ASHRAE 90.1 - 2010
Understanding Code Compliance and Energy Efficiency

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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.
Your Presenter

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- 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
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.
It's the “Reference” Association:

6.2.1.1. Good Engineering Practice

(See Appendix A.)

1) Heating, ventilating and air-conditioning systems, including mechanical refrigeration, are 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, and Air Conditioning,”
Code vs. Standards

Codes, Standards and Guidelines

What is a Code?

• Least Safe...
• Least Strong...
• Least energy efficient ... Building allowed by Law
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

The graph shows the energy savings and energy use index from 1975 to 2016. The code minimum is still a long way from "Net Zero". The target for 2004 was 30% better than 2004, and the target for 2010 was 50% better than 2004.
Climate Zones

- Lower Mainland: 4C
- Vancouver: 5C
90.1 Compliance

Building System (technical sections)

5. Envelope
6. HVAC
7. SWH
8. Power
9. Lighting
10. Other

Mandatory Provisions (required for most compliance options)

Prescriptive Option
Trade Off Option
Energy Cost Budget
Simplified

Energy Code Compliance
Where 90.1 Applies?

- **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?

• Changing Space Occupancy
  – Entire space shall comply as if new construction
Where 90.1 Applies?

• 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

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

- **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 6.8.1I – 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
## TABLE 6.8.1A  Electronically Operated Unitary Air Conditioners and Condensing Units—Minimum Efficiency Requirements

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Size Category</th>
<th>Heating Section Type</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Test Procedure&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air conditioners, air cooled</td>
<td>&lt;65,000 Btu/h&lt;sup&gt;c&lt;/sup&gt;</td>
<td>All</td>
<td>Split system</td>
<td>13.0 SEER</td>
<td>AHRI 210/240</td>
</tr>
<tr>
<td></td>
<td>≤30,000 Btu/h&lt;sup&gt;c&lt;/sup&gt;</td>
<td>All</td>
<td>Single package</td>
<td>12.0 SEER</td>
<td></td>
</tr>
<tr>
<td>Through-the-wall (air cooled)</td>
<td>≥65,000 Btu/h and &lt;135,000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.2 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Single package</td>
<td>11.4 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥135,000 Btu/h and &lt;240,000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>11.0 EER</td>
<td>AHRI 340/360</td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>11.2 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥240,000 Btu/h and &lt;760,000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>10.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>10.1 IEER</td>
<td></td>
</tr>
<tr>
<td></td>
<td>≥760,000 Btu/h and &lt;1,550,000 Btu/h</td>
<td>Electric resistance (or none)</td>
<td>Split system and single package</td>
<td>9.8 EER</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>All other</td>
<td>Split system and single package</td>
<td>9.9 IEER</td>
<td></td>
</tr>
</tbody>
</table>
B. Calculations

• Load Calculations
  – In accordance with ASHRAE 183

• Pump Head
  – Determined in accordance with generally accepted engineering standards
C. Controls

• 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

• Automatic shutdown
• Setback controls
• Optimum start
• Zone isolation
C. Ventilation Controls

- O/A intake & exhaust systems shall be equipped with motorized dampers that will automatically shut when the systems or spaces served are not in use.

Exceptions:
- BDD acceptable 3 stories*
- Less than 300 cfm
- Serving unconditioned space
- Type 1 kitchen exhaust hoods

### TABLE 6.4.3.4.3 Maximum Damper Leakage (cfm per ft² at 1” w.g.)

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Ventilation Air Intake</th>
<th>Exhaust/Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-motorized</td>
<td>Motorized</td>
</tr>
<tr>
<td>1,2 Any height</td>
<td>---</td>
<td>20</td>
</tr>
<tr>
<td>3 Any height</td>
<td>---</td>
<td>20</td>
</tr>
<tr>
<td>4, 5b, 5c &lt; 3 stories</td>
<td>Not allowed</td>
<td>10</td>
</tr>
<tr>
<td>4, 5b, 5c ≥ 3 stories</td>
<td>Not allowed</td>
<td>10</td>
</tr>
<tr>
<td>5a, 6, 7, 8 &lt; 3 stories</td>
<td>Not allowed</td>
<td>4</td>
</tr>
<tr>
<td>5a, 6, 7, 8 ≥ 3 stories</td>
<td>Not allowed</td>
<td>4</td>
</tr>
</tbody>
</table>
C. Ventilation Controls

• 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

• Demand control ventilation (DCV*) required for spaces > 500 ft² and > 40 people / 1000 ft² 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

- Duct Insulation: per 6.8.2A & B

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Exterior</th>
<th>Ventilated Attic</th>
<th>Unvented Attic Above Insulated Ceiling</th>
<th>Unvented Attic with Roof Insulation</th>
<th>Unconditioned Space</th>
<th>Indirectly Conditioned Space</th>
<th>Buried</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply Ducts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>R-6</td>
<td>R-6</td>
<td>R-8</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>2</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>3</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>4</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>5</td>
<td>R-6</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>6</td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>7</td>
<td>R-8</td>
<td>R-6</td>
<td>R-6</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
<tr>
<td>8</td>
<td>R-8</td>
<td>R-8</td>
<td>R-8</td>
<td>R-1.9</td>
<td>R-3.5</td>
<td>none</td>
<td>R-3.5</td>
</tr>
</tbody>
</table>

Return Ducts

<table>
<thead>
<tr>
<th>气候区</th>
<th>封闭</th>
<th>露天</th>
<th>无</th>
<th>无</th>
<th>无</th>
<th>无</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-8</td>
<td>R-3.5</td>
<td>R-3.5</td>
<td>none</td>
<td>none</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

注释:
- Insulation R-values, measured in (h·ft²·°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 6.5. Insulation resistance measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 75°F at the installed thickness.
- Includes crawlspace, both ventilated and unventilated.
- Includes return air plenums with or without exposed roofs above.
## D. Insulation

- **Piping Insulation: Per 6.8.3A & B**

### TABLE 6.8.3A  Minimum Pipe Insulation Thickness
+(Steam, Steam Condensate, Hot Water Heating and Domestic Water Systems)

<table>
<thead>
<tr>
<th>Fluid Operating Temperature Range (°F) and Usage</th>
<th>Insulation Conductivity</th>
<th>Mean Rating Temperature, °F</th>
<th>Nominal Pipe or Tube Size (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conductivity Btu-in./(h ft².°F)</td>
<td></td>
<td>&lt;1</td>
</tr>
<tr>
<td>&gt;350 °F</td>
<td>0.32–0.34</td>
<td>250</td>
<td>4.5</td>
</tr>
<tr>
<td>251°F–350°F</td>
<td>0.29–0.32</td>
<td>200</td>
<td>3.0</td>
</tr>
<tr>
<td>201°F–250°F</td>
<td>0.27–0.30</td>
<td>150</td>
<td>2.5</td>
</tr>
<tr>
<td>141°F–200°F</td>
<td>0.25–0.29</td>
<td>125</td>
<td>1.5</td>
</tr>
<tr>
<td>105°F–140°F</td>
<td>0.22–0.28</td>
<td>100</td>
<td>1.0</td>
</tr>
</tbody>
</table>

---

**a** For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: \( T = r[(1 + vt)^{1/k} - 1] \) 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 1-1/2” 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

• 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

- 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

- 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

- 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

Section 6.5.2
C. Air System Design

- Fan system Power Limitations
  - Fan motor operation limits

### TABLE 6.5.3.1.1A  Fan Power Limitation

<table>
<thead>
<tr>
<th>Limit</th>
<th>Constant Volume</th>
<th>Variable Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option 1: Fan System</td>
<td>Allowable Nameplate Motor hp</td>
<td>hp ≤ $CFM_S \cdot 0.0011$</td>
</tr>
<tr>
<td>Motor Nameplate hp</td>
<td></td>
<td>hp ≤ $CFM_S \cdot 0.0015$</td>
</tr>
<tr>
<td>Option 2: Fan System bhp</td>
<td>Allowable Fan System bhp</td>
<td>bhp ≤ $CFM_S \cdot 0.00094 + A$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bhp ≤ $CFM_S \cdot 0.0013 + A$</td>
</tr>
</tbody>
</table>

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 $(PD \times CFM_S/4131)$

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

- 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

• 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

- CHW piping sizing based on pump operating hours per year

<table>
<thead>
<tr>
<th>Nominal Pipe Size, in.</th>
<th>Operating Hours/Year</th>
<th>Piping System Design Maximum Flow Rate in GPM</th>
<th>Variable Flow/Variable Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤2000 Hours/Year</td>
<td>&gt;2000 and ≤ 4400 Hours/Year</td>
<td>&gt;4400 Hours/Year</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>2 1/2</td>
<td>120</td>
<td>85</td>
<td>68</td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>140</td>
<td>110</td>
</tr>
<tr>
<td>4</td>
<td>350</td>
<td>260</td>
<td>210</td>
</tr>
<tr>
<td>5</td>
<td>410</td>
<td>310</td>
<td>250</td>
</tr>
<tr>
<td>6</td>
<td>740</td>
<td>570</td>
<td>440</td>
</tr>
<tr>
<td>8</td>
<td>1200</td>
<td>900</td>
<td>700</td>
</tr>
<tr>
<td>10</td>
<td>1800</td>
<td>1300</td>
<td>1000</td>
</tr>
<tr>
<td>12</td>
<td>2500</td>
<td>1900</td>
<td>1500</td>
</tr>
</tbody>
</table>

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

• 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*
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

• Kitchen Hoods
  o >5000 cfm require DCV

• Labs
  o Demand Control Ventilation or
  o Heat recovery system
H. Radiant Heating & Hot Gas Bypass

• **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>
<thead>
<tr>
<th>TABLE 6.5.9</th>
<th>Hot Gas Bypass Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Capacity</td>
<td>Maximum Hot Gas Bypass Capacity (%) of Total Capacity</td>
</tr>
<tr>
<td>≤240,000 Btu/h</td>
<td>50%</td>
</tr>
<tr>
<td>&gt;240,000 Btu/h</td>
<td>25%</td>
</tr>
</tbody>
</table>
Measured Daily Profile of Kitchen Exhaust Fan Speed

Before retrofit
After retrofit
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

- Section 7 - Service Water Heating
  - 7.1 - General
  - 7.2 - Definition of Compliance Paths
  - 7.4 - Mandatory Provisions
    - 7.5 - Prescriptive Path
    - Section 11 - Energy Cost Budget Method
  - 7.7 - Submittals
  - 7.8 - Product Information
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

- 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

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

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

- 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 110°F 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

• 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

• Combined service and heating systems acceptable if:
  – Standby losses do not exceed: \(13.3 \times \frac{pmd}{n} + 400\) 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

- **Electric Motors**

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

![Table 10.8C: Minimum Nominal Full-Load Efficiency of General Purpose Electric Motors (Subtype II and Design B)](images)
Energy Cost Budget

Mandatory Provisions
(Sections 5.4, 6.4, 7.4, 8.4, 9.4 & 10.4)

Prescriptive Path (X.5)

Energy Cost Budget (11)

Compliance

← OR →
ECB Compliance

Proposed Design
Meets mandatory requirements
As designed:
Envelope Lighting
HVAC  SHW

Budget Building Design
Meets mandatory requirements
Meets prescriptive requirements:
Envelope Lighting
HVAC  SHW

Identical
Surfaces
Orientations*

Simulation Model

Identical
Weather
Schedules
Energy rates

Design Energy Cost
*Unless glazing area in budget design
requires adjustment

≤

Energy Cost Budget
Resources

- ASHRAE 90.1 Users Guide
- City of Vancouver Checklists
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.

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