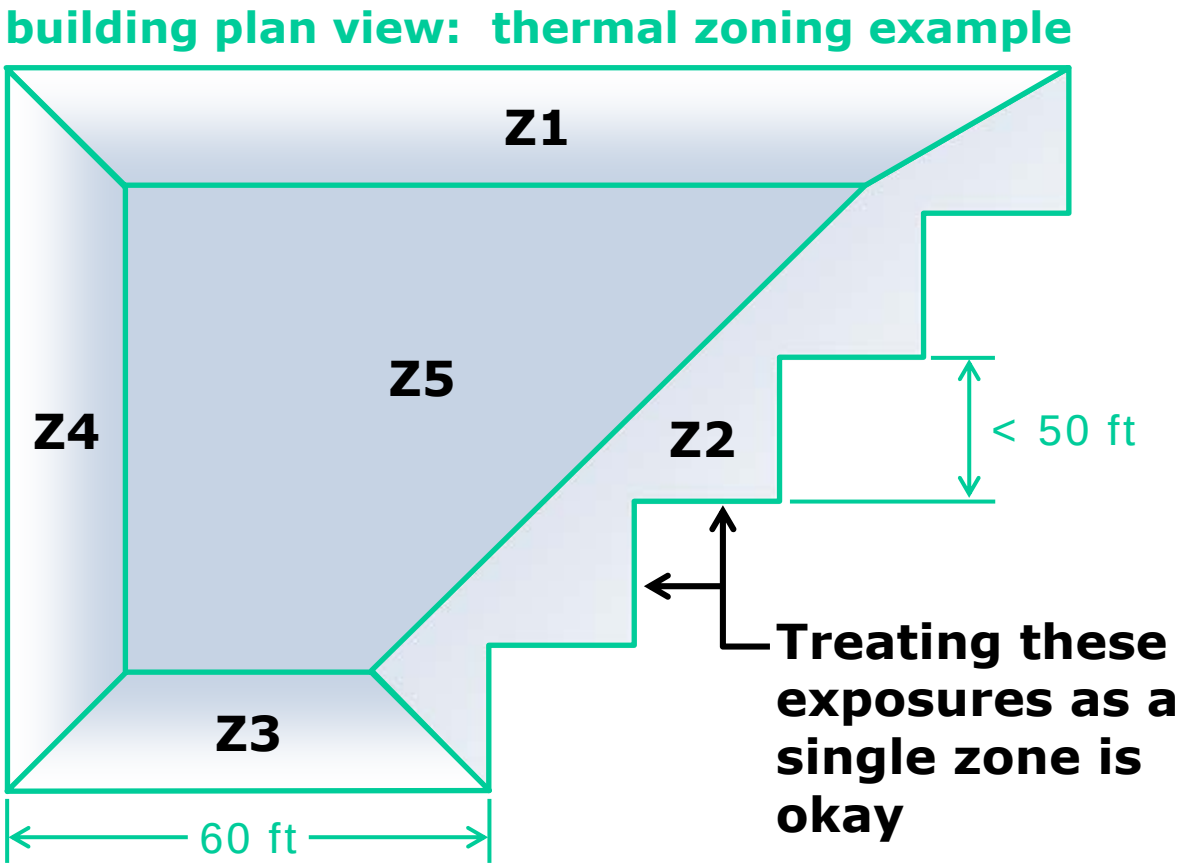
Required for each zone

Perimeter can be treated differently

- Capable of 5ºF dead band or larger
  Dual setpoint or dead band (can be software for DDC)
- The standard defines equipment capability not operation

Mandatory HVAC Provisions
Zone Thermostatic Controls (§6.4.3.1)

Core and each long exposure must be zoned separately



Mandatory HVAC Provisions

Setpoint Overlap Restriction (§6.4.3.2)

- Limit switches
- Mechanical stops
- Software programming (DDC)

Mandatory HVAC Provisions
Off-Hour Controls (§6.4.3.3)

- Automatic Shutdown (§6.4.3.3.1)
- Setback Controls (§6.4.3.3.2)
- Optimum Start (§6.4.3.3.3)
- Zone Isolation (§6.4.3.3.4)
- 90.1q Exceptions to 6.4.3.3
  - Systems that operate continuously
  - Systems with cooling capacity <15,000 Btuh with manual on/off controls

Mandatory HVAC Provisions

Automatic Shutdown (§6.4.3.3.1)

- Automatic 7-day/week time clock with 10-hour battery backup
  - Exception: 2-day/week thermostat for residential applications
- Occupancy sensor
- Manually operated timer (maximum duration: 2 hours)
- Security system interlock

Mandatory HVAC Provisions

Setback Controls (§6.4.3.3.2)

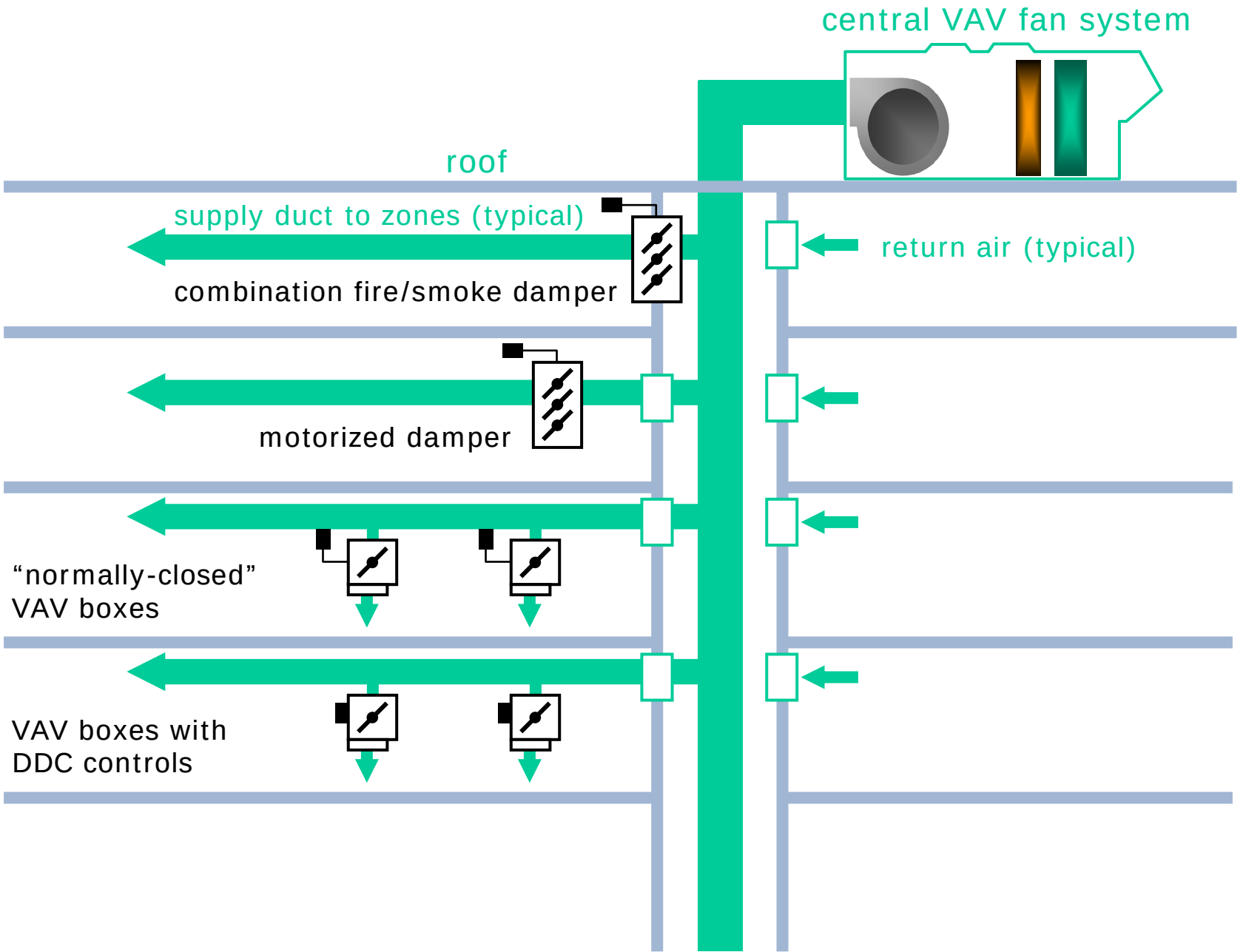
- Climate zones 2-8:
  Lower heating setpoint to 55°F or less
- Climate zones 1b, 2b, 3b (hot/dry):
  Automatically restart, temporarily operate
  - Raise cooling setpoint to 90°F or higher

    Or
  - Prevent high space humidity levels

Mandatory HVAC Provisions
Other Off-Hour Controls

- Optimum start (§6.4.3.3.3)
  - If system supply-air capacity > 10,000 cfm
- Zone isolation(§6.4.3.3.4) (see next slide)
  - Applies to:
    - Each floor in multistory building
    - Limit to <=25,000 ft² maximum isolation zone size on each floor
  - Requirements:
    - Isolation devices to shut off outdoor and exhaust airflow when > 5,000 cfm
    - Central systems shall be capable of stable operation with one isolation zone
    - Capable of separate time schedules for each isolation zone

Zone Isolation - Example



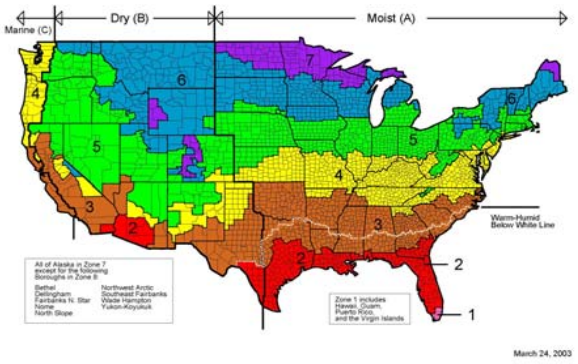
Mandatory HVAC Provisions
Ventilation System Controls (§6.4.3.4)

Provide motorized dampers:

- In stair and elevator shafts
- On gravity hoods, vents, and ventilators

  Exceptions:

  - Buildings < 3 stories high
  - Any building in climate zones 1,2,3 (hot climates)
  - Ventilation systems serving unconditioned spaces



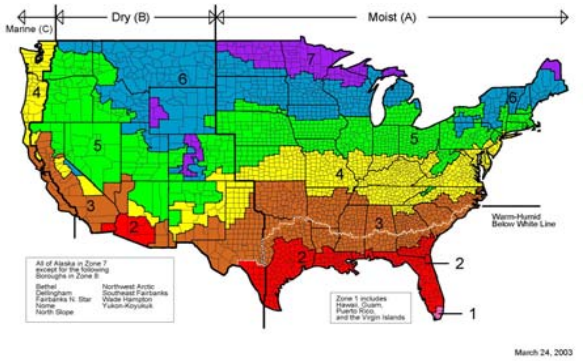
Mandatory HVAC Provisions
Ventilation System Controls (§6.4.3.4) continued

Provide shutoff-damper control for outdoor-air supply and exhaust systems

- Automatically shut when systems or spaces are not in use
- Automatically shut during building warm-up, cool-down, and setback

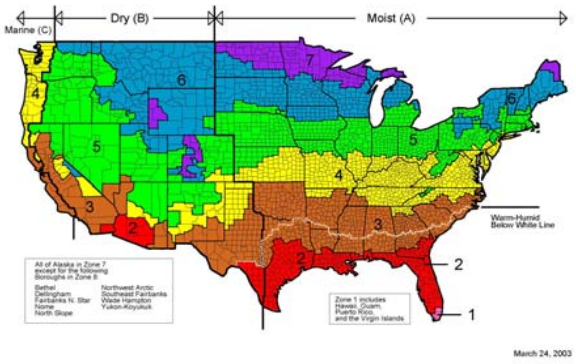
Exceptions for gravity (non-motorized) dampers:

- Buildings < 3 stories high everywhere
- any building in climate zones 1,2,3
- Outdoor-air intake or exhaust < 300 cfm



Mandatory HVAC Provisions
Ventilation System Controls (§6.4.3.4) concluded

	Maximum leakage at 1.0 in. wg, cfm/ft² of damper area	
Climate zone	Motorized	Non-motorized
1, 2, 6, 7, 8	**4 cfm/ft²**	**Not allowed**
All others	**10 cfm/ft²**	**20 cfm/ft²***



* Dampers < 24 inches in either dimension may have leakage of 40 cfm/ft²

Applies to OSA, EA and RA (economizer) dampers

Mandatory HVAC Provisions
Heat Pumps: Auxiliary Heat (§6.4.3.5)

For heat pumps with internal electric heaters, controls must lock out electric heat when load can be met by heat pump alone

Exception:
Heat pumps regulated by NAECA if HSPF rating meets Table 6.8.1B and includes electric resistance heating

Mandatory HVAC Provisions
Humidification Controls (§6.4.3.6 & §6.4.3.7)

- Humidifier preheat (§6.4.3.6)
  Shut off humidifier preheat when humidification is not required

- Humidification and dehumidification (§6.4.3.7)
  Prevent simultaneous operation

  Exception:
  90.1h
  Spaces that require specific humidity levels (museums or hospitals) if approved by authority having jurisdiction

Mandatory HVAC Provisions
Ventilation: High Occupancy (§6.4.3.9)

90.1v

DCV must be provided for each zone with a area > 500 ft² and the design occupancy > 40 people/1000 ft² where the HVAC system has:

- An air-side economizer,
- Automatic modulating control of the OSA dampers, 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.

Mandatory HVAC Provisions
Ventilation: High Occupancy (§6.4.3.9) cont.

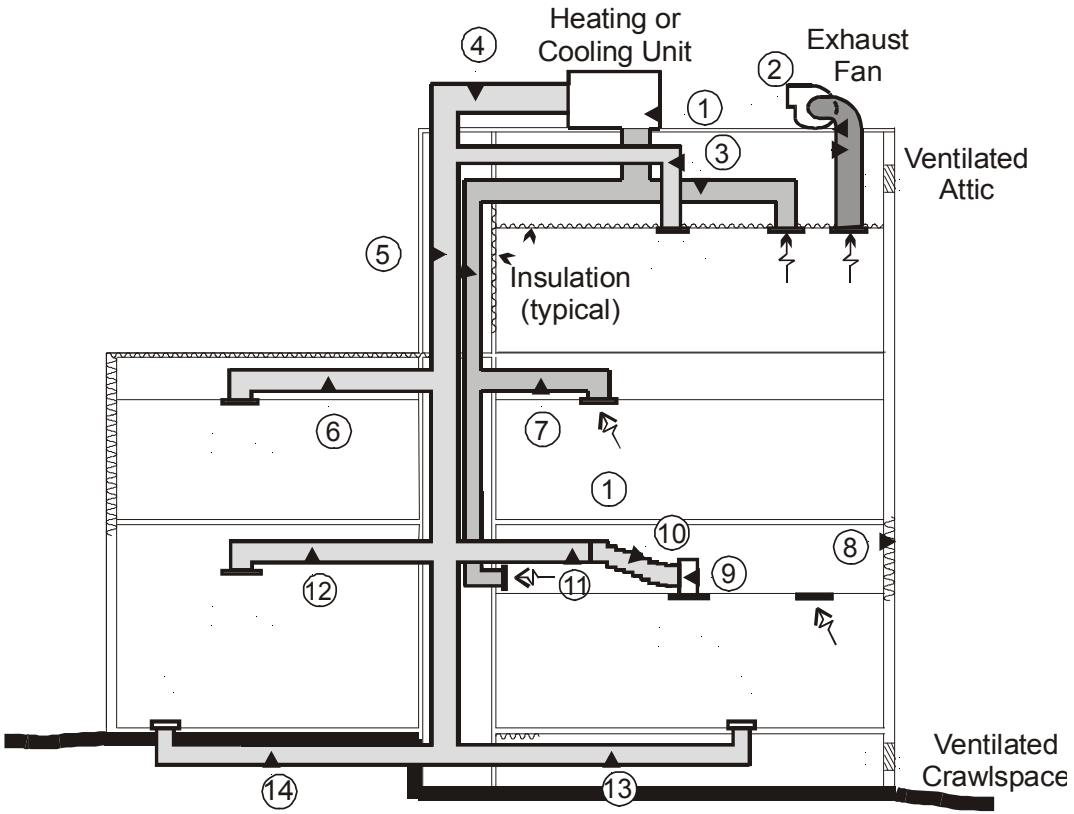
- Exceptions:
  - Systems with exhaust-air energy recovery complying with Section 6.5.6.1
  - Multiple zone systems without DDC to the zone level
  - Systems with a design OSA airflow <1,200 cfm
  - Spaces where supply-exhaust <1,200 cfm

Mandatory HVAC Provisions
Construction & Insulation (§6.4.4)

Insulation must be suited to environment

- Duct, plenum insulation
  - Climate zone
  - Location
- Piping insulation
  - Heating, domestic hot water, or cooling
  - Temperature
  - Pipe size

Duct Insulation Example



KEY

1. Insulation of unit casing
2. Exhaust
3. Supply and return in vented attic
4. Supply on exterior of building
5. Supply and return in shaft
6. Supply in unvented attic
7. Return in indirectly conditioned ceiling space
8. Exterior wall of return plenum
9. Supply outlet in plenum
10. Supply runout in plenum
11. Supply in plenum
12. Supply in conditioned space
13. Supply in vented crawlspace
14. Buried supply

Figure 6-G from 90.1 User's Manual

Mandatory HVAC Provisions
Construction & Insulation (§6.4.4)

Minimum sealing levels for ducts by location, service and pressure class

Must leak-test 25% of the ductwork with design static pressure > 3 in. wg

Mandatory HVAC Provisions
Completion Requirements (§6.4.5 & 6.7)

Documentation within 90 days of system acceptance:

- Drawings of actual installation
- Submittal data
- Operation and maintenance manuals
- Service agency information
- Control sequences and schematics

Completion Requirements

continued

System balancing (§6.7.2.3)

- Written report conditioned spaces > 5000 ft²
- For airside system fan power > 1 hp and hydronic pumps >10 hp:

  1. Minimize throttling losses

  2. Trim impeller or adjust design speed

Completion Requirements

concluded

Commissioning (§6.7.2.4 & Appendix E)

- Control elements calibrated, adjusted, and in working order
- Designer must provide detailed instructions (per Appendix E) for projects > 50,000 ft²

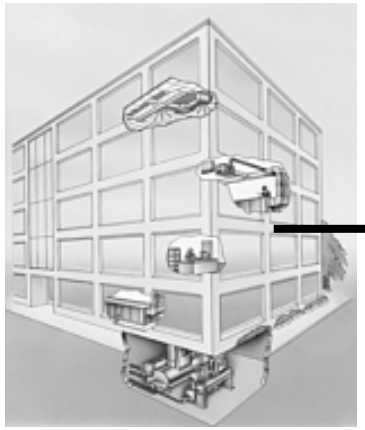
  Exceptions:
  Warehouses, semi-heated spaces

Mandatory Provisions Recap

- Must be met whether using prescriptive or performance (ECB method) path
- Mandates include:
  - Equipment efficiency
  - Controls
  - Construction and insulation
  - Completion requirements (drawings, manuals)
  - Balancing and commissioning

Section 6: HVAC

Prescriptive Requirements



proposed HVAC design

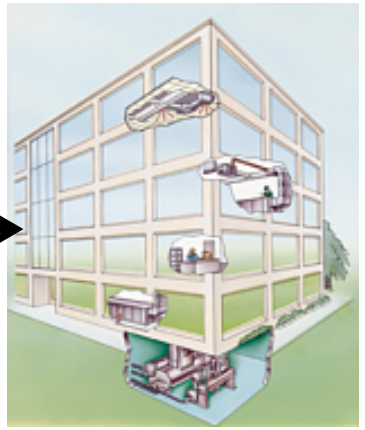
mandatory provisions (§6.4)

prescriptive requirements (§6.5)

Energy Cost Budget Method (ECB, §11)

Simplified Approach Option (§6.3)

(small buildings only)



90.1-compliant HVAC system

Section 6: HVAC

Prescriptive Requirements (§6.5)

- Economizers (§6.5.1)
- Simultaneous heating and cooling (§6.5.2)
- Air system design and control (§6.5.3)
- Hydronic system design and control (§6.5.4)
- Heat rejection equipment (§6.5.5)
- Energy recovery (§6.5.6)
- Exhaust hoods (§6.5.7)
- Radiant heating (§6.5.8)
- Hot gas bypass limitation (§6.5.9)

Prescriptive HVAC Requirements

Economizers (§6.5.1)

- Climate and system size determine need for an economizer
- May be either airside or waterside
- Numerous exceptions (see next slide)
- Control must be integrated with mechanical cooling
- Operation must not increase heating energy consumption

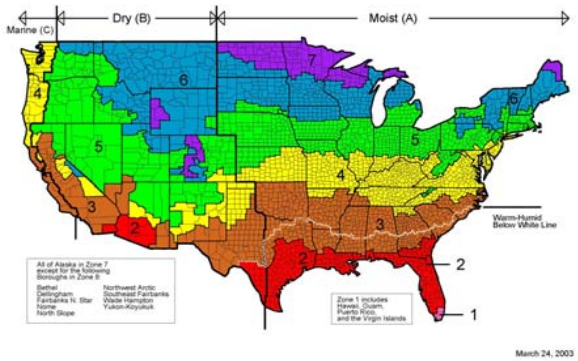
Prescriptive HVAC Requirements

Economizers (§6.5.1)

- Exceptions:
  - Cooling capacity - Table 6.5.1 (next slide)
  - Systems with gas phase air cleaning per Standard 62
  - Where >25% of the air must be humidified >35°Fdp
  - Systems with condenser heat recovery per 6.5.6.2
  - Residential systems <5X limits in Table 6.5.1
  - Systems with a balance point <=60°F
  - Systems expected to operate < 20hrs/wk
  - Systems serving zones with refrigerated casework
  - Where cooling efficiency exceeds Table 6.3.2

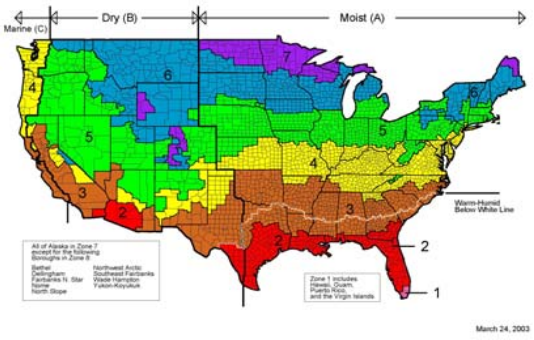
Climate and System Size Determinants
Economizers (Table 6.5.1)

Climate zone	Cooling capacity for which an economizer is required
1a, 1b, 2a, 3a, 4a (Miami, St. Louis, Charlotte)	**Economizer unnecessary**
2b, 5a, 6a, 7, 8 (Yuma, Chicago, Edmonton)	**≥ 135,000 Btu/h**
3b, 3c, 4b, 4c, 5b, 5c, 6b (Denver, Lubbock, Vancouver)	**≥ 65,000 Btu/h**



Prescriptive HVAC Requirements
Air Economizers (§6.5.1.1)

- Prohibited control types (Table 6.5.1.1.3A)
  - **Fixed enthalpy** in climate zones 1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8
  - **Differential dry bulb** in climate zones 1a, 2a, 3a, 4a
- High-limit shutoff control settings (Table 6.5.1.1.3B)
- Damper leakage ratings OA and RA (see 6.4.3.3.4)
- Able to relieve excess outdoor air without recirculation of exhaust



Prescriptive HVAC Requirements
Water Economizers (§6.5.1.2)

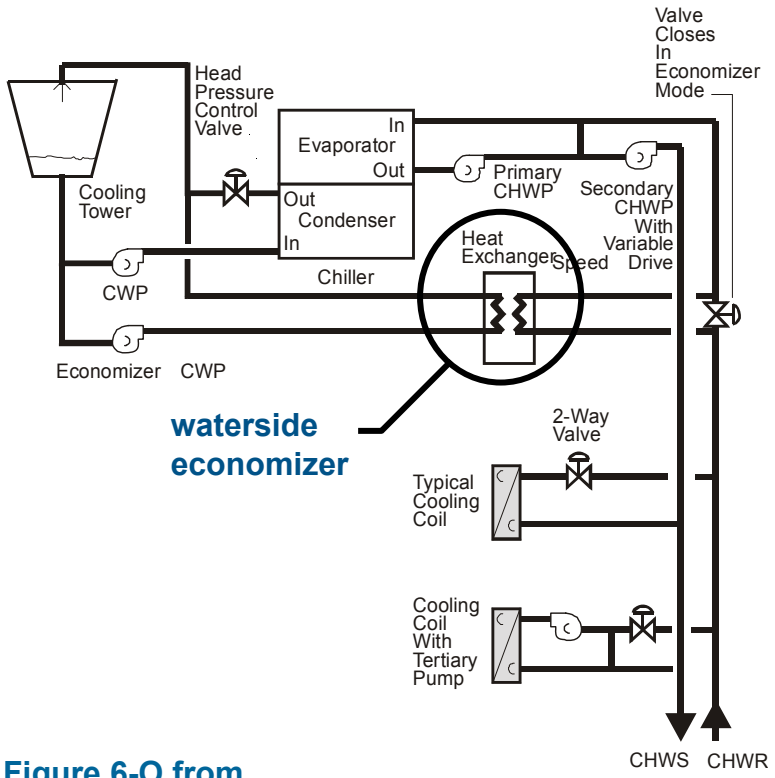
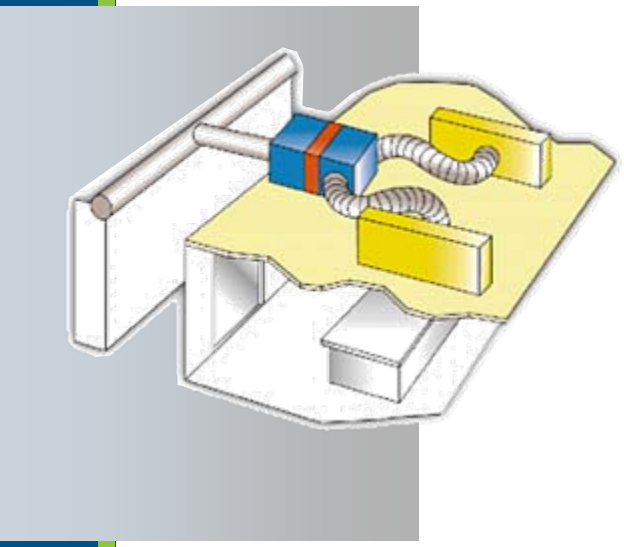


Figure 6-O from 90.1 User's Manual

- Capacity: 100% of system cooling load at 50°F DB/45°F WB **(45°F DB/40°F WB for systems with dehumidification)**
- Maximum pressure drop < 15 ft (or bypassed) when not in use
- Must be integrated (some exceptions)

Prescriptive HVAC Requirements
Simultaneous Heating–Cooling (§6.5.2)



Zone controls

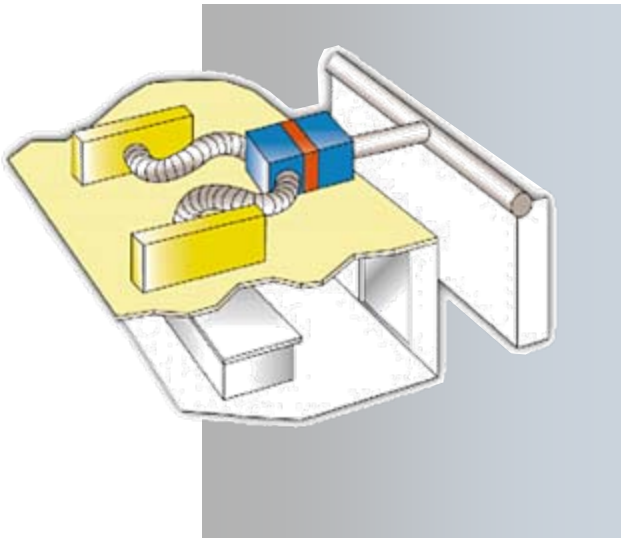
- No reheating
- No recooling
- No mixing of simultaneously supplying mechanically (or economizer) cooled and mechanically heated air
- No simultaneous heating and cooling of the same zone
- Multiple exceptions (see next slide)

Simultaneous Heating–Cooling

Zone-Control Exceptions (§6.5.2.1)

Zone airflow does not exceed whichever is largest:

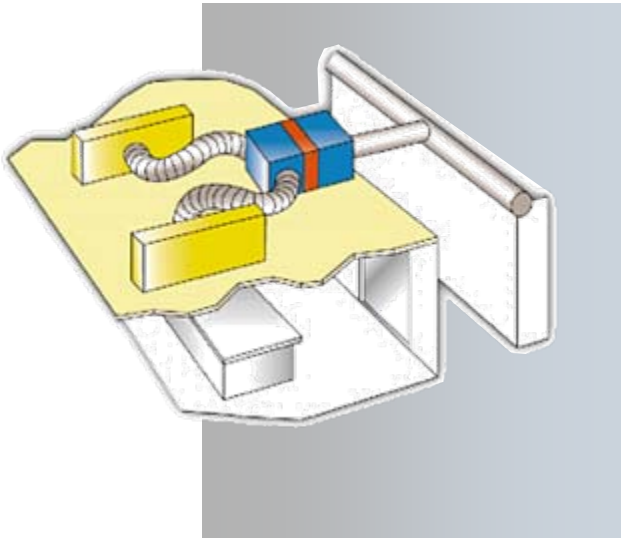
- Code required ventilation
- 0.4 cfm/ft²
- 30% of supply air
- 300 cfm
- Where it would reduce overall system energy due to ventilation requirements of a critical zone



Simultaneous Heating–Cooling

Zone-Control Exceptions (§6.5.2.1) concluded

- Zones with special pressurization requirements
- Zones with code-required minimum circulation rates
- Site-recovered or site-solar energy provides ≥ 75% of reheat energy



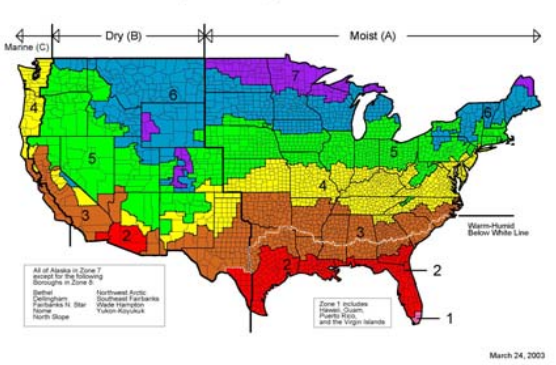
Prescriptive HVAC Requirements
Hydronic System Controls (§6.5.2.2)

- Three-pipe: Not allowed
- Two-pipe changeover: Controls must prevent changeover unless …
  - Controlled by OA with dead band ≥ 15°F
  - System operates in each mode for a minimum of 4 hours
  - Difference between reset cooling and heating temperatures is ≤ 30°F

Prescriptive HVAC Requirements

WLHP Systems (§6.5.2.2.3)

- Loop temperature dead band ≥ 20°F (Exception: Optimized loop control)
- For climate zones 3-8:
  - Closed-circuit fluid cooler shall have either:
    - Bypass all but minimum flow (for freeze protection, or
    - Low leakage automatic air dampers on tower
  - Isolate open towers from heat-pump loop using bypass or shutting down tower pump where provided with HX



Prescriptive HVAC Requirements

Dehumidification (§6.5.2.3)

Prohibited:

- Reheating, mixing or simultaneous heating and cooling for humidity control

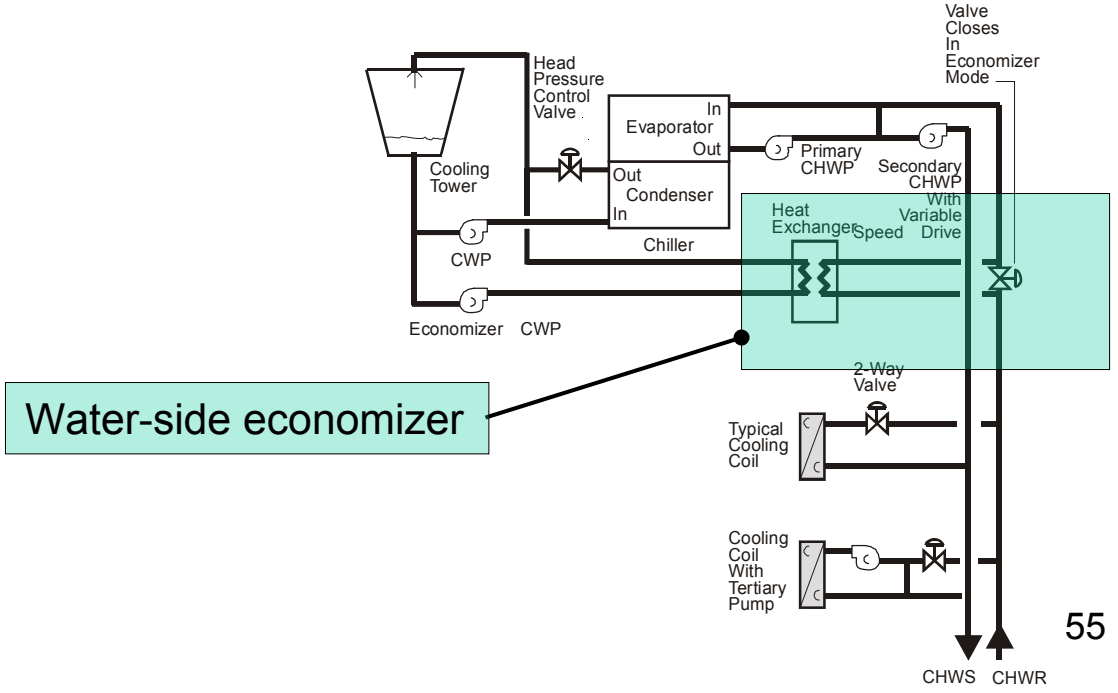
Exceptions:

- Reducing supply airflow to <=50%, or minimum ventilation rate
- Systems < 6.67 tons that can unload at least 50%
- Systems smaller than 3.3 tons
- Systems with specific humidity requirements (museums, surgical suites)
- 75% of reheat/recool energy is site-recovered or site-solar
- Desiccant system with heat recovery (see standard)

Prescriptive HVAC Requirements
Humidification (§6.5.2.4)

Water side economizer required if:

- An economizer is required by 6.5.1
- System has hydronic cooling, and
- Humidification system is designed to maintain inside humidity at >35°F dew-point temperature



Prescriptive HVAC Requirements
Air System Design & Control (§6.5.3)

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- Fan system power limitation:
  - Two methods of compliance
    - By motor nameplate HP (Option 1)
      $hp \leq CFM_S$-0.0011 Constant Volume, or
      $hp \leq CFM_S$-0.0015 Variable Volume
    - By fan system BHP (Option 2)
      $bhp \leq CFM_S$-0.00094+A Constant Volume, or
      $bhp \leq CFM_S$-0.0013+A Variable Volume
    - Fan power credits (A) only apply to BHP (Option 2) method
  - Motor oversizing limitations (§6.5.3.1.2)
    - Motors must be sized according to §6.5.3.1.2
    - Fan hp and bhp must be indicated on the design documents

Prescriptive HVAC Requirements
Air System Design & Control (§6.5.3) cont.

Fan system power credits (A)

$$A = \frac{\sum_i PD_i \times CFMD_i}{4131}$$

- A is the fan power credit in units of horsepower (hp)
- PD_i are the pressure drop credits for components from Table 6.5.3.1.1B (next slide)
- $CFMD_i$ are the airflows (in ft^3/min) for through the applicable device.
- See User's Manual for examples

Prescriptive HVAC Requirements
Air System Design & Control (§6.5.3) cont.

Fan system power credits (A, Table 6.5.3.1.1B)

Table 6.5.3.1B Fan Power Limitation Pressure Drop Adjustment	
Device	**Adjustment**
Credits	
Fully ducted return and/or exhaust air system	0.5 in. w.c.
Return and/or exhaust airflow control device	0.5 in. w.c.
Exhaust filters, scrubbers or other treatment	The pressure drop of the device calculated at fan system design condition
Particulate Filtration Credit: MERV 9 through 12	0.5 in. w.c.
…	…
Deductions	
Fume Hood Exhaust Exception (required if 6.5.3.1.1 Exception [c] is taken)	-1.0 in. w.c.

Prescriptive HVAC Requirements
Air System Design & Control (§6.5.3) cont.

Fan system power exceptions

- Hospital and laboratory systems that utilize flow control devices
- Individual exhaust fans with motor nameplate horsepower ≤ 1hp
- Fume exhaust fans however no credits can be taken from Table 6.5.3.1.1B and -1” w.c. deduction must be applied to the exhaust airflow

Prescriptive HVAC Requirements
VAV Fan Control (§6.5.3.2)

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Motors ≥ 10 hp require one of the following:

- **Variable-speed drive**
- **Vaneaxial fan with variable-pitch blades**
- **Design wattage ≤ 30% at 50% air volume**

Photo courtesy of Greenheck

For systems without DDC zone controls

- **Locate pressure sensor so that control setpoint is ≤1/3 SP_{design}**

For systems with DDC zone controls

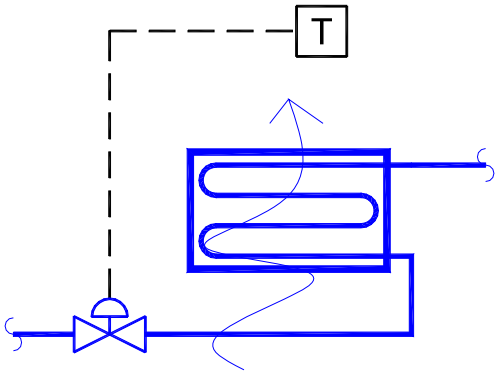
- **Provide pressure reset by zone demand**
- **Sensor placement is not important**

Prescriptive HVAC Requirements
Hydronic System Design & Control (§6.5.4)

- Systems with total pump system hp > 10 shall meet all of the following
  - Hydronic variable flow design (§6.5.4.1)
  - Pump isolation (§6.5.4.2)
  - Chilled and hot water reset (§6.5.4.3)
  - WLHP variable flow (§6.5.4.4)

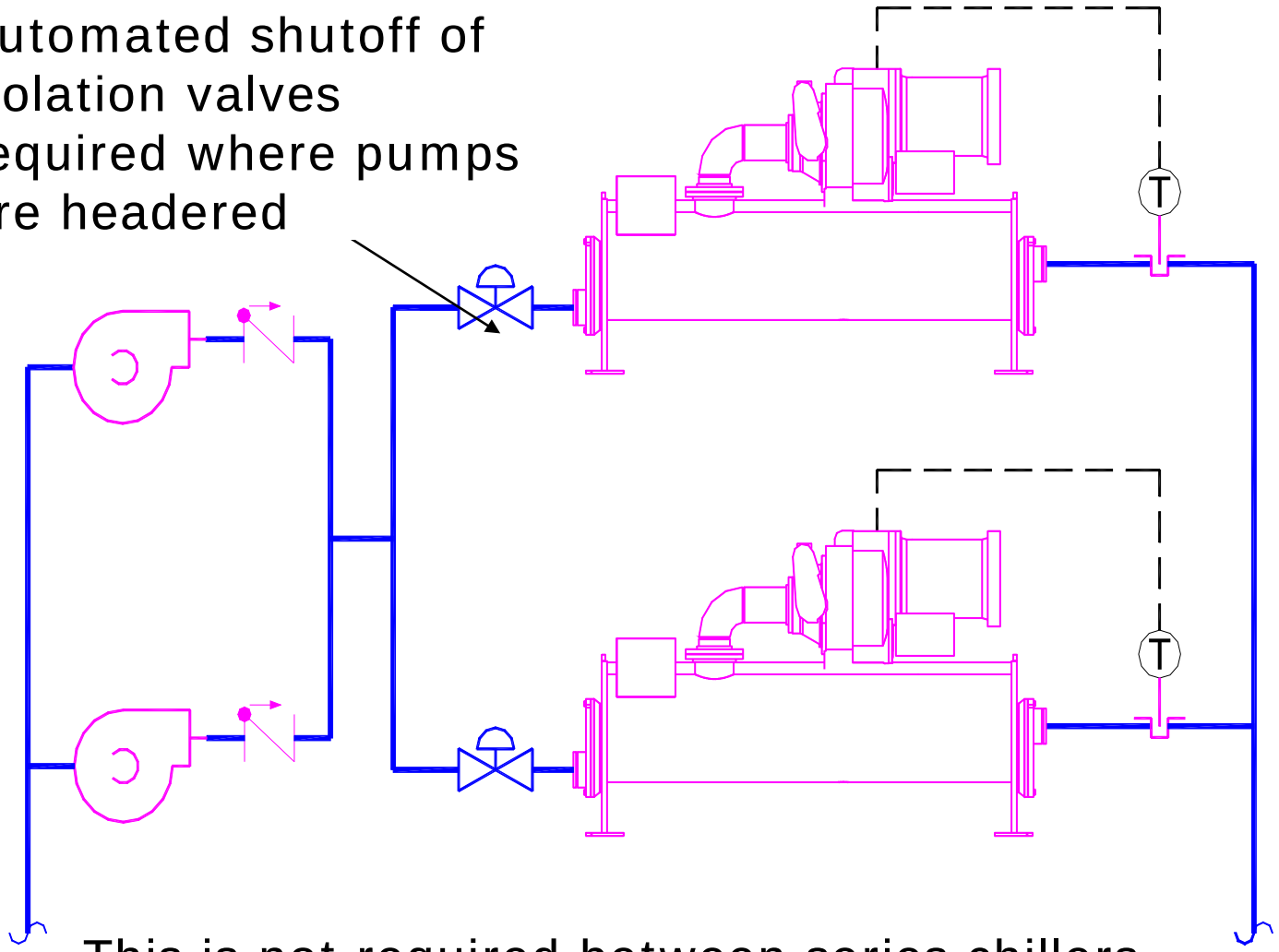
Prescriptive HVAC Requirements
Hydronic Variable Flow (§6.5.4.1)

- Must be able to reduce flow <=50%
- Limit demand of individual variable-flow pumps to 30% of design wattage at 50% flow (e.g., use VSD) where:
  - Pump head > 100 ft, and
  - Motor > 50 hp
- Exceptions:
  - System that have <= 3 control valves
  - Minimum flow required for equipment with <75 hp of pumping



Prescriptive HVAC Requirements
Pump Isolation (§6.5.4.2)

Automated shutoff of isolation valves required where pumps are headered



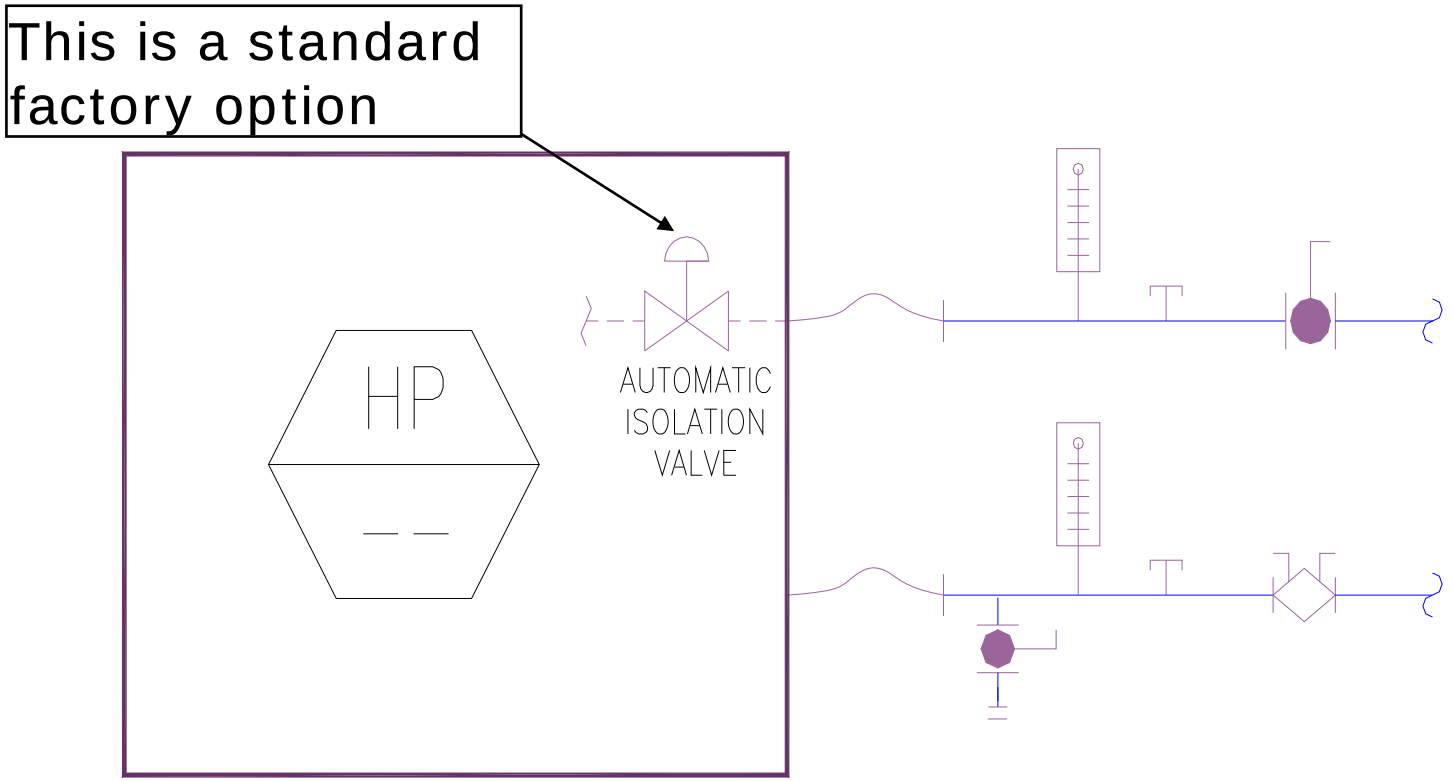
This is not required between series chillers

Prescriptive HVAC Requirements
CHW and HW Water Reset (§6.5.4.3)

- Required where capacity > 300,000 Btu/h unless:
  - Improper operation results
  - System is variable flow per §6.5.4.1

Prescriptive HVAC Requirements
WLHP Isolation (§6.5.4.4)

Two-position shutoff valves are required for each heat pump



Prescriptive HVAC Requirements
Heat-Rejection Equipment (§6.5.5)

Fan speed control

- Motors ≥7.5 hp must be able to operate at 2/3 of full speed or less
- Exceptions:
  - Condenser fans serving multiple circuits or flooded condensers
  - Installations in climate zones 1 and 2
  - Up to 1/3 of the fans on a multiple-fan application (if lead fans meet speed control requirement)

Prescriptive HVAC Requirements
Airside Energy Recovery (§6.5.6.1)

- Required if:
  - Supply air capacity ≥ 5,000 cfm
  - Minimum outdoor air ≥ 70%
- Recovery system effectiveness ≥ 50%
- Exceptions (9)
  - Labs, toxic exhaust, etc.
  - Largest exhaust < 75% outdoor airflow
  - …

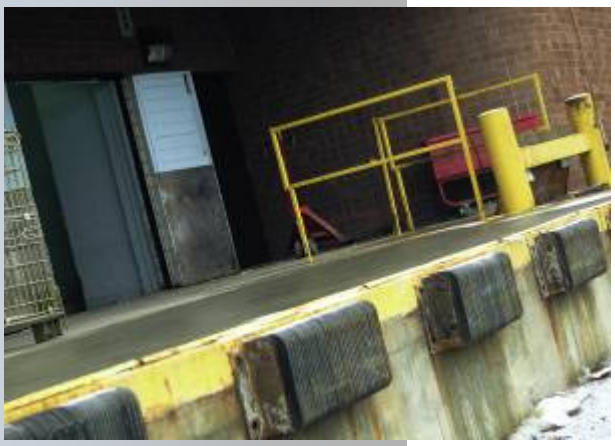
Prescriptive HVAC Requirements
Waterside Energy Recovery (§6.5.6.1)

- Must recover condenser heat for service water heating (SWH) if:
  - Facility operates “24/7” and
  - Heat rejection > 6,000,000 Btu/h and
  - SWH load > 1,000,000 Btu/h
- Where required, meet the smaller of:
  - Recover 60% of rejected condenser heat or
  - Preheat water to 85°F

Prescriptive HVAC Requirements
Exhaust Hoods (§6.5.7)

- Kitchen hoods > 5,000 cfm:
  Provide makeup air ≥ 50% of exhaust air volume
- Fume hoods if total capacity > 15,000 cfm:
  - Capability to reduce exhaust and makeup-air volumes to ≤ 50% or
  - Direct makeup-air supply ≥ 75% of exhaust rate at specified conditions or
  - Heat recovery to precondition makeup air

Prescriptive HVAC Requirements
Radiant Heating (§6.5.8)



- Required for unenclosed spaces
- Exception: Loading docks with air curtains

Prescriptive HVAC Requirements
Hot Gas Bypass Limitation (§6.5.9)

Rated capacity of system	Maximum HGBP capacity, % of total capacity
≤ 240,000 Btu/h	**50%**
> 240,000 Btu/h	**25%**

- Applied in systems with stepped or continuous unloading
- Limitation also pertains to chillers
- Exception: Packaged unitary systems ≤ 90,000 Btu/h (7.5 tons)

Section 7:
Service Water Heating

- Mandatory provisions:
  - Equipment efficiency
  - Piping insulation
  - SWH system controls (temperature, pump operation)
  - Pool heaters and covers
- Prescriptive requirements:
  - Space and water heating
  - Service water heating

More Information?

- Standard 90.1-2007, the User's Manual, and more detailed training opportunities are available from:

www.ashrae.org

- More information on the standard and compliance tools available from:

www.energycodes.gov