Thank you!

This presentation includes video clips filmed on site at building construction projects. We would like to extend our thanks to the Ben Franklin Transit District of Richland, WA and the Columbia Basin College of Pasco, WA for their generous time and flexibility in allowing us to film onsite.
The purpose of this training is to provide the tools needed and specific training to evaluate compliance with ASHRAE 90.1-07 for commercial buildings. It will also provide useful training for the commercial provisions of the 2009 IECC and general commercial field inspection for energy code compliance of commercial buildings. The recommended background for taking this class is significant experience with plan review and/or inspection of commercial buildings.

With the goal of providing complete and engaging materials, this presentation includes essential videos on plan review.

- The presentation is not complete without the video clips, hyperlinks are included on the appropriate slides. They can be viewed if you have windows media player, or comparable software.

- If you are downloading the materials to your computer, the presentation and clips must be kept in the same folder.

Feedback on these materials is welcome, and should be directed to techsupport@bepc.pnl.gov. Please note the title of the training materials in the subject line.
Training Outline

- Objectives and Benefits of Adopting Building Energy Codes and Ensuring Compliance
- Compliance Evaluation Procedures
  - Sample Populations
  - Sample Size
  - Sample Distribution
  - Sample Makeup
  - Assigning Compliance Rates
    - Individual Building Metrics
    - State Compliance Rates
- Using the Evaluation Checklists
Energy Use in Buildings

U.S. Energy Use

- Industry: 27%
- Transportation: 34%
- Buildings: 39%
Reduced energy consumption by approximately 0.5-quadrillion Btu per year by 2015, and 3.5-quadrillion Btu per year by 2030.

Reduced CO₂ emissions by roughly 3 percent in terms of the projected national CO₂ emissions in 2030.

Rising cost savings more than $4 billion per year back in homeowners’ pockets by 2015, a figure that could rise to over $30 billion per year by 2030.

$1 spent in compliance and enforcement work saves $6 over life of a buildinga
Baseline: IECC and ASHRAE 90.1

Both IECC and ASHRAE 90.1 apply, either used to comply.
Both IECC and ASHRAE 90.1 apply, ASHRAE 90.1 likely used.
Compliance Evaluation Procedures

- 44 new residential, 44 ± commercial, and 44 each of renovations to existing residential and commercial
- Distributed throughout state based on climate zone and population
- Distributed over a representative sample of different building sizes and uses
• Evaluating compliance of four distinct building populations:
  - Residential new construction
  - Commercial new construction
  - Residential renovations
  - Commercial renovations

**Commercial Renovations:** Any work on or in existing commercial buildings where all or part of the work being performed is required to meet code and for which a permit was issued, including additions, alterations, and repairs.
Compliance Evaluation Procedures
Sample Size

44

plus/minus for sample
Compliance Evaluation Procedures

Sample Size – New Commercial

- Small: 1-2 stories, single zone, up to 25,000 ft$^2$
- Medium: Larger than 25,000 ft$^2$ but smaller than 60,000 ft$^2$
- Large: Larger than 60,000 ft$^2$ but smaller than 250,000 ft$^2$
- X-Large: Larger than 250,000 ft$^2$ but smaller than 400,000 ft$^2$
- XX-Large: Larger than 400,000 ft$^2$

a. Gross square footage of conditioned space
• Reasonable Cross Section of Building
  ▪ Type – New/Renovation
  ▪ Use – Office/Retail
  ▪ Ownership – Tenants/Owners
  ▪ Design/Materials
Evaluated buildings are each assigned a compliance rating of 0–100% based on the proportion of code requirements that each has met, and the evaluated buildings’ scores within a state are averaged to derive an overall compliance metric with an associated confidence.
### Compliance Evaluation Procedures

**Generating Buildings/Data**

1. Address for various compliance approaches
   - Prescriptive
   - Trade-Off
   - Performance

2. Divided into phases of construction
3. Code requirements are divided into tiers based on energy impact
4. Record values and capture comments, including generic information (building type, use, size, etc.)

---

#### Commercial Building Data Collection Checklist

ANSI/ASHRAE/IESNA Standard 90.1-2007

<table>
<thead>
<tr>
<th>Building ID</th>
<th>Plant Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Name of Evaluator(s):</td>
</tr>
<tr>
<td>Building Contact</td>
<td>Name:</td>
</tr>
<tr>
<td>Building Name &amp; Address:</td>
<td>Conditioned Floor Area:</td>
</tr>
<tr>
<td>State:</td>
<td>Jurisdiction:</td>
</tr>
<tr>
<td>Compliance Approach (check all that apply):</td>
<td>Prescriptive</td>
</tr>
<tr>
<td>Compliance Software Used:</td>
<td>Green Building/Above-Code Program?</td>
</tr>
<tr>
<td>Building Use:</td>
<td>Commercial/Industrial</td>
</tr>
<tr>
<td>Building Ownership:</td>
<td>Owner's Contact:</td>
</tr>
<tr>
<td>Project Type:</td>
<td>New Building</td>
</tr>
</tbody>
</table>

---

#### 90.1-2007

<table>
<thead>
<tr>
<th>Section #</th>
<th>Plan Review</th>
<th>Complies</th>
<th>Comments/Assumptions¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.2</td>
<td>Plans describe individual components in which compliance can be determined for the building envelope and delineate and document where exceptions to the standard are claimed.</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>4.2.6.4.2</td>
<td>Plans, specifications, and/or calculations provide all information with which compliance can be determined for the mechanical systems and equipment and delineate and document where exceptions to the standard are claimed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2.7.4.1</td>
<td>Plans, specifications, and/or calculations provide all</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

1. www.energycodes.gov/training

---

**Building Energy Codes University**
The checklists can be used to gather data during different stages of construction on different buildings that have the same general attributes.
**Commercial Building Data Collection Checklist**

ANSI/ASHRAE/IESNA Standard 90.1-2007

<table>
<thead>
<tr>
<th>Building ID:</th>
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</tr>
<tr>
<td>State:</td>
<td>County:</td>
</tr>
<tr>
<td>Jurisdiction:</td>
<td></td>
</tr>
<tr>
<td>Compliance Approach (check all that apply):</td>
<td>Prescriptive</td>
</tr>
<tr>
<td>Compliance Software Used:</td>
<td>Green Building/Above-Code Program? Yes No</td>
</tr>
<tr>
<td>Building Use:</td>
<td>Office</td>
</tr>
<tr>
<td>Restaurant/Dining/Fast Food</td>
<td>Public Assembly/Religious</td>
</tr>
<tr>
<td>Building Ownership:</td>
<td>State-owned</td>
</tr>
<tr>
<td>Project Type:</td>
<td>New Building</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>90.1-2007 Section #</th>
<th>Plan Review</th>
<th>Complies</th>
<th>Comments/Assumptions¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.2 [PR1]¹</td>
<td>Plans and/or specifications provide all information with which compliance can be determined for the <strong>building envelope</strong> and delineate and document where exceptions to the standard are claimed.</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>4.2.2, 6.4.2 [PR21]¹</td>
<td>Plans, specifications, and/or calculations provide all information with which compliance can be determined for the <strong>mechanical systems and equipment</strong> and delineate and document where exceptions to the standard are claimed.</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>4.2.2, 7.4.1</td>
<td>Plans, specifications, and/or calculations provide all</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>
# Using the Evaluation Checklists

## Commercial Building Data Collection Checklist

**ANSI/ASHRAE/IESNA Standard 90.1-2007**

### Form Fields

- **Building ID:**
- **Climate Zone:**
- **Date:**
- **Name of Evaluator(s):**
- **Phone:**
- **Email:**
- **Building Name & Address:**
- **State:**
- **County:**
- **Jurisdiction:**
- **Compliance Approach (check all that apply):**
  - [ ] Prescriptive
  - [ ] Trade-Off
  - [ ] Performance
- **Compliance Software Used:**
- **Building Use:**
  - [ ] Office
  - [ ] Retail/Mercantile
  - [ ] Warehouse/Storage
  - [ ] Education/School
  - [ ] Lodging/Hotel/Motel
  - [ ] Restaurant/Dining/Fast Food
  - [ ] Public Assembly
  - [ ] Healthcare
  - [ ] High-Rise Residential
  - [ ] Other
- **Building Ownership:**
  - [ ] State-owned
  - [ ] Locally-owned
  - [ ] Federal
  - [ ] Internal account
  - [ ] Speculative
  - [ ] Other
- **Project Type:**
  - [ ] New Building
  - [ ] Existing Building Addition
  - [ ] Existing Building Renovation
  - [ ] Other
  - [ ] Valuation (If Renovation): $______

### Plan Review Stages

#### Plan Review

- Footing and Foundation
- Framing/Rough-In
- Plumbing Rough-In
- Mechanical Rough-In

### 90.1-2007 Section #

| Section # | Plan Review | Y | N | N/A | Comments/Assumptions
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2.2.0.4.2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2.2.7.4.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Building Energy Codes University**

[www.energycodes.gov/training](http://www.energycodes.gov/training)
• Plans and specs document compliance for
  • Building envelope
  • Mechanical systems and equipment
  • Service water heating systems and equipment
  • Lighting and electrical systems and equipment
• Detailed instructions for HVAC systems commissioning included on the plans for specifications
• Construction documents require HVAC “as-built” drawings submitted within 90 days of system acceptance
4.2.2, 7.4.1 [PR3]¹

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.2, 7.4.1 [PR3]¹</td>
<td>Plans, specifications, and/or calculations provide all information with which compliance can be determined for the service water heating systems and equipment and delineate and document where exceptions to the standard are claimed.</td>
</tr>
</tbody>
</table>
Where Do You Start?

- Step 1 - Identify the type of system
  - Heat and cool source
  - Air distribution system
- Step 2 – Determine the provisions that apply to that system
- Step 3 – Review the Mechanical Plans and specifications to determine if the provisions have been addressed
Using the Evaluation Checklist
Plan Review - HVAC Systems

- Components that are easy to verify
  - Equipment sizes and efficiencies
  - Motor types (e.g., variable frequency drives)
  - Economizers
- Components that are difficult to verify
  - Control requirements (e.g., temperature reset for chillers and boilers)
Energy for Lighting in Buildings

• Accounts for nearly one-third of energy use
• Contributes significantly to cooling load

| 4.2.2, 8.4.1.1, 8.4.1.2 [PR4]| Plans and/or specifications provide all information with which compliance can be determined for the **lighting and electrical systems and equipment** and delineate and document where exceptions to the standard are claimed. Information provided should include interior and exterior lighting power calculations, wattage of bulbs and ballasts, transformers and control devices. |
### Additional Evaluation Checklist Plan Review Items

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.7.2.1 [PR5]¹</td>
<td>Construction documents require HVAC “as-built” drawings submitted within 90 days of system acceptance.</td>
</tr>
<tr>
<td>6.7.2.4 [PR6]¹</td>
<td>Detailed instructions for HVAC systems commissioning included on the plans or specifications for ≥50,000 ft².</td>
</tr>
<tr>
<td>8.7.1, 8.7.2 [PR7]¹</td>
<td>Construction documents require as-built drawings for electric power systems and O&amp;M manual for electrical power systems and equipment.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Footing/Foundation Field Inspection

- Exterior insulation protected against damage, sunlight, moisture, wind, landscaping, and equipment maintenance activities.
- Insulation in contact with the ground has ≤0.3% water absorption rate per ASTM C272.
- Piping, ducts, and plenum are insulated and sealed when installed in or under a slab.
- Any SWH piping in or under slab is insulated.
- Below-grade wall insulation R-value. Installed per manufacturer’s instructions.
- Slab edge insulation R-value, depth/length. Installed per manufacturer’s instructions.
- Freeze protection and snow/ice melting system sensors for future connection to controls.

<table>
<thead>
<tr>
<th>Code Section</th>
<th>Description</th>
<th>Verified Value</th>
<th>Complies</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5.3.5.5</td>
<td>Exterior insulation protected against damage</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>6.3.2.2</td>
<td>Insulation in contact with the ground has ≤0.3% water absorption rate per ASTM C272</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>6.4.4.2</td>
<td>Piping, ducts, and plenum are insulated and sealed</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>7.4.3</td>
<td>Any SWH piping in or under slab is insulated</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>8.5.3.5</td>
<td>Below-grade wall insulation R-value, depth/length. Installed per manufacturer’s instructions.</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>9.1.2</td>
<td>Slab edge insulation R-value, depth/length. Installed per manufacturer’s instructions.</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>9.3.1.2</td>
<td>Freeze protection and snow/ice melting system sensors for future connection to controls</td>
<td>N</td>
<td>N</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Exterior insulation protected against damage, sunlight, moisture, wind, landscaping and equipment maintenance activities.
Insulation in contact with the ground has ≤0.3% water absorption rate per ASTM C272.
### Using the Evaluation Checklists

**Insulation in or under Slab- Footings/Foundations**

<table>
<thead>
<tr>
<th>Checklists</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.3.2, 6.4.4.1, 6.4.4.2 [FO3]**</td>
<td>Piping, ducts and plenum are insulated and sealed when installed in or under a slab.</td>
</tr>
<tr>
<td>6.5.8.2, 7.4.3 [FO4]**</td>
<td>Any SWH piping in or under slab is insulated.</td>
</tr>
<tr>
<td>5.5.3.3 [FO5]²</td>
<td>Below-grade wall insulation R-value.</td>
</tr>
<tr>
<td>----------------------</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td>5.8.1.2 [FO6]²</td>
<td>Below-grade wall insulation installed per manufacturer’s instructions.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists
Below-Grade Insulation - Walls

5.5.3.3 [FO5]\(^2\)  
Below-grade wall insulation R-value.

5.8.1.2 [FO6]\(^2\)  
Below-grade wall insulation installed per manufacturer’s instructions.

Photo courtesy of Dow Building Solutions
Slab edge insulation R-value, depth/length.

Slab edge insulation installed per manufacturer’s instructions.
Using the Evaluation Checklists
Framing Rough-In Inspection

- Roof insulation R-value provided
- Installed per manufacturer’s instructions
- Performance compliance approach submitted for vertical fenestration area >40% or skylight area >5%
- Vertical fenestration U-Factor
- Skylight fenestration U-Factor
- Vertical fenestration SHGC value
- Skylight SHGC value
- Fenestration products are certified as to performance labels or certificates provided
- Fenestration products rated in accordance with NFRC
- Fenestration and doors meet maximum air leakage requirements
- Vestibules installed per approved plans
Using the Evaluation Checklists

Glazing Video
Using the Evaluation Checklists

Roof Insulation R-Value

5.5.3.1 [FR1]  
Roof insulation R-value.

5.8.1.2 [FR2]  
Roof insulation installed per manufacturer’s instructions.
Using the Evaluation Checklists
Roof Insulation R-Value

Photos courtesy of MBMA

<table>
<thead>
<tr>
<th>5.5.3.1 [FR1](^1)</th>
<th>Roof insulation R-value.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8.1.2 [FR2](^1)</td>
<td>Roof insulation installed per manufacturer’s instructions.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Roof Insulation R-Value

5.5.3.1 [FR1]\(^1\)  
Roof insulation R-value.

5.8.1.2 [FR2]\(^1\)  
Roof insulation installed per manufacturer’s instructions.
Using the Evaluation Checklists
Buildings with >40% Fenestration

High Glass Buildings
• > 40% WWR
  or
• > 5% SRR
If exceeds must document compliance via performance

5.5.4.2.1, 5.5.4.2.2 [FR3]¹
Performance compliance approach submitted for vertical fenestration area >40% or skylight area >5%.
### Fenestration

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8.2.2 [FR8]¹</td>
<td>Fenestration products are certified as to performance labels or certificates provided.</td>
</tr>
<tr>
<td>5.8.2.1 [FR9]²</td>
<td>Fenestration products rated in accordance with NFRC.</td>
</tr>
</tbody>
</table>

#### World's Best Window Co.

**Millennium 2000**
*Vinyl-Clad Wood Frame, Double Glazing* • Argon Fill • Low E

**Product Type:** Vertical Slider

<table>
<thead>
<tr>
<th>ENERGY PERFORMANCE RATINGS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>U-Factor (U.S./I-P)</td>
<td>0.30</td>
</tr>
<tr>
<td>Solar Heat Gain Coefficient</td>
<td>0.30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ADDITIONAL PERFORMANCE RATINGS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Visible Transmittance</td>
<td>0.51</td>
</tr>
<tr>
<td>Air Leakage (U.S./I-P)</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer’s literature for other product performance information. [www.nfrc.org](http://www.nfrc.org)
Using the Evaluation Checklists
Fenestration Air Leakage

Exceptions:
- Field Fabricated
- Garage door test can be per ANSI/DASMA Standard 105

World's Best Window Co.
Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing • Argon Fill • Low-E
Product Type: Vertical Slider

<table>
<thead>
<tr>
<th>ENERGY PERFORMANCE RATINGS</th>
<th>ADDITIONAL PERFORMANCE RATINGS</th>
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<tr>
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</tr>
<tr>
<td>0.51</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information.

5.4.3.2 [FR10]³
Fenestration and doors meet maximum air leakage requirements.
### Vestibules installed per approved plans.

| 5.4.3.4 [FR11]³ | Vestibules installed per approved plans. |
Using the Evaluation Checklists
Plumbing and Rough-In Inspection

• Automatic time switches installed to automatically switch off the recirculating hot-water system or heat trace
• Pump controls installed to limit operation of recirculating pumps
• Piping for recirculating and non-recirculating service hot-water systems insulated
• Heat traps installed on non-circulating storage water tanks

<table>
<thead>
<tr>
<th>90.1.1(c)</th>
<th>Plumbing Rough-In Inspection</th>
<th>Complies</th>
<th>Comments/Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.4.4.2 [PL1]</td>
<td>Automatic time switches installed to automatically switch off the recirculating hot-water system or heat trace.</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>7.4.4.4 [PL2]</td>
<td>Pump controls installed to limit operation of recirculating pumps</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>7.4.3 [PL3]</td>
<td>Piping for recirculating and non-recirculating service hot-water systems insulated.</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>7.4.6 [PL4]</td>
<td>Heat traps Installed on non-circulating storage water tanks</td>
<td>Y N N/A</td>
<td></td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists
Recirculating Controls

| 7.4.4.2 [PL1]¹ | Automatic time switches installed to automatically switch off the recirculating hot-water system or heat trace. |
| 7.4.4.4 [PL2]¹ | Pump controls installed to limit operation of recirculating pumps |
Using the Evaluation Checklists

Mechanical Rough-In Inspection

- Demand control ventilation provided for spaces >500 ft² and >40 people/1000 ft² occupant density and served by systems with air side economizer, auto modulating outside air damper control or design airflow >3,000 cfm
- Insulation exposed to weather protected from damage. Insulation outside of the conditioned space and associated with cooling systems is vapor retardant
- Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control
- Means provided to relieve excess outside air
- Water economizers provided where required, meet the requirements for design capacity, maximum pressure drop and integrated economizer control and heating system impact
Demand control ventilation correlates the volume of outside (fresh) air to the actual occupancy load of the space by monitoring carbon dioxide levels in the air. When a room is occupied for a period of time and carbon dioxide levels rise, the sensors trigger increased outdoor air into the system.

6.4.3.9
[ME1] Demand control ventilation provided for spaces >500 ft\(^2\) and >40 people/1000 ft\(^2\) occupant density and served by systems with air side economizer, auto modulating outside air damper control or design airflow >3,000 cfm.
HVAC System Insulation

• Insulation exposed to weather must be protected
• Insulation covering cooling systems outside the conditioned space should include vapor retardant

6.4.4.1.1 [ME2]¹ Insulation exposed to weather protected from damage. Insulation outside of the conditioned space and associated with cooling systems is vapor retardant.
Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control.
To prevent overpressurizing of the building, ensure systems include a means to relieve excess outdoor air during air economizer operations.

The relief air outlet should be located so that recirculation back into the building is avoided.
Using the Evaluation Checklists
Economizer Requirements

Economizer Types
Water Pre-cooling Water Economizer with Two-Way Valves

6.5.1.2, 6.5.1.2.1, 6.5.1.2.2, 6.5.1.3 [ME5]¹ C
Water economizers provided where required, meet the requirements for design capacity, maximum pressure drop and integrated economizer control and heating system impact.

6.5.1.4 [ME6]¹
Economizer operation will not increase heating energy use during normal operation.
Using the Evaluation Checklists
Exhaust Air Recovery System

6.5.6.1
[ME7]¹

Exhaust air energy recovery on systems ≥5,000 cfm and 70% of design supply outside air.
• VAV hood exhaust and supply systems,
• direct make-up air or heat recovery

6.5.7.2 [ME8]¹C
Fume hoods exhaust systems ≥15,000 cfm have VAV hood exhaust and supply systems, direct make-up air or heat recovery.
• Ensure the capacity of the hot gas bypass is limited as indicated in Table 6.5.9

• Hot gas bypass may only be used in cooling systems designed with multiple steps of unloading or continuous capacity modulation

<table>
<thead>
<tr>
<th>6.5.9 [ME9]^1 C</th>
<th>Hot gas bypass limited to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>≤240 kBtu/h – 50%</td>
</tr>
<tr>
<td></td>
<td>&gt;240 kBtu/h – 25%</td>
</tr>
</tbody>
</table>
6.4.1.4 [ME10]²

HVAC equipment efficiency verified.
• Piping Serving as Part of Heating or Cooling System Must be Insulated in Accordance with Table 6.8.3

**TABLE 6.8.3 Minimum Pipe Insulation Thickness**

<table>
<thead>
<tr>
<th>Fluid Design Operating Temp. Range (°F)</th>
<th>Insulation Conductivity</th>
<th>Nominal Pipe or Tube Size (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conductivity Btu/hr-ft²-°F</td>
<td>Mean Rating Temp. °F</td>
</tr>
<tr>
<td>Heating Systems (Steam, Steam Condensate, and Hot Water)b,c</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;350</td>
<td>0.32 – 0.34</td>
<td>250</td>
</tr>
<tr>
<td>251 – 350</td>
<td>0.29 – 0.32</td>
<td>200</td>
</tr>
<tr>
<td>201 – 250</td>
<td>0.27 – 0.30</td>
<td>150</td>
</tr>
<tr>
<td>141 – 200</td>
<td>0.25 – 0.29</td>
<td>125</td>
</tr>
<tr>
<td>105 – 140</td>
<td>0.22 – 0.28</td>
<td>100</td>
</tr>
<tr>
<td>Domestic and Service Hot-Water Systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>105+</td>
<td>0.22 – 0.28</td>
<td>100</td>
</tr>
<tr>
<td>Cooling Systems (Chilled Water, Brine, and Refrigerant)d</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 – 60</td>
<td>0.22 – 0.28</td>
<td>100</td>
</tr>
<tr>
<td>&lt;40</td>
<td>0.22 – 0.28</td>
<td>100</td>
</tr>
</tbody>
</table>

---

a For insulation outside the stated conductivity range, the minimum thickness (T) shall be determined as follows: 

\[ T = \frac{r}{r + 0.125 K} \] 

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/hr 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 Piping insulation is not required between the control valve and coil on run-outs when the control valve is located within 4 ft of the coil and the pipe size is 1 in. or less.

d These thicknesses are based on energy efficiency considerations only. Issues such as water vapor permeability or surface condensation sometimes require vapor retarders or additional insulation.

6.4.4.1.3 [ME13]²

HVAC piping insulated.
6.5.1.1.4
[ME15]²

Return air and outdoor air dampers meet minimum air leakage requirements.
Hydronic (water loop) Heat Pump Systems
- Heat pumps connected to heat pump water loop with heat rejection and heat addition
  - Controls capable of providing 20°F dead band between initiation of heat rejection and heat addition
  - Climate zones 3-8:
    - Closed-circuit cooling tower
      » Automatic valve to bypass all but minimal flow around tower, or
      » Provide lower leakage positive closure dampers
    - Open-circuit cooling tower
      » Automatic valve to bypass all heat pump water flow around the tower
    - Open-circuit used in conjunction with a separate heat exchanger
      » Heat loss to be controlled by shutting down the circulation pump on the cooling tower loop

6.5.2.2.3 [ME16]² C
Hydronic heat pump systems connected to a common water loop meet heat rejection and heat addition requirements.
Verify the fan motor is no larger than the first available motor size greater than the bhp, which must be shown on the design documents.
Using the Evaluation Checklists

VAV Fans

6.5.3.2.1 [ME18]² C
VAV fan motors ≥10 hp to be driven by mechanical or electrical variable speed drive, or have a vane-axial fan with variable pitch blades, or have controls or devices to limit fan motor demand to ≤30% of design wattage at 50% design air volume at static pressure of 1/3 total rated static pressure of the fan.

6.5.3.2.2 [ME19]² C
VAV fans have static pressure sensors positioned so setpoint ≤1/3 total design pressure.
Reset static pressure setpoint for DDC controlled VAV boxes reporting to central controller based on the zones requiring the most pressure.
Individual kitchen exhaust hoods larger than 5000 cfm must include make-up ≥50% of exhaust air volume.
Service water heating equipment meets efficiency requirements.
Using the Evaluation Checklists
Space and Water Heating

7.5.1 [ME23]² C
Combined space and water heating system not allowed unless standby loss less than calculated maximum. AHJ has approved or combined connected load <150 KBtu/h.
Service water heating equipment used for space heating complies with the service water heating equipment requirements.
Using the Evaluation Checklists

HVAC Ducts and Plenums Video
Using the Evaluation Checklists

Motorized Dampers

6.4.3.4.2, 6.4.3.4.3, 6.4.3.4.4

[ME27]^3

Outdoor air and exhaust systems have motorized dampers that automatically shut when not in use and meet maximum leakage rates. Check gravity dampers where allowed.
Using the Evaluation Checklists

Rough-In Electrical Inspection

- Verify separate lighting control devices for specific uses installed per approved lighting plans
- Exit signs do not exceed 5 watts per face
- Exterior grounds lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD
- Additional interior lighting power allowed for special functions per the approved lighting plans and is automatically controlled and separated from general lighting
- Feeder connectors sized in accordance with approved plans
- Branch circuits sized for maximum drop of 3%
- Automatic lighting control to shut off all building lighting installed in buildings >5,000 ft²
- Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants
- Automatic lighting controls for exterior lighting installed
- Electric motors meet requirements where applicable
- Ballasted one and three lamp fixtures with >30 W/lamp have two lamp tandem wired ballasts when >2 fixtures in same space on same control
9.4.1.4 [EL1]¹ Verify separate lighting control devices for specific uses installed per approved lighting plans.
| 9.4.3 [EL2] | Exit signs do not exceed 5 watts per face. |

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2. www.energycodes.gov/training
Using the Evaluation Checklists

Exterior Grounds Lighting Controls

9.4.4 [EL3] Exterior grounds lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD.
Additional interior lighting power allowed for special functions per the approved lighting plans and is automatically controlled and separated from general lighting.
• Verify feeder conductors are sized for a maximum voltage drop of 2% at design load
• Verify branch circuit conductors are sized for a maximum voltage drop of 3% at design load
9.4.1.1 [EL7]\(^2\)

Automatic lighting control to shut off all building lighting installed in buildings >5,000 ft\(^2\).
• Lighting controls required for each area enclosed by ceiling height partitions

• Switch locations
  ▪ In view of lights
  ▪ “On” or “off” indication from remote location

9.4.1.2 [EL8] ²

Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants.
Auto Controls Turn Lights off During Daylight Hours
- Photo Cell
- Automatic Time Switches
  - Seven Day/Seasonal Daylight Program
  - 10 hour Minimum Backup
- Exception
  - Covered vehicle entrances/exits or parking where security or safety is an issue.
Ensure that electric motors comply with Table 10.8, where applicable.

<table>
<thead>
<tr>
<th>TABLE 10.8 Minimum Nominal Efficiency for General Purpose Design A and Design B Motors&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum Nominal Full-Load Efficiency (%)</strong></td>
</tr>
<tr>
<td>Number of Poles ⇒</td>
</tr>
<tr>
<td>Synchronous Speed (RPM) ⇒</td>
</tr>
<tr>
<td>Motor Horsepower</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>1.5</td>
</tr>
</tbody>
</table>

10.4.1 [EL10]<sup>2</sup>

Electric motors meet requirements where applicable.
Insulation Inspection Checklist

- All sources of air leakage in building thermal envelope are sealed, caulked, gasketed or weather stripped to minimize air leakage
- Roof insulation R-value and installed per manufacturer’s instructions. Blown or poured loose-fill insulation is installed only where the roof slope is \(\leq 3\) in 12
- Above-grade wall insulation R-value and installed per manufacturer’s instructions
- Floor insulation R-value and installed per manufacturer’s instructions
- Insulation labeled with R-value or insulation certificate providing R-value and other relevant data
- Eaves are baffled to deflect air to above the insulation
- Insulation installed in substantial contact with the inside surface separating conditioned from unconditioned space
- Recessed equipment installed in building envelope assemblies does not compress the adjacent insulation
- Exterior insulation is protected from damage with a protective material
Using the Evaluation Checklists
Above-Grade Wall Insulation

Photos courtesy of Dow Building Solutions

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Using the Evaluation Checklists

Above-Grade Wall Insulation

Photos courtesy of Dow Building Solutions
Using the Evaluation Checklists
Above-Grade Wall Insulation
Using the Evaluation Checklists
Insulation Compression
Using the Evaluation Checklists
Insulation Compression
Using the Evaluation Checklists

Roof Insulation – Rigid Application

Photos courtesy of PIMA (Polyisocyanurate Insulation Manufacturers Association)
Eaves are baffled to deflect air to above the insulation.
5.8.1.5 [IN10] Insulation is installed in substantial contact with the inside surface separating conditioned space from unconditional space.

5.8.1.7 [IN12] Exterior insulation is protected from damage with a protective material.

5.8.1.7.1 [IN14] Attics and mechanical rooms have insulation protected where adjacent to attic or equipment access.
Foundation vents do not interfere with insulation.

5.8.1.7.2

\[IN13\]^2
High-albedo roofs meet solar reflectance of 0.70 and thermal remittance of 0.75 or SRI of 82.
Using the Evaluation Checklists

**Roof Insulation**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8.1.8</td>
<td>Roof Insulation not installed on suspended ceiling with removable panels.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists
Final Inspection Checklist

• Weatherseals installed on all loading dock cargo doors in Climate Zones 4-8
• An air and/or hydronic system balancing report is provided for HVAC systems serving zones >5,000 ft² of conditioned area
• Verify HVAC control systems have been tested to ensure proper operation, calibration and adjustment of controls
• Installed lamps and fixtures are consistent with what is shown on the approved lighting plans
• U-factor and air leakage of opaque doors associated with the building thermal envelope meets requirements
• Heating and cooling to each zone is controlled by a thermostat control

Temperature controls have the following features: dead band controls, setpoint overlap restrictions, off-hour controls, automatic shutdown, setback controls.

Systems with air capacity >10,000 cfm include optimum start controls
Climate zones 4 – 8
Equip cargo doors and loading dock doors with weatherseals to restrict infiltration

Weatherseals installed on all loading dock cargo doors in Climate Zones 4-8.
Verify the construction documents show the HVAC systems are balanced and a written report provided for all systems serving zones >5,000 ft² of conditioned area.

6.7.2.3 \[\text{FI2}]^1\text{C} \quad \text{An air and/or hydronic system balancing report is provided for HVAC systems serving zones >5,000 ft}^2\text{ of conditioned area.}
Verify HVAC control systems have been tested to ensure proper operation, calibration and adjustment of controls.
### Installed Lamps and Fixtures

Installed lamps and fixtures are consistent with what is shown on the approved lighting plans.

<table>
<thead>
<tr>
<th>9.1.3 [FI4]</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installed lamps and fixtures are consistent with what is shown on the approved lighting plans.</strong></td>
<td></td>
</tr>
</tbody>
</table>
Opaque Door Requirements

- Permanently installed nameplate on all manufactured doors showing U-factor and Air Leakage Rate
- Opaque doors must meet U-factor requirements of Tables 5.5-1 through 5.5-8

5.8.2.3, 5.5.3.6 [F15]^2

U-factor and air leakage of opaque doors associated with the building thermal envelope meets requirements.
Heating and cooling to each zone must be thermostatically controlled, based on temperatures within that zone.
Temperature Controls Must Include:

- Dead band controls,
- Set point overlap restrictions,
- Off-hour controls,
- Automatic shutdown,
- Setback controls.

Temperature controls have the following features: dead band controls, set point overlap restrictions, off-hour controls, automatic shutdown, setback controls.
Provides for:
Individual heating and cooling air distribution systems meeting the following criteria:

- A total design supply air capacity exceeding 10,000 cfm
- Served by one or more supply fans
- Control algorithm to be a function of space temp, occupied set point, and time prior to occupancy
Next Step - Data Submission

Checklist Consolidation and Scoring

• BECP will provide an online database and web form

• BECP will provide services to states for converting paper checklists to the electronic format
BECP – Your Resource

Additional resources, including:
- Code Notes
- Technical Assistance to Users
- Energy Codes 101
- Setting the Standard
- Training Materials
- Resource Center

Are available through the Building Energy Codes Program

www.energycodes.gov
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<td><strong>Status of State Energy Codes</strong></td>
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<td><strong>Building Energy Codes Knowledge Base</strong></td>
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<tr>
<td><strong>The Building Codes Assistance Project (BCAP)</strong></td>
</tr>
</tbody>
</table>