Prism ENGINEERING 25 YEARS

saving you energy

ASHRAE 90.1 – 2010

Understanding Code Compliance and Energy Efficiency

Stephen Kooiman, P.Eng., MASc, Mechanical Team Lead

CIPHEX West 2016

November 2, 2016

Introductions

Prism ENGINEERING 25 YEARS

saving you energy

Prism Engineering provides consulting services to address technical, behavioural and organizational aspects of Energy Management

We design and implement cost effective approaches to address comfort, efficiency and reliability.

Our Work By the Numbers

We've had the privilege of serving our clients since 1990:

- **1,100** energy audits
- **2,500** buildings modernized
- **100 million sq ft** assessed
- **15,000** energy accounts analyzed
- **8,000** workshop attendees
- **$30 million** in annual savings identified

Your Presenter

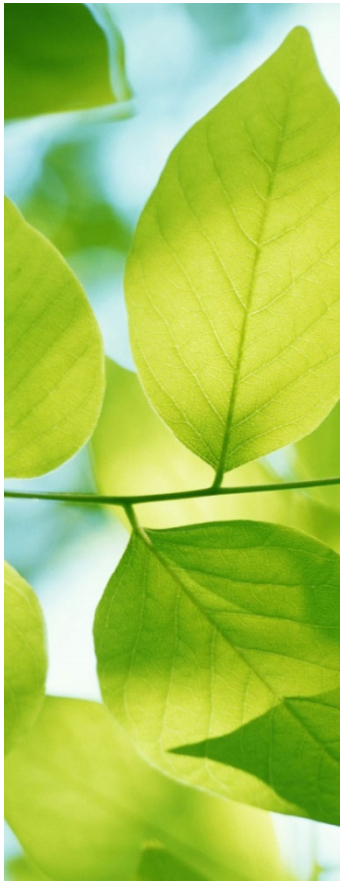
Stephen Kooiman, P.Eng, M.A.Sc.

- Past President of the **ASHRAE BC Chapter**
- Active member of **CHES** and **ASPE**
- Mechanical Team Lead at Prism Engineering
- M.A.Sc. in thermal fluid dynamics
- Specializes in energy upgrades, renovations and capital renewal projects for HVAC , plumbing systems, controls in the Institutional, Healthcare Commercial and Industrial sectors

Before we get Started

- Who is in the room
  - Architects
  - Engineers
  - Contractors
  - Building Operators
  - Property or Facility Managers
  - Building Owners
- Familiarity with ASHRAE 90.1

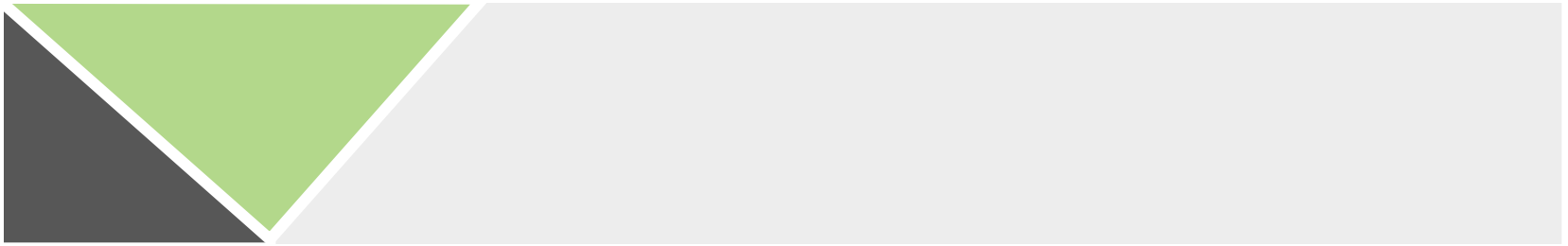
Agenda



1. **Introduction to the Standard**
2. **Administration and Enforcement**
3. **Core Components**
   i. Overview (Section 4)
   ii. Heating Ventilation and Air Conditioning (Section 6)
   iii. Service Water Heating (Section 7)
   iv. Energy Cost Budget Method (Section 11)
4. **Review**

Q&A Throughout

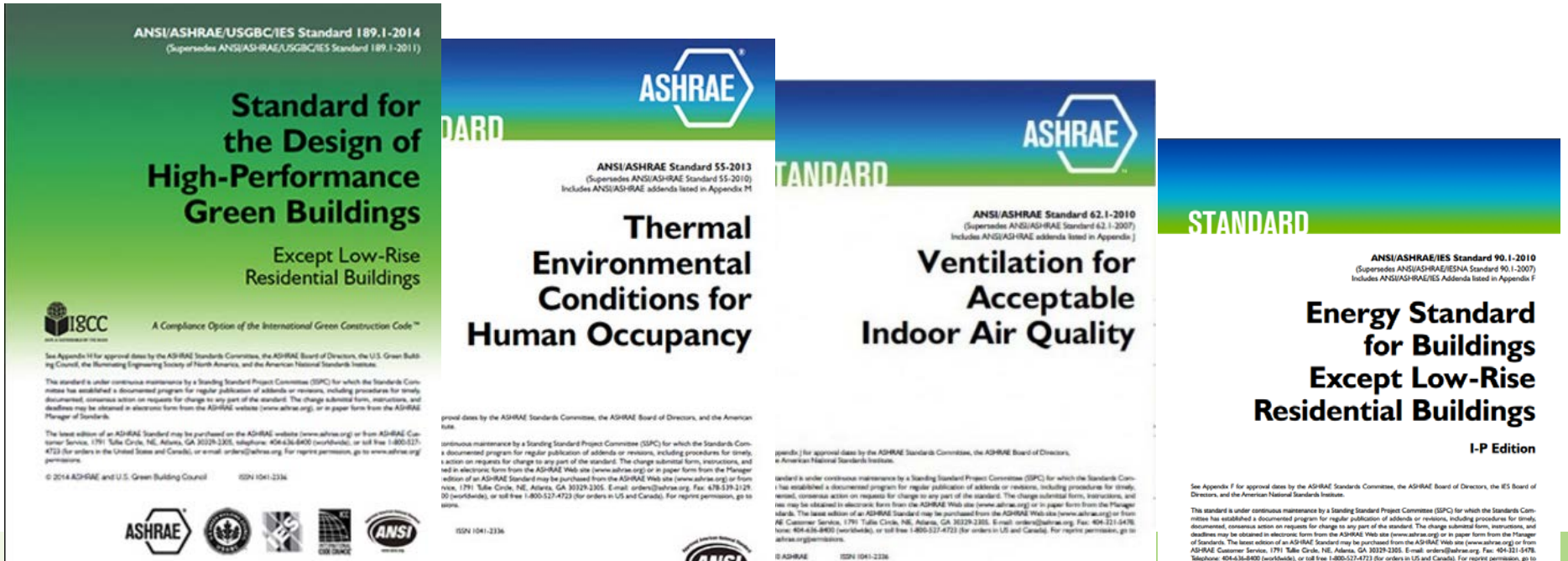
PURPOSE OF ASHRAE STANDARDS



Introduction to ASHRAE

American Society of Heating, Refrigeration, and Air-Conditioning Engineers

- To advance the arts and sciences of heating, ventilation, air conditioning and refrigeration to serve humanity and promote a sustainable world.



ASHRAE Referred to in Codes

It's the "Reference" Association:

6.2.1.1. Good Engineering Practice

(See Appendix A.)

1) Heating, ventilating and air-conditioning systems, including mechanical refrige
not limited to,

a) the ASHRAE Handbooks and Standards,

b) the HRAI Digest,

c) the Hydronics Institute Manuals,

d) the NFPA Standards,

e) the SMACNA Manuals,

f) the Industrial Ventilation Manual published by the ACGIH,

g) CAN/CSA-B214, "Installation Code for Hydronic Heating Systems,"

h) CAN/CSA-Z317.2, "Special Requirements for Heating, Ventilation, ar

i) EPA 625/R-92/016, "Radon Prevention in the Design and Constructi

Code vs. Standards

Codes, Standards and Guidelines

What is a Code?

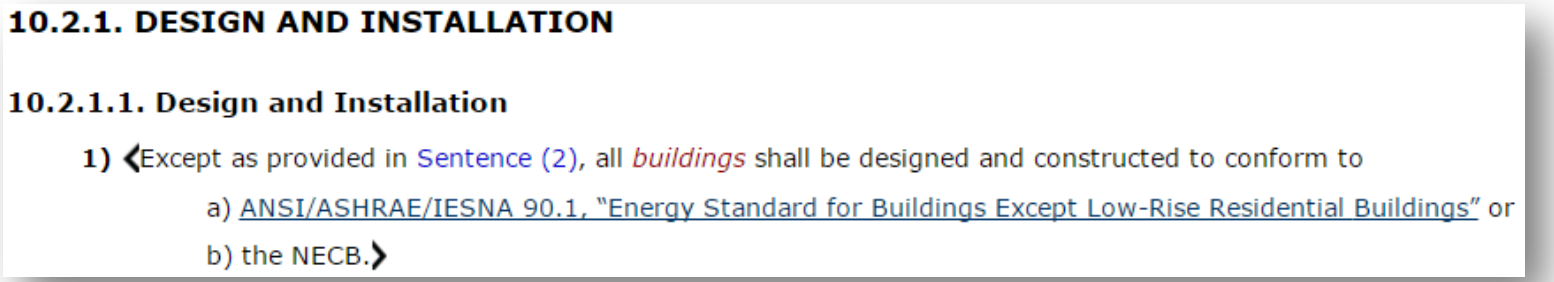
- Least Safe…
- Least Strong…
- Least energy efficient … Building allowed by Law

ASHRAE 90.1

Introduction to ASHRAE 90.1

Why is 90.1 - 2010 important

- Part 10 — Energy and Water Efficiency



10.2.1. DESIGN AND INSTALLATION

10.2.1.1. Design and Installation

1) ❮Except as provided in Sentence (2), all *buildings* shall be designed and constructed to conform to

a) ANSI/ASHRAE/IESNA 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings" or

b) the NECB.❯

Adoption of 90.1

- Vancouver:
  - v2001 in 2004
  - v2007 in 2009
  - v2010 in 2013
  - v2013 in ???
- BC:
  - v2004 in 2008
  - v2010 in 2013

Purpose

ASHRAE 90.1 Purpose:

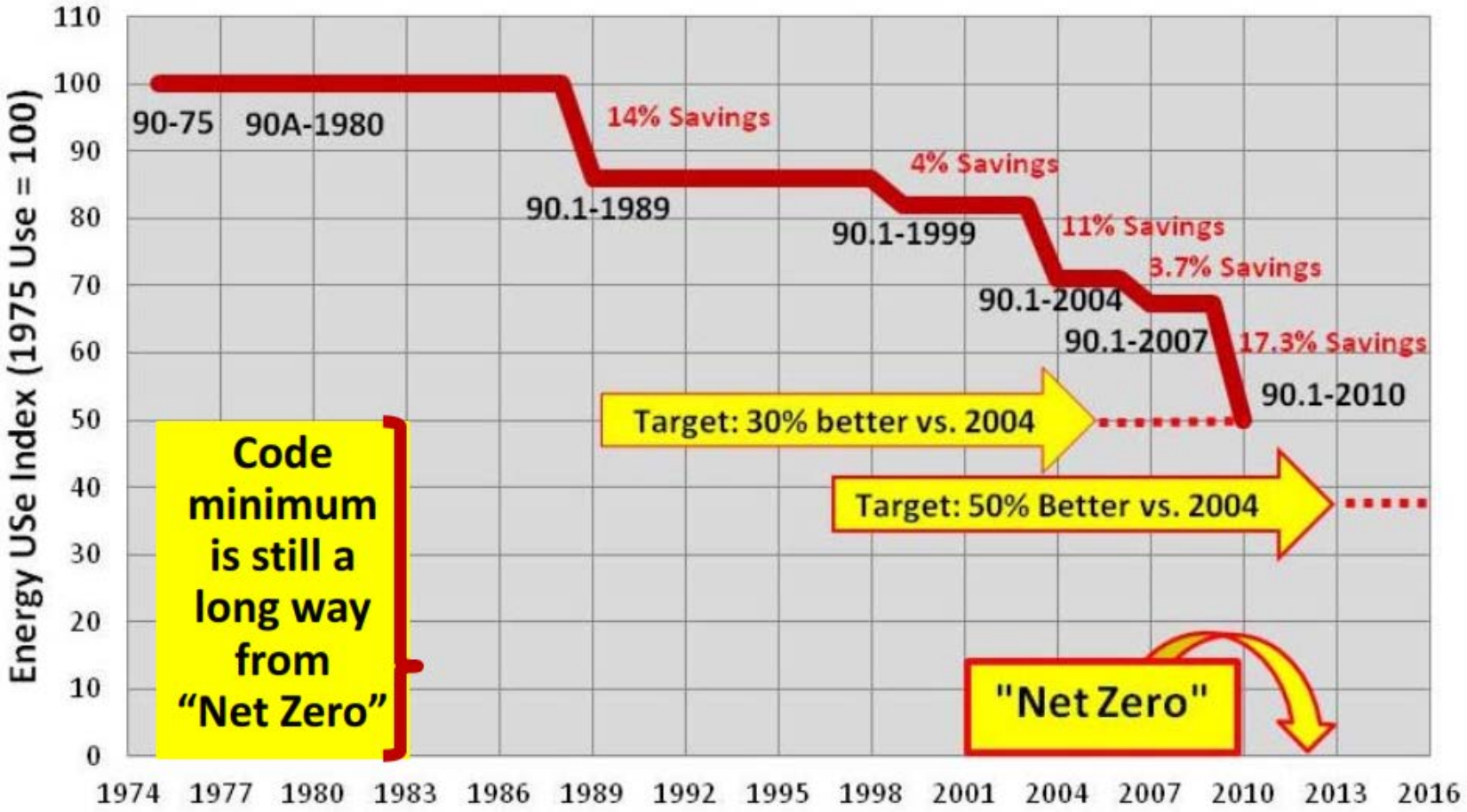
- To establish the minimum energy efficiency requirements of buildings and building systems

Application:

- to all buildings except low-rise residential
- New Buildings, Expansions, Renovations, Capital Equipment Upgrades

On "Continuous Maintenance" since 2001

Energy Impact of Ashrae 90.1

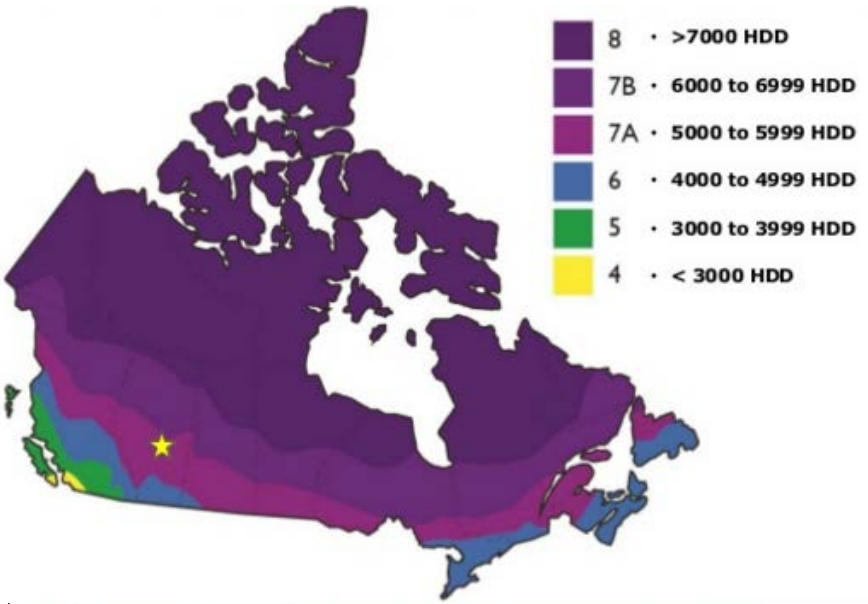


Climate Zones

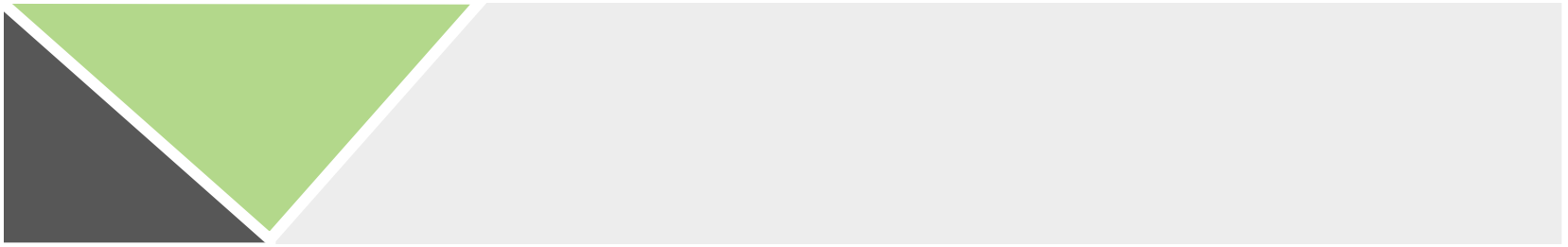
- Lower Mainland: 4C
- Vancouver: 5C

ASHRAE 90.1-2010 Table B-4 *International Climate Zone Definitions*

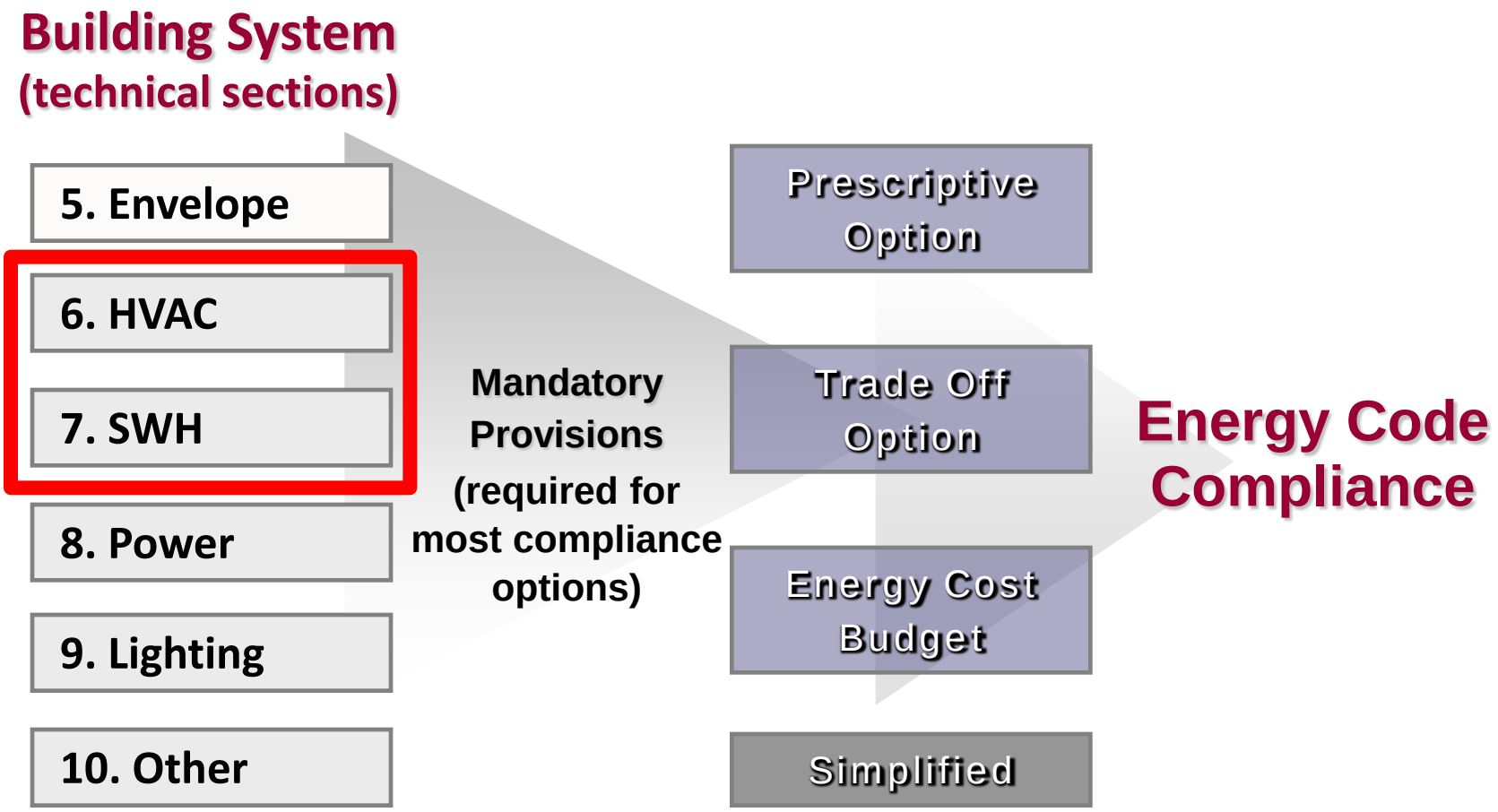
International Climate Zone Definitions Zone Number	Zone Name	Thermal Criteria (I-P Units)	Thermal Criteria (SI Units)
1A and 1B	Very Hot – Humid (1A) Dry (1B)	9000 < CDD50°F	5000 < CDD10ºC
2A and 2B	Hot-Humid (2A) Dry (2B)	6300 < CDD50°F ≤ 9000	3500 < CDD10ºC ≤ 5000
3A and 3B	Warm – Humid (3A) Dry (3B)	4500 < CDD50°F ≤ 6300	2500 < CDD10ºC < 3500
3C	Warm – Marine (3C)	CDD50°F ≤ 4500 AND HDD65°F ≤ 3600	CDD10ºC ≤ 2500 AND HDD18ºC ≤ 2000
4A and 4B	Mixed-Humid (4A) Dry (4B)	CDD50°F ≤ 4500 AND 3600 < HDD65°F ≤ 5400	CDD10ºC ≤ 2500 AND HDD18ºC ≤ 3000
4C	Mixed – Marine (4C)	3600 < HDD65°F ≤ 5400	2000 < HDD18ºC ≤ 3000
5A, 5B, and 5C	Cool-Humid (5A) Dry (5B) Marine (5C)	5400 < HDD65°F ≤ 7200	3000 < HDD18ºC ≤ 4000
6A and 6B	Cold – Humid (6A) Dry (6B)	7200 < HDD65°F ≤ 9000	4000 < HDD18ºC ≤ 5000
7	Very Cold	9000 < HDD65°F ≤ 12600	5000 < HDD18ºC ≤ 7000
8	Subarctic	12600 < HDD65°F	7000 < HDD18ºC



ADMINISTRATION & ENFORCEMENT



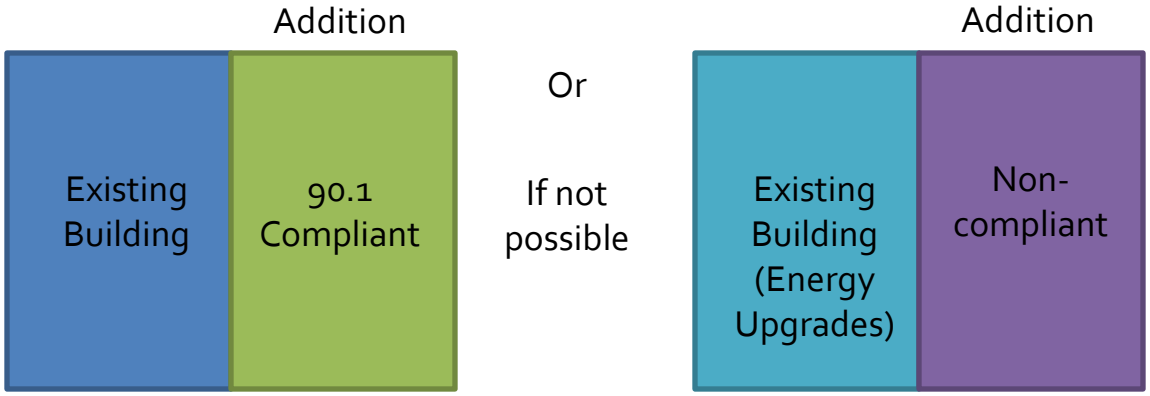
90.1 Compliance



Where 90.1 Applies?

Section
4.1.1.1 & 4.1.1.2

- **New Buildings**
  - Comply with Sections 5-10 or 11
- **Additions**
  - Comply with Sections 5-10 or 11*

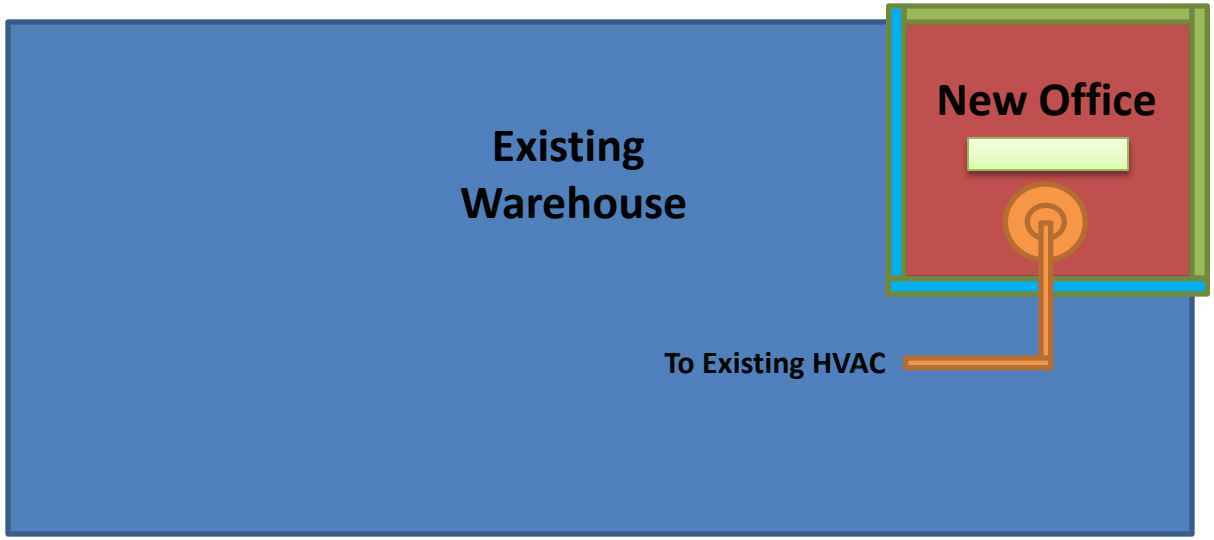


*Exception © climate zone dependent

Where 90.1 Applies?

Section
4.1.1.4 & 4.1.1.5

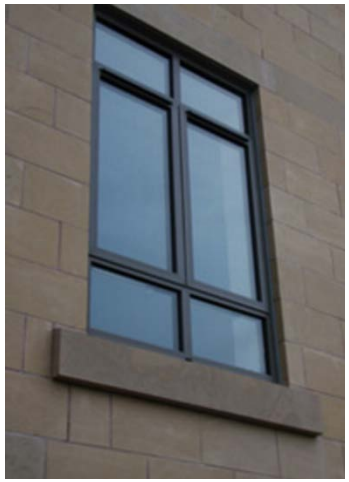
- Changing Space Occupancy
  - Entire space shall comply as if new construction



Where 90.1 Applies?

Section
4.1.1.4 & 4.1.1.5

- **Alterations of Existing Building**
  - Components shall comply with Sections 5-10
  - Overall comprehensive design shall not exceed energy use for modelled standard
    - Exception for "Extensive revisions to other systems"



Alterations to Existing Mechanical Systems

Section
4.2.1.3.b
6.1.1.3 & 7.1.1.3

- **The following must be in compliance:**
  - New HVAC equipment
  - Service water heating equipment
  - New piping & insulation
  - New ductwork and insulation

Section
4.2.2

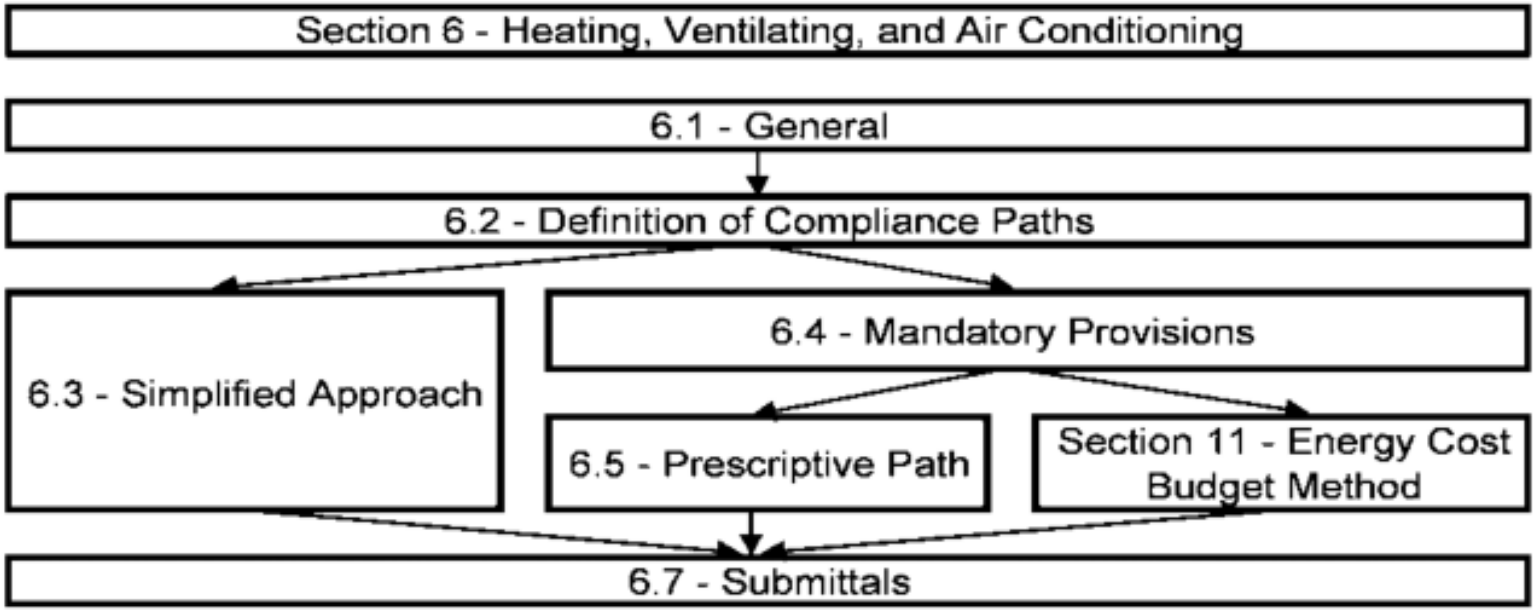
Compliance Documentation

- Shall be made available to the building official to demonstrate compliance
  - Including calculations, worksheets, forms, vendor literature
- O&M manuals and record drawings within 90 days

HVAC

Ashrae 90.1 Section 6 HVAC

- Conformance Paths



6.3 Simplified Approach

- **Simplified method applies for:**
  - For Buildings 1 or 2 stories
  - Total area of <25,000 sqft
- **Must meet 17 requirements**
  - a) **Thermal zoning** – Units must serve a single zone
  - b) **Variable flow** per 6.4.3.1
  - c & e) **Cooling and heating equipment** efficiencies
  - d) **Air side economizers** for units >54 MBH cooling capacity (6.5.1)

6.3 Simplified Approach

f) Energy recovery efficiencies (6.5.6.1)

g) Controls:

- g) Manual changeover or dual setpoint thermostat
- i) No simultaneous heating & cooling for humidity control
- j) HVAC controlled on occupancy
- o) Interlock thermostats for units serving the same zone
- p) Optimum start (systems > 10,000 cfm)
- q) Demand control ventilation

h) Heat pump secondary heating controls

k & l) Piping & duct insulation

6.3 Simplified Approach

m) Air balancing

n) Outdoor air intake & exhaust (6.4.3.4)

Sample from 90.1 - 2010

6.4.3.4.2 Shutoff Damper Controls. All *outdoor air* intake and exhaust *systems* shall be equipped with motorized dampers that will automatically shut when the *systems* or *spaces* served are not in use. *Ventilation outdoor air* and exhaust/relief dampers shall be capable of automatically shutting off during preoccupancy building *warm-up*, *cool down*, and *setback,* except when *ventilation* reduces *energy* costs or when *ventilation* must be supplied to meet code requirements.

Exceptions:

a. Backdraft gravity (nonmotorized) dampers are acceptable for exhaust and relief in buildings less than three stories in height and for *ventilation* air intakes and exhaust and relief dampers in buildings of any height located in climate zones 1, 2, and 3. Backdraft dampers for *ventilation* air intakes must be protected from direct exposure to wind.

b. Backdraft gravity (nonmotorized) dampers are acceptable in *systems* with a design *outdoor air* intake or exhaust capacity of 300 cfm or less.

c. Dampers are not required in *ventilation* or exhaust *systems* serving *unconditioned spaces*.

d. Dampers are not required in exhaust *systems* serving Type 1 kitchen exhaust hoods.

6.4 Mandatory Provisions

A. Equipment Efficiencies
B. Calculations
C. Controls
D. HVAC Construction and Insulation

A. Equipment Efficiencies

Section
6.4.1

- Tables:
  - Table 6.8.1A – Air conditioners and condensing units
  - Table 6.8.1B – Heat pumps
  - Table 6.8.1C – Water chillers
  - Table 6.8.1D – Packaged terminal AC/HP
  - Table 6.8.1E – Furnaces, duct furnaces, and unit heaters
  - Table 6.8.1F – Boilers
  - Table 6.8.1G – Heat rejection equipment
  - Table 6.8.1H – Heat transfer equipment (liquid-to-liquid HX)
  - Table 6.8.1 I – Variable Refrigerant Flow (VRF) A.C.
  - Table 6.8.1J – VRF air-to-air & applied heat pumps
  - Table 6.8.1K – AC serving computer rooms

Sample Table

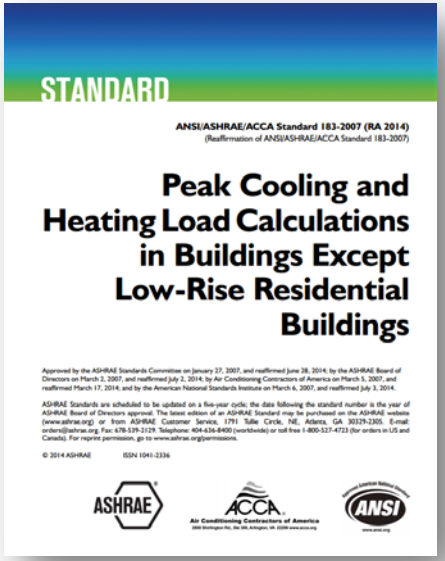
TABLE 6.8.1A Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency[a]	Test Procedure[b]
Air conditioners, air cooled	<65,000 Btu/h[c]	All	Split system	13.0 SEER	AHRI 210/240
			Single package	13.0 SEER	
Through-the-wall (air cooled)	≤30,000 Btu/h[c]	All	Split system	12.0 SEER	
			Single package	12.0 SEER	
Air conditioners, air cooled	≥65,000 Btu/h and <135,000 Btu/h	Electric resistance (or none)	Split system and single package	11.2 EER 11.4 IEER	AHRI 340/360
		All other	Split system and single package	11.0 EER 11.2 IEER	
	≥135,000 Btu/h and <240,000 Btu/h	Electric resistance (or none)	Split system and single package	11.0 EER 11.2 IEER	
		All other	Split system and single package	10.8 EER 11.0 IEER	
	≥240,000 Btu/h and <760,000 Btu/h	Electric resistance (or none)	Split system and single package	10.0 EER 10.1 IEER	
		All other	Split system and single package	9.8 EER 9.9 IEER	

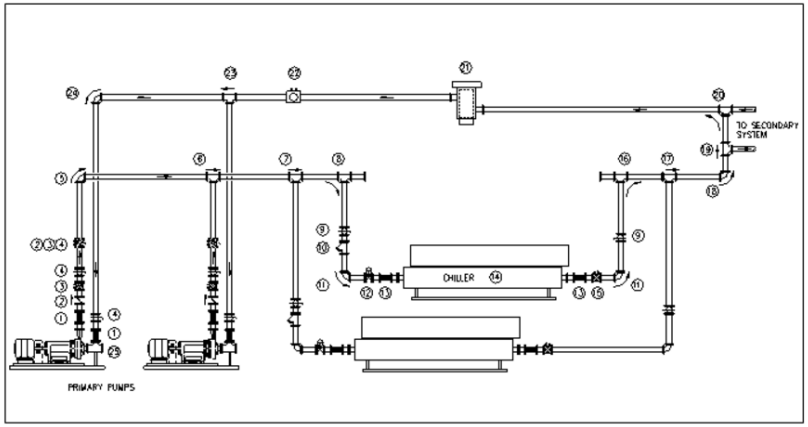
B. Calculations

Section
6.4.2

- Load Calculations
  - In accordance with ASHRAE 183
- Pump Head
  - Determined in accordance with generally accepted engineering standards



PUMP HEAD CALC. DIAGRAM



PRIMARY PUMPS

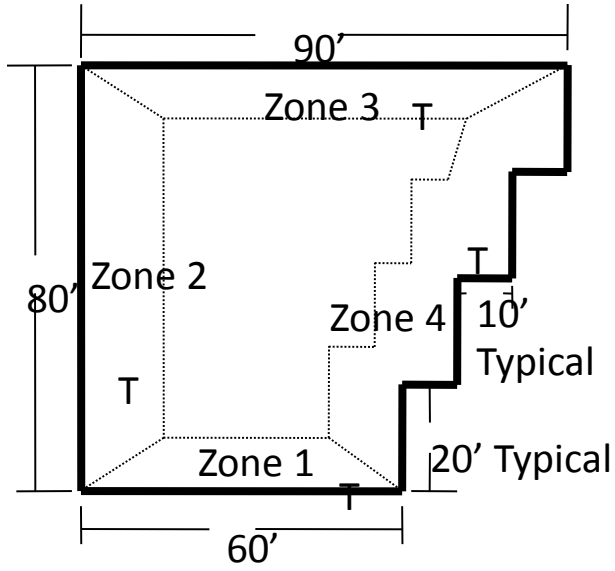
C. Controls

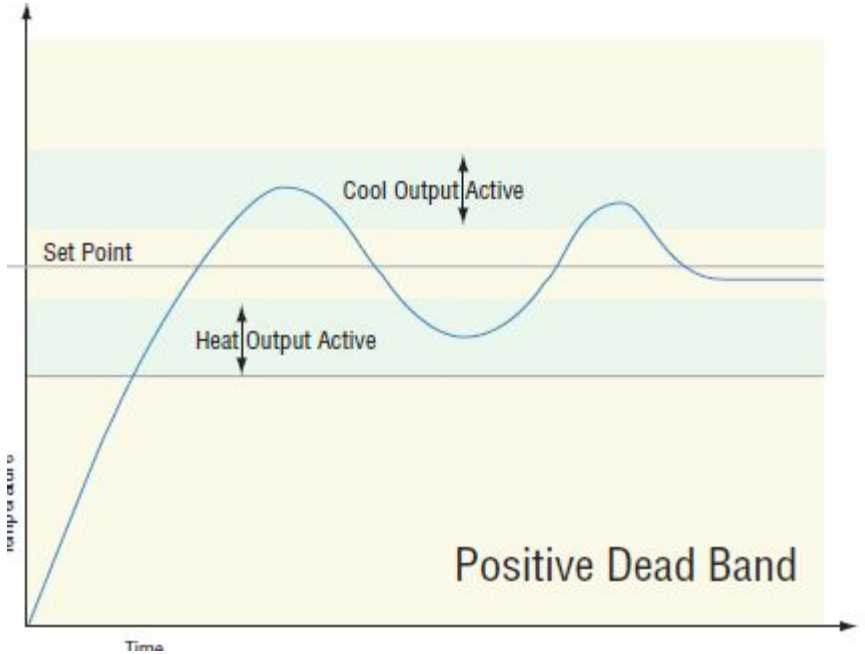
Section
6.4.3

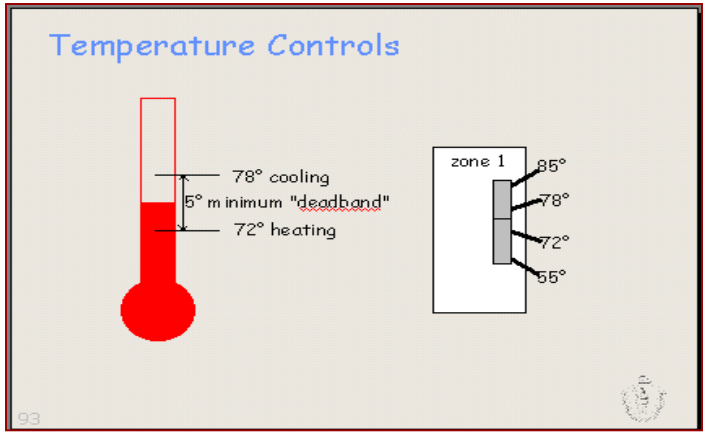
- Sections:
  - Zone Thermostat
  - Off Hours
  - Ventilation Systems

C. Zone Thermostat Controls

- Zone Thermostat controls
  - Required for each zone
  - Dead band controls of at least 5°F







C. Off Hours Controls

Section 6.4.3.3

- Automatic shutdown
- Setback controls
- Optimum start
- Zone isolation

C. Ventilation Controls

Section 6.4.3.4

- O/A intake & exhaust systems

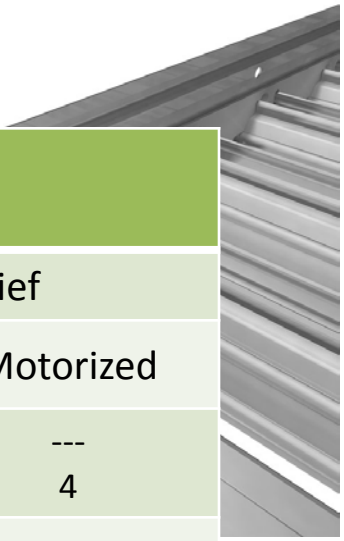


TABLE 6.4.3.4.3 Maximum Damper Leakage (cfm per ft^2 at 1" w.g.)

Climate Zone	Ventilation Air Intake		Exhaust/Relief	
	Non-motorized	Motorized	Non-motorized	Motorized
1,2 Any height	--- 20	--- 4	--- 20	--- 4
3 Any height	--- 20	--- 10	--- 20	--- 10
4, 5b, 5c < 3 stories ≥ 3 stories	--- Not allowed Not allowed	--- 10 10	--- 20 Not allowed	--- 10 10
5a, 6, 7, 8 < 3 stories ≥ 3 stories	--- Not allowed Not allowed	--- 4 4	--- 20 Not allowed	--- 4 4

C. Ventilation Controls

Sections
6.4.3.5, 6.4.3.6, 6.4.3.7, 6.4.3.8, 6.4.3.10

- Automatic controls for Fans > 0.75 HP
- Heat Pump aux. heating controls
- Humidification and dehumidification
- Freeze protection and snow melting systems

C. Demand Control Ventilation

Section 6.4.3.9

- Demand control ventilation (DCV*) required for spaces > 500 ft^2 and > 40 people / 1000 ft^2 that are served by any of these:
  - Air-side economizer, or
  - Auto modulation of O.A. damper, or
  - Design O.A. air flow > 3000 cfm

D. HVAC Construction and Insulation

Section 6.4.4.1.2

- Duct Insulation: per 6.8.2A & B

TABLE 6.8.2B Minimum Duct Insulation R-Value,[a] Combined Heating and Cooling Supply Ducts and Return Ducts

Climate Zone	Duct Location						
	Exterior	Ventilated Attic	Unvented Attic Above Insulated Ceiling	Unvented Attic with Roof Insulation[a]	Unconditioned Space[b]	Indirectly Conditioned Space[c]	Buried
				Supply Ducts			
1	R-6	R-6	R-8	R-3.5	R-3.5	none	R-3.5
2	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
3	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
4	R-6	R-6	R-6	R-3.5	R-3.5	none	R-3.5
5	R-6	R-6	R-6	R-1.9	R-3.5	none	R-3.5
6	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
7	R-8	R-6	R-6	R-1.9	R-3.5	none	R-3.5
8	R-8	R-8	R-8	R-1.9	R-6	none	R-6
				Return Ducts			
1 to 8	R-3.5	R-3.5	R-3.5	none	none	none	none

[a] Insulation R-values, measured in $(h \cdot ft^2 \cdot °F)/Btu$, are for the insulation as installed and do not include film resistance. The required minimum thicknesses do not consider water vapor transmission and possible surface condensation. Where exterior *walls* are used as *plenum walls*, *wall* insulation shall be as required by the most restrictive condition of Section 6.4.4.2 or Section 5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a *mean temperature* of 75°F at the installed thickness.

[b] Includes crawlspaces, both ventilated and nonventilated.

[c] Includes return air *plenums* with or without exposed *roofs* above.

D. Insulation

Section 6.4.4.1.2

- Piping Insulation: Per 6.8.3A & B

TABLE 6.8.3A Minimum Pipe Insulation Thickness
Heating and Hot Water Systems[a,b,c,d]
(Steam, Steam Condensate, Hot Water Heating and Domestic Water Systems)

Fluid Operating Temperature Range (°F) and Usage	Insulation Conductivity		Nominal Pipe or Tube Size (in)				
	Conductivity Btu·in./(h·ft²·°F)	Mean Rating Temperature, °F	<1	1 to <1-1/2	1-1/2 to <4	4 to <8	≥8
			Insulation Thickness (in)				
>350 °F	0.32–0.34	250	4.5	5.0	5.0	5.0	5.0
251°F–350°F	0.29–0.32	200	3.0	4.0	4.5	4.5	4.5
201°F–250°F	0.27–0.30	150	2.5	2.5	2.5	3.0	3.0
141°F–200°F	0.25–0.29	125	1.5	1.5	2.0	2.0	2.0
105°F–140°F	0.22–0.28	100	1.0	1.0	1.5	1.5	1.5

a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: $T = r\{(1 + t/r)^{K/k} - 1\}$ where T = minimum insulation thickness (in.), r = actual outside radius of pipe (in.), t = insulation thickness listed in this table for applicable fluid temperature and pipe size, K = conductivity of alternate material at mean rating temperature indicated for the applicable fluid temperature (Btu·in./h·ft2·°F); and k = the upper value of the conductivity range listed in this table for the applicable fluid temperature.

b These thicknesses are based on energy *efficiency* considerations only. Additional insulation is sometimes required relative to safety issues/surface temperature.

c For piping smaller than 1½" and located in partitions within *conditioned spaces*, reduction of these thicknesses by 1" shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 1".

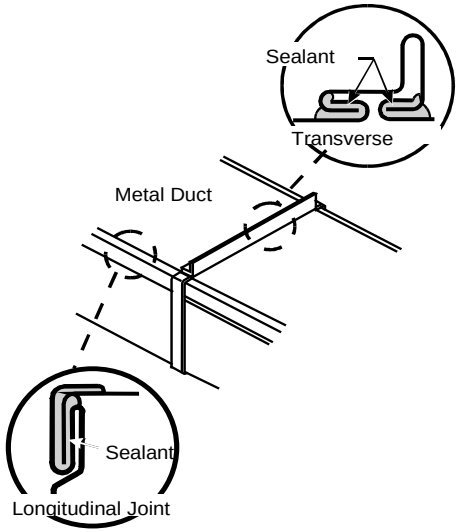
d For direct-buried heating and hot water *system* piping, reduction of these thicknesses by 1.5" shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 1".

e The table is based on steel pipe. Non-metallic pipes schedule 80 thickness or less shall use the table values. For other non-metallic pipes having *thermal resistance* greater than that of steel pipe, reduced insulation thicknesses are permitted if documentation is provided showing that the pipe with the proposed insulation has no more heat transfer per foot than a steel pipe of the same size with the insulation thickness shown in the table.

D. Ductwork Leakage & Testing

Section 6.4.4.1.2

- Ductwork and all plenums with pressure class ratings shall include sealing of all transverse joints, longitudinal seams, and duct wall penetrations.
- Meet requirements of leakage tests.
- Duct tape or other pressure-sensitive tape shall not be used as the primary sealant unless certified.



D. Ductwork Leakage & Testing

Section
6.4.4.2.2

- Ductwork operating at static pressures exceeding 3 in wc and all outdoor ductwork shall be leak tested

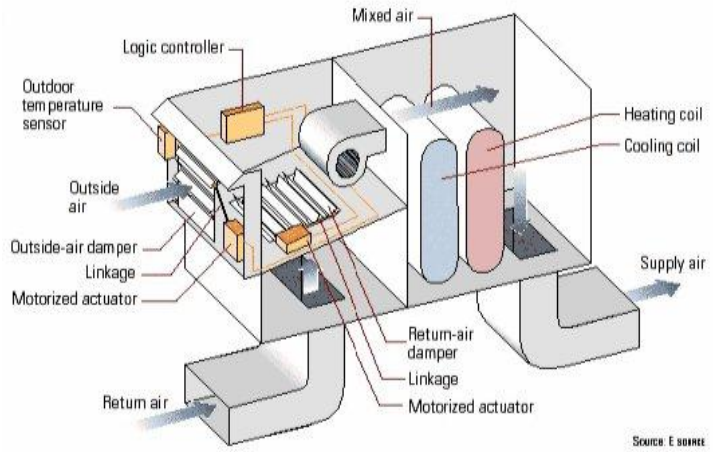
6.5 Prescriptive Path

A. Economizers
B. Simultaneous Heating and Cooling
C. Air System Design
D. Hydronic System Design
E. Heat Rejection Equipment
F. Energy Recovery
G. Exhaust Systems
H. Radiant Heating and Hot Gas Bypass

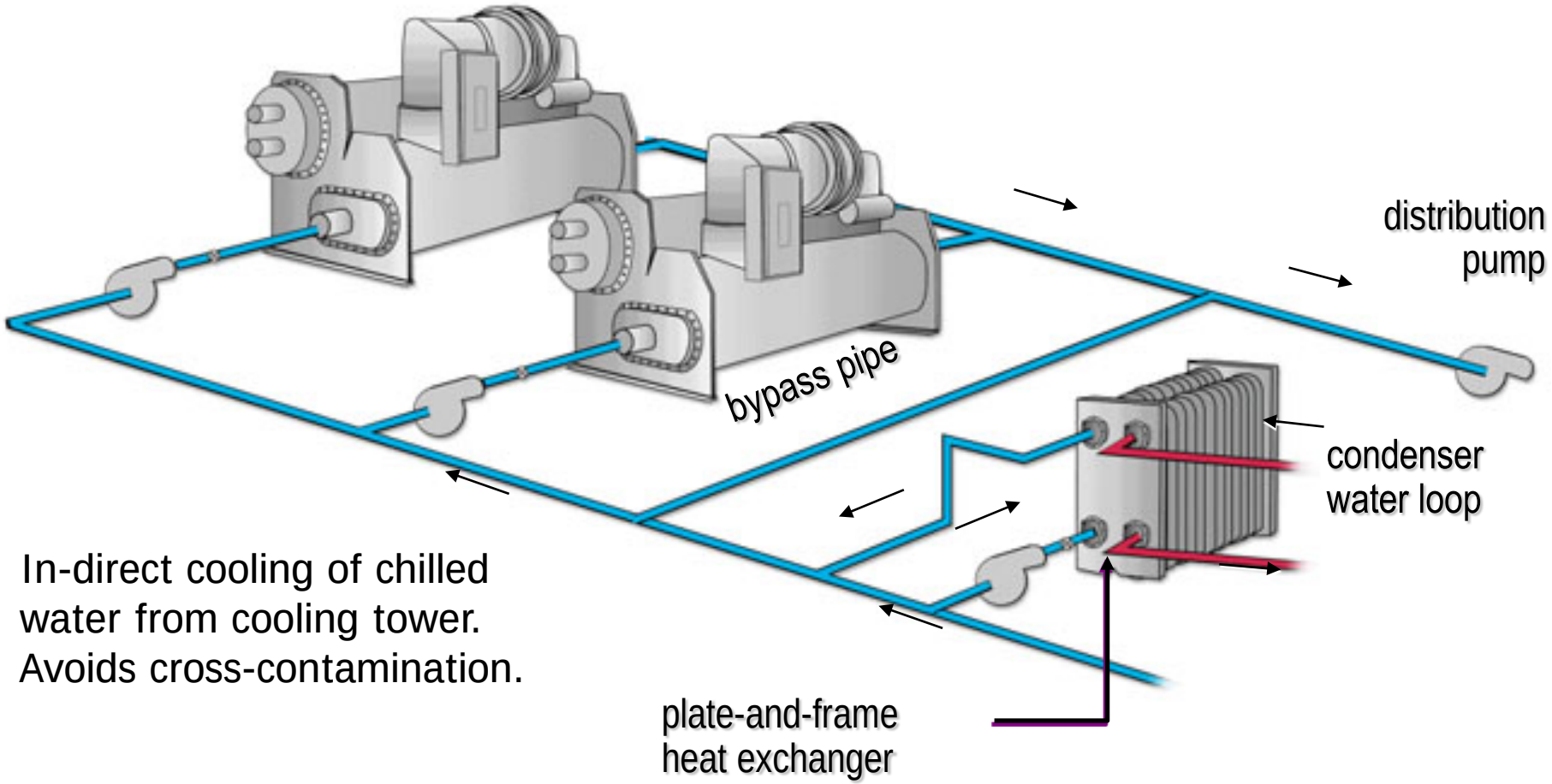
A. Economizers

Section
6.5.1

- **Economizers**
  - Cooling systems shall have air or water economizer
  - Air Side:
    - Sequencing with cooling equipment, High limit shut off
    - Dampers meeting section 6.4.3, c/w relief dampers
  - Water Side:
    - 100% cooling load at 40F, Maximum pressure drop of 15', Integrated controls



Waterside Economizer
Plate-and-Frame Heat Exchanger



In-direct cooling of chilled water from cooling tower. Avoids cross-contamination.

B. Simultaneous Htg/Clg

Section 6.5.2

- **Simultaneous Heating and Cooling Limitations**
  - Zone controls preventing reheating/re-cooling
  - Hydronic controls eliminating mixing HW & CHW
- 3 Pipe hydronic system not permitted
- Heat pump water loop
  - Dead band of 20F b/w heating and cooling
- Humidity controls to prevent reheat

C. Air System Design

Section 6.5.3.1

- **Fan system Power Limitations**
  - Fan motor operation limits

TABLE 6.5.3.1.1A Fan Power Limitation[a]

	Limit	Constant Volume	Variable Volume
Option 1: Fan System Motor Nameplate hp	Allowable Nameplate Motor hp	hp ≤ $CFM_S \cdot 0.0011$	hp ≤ $CFM_S \cdot 0.0015$
Option 2: Fan System bhp	Allowable Fan System bhp	bhp ≤ $CFM_S \cdot 0.00094 + A$	bhp ≤ $CFM_S \cdot 0.0013 + A$

[a] where

CFM_S = the maximum design supply airflow rate to *conditioned spaces* served by the *system* in cubic feet per minute
hp = the maximum combined motor *nameplate horsepower*
bhp = the maximum combined *fan brake horsepower*
A = sum of ($PD \times CFM_D$/4131)

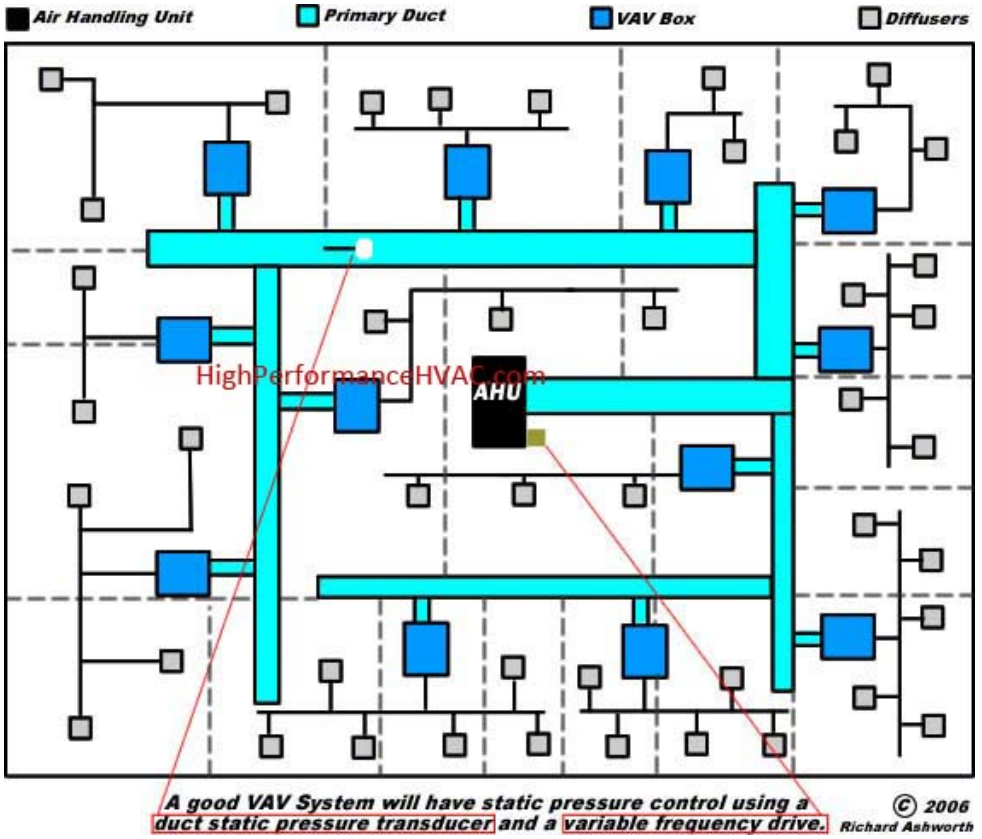
where

PD = each applicable pressure drop adjustment from Table 6.5.3.1.1B in in. w.c.
L/S = the design airflow through each applicable device from Table 6.5.3.1.1B in cubic feet per minute

C. Air System Design

Section 6.5.3.2

- **VAV Fan Control**
  - Fans 10HP and larger require variable speed capabilities
  - Sensor located at a maximum of 1/3rd the design static pressure
  - Setpoint reset



D. Hydronic System Design

Section
6.5.4.1

- Pumps > 10 HP require variable speed operation
- Temperature Reset on Chilled and Hot water systems > 300MBH
- Flow isolation for offline chillers and boilers

D. Hydronic System Design

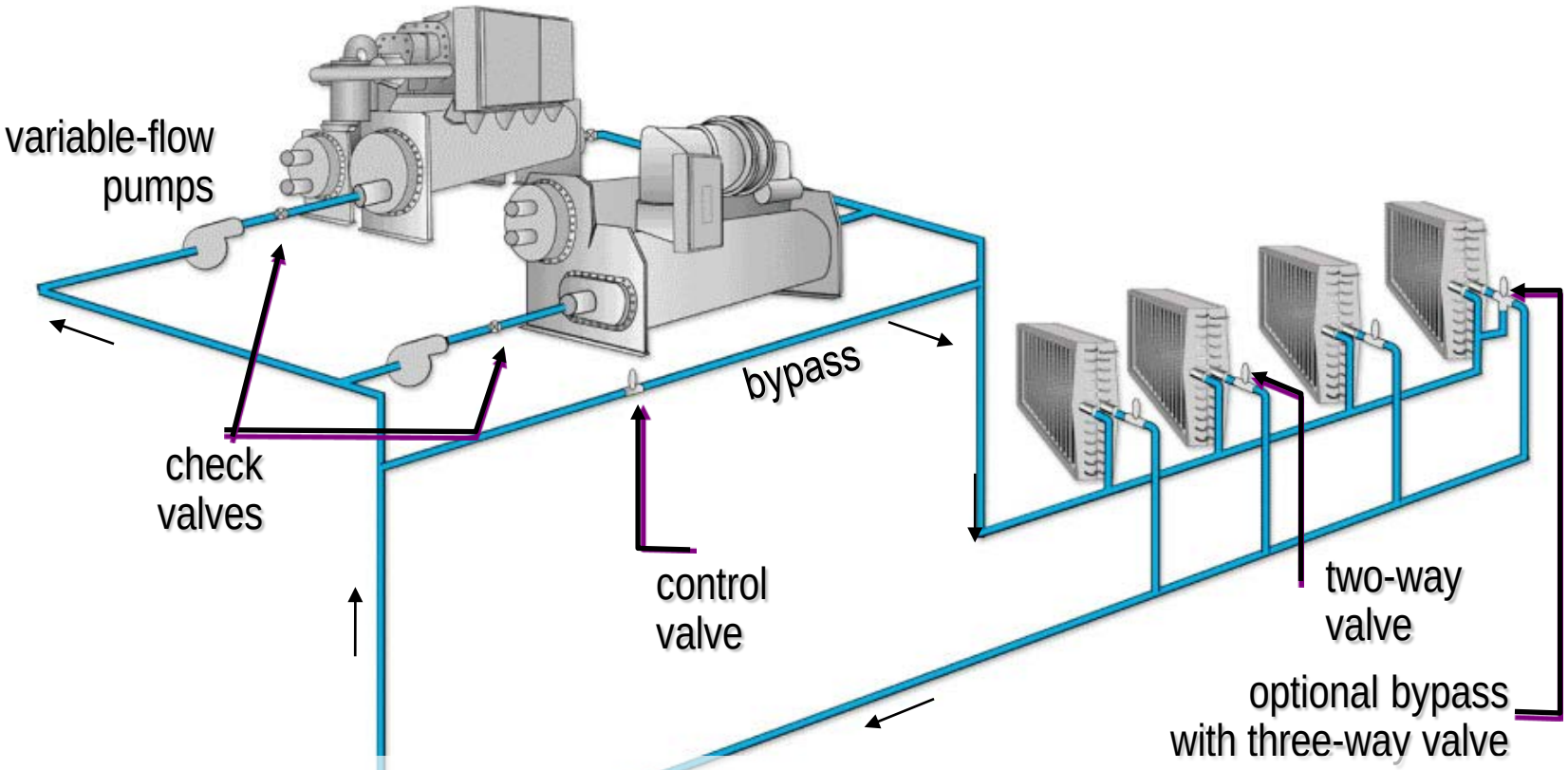
Section 6.5.4.1

- CHW piping sizing based on pump operating hours per year

TABLE 6.5.4.5 Piping System Design Maximum Flow Rate in GPM

Operating Hours/Year	≤2000 Hours/Year		>2000 and ≤ 4400 Hours/Year		>4400 Hours/Year	
Nominal Pipe Size, in.	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed	Other	Variable Flow/ Variable Speed
2 1/2	120	180	85	130	68	110
3	180	270	140	210	110	170
4	350	530	260	400	210	320
5	410	620	310	470	250	370
6	740	1100	570	860	440	680
8	1200	1800	900	1400	700	1100
10	1800	2700	1300	2000	1000	1600
12	2500	3800	1900	2900	1500	2300
Maximum Velocity for Pipes over 12 in. Size	8.5 fps	13.0 fps	6.5 fps	9.5 fps	5.0 fps	7.5 fps

Variable-Primary-Flow (VPF) Systems



- Flow of water varies through entire system
- Flow is monitored, and controlled between upper and lower limits
- specified by the chiller manufacturer
- Improved overall system efficiency through variable flow control

E. Heat Rejection Equipment

- Motors >7.5 HP require to operate at 2/3 speed or less with automatic controls

F. Energy Recovery

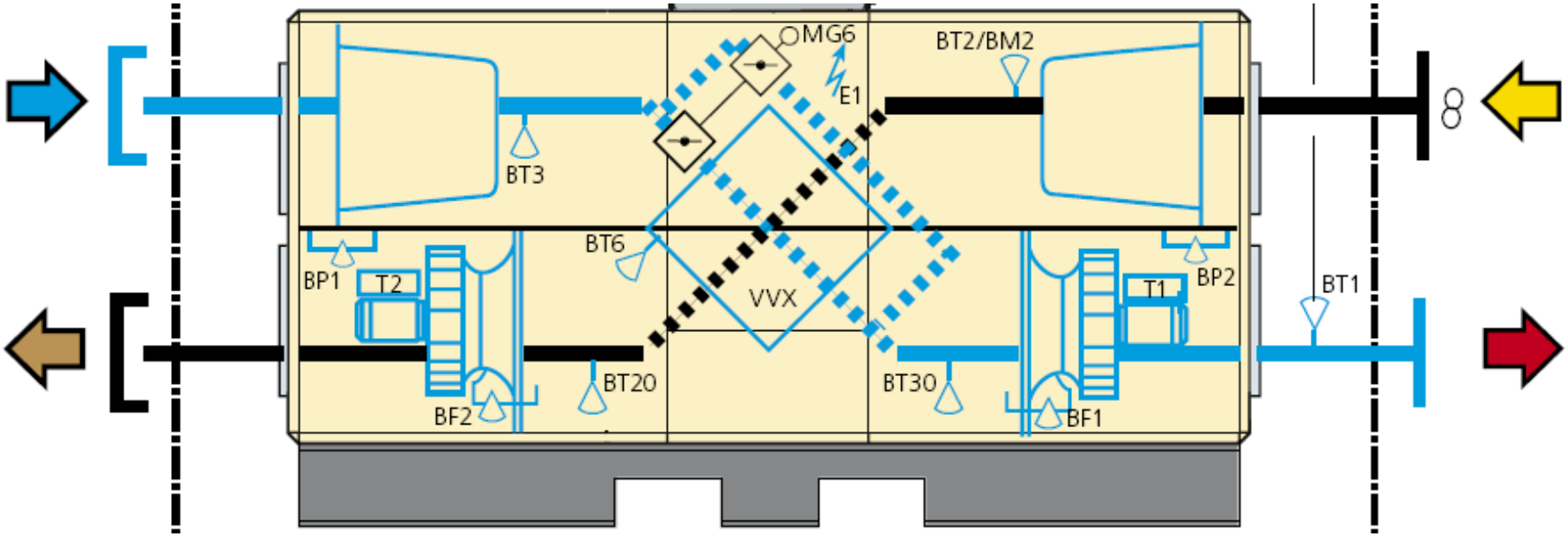
Section 6.5.6

- **6.5.6 Energy Recovery**
  - Exhaust energy recovery required when exceeds table 6.5.6.1
  - Shall be 50% effective
  - Condensers shall service preheat service water*

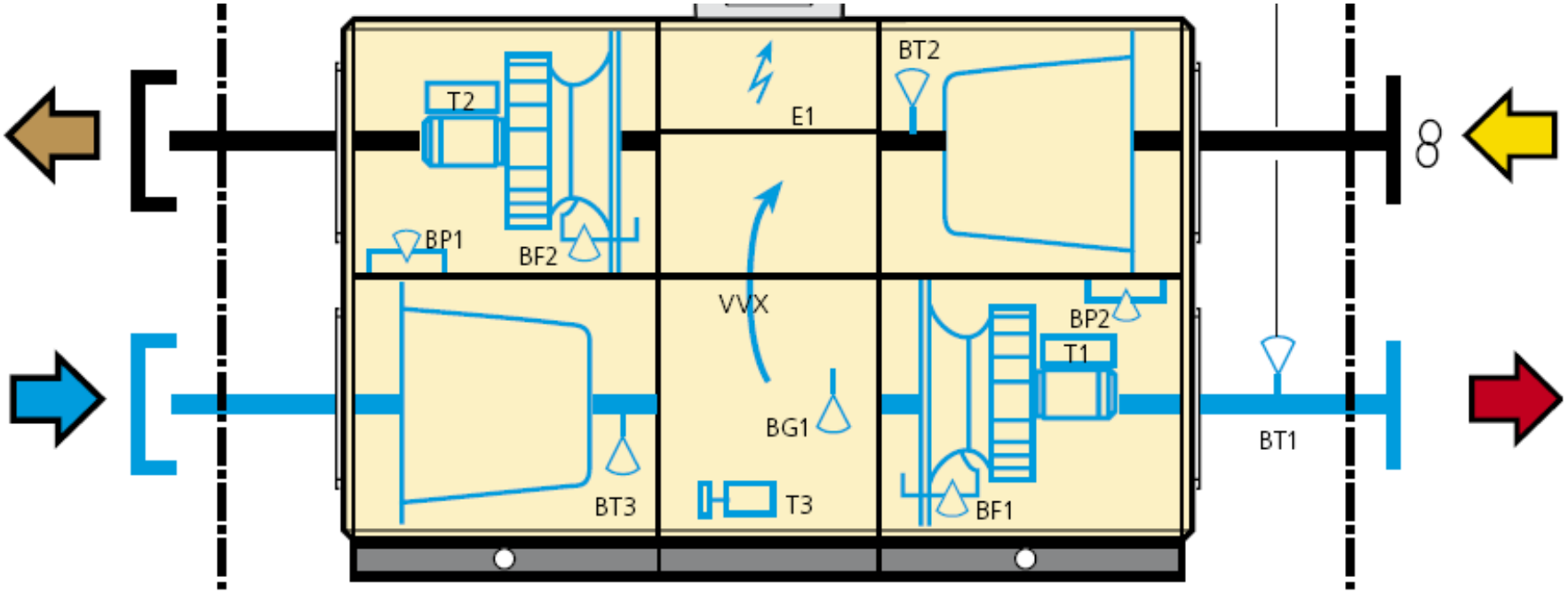
Zone	% *Outdoor Air* at Full Design Airflow Rate					
	≥30% and < 40%	≥40% and < 50%	≥50% and < 60%	≥60% and < 70%	≥70% and < 80%	≥80%
	Design Supply Fan Airflow Rate (cfm)					
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	≥5000	≥5000
1B, 2B,5C	NR	NR	≥26000	≥12000	≥5000	≥4000
6B	≥11000	≥5500	≥4500	≥3500	≥2500	≥1500
1A, 2A, 3A, 4A, 5A, 6A	≥5500	≥4500	≥3500	≥2000	≥1000	>0
7,8	≥2500	≥1000	>0	>0	>0	>0

NR—Not required

Schematic of the Plate Heat Exchanger

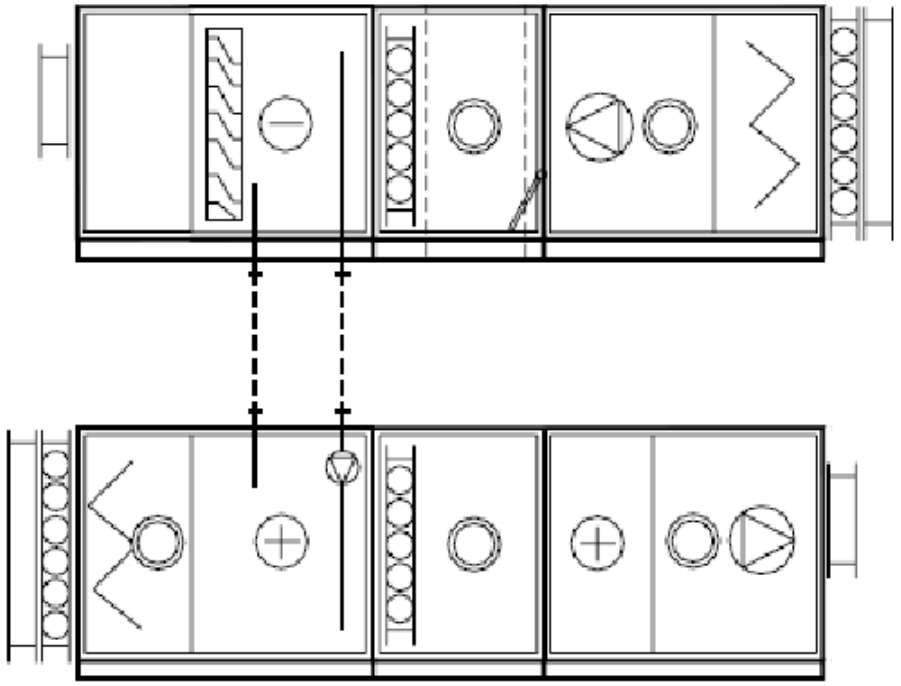


Schematic of the Recovery Wheel



Schematic of the Heat Recovery Glycol Loop

- This system is attractive in upgrades of existing systems **when the exhaust fans are located far from the supply fans**.
- It is also often used in Hospital upgrades due to **100% separation of exhaust and supply flows**.



G. Exhaust Systems

Section
6.5.7

- **Kitchen Hoods**
  - >5000 cfm require DCV
- **Labs**
  - Demand Control Ventilation or
  - Heat recovery system

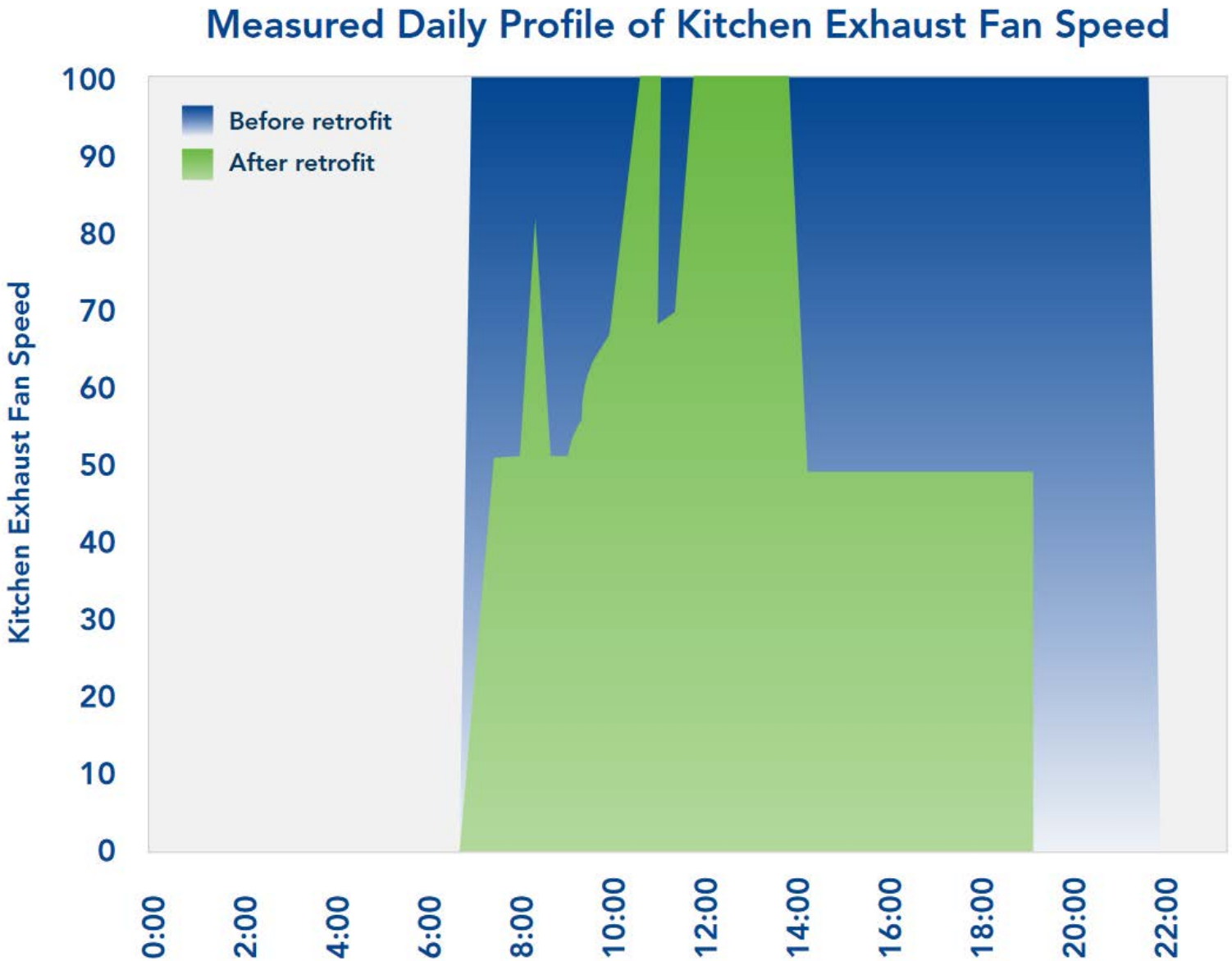
H. Radiant Heating & Hot Gas Bypass

Section
6.5.8 & 6.5.9

- 6.5.8 Radiant Heating Systems
  - Only type of heating permitted for unenclosed spaces
- 6.5.9 Hot Gas Bypass Limitations
  - Allowed for systems < 90 MBH

TABLE 6.5.9 Hot Gas Bypass Limitation

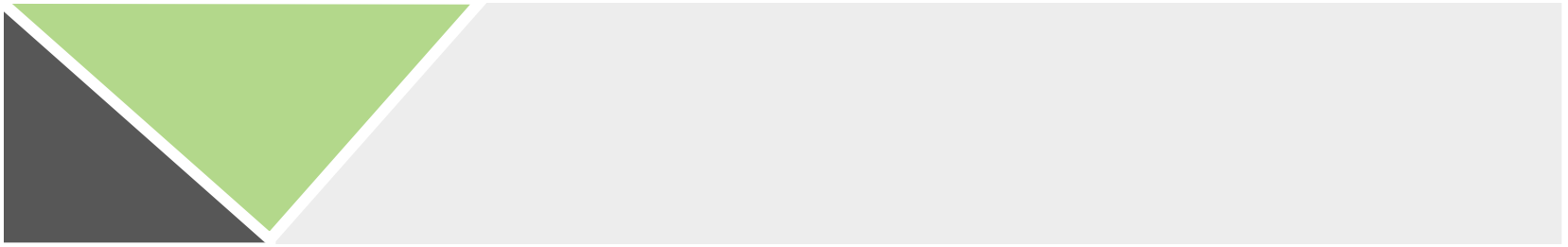
Rated Capacity	Maximum Hot Gas Bypass Capacity (% of Total Capacity)
≤240,000 Btu/h	50%
>240,000 Btu/h	25%


Measured Daily Profile of Kitchen Exhaust Fan Speed
Kitchen Exhaust Fan Speed
100
90
80
70
60
50
40
30
20
10
0
Before retrofit
After retrofit
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00

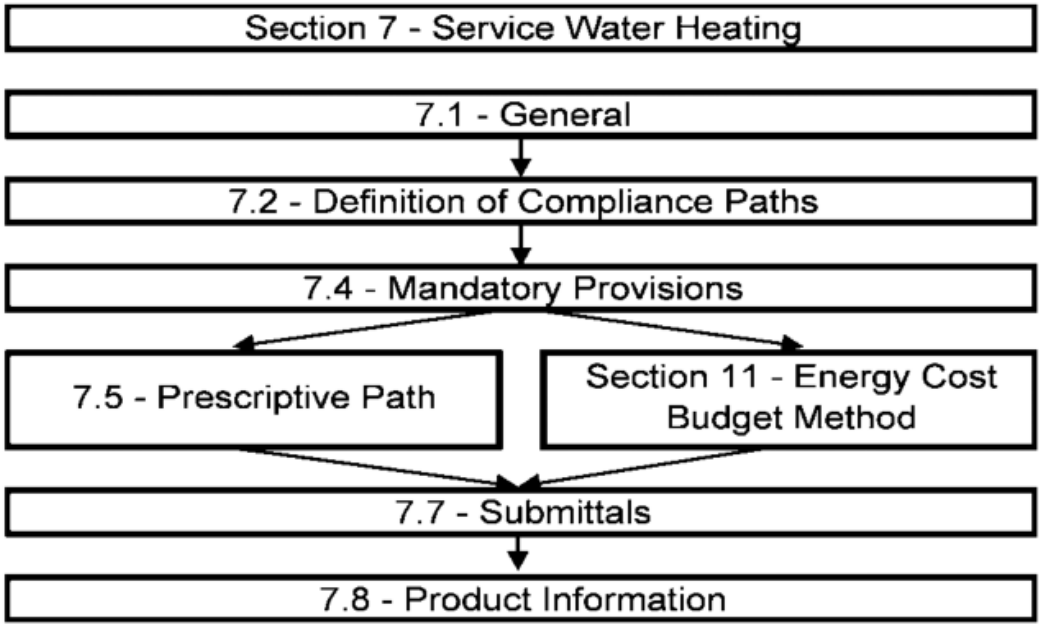
6.7 Submittals

- AHJ may request compliance documentation (4.2.2)
- Required within 90 days of substantial completion:
  - Record drawings
  - O&M manuals
  - System Balancing reports
  - System commissioning report
    - Detailed plan required in specifications if >50,000 sqft

SERVICE WATER HEATING



Ashrae 90.1 Section 7 - Service Water Heating



Mandatory Requirements

1. Load calculations
2. Equipment efficiency
3. Service hot water piping insulation
4. Service water controls
5. Pools
6. Heat traps

Equipment Efficiencies

Section 7.4.2

- Minimum efficiencies are shown in Table 7.8
- Equipment not listed in Table 7.8 has no minimum performance requirements.
- **Exception:** Water heaters and hot water supply boilers > 140 gal storage capacity don't have to meet standby loss (SL) requirements when
  - tank surface is thermally insulated to R-12.5, and
  - a standing pilot light is not installed, and
  - gas- or oil-fired water heaters have a flue damper or fan-assisted combustion."

Example - Portion of Table 7.8

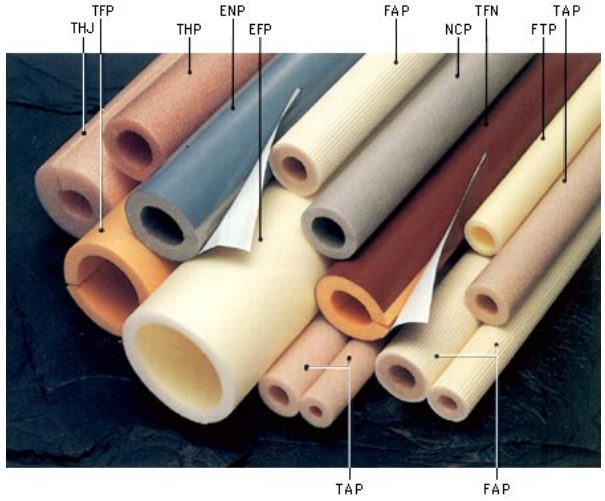
Equipment Type	Size Category	Sub-category or Rating Condition	Performance Required, (EF=Efficiency Factor SL=Standby Losses)
Gas Storage Water Heaters	≤ 75,000 Btu/h	≥ 20 gallons	0.67-0 %19V (EF)
	> 75,000 Btu/h	< 4000 (Btu/h)/gal.	min. 80% E_t & max. [Q/800 + 110 $\sqrt{V}$] (SL), Btu/h
Hot Water Supply Boilers, Gas		≥ 4000 (Btu/h)/ gal. and ≥ 10 gal.	min. 80% E_t & max. [Q/800 + 110 $\sqrt{V}$] (SL), Btu/h
Hot Water Supply Boilers, Oil		≥ 4000 (Btu/h)/ gal. and ≥ 10 gal.	min. 78% E_t & max. [Q/800 + 110 $\sqrt{V}$] (SL), Btu/h
Heat pump pool heater	All	50F DB & 44.2F WB o.a. & 80F entering water.	4.0 COP

Note: Q = nameplate input rating (Btu/h); V = tank volume (gallons); E_t = thermal efficiency

Service HW Insulation

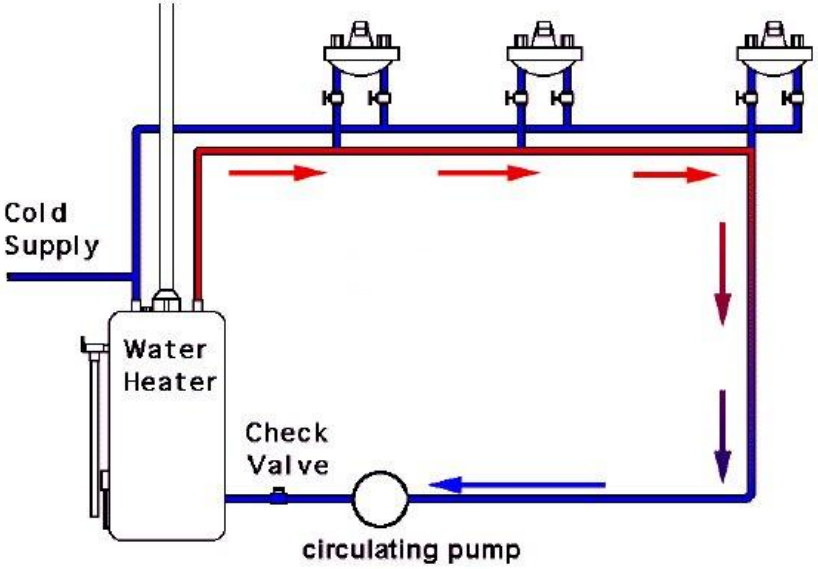
Section
7.4.3

- **The following shall comply with Table 6.8.3 in the HVAC Section 6:**
  - Recirculating system piping, including supply and return piping.
  - Nonrecirculating storage system --
    - First 8 ft of outlet piping.
    - Inlet pipe between storage tank and heat trap.
  - Externally-heated pipes (heat trace or impedance heating)



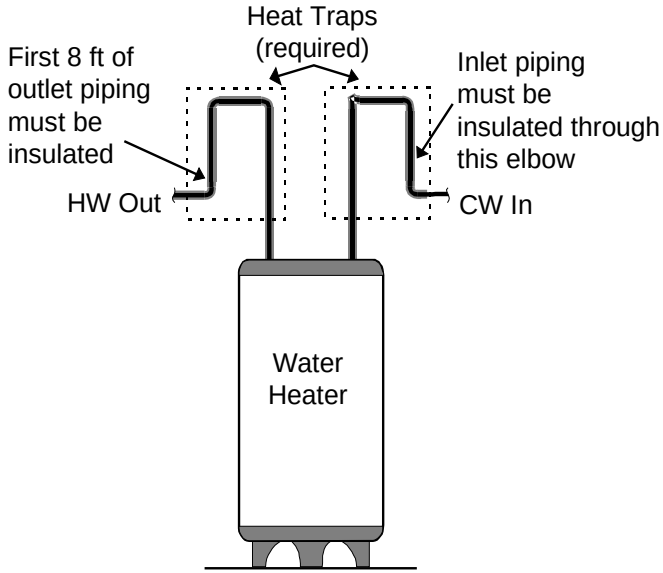
Service Water Controls

- Temperature controls
- Maintenance controls
- Outlet temperature control to 110F for Lav
- Circulating pump enable controls



Heat Traps

- **Vertical pipe risers** serving water heaters with a non-recirculating systems shall have **heat traps** on both the inlet and outlet piping as close as practical



Pools

Section
7.4.5

- Heaters shall be equipped with readily accessible on-off switch.
- Heated pools shall have a pool cover
- High temp pools (+90F) shall have a minimum R-12 cover
- Shall have a time switch

Prescriptive Path

Section 7.5.1

- Combined service and heating systems acceptable if:
  - Standby losses do not exceed: $\frac{(13.3 \times pmd + 400)}{n}$ or
  - Energy consumption will be less than two separate plants; or
  - The combined input is 150 MBH

Or

- Energy Cost Budget Method (Section 11)

OTHER EQUIPMENT

Other Equipment

Section 7.5.1

- **Electric Motors**
  - Energy Policy Act 1992 compliant

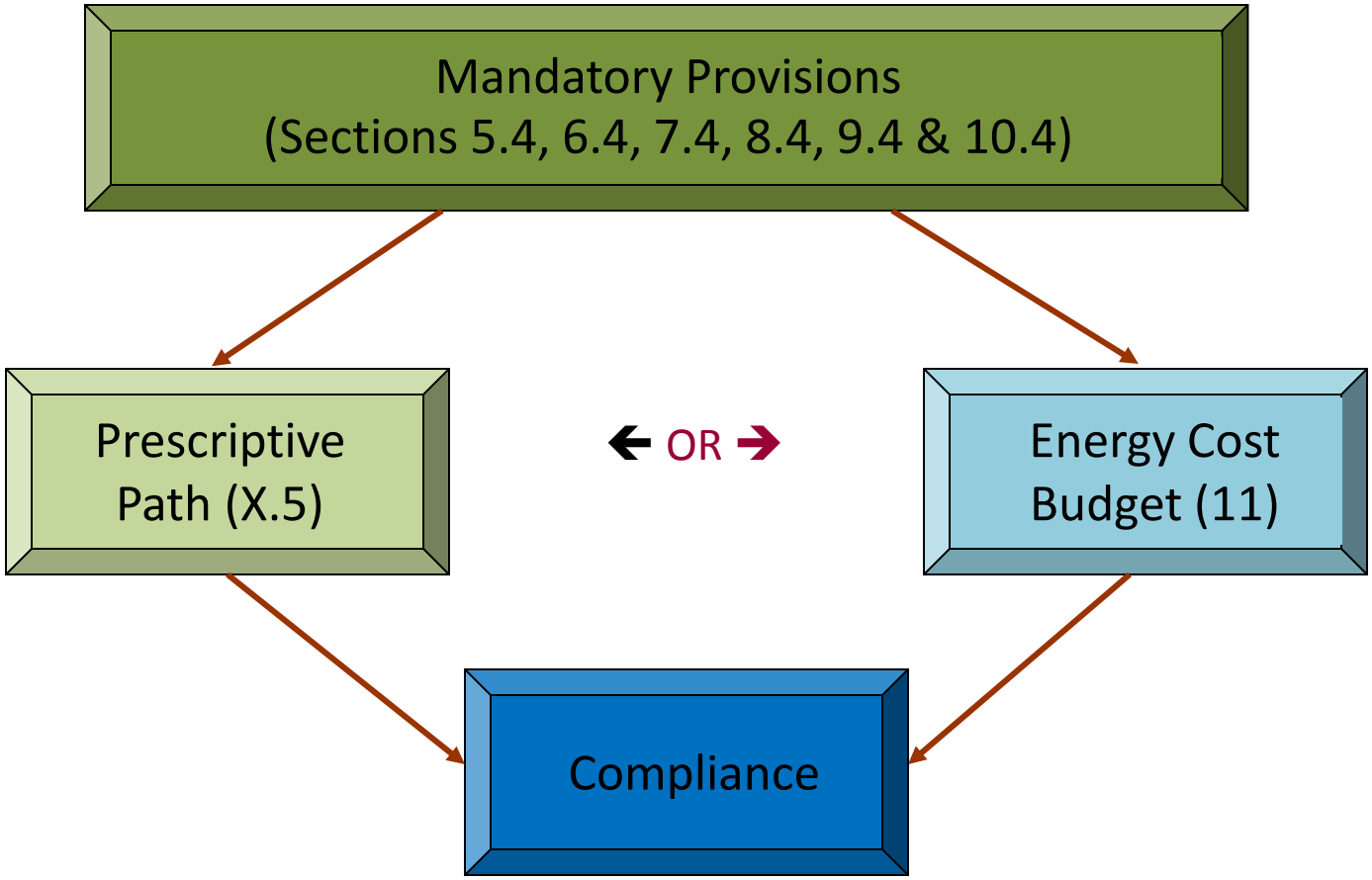
TABLE 10.8C Minimum Nominal Full-Load Efficiency of General Purpose Electric Motors (Subtype II and Design B)[a]

Minimum Nominal Full Load Efficiency (%) for Motors Manufactured on or after December 19, 2010								
	Open Drip-Proof Motors				Totally Enclosed Fan Cooled Motors			
Number of Poles ==>	2	4	6	8	2	4	6	8
Synchronous Speed (RPM)==>	3600	1800	1200	900	3600	1800	1200	900
Motor Horsepower								
1	NR	82.5	80.0	74.0	75.5	82.5	80.0	74.0
1.5	82.5	84.0	84.0	75.5	82.5	84.0	85.5	77.0
2	84.0	84.0	85.5	85.5	84.0	84.0	86.5	82.5
3	84.0	86.5	86.5	86.5	85.5	87.5	87.5	84.0

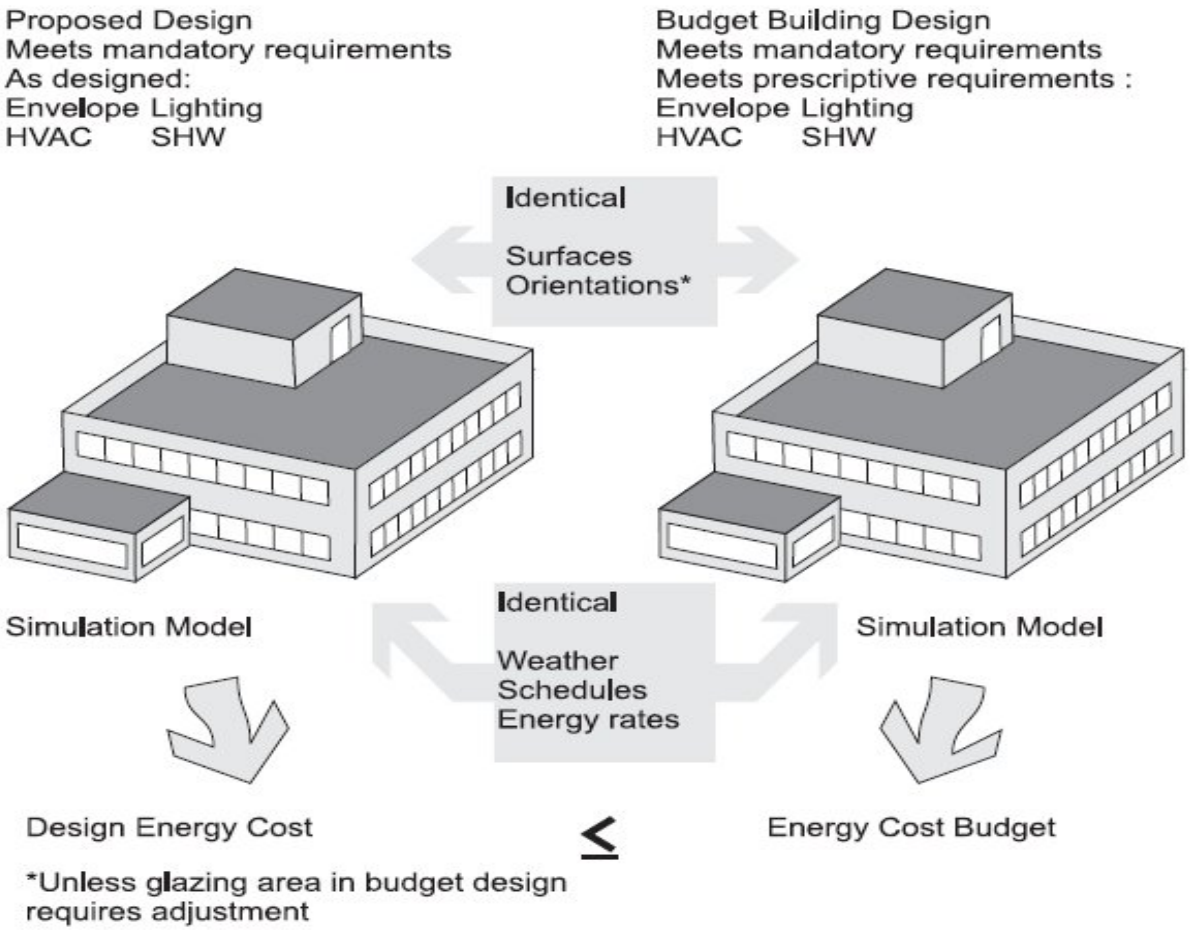
- **Booster Pumps**
  - Flow control with remote pressure sensors
  - No main RP

ENERGY COST BUDGET

Energy Cost Budget

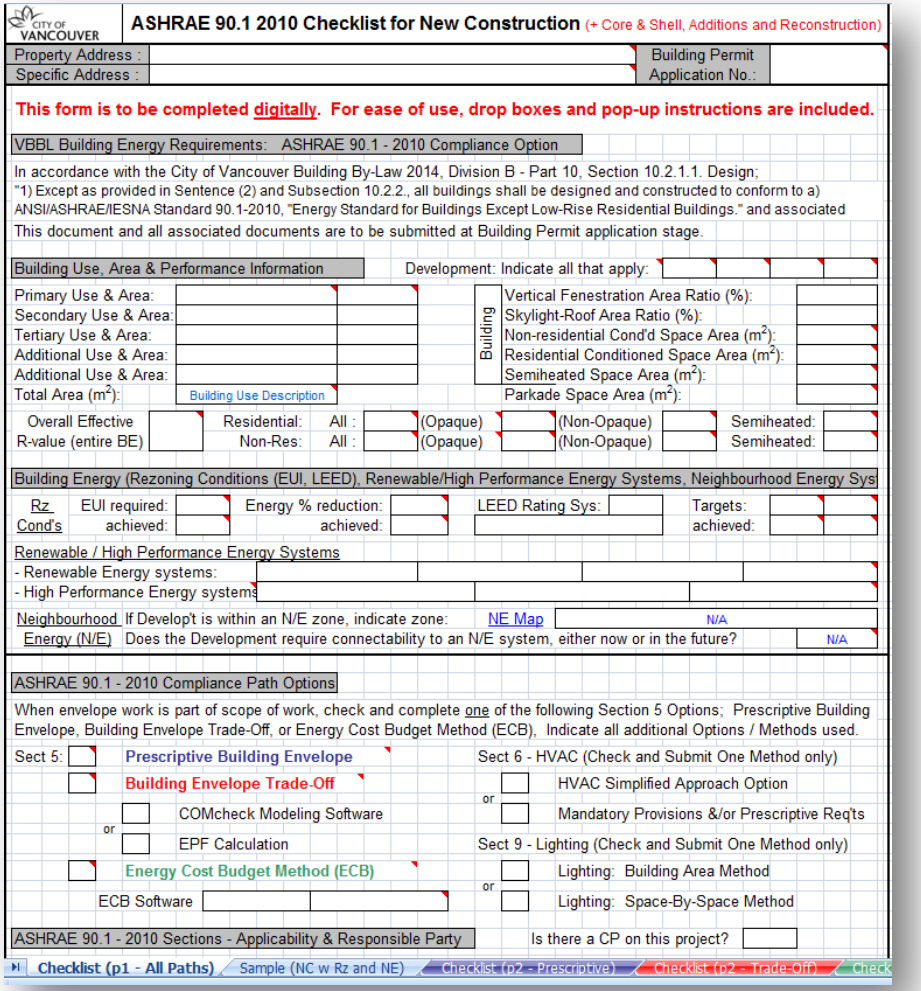


ECB Compliance



Resources

- ASHRAE 90.1 Users Guide
- City of Vancouver Checklists



CITY OF VANCOUVER

ASHRAE 90.1 2010 Checklist for New Construction (+ Core & Shell, Additions and Reconstruction)

Property Address :
Specific Address :
Building Permit Application No.:

This form is to be completed digitally. For ease of use, drop boxes and pop-up instructions are included.

VBBL Building Energy Requirements: ASHRAE 90.1 - 2010 Compliance Option

In accordance with the City of Vancouver Building By-Law 2014, Division B - Part 10, Section 10.2.1.1. Design;
"1) Except as provided in Sentence (2) and Subsection 10.2.2., all buildings shall be designed and constructed to conform to a) ANSI/ASHRAE/IESNA Standard 90.1-2010, "Energy Standard for Buildings Except Low-Rise Residential Buildings." and associated
This document and all associated documents are to be submitted at Building Permit application stage.

Building Use, Area & Performance Information — Development: Indicate all that apply:

Primary Use & Area:
Secondary Use & Area:
Tertiary Use & Area:
Additional Use & Area:
Additional Use & Area:
Total Area (m^2): Building Use Description

Building:
Vertical Fenestration Area Ratio (%):
Skylight-Roof Area Ratio (%):
Non-residential Cond'd Space Area (m^2):
Residential Conditioned Space Area (m^2):
Semiheated Space Area (m^2):
Parkade Space Area (m^2):

Overall Effective R-value (entire BE)
Residential: All : (Opaque) (Non-Opaque) Semiheated:
Non-Res: All : (Opaque) (Non-Opaque) Semiheated:

Building Energy (Rezoning Conditions (EUI, LEED), Renewable/High Performance Energy Systems, Neighbourhood Energy Sys

Rz Cond's — EUI required: achieved: — Energy % reduction: achieved: — LEED Rating Sys: — Targets: achieved:

Renewable / High Performance Energy Systems
- Renewable Energy systems:
- High Performance Energy systems:

Neighbourhood Energy (N/E) — If Develop't is within an N/E zone, indicate zone: NE Map N/A
Does the Development require connectability to an N/E system, either now or in the future? N/A

ASHRAE 90.1 - 2010 Compliance Path Options

When envelope work is part of scope of work, check and complete one of the following Section 5 Options; Prescriptive Building Envelope, Building Envelope Trade-Off, or Energy Cost Budget Method (ECB), Indicate all additional Options / Methods used.

Sect 5:
- Prescriptive Building Envelope
- Building Envelope Trade-Off
  - COMcheck Modeling Software
  - or EPF Calculation
- Energy Cost Budget Method (ECB)
  - ECB Software

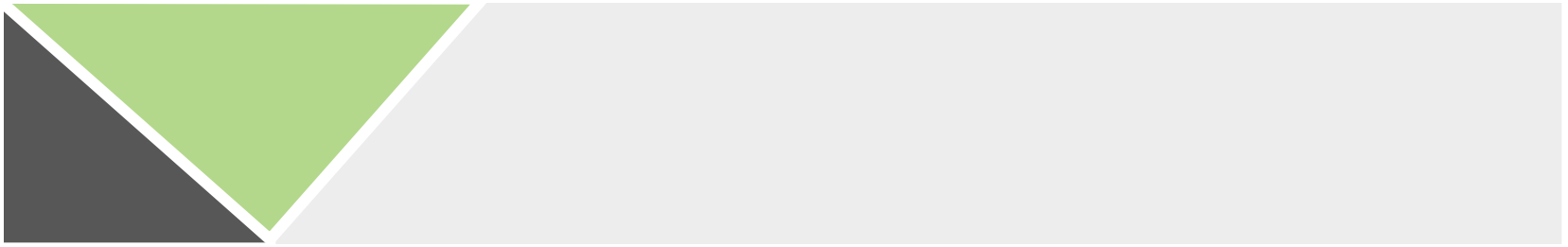
Sect 6 - HVAC (Check and Submit One Method only)
- HVAC Simplified Approach Option
- or Mandatory Provisions &/or Prescriptive Req'ts

Sect 9 - Lighting (Check and Submit One Method only)
- Lighting: Building Area Method
- or Lighting: Space-By-Space Method

ASHRAE 90.1 - 2010 Sections - Applicability & Responsible Party — Is there a CP on this project?

Checklist (p1 - All Paths) | Sample (NC w Rz and NE) | Checklist (p2 - Prescriptive) | Checklist (p2 - Trade-Off) | Check

WRAP UP



Lessons Learned

- Nearly all mechanical and plumbing systems are affected by 90.1
- New construction compliance paths well defined
- Extent of component upgrades can result in additional system modifications
- 90.1 is the least energy efficient system allowed by law

Thank you.

Prism ENGINEERING 25 YEARS

saving you energy

Stephen Kooiman, P.Eng., MASc
Mechanical Team Lead

Tel: 604-205-5509
stephenk@prismengineering.com
www.prismengineering.com
320 - 3605 Gilmore Way, Burnaby, BC V5G 4X5

Limits of Liability

This presentation was prepared by Prism Engineering Limited for the Simon Fraser University. The material in it reflects our professional judgement in light of the information available to us at the time of preparation. The estimates of savings potential and are not guaranteed. Without express written permission, any use which a third party makes of this presentation, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Prism Engineering Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this presentation.