ASHRAE STANDARD 90.1, 2016
HVAC System Requirements for Reducing Energy Consumption in Commercial Buildings

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LEARNING OBJECTIVES

Provide an overview of the major requirements of the 90.1-2016 Standard that are of interest to engineers, designers, and contractors.

AND

Understand the significant changes in the Mechanical and Performance Compliance Path sections of Standard 90.1-2016 versus the 2013 edition (as well as some pre-existing requirements)

PRESENTATION NOTES:
1. All section numbers in this presentation apply to the Standard 90.1-2016 only. Section numbers may differ in other versions.
2. The year listed in the heading of each slide is the year (version) the change was integrated into the Standard.
Topics

Changes covered:

- General Overview
- Equipment Efficiency
- Controls
- Fan Power/Efficiency
- Exhaust Air Energy Recovery
- Hydronic Systems
- Computer Room Cooling
- Appendix G Compliance Path
GENERAL OVERVIEW
SSPC Objectives for 2016

Create a consensus standard that

- Saves energy
- Is technically feasible
- Is cost effective
SSPC Objectives for 2016

Additional strategic objectives

- Ease of use
- Preparation for moving to the electronic environment
- Whole building energy consumption
- Move towards performance methodologies
RESULTS - 2016

- Over 120 addenda (whole standard)
- Major format changes
- Weather data alignment with Standard 169
- Appendix G Compliance Path
FORMAT CHANGES - 2016

- Single column format for easier reading
- Exceptions separated, indented and set apart with a smaller font size
- Defined terms are Italicized
- Alternating coloring scheme for table rows
Format Changes - 2016

6 Heating, Ventilating, and Air Conditioning

Table 6.4.3.4.3 Maximum Damper Leakage, cfm per ft² at 1.0 in. of water

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>Ventilation Air Intake</th>
<th>Exhaust/Relief</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nonmotorized*</td>
<td>Motorized</td>
</tr>
<tr>
<td>0, 1, 2</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Any height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Any height</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4, 5B, 5C</td>
<td>Fewer than three stories</td>
<td>NA</td>
</tr>
<tr>
<td>Three or more stories</td>
<td>NA</td>
<td>10</td>
</tr>
<tr>
<td>5A, 0, 7, 8</td>
<td>Fewer than three stories</td>
<td>NA</td>
</tr>
<tr>
<td>Three or more stories</td>
<td>NA</td>
<td>4</td>
</tr>
</tbody>
</table>

* Damper smaller than 24 in. in either dimension may have leakage of 40 cfm/ft².
NA = Not allowed

6.4.3.4 Ventilation System Controls

6.4.3.4.1 Stair and Shaft Vents
Stair and elevator shaft vents shall be equipped with motorized dampers that are capable of and configured to automatically close during normal building operation and are interlocked to open as required by fire and smoke detection systems.

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 and configured to automatically shut off during preoccupancy building warm-up, cooldown, and setback, except when ventilation reduces energy costs or when ventilation must be supplied to meet code requirements.

Exceptions to 6.4.3.4.2

1. Back-draft 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 0, 1, 2, and 3.
Climate Zones - 2016

- Approximately 10% of the counties in the U.S. have been re-assigned to a different climate zone.
- Climate Zone 1 has been subdivided into Climate Zones 0 and 1.
Mechanical
SECTION 6 COMPLIANCE FLOWCHART - 2016

Section 6 Heating, Ventilating, and Air Conditioning

Section 6.1 General

Section 6.2 Definitions of Compliance Paths

Section 6.4 Mandatory Provisions

Section 6.3 Simplified Approach

Section 6.5 Prescriptive Path

Section 6.6 Alternate Compliance Path

Section 11 Energy Cost Budget

Appendix G Performance Rating Method

Section 6.7 Submittals

Section 6.8 Equipment Efficiency Tables

Changes
EQUIPMENT PERFORMANCE
REPLACEMENT EQUIPMENT - 2016

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

a. 6.3, “Simplified Approach Option for HVAC Systems”
b. 6.4.1, “Equipment Efficiencies, Verification, and Labeling Requirements”
c. 6.4.3.1, “Zone Thermostatic Controls”
d. 6.4.3.2, “Set-Point Overlap Restrictions”
e. 6.4.3.3, “Off-Hour Controls” except for Section 6.4.3.3.4, “Zone Isolation”
f. 6.4.3.4, “Ventilation System Controls”
g. 6.4.3.7, “Freeze Protection and Snow/Ice Melting Systems”
h. 6.4.3.8, “Ventilation Controls for High-Occupancy Areas” only for single-zone equipment
i. 6.4.3.9, “Heated or Cooled Vestibules”
j. 6.4.5, “Walk-In Coolers and Walk-In Freezers”
k. 6.5.1.1, “Air Economizers” for units located outdoors
l. 6.5.1.3, “Integrated Economizer Control”
m. 6.5.1.4, “Economizer Heating System Impact”
n. 6.5.3.1.3, “Fan Efficiency”
o. 6.5.3.2.1, “Supply Fan Airflow Control”
p. 6.5.3.6, “Fractional Horsepower Fan Motors”
q. 6.5.4.1, “Boiler Turndown”
r. 6.5.4.3, “Chiller and Boiler Isolation”
s. 6.5.5.2, “Fan Speed Control”
ADJUSTED EQUIPMENT PERFORMANCE TABLES (6.8.1) – 2016

- New equipment types (new tables)
- Increased efficiency for many Equipment Types
- Improvements focus on annualized efficiency rather than full load efficiency
  - Systems rarely, if ever operate at full load
  - Mechanical efficiencies have reached diminishing return
  - Inexpensive controls enable improved part load efficiency
NEW EQUIPMENT PERFORMANCE TABLES (6.8.1)

- 2010 added tables for
  - Heat transfer equipment
  - VRF systems
  - CRAC units

- 2013 added tables for
  - Commercial refrigerators and freezers
  - Commercial refrigeration

- 2016 added tables for
  - CRAC units (major revision)
  - Indoor pool dehumidification units
  - DX Dedicated outdoor air supply equipment
    - With and without energy recovery
Table 6.8.1-11
Computer Room Units - 2016

Table 6.8.1-11 was revised to add 3 classification of computer units to reflect industry standard:
- Class 1 – 75 F DB/52 F WB
- Class 2 – 85 F DB/52 F WB
- Class 3 – 95 F DB/52 F WB

New efficiency ratings align with AHRI 1360
Min. efficiency rating using new rating standard, AHRI 910

Efficiency metric: MRE

- *Moisture Removal Efficiency (MRE).* A ratio of the Moisture removal capacity to the total power input (lb/kWh)

### Table 6.8.1-14 Vapor Compression Based Indoor Pool Dehumidifiers—Minimum Efficiency Requirements

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single package indoor&lt;sup&gt;a&lt;/sup&gt; (with or without economizer)</td>
<td>Rating Conditions: A, B, or C</td>
<td>3.5 MRE</td>
<td>AHRI 910</td>
</tr>
<tr>
<td>Single package indoor water-cooled (with or without economizer)</td>
<td></td>
<td>3.5 MRE</td>
<td></td>
</tr>
<tr>
<td>Single package indoor air-cooled (with or without economizer)</td>
<td></td>
<td>3.5 MRE</td>
<td></td>
</tr>
<tr>
<td>Split system indoor air-cooled (with or without economizer)</td>
<td></td>
<td>3.5 MRE</td>
<td></td>
</tr>
</tbody>
</table>
**Table 6.8.1-15 & 16**  
**DX-DOAS Equipment - 2016**

- Min. efficiency rating using new rating standard, AHRI 920
- Efficiency metric: ISMRE
  - *Integrated Seasonal Moisture Removal Efficiency (ISMRE).* A seasonal efficiency number for MRE (lb/kWh)
  - Table for equipment with or without energy recovery

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### Table 6.8.1-15 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery—Minimum Efficiency Requirements

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Subcategory or Rating Condition</th>
<th>Minimum Efficiency</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air cooled (dehumidification mode)</td>
<td></td>
<td>4.0 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Air source heat pumps (dehumidification mode)</td>
<td></td>
<td>4.0 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Water cooled (dehumidification mode)</td>
<td>Cooling tower condenser water</td>
<td>4.9 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Water cooled (dehumidification mode)</td>
<td>Chilled Water</td>
<td>6.0 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Air source heat pump (heating mode)</td>
<td></td>
<td>2.7 ISCOP</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Water source heat pump (dehumidification mode)</td>
<td>Ground source, closed loop</td>
<td>4.8 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Water source heat pump (dehumidification mode)</td>
<td>Ground-water source</td>
<td>5.0 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Water source heat pump (dehumidification mode)</td>
<td>Water source</td>
<td>4.0 ISMRE</td>
<td>AHRI 920</td>
</tr>
<tr>
<td>Water source heat pump</td>
<td>Ground source, closed loop</td>
<td>2.0 ISCOP</td>
<td>AHRI 920</td>
</tr>
</tbody>
</table>
HVAC Controls
MANDATORY DIRECT DIGITAL CONTROLS (6.4.3.10) - 2013

- DDC Systems are now mandatory in many applications
- Larger new building applications dependent upon:
  - Type and size of equipment
- Also required in many renovations dependent upon:
  - Scope of renovation
  - Type and size of new equipment
  - Existing control system
For electric-motor-driven chilled-water plants, measure and log the electric energy use and efficiency of the chilled-water plant

- water-cooled plant >1500 tons, Climate Zones 5-8, 3C, and 4C
- water-cooled plant >1000 tons, all other Climate Zones
- air-cooled plant > 860 tons, Climate Zones 5-8, 3C, and 4C
- air-cooled plant > 570 tons, all other Climate Zones.

Calculate efficiency in COP of operating capacity
Log 15 min. periods, retain for 36 months
Whole-Building Energy Monitoring (10.4.5) - 2013

Measurement devices to monitor and store hourly energy data for the following utility energy types for 36 months:

- Natural gas
- Fuel oil
- Propane
- Steam
- Chilled water
- Heating water
Whole-Building Energy Monitoring Exceptions (10.4.5) - 2013

Energy monitoring is NOT required for:
- Buildings or additions < 25,000 ft$^2$
- Tenant spaces < 10,000 ft$^2$
- Dwelling units
- Residential buildings with common area < 10,000 ft$^2$
- Fuel for emergency equipment
Demand Control Ventilation (6.4.3.8) - 2013

- Occupant Density has been reduced
  - 2010 Threshold ≥40 people/1000 ft²
  - 2013 Threshold ≥25 people/1000 ft²
- New threshold aligns with green rating systems
- Change will require DCV in many spaces which previously did not require it.
  - Notably, classrooms

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.
Economizer Control Diagnostics
(6.4.3.12) - 2016

- Air-cooled DX cooling units (Tables 6.8.1-1 and 6.8.1-2) shall include economizer fault detection and diagnostics (FDD)
  - Various air temp sensors
  - Air temp display
  - System status
  - Manual override
  - Specific faults identified
  - Report faults to maintenance staff or occupants
Acceptable control methods have changed
- Dry bulb or enthalpy control only

<table>
<thead>
<tr>
<th>Control Type</th>
<th>Allowed Only in Climate Zone at Listed Setpoint</th>
<th>Required High-Limit Setpoints (Economizer Off When):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed dry-bulb temperature</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5b, 5c, 6b, 7, 8</td>
<td>- $T_{OA} &gt; 75^\circ F$ Outdoor air temperature exceeds $75^\circ F$</td>
</tr>
<tr>
<td></td>
<td>5a, 6a</td>
<td>- $T_{OA} &gt; 70^\circ F$ Outdoor air temperature exceeds $70^\circ F$</td>
</tr>
<tr>
<td></td>
<td>1a, 2a, 3a, 4a</td>
<td>- $T_{OA} &gt; 65^\circ F$ Outdoor air temperature exceeds $65^\circ F$</td>
</tr>
<tr>
<td>Differential dry-bulb temperature</td>
<td>1b, 2b, 3b, 3c, 4b, 4c, 5a, 5b, 5c, 6a,</td>
<td>- $T_{OA} &gt; T_{RA}$ Outdoor air temperature exceeds return air temperature</td>
</tr>
<tr>
<td></td>
<td>6b, 7, 8</td>
<td></td>
</tr>
<tr>
<td>Fixed enthalpy with fixed dry-bulb temperature</td>
<td>All</td>
<td>- $h_{OA} &gt; 28$ Btu/lb$^a$ or $T_{OA} &gt; 75^\circ F$ Outdoor air enthalpy exceeds 28 Btu/lb$^a$ of dry air$^a$ or or outdoor air temperature exceeds $75^\circ F$</td>
</tr>
<tr>
<td>Differential enthalpy with fixed dry-bulb temperature</td>
<td>All</td>
<td>- $h_{OA} &gt; h_{RA}$ or $T_{OA} &gt; 75^\circ F$ Outdoor air enthalpy exceeds return air enthalpy or outdoor air temperature exceeds $75^\circ F$</td>
</tr>
</tbody>
</table>

a. At altitudes substantially different than sea level, the fixed enthalpy limit shall be set to the enthalpy value at $75^\circ F$ and 50% RH. As an example, at approximately 6000 ft elevation, the fixed enthalpy limit is approximately 30.7 Btu/lb.

b. Devices with selectable rather than adjustable setpoints shall be capable of being set to within 2°F and 2 Btu/lb of the setpoint listed.
INTEGRATED ECONOMIZER (6.5.1.3) - 2013

Additional requirements added for DX cooling
- Prohibits/limits false loading mech cooling
- Min compressor run time – OA damper may not close until SAT <45°F
- Single zone systems must have at least 2 cooling stages (Capacity dependent)
- Variable air volume systems must have 3 or 4 cooling stages (Capacity dependent)
ECONOMIZER & HUMIDIFICATION (6.5.1.5) - 2013

When humidification maintains indoor air wetbulb temp. >35°F:
- Airside economizer is prohibited
- Water Economizer must be used

This is not a new requirement:
Moved from 6.5.2.4 in 2010 to a more relevant section in 2013
SIMULTANEOUS HEATING AND COOLING (6.5.2) - 2013

As in 2010 Zone controls must prevent:

- Reheating
- Recooling
- Mixing of heated and cooled air
- Any form of simultaneously heating and cooling a zone

NOT allowed unless.....
SIMULTANEOUS HEATING AND COOLING EXCEPTIONS (6.5.2) - 2013

With DDC reheat/recool (continued)
Fan Control (6.5.3.2) - 2013

- Applies to single zone systems too
- Specifies variable speed fan operation
- Includes allowable fan power at intermediate flow rates
Supply Fan Control (6.5.3.2.1) - 2013

Cooling load met by adjusting cooling capacity
(typical single zone system)

- Minimum of 2 fan speeds
  - 100% flow @ 100% design fan power
  - ≤ 66% flow @ 40% design fan power

- Must have at least two speeds of operation when using air economizer
Supply Fan Control (6.5.3.2.1) - 2013

Cooling load met by adjusting air flow
(typical VAV system)

- Modulate fan speed between the following points
  - 100% flow @ 100% design fan power
  - 50% flow @ 30% design fan power or less

- Must have at least two speeds of operation when using air economizer (but would likely just modulate)
Return and Relief Fan Control

Return and Relief Fan Control

- Maintain building pressure directly or via tracking (with supply fan speed or OA damper modulation).
- 50% design flow @ 30% or less design power

Exceptions to 6.5.3.2.4

- Fans with motors ≤ 0.5 hp
- Staged relief fans with stages ≥ 4
Automatic controls:

- terminal fan runs only when space heating is required or if required for ventilation
- terminal fan is the first stage of heat
- during heating for warmup or setback temperature control, using either
  1. terminal fan and heating coil (primary air is stopped)
  2. primary air (terminal fan and heating coil are off)
HVAC Control in Hotel/Motel Guest Rooms (6.4.3.3.4) - 2016

>50 guest rooms, each guest room shall be provided with automatic controls

- **Guest Room HVAC Setpoint Control**
  - Rented/unoccupied for 30 min. = 4°F setback (htg and clg).
  - Unrented 80°F or higher in the cooling mode and 60°F or lower in the heating mode.

- **Guest Room Ventilation Control**
  - Ventilation and exhaust stop within 30 min. of last occupant leaving.

Captive key cards are permitted to be used for compliance

Refer to the standard for further details and exceptions
Control Language Clarification
Many instances:
“controls capable of…” changed to
“controls capable of and configured to…”

Example: 6.4.3.4 Ventilation outdoor air and exhaust/relief dampers shall be capable of and configured to automatically…..

Chilled and Hot Water Temperature Reset Control 6.5.4.4
- Supply water temperature set point shall be reset based on zone valve positions.
FAN POWER & EFFICIENCY
Fan Power (6.5.3.1) - 2013

- Fan power allowance equations same as 2010
- Pressure drop adjustments changed
  - Modified sound attenuation credit (added sound level goal)
  - Added deductions for elimination of coils

<table>
<thead>
<tr>
<th>Device</th>
<th>Adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Credits</strong></td>
<td></td>
</tr>
<tr>
<td>Sound attenuation section (fans serving spaces with design background noise goals below NC35)</td>
<td>0.15 in. wc</td>
</tr>
<tr>
<td><strong>Deductions</strong></td>
<td></td>
</tr>
<tr>
<td>Systems without central cooling device</td>
<td>–0.6 in. wc</td>
</tr>
<tr>
<td>Systems without central heating device</td>
<td>–0.3 in. wc</td>
</tr>
<tr>
<td>Systems with central electric resistance heat</td>
<td>–0.2 in. wc</td>
</tr>
</tbody>
</table>
Fan Efficiency (6.5.3.1.3) - 2013

- In addition to fan power requirements
- Fan must have a Fan Efficiency Grade (FEG) of not less than 67 (per AMCA 205)
- The fan efficiency at design conditions must be within 15 efficiency percent of the max total fan efficiency

- Many exceptions, notably
  - Small fans
  - Fans part of equipment rated as a package
Fraction HP Fan Motors (6.5.3.6) - 2013

- Motors $\geq 1/12$ HP and $< 1$ HP must be:
  - Electronically Commutated Motors (DC Brushless)
  - $\geq 70\%$ Efficient (rated in accordance with DOE 10 CFR 431)

- Exceptions:
  - Heating only applications (fan in airstream)
  - Motors in space conditioning equipment rated as a package
  - Motors already covered in Chapter 10 of 90.1
Exhaust Air Energy Recovery
Exhaust Air Energy Recovery (6.5.6.1) - 2016

- New definitions added for energy recovery efficiency
  - enthalpy recovery ratio: change in the enthalpy of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air enthalpy, expressed as a percentage (for 6.5.6.1)
  - sensible energy recovery ratio: change in the dry-bulb temperature of the outdoor air supply divided by the difference between the outdoor air and entering exhaust air dry-bulb temperatures, expressed as a percentage. (for kitchen hood exh, 6.5.7.2.3)

- The enthalpy recovery ratio is unchanged at 50%
- Required thresholds have changed to account for availability of small energy recovery products (no more thresholds of 0).
- Some the exemptions for toxic, flammable, point and corrosive fumes and for commercial kitchen hoods were eliminated.
- A clarification on the exemption for exhaust airflow rates below 75% was added to added (20’ separation).
# Revised Exhaust Air Energy Recovery Tables - 2016

**Table 6.5.6.1-1 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Less than 8000 Hours per Year**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>% Outdoor Air at Full Design Airflow Rate</th>
<th>Design Supply Fan Airflow Rate, cfm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥10% and &lt;20%</td>
<td>≥20% and &lt;30%</td>
</tr>
<tr>
<td>3B, 3C, 4B, 4C, 5B</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>0B, 1B, 2B, 5C</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>6B</td>
<td>≥28,000</td>
<td>≥26,500</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4A, 5A, 6A</td>
<td>≥26,000</td>
<td>≥16,000</td>
</tr>
<tr>
<td>7, 8</td>
<td>≥4500</td>
<td>≥4000</td>
</tr>
</tbody>
</table>

NR—Not required

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**Table 6.5.6.1-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Greater than or Equal to 8000 Hours per Year**

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>% Outdoor Air at Full Design Airflow Rate</th>
<th>Design Supply Fan Airflow Rate, cfm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≥10% and &lt;20%</td>
<td>≥20% and &lt;30%</td>
</tr>
<tr>
<td>3C</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>0B, 1B, 2B, 3B, 4C, 5C</td>
<td>NR</td>
<td>≥19,500</td>
</tr>
<tr>
<td>0A, 1A, 2A, 3A, 4B, 5B</td>
<td>≥2500</td>
<td>≥2000</td>
</tr>
<tr>
<td>4A, 5A, 6A, 6B, 7, 8</td>
<td>≥200</td>
<td>≤130</td>
</tr>
</tbody>
</table>

NR—Not required
**TRANSFER AIR (6.5.7.1) - 2016**

**Section objective:** Reduce treatment of OA by minimizing required make-up.

**6.5.7.1** Conditioned supply air delivered to any space with mechanical exhaust shall not exceed the greater of:

a. the supply flow required to meet the space heating or cooling load;

b. the required ventilation rate; or

c. the mechanical exhaust flow minus the available transfer air from conditioned spaces or return air plenums on the same floor...
Hydronic Systems
**VARIABLE FLOW PUMPING REQUIREMENTS (6.5.4.2) - 2016**

2013 requirements were clarified in 2016 to apply to both heating and chilled water pump systems:
- Variable flow pumping required by HP based on climate zone and # of control valves (>3)
- Min. flow $\leq 25\%$ design flow
- $50\%$ flow @ $30\%$ design power or less

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**Table 6.5.4.2 Pump Flow Control Requirements**

<table>
<thead>
<tr>
<th>Chilled-Water Pumps in These Climate Zones</th>
<th>Heating Water Pumps in These Climate Zones</th>
<th>Motor Nameplate Horsepower</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A, 0B, 1A, 1B, 2B</td>
<td>NR</td>
<td>$\geq 2$ hp</td>
</tr>
<tr>
<td>2A, 3B</td>
<td>NR</td>
<td>$\geq 3$ hp</td>
</tr>
<tr>
<td>3A, 3C, 4A, 4B</td>
<td>7, 8</td>
<td>$\geq 5$ hp</td>
</tr>
<tr>
<td>4C, 5A, 5B, 5C, 6A, 6B</td>
<td>3C, 5A, 5C, 6A, 6B</td>
<td>$\geq 7.5$ hp</td>
</tr>
<tr>
<td>4A, 4C, 5B</td>
<td>4C, 5A</td>
<td>$\geq 10$ hp</td>
</tr>
<tr>
<td>4B</td>
<td>4B</td>
<td>$\geq 15$ hp</td>
</tr>
<tr>
<td>7, 8</td>
<td>2A, 2B, 3A, 3B</td>
<td>$\geq 25$ hp</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>$\geq 100$ hp</td>
</tr>
</tbody>
</table>
The following figure applies to both chillers and boilers.

Figure courtesy ASHRAE 90.1, 2013 Users Manual
CHILLED WATER COIL SELECTION
(6.5.4.7) - 2016

Chilled water coil must be selected for design conditions with:
- $DT \geq 15^\circ F$
- $LWT \geq 57^\circ F$

Exceptions to 6.5.4.7

1. Chilled-water cooling coils that have an air-side pressure drop exceeding 0.70 in. of water when rated at 500 fpm face velocity and dry conditions (no condensation).
2. Individual fan-cooling units with a design supply airflow rate 5000 cfm and less.
3. Constant-air-volume systems.
4. Coils selected at the maximum temperature difference allowed by the chiller.
5. Passive coils (no mechanically supplied airflow).
6. Coils with design entering chilled-water temperatures of 50°F and higher.
7. Coils with design entering air dry-bulb temperatures of 65°F and lower.
COMPUTER ROOM COOLING (DATA CENTERS)
CRAC Units - 2010

90.1 Scope Changed in 2010

- Included equipment for process cooling
- CRAC Unit requirements are scattered throughout the standard
  - Variable air flow
  - Humidification
  - Dehumidification
  - Efficiencies
  - Economizer
Water economizer requirements have changed
- Table 6.5.1.2.1 provides ambient conditions at which the water economizer must satisfy 100% of the cooling load
SECTION 6.6 - 2013

Computer Rooms (and Data Centers) may use Section 6.6 as an alternative compliance path using PUE

PUE: Power Usage Effectiveness

Reference: Recommendations for Measuring and Reporting Overall Data Center Efficiency v2 17 May 2011, The Green Grid
SECTION 6.6 - 2013

\[ \text{PUE}_1 \leq \text{Table 6.6.1} \]

or

\[ \text{PUE}_0 \leq \text{Table 6.6.1} \]

\[
\text{PUE}_1 = \frac{\text{Computer Room Energy}}{\text{IT Equipment Energy}}
\]

*Hourly Annual Energy Consumption using Appendix G*

\[
\text{PUE}_0 = \frac{\text{Computer Room Power}}{\text{IT Equipment Power}}
\]

*Peak Power Demand using Outdoor Design Cooling Conditions at 100% and 50% IT Equipment Power*

<table>
<thead>
<tr>
<th>Climate Zone</th>
<th>PUE$^a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0A</td>
<td>1.64</td>
</tr>
<tr>
<td>0B</td>
<td>1.62</td>
</tr>
<tr>
<td>1A</td>
<td>1.61</td>
</tr>
<tr>
<td>1B</td>
<td>1.53</td>
</tr>
<tr>
<td>2A</td>
<td>1.49</td>
</tr>
<tr>
<td>2B</td>
<td>1.45</td>
</tr>
<tr>
<td>3A</td>
<td>1.41</td>
</tr>
<tr>
<td>3B</td>
<td>1.42</td>
</tr>
<tr>
<td>3C</td>
<td>1.39</td>
</tr>
<tr>
<td>4A</td>
<td>1.36</td>
</tr>
<tr>
<td>4B</td>
<td>1.38</td>
</tr>
<tr>
<td>4C</td>
<td>1.38</td>
</tr>
<tr>
<td>5A</td>
<td>1.36</td>
</tr>
<tr>
<td>5B</td>
<td>1.33</td>
</tr>
<tr>
<td>5C</td>
<td>1.36</td>
</tr>
<tr>
<td>6A</td>
<td>1.34</td>
</tr>
<tr>
<td>6B</td>
<td>1.33</td>
</tr>
<tr>
<td>7</td>
<td>1.32</td>
</tr>
<tr>
<td>8</td>
<td>1.30</td>
</tr>
</tbody>
</table>

*Note:* PUE0 and PUE1 shall not include energy for battery charging.
P A S T  9 0 . 1  P E R F O R M A N C E  P A T H S

Standard 90.1 – 2013 and older
COMPLIANCE WITH STANDARD 90.1

Through 2013 Standard 90.1 only Two Paths for Compliance:

Prescriptive

Performance – (ECB)
ECB – Dependent Baseline

- Current Performance Path
- Baseline is **Dependent** on the Proposed Design
- Baseline matches the proposed design in most ways, except backed down to prescriptive limits

### Baseline Modeling Assumption

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Energy Cost Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window Area</td>
<td>Matches proposed design (up to 40%)</td>
</tr>
<tr>
<td>HVAC System Type</td>
<td>Matches proposed design</td>
</tr>
<tr>
<td>HVAC System Sizing</td>
<td>Matches proposed design</td>
</tr>
<tr>
<td>Orientation</td>
<td>Matches proposed design</td>
</tr>
<tr>
<td>Fan power</td>
<td>Matches proposed design (up to limit)</td>
</tr>
<tr>
<td>Air Tightness</td>
<td>Matches proposed design</td>
</tr>
<tr>
<td>Use of Thermal Mass</td>
<td>Matches proposed design</td>
</tr>
</tbody>
</table>
APPENDIX G – PERFORMANCE RATING METHOD

- Performance path similar to Energy Cost Budget, but more flexible
- Not for code compliance (prior to 2016)
- Used for beyond code programs
  - LEED
  - ASHRAE Standard 189.1
  - International Green Construction Code (IgCC)
  - EPACT Tax Credits
  - Federal Energy Management Program (FEMP)
Appendix G – Independent Baseline

- Baseline is more **Independent** on the Proposed Design
- Design parameters set at standard practice.
- Offers more credit for good design choices

<table>
<thead>
<tr>
<th>Design Parameter</th>
<th>Energy Cost Budget</th>
<th>Appendix G</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window Area</td>
<td>Matches proposed design (up to 40%)</td>
<td>Set at standard practice based on building type</td>
</tr>
<tr>
<td>HVAC System Type</td>
<td>Matches proposed design</td>
<td>Set at standard practice based on building type and climate zone</td>
</tr>
<tr>
<td>HVAC System Sizing</td>
<td>Matches proposed design</td>
<td>Set at standard practice</td>
</tr>
<tr>
<td>Orientation</td>
<td>Matches proposed design</td>
<td>Neutral (average of 4 rotations)</td>
</tr>
<tr>
<td>Fan power</td>
<td>Matches proposed design (up to limit)</td>
<td>Set at standard practice</td>
</tr>
<tr>
<td>Air Tightness</td>
<td>Matches proposed design</td>
<td>Set at standard practice</td>
</tr>
<tr>
<td>Use of Thermal Mass</td>
<td>Matches proposed design</td>
<td>Set at standard practice</td>
</tr>
</tbody>
</table>
MULTIPLE PERFORMANCE RULESETS FOR CODES AND BEYOND CODE PROGRAMS
Through 2013, baseline is a moving target.

Baseline stringency changes with each new version of the Standard.

Which is better?
- 40% below 2004 or
- 30% below 2007?
FUTURE 90.1 PERFORMANCE PATHS

Standard 90.1 – 2016 and beyond
Addendum BM – 3rd Compliance Path

- New Compliance Path for 2016
  1. Prescriptive
  2. Energy Cost Budget
  3. Appendix G

4.2 Compliance
4.2.1 Compliance Paths
4.2.1.1 New Buildings

New buildings shall comply with either the provisions of

a. Section 5, Building Envelope; Section 6, Heating, Ventilating, and Air Conditioning; Section 7, Service Water Heating; Section 8, Power; Section 9, Lighting; and Section 10, Other Equipment, or
b. Section 11, Energy Cost Budget Method, or
ADDENDUM BM – 3RD COMPLIANCE PATH

- Requires a Performance Cost Index (PCI) specific to building type and climate zone

Performance Cost Index (PCI) = \frac{\text{Proposed Building Performance}}{\text{Baseline Building Performance}}

- Performance Cost Index of 1.0 = baseline building
- Performance Cost Index of 0.0 = zero net energy
- For compliance, PCI < PCI_t
- PCI_t specific for building type, climate zone, and proportion of regulated loads: unregulated load

\[ PCI_t = \frac{(BBUEC + (BPF \cdot BBREC))}{BBP} \]
ADDENDUM BM – 3RD COMPLIANCE PATH

Minimum Building Performance Factor is dependent upon building type and climate zone

Table 4.2.1.1 Building Performance Factor (BPF)

<table>
<thead>
<tr>
<th>Building Area Type</th>
<th>Climate Zone</th>
<th>0A and 1A</th>
<th>0B and 1B</th>
<th>2A</th>
<th>2B</th>
<th>3A</th>
<th>3B</th>
<th>3C</th>
<th>4A</th>
<th>4B</th>
<th>4C</th>
<th>5A</th>
<th>5B</th>
<th>5C</th>
<th>6A</th>
<th>6B</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multifamily</td>
<td></td>
<td>0.73</td>
<td>0.73</td>
<td>0.71</td>
<td>0.69</td>
<td>0.74</td>
<td>0.73</td>
<td>0.68</td>
<td>0.78</td>
<td>0.81</td>
<td>0.81</td>
<td>0.76</td>
<td>0.80</td>
<td>0.81</td>
<td>0.76</td>
<td>0.79</td>
<td>0.74</td>
<td>0.80</td>
</tr>
<tr>
<td>Healthcare/hospital</td>
<td></td>
<td>0.64</td>
<td>0.56</td>
<td>0.60</td>
<td>0.56</td>
<td>0.60</td>
<td>0.56</td>
<td>0.54</td>
<td>0.57</td>
<td>0.53</td>
<td>0.55</td>
<td>0.59</td>
<td>0.52</td>
<td>0.55</td>
<td>0.57</td>
<td>0.52</td>
<td>0.56</td>
<td>0.56</td>
</tr>
<tr>
<td>Hotel/motel</td>
<td></td>
<td>0.64</td>
<td>0.65</td>
<td>0.62</td>
<td>0.60</td>
<td>0.63</td>
<td>0.65</td>
<td>0.64</td>
<td>0.62</td>
<td>0.62</td>
<td>0.60</td>
<td>0.61</td>
<td>0.60</td>
<td>0.59</td>
<td>0.61</td>
<td>0.57</td>
<td>0.58</td>
<td>0.58</td>
</tr>
<tr>
<td>Office</td>
<td></td>
<td>0.58</td>
<td>0.62</td>
<td>0.57</td>
<td>0.62</td>
<td>0.60</td>
<td>0.64</td>
<td>0.54</td>
<td>0.58</td>
<td>0.60</td>
<td>0.61</td>
<td>0.58</td>
<td>0.61</td>
<td>0.61</td>
<td>0.58</td>
<td>0.61</td>
<td>0.57</td>
<td>0.61</td>
</tr>
<tr>
<td>Restaurant</td>
<td></td>
<td>0.62</td>
<td>0.62</td>
<td>0.58</td>
<td>0.61</td>
<td>0.60</td>
<td>0.61</td>
<td>0.58</td>
<td>0.55</td>
<td>0.60</td>
<td>0.62</td>
<td>0.58</td>
<td>0.60</td>
<td>0.63</td>
<td>0.60</td>
<td>0.65</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Retail</td>
<td></td>
<td>0.52</td>
<td>0.58</td>
<td>0.53</td>
<td>0.58</td>
<td>0.54</td>
<td>0.62</td>
<td>0.60</td>
<td>0.55</td>
<td>0.60</td>
<td>0.60</td>
<td>0.55</td>
<td>0.61</td>
<td>0.55</td>
<td>0.58</td>
<td>0.53</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>School</td>
<td></td>
<td>0.46</td>
<td>0.53</td>
<td>0.47</td>
<td>0.53</td>
<td>0.49</td>
<td>0.52</td>
<td>0.50</td>
<td>0.49</td>
<td>0.50</td>
<td>0.49</td>
<td>0.50</td>
<td>0.50</td>
<td>0.49</td>
<td>0.50</td>
<td>0.47</td>
<td>0.51</td>
<td></td>
</tr>
<tr>
<td>Warehouse</td>
<td></td>
<td>0.51</td>
<td>0.52</td>
<td>0.56</td>
<td>0.58</td>
<td>0.57</td>
<td>0.59</td>
<td>0.63</td>
<td>0.58</td>
<td>0.60</td>
<td>0.63</td>
<td>0.60</td>
<td>0.61</td>
<td>0.65</td>
<td>0.66</td>
<td>0.66</td>
<td>0.67</td>
<td>0.67</td>
</tr>
<tr>
<td>All others</td>
<td></td>
<td>0.62</td>
<td>0.61</td>
<td>0.55</td>
<td>0.57</td>
<td>0.56</td>
<td>0.61</td>
<td>0.59</td>
<td>0.58</td>
<td>0.57</td>
<td>0.61</td>
<td>0.57</td>
<td>0.57</td>
<td>0.61</td>
<td>0.56</td>
<td>0.56</td>
<td>0.53</td>
<td>0.52</td>
</tr>
</tbody>
</table>
Appendix G - Fixed Baseline

Baseline set ~ 90.1-2004

- Intent is that the stringency of the baseline doesn’t change
- PCI target changes with each version of a code
- Beyond code programs can choose a PCI to meet their needs
ADDENDUM BM – APPENDIX G – ONE RULESET FOR MANY PURPOSES

- Higher possibility for automated baseline creation
- One model for multiple purposes
- Simpler, less costly, less opportunity for error
ADDENDUM BM SUMMARY

Standard 90.1-2016 Appendix G benefits:

- Increased flexibility with new third option for compliance
- Saves time and money dedicated to energy modeling by allowing a single modeling approach to be used for multiple functions
- Encourages production of tools to automate baseline building creation
- Provides credit for good design practice not recognized by previous compliance paths
SUMMARY
SUMMARY

Changes covered:
- Equipment Efficiency
- Controls
- Fan Power/Efficiency
- Exhaust Air Energy Recovery
- Hydronic Systems
- Computer Room Cooling
- Appendix G Compliance Path
THANK YOU

Questions?