Michigan Energy Code Training and Implementation Program

4.0 Hour Commercial Program Course Number 16142
2009 Michigan Uniform Energy Code
Presenters

Michigan Commercial Energy Code Training and Implementation Program:

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Course Number: 16142

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Instructor # 1540

4 Hours Technical:
*BI, MI, or registrants with only BO/PR but no inspector registration*

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Project Support

Prepared by the School of Planning, Design and Construction at Michigan State University. Oversight provided by MSU faculty and the Center for Construction Project Performance Assessment and Improvement (C2P2ai).

Project Objectives

To train building officials, inspectors, builders, subcontractors, suppliers, engineers and architects in the revised Michigan energy code for the purpose of:

1. Increasing understanding
2. Improving compliance
3. Reducing administrative time
4. Improving customer relationships
Presentation Overview

• Need For Energy Codes
• Michigan Code Status
• 2009 MUEC\(^1\) and ASHRAE 90.1
• Compliance Tools\(^1\)
• COMcheck Software\(^2\)
• Additional Resources

\(^1\)As adapted from U.S. DOE provided instructional resources on ASHRAE 90.1—2007 with MI amendments

\(^2\)Based on U.S. DOE COMcheck training case study

[Links to related documents and resources]
The Need For Energy Codes

U.S. Energy Use

- Industry: 27%
- Transportation: 34%
- Buildings: 39%


http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
What Do Building Energy Codes and Standards Cover?

For both residential and commercial:

- Building Envelope
- Mechanical
- Service Water Heating
- Lighting
- Electrical Power

Project Objectives

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1. Increasing understanding
2. Improving compliance
3. Reducing administrative time
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Michigan Code Status
Michigan Code Status

**Status of State Energy Codes**

**Michigan**

*as of 2011-03-09*

Do you know if updates to the information on this page? If so, please [let us know](http://www.energycodes.gov/becu/trainers.stm).

**CURRENT NEWS**

The energy code in Michigan has been finalized. The new code will be the 2009 International Energy Conservation Code for residential dwellings and ASHRAE 90.1-2007 for commercial buildings. The code will go into effect in March 2011.

<table>
<thead>
<tr>
<th>RESIDENTIAL</th>
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<tbody>
<tr>
<td><strong>Residential Code</strong></td>
<td>2009 IECC</td>
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<td><strong>Approved Compliance Tools</strong></td>
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<tr>
<td><strong>Approximate Stringency</strong></td>
<td>As stringent as the 2008 IECC</td>
</tr>
<tr>
<td><strong>Effective Date</strong></td>
<td>March 1, 2011</td>
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<tr>
<td><strong>DOE Determination/State Certification</strong></td>
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<table>
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<th>COMMERCIAL</th>
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<tr>
<td><strong>Commercial Code</strong></td>
<td>ASHRAE 90.1-2007</td>
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<td><strong>MI Amendments</strong></td>
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<td><strong>Approved Compliance Tools</strong></td>
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<tr>
<td><strong>Approximate Stringency</strong></td>
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<tr>
<td><strong>DOE Determination/State Certification</strong></td>
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</table>
Code Status: Commercial

Commercial State Energy Code Status
AS OF MARCH 9, 2011

NOTE:
These maps reflect only mandatory statewide codes currently in effect.

http://bcap-ocean.org/code-status-commercial
Date visited: 2/11/2011
Residential State Energy Code Status
AS OF MARCH 9, 2011

Code Status: Residential

NOTE:
These maps reflect only mandatory statewide codes currently in effect.

http://bcap-ocean.org/code-status-residential

Date visited: 2/11/2011
Michigan Code Status


Rules to update the 2009 Michigan Uniform Energy Code (MUEC), Part 10 (Residential) and Part 10a (Commercial) were filed with the Secretary of State on November 8 and will be effective March 9, 2011. The rules will adopt the 2009 IECC with Michigan amendments and ASHRAE Standard 90.1-2007 (the MUEC is currently based on the 2003 IRC and ASHRAE 90.1-1999). The new codes were originally approved on July 20 by the Department of Energy, Labor & Economic Growth (DELEG) Bureau of Construction Codes.

A web link will be added to the Bureau's web site at www.michigan.gov/boc, via the Codes and Standards Order Form to allow customers to purchase the code book directly from the International Code Council (ICC) for $38.00. Books are now available.

More Information: MUEC: Residential & Commercial | Bureau of Construction Codes


Date visited: 3/15/2011
2009 Michigan Uniform Energy Code (MUEC)

Michigan Department of Labor & Economic Growth
Bureau of Construction Codes

Providing for Michigan’s Safety in the Built Environment

2009 Michigan Uniform Energy Code (MUEC)

DEPARTMENT OF ENERGY, LABOR, AND ECONOMIC GROWTH

DIRECTOR'S OFFICE

CONSTRUCTION CODE

Filed with the Secretary of State on November 8, 2010
These rules take effect March 9, 2011

(By authority conferred on the director of the department of energy, labor, and economic growth by section 4 of 1972 PA 230, MCL 125.1504, and Executive Reorganization Order Nos. 2003-1 and 2008-20, MCL 445.2011 and MCL 445.2025)

R 408.31087, R 408.31088, R 408.31089, and R 408.31090 of the Michigan Administrative Code are amended and R 408.31087a is added to the code as follows:

PART 10a
MICHIGAN UNIFORM ENERGY CODE

R 408.31087 Applicable code.
Rule 1087. Rules governing the energy efficiency for the design and construction of buildings and structures, not including residential buildings, shall be those contained in the international energy conservation code, 2009 edition, section 501.1 and the ASHRAE energy standard for buildings except low-rise residential buildings.
ANSI/ASHRAE/IESNA standard 90.1-2007 (hereafter the standard), including appendices A, B, C, and D. With the amendments noted. Section 501.1 of the international energy conservation code and the standard are adopted in these rules by reference. The Michigan uniform energy code is available for inspection or purchase at the Okemos office of the Michigan Department of Energy, Labor and Economic Growth, Bureau of Construction Codes, 2501 Woodlake Circle, Okemos, Michigan 48864, at a cost as of the time of adoption of these rules of $38.00 or may be purchased from the International Code Council, 500 New Jersey Avenue, N.W., 6th Floor, Washington, D.C. 20001. The ASHRAE 90.1-2007 standard is available for inspection at the Okemos office of the Michigan Department of Energy, Labor and Economic Growth, Bureau of Construction Codes. The standard may be purchased from the American Society of Heating, Refrigeration and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, NE, Atlanta, Georgia 30329, at a cost as of the time of adoption of these rules of $119.95 each. Copies may be obtained from the Michigan Department of Energy, Labor and Economic Growth, Bureau of Construction Codes, 2501 Woodlake Circle, Okemos, Michigan 48864, at a cost as of the time of adoption of these rules of $119.95 each plus the department’s cost for shipping and handling.


Date Visited: 2/11/2011

Presenters Note: Part 10a dependent on Part 10
Free Download of Standard 90.1-2007 Now Closed

Thank you for your interest in the free download of Standard 90.1-2007, which was made available by ASHRAE through funding from the U.S. Department of Energy.

25,000 copies of the standard are now in circulation as a result of the free download promotion, and the promotion has now come to a close.

To continue to advance ASHRAE and the Department of Energy's goal to reduce building energy use, ASHRAE is now offering the digital version of the standard at a reduced price of $19.00 for a limited time. This standard normally sells — both digitally and in print — for $119 (ASHRAE Member, $99).

To purchase your digital copy of Standard 90.1-2007 (I-P edition) at the reduced price please click on the link below.

- Purchase Standard 90.1-2007

ASHRAE 90.1—2007 available for download at a discounted rate made possible by the U.S. Dept. of Energy:
Code Compliance Software Tools

- **Prescriptive**
  - None Needed

- **Total Building “UA” Trade Off**
  - COMcheck Software
    - (Web-based & Desktop)

- **Energy Analysis**
  - **Software**
    - *For example:*
      - DOE-2 Software
      - Carrier H.A.P.
      - eQuest

Why is Standard 90.1-2007 Important?

• It replaces ANSI/ASHRAE/IESNA Standard 90.1-1999, used in Michigan until 9 March 2011
• It is the professional “standard of care” set by ASHRAE consensus

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Standard 90.1-2007

• Section 1 - Purpose
• Section 2 - Scope
• Section 3 - Definitions, Abbreviations, and Acronyms
• Section 4 - Administration and Enforcement
• Section 5 - Building Envelope
• Section 6 - Heating, Ventilating, and Air Conditioning
• Section 7 - Service Water Heating
• Section 8 - Power
• Section 9 - Lighting
• Section 10 - Other Equipment
• Section 11 - Energy Cost Budget Method
• Section 12 - Normative References

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Standard 90.1-2007 Appendices

• **A** Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations
• **B** Building Envelope Climate Criteria
• **C** Methodology for Building Envelope Trade-Off Option in Subsection 5.6
• **D** Climatic Data
• **E** Informative References
• **F** Addenda Description Information (Informative)
• **G** Performance Rating Method (Informative, LEED®)

Presenters Note:
Appendices E,F, and G have not been adopted by Michigan
Purpose *(Section 1)*

- To provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings
- MUEC residential provisions cover all low-rise (1-3 stories) houses, condos, townhouses, and apartments [R-2, R-3, R-4], but not hotels/motels [R-1]
Scope (Section 2)

(Section 2.1.a)

• New buildings and their systems
• New portions of buildings and their systems (additions)
• New systems and equipment in existing buildings (alterations)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Scope *(Section 2)*

- Envelope *(Section 2.2.a)*
  - if heated by a heating system with an output capacity \( \geq 3.4 \text{ Btu/h-ft}^2 \) (1 watt/ft\(^2\)) OR
  - if cooled by a cooling system with a sensible output capacity \( \geq 5 \text{ Btu/h-ft}^2 \)

- Virtually all mechanical, power, and lighting systems are covered *(Section 2.2.b)*
Scope Exceptions (*Section 2.3*)

- Too little heating or cooling
- Single-family, multifamily of three stories or less, manufactured or modular homes
- Buildings that don’t use electricity or fossil fuel
- Equipment and portions of building systems that use energy primarily for industrial, manufacturing, or commercial processes
Definitions, Abbreviations, and Acronyms (Section 3)

- 10 pages of definitions
  - some added, some deleted, some revised from 90.1-1999
- 1 page of abbreviations and acronyms
- Defined terms are italicized in text of standard

http://www.energycodes.gov/becu/trainers.stm

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Administration and Enforcement (Section 4)

- New buildings (Section 4.1.1.1), additions to existing buildings (Section 4.1.1.2), and alterations to existing buildings (Section 4.1.1.3)
- Replacement of portions of existing buildings (Section 4.1.1.4)
- Changes in space conditioning (Section 4.1.1.5)
Administration and Enforcement (*Section 4*)

- **Compliance documentation** (*Section 4.2.2.1*)
  - all the pertinent data of the building, systems, and equipment
- **Labeling of materials and equipment** (*Section 4.2.3*)
  - Fenestration, doors, insulation, mechanical equipment, and packaged terminal air conditioners
- **Alternative materials and methods of construction** (*Section 4.1.3*)
- **Inspections** (*Section 4.2.4*)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Administration and Enforcement (Section 4)

• Section 4 merely provides the overall statement that new buildings, additions, alterations, replacements, and changes in space conditioning fall under the requirements of the Standard.

• Details of which requirements the building must actually meet in various situations are discussed in the technical sections 5, 6, 7, 8, 9, 10, and 11 in the X.1 section named “General”.

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Exceptions for Alterations

- Buildings that are specifically designated as historic (Section 4.2.1.3.a)
  - by the adopting authority or
  - on the National Register of Historic Places or
  - eligible for listing by the U.S. Secretary of Interior

- If the building’s annual energy consumption is the same as a building that meets the requirements of Sections 5-10 (Section 4.2.1.3.b)
  - verified by a design professional using methods acceptable to the authority having jurisdiction
Compliance Approaches

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options

- Mandatory Provisions
  (required for most compliance options)

- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified

Energy Code Compliance

http://www.energycodes.gov/becu/trainers.stm

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Building Envelope *(Section 5)*

• **General (Section 5.1)**
  - Scope
  - Space-Conditioning Categories
  - Envelope Alterations
  - Climate

• **Compliance Methods (Section 5.2)**

• **Simplified Building (Section 5.3) Not Used**

• **Mandatory Provisions (Section 5.4)**
  - Insulation
  - Fenestration and Doors
  - Air Leakage
Building Envelope (Section 5)

• Prescriptive Building Envelope Option (Section 5.5)
  – Opaque Areas
  – Fenestration
• Building Envelope Trade-Off Option (Section 5.6)
• Submittals (Section 5.7)
• Product Information and Installation Requirements (Section 5.8)
Scope

- Envelope components that enclose (*Section 5.1.2.1*)
  - Conditioned space
  - Semi-heated space
    - Has a heating system with a capacity > 3.4 Btu/h·ft² of floor area but is not conditioned space

- Requirements apply to three types of spaces (*Section 5.1.2.1*)
  - Nonresidential
  - Residential
  - Semi-heated

- **Exceptions**
Building Envelope

(Figure 5.5)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Space-Conditioning Categories and Basis

Envelope Requirements Are Specified by Space-Conditioning Categories

• Each space to be included in a category (*Section 5.1.2.1*)
  - Nonresidential conditioned space
  - Residential conditioned space
  - Semi-heated space

• Spaces in climate zones 3-8 assumed to be conditioned space unless (*Section 5.1.2.3*)
  - Space will only be semi-heated or unconditioned and
  - Approved as such by the building official
Semi-heated Space

• Has a heating system with a capacity > 3.4 Btu/h.ft² (1 W/ft²) of floor area but is not conditioned space (Section 3.2 Definition)

• **Space is not cooled at all**
Envelope Alterations

• Alterations to the building envelope shall comply with the requirements of Section 5 (Section 5.1.3)
  
  - Exceptions are allowed if they don’t increase energy usage of building
    
    • Installation of storm windows
    
    • Replacement of glazing in existing sash and frame
    
    • Alterations to envelope cavities provided they are insulated to full depth with a nominal R-3.0 per in.
    
    • Roof and floor alterations where no new cavities are created
    
    • Replacement of roof membranes
    
    • Replacement of existing doors
    
    • Replacement of existing fenestration, provided area of replacement is no more than 25% of total fenestration area
Climate Zones (Section 5.1.4)

- Zones based on several climatic parameters
  - Locations listed in Appendix B on county-by-county basis for United States

http://www.energycodes.gov/becu/trainers.htm

Date visited: 2/11/2011
Climate Zones—ASHRAE 90.1—2007

http://www.energycodes.gov/becu/trainers.stm

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### 2009 MUEC Climate Zones

The State of Michigan is divided into 3 climate zones:

<table>
<thead>
<tr>
<th>Zone Number</th>
<th>Thermal Criteria IP Units</th>
<th>Thermal Criteria SI Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>5A</td>
<td>5400 &lt; HDD65°F ≤ 7200</td>
<td>3000 &lt; HDD18°C ≤ 4000</td>
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<tr>
<td>6A</td>
<td>7200 &lt; HDD65°F ≤ 9000</td>
<td>4000 &lt; HDD18°C ≤ 5000</td>
</tr>
<tr>
<td>7</td>
<td>9000 &lt; HDD65°F ≤ 12600</td>
<td>5000 &lt; HDD18°C ≤ 7000</td>
</tr>
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</table>

For SI: °C = [(°F)-32]/1.8
Figure 301.1A: Climate Zones

2009 Michigan Uniform Energy Code
Figure 301.1a


Date Visited: 2/11/2011
Table 301.1: Climate Zones by County

<table>
<thead>
<tr>
<th>Zones</th>
<th>5A</th>
<th>6A</th>
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<tr>
<td>Allegan</td>
<td>Alcona</td>
<td>Baraga</td>
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<tr>
<td>Barry</td>
<td>Alger</td>
<td>Chippewa</td>
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<tr>
<td>Bay</td>
<td>Alpena</td>
<td>Gogebic</td>
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<td>Berrien</td>
<td>Antrim</td>
<td>Houghton</td>
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<tr>
<td>Branch</td>
<td>Arenac</td>
<td>Iron</td>
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<tr>
<td>Calhoun</td>
<td>Benzie</td>
<td>Keweenaw</td>
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<td>Cass</td>
<td>Charlevoix</td>
<td>Luce</td>
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<td>Clinton</td>
<td>Cheboygan</td>
<td>Mackinac</td>
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<td>Ontonagon</td>
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</table>

Key: A – Moist. Absence of moisture designation indicates moisture regime is irrelevant.


Date Visited: 2/11/2011
Envelope Compliance Paths
(Section 5.2.1)

• You have to follow Sections
  – 5.1 (General),
  – 5.4 (Mandatory Provisions),
  – 5.7 (Submittals), and
  – 5.8 (Product Information and Installation Requirements),
• and THEN you can either follow
  – Section 5.5 (Prescriptive) or Section 5.6 (Trade-off)
• If you use the Energy Cost Budget method in Section 11, Section 5.4 is mandatory (Section 5.2.2)
  – However, Section 5.4 merely refers to Section 5.8
Mandatory Provisions

• Insulation (Section 5.8.1)
  − Labeling (Section 5.8.1.1)
  − Substantial Contact (Section 5.8.1.5)
  − Recessed Equipment (Section 5.8.1.6)
  − Insulation Protection (Section 5.8.1.7)
  − Insulation Above Suspended Ceilings (Section 5.8.1.8)

• Fenestration and Doors (Section 5.8.2)

• Air Leakage (Section 5.4.3)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Air Leakage

• Seal, caulk, gasket, or weather-strip (Section 5.4.3.1)
  - Openings and joints in building envelope
  - Fenestration and doors per NFRC 400 (Section 5.4.3.2)
  - Loading docks in climate zones 4-8 (Section 5.4.3.3)
  - Vestibules and doors separating conditioned space from exterior (Section 5.4.3.4)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Air Leakage - Building Envelope Sealing
(Section 5.4.3.1)

• Joints around fenestration and door frames \((a)\)
• Junctions between walls \((b)\)
  – and foundations
  – at building corners
  – and structural floors or roofs
  – and roof or wall panels
• Openings for utility services through roofs, walls, and floors \((c)\)
• Site-built fenestration and doors \((d)\)
• Building assemblies used as ducts or plenums \((e)\)
• Joints, seams, and penetrations of vapor retarders \((f)\)
• All other openings in the building envelope \((g)\)
Air Leakage - Fenestration and Doors
(Section 5.4.3.2)

• NFRC 400
• Labeled and certified by manufacturer
• Glazed swinging entrance doors and revolving doors – not to exceed 1.0 cfm/ft$^2$
• All other products – not to exceed 0.4 cfm/ft$^2$
• Exceptions
  - Field-fabricated fenestration and doors
  - Garage doors – ANSI/DASMA 105

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Air Leakage - Loading Dock Weather Seals (Section 5.4.3.3)

In climate zones 4-8:

• Cargo doors and loading dock doors equipped with weather seals
  - To restrict infiltration when vehicles are parked in the doorway


http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Air Leakage – Vestibules (Section 5.4.3.4)

- Required in Climate Zones 5-8 for entrances in buildings > 1000 ft²
- Vestibules must have:
  - Self-closing doors
  - Interior and exterior doors not open at the same time
  - Distance between interior and exterior doors not < 7 ft when in closed position (remember ADA!) (>10 ft for LEED IEQ 5.3 entrance mat)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Air Leakage - Vestibule Exceptions (Section 5.4.3.4)

- Non-entrance doors
- Building entrances with revolving doors
- Buildings < 1000 ft\(^2\) in **climate zones 5-8**
- All doors that open from spaces < 3000 ft\(^2\) (separate from building entrance) **OR** from dwelling units

[Source: U.S. Department of Energy (2010)]

[Image: Glass structure, possibly a conservatory or greenhouse]
Prescriptive Building Envelope Option (Section 5.5)

8 criteria sets for different climate types
• Set = single page that summarizes all prescriptive requirements
  – Insulation levels for roofs, walls, floors
  – Fenestration criteria

WWR ≤ 40% of gross wall area
Skylight-roof ratio ≤ 5% of roof area
Each envelope component must separately meet requirements

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Building Envelope Requirements

(Tables 5.5-1 through 5.5-8)

Requirements for Nonresidential, Residential, and Semiheated spaces

• Opaque Elements
  – Roofs, Walls, Floors, and Doors
  – Assembly maximum values or insulation minimum R-values

• Fenestration
  – Vertical Glazing and Skylights
  – Assembly maximum U-values or assembly maximum SHGC
Building Envelope Requirements
*(Table 5.5-5)*

Climate Zone 5

- **Nonresidential Examples**
  - Roofs: insulation entirely above deck = R-20.0 c.i. (R-15.0 c.i.)
  - Roofs: Attic and other = R-38.0 (R-30.0)
  - Above-Grade Walls: mass = R-11.4 c.i. (R-7.6 c.i.)
  - Above-Grade Walls: steel-framed = R-13.0 + R-7.5 c.i. (R-13.0 + R-3.8 c.i.)
  - Above-Grade Walls: wood-framed = R-13.0 + R-3.8 c.i. (R-13.0)
  - Below-Grade Walls: below-grade wall = R-7.5 c.i. (No Requirement)
  - Floors: mass = R-10.4 c.i. (R-8.3 c.i.)
  - Floors: steel joist = R-30.0 (R-19.0)
  - Slab-On-Grade Floors: heated = R-15 for 24 in. (R-10 for 36 in.)
  - Doors: nonswinging = U-0.500 (U-1.450)

Presenter’s note: ( ) = 1999 ASHRAE 90.1 values
**Designers**

- **Specify:**
  - R-values for walls, floors, and roofs
  - U-factors for opaque doors
  - U-factor and SHGC for fenestration, OR

- **Use:**
  - Pre-calculated assemblies from Appendix A

*U.S. Department of Energy (2010)*
Opaque Areas *(Section 5.5.3)*

Compliance:

• Meet or exceed minimum R-values in table
  - Only R-value of insulation, not to include air films, etc
  **OR**
• Meet maximum U-factor, C-factor, or F-factor for the entire assembly
  **OR**
• Perform area-weighted average U-factor, C-factor, or F-factor
  - Only if there are multiple assemblies within a *single* class of construction for a *single* space-conditioning category

http://www.energycodes.gov/becu/trainers.stm

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Roof Insulation \textit{(Section 5.5.3.1)}

• Meet or exceed minimum R-value in table for climate zone (Table 5.5-1 thru 8)
• Skylight curbs insulated to level of roofs with insulation entirely above deck or R-5, whichever is less
• Three types of roofs are defined:
  − Roofs with insulation entirely above deck
    • R-value is for continuous insulation
    • Interruptions for mechanical equipment ≤ 1% of surface of the total roof area

\url{http://www.energycodes.gov/becu/trainers.stm}

\textit{Date visited: 2/11/2011}
Roof Insulation (*Section 5.5.3.1*)

- **Metal building roofs**
  - First value is for insulation
    - draped over purlins and then compressed when metal spanning members attached or
    - hung between purlins provided there’s a min. of 1” thermal break between purlins and metal spanning members
  - Second value is for double-layer installations with insulation installed parallel to the purlins
- **Attics and other roofs**
  - R-value is for insulation installed both inside and outside the roof or entirely inside the roof cavity
Roofs with a minimum total solar reflectance of 0.70 and a minimum thermal emittance of 0.75 or a minimum Solar Reflective Index of 82, other than roofs with ventilated attics or roofs of semiheated spaces or roofs over conditioned spaces that are not cooled spaces shall comply with the values in Table 5.5.3.1.

Basically, “cool roofs” are allowed to have less insulation.
Above-Grade Wall Insulation (Section 5.5.3.2)

- Meet or exceed R-value in appropriate table for climate zone
- Four types of walls are defined:
  - Mass walls:
    - heat capacity determined from Table A3.1B or A3.1C
    - R-value is for continuous insulation or when uninterrupted by framing other than metal clips no closer than 24 in. o.c. horizontally and 16 in. o.c. vertically
  - Exception – requirement of U-0.151

http://www.energycodes.gov/becu/trainers.stm

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Above-Grade Wall Insulation  
(*Section 5.5.3.2*)

**Metal building wall R-value**
- for insulation compressed between metal wall panels and the steel structure

**Steel-framed wall R-value**
- for uncompressed insulation installed in the cavity between steel studs

**Wood-framed and other R-value**
- for uncompressed insulation installed in the cavity between wood studs; also acceptable to be continuous insulation uninterrupted by studs

http://www.energycodes.gov/becu/trainers.stm

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Below-Grade Wall Insulation (Section 5.5.3.3)

- Meet or exceed values in appropriate table for climate zone
- R-value is for continuous insulation
- If framing is used, compliance is based on maximum assembly C-factor

[Image of below-grade wall insulation]

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Floor Insulation (Section 5.5.3.4)

• Meet or exceed values in appropriate table for climate zone

• 3 classes of floors over unconditioned space are defined:
  − Mass floors
    • R-value is for continuous insulation
    • If framing is used, compliance is based on maximum assembly U-factor
  − Steel-joist floors
    • R-value is for uncompressed insulation or spray-on insulation, but is also acceptable for continuous insulation
  − Wood-framed and others
    • R-value is for uncompressed insulation, but is also acceptable for continuous insulation


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Slab-on-Grade Floor Insulation (Section 5.5.3.5)

• Meet or exceed values in appropriate table for climate zone (includes R-value and depth or width of insulation)

• Be installed around the perimeter to the distance specified
  - **Inside foundation wall** – extend downward from top of slab a minimum distance specified or to the top of the footing, whichever is less
  - **Outside foundation wall** – extend from top of the slab or downward to at least the bottom of the slab and then horizontally to a minimum distance specified

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Slab Edge Insulation *(Section 5.5.3.5)*

**Slab-on-Grade Floors**

Can use R factor or F factor from 5.5-5 thru 7

When using the F factor must refer to Table A6.3

- Downward from top of slab a minimum of 24”
- R-10 for unheated floors, R-15 for heated floors
- No requirement for insulation in CZ5 for unheated floors
- Insulation can be vertical or extend horizontally under the slab or out from the building (must be under 10 inches of soil) But only with computer based methods and not with prescriptive


no longer allowed
Opaque Doors *(Section 5.5.3.6)*

- Meet or exceed maximum U-factors in appropriate table for climate zone

- Example: Climate Zone 5
  - Nonresidential
    - Swinging = U-0.700 (U-0.700)
    - Non-swinging = U-0.500 (U-1.450)
  - Residential
    - Swinging = U-0.500 (U-0.700)
    - Non-swinging = U-0.500 (U-0.500)
  - Semiheated
    - Swinging = U-0.700 (U-0.700)
    - Non-swinging = U-1.450 (U-1.450)

*Presenter’s note:*

( ) = 1999 ASHRAE 90.1 values


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Fenestration (*Section 5.5.4*)

- Criteria apply to fenestration, including windows, glass doors, glass block, plastic panels, and skylights

- Compliance
  - Meet or exceed maximum U-factors in table
  - Meet or exceed minimum SHGC in table
  - Use NFRC ratings or default values in Appendix A


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Fenestration Area

- Total vertical fenestration area to be < 40% of gross wall area (*Section 5.5.4.2.1*)
  - Including both fixed and operable vertical fenestration
- Total skylight area to be < 5% of gross roof area (*Section 5.5.4.2.2*)
  - Including glass skylights, plastic skylights with a curb, and all skylights without a curb

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Fenestration U-Factor *(Section 5.5.4.3)*

U-factor not greater than specified in Tables 5.5-1 through 5.5-8 For example:

Zone 5 and 6 vertical glazing metal framing
U=0.45 and SHGC 0.40

Zone 7 vertical glazing metal framing
U=0.40 and SHGC 0.45

Unit U value rather than glass only (must include frame)

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Fenestration SHGC

• Vertical fenestration (*Section 5.5.4.4.1*)
  - SHGC values < Table value for appropriate
total vertical fenestration area

• Skylights (*Section 5.5.4.4.2*)
  - SHGC values < Table value for appropriate
total skylight area

• No SHGC requirements for semi-heated spaces

• No criteria for Visible Light Transmittance in Prescriptive Building
  Envelope Option, but there are minimum criteria in the Trade-Off
  Option (Details in Appendix C)

• Exceptions


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Overhangs

- Standard credits permanent overhangs by adjustment to SHGC
- Size of overhang is determined by projection factor

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Building Envelope Trade-Off Option

Building complies if:

- It satisfies the provisions of 5.1, 5.4, 5.7, and 5.8 (Section 5.6.1a)
- Envelope performance factor (EPF) of proposed building is ≤ EPF of budget building (Section 5.6.1b)
  - EPF considers only the building envelope components (Section 5.6.1.1) and is calculated using procedures in Normative Appendix C (Section 5.6.1.3)
  - Schedules of operation, lighting power, equipment power, occupant density, and mechanical systems to be the same for both the proposed building and the budget building (Section 5.6.1.2)

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Product Information and Installation Requirements

- Labeling of Building Envelope Insulation (*Section 5.8.1.1*)
- Compliance with Manufacturers’ Requirements (*Section 5.8.1.2*)
- Loose-Fill Insulation Limitation (*Section 5.8.1.3*)
- Baffles (*Section 5.8.1.4*)
- Substantial Contact (*Section 5.8.1.5*)
- Recessed Equipment (*Section 5.8.1.6*)
- Insulation Protection (*Section 5.8.1.7*)
- Location of Roof Insulation (*Section 5.8.1.8*)
- Extent of Insulation (*Section 5.8.1.9*)


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Insulation Installation

- Per manufacturer’s instructions *(Section 5.8.1.2)*
- Achieve rated R-value *(Section 5.8.1.2)*
- No open-blown or poured loose-fill insulation when ceiling slope is > 3/12 *(Section 5.8.1.3)*
- If eave vents installed *(Section 5.8.1.4)*
  - Provide baffling of air vents to deflect incoming air above the surface of the insulation
- Exception *(Section 5.8.1.2)*
  - Metal buildings – if roof and wall insulation is compressed between roof or wall skin and the structure


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Insulation - Substantial Contact (Section 5.8.1.5)

- Install insulation in a permanent manner in substantial contact with inside surface
- Flexible batt insulation in floor cavities
  - Supported in a permanent manner by supports no more than 24 in. on center (o.c.)
Recessed Equipment (Section 5.8.1.6)

• Do not recess equipment to affect insulation thickness
  – Lighting fixtures
  – HVAC equipment (includes wall heaters, ducts, and plenums)
  – Other

• Except when
  – Total combined area affected (include necessary clearances) is
    < 1% of opaque area of the assembly, OR
  – Entire roof, wall, or floor is covered with insulation to the full depth required, OR
  – Effects of reduced insulation are included in area-weighted calculations
Insulation Protection:

• Cover exterior insulation with protective material *(Section 5.8.1.7)*
  - Sunlight
  - Moisture
  - Landscaping operations
  - Equipment maintenance
  - Wind

• Access to attics and mechanical rooms without damaging or compressing insulation *(Section 5.8.1.7.1)*

• Insulation materials in ground contact to have a water absorption rate ≤ 0.3% *(ASTM C272)* *(Section 5.8.1.7.3)*

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Suspended Ceilings

Roof Insulation:
• Not installed on a suspended ceiling with removable ceiling panels (Section 5.8.1.8)


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Fenestration and Doors

U-factors (Section 5.8.2.4)
• NFRC 100 or
• Assemblies listed in Appendix A

SHGC (Section 5.8.2.5)
• NFRC 200 or
• Assemblies listed in Appendix A

Visible Light Transmittance (Section 5.8.2.6)
• NFRC 200 when building envelope trade-off option is used

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U-Factor *(Section 5.8.2.4)*

- Skylights – Manufacturer to determine at a slope of 20° above the horizontal
- Labeled and certified by manufacturer *(Sections 5.8.2.1 and 5.8.2.2)*
- Limited to max 5% of roof for prescriptive applied to each space categories *(Tables 5.5-1 through 5.5-8)*
- U Factor depends on skylight class i.e. glass with curb, plastic with curb and without curb
- Exceptions
  - Glazed wall systems in vertical fenestration and skylights – may use U-factors in A.8.1
  - A8.2 acceptable for other vertical fenestration
  - A7 acceptable for opaque doors
  - ANSI/DASMA 105 acceptable for garage doors

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Solar Heat Gain Coefficient (Section 5.8.2.5)

- The glazing’s effectiveness in rejecting solar heat gain
- NFRC 200
- Exceptions
  - SC x 0.86 is acceptable for overall fenestration area (NFRC 300)
  - SHGC of center-of-glass is acceptable (NFRC 300) for overall fenestration area
  - SHGC from A8.1 for glazed wall systems in vertical fenestration and skylights
  - SHGC from A8.2 for other vertical fenestration

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SHGC

- Part of a system for rating window performance
  - used by the National Fenestration Rating Council (NFRC)
- Gradually replacing shading coefficient (SC) in product literature and design standards
  - convert SC to SHGC by multiplying the SC value by 0.86


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Visible Light Transmittance

- A measure of the amount of visible light that passes through fenestration
- Affected by:
  - composition of the glass
  - coatings
  - internal shading devices
- Relationship between VLT and SHGC
  - Day-lighting without excessive solar gain – VLT at least 1.2 x SHGC


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HVAC Compliance

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options

- Mandatory Provisions (required for most compliance options)
  - Prescriptive Option
  - Trade Off Option
  - Energy Cost Budget
  - Simplified

Energy Code Compliance

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HVAC Alterations (Section 6.1.1.3)

• **Equipment** - New equipment shall meet the minimum efficiency requirements (Section 6.1.1.3.1)

• **Cooling Systems**
  - New cooling systems installed to serve previously un-cooled spaces shall comply with this section (Section 6.1.1.3.2)
  - Alterations to existing cooling systems shall not decrease economizer capacity (unless economizer tradeoff is used) (Section 6.1.1.3.3)

• **Ductwork** - New and replacement ductwork shall comply with applicable requirements (Section 6.1.1.3.4)

• **Piping** - New and replacement piping shall comply with applicable requirements (Section 6.1.1.3.5)
HVAC Alterations *(Section 6.1.1.3)*

Alterations to the building HVAC system shall comply with the requirements of Section 6

- **Exceptions** that are allowed:
  - Equipment being modified or repaired (not replaced)
    - Provided such modifications will not result in an increase in the annual energy consumption
  - Equipment being replaced or altered which requires extensive revisions to other systems and such replaced or altered equipment is a like-for-like replacement
  - Refrigerant change of existing equipment
  - Relocation of existing equipment
  - Ducts and pipes where there is insufficient space or access to meet these requirements
HVAC Compliance Paths

(Section 6.2.1)

• You have to follow Sections
  – 6.1 General,
  – 6.7 Submittals, and
  – 6.8 Minimum Equipment Efficiency,

• And then you can follow either
  – Section 6.3 Simplified Approach OR
  – Sections 6.4 Mandatory Provisions and 6.5 Prescriptive Path

Alternatively, you can follow Section 11 (ECB), in which case Section 6.4 is mandatory (Section 6.2.2)
Simplified Approach Option

(Section 6.3.1)
Limited to:
• Buildings with 1 or 2 stories
• Buildings < 25,000 ft²

(Section 6.3.2)
• Single-zone systems (unitary or split) Can have several single-zone systems in building
• Air-cooled or evaporatively cooled
• 15 paragraphs cover Simplified Approach

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Simplified Approach Option *(Section 6.3.2)*

The system shall have an economizer, unless the economizer Trade-off Option is used (c)

*(Table 6.3.2)*

- Limited to unitary systems
- Requires higher minimum cooling efficiency (EER)
- Trade-off EER by
  - System size
  - Climate zone


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Simplified Approach Option *(Section 6.3.2)*

- Manual changeover or dual set-point thermostat *(f)*
- Heat pump supplementary control *(g)*
- No reheat or simultaneous heating and cooling for humidity control *(h)*
- “Time clocks” (except hotel/motel guest rooms and systems requiring continuous operation) *(i)*
  (In reality: programmable thermostat)
- Piping and ductwork insulated *(j and k)*
Simplified Approach Option (Section 6.3.2)

- Balancing of ducted systems \((l)\)
- Interlocked thermostats for separate heating and cooling of same zone \((m)\)
- Exhaust > 300 cfm: gravity or motorized dampers unless operated continuously \((n)\)
- System > 10,000 cfm: optimum start controls \((o)\)

HVAC Mandatory Provisions

• Minimum Equipment Efficiency (Section 6.4.1)
• Load Calculations (Section 6.4.2)
• Controls (Section 6.4.3)
• HVAC System Construction and Insulation (Section 6.4.4)
• Completion Requirements (Section 6.4.5)

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Equipment Covered

- Package air conditioners and condensing units (*Table 6.8.1A*)
- Heat pumps (air, water, and ground source) (*Table 6.8.1B*)
- Packaged terminal and room air conditioners (*Table 6.8.1D*)
- Chillers including absorption chillers (*Table 6.8.1C*)
- Furnaces and unit heaters (*Table 6.8.1E*)
- Boilers (*Table 6.8.1F*)
- Heat rejection equipment (*Table 6.8.1G*)
Mechanical Equipment Efficiency

• Tables 6.8.1A – 6.8.1G

• Tables 6.8.1H-6.8.1J used for water cooled centrifugal chillers that operate at non-standard rating conditions

• Combination HVAC and water heating systems to meet all requirements for appropriate space heating or cooling category

• Gas-fired and oil-fired forced air furnaces with input ratings ≥ 225,000 Btu/h to have intermittent or interrupted ignition device and have either power venting or a flue damper (*Table 6.8.1E footnote h*)

• All furnaces with input ratings ≥ 225,000 Btu/h, including electric furnaces, not located in conditioned space, to have jacket losses ≤ 0.75% of the input rating (*Section 6.4.1.1*)
Verification of Equipment Efficiencies (Section 6.4.1.4)

Equipment efficiency information from manufacturers verified as follows:

• EPACT equipment – to comply with DOE certification requirements \((a)\)

• If certification program exists for covered product and includes provisions for verification and challenge of equipment efficiency ratings, product listed in program OR \((b)\)

• If product not listed in program, ratings verified by an independent laboratory test report OR \((c)\)

• If no certification program exists, equipment efficiency ratings supported by data furnished by manufacturer OR \((d)\)

• Where components from different manufacturers are used, system designer specifies components whose combined efficiency meets Section 6.4.1 \((e)\)

• Products in Table 6.8.1G shall have efficiency ratings supported by data furnished by manufacturer.

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Labeling

• Mechanical equipment – equipment not covered by NAECA shall carry a permanent label stating equipment complies with 90.1 (Section 6.4.1.5.1)

• Packaged terminal air conditioners – packaged terminal air conditioners and heat pumps with sleeve sizes < 16 in. high and 42 in. wide shall be factory labeled as follows: (Section 6.4.1.5.2)
  - Manufactured for replacement applications only: not to be installed in new construction projects
Load Calculations *(Section 6.4.2)*

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

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Controls – Zone Thermostatic and Dead Band

Required for each zone *(Section 6.4.3.1.1)*

- Perimeter can be treated differently

Dead band controls *(Section 6.4.3.1.2)*

- Thermostats must have at least a $5^\circ F$ dead band
- **Exceptions**
  - Thermostats that require manual changeover between heating and cooling modes
  - Special occupancy or applications where wide temperature ranges aren’t acceptable (e.g., retirement homes) and approved by adopting authority

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Controls – Setpoint Overlap Restriction (Section 6.4.3.2)

If limit switches, mechanical stops, or software programming for DDC systems are used
  − Means will be provided to prevent the heating set point from exceeding the cooling set point minus any applicable proportional band
Controls – Off-Hour

- Automatic shutdown (Section 6.4.3.3.1)
- Setback controls (Section 6.4.3.3.2)
- Optimum start (Section 6.4.3.3.3)
- Zone isolation (Section 6.4.3.3.4)
- Exceptions, HVAC systems (Section 6.4.3.3)
  - with heating/cooling capacity < 15,000 Btu/h
  - intended to operate continuously
Controls - Automatic Shutdown (Section 6.4.3.3.1)

• Automatic 7-day/week time clock with 10-hour battery backup
  – Exception: 2-day/week thermostat for residential applications

• Each control to have
  – Occupant sensor, OR
  – Manually-operated timer with maximum two hour duration, OR
  – Security system interlock

• Exception
  – Residential occupancies allowed to operate with only 2 different time schedules/wk
Controls – Setback *(Section 6.4.3.3.2)*

Climate Zones 2-8

- Lower heating set point to 55ºF or less

Climate Zones 1b, 2b, 3b (hot/dry)

- Automatically restart, temporarily operate
  - Raise cooling set point to 90ºF or higher **OR**
  - Prevent high space humidity levels

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Controls - Optimum Start 
(Section 6.4.3.3.3)

Individual heating and cooling air distribution systems with

- Total design supply air capacity > 10,000 cfm
- Served by one or more supply fans

Control algorithm to at least be a function of

- Difference between space temperature and occupied setpoint and amount of time prior to scheduled occupancy

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Controls - Zone Isolation
(Section 6.4.3.3.4)

• Applies to:
  − Each floor in a multistory building
  − Maximum 25,000 ft² zone on one floor

• Requirements:
  − Isolation devices to shut off outdoor and exhaust airflow when > 5,000 cfm
  − Central systems shall be capable of stable operation with one isolation zone
  − Capable of separate time schedules for each isolation zone

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Controls – Ventilation System

• Motorized dampers for:
  - Stair and Shaft Vents *(Section 6.4.3.4.1)*
  - Gravity Hoods, Vents, and Ventilators *(Section 6.4.3.4.2)*

  *Exceptions:*
  - <3 stories high
  - CZ 1-3
  - Unconditioned spaces
Motorized dampers:

- Can be automatically closed during normal building operation
- Interlocked to open as required by fire and smoke detection systems

Gravity Hoods, Vents, and Ventilators (Section 6.4.3.4.2)

- Motorized dampers to automatically shut when spaces served are not in use
- **Exceptions:**
  - Gravity dampers okay in buildings
    - < 3 stories in height *above* grade
    - Of any height in climate zones 1 - 3
  - Ventilation systems serving unconditioned spaces
Controls - Shutoff Damper (Section 6.4.3.4.3)

- Motorized dampers for outdoor air supply and exhaust systems
- Ventilation outside air dampers to 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)
Controls - Shutoff Damper (Section 6.4.3.4.3)

• **Exceptions:**
  - Gravity dampers okay in buildings
    • < 3 stories in height
    • Of any height in climate zones 1-3
  - Outdoor-air intake or exhaust < 300 cfm

• **Table 6.4.3.4.4 provides maximum leakage rates for outdoor air supply and exhaust dampers (Section 6.4.3.4.4)**


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Dampers (Section 6.4.3.4.4)

Where OA supply and exhaust air dampers are required by Section 6.4.3.4

• They shall have a maximum leakage rate when tested in accordance with AMCA Standard 500 as indicated in Table 6.4.3.4.4

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Ventilation Fan Controls

(Section 6.4.3.4.5)

• Fans with motors > 0.75 hp shall have automatic controls complying with Section 6.4.3.3.1 that are capable of shutting off fans when not required

• *Exception:*
  - HVAC systems intended to operate continuously


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Heat Pump Auxiliary Heat Control (Section 6.4.3.5)

• Controls to prevent supplementary heat when heat pump can handle the load

• Exception:
  – Heat pumps
    • With minimum efficiencyregulated by NAECA
    • With HSPF rating meeting Table 6.8.1B
      (Includes all usage of internal electric resistance heating)

Controls - Humidifier Preheat (Section 6.4.3.6)

Automatic valve to shut off preheat when humidification is not required
Controls - Humidification and Dehumidification (Section 6.4.3.7)

Provide means to prevent simultaneous operation of humidification and dehumidification equipment

• Limit switches, mechanical stops, or software programming (DDC systems)

Exceptions:

• Zones served by desiccant systems, used with direct evaporative cooling in series

• Systems serving zones where specific humidity levels are required and approved by jurisdiction
  – Museums and hospitals

http://www.energycodes.gov/becu/trainers.stm

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Controls - Freeze Protection and Snow/Ice (Section 6.4.3.8)

Automatic controls for:

• Freeze protection systems
  - outside air temperatures > 40°F or when conditions of protected fluid will prevent freezing

• Snow- and ice-melting systems
  - pavement temperature > 50°F and no precipitation is falling and outdoor temperature > 40°F
Ventilation Controls for High-Occupancy Areas (Section 6.4.3.9)

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

- An air-side economizer,
- Automatic modulating control of the outdoor air damper, OR
- A design outdoor airflow > 3,000 cfm

Demand control ventilation (DCV): a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

http://www.energycodes.gov/becu/trainers.stm

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Ventilation: High Occupancy Exceptions (Section 6.4.3.9)

Exceptions:

- Systems with exhaust-air energy recovery complying with Section 6.5.6.1
- Multiple zone systems without DDC to the zone level
- Systems with a design OA airflow < 1,200 cfm
- Spaces where supply-exhaust < 1,200 cfm
HVAC System Construction and Insulation

- Insulation installed in accordance with industry-accepted standards (*Section 6.4.4.1.1*)
- Insulation protection (*Section 6.4.4.1.1*)
- Duct and plenum insulation (*Section 6.4.4.1.2*)
- Piping insulation (*Section 6.4.4.1.3*)
- Duct sealing (*Section 6.4.4.2.1*)
- Duct leakage tests (*Section 6.4.4.2.2*)


http://www.energycodes.gov/becu/trainers.stm

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General *(Section 6.4.4.1.1)*

- Insulation installed in accordance with industry-accepted standards
- Insulation:
  - Protected from damage due to sunlight, moisture, equipment maintenance, and wind
  - Exposed to weather to be suitable for outdoor service
  - Covering chilled water piping, refrigerant suction piping, or cooling ducts located outside the conditioned space to include a vapor retardant located outside the insulation, all penetrations and joints of which to be sealed

*http://www.energycodes.gov/becu/trainers.stm*

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Duct and Plenum Insulation (Section 6.4.4.1.2)

• All *supply* and *return* ducts and plenums to be insulated per Tables 6.8.2A and 6.8.2B

• *Exceptions:*
  - Factory-installed plenums, casings, or ductwork furnished as part of HVAC equipment
  - Ducts located in heated, semi-heated, or cooled spaces
  - For runouts < 10 ft in length to air terminals or air outlets, the R-value need not exceed R-3.5
  - Backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces with face areas > 5 ft² need not exceed R-2; those ≤ 5 ft² need not be insulated
Piping Insulation (Section 6.4.4.1.3)

• Table 6.8.3
• Exceptions:
  − Factory-installed
  − Piping conveying fluids
    • design operating temperature range between 60°F-105°F, inclusive
    • that haven’t been heated or cooled through the use of nonrenewable energy or where heat gain or heat loss will not increase energy usage
  − Hot water piping between shut off valve and coil, not > 4 ft in length, when located in conditioned spaces
  − Pipe unions in heating systems (steam, steam condensate, and hot water)

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Duct Sealing *(Section 6.4.4.2.1)*

- Tables 6.4.4.2A and 6.4.4.2B
- Requirements of 6.4.4.2.2
- Based on standard industry practice and definitions

*U.S. Department of Energy (2010)*

http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Duct Leakage Tests *(Section 6.4.4.2.2)*

- Designed > 3 in. w.c.
  - Leak tested
  - Representative sections ≥ 25% of the total installed duct area shall be tested
  - Ratings > 3 in. w.c. to be identified on drawings
  - Maximum permitted duct leakage
    - \[ L_{\text{max}} = C_L P^{0.65} \]
    - Where \( L_{\text{max}} \) = maximum permitted leakage in cfm/100 ft\(^2\) duct surface area


http://www.energycodes.gov/becu/trainers.stm

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Completion Requirements *(Section 6.4.5)*

- Refers to Section 6.7 for Submittal and Completion Requirements including
  - Record drawings *(Section 6.7.2.1)*
  - Operating and maintenance manuals *(Section 6.7.2.2)*
  - System balancing *(Section 6.7.2.3)*
  - System commissioning *(Section 6.7.2.4)*


http://www.energycodes.gov/becu/trainers.stm

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Prescriptive Requirements

proposed HVAC design

mandatory provisions (§6.4)

prescriptive requirements (§6.5)

Energy Cost Budget Method (ECB, §11)

Simplified Approach Option (§6.3)

90.1-compliant HVAC system

(small buildings only)


http://www.energycodes.gov/becu/trainers.stm

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HVAC Prescriptive Path (Section 6.5)

- Economizers (Section 6.5.1)
- Simultaneous Heating and Cooling Limitation (Section 6.5.2)
- Air System Design and Control (Section 6.5.3)
- Hydronic System Design and Control (Section 6.5.4)
- Heat Rejection Equipment (Section 6.5.5)
- Energy Recovery (Section 6.5.6)
- Exhaust Hoods (Section 6.5.7)
- Radiant Heating Systems (Section 6.5.8)
- Hot Gas Bypass Limitation (Section 6.5.9)
Economizers *(Section 6.5.1)*

- Climate and size dependent (Table 6.5.1)
- There are LOTS of exceptions
- Can use air economizers *(Section 6.5.1.1)*
  - 100% of design supply air
  - Sequenced with mechanical cooling equipment
  - High limit shutoff
  - Dampers
- Can use water economizers *(Section 6.5.1.2)*
  - 100% of expected system cooling load at 50°F DB, 45°F WB
  - Maximum pressure drop limitation
Economizer Exceptions *(Section 6.5.1)*

**Exceptions:**

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


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## Economizers (Table 6.5.1)

<table>
<thead>
<tr>
<th>Climate zone</th>
<th>Cooling capacity for which an economizer is required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a, 1b, 2a, 3a, 4a (Miami, St. Louis, Charlotte)</td>
<td>Economizer unnecessary</td>
</tr>
<tr>
<td>2b, 5a, 6a, 7, 8 (Yuma, AZ, Michigan, Alaska)</td>
<td>≥ 135,000 Btu/h</td>
</tr>
<tr>
<td>3b, 3c, 4b, 4c, 5b, 5c, 6b (Denver, Lubbock, Vancouver)</td>
<td>≥ 65,000 Btu/h</td>
</tr>
</tbody>
</table>


*Date visited: 2/11/2011*
Design Capacity – Air Economizers (Section 6.5.1.1.1)

System capable of modulating outside air and return air dampers to provide up to 100% of the design supply air quantity as outside air for cooling
Economizer Control Signal (Section 6.5.1.1.2)

• Dampers capable of being sequenced with the mechanical cooling equipment and shall not be controlled by only mixed air temperature

• Exception:
  – Systems controlled from space temperature (such as single-zone systems)

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High Limit Shutoff (Section 6.5.1.1.3)

• Automatically reduce outdoor air intake to minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage

• Control types for specific climates from Table 6.5.1.1.3A

• Settings from Table 6.5.1.1.3B

http://www.energycodes.gov/becu/trainers.stm

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Dampers (Section 6.5.1.1.4)

Return air and outdoor air dampers to meet the damper leakage specified in Section 6.4.3.4.4 for outdoor air supply and exhaust dampers.

Presenter’s Note:
This is the second reference to the same table
Relief of Excess Outside Air (Section 6.5.1.1.5)

• Means to relieve excess outdoor air during economizer operation to prevent over-pressurizing the building
• Outlet located to avoid recirculation into the building

http://www.energycodes.gov/becu/trainers.stm

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Design Capacity – Water Economizers (Section 6.5.1.2.1)

- System capable of cooling supply air by indirect evaporation and providing up to 100% of expected system cooling load at outside air temperatures of 50°F dry bulb/45°F wet bulb and below

- **Exception:**
  - You can also meet this requirement if your design can meet 100% of expected cooling load at 45°F dry bulb/40°F wet bulb


*Date visited: 2/11/2011*
Maximum Pressure Drop *(Section 6.5.1.2.2)*

- Pre-cooling coils and water-to-water heat exchangers to have either
  - Water-side pressure drop of < 15 ft of water
  - Bypassed when not in use

Figure 6-O from 90.1 User's Manual

Integrated Economizer Control (Section 6.5.1.3)

• Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required (Generally, 55 dF. O.A – 75 dF. O.A.)

• Some exceptions to this
Economizer Heating System Impact (Section 6.5.1.4)

- Designed so economizer operation doesn’t increase the building heating energy use during normal operation (High enthalpy O.A.)
- **Exception:**
  - Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature

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Zone Controls (Section 6.5.2.1)

• Capable of operating in sequence the supply of heating and cooling energy to the zone
• Controls prevent
  − Reheating
  − Re-cooling
  − Mixing or simultaneously supplying air previously heated or cooled
  − Other simultaneous operation of heating and cooling systems to the same zone
Zone Controls – Exceptions *(Section 6.5.2.1)*

- Zones for which volume of air that is reheated, recooled, or mixed is no greater than the larger of the following:
  - Volume of outside air to meet 6.2 of ASHRAE 62 for the zone
  - 0.4 cfm/ft² of zone conditioned floor area
  - 30% of zone design peak supply
  - 300 cfm for zones whose peak flow rate totals no more than 10% of the total fan system flow rate
  - Any higher rate that can be demonstrated to jurisdiction to reduce overall system annual energy usage

- Zones where special pressurization relationships, cross-contamination requirements, or code-required minimum circulation rates are such that the variable air volume systems are impractical

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Hydronic System Controls (Section 6.5.2.2)

Limit heating and cooling of fluids previously heated or cooled mechanically per 6.5.2.2.1 through 6.5.2.2.3, which follows.

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Three-Pipe System – NOT APPROVED (Section 6.5.2.2.1)

Common return system for both hot and chilled water shall not be used.

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Two-Pipe Changeover System (Section 6.5.2.2.2)

Common distribution system acceptable if:

• Dead-band from one mode to another is \( \geq 15^\circ\text{F} \) outside air temperature
• Controls to allow operation of \( \geq 4 \) hours before changing over
• Reset controls so heating and cooling supply temperatures at changeover point no more than \( 30^\circ\text{F} \) apart

http://www.energycodes.gov/becu/trainers.stm

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Hydronic (Water Loop) Heat Pump Systems (Section 6.5.2.2.3)

• Controls to provide heat pump water supply temperature deadband of at least 20°F between initiation of heat rejection and heat addition by central devices

• Cooling tower bypass or cooling tower isolation dampers

• Exception:
  – If system loop temperature optimization controller is used, deadband < 20°F is allowed
Dehumidification *(Section 6.5.2.3)*

Humidistatic controls to prevent

- Reheating
- Mixing of hot and cold air streams
- Heating and cooling of same air stream
Dehumidification Exceptions (Section 6.5.2.3)

- Systems capable of reducing supply air flow to 50%, or to minimum ventilation
- Systems under 6.67 tons that can unload at least 50%
- Systems smaller than 3.3 tons
- Process applications
- 75% of reheat or recool energy is recovered or solar

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Systems with hydronic cooling and humidification systems designed to maintain inside humidity at > 35°F dew point temperature shall use a **water** economizer if an economizer is required by 6.5.1

Air System Design and Control (Section 6.5.3)

HVAC systems with total fan system power > 5 hp to meet 6.5.3.1 through 6.5.3.2

• Fan Power Limitation (Section 6.5.3.1)

• VAV Fan Control
  – Part Load Fan Power Limitation (Section 6.5.3.2.1)
  – Static Pressure Sensor location (Section 6.5.3.2.2)
  – Set Point Reset (Section 6.5.3.2.3)
Fan Power Limitation (Section 6.5.3.1)

• Not to exceed allowances in Table 6.5.3.1.1A
• Allowable fan system power may be adjusted according to specific conditions listed in Table 6.5.3.1.1B
• Exceptions noted
Motor Nameplate Horsepower
(Section 6.5.3.1.2)

• Selected fan motor to be no larger than first available motor size greater than bhp
• Fan bhp on design documents
• Exceptions:
  - Fans < 6 bhp, where first available motor larger than bhp has nameplate rating within 50% of bhp, next larger nameplate motor size may be selected (example: 4 bhp may use 7.5 hp motor)
  - Fans ≥ 6 bhp, where first available motor larger than bhp has nameplate rating within 30% of bhp, next larger nameplate motor size may be selected (example: 8 bhp may use 15 hp motor)
Part-Load Fan Power Limitation (Section 6.5.3.2.1)

Individual VAV fans with motors $\geq 10$ hp

• Must have either:
  - Variable Speed Drive
  - Vane-axial fan with variable-pitch fan blades
  - Other controls and devices to result in fan motor demand $\leq 30\%$ of design wattage at 50% of design air volume when static pressure set point $= 1/3$ of total design static pressure, based on manufacturer’s certified fan data

Static Pressure Sensor Location
(Section 6.5.3.2.2)

• Placed so controller set point is $\leq 1/3$ the total design fan static pressure
  – *Except* for digital control systems with zone reset capabilities where it may be at the fan discharge

• Install multiple sensors in each major branch if sensor would be located downstream of a major duct split
Set Point Reset (Section 6.5.3.2.3)

For systems with direct digital control of individual zone boxes reporting to the central control panel

• Static pressure set point reset based on zone requiring the most pressure

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Hydronic System Design and Control (Section 6.5.4)

HVAC hydronic systems with total pump system power > 10 hp shall meet Sections 6.5.4.1 – 6.5.4.4

• Hydronic Variable Flow Systems (Section 6.5.4.1)
• Pump Isolation (Section 6.5.4.2)
• Chilled- and Hot-Water Temperature Reset (Section 6.5.4.3)
• Hydronic (water-loop) Heat Pump Systems (Section 6.5.4.4)
Hydronic Variable Flow (Section 6.5.4.1)

• HVAC pumping systems to include control valves
  − Designed to modulate or step open and close as a function of load
  − Designed for variable fluid flow
  − Capable of reducing flow rates to ≤ 50% of design flow rate

• Individual pumps serving variable flow systems with a pump head > 100 ft and motor > 50 hp
  − Have controls and/or devices resulting in pump motor demand ≤ 30% of design wattage at 50% of design water flow
Hydronic Variable Flow – Exceptions (Section 6.5.4.1)

• Systems where:
  – Minimum flow is < minimum flow required by equipment manufacturer for proper operation of equipment served by the system
  – Total pump system power ≤ 75 hp

• Systems that include ≤ 3 control valves

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Pump Isolation (Section 6.5.4.2)

If chilled water plant has more than one chiller or boiler plant has more than one boiler

• Provide for flow reduction when chiller or boiler is shut down

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Chilled and Hot Water Temperature Reset Controls (Section 6.5.4.3)

• Affects systems with design capacity > 300,000 Btu/h
  − To include controls to automatically reset supply water temperatures by representative building loads (including return water temperature) or by outside air temperature

• Exceptions:
  − If controls would result in improper operation
  − Hydronic systems with variable flow

Presenter’s note:
O.A. reset controls recommended for all boilers
Hydronic Heat Pump *(Section 6.5.4.4)*

For heat pump loops with total pump system power > 10 hp *(Section 6.5.4)*

- Two-position valves at each hydronic heat pump must be provided and interlocked to shut off water flow to the heat pump when the compressor is off
  - This basically converts the system into a variable flow system. As such, these systems must also comply with *Section 6.5.4.1*

http://www.energycodes.gov/becu/trainers.stm

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Heat Rejection Equipment *(Section 6.5.5.1)*

- Applies to heat rejection equipment used in comfort cooling systems such as
  - Air-cooled condensers
  - Open cooling towers
  - Closed-circuit cooling towers
  - Evaporative condensers

- **Exceptions:**
  - Heat rejection devices included as an integral part of equipment listed devices whose energy usage is included in Tables 6.8.1A-6.8.1D

http://www.energycodes.gov/becu/trainers.stm

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Heat Rejection Fan Speed Control (Section 6.5.5.2)

• Each condenser or tower fan powered by a motor ≥ 7.5 hp
  – Have capability to operate fan at ≤ 2/3 full speed
  – Have controls to automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device

• Exceptions:
  – Condenser fans serving multiple refrigerant circuits or flooded condensers
  – Installations located in climates zones 1 and 2
  – 1/3 of the fans on a multiple fan application speed controlled

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Exhaust Air Energy Recovery (Section 6.5.6.1)

Incorporate exhaust air energy recovery in systems with

- $\geq 70\%$ outside air and $\geq 5000$ cfm total
- Minimum 50% energy recovery effectiveness


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Exhaust Air Energy Recovery Exceptions (Section 6.5.6.1)

- Lab systems meeting Section 6.5.7.2
- Systems serving uncooled spaces that are heated to < 60°F
- Systems exhausting toxic, flammable, paint or corrosive fumes or dust
- Commercial kitchen hoods used for collecting grease or smoke
- Where > 60% of outdoor heating energy is provided from site-recovered or site solar energy
- Heating systems in climate zones 1 through 3
- Cooling systems in climate zones 3c, 4c, 5b, 5c, 6b, 7, and 8
- Where largest exhaust source is < 75% of the design outdoor airflow
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil
Heat Recovery for Service Water Heating
(Section 6.5.6.2)

• Condenser recovery required if
  - 24 hrs per day and
  - Heat rejection > 6,000,000 Btu/h and
  - SWH load > 1,000,000 Btu/h

• Exceptions
Kitchen Hoods (Exhaust)  
(Section 6.5.7.1)

• Hoods > 5,000 cfm to be provided with makeup air sized for at least 50% of exhaust air volume that is a) unheated or heated to no more than 60°F and b) uncooled or cooled without the use of mechanical cooling

• Exceptions
  - Where hoods are used to exhaust ventilation air that would otherwise exfiltrate or be exhausted by other fan systems
  - Certified grease extractor hoods that require a face velocity no greater than 60 fpm

*Presenter’s note: MMC 508 requires make-up air for all commercial hoods*

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Fume Hoods (Section 6.5.7.2)

Hood systems with a total exhaust rate > 15,000 cfm to have ONE of the following features

• Operation to ≤ 50% design flow OR
• Direct make up at least 75% of exhaust rate at specified conditions OR
• Heat recovery for make-up air

http://www.energycodes.gov/becu/trainers.stm

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Radiant Heating Systems (Section 6.5.8)

• Required for unenclosed spaces except loading docks with air curtains (Section 6.5.8.1)

• “Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard” (Section 6.5.8.2)

Presenter’s note:
“standard” is undefined

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Hot Gas Bypass Limitation *(Section 6.5.9)*

- Not used (including other evaporator pressure control systems) unless system is designed with multiple steps of unloading or continuous capacity modulation

- **Exception:**
  - Unitary packaged systems with cooling capacities ≤ 90,000 Btu/h
Submittals

• Record drawings (Section 6.7.2.1)
• Operating and maintenance manuals (Section 6.7.2.2)
• System balancing (Section 6.7.2.3)
• System commissioning (Section 6.7.2.4)
Drawings (Section 6.7.2.1)

Record drawings of actual installation to building owner within 90 days of system acceptance and include, as a minimum:

- Location and performance data on each piece of equipment
- General configuration of duct and pipe distribution system including sizes
- Terminal air or water design flow rates

http://www.energycodes.gov/becu/trainers.stm

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Manuals *(Section 6.7.2.2)*

Operating and maintenance manuals to building owner within 90 days of system acceptance and include several items

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System Balancing (Section 6.7.2.3)

(Section 6.7.2.3.1)
• Systems shall be balanced in accordance with accepted engineering standards
• Written report for conditioned spaces > 5000 ft$^2$

(Section 6.7.2.3.2)
• Minimize throttling losses
• For fans with system power > 1 hp
  – Adjust fan speed to meet design flow conditions

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Hydronic System Balancing *(Section 6.7.2.3.3)*

- Proportionately balanced to minimize throttling losses
- Pump impeller trimmed or pump speed adjusted to meet design flow conditions
- Each system to have either the ability to measure differential pressure increase across the pump or have test ports at each side of the pump
- **Exceptions:**
  - Pumps with pump motors ≤ 10 hp
  - When throttling results in < 5% of the nameplate hp draw, or 3 hp, whichever is greater, above that required if the impeller was trimmed


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System Commissioning (Section 6.7.2.4)

• Control elements shall be calibrated, adjusted, and in proper working condition

• > 50,000 ft$^2$ conditioned area requires commissioning instructions
  – *Except* warehouses and semi-heated spaces

http://www.energycodes.gov/becu/trainers.stm

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Minimum Equipment Efficiency Tables

- Equipment Efficiency Tables 6.8.1A to 6.8.1J
- Duct Insulation Tables 6.8.2A and 6.8.2B
- Pipe Insulation Table 6.8.3
SWH Compliance

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options

- Mandatory Provisions
  (required for most compliance options)
- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified

Energy Code Compliance

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Service Water Heating (Section 7)

- General (Section 7.1)
- Compliance Path(s) (Section 7.2)
- Mandatory Provisions (Section 7.4)
  - Load calculations
  - Equipment efficiency
  - Service hot water piping insulation
  - System controls
  - Pools
  - Heat traps
- Prescriptive Path (Section 7.5)
  - Space heating and water heating
  - Service water heating equipment
- Submittals (Section 7.7)

http://www.energycodes.gov/becu/trainers.stm

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SWH Alterations (Section 7.1.1.3)

SWH equipment installed as a direct replacement shall meet these requirements unless there is not sufficient space or access to meet these requirements.
SWH Compliance Paths (Section 7.2)

• You have to follow Sections
  - 7.1,
  - 7.4,
  - 7.5,
  - 7.7, and
  - 7.8

• Alternatively, you can follow Section 11 (ECB), in which case Section 7.4 is mandatory
Load Calculations *(Section 7.4.1)*

In accordance with manufacturer’s published sizing guidelines or generally accepted engineering standards and handbooks.

http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Equipment Efficiency *(Section 7.4.2)*

- Refers to Table 7.8 for equipment efficiencies
- 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* requirements when
    - Tank surface is thermally insulated to R-12.5, and
    - A standing pilot light isn’t installed, and
    - Gas- or oil-fired water heaters have a flue damper or fan-assisted combustion

http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Service Hot Water Piping Insulation (Section 7.4.3)

- Table 6.8.3, Section 6
- Circulating water heater
  - Re-circulating system piping, including supply and return piping (a)
- Non-re-circulating storage system
  - First 8 ft of outlet piping (b)
  - Inlet pipe between storage tank and heat trap (c)
- Externally-heated pipes (heat trace or impedance heating) (d)

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Service Water Heating System Controls
(Section 7.4.4)

- Temperature Controls *(Section 7.4.4.1)*
- Temperature Maintenance Controls *(Section 7.4.4.2)*
- Outlet Temperature Controls *(Section 7.4.4.3)*
- Circulating Pump Controls *(Section 7.4.4.4)*

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Temperature Controls (Section 7.4.4.1)

• To allow for storage temperature adjustment from 120°F or lower to a maximum temperature compatible with the intended use

• Exception:
  – If manufacturer’s installation instructions specify a higher minimum thermostat setting to minimize condensation and resulting corrosion
Temperature Maintenance Controls
(Section 7.4.4.2)

Automatic time switches or other controls:

• Set to switch off usage temperature maintenance system during extended periods when hot water is not required
Outlet Temperature Controls (Section 7.4.4.3)

Controls provided:

• To limit maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F
Circulating Pump Controls (Section 7.4.4.4)

To limit operation of a storage tank circulating pump to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Pools *(Section 7.4.5)*

- Pool heaters to have readily accessible on-off switch *(Section 7.4.5.1)*
- Pool heaters fired by natural gas can NOT have continuously burning pilot lights *(Section 7.4.5.1)*
- Vapor retardant pool covers required (unless > 60% from site-recovered or solar heat) *(Section 7.4.5.2)* Time switches required *(Section 7.4.5.3)*


*Date visited: 2/11/2011*
Heat Traps *(Section 7.4.6)*

Non-circulating systems to have heat traps on both the inlet and outlet piping as close as practical to storage tank (if no integral heat traps)

- Either a device specifically designed for this purpose or
- Arrangement of tubing that forms a loop of 360° or piping that from the point of connection to the water heater includes a length of piping directed downward before connection to the vertical piping of the supply water or hot water distribution system, as applicable

http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Space Heating + Water Heating *(Section 7.5.1)*

- Gas- or oil-fired space heating boiler system (complying with Section 6) is allowed to provide total space heating and water heating when ONE of the following conditions is met
  - Single boiler or component that is heating the service water has a standby loss in Btu/h not exceeding
    - \((13.3 \times \text{pmd} + 400) / n\); where \(\text{pmd}\) is probable maximum demand in gal/h and \(n\) is the fraction of the year when outdoor daily mean temperature is > 64.9°F
  - Jurisdiction agrees use of a single heat source will consume less energy than separate units
  - Energy input of the combined boiler and water heater system is < 150,000 Btu/h
- Instructions for determining standby loss are included in this Section

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Service Water Heating Equipment (Section 7.5.2)

Equipment used to provide the additional function of space heating as part of a combination (integrated) system shall satisfy all requirements for service water heating equipment.

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Service Water Heating Submittals (Section 7.7.1)

Authority having jurisdiction may require submittal of compliance documentation and supplemental information in accord with Section 4.2.2 of this standard.

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Power Compliance

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options

- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified

Mandatory Provisions
(required for most compliance options)

Energy Code Compliance

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Power (Section 8)

- Voltage drop (Section 8.4.1)
- Submittals (Section 8.7)
Voltage Drop (Section 8.4.1)

Two types of conductors:

1. Feeder conductors (Section 8.4.1.1)
   - Connect service equipment to the branch circuit breaker panels
   - 2% maximum voltage drop allowed at design load

2. Branch circuit conductors (Section 8.4.1.2)
   - Run from the final circuit breaker to the outlet or load
   - 3% maximum voltage drop allowed at design load

   These are more stringent than non-enforceable requirements in the National Electric Code (NEC)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Power Submittals *(Section 8.7)*

Owner gets information about the building’s electrical system

- **Record drawings of actual installation within 30 days (Section 8.7.1)**
  - Single-line diagram of electrical distribution system
  - Floor plans showing location and areas served for all distribution
- **Manuals (Section 8.7.2):**
  - Submittal data stating equipment rating
  - O&M manuals for equipment
  - Qualified service agency
  - Complete narrative of system as it’s normally intended to operate

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Lighting (Section 9)

• General Application (Section 9.1)
  - Scope
  - Lighting Alterations
  - Installed Interior Lighting Power
  - Luminaire Wattage

• Compliance Path(s) (Section 9.2)

• Mandatory Provisions (Section 9.4)
  - Lighting control
  - Tandem wiring
  - Exit signs
  - Exterior building grounds lighting
  - Exterior building lighting power

• Building Area Method Compliance Path (Section 9.5)

• Alternative Compliance Path: Space-by-Space Method (Section 9.6)


http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Lighting General *(Section 9.1)*

- **Scope (Section 9.1.1):**
  - Interior spaces of buildings *(a)*
  - Exterior building features *(b)*
  - Exterior grounds lighting powered through building *(c)*
  - Exceptions
    - Emergency lighting
    - Lighting required by life safety statute
    - Lighting within dwelling units of buildings
    - Decorative gas lighting

- **Lighting Alterations (Section 9.1.2):**
  - New lighting and lighting controls must comply with this section, unless an alteration replaces less than 50% of luminaires in a space and that alteration does not increase the installed lighting power


*Date visited: 2/11/2011*
Lighting General

(Section 9.1.3)

• Installed Interior Lighting Power shall include all power used by the luminaires, including lamps, ballasts, transformers, and controls
  − **Exception**: in the case where there are two independently operated lighting systems that are controlled to prevent simultaneous operation
    • Include only the higher wattage system

(Section 9.1.4)

• Luminaire Wattage for various systems shall be determined in accordance with details in this section

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Basic Lighting Requirements

Mandatory Requirements (Interior and Exterior)
- Controls
- Switching
- Efficiency

Exemptions

Interior Lighting Power Limits
- Total Connected Power
- Interior Lighting Power Allowance

Whole Building
- Space-by-Space

Additional Allowances

Exterior Lighting Power Limits
- Tradable
- Non-Tradable


http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Luminaire Wattage \textit{(Section 9.1.4)}

- Standard incandescent = max. labeled wattage of the luminaire \textit{(a)}
- Luminaires with ballasts or transformers = wattage of the maximum lamp/ballast combination OR max. labeled wattage of the luminaire \textit{(b)}
- Line voltage track = actual wattage with a min. 30 W per foot OR wattage limit of system’s circuit breaker OR wattage limit of other permanent-current-limiting device(s) on the system \textit{(c)}
- Low voltage track = transformer wattage \textit{(d)}
- All others as specified on equipment \textit{(e)}
Mandatory: Individual Space Control (Section 9.4.1.2)

- At least one for each room or space enclosed by ceiling-height partitions
  - in spaces ≤ 10,000 ft$^2$, each control serves 2500 ft$^2$ maximum and in spaces > 10,000 ft$^2$, serves 10,000 ft$^2$ maximum
- Readily accessible to occupants
- Remote location is allowed to accommodate areas where safety or security is a concern

Mandatory: Additional Space Controls (Section 9.4.1.4)

Hotel/motel guest room lighting must be controlled at room entry (c)

Occupancy sensors are required in:

- Classrooms (except shop, lab, K-12)
- Conference/meeting rooms
- Employee lunch/break rooms

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Mandatory: Individual Space Control (Section 9.4.1.4)

Additional control required for:
- Display/accent lighting \((a)\)
- Case lighting \((b)\)
- Task lighting \((d)\)
- Non-visual lighting \((e)\)
- Demonstration lighting \((f)\)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Mandatory: Automatic Shutoff (Section 9.4.1.1)

- Automatic lighting shutoff control device required in all buildings larger than 5,000 ft²

- Override of automatic shutoff required for not more than 4 hours (Section 9.4.1.2)

- *Exceptions* to automatic shutoff:
  - Lighting for 24-hour operation
  - Patient care spaces
  - Areas with safety or security concerns

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Automatic Shutoff *(Section 9.4.1.1)*

- Compliance options:
  - Control lights on a scheduled basis (automatic time switch) *(a)*
    - Time-of-day controller
    - Controls ≤ 25,000 ft\(^2\) and not more than one floor
  - Occupant sensor *(b)*
    - Turn lights off within 30 minutes of occupant leaving the space
  - Signal from another control or alarm that indicates the area is unoccupied *(c)*


http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Application of Automatic Shutoff

Intent is to apply to business entities or structures where whole building control is practical

*Example* application:
- Strip mall – individual business unit

Exterior Lighting Control (Section 9.4.1.3)

- For dusk-to-dawn lighting: astronomical time switch or photosensor
- For all other: astronomical time switch OR photosensor + time switch [REVISED!]
- All time switches must have 10 hour battery backup
- Exceptions:
  - Covered vehicle entrances
  - Exits from buildings or parking structures
  - (where required for safety, security, or eye adaptation)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Additional Control *(Section 9.4.1.4)*

Many special lighting applications must be controlled separately:

- Display/accent lighting *(a)*
- Case lighting *(b)*
- Hotel/motel guest room lighting *(c)*
- Task lighting *(d)*
- Non-visual lighting *(e)*
- Demonstration lighting *(f)*
Tandem Wiring (Section 9.4.2)

Eliminate use of single lamp, low-frequency ballast where possible


http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Tandem Wiring Exceptions *(Section 9.4.2)*

- Separated surface or pendant luminaires
- Recessed luminaires more than 10 ft apart
- Other luminaires
  - With three-lamp ballasts
  - On emergency lighting circuits
  - With no available pair
  - With one lamp, high frequency, electronic ballast


*Date visited: 2/11/2011*
Exit Signs *(Section 9.4.3)*

Limited to 5 watts per face


http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Exterior Lighting Power

- Building grounds lighting luminaires over 100 watts must have lamp efficacy of at least 60 lumen/Watt. 
  **Exception:** motion sensor controls. *(Section 9.4.4)*
- Exterior Building Lighting Power must meet prescribed wattage limits. Exterior applications divided into 2 categories *(Section 9.4.5)*:
  
  ** Tradable:** allowed wattage may be traded among these applications

  **Non-Tradable:** allowed wattage cannot be traded between surfaces or with other exterior lighting

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011

Efficacy *(Section 3 definition)*

- The ratio of light output to watts input
  - lumens per watt
- The higher the efficacy, the more efficient the light source
  - 40 watt incandescent = 480 lumens (12 L / W)
  - 40 watt fluorescent = 2640 lumens (66 L / W)
Efficacy

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011

Exterior Building Lighting Power (Section 9.4.5)

• The total exterior lighting power allowance is the sum of the individual lighting power densities [LPD]....

• ....plus an additional unrestricted allowance of 5% of that sum. Trade-offs are allowed only among “Tradable Surfaces” applications.

• Some exemptions apply
Exterior Building Lighting Power (Section 9.4.5)

Lighting used for the following exterior applications is exempt when equipped with a control device independent of the control of the nonexempt lighting:

- specialized signal, directional, and marker lighting associated with transportation;
- lighting that is integral to advertising signage or directional signage;
- lighting that is integral to equipment or instrumentation and is installed by its manufacturer;
- lighting for theatrical purposes, including performance, stage, film, and video production;
- lighting for athletic playing areas;
- temporary lighting;
- lighting for industrial production, material handling, transportation sites, and associated storage areas;
- theme elements in theme/amusement parks;
- lighting used to highlight features of public monuments and registered historic landmark structures or buildings
Exterior LPDs: 90.1-2007 (*Table 9.4.5*)

**Example:**

<table>
<thead>
<tr>
<th>Applications</th>
<th>Lighting Power Densities</th>
</tr>
</thead>
<tbody>
<tr>
<td>** Tradable Surfaces:**</td>
<td></td>
</tr>
<tr>
<td><strong>Uncovered Parking Areas</strong></td>
<td></td>
</tr>
<tr>
<td>Parking lots and drives</td>
<td>0.15 W/ft² (12 fc @ 80 L/W)</td>
</tr>
<tr>
<td><strong>Building Grounds</strong></td>
<td></td>
</tr>
<tr>
<td>Walkways less than 10 feet wide</td>
<td>1.0 W/linear foot</td>
</tr>
<tr>
<td>Walkways 10 feet wide or greater, Plaza areas and Special feature areas</td>
<td>0.2 W/ft² (16 fc @ 80 L/W)</td>
</tr>
<tr>
<td>Stairways</td>
<td>1.0 W/ft²</td>
</tr>
</tbody>
</table>


*Date visited: 2/11/2011*
Exterior LPDs: 90.1-2007 *(Table 9.4.5)*

**Example:**

<table>
<thead>
<tr>
<th>Applications</th>
<th>Lighting Power Densities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-Tradable Surfaces</strong></td>
<td></td>
</tr>
<tr>
<td>Building facades</td>
<td>0.2 W/ft² for each illuminated wall or surface or 5.0 W/linear foot for each illuminated wall or surface length</td>
</tr>
<tr>
<td>Automated teller machines &amp; night depositories</td>
<td>270 W per location plus 90 watts per additional ATM per location</td>
</tr>
<tr>
<td>Entrances and gatehouse inspection stations at guarded facilities</td>
<td>1.25 W/ft² of uncovered area (covered areas are included in the Canopies and Overhangs section of Tradable Surfaces)</td>
</tr>
</tbody>
</table>


*Date visited: 2/11/2011*
Interior Lighting Power *(Section 9.2.2.3)*

- Lots of exemptions
- Calculation methods
  - Building area *(Section 9.5)*
  - Space-by-space *(Section 9.6)*
  - Trade-offs of interior lighting power allowance among portions of the building for which a different calculation method has been used is not permitted

http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Lighting Power Allowance Exemptions (Section 9.2.2.3)

- Theatrical, stage, film, and video production
- Medical and dental procedures
- Exhibit displays for museums, monuments, and galleries
- Plant growth or maintenance
- Integral to equipment or instrumentation installed by manufacturer
- Integral to both open and glass-enclosed refrigerator and freezer cases
- Retail display windows, provided the display is enclosed by ceiling-height partitions
- Food warming and food preparation equipment
- Interior spaces specifically designated as registered interior historic landmarks
- Integral part of advertising or directional signage
- Exit signs
- Sale or lighting educational demonstration systems
- Lighting for television broadcasting in sporting activity areas
- Casino gaming areas
- Furniture-mounted supplemental task lighting controlled by automatic shutoff and complying with 9.4.1.4(d)
- For use in areas specifically designed for occupants with special needs

Date visited: 2/11/2011
Exemption Example

http://www.energycodes.gov/becu/trainers.stm

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Building Area Method of Calculating Interior Lighting Power Allowance (Section 9.5.1)

• Used for projects involving
  – An entire building
  – A single, independent, and separate occupancy in a multi-occupancy building

• Gross lighted area is multiplied by allowance from Table 9.5.1

• Limitations:
  – Insensitive to specific space functions and room configurations
  – Generally is more restrictive
  – Does not apply to all building types - but “selection of a reasonably equivalent type” is permitted

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Gross Lighted Area (Section 3 definition)

- Sum of total lighted area of a building
  - Measured from the exterior faces of the exterior walls or from the centerline of walls separating buildings, but excluding a long list of areas. (See Standard).

- Used in the building area method of determining interior lighting power allowance

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
## Building Area Allowances

### Table 9.5.1

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Lighting Power Density (W/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Court House</td>
<td>1.2 (1.4)</td>
</tr>
<tr>
<td>Dining: Bar Lounge/Leisure</td>
<td>1.3 (1.5)</td>
</tr>
<tr>
<td>Dining: Cafeteria/Fast Food</td>
<td>1.4 (1.8)</td>
</tr>
<tr>
<td>Dining: Family</td>
<td>1.6 (1.9)</td>
</tr>
<tr>
<td>Dormitory</td>
<td>1.0 (1.5)</td>
</tr>
<tr>
<td>Exercise Center</td>
<td>1.0 (1.4)</td>
</tr>
<tr>
<td>Office</td>
<td>1.0 (1.3)</td>
</tr>
</tbody>
</table>

Presenter’s note:  
( ) = 1999 ASHRAE 90.1 values

Space-by-Space Method of Calculating Interior Lighting Power Allowance *(Section 9.6.1)*

- Identify different building types in your project
- Divide gross lighted area of the building into each of the space types
- Calculate lighting power allowance by multiplying area of space type by lighting power density for that specific space type
- Sum all the allowances
- Advantages:
  - More flexible
  - Applicable to all building types
  - Accounts for room geometry (e.g., lighting needs of enclosed office vs. open office)
## Space-by-Space LPD

### Table 9.6.1

<table>
<thead>
<tr>
<th>Space Type</th>
<th>Lighting Power Density (W/ft²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Court House</td>
<td>1.9 (1.5)</td>
</tr>
<tr>
<td>Dining: Bar Lounge/Leisure</td>
<td>1.4 (1.5)</td>
</tr>
<tr>
<td>Dining: Cafeteria/Fast Food</td>
<td>2.1 (1.5)</td>
</tr>
<tr>
<td>Dining: Family</td>
<td>2.1 (1.5)</td>
</tr>
<tr>
<td>Dormitory</td>
<td>1.1 (1.5)</td>
</tr>
<tr>
<td>Exercise Center</td>
<td>0.9 (1.3)</td>
</tr>
<tr>
<td>Office, Enclosed</td>
<td>1.1 (1.5)</td>
</tr>
</tbody>
</table>

*Presenter’s note: ( ) = 1999 ASHRAE 90.1 values*

Additional Interior Lighting Power (Section 9.6.2)

An increase in the ILPA is allowed for specific space functions when using the space-by-space method. Applications must be automatically controlled, separately from the general lighting, to be turned off during non-business hours.

- Decorative in addition to general lighting – 1.0 W/ft² in space used
- Retail display lighting

Retail Display Lighting (Section 9.6.2)

Additional Interior Lighting Power Allowance = 1000 watts +
   (Retail Area 1 x 1.0 W/ft2) +
   (Retail Area 2 x 1.7 W/ft2) +
   (Retail Area 3 x 2.6 W/ft2) +
   (Retail Area 4 x 4.2 W/ft2),

Where:

Retail Area 1 = the floor area for all products not listed in Retail Area 2, 3 or 4
Retail Area 2 = the floor area used for the sale of vehicles, sporting goods and small electronics
Retail Area 3 = the floor area used for the sale of furniture, clothing, cosmetics and artwork
Retail Area 4 = the floor area used for the sale of jewelry, crystal, and china

Exception: Other merchandise categories may be included in Retail Areas 2 through 4 above, provided that justification documenting the need for additional lighting power based on visual inspection, contrast, or other critical display is approved by the authority having jurisdiction.

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Submittals *(Section 9.7)*

There are no submittals associated with the lighting requirements


*Date visited: 2/11/2011*
Other Compliance

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting
- Other

Compliance Options

- Mandatory Provisions (required for most compliance options)
- Prescriptive Option
- Trade Off Option
- Energy Cost Budget
- Simplified

Energy Code Compliance

http://www.energycodes.gov/becu/trainers.stm
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Other Equipment – Motors *(Section 10)*

- Motor efficiency levels correspond to Energy Policy Act of 1992 manufacturing standards *(Section 10.4.1)*
- Mandatory provisions are for General Purpose Design A and Design B motors only *(Section 10.8)*
- Motors in new buildings, additions to existing buildings, and alterations to existing buildings must comply *(Sections 10.1.1.1 through 10.1.1.3)*
  - Relocated or reused existing motors do not have to meet these requirements *(Section 10.1.1.3.2)*
- No small building option, no prescriptive compliance path, no alternative compliance paths, no submittals *(Sections 10.3 and 10.5 through 10.7)*


*Date visited: 2/11/2011*
Energy Cost Budget Method (Section 11)

- The ultimate trade-off method allowing you to trade-off across building systems through the use of annual, hourly simulation tools and a baseline building.
- The only real way to deal with unique designs, renewables, high-efficiency equipment, etc.
- The basis of the energy portion of the LEED rating.
- Limits allowable energy costs of the design to those of a building meeting the Standard.
- Buildings must still meet all mandatory requirements (Section X.4).

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Energy Cost Budget Method

• Tradeoff limited to building permit (Section 11.1.2)
• You have to have an approved building envelope design prior to ECB submittal (Section 11.1.3)
• You must meet all the X.4 sections AND the design energy cost cannot exceed the energy cost budget AND the energy efficiency level of components must meet or exceed the levels used to calculate the design energy cost (Section 11.1.4)
• You must document all this in great detail (Section 11.1.5)

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Energy Cost Budget Method

• Use a good and approved simulation program (Section 11.2.1)
• Use appropriate and approved climate data (Section 11.2.2)
• Use appropriate and approved purchased energy rates (Section 11.2.3)
• Use the same simulation program, climate data, and purchased energy rates for both the design energy cost and energy cost budget (Section 11.2.4)
• Get approval to deal with exceptional calculations that aren’t covered in the simulation program (Section 11.2.5)
Energy Cost Budget Method

• Develop your proposed building design and budget building design in accordance with Table 11.3.1 (Section 11.3.1)
  – This table “locks down” a number of building design parameters

• Choose your budget building HVAC system from Figure 11.3.2 and Table 11.3.2A (Section 11.3.2)
Energy Cost Budget Method

If you are attempting to show that your building goes “above code” (say, for instance, for LEED energy points) as opposed to simply using ECB as a very flexible and complex code compliance tradeoff option,

• Be sure to see Informative Appendix G, which contains many of the same elements as Section 11, but with modifications to accommodate the needs of “above code” programs

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Normative References (Section 12)

- Normative (read “mandatory”) reference documents
- Includes test methods, rating procedures, and other standards

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Includes pre-calculated U-factors, C-factors, and F-factors:

• Above-grade walls *(Section A3)*
• Below-grade walls *(Section A4)*
• Floors *(Section A5)*
• Slab-on-grade floors *(Section A6)*
• Opaque doors *(Section A7)*
• Fenestration *(Section A8)*
Building Envelope Climate Criteria (Normative Appendix B)

• Defines which of the envelope criteria tables (Tables 5.5-X) to use for your location

• General (Section B1):
  • Climate Zone Map
  • U.S. Climate Zones (by County)
  • Canadian Climatic Zones (by City)
  • International Climate Zone (by City)

• Major Climate Type Definitions (for use with non-U.S. locations) (Section B2)

http://www.energycodes.gov/becu/trainers.stm
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Methodology for Building Envelope Trade-Off Option in Subsection 5.6 *(Normative Appendix C)*

- The details of how the envelope trade-off option referenced in Section 5.6 is implemented
- This methodology is implemented in the ENVSTD software distributed with the 90.1 Users Manual

http://www.energycodes.gov/becu/trainers.stm

*Date visited: 2/11/2011*
Climate Data *(Normative Appendix D)*

- Climatic data for a number of US, Canadian, and international locations
  - HDD65 and CDD50
  - Heating and cooling design temperatures
  - “number of hours between 8 am and 4 pm with Tdb between 55 and 69”
- Used exclusively for HVAC calculations
Informative References (Informative Appendix E)

• Other useful references that are not mandatory, but are useful as examples for the user of Standard 90.1-2007
• In general, these are not consensus documents so ASHRAE procedures do not allow them to be mandatory references
Addenda Description Information (Informative Appendix F)

- Information on addenda to ANSI/ASHRAE/IENSA Standard 90.1-2004 (the predecessor to Standard 90.1-2007)
- ASHRAE issued 44 addenda to Standard 90.1-2004
- Standard 90.1-2004 plus these addenda forms the basis of Standard 90.1-2007

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Performance Rating Method
(Informative Appendix G)

Instructions for using the ANSI/ASHRAE/IESNA Standard 90.1-2007 Energy Cost Budget Method in conjunction with the U.S. Green Buildings Council (USGBC) Leadership in Energy and Environmental Design (LEED) program

http://www.energycodes.gov/becu/trainers.stm

Date visited: 2/11/2011
Compliance and Implementation Tools

Training Module

School of Planning, Design & Construction

Michigan State University
East Lansing, Michigan
What Does This Mean to Me?


Target Codes:

- **Residential**: 2009 IECC
- **Commercial**: ASHRAE 90.1-2007

90% compliance within 8 years

*One time* demonstration of 90% compliance required

Transitional Period

BECP is developing guidelines and tools to use in measuring compliance with building energy codes, which:

- Foster uniformity and objectivity in measuring compliance rates
- Eliminate need for each state to develop its own procedures and tools
- Provide tools that states can adapt for their own preferred use
- Collect additional data and support related activities.

PNNL Topic Briefs

- Brief 1: Measuring 90% Compliance
- Brief 2: Sample Size
- Brief 3: Onsite Compliance Evaluation
- Brief 4: Above-Code Programs
- Brief 5: Sample Distribution and Makeup
- Brief 6: Evaluation Checklists
- Brief 7: Compliance Roadmap
- Brief 8: Renovations
- Brief 9: Alternative Codes
- Period of Evaluation
- Annual Measurement Requirements
- Approaching Jurisdictions
- Training and Tools
- Related Outcomes

Compliance Report

*Measuring State Energy Code Compliance Report:*

- Aggregate of previously released energy code compliance topic briefs and additional information on remaining topics
- 74 page document
  - Code adoption and equivalency
  - Annual measurement
  - Planning for compliance
  - Evaluation
  - Onsite compliance evaluation procedures (includes generating the sample sets)
  - Evaluation checklists

http://www.energycodes.gov/arra/compliance_evaluation.stm  
*Date visited: 11/22/2010*
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

Commercial Building Data Collection Checklist
ANSI/ASHRAE/IESNA Standard 90.1-2007

| Date:_________ | Name of Evaluator(s):________________________________________ |
| Building Name & Address:________________________ | Conditioned Floor Area:________ ft² |
| Building Contact: Name:_____________________ Phone:____________ Email:________ |
| Compliance Approach: [ ] Prescriptive [ ] Trade-Off (Section 5.6) [ ] Performance (ECB Section 11) |
| State:_________ Jurisdiction:_________________ |
| Building Use: [ ] Office [ ] Retail [ ] Storage [ ] Education [ ] Lodging [ ] Dining |
| Project Type: [ ] New Construction [ ] Addition [ ] Renovation |

### Pre-Inspection/Plan Review

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Plan Review</th>
<th>Compl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR1 [4.2.2]¹</td>
<td>Plans and/or specifications provide all information with which compliance can be determined for the building envelope and delineate and document where exceptions to the standard are claimed.</td>
<td>Y N</td>
</tr>
<tr>
<td>PR2 [4.2.2]¹</td>
<td>Plans and/or specifications 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>Y N</td>
</tr>
<tr>
<td>PR3 [4.2.2]¹</td>
<td>Plans and/or specifications 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</td>
<td>Y N</td>
</tr>
</tbody>
</table>

**Documentation.** Determine if a complete set of plans/construction drawings, specifications, and energy code compliance documentation is available in the building department. If there is no building department or the locality does not conduct plan review, this information should be obtained from the registered design professional or builder having responsibility for the project. If documentation indicating a trade-off or performance approach is not provided, a prescriptive approach must be assumed for verifying compliance. Construction documents should sufficiently demonstrate energy code compliance, including but not limited to the following information:

- The location and R-values of insulation materials
- U-factors and SHGC values for windows, doors, skylights, and other fenestration products
- Information related to duct and piping location, insulation type and R-value, and means of sealing

Under the assumption that only state or local government with a responsible enforcement and/or permitting agency are included in compliance evaluations, plans and documentation are expected to be held by the responsible agency. If this is not the case, mark this code requirement and the next (PR1 and PR2) as non-compliant, unless there is another entity responsible for enforcement identified (e.g. utility, contractor licensing board, etc.) in which case they should be contacted to review PR1 and PR2 information.

**PR2 [403.6]²**

**HVAC Load Calculations.** Verify that HVAC load calculations have been completed and submitted. Verify the methodology used in the load calculations. List the resultant heating and/or cooling loads as applicable in the Verified Value column.
Code Officials Companion Guide

Building Energy Codes Resource Guide:

*Code Officials Edition*

View or download:


- Plan review and inspection resources
- REScheck and COMcheck reference guides
- Case studies
- Sample checklists

- Download the PDF or flip through the online version
- Register for automatic updates


To support greater compliance with energy codes, the U.S. Department of Energy's Building Energy Codes Program (BECP) and the International Code Council (ICC) have collaborated to publish a collection of each organization's most useful resources for code enforcement officials.

The guide includes practical plan review and inspection resources, including BECP's REScheck™ and COMcheck™ quick reference guides, case studies, and sample inspection checklists, as well as excerpts from ICC's commentaries, workbooks, and code companion materials.

This collection also includes many other helpful items and points to further resources available on the web. Residential and commercial building officials can easily add state and local guidance in order to use the binder as a one-stop resource to support compliance in the field.

Take a Tour!

Flip through the online version of Building Energy Codes Resource Guide: Code Officials Edition now!

Keep your guide current!


Download a copy!

Download a PDF copy of the Building Energy Codes Resource Guide for in-house printing.
Commercial Checklist Inspection Stages:

- **Plan Review**
- **Footing and Foundation**
- **Framing/Rough-In**
- **Plumbing Rough-In**
- **Mechanical Rough-In**
- **Rough-In Electrical**
- **Insulation**
- **Final**
## Plan Review Stage

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Plan Review</th>
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<th>Comments/Notes/Findings</th>
</tr>
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<tbody>
<tr>
<td>PR1 [4.2.2]</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>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR2 [4.2.2]</td>
<td>Plans and/or specifications 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>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR3 [4.2.2]</td>
<td>Plans and/or specifications provide all information with which compliance can be determined for the <strong>service water heating systems and equipment</strong> and delineate and document where exceptions to the standard are claimed.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR4 [4.2.2]</td>
<td>Plans and/or specifications provide all information with which compliance can be determined for the <strong>lighting and electrical systems and equipment</strong> 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.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR5 [6.4.2]</td>
<td>HVAC load calculations submitted.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR6 [7.4.01]</td>
<td>Service water heating load calculations submitted.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR7 [6.7.2.4]</td>
<td>Detailed instructions for HVAC systems commissioning included on the plans or specifications.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>PR8 [6.7.2.1]</td>
<td>Construction documents require HVAC “as-built” drawings submitted within 90 days of system acceptance.</td>
<td>□ □ □</td>
<td></td>
</tr>
</tbody>
</table>

**PR1 [4.2.2]**

Plans and/or specifications provide all information with which compliance can be determined for the **building envelope** and delineate and document where exceptions to the standard are claimed.
### Plan Review Stage

<table>
<thead>
<tr>
<th>PR3 [4.2.2](^1)</th>
<th>Plans and/or specifications provide all information with which compliance can be determined for the <strong>service water heating systems and equipment</strong> and delineate and document where exceptions to the standard are claimed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR6 [7.4.01](^1)</td>
<td>Service water heating load calculations submitted.</td>
</tr>
</tbody>
</table>
Plan Review Stage

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
Plan Review Stage

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)
Plan Review Stage

Plan Review for Lighting and Electrical Systems:
Energy for Lighting in Buildings

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

Plan Review Stage

Plan Review for Lighting and Electrical Systems:
Energy for Lighting in Buildings

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

PR4 [4.2.2][1]

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.
### Plan Review Stage

#### Additional Evaluation Checklist Plan Review Items

<table>
<thead>
<tr>
<th>PR7</th>
<th>Detailed instructions for HVAC systems commissioning included on the plans or specifications.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PR8</td>
<td>Construction documents require HVAC “as-built” drawings submitted within 90 days of system acceptance.</td>
</tr>
<tr>
<td>PR9</td>
<td>Feeder and branch circuit load and sizing calculations provided that allow verification of voltage drop.</td>
</tr>
<tr>
<td>PR10</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 Inspection

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
<th>Verified Value</th>
<th>Complies</th>
<th>Comments/Notes/Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO1 [5.8.1.7]</td>
<td>Exterior insulation protected against damage, sunlight, moisture, wind, landscaping and equipment maintenance activities.</td>
<td>R-</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>FO2 [5.8.1.7.3]</td>
<td>When contacting ground insulation has ≤0.3% water absorption (ASTM C272).</td>
<td>R-</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>FO3 [6.3.2, 6.4.4.1 6.4.4.2]</td>
<td>Piping, ducts and plenum are insulated and sealed when installed in or under a slab.</td>
<td>R-</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>FO4 [6.5.8.2, 7.4.3]</td>
<td>Any SWH piping in or under slab is insulated.</td>
<td>R-</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>FO5 [5.5.3.3, 5.8.1.2]</td>
<td>Below-grade wall insulation R-value. Installed per manufacturer’s instructions.</td>
<td>R-</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>FO6 [5.5.3.5, 5.8.1.2]</td>
<td>Slab edge insulation R-value, depth/length. Installed per manufacturer’s instructions.</td>
<td>R-ft</td>
<td>Y N N/A</td>
<td></td>
</tr>
<tr>
<td>FO7 [6.4.3.8]</td>
<td>Freeze protection and snow/ice melting system sensors for future connection to controls.</td>
<td>R-</td>
<td>Y N N/A</td>
<td></td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Exterior Insulation

Exterior insulation protected against damage, sunlight, moisture, wind, landscaping and equipment maintenance activities.
| FO2 [5.8.1.7.3] | When contacting ground insulation has $\leq 0.3\%$ water absorption (ASTM C272). |
### Using the Evaluation Checklists

#### Insulation in Slab

<table>
<thead>
<tr>
<th>FO3 [6.3.2, 6.4.4.1, 6.4.4.2]</th>
<th>Piping, ducts and plenum are insulated and sealed when installed in or under a slab.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FO4 [6.5.8.2, 7.4.3]</td>
<td>Any SWH piping in or under slab is insulated.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Below-Grade Insulation

FO5 [5.5.3.3, 5.8.1.2]²

Below-grade wall insulation R-value. Installed per manufacturer’s instructions.
Using the Evaluation Checklists

**Slab Edge Insulation**

| FO6 [5.5.3.5, 5.8.1.2]² | Slab edge insulation R-value, depth/length. Installed per manufacturer’s instructions. |

![Diagram of Slab Edge Insulation](image)
Using the Evaluation Checklists

Framing Rough-In Inspection

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Framing / Rough-In Inspection</th>
<th>Verified Value</th>
<th>Complies</th>
<th>Comments/Notes/Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR1 [5.8.2.2]</td>
<td>Fenestration products are certified as to performance labels or certificates provided.</td>
<td>Y</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR2 [5.5.3.1, 5.8.1.2]</td>
<td>Roof insulation R-value provided. Installed per manufacturer’s instructions.</td>
<td>R</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR3 [5.5.4.2.1, 5.5.4.2.2]</td>
<td>Performance compliance approach submitted for vertical fenestration area &gt;40% or skylight area &gt;5%.</td>
<td></td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR4 [5.5.4.3a]</td>
<td>Vertical fenestration U-Factor.</td>
<td>U</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR5 [5.5.4.3b]</td>
<td>Skylight fenestration U-Factor.</td>
<td>U</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR6 [5.5.4.4.1]</td>
<td>Vertical fenestration SHGC value.</td>
<td>SHGC -</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR7 [5.5.4.4.2]</td>
<td>Skylight SHGC value.</td>
<td>SHGC -</td>
<td>N</td>
<td>N/A</td>
</tr>
<tr>
<td>FR8 [5.8.2.1]</td>
<td>Fenestration products rated in accordance with NFRC.</td>
<td></td>
<td>N</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Glazing Video
Using the Evaluation Checklists

**Roof Insulation R-Value**

<p>| FR2 | 5.5.3.1, 5.8.1.2| Roof insulation R-value provided. Installed per manufacturer’s instructions. |</p>
<table>
<thead>
<tr>
<th>FR3</th>
<th>Performance compliance approach submitted for vertical fenestration area &gt;40% or skylight area &gt;5%.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5.5.4.2.1, 5.5.4.2.2]¹</td>
<td></td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Fenestration

Fenestration products rated in accordance with NFRC.

FR8
[5.8.2.1]^2
Roof insulation not installed on a suspended ceiling with removable ceiling panels.
Using the Evaluation Checklists

Fenestration Air Leakage

FR10 [5.4.3.2]³

Fenestration and doors meet maximum air leakage requirements.
Using the Evaluation Checklists

Vestibules - Video

FR12
[5.4.3.4]^3

Vestibules installed per approved plans.
Using the Evaluation Checklists

**Plumbing and Rough-In Inspection**

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Item Description</th>
<th>Complies Y</th>
<th>N</th>
<th>N/A</th>
<th>Comments/Notes/Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL1 [7.4.4.4]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Pump controls installed to limit operation of recirculating pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL2 [7.4.4.2]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Automatic time switches installed to automatically switch off the recirculating hot-water system or heat trace.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PL3 [7.4.6]&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Heat traps installed on non-circulating storage water tanks</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Comments: ___________________________________________________________
Using the Evaluation Checklists

**Recirculating Controls**

<table>
<thead>
<tr>
<th>PL1</th>
<th>[7.4.4.4](^1)</th>
<th>Pump controls installed to limit operation of recirculating pumps</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL2</td>
<td>[7.4.4.2](^1)</td>
<td>Automatic time switches installed to automatically switch off the recirculating hot-water system or heat trace.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Mechanical Rough-In Inspection

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Description</th>
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</tr>
</thead>
<tbody>
<tr>
<td>ME1 [6.5.6.1]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Exhaust air energy recovery on systems ≥ 5,000 cfm and 70% of design supply outside air.</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME2 [6.5.7.2]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Fume hoods exhaust systems ≥15,000 cfm have VAV hood exhaust and supply systems, direct make-up air or heat recovery.</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME3 [6.5.9]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Hot gas bypass limited to: ≤24 kBtu/h – 50% &gt;24 kBtu/h – 25%</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME4 [6.4.3.9]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Demand control ventilation provided for spaces &gt;500 ft², &gt;40 people/1000 ft² occupant density and served by systems with air side economizer, auto modulating outside air damper control or design airflow &gt;3,000 cfm.</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ME5 [6.5.1, 6.5.1.1.1, 6.5.1.1.2, 6.5.1.1.3, 6.5.1.3]&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control.</td>
<td>☐ ☐ ☐</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Exhaust Air Recovery System

ME1

[6.5.6.1]¹

Exhaust air energy recovery on systems ≥ 5,000 cfm and 70% of design supply outside air.
Using the Evaluation Checklists

Fume Hood Exhaust System

- VAV hood exhaust and supply systems,
- direct make-up air or heat recovery

Courtesy: Hamilton Labs

Fume hoods exhaust systems $\geq 15,000$ 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>ME3</th>
<th>Hot gas bypass limited to:</th>
</tr>
</thead>
<tbody>
<tr>
<td>[6.5.9]¹ C</td>
<td>≤24 kBtu/h – 50%</td>
</tr>
<tr>
<td></td>
<td>&gt;24 kBtu/h – 25%</td>
</tr>
</tbody>
</table>
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.

| ME4 [6.4.3.9]| Demand control ventilation provided for spaces >500 ft², >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. |
Using the Evaluation Checklists

Economizers

Air economizers provided where required, meet the requirements for design capacity, control signal, and high-limit shut-off and integrated economizer control.

ME5
[6.5.1, 6.5.1.1.1, 6.5.1.1.2, 6.5.1.1.3, 6.5.1.3]¹

Courtesy: Carleton College
To prevent over pressurizing 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.

ME6
[6.5.1.1.5]¹
Means provided to relieve excess outside air.
Using the Evaluation Checklists

Exposed Insulation

HVAC System Insulation

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

ME7 [6.4.4.1.1] Insulation exposed to weather to be protected from damage. Insulation outside of the conditioned space and associated with cooling systems is vapor retardant.
Using the Evaluation Checklists

Economizer Requirements

Economizer Types
Water Pre-cooling Water Econo

Water economizers provided where required, meet the requirements for design capacity, max pressure drop and integrated economizer control and heating system impact.

Economizer operation will not increase heating energy use during normal operation.

ME8
[6.5.1.2, 6.5.1.2.1, 6.5.1.2.2, 6.5.1.3] C

ME9
[6.5.1.4]
Using the Evaluation Checklists

Service Water Heating Equipment

ME10

[7.4.2]^2 C

Service water heating equipment meets efficiency requirements.
Using the Evaluation Checklists

Space and Water Heating

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.

Courtesy of Richard Ashworth and High Performance HVAC.com
Using the Evaluation Checklists

HVAC Equipment Efficiency

HVAC equipment efficiency verified.

ME13

[6.4.1.4]^2
Using the Evaluation Checklists

HVAC Ducts and Plenums Video
Using the Evaluation Checklists

HVAC Piping Insulation

- Piping Serving as Part of Heating or Cooling System Must be Insulated in Accordance with Table 6.8.3
Using the Evaluation Checklists

Return Air Dampers

ME18 [6.5.1.1.4]²

Return air and outdoor air dampers meet minimum air leakage requirements.
Hydronic Heat Pumps

- 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
Individual kitchen exhaust hoods larger than 5000 cfm must include make-up >50% of exhaust air volume.
### Using the Evaluation Checklists

#### VAV Fans

| ME21 [6.5.3.2.1]² | 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. | Circle One:  
VSD  
Vane axial fan  
Other |
| ME22 [6.5.3.2.2]² | VAV fans have static pressure sensors positioned so setpoint ≤1/3 total design pressure. |
Reset static pressure set point for DDC controlled VAV boxes reporting to central controller based on the zones requiring the most pressure.
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.
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**

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Rough-In Electrical Inspection</th>
<th>Complies</th>
<th>Comments/Notes/Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL1 [9.4.1.4]</td>
<td>Verify separate lighting control devices for specific uses installed per approved lighting plans.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL2 [9.4.3]</td>
<td>Exit signs do not exceed 5 watts per face.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL3 [9.4.4]</td>
<td>Exterior ground lighting over 100 W provides &gt;60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL4 [9.6.2]</td>
<td>Additional interior lighting power allowed for special functions per the approved lighting plans and is automatically controlled and separated from general lighting.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL5 [8.4.1.1]</td>
<td>Feeder connectors sized in accordance with approved plans.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL6 [8.4.1.2]</td>
<td>Branch circuits sized for maximum drop of 3%.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL7 [9.4.1.1]</td>
<td>Automatic lighting control to shut off all building lighting installed in buildings &gt;5,000 ft².</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EL8 [9.4.1.2]</td>
<td>Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Verify separate lighting control devices for specific uses installed per approved lighting plans.
Exit Signs

Exit signs do not exceed 5 watts per face.
Exterior ground lighting over 100 W provides >60 lm/W unless on motion sensor or fixture is exempt from scope of code or from external LPD.
Using the Evaluation Checklists

Additional Interior Lighting Power

- Space-by-space increases
  - Specific lighting function
  - Only if specific lighting is installed
  - Only for specified luminaries
  - Shall not be used for any other purpose or space

**EL4 [9.6.2]**

Additional interior lighting power allowed for special functions per the approved lighting plans and is automatically controlled and separated from general lighting.
Using the Evaluation Checklists

Feeder Connectors and Branch Circuits

Verify feeder conductors are sized for a maximum voltage drop of 2% at design load, and the branch circuit conductors are sized for a maximum voltage drop of 3% at design load.

<table>
<thead>
<tr>
<th>EL5</th>
<th>[8.4.1.1]²</th>
<th>Feeder connectors sized in accordance with approved plans.</th>
</tr>
</thead>
<tbody>
<tr>
<td>EL6</td>
<td>[8.4.1.2]²</td>
<td>Branch circuits sized for maximum drop of 3%.</td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

**Automatic Lighting Controls Video**

| EL7  | [9.4.1.1]² | Automatic lighting control to shut off all building lighting installed in buildings >5,000 ft². |
Using the Evaluation Checklists

**Independent Lighting Controls - Video**

- Lighting controls required for each area enclosed by ceiling height partitions
- Switch locations
  - In view of lights
  - “On” or “off” indication from remote location

---

**EL8 [9.4.1.2]**

Independent lighting control installed per approved lighting plans and all manual control readily accessible and visible to occupants.
Using the Evaluation Checklist

Exterior Lighting Controls Video

• Turn Lights off During Daylight Hours
  − Photo Cell
  − Automatic Time Switches
    • Seven Day/Seasonal Daylight Program
    • 4 hour Minimum Backup
  − Exception
    • Lights Intended for 24-hour Operation
Using the Evaluation Checklist

**Electrical Motors Video**

Ensure that electric motors comply with Table 10.8, where applicable.

<table>
<thead>
<tr>
<th>EL10</th>
<th>Electric motors meet requirements where applicable.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[10.4.1]²</td>
<td></td>
</tr>
</tbody>
</table>
# Using the Evaluation Checklists

## Insulation Inspection Checklist

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Insulation Inspection</th>
<th>Verified Value</th>
<th>Complies</th>
<th>Comments/Notes/Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN1 [5.5.3.1]</td>
<td>Roof insulation R-value. Installed per manufacturer’s instructions. Blown or poured loose-fill insulation is installed only where the roof slope is ≤3 in 12.</td>
<td>R-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN3 [5.5.3.2]</td>
<td>Above-grade wall insulation R-value. Installed per manufacturer’s instructions.</td>
<td>R-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN12 [5.4.3.1]</td>
<td>All sources of air leakage in the building thermal envelope are sealed, caulked, gasketed or weather stripped to minimize air leakage.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN4 [5.8.1.1]</td>
<td>Building envelope insulation is labeled with R-value or insulation certificate providing R-value and other relevant data.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN5 [5.8.1.4]</td>
<td>Eaves are baffled to deflect air to above the insulation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN6 [5.8.1.5]</td>
<td>Insulation is installed in substantial contact with the inside surface separating conditioned space from unconditional space.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN7 [5.8.1.6]</td>
<td>Recessed equipment installed in building envelope assemblies does not compress the adjacent insulation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IN8 [5.8.1.7]</td>
<td>Exterior insulation is protected from damage with a protective material.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Wall and Floor Insulation Video
Using the Evaluation Checklists

Roof Insulation - Baffling

Eaves are baffled to deflect air to above the insulation.

IN5 [5.8.1.4]²
Using the Evaluation Checklists

**Insulation Compression**

Recessed equipment installed in building envelope assemblies does not compress the adjacent insulation.

IN7 [5.8.1.6]²
Using the Evaluation Checklists

**Insulation Protection**

<table>
<thead>
<tr>
<th>IN8</th>
<th>Exterior insulation is protected from damage with a protective material.</th>
</tr>
</thead>
<tbody>
<tr>
<td>IN10</td>
<td>Insulation in contact with the ground has $\leq0.3%$ water absorption rate per ASTM C272.</td>
</tr>
<tr>
<td>IN11</td>
<td>Attics and mechanical rooms have insulation protected where adjacent to attic or equipment access.</td>
</tr>
</tbody>
</table>
Foundation vents do not interfere with insulation.
<table>
<thead>
<tr>
<th>IN14</th>
<th>High-albedo roofs meet solar reflectance of 0.70 and thermal remittance of 0.75 or SRI of 82.</th>
</tr>
</thead>
<tbody>
<tr>
<td>[5.5.3.1.1]³</td>
<td></td>
</tr>
</tbody>
</table>
Using the Evaluation Checklists

Roof Insulation

IN15 [5.8.1.8]³

Roof Insulation not installed on suspended ceiling with removable panels.
Using the Evaluation Checklists
Final Inspection Checklist

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Final Inspection</th>
<th>Complies</th>
<th>Comments/Notes/Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>F11 [6.7.2.3]</td>
<td>An air and/or hydronic system balancing report is provided for HVAC systems serving zones &gt;5,000 ft² of conditioned area.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F12 [6.7.2.4]</td>
<td>Verify HVAC control systems have been tested to ensure proper operation, calibration and adjustment of controls.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F13 [9.1.3]</td>
<td>Installed lamps and fixtures are consistent with what is shown on the approved lighting plans.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F14 [5.4.3.3]</td>
<td>Weatherseals installed on all loading dock cargo doors in Climate Zones 4-8.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F15 [5.8.2.3, 5.5.3.6]</td>
<td>U-factor and air leakage of opaque doors associated with the building thermal envelope meets requirements.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F16 [6.4.3.1.1]</td>
<td>Heating and cooling to each zone is controlled by a thermostat control.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F17 [6.4.3.1.2, 6.4.3.2, 6.4.3.3, 6.4.3.3.1, 6.4.3.3.2]</td>
<td>Temperature controls have the following features: dead band controls, setpoint overlap restrictions, off-hour controls, automatic shutdown, setback controls.</td>
<td>□ □ □</td>
<td></td>
</tr>
<tr>
<td>F18 [6.4.3.3.3]</td>
<td>Systems with air capacity &gt;10,000 cfm include optimum start controls.</td>
<td>□ □ □</td>
<td></td>
</tr>
</tbody>
</table>
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.

FI1 [6.7.2.3]¹
C

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.
Using the Evaluation Checklists

Installed Lamps and Fixtures

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

FI3 [9.1.3] ¹
Climate zones 4 – 8

Equip cargo doors and loading dock doors with weather seals

Restrict infiltration

FI4 [5.4.3.3]¹ Weather seals installed on all loading dock cargo doors in Climate Zones 4-8.
Using the Evaluation Checklists

Thermal Envelope Requirements

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- through 5.5-8

F15
[5.8.2.3, 5.5.3.6]²

U-factor and air leakage of opaque doors associated with the building thermal envelope meets requirements.
Using the Evaluation Checklists

Thermostat Control

Heating and cooling to each zone must thermostatically controlled, based on temperatures within that zone.

F16 [6.4.3.1.1]^2 Heating and cooling to each zone is controlled by a thermostat control.
Temperature Controls Must Include:
- Dead band controls,
- Set point overlap restrictions,
- Off-hour controls,
- Automatic shutdown,
- Setback controls.
Using the Evaluation Checklists

Air Systems Controls

Optimum Start Controls are Required 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 fan

FI8
[6.4.3.3.3]²

Systems with air capacity >10,000 cfm include optimum start controls.
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.
PNNL Survey:

• Better understand compliance rates
• Jurisdictional practices
• Identify training needs
• Attempt to coordinate best practices with measured compliance rates
• Confidential results
Demonstrate Compliance

Prescriptive

“Prescriptive Packages Approach”

Trade-off

“Trade-off Approach”

Performance

“Performance Approach”

COMcheck Introduction

• Based on UA tradeoff
• COMcheck Software Options
  – Web-based Version
    • Automatically updates
    • Save files online or download
  – Desktop Version
    • No internet connection required
    • Must check for updates
  – COMcheck package generator
    • Design your own code-compliant insulation and window packages based on regional requirements

Before Using COMcheck, You Will Need:

• Basic understanding of Windows-based programs
• Basic information about the builder and building to be constructed
• Plans including:
  − Areas of exterior walls, glazing, roof/ceiling, basement walls, doors, crawl walls and floors
  − R-values, U-values, wall heights and insulation depths
  − Heating and cooling system efficiencies
COMcheck Online Tool

COMcheck-Web simplifies commercial and high-rise residential energy code compliance.

It performs just like COMcheck, the desktop version, but you don’t need to download or install any software on your computer.

Contact: Technical Support
Security & Privacy

https://energycode.pnl.gov/COMcheckWeb/
COMcheck Project Screen

https://energycode.pnl.gov/COMcheckWeb/index.html
Case Study – Sample Office Building
2222 Redwood Rd.
Wall Assembly:
- Steel Frame
- 16” oc
- R21 Cavity Insulation

Roof Assembly:
- Single membrane
- R30 Continuous Insulation
Define Assembly, Construction Details, Gross Area and insulation R-value

<table>
<thead>
<tr>
<th>Building</th>
<th>Component</th>
<th>Assembly</th>
<th>Construction Details</th>
<th>Gross Area</th>
<th>Cavity Insulation R-Value</th>
<th>Continuous Insulation R-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Roof 1</td>
<td>Insulation Entirely Above...</td>
<td></td>
<td>11570 ft²</td>
<td>30.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Front Exterior Wall</td>
<td>Steel-Framed, 16&quot; o.c.</td>
<td></td>
<td>6075 ft²</td>
<td>21.0</td>
<td>0.0</td>
</tr>
<tr>
<td>3</td>
<td>Window 1</td>
<td>Metal Frame with Therma...</td>
<td>Glazing: Ti...</td>
<td>2185 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Storefront Window</td>
<td>Metal Frame:Double Pan...</td>
<td>Glazing: Ti...</td>
<td>46 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Entrance Door</td>
<td>Glass (&gt; 50% glazing):M...</td>
<td>Type: Entry...</td>
<td>47 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Back Exterior Wall</td>
<td>Steel-Framed, 16&quot; o.c.</td>
<td></td>
<td>6075 ft²</td>
<td>21.0</td>
<td>0.0</td>
</tr>
<tr>
<td>7</td>
<td>Window 1</td>
<td>Metal Frame with Therma...</td>
<td>Glazing: Ti...</td>
<td>2183 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Storefront Window</td>
<td>Metal Frame:Double Pan...</td>
<td>Glazing: Ti...</td>
<td>27 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Entrance Door</td>
<td>Glass (&gt; 50% glazing):M...</td>
<td>Type: Entrance...</td>
<td>47 ft²</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Envelope – Window Schedule

#### WINDOW SCHEDULE

<table>
<thead>
<tr>
<th>WINDOW TYPE</th>
<th>WIDTH</th>
<th>HEIGHT</th>
<th>THICK</th>
<th>DETAILS</th>
<th>GLAZING</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9'-5 1/2&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>7/A6.4</td>
<td>3/A6.4</td>
<td>1/A6.3</td>
</tr>
<tr>
<td>B</td>
<td>9'-0&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>7/A6.4</td>
<td>3/A6.4</td>
<td>1/A6.3</td>
</tr>
<tr>
<td>C</td>
<td>15'-0&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>7/A6.4</td>
<td>3/A6.4</td>
<td>1/A6.3</td>
</tr>
<tr>
<td>D</td>
<td>17'-10&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>7/A6.4</td>
<td>3/A6.4</td>
<td>1/A6.3</td>
</tr>
<tr>
<td>E</td>
<td>16'-8&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>7/A6.4</td>
<td>3/A6.4</td>
<td>1/A6.3</td>
</tr>
<tr>
<td>F</td>
<td>9'-5 1/2&quot;</td>
<td>8'-6&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>3/A6.4</td>
<td>2/A6.3</td>
</tr>
<tr>
<td>G</td>
<td>9'-0&quot;</td>
<td>8'-6&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>3/A6.4</td>
<td>2/A6.3</td>
</tr>
<tr>
<td>H</td>
<td>15'-0&quot;</td>
<td>8'-6&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>3/A6.4</td>
<td>2/A6.3</td>
</tr>
<tr>
<td>J</td>
<td>12'-2&quot;</td>
<td>8'-6&quot;</td>
<td>4 1/2&quot;</td>
<td>10/A6.4</td>
<td>4/A6.4</td>
<td>1/A6.4</td>
</tr>
<tr>
<td>K</td>
<td>17'-10&quot;</td>
<td>8'-6&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>3/A6.4</td>
<td>2/A6.3</td>
</tr>
<tr>
<td>L</td>
<td>16'-8&quot;</td>
<td>8'-6&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>3/A6.4</td>
<td>2/A6.3</td>
</tr>
<tr>
<td>M</td>
<td>9'-5 1/2&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>5/A6.4</td>
<td>3/A6.3</td>
</tr>
<tr>
<td>N</td>
<td>9'-0&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>5/A6.4</td>
<td>3/A6.3</td>
</tr>
<tr>
<td>P</td>
<td>15'-0&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>5/A6.4</td>
<td>3/A6.3</td>
</tr>
<tr>
<td>Q</td>
<td>12'-2&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>10/A6.4</td>
<td>7/A6.4</td>
<td>2/A6.4</td>
</tr>
<tr>
<td>R</td>
<td>17'-10&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>5/A6.4</td>
<td>3/A6.3</td>
</tr>
<tr>
<td>S</td>
<td>16'-8&quot;</td>
<td>6'-0&quot;</td>
<td>4 1/2&quot;</td>
<td>9/A6.4</td>
<td>5/A6.4</td>
<td>3/A6.3</td>
</tr>
</tbody>
</table>

- GLAZING: 1" INSULATED W/ LOW E
- REMARKS: 2" X 4 1/2" ALUM STOREFRONT W/ T-BREAK
### Define Assembly, Construction Details, Gross Area, U-factor and SHGC

![Image of COMcheck software interface]

#### Table Example

<table>
<thead>
<tr>
<th>Component</th>
<th>Assembly</th>
<th>Gross Area</th>
<th>Cavity Insulation R-Value</th>
<th>Continuous Insulation R-Value</th>
<th>U-Factor</th>
<th>SHGC</th>
<th>Projection Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1</td>
<td>Insulation Entirely Above...</td>
<td>11570 ft²</td>
<td>30.0</td>
<td>0.0</td>
<td>0.032</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Front Exterior Wall</td>
<td>Steel-Framed, 16&quot; o.c.</td>
<td>6075 ft²</td>
<td>21.0</td>
<td>0.0</td>
<td>0.106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window 1</td>
<td>Metal Frame with Therma...</td>
<td>2185 ft²</td>
<td>21.0</td>
<td>0.0</td>
<td>0.500</td>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Storefront Window</td>
<td>Metal Frame:Double Pan...</td>
<td>46 ft²</td>
<td>21.0</td>
<td>0.0</td>
<td>0.500</td>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Entrance Door</td>
<td>Glass (&gt; 50% glazing):M...</td>
<td>47 ft²</td>
<td>21.0</td>
<td>0.0</td>
<td>0.800</td>
<td>0.40</td>
<td>0.00</td>
</tr>
<tr>
<td>Back Exterior Wall</td>
<td>Steel-Framed, 16&quot; o.c.</td>
<td>6075 ft²</td>
<td>21.0</td>
<td>0.0</td>
<td>0.106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Window 1</td>
<td>Metal Frame with Therma...</td>
<td>2183 ft²</td>
<td>21.0</td>
<td>0.0</td>
<td>0.500</td>
<td>0.40</td>
<td>0.00</td>
</tr>
</tbody>
</table>
# Envelope – COMcheck™ Summary

## Building Envelope Summary

<table>
<thead>
<tr>
<th>Assembly Type</th>
<th>Description</th>
<th>Area</th>
<th>R-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Building Area</td>
<td>34,710 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Floors</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Finished Out Area</td>
<td>2,014 ft²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roof</td>
<td>Single Ply Membrane Roof on 4.75” Rigid Insulation on 1 1/2” Steel Deck</td>
<td>11,570 ft²</td>
<td>R-30</td>
</tr>
<tr>
<td>Exterior Walls</td>
<td>6” Steel Studs @ 16” O.C. w/R-19 unfaced Batts</td>
<td>19,152 ft²</td>
<td>R-19</td>
</tr>
<tr>
<td>Floor</td>
<td>Slab-on-grade – R-5 perimeter insulation down 2 ft.</td>
<td>447 Linear feet</td>
<td>R-5</td>
</tr>
<tr>
<td>Glazing</td>
<td>Storefront Window Metal Frame with Thermal Break, Double Glazed Low E</td>
<td>6,436 ft²</td>
<td>U-0.50</td>
</tr>
<tr>
<td></td>
<td>Storefront Window Metal Frame with Thermal Break, Double Glazed Low E</td>
<td>294 ft²</td>
<td>U-0.50</td>
</tr>
<tr>
<td></td>
<td>All Glass Metal Frame Entrance Doors</td>
<td>188 ft²</td>
<td>U-0.80</td>
</tr>
</tbody>
</table>

**SHGC**:
- 0.40

[www.energycodes.gov/becu](http://www.energycodes.gov/becu)
## Packaged Rooftop Unit Schedule

<table>
<thead>
<tr>
<th>RTU-1</th>
<th>RTU-2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DESCRIPTION:</strong></td>
<td>PACKAGED ROOFTOP MOUNTED VARIABLE AIR VOLUME AIR CONDITIONING UNIT COMPLETE WITH INDOOR BLOWER WITH VARIABLE FREQUENCY DRIVE, 100% EXHAUST BLOWER WITH ADJUSTABLE V-BELT DRIVE, HIGH EFFICIENCY VFD COMPATIBLE MOTORS, INSULATED CABINET; PACKAGED DX REFRIGERATION COILS AND COMPRESSORS WITH MULTIPLE STEP LOADING / UNLOADING AND LOW AMBIENT OPERATION CAPABILITY; VAV CONTROLS; FILTER RACKS WITH FILTERS; FULL ECONOMIZER CAPABILITY WITH FIXED MINIMUM POSITION OUTSIDE AIR DAMPER; FACTORY ROOF MOUNTING CURE/FRAME. APPROX. OPERATING HEIGHT: 10,500 LB.</td>
</tr>
<tr>
<td><strong>COOLING:</strong></td>
<td>55.0 NOM. TONS. 565.5 MBH TOTAL COOLING CAPACITY; 565.5 GROSS SENSIBLE AT OUTPUT AT 80.0 DEG. F. ENT. D.B.; 59.0 DEG. F. ENT. W.B., 91 DEG. F. AMB., 22,000 CFM AT 55.4 DEG. F. LDB, 55.6 DEG. F. LWB. ALL AT 4400 FT. ELEVATION. THREE 15 TON AND ONE 10 TON COMPRESSORS. 4.7 EER.</td>
</tr>
<tr>
<td><strong>SUPPLY BLOWER:</strong></td>
<td>22,000 CFM S.A., 2200 CFM MIN. O.A. AT 1.75 IN. WS. EXTERNAL. 565.5 MBH TOTAL STATIC. 100% VARIABLE SPEED BLOWER, 24.8 BHP. ALL AT 4400 FT. ELEV. 25.0 HP 460 V 3PH VFD COMPATIBLE BLOWER MOTOR.</td>
</tr>
<tr>
<td><strong>EXHAUST BLOWER:</strong></td>
<td>20,000 CFM EXHAUST AIR AT 0.75 IN. WS. EXTERNAL. O.B. IN WS TOTAL STATIC. 784 RPM BELT DRIVE BLOWER. 9.0 BHP ALL AT 4400 FT. ELEV. 10.0 HP 460 V 3PH SINGLE SPEED BLOWER MOTOR.</td>
</tr>
<tr>
<td><strong>UNIT WIRING:</strong></td>
<td>946.6 MCA, 450 A. MINIMUM RECOMMENDED RCD FUSE AT 208 VOLTS, 3 PHASE.</td>
</tr>
<tr>
<td><strong>FILTERS:</strong></td>
<td>16 - 20&quot; X 25&quot; X 2&quot; DISPOSABLE PLEATED GLASS MEDIA FILTERS IN FRAME.</td>
</tr>
<tr>
<td><strong>MANUFACTURER:</strong></td>
<td>TRANE CO. MODEL SXHPC554 OR ENGINEER APPROVED EQUAL.</td>
</tr>
</tbody>
</table>
## Mechanical – VAV Terminal Unit

### VAV Terminal Unit Schedule

<table>
<thead>
<tr>
<th>UNIT TAG</th>
<th>TRANE CO. MODEL NO.</th>
<th>INLET DIA (IN)</th>
<th>DSGN CLG FLOW (CFM)</th>
<th>MIN CLG FLOW (CFM)</th>
<th>MIN HTG FLOW (CFM)</th>
<th>PD @DESIGN CLG FLOW (IN.WG)</th>
<th>PRIM HTG FLOW (CFM)</th>
<th>UNIT HTG FLOW (CFM)</th>
<th>FAN FLOW (CFM)</th>
<th>FAN SPEED</th>
<th>FAN MOTOR POWER (HP)</th>
<th>COIL HEAT (MBH)</th>
<th>WATER FLOW (GPM)</th>
<th>COIL WPD (FT)</th>
<th>B&amp;G CIRC. SET.</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-101</td>
<td>VPWF-12035Q</td>
<td>12</td>
<td>1600</td>
<td>240</td>
<td>240</td>
<td>0.01</td>
<td>240</td>
<td>800</td>
<td>560</td>
<td>VAR</td>
<td>1/3 HP</td>
<td>36.05</td>
<td>2.88</td>
<td>2.55</td>
<td>1/2''</td>
</tr>
<tr>
<td>V-102</td>
<td>VPWF-10035Q</td>
<td>10</td>
<td>1200</td>
<td>180</td>
<td>180</td>
<td>0.03</td>
<td>180</td>
<td>600</td>
<td>420</td>
<td>VAR</td>
<td>1/3 HP</td>
<td>18.34</td>
<td>1.47</td>
<td>0.57</td>
<td>1/2''</td>
</tr>
<tr>
<td>V-103</td>
<td>VPWF-08025Q</td>
<td>8</td>
<td>800</td>
<td>120</td>
<td>120</td>
<td>0.14</td>
<td>180</td>
<td>500</td>
<td>380</td>
<td>VAR</td>
<td>1/8 HP</td>
<td>16.53</td>
<td>1.32</td>
<td>1.26</td>
<td>1/2''</td>
</tr>
</tbody>
</table>

### NOTES:

1. Fan motors for VAV boxes shall be 115 V. Single phase.
2. Coil heat capacities for fan powered units are based on 715 deg. EWT, 65 deg. EAT. 105 deg. LAT, approx 30 deg. WTD. All coils shall be high cap.
3. Coil heat capacities for re-heat units are based on 715 deg. EWT, 55 deg. EAT.
4. All capacities shown are based on actual air, derated for altitude.
Heating Water Boiler Schedule

Packaged Atmospheric Pressure, Natural Gas Fired Water Tube Style Heating Water Boiler Complete with: Operating Controls; Atmospheric Burners; Main and Pilot Gas Cocks; Gas Pressure Regulator(s); Barometric Damper; Low Water Cut-Off; 60 lb. ASME Relief Valve; High Limit Control; Pressure and Temperature Gauge.

1250 MBH Input, 1,037.5 MBH Output at Sea Level, 850 MBH Output at 4500 Ft. Elevation. 73 Gal Capacity; 161 sq.ft. Heating Surface; Rated at Up to 2,075 GPH at 60 Deg. F. Temp Rise. 1-16" Dia. Vent Collar. Approx. 3,510 lbs Operating Weight.

120 Volt Control Circuit.

Ajax Co. Model WRN-1250 or Engineer Approved Equal.
<table>
<thead>
<tr>
<th>TYPE</th>
<th>MANUFACTURER</th>
<th>CATALOG NUMBER</th>
<th>LAMPING</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>DAY-BRITE LIGHTING</td>
<td>2LP3GS33236ALUV-1/3-EB</td>
<td>(3) 32W T8</td>
<td>FLUORESCENT 2'X4' LAY-IN 18 CELL PARABOLIC LOUEVER</td>
</tr>
<tr>
<td>A-EM</td>
<td>DAY-BRITE LIGHTING</td>
<td>2LP3GS33236ALUV-1/3-EB</td>
<td>(3) 32W T8</td>
<td>SAME AS A BUT WITH ONE LAMP ON EMERGENCY BATTERY PACK</td>
</tr>
<tr>
<td>B</td>
<td>CAPRI LIGHTING</td>
<td>CM6-FV26/32/42U-V65</td>
<td>(1) 26W CFM</td>
<td>COMPACT FLUORESCENT RECESSED DOWNLIGHT</td>
</tr>
<tr>
<td>B-EM</td>
<td>CAPRI LIGHTING</td>
<td>CM6-FV26/32/42UER-V65</td>
<td>(1) 26W CFM</td>
<td>SAME AS B BUT WITH AN EMERGENCY BATTERY PACK</td>
</tr>
<tr>
<td>C</td>
<td>DAY-BRITE LIGHTING</td>
<td>CAN32UNV-1/2-EB</td>
<td>(2) 32W T8</td>
<td>NARROW FLUORESCENT WRAPAROUND</td>
</tr>
<tr>
<td>D</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>BATHROOM VANITY LIGHT ($200.00 ALLOWANCE)</td>
</tr>
<tr>
<td>E</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>T.B.D. MIN EFFICACY: 60 LUMENS/WATT</td>
<td>CONTEMPORARY WALL SCONCE ($200.00 ALLOWANCE)</td>
</tr>
<tr>
<td>E-EM</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>SAME AS E BUT WITH AN EMERGENCY BATTERY PACK</td>
</tr>
<tr>
<td>F</td>
<td>US ARCHITECTURAL LIGHTING</td>
<td>DSSHR-111250MH120XPDDBM</td>
<td>250W MH</td>
<td>PARKING AREA LIGHTS MOUNTED ON 20'-0&quot; POLE</td>
</tr>
<tr>
<td>G</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>T.B.D.</td>
<td>LOBBY CEILING CHANDELIER ($300.00 ALLOWANCE)</td>
</tr>
<tr>
<td>EX1</td>
<td>DAY-BRITE LIGHTING</td>
<td>VEGWEM</td>
<td>LED</td>
<td>GREEN LED EMERGENCY EXIT LIGHT</td>
</tr>
<tr>
<td>EX2</td>
<td>DAY-BRITE LIGHTING</td>
<td>VEGWEM</td>
<td>LED</td>
<td>DOUBLE SIDED GREEN LED EMERGENCY EXIT LIGHT</td>
</tr>
<tr>
<td>EX3</td>
<td>DAY-BRITE LIGHTING</td>
<td>CCTXL1GWLH</td>
<td>LED</td>
<td>GREEN LED EMERGENCY EXIT LIGHT WITH EMERGENCY BUG LIGHTS</td>
</tr>
</tbody>
</table>
## Interior Lighting Inputs

<table>
<thead>
<tr>
<th>Building</th>
<th>Allowed wattage</th>
<th>Proposed wattage</th>
<th>Component</th>
<th>Fixture ID</th>
<th>Fixture Description</th>
<th>Lamp Description/Wattage Per Lamp</th>
<th>Ballast</th>
<th>Lamps Per Fixture</th>
<th>Number of Fixtures</th>
<th>Fixture Wattage</th>
<th>Track Lighting Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office (2014 sq.ft.)</td>
<td>Allowed wattage = 2014</td>
<td>Proposed wattage = 1765</td>
<td>Linear Fluorescent 2</td>
<td>Type A</td>
<td>32 W T8</td>
<td>48” T8 32W</td>
<td>Electronic</td>
<td>3</td>
<td>10</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>Compact Fluorescent 1</td>
<td>Type B</td>
<td>CFL</td>
<td>Triple 4-pin 26W</td>
<td>Electronic</td>
<td>1</td>
<td>10</td>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Fluorescent 1</td>
<td>Type C</td>
<td>32 W T8</td>
<td>48” T8 32W</td>
<td>Electronic</td>
<td>2</td>
<td>5</td>
<td>65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incandescent 1</td>
<td>Type D</td>
<td>Bathroom Fan Lighting</td>
<td>Incandescent 100W</td>
<td>Electronic</td>
<td>1</td>
<td>2</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Lighting – Parking Lot

LOT 4

NEW MASONRY WALLS
3'-3 1/16" - 1'-0"

NEW GROUND SLEEVE

MURRAY POWER PAD MOUNTED TRANSFORMER

NEW VOLTAGE PRIMARY SEE SINGLE-LINE DIAGRAM FOR MORE INFORMATION

3-STORE OFFICE BUILDING

LOT 1

LOT 2

GAS METER

MULTIPLE CONDUITS TO PANELS SEE SHEET 107
# Exterior Lighting Applications

<table>
<thead>
<tr>
<th>Description</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncovered Parking Areas - Parking Lots and Drives</td>
<td>40,360 ft²</td>
</tr>
<tr>
<td>Building Grounds - Walkways (&lt;10 ft wide)</td>
<td>355 ft</td>
</tr>
<tr>
<td>Building Grounds - Walkways (≥ 10 ft wide)</td>
<td>4,320 ft²</td>
</tr>
<tr>
<td>Building Entrances - Main Entries</td>
<td>12 ft</td>
</tr>
<tr>
<td>Building Entrances – Other Doors</td>
<td>12 ft</td>
</tr>
</tbody>
</table>
# Lighting – COMcheck™ Exterior Lighting Inputs

![Case Study.cck: COMcheck 3.8.0](Image)

**Code:** 2009 IECC

<table>
<thead>
<tr>
<th>Component</th>
<th>Fixture ID</th>
<th>Fixture Description</th>
<th>Lamp Description/Wattage Per Lamp</th>
<th>Ballast</th>
<th>Lamps Per Fixture</th>
<th>Number of Fixtures</th>
<th>Fixture Wattage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Lighting Areas:</td>
<td>Tradable Wattage: Allowed = 3754 Proposed = 3480 Supplemental wattage: 600 (see Help for details)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 Parking area (40360 ft²)</td>
<td>HID 1</td>
<td>Metal Halide 250W Pulse start</td>
<td>1</td>
<td>8</td>
<td>255</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>HID 2</td>
<td>Metal Halide 75W Pulse start</td>
<td>1</td>
<td>4</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>HID 2 copy 1</td>
<td>Metal Halide 75W Pulse start</td>
<td>1</td>
<td>10</td>
<td>80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Main entry (12 ft of door width)</td>
<td>HID 2 copy 2</td>
<td>Metal Halide 75W Pulse start</td>
<td>1</td>
<td>2</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Other door (not main entry) (12 ft of</td>
<td>HID 2 copy 3</td>
<td>Metal Halide 75W Pulse start</td>
<td>1</td>
<td>2</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**

- For HID lamps, pulse start ballasts are used to allow for dimming.
- Supplemental wattage is included in the total wattage calculations.
- Details about how to calculate the wattage can be found in the Help section of the software.
Plan review for energy code compliance can be conducted quickly and efficiently. The U.S. Department of Energy’s COMcheck™ Compliance Software is designed to create simplified compliance certificates that can be easily reviewed by enforcement personnel. The Quick Reference Guide identifies the objectives of plan review and code compliance responsibilities, and will take you step-by-step through a typical plan review of a COMcheck™ submittal.

**Plan Review Objectives:** There are three objectives in conducting a building energy code plan review; verify:

A. the documentation has been correctly prepared
B. the levels of efficiency shown on the plans meet or exceed that shown in the documentation
C. all information needed to conduct a field inspection is included in the plans or documentation for the inspector to use on site

**Code Compliance Responsibilities:** Successful compliance requires the cooperation of many individuals involved in a building project: designers, engineers, architects, building owners, etc. Compliance also requires the efforts of certain individuals to whom the code gives specific responsibilities:

- Applicant
- Building Official
- Plans Examiner or Special Plans Examiner
- Inspector or Special Inspector
Commercial Plan Review

COMcheck Software Version 3.8.0

Envelope Compliance Certificate

2009 IECC

Section 1: Project Information

Project Type: New Construction
Project Title: Sample Office Building

Construction Site:
2222 Redwood Road
Salt Lake City, UT 22262
Permit No. 10-463
Permit Date: August 19, 2010

Owner/Agent:
ABC Property Company
1677 2nd Street
Salt Lake City, UT 22311

Designer/Contractor:
Designs Are Us
1453 McMinnion Street
Park City, UT 99422

Step 1: Verify the Project Information matches the information on the building plans. The code, location, and project type will impact compliance.

Commercial Plan Review

Step 2: Verify the Building Type or Activity Type(s) and Floor Area match the project type. Verify the floor area does not exceed the project floor area shown on the building plans. Single occupancy buildings should always use Whole Building Method unless each Activity Type within the building is identified separately.

Section 2: General Information

Building Location (for weather data): Salt Lake City, Utah
Climate Zone: 5b
Vertical Glazing / Wall Area Pct.: 26%
Activity Type(s): Office
Floor Area: 2014
Commercial Plan Review

Step 3: Verify the exterior building thermal envelope complies with the code by +0% or greater.

Step 4: Verify the construction assemblies listed under Component Name/Description match the construction assemblies shown on the plans.

Step 5: Verify the Gross Area or Perimeter values represent the proposed project. Verify the fenestration is calculated correctly (rough opening).

Section 3: Requirements Checklist

<table>
<thead>
<tr>
<th>Component Name/Description</th>
<th>Gross Area or Perimeter</th>
<th>Cavity R-Value</th>
<th>Cont. R-Value</th>
<th>Proposed U-Factor</th>
<th>Budget U-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof 1: Insulation Entirely Above Deck</td>
<td>11570</td>
<td>30.0</td>
<td>0.0</td>
<td>0.032</td>
<td>0.048</td>
</tr>
<tr>
<td>Front Exterior Wall: Steel-Framed, 16&quot; o.c.</td>
<td>6075</td>
<td>21.0</td>
<td>0.0</td>
<td>0.106</td>
<td>0.064</td>
</tr>
<tr>
<td>Window 1: Metal Frame with Thermal Break:Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>2185</td>
<td>0.0</td>
<td>0.500</td>
<td>0.550</td>
<td></td>
</tr>
<tr>
<td>Storefront Window: Metal Frame:Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>46</td>
<td>---</td>
<td>---</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Entrance Door: Glass (&gt; 50% glazing):Metal Frame, Entrance Door, SHGC 0.40</td>
<td>47</td>
<td>---</td>
<td>---</td>
<td>0.800</td>
<td>0.800</td>
</tr>
<tr>
<td>Back Exterior Wall: Steel-Framed, 16&quot; o.c.</td>
<td>6075</td>
<td>21.0</td>
<td>0.0</td>
<td>0.106</td>
<td>0.064</td>
</tr>
<tr>
<td>Window 1: Metal Frame with Thermal Break:Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>2183</td>
<td>---</td>
<td>---</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Storefront Window: Metal Frame:Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>27</td>
<td>---</td>
<td>---</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Entrance Door: Glass (&gt; 50% glazing):Metal Frame, Entrance Door, SHGC 0.40</td>
<td>47</td>
<td>---</td>
<td>---</td>
<td>0.800</td>
<td>0.800</td>
</tr>
</tbody>
</table>

Envelope PASSES: Design 0.4% better than code.
### Commercial Plan Review

#### Table:

<table>
<thead>
<tr>
<th>Component</th>
<th>U-Value 1</th>
<th>U-Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance Door: Glass (50% glazing)</td>
<td>0.800</td>
<td>0.800</td>
</tr>
<tr>
<td>Door, SHGC 0.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Exterior Wall: Steel-Framed, 16” o.c.</td>
<td>0.106</td>
<td>0.064</td>
</tr>
<tr>
<td>Window 1: Metal Frame with Thermal Break: Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Storefront Window: Metal Frame: Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Entrance Door: Glass (50% glazing): Metal Frame, Entrance Door, SHGC 0.40</td>
<td>0.800</td>
<td>0.800</td>
</tr>
<tr>
<td>Right Exterior Wall: Steel-Framed, 16” o.c.</td>
<td>0.106</td>
<td>0.064</td>
</tr>
<tr>
<td>Window 1: Metal Frame with Thermal Break: Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Storefront Window: Metal Frame: Double Pane with Low-E, Tinted, SHGC 0.40</td>
<td>0.500</td>
<td>0.550</td>
</tr>
<tr>
<td>Entrance Door: Glass (50% glazing): Metal Frame, Entrance Door, SHGC 0.40</td>
<td>0.800</td>
<td>0.800</td>
</tr>
<tr>
<td>Floor 1: Slab-On-Grade: Unheated, Vertical 2 ft.</td>
<td>---</td>
<td>5.0</td>
</tr>
</tbody>
</table>

---

**Step 6:** Verify the insulation R-values shown on the building plans meet or exceed the values in the **Cavity R-Value and Continuous R-Value** section. Verify the insulation will fit uncompressed in the framing cavity. Continuous R-values are for insulation installed over the face of framing; insulation installed with no thermal breaks.

---

**Step 7:** Verify the fenestration and door **U-Factors** shown meet or exceed what is provided on the building plans. If shown, **SHGC and Projection Factor (PF)** should also be verified.
Commercial Plan Review

Air Leakage, Component Certification, and Vapor Retarder Requirements:

☐ 1. All joints and penetrations are caulked, gasketed or covered with a moisture vapor-permeable wrapping material installed in accordance with the manufacturer’s installation instructions.
☐ 2. Windows, doors, and skylights certified as meeting leakage requirements.
☐ 3. Component R-values & U-factors labeled as certified.
☐ 4. No roof insulation is installed on a suspended ceiling with removable ceiling panels.
☐ 5. ‘Other’ components have supporting documentation for proposed U-Factors.
☐ 6. Insulation installed according to manufacturer’s instructions, in substantial contact with the surface being insulated, and in a manner that achieves the rated R-value without compressing the insulation.
☐ 7. Stair, elevator shaft vents, and other outdoor air intake and exhaust openings in the building envelope are equipped with motorized dampers.
☐ 8. Cargo doors and loading dock doors are weather sealed.
☐ 9. Recessed lighting fixtures installed in the building envelope are Type IC rated as meeting ASTM E283, are sealed with gasket or caulk.
☐ 10. Building entrance doors have a vestibule equipped with closing devices.

Exceptions:
- Building entrances with revolving doors.
- Doors that open directly from a space less than 3000 sq. ft. in area.

Section 4: Compliance Statement

Compliance Statement: The proposed envelope design represented in this document is consistent with the building plans, specifications and other calculations submitted with this permit application. The proposed envelope system has been designed to meet the 2009 IECC requirements in COMcheck Version 3.8.0 and to comply with the mandatory requirements in the Requirements Checklist.

Name: 
Title: 
Signature: 
Date: 

Project Notes:
Core and Shell Example. Energy Code Compliance is for the building envelope, mechanical system and lighting for the Floor 1 finished out core area.

Step 8: Checklist items: Insulation, Fenestration and Doors, and Air Leakage and Component Certification should be reviewed to ensure these mandatory requirements will be met or are exempt (not applicable). For example, review documentation as to whether a vestibule is required.
Commercial Plan Review

COMcheck Software Version 3.8.0

Interior Lighting Compliance Certificate

2009 IECC

Section 1: Project Information

Project Type: New Construction
Project Title: Sample Office Building

Construction Site:
2222 Redwood Road
Salt Lake City, UT 22262
Permit No. 10-463

Owner/Agent:
ABC Property Company
1677 2nd Street
Salt Lake City, UT 22311

Designer/Contractor:
Designs Are Us
1453 McMinnion Street
Park City, UT 99422

Step 1: Verify the Project Information matches the information on the building plans. The code, location, and project type will impact compliance.
Commercial Plan Review

Section 2: Interior Lighting and Power Calculation

<table>
<thead>
<tr>
<th>Area Category</th>
<th>Floor Area (ft²)</th>
<th>Allowed Watts / ft²</th>
<th>Allowed Watts (B x C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>2014</td>
<td>1</td>
<td>2014</td>
</tr>
</tbody>
</table>

Total Allowed Watts = 2014

Step 2: Verify the Building Type or Area Category(s) and **Floor Area** match the project type. Verify the floor area does not exceed the project floor area shown on the building plans. Single occupancy buildings should always use Whole Building Method unless each **Area Category** within the building is identified separately.

Step 3: Verify the Lighting Power Calculation is consistent with the lighting plans.
Commercial Plan Review

Step 4: Verify the Fixture Description, Lamps per Fixture, Ballast Type, and Number of Fixtures shown in the documentation is consistent with the lighting plans/fixture schedule.

Step 5: Verify the **Fixture Wattage** is accurate. Default values can be used in COMcheck or from the manufacture literature. However, careful attention to overall wattage installed against the proposed should be reviewed.

### Section 3: Interior Lighting Fixture Schedule

<table>
<thead>
<tr>
<th>Fixture ID</th>
<th>Description</th>
<th>Lamp</th>
<th>Wattage Per Lamp</th>
<th>Ballast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office (2014 sq.ft.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Fluorescent 2: Type A: 32 W T8 / 48&quot; T8 32W / Electronic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compact Fluorescent 1: Type B: CFL / Triple 4-pin 26W / Electronic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linear Fluorescent 1: Type C: 32 W T8 / 48&quot; T8 32W / Electronic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incandescent 1: Type D: Bathroom Fan Lighting / Incandescent 100W</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamps/ Fixture</td>
<td># of Fixtures</td>
<td>Fixture Watt</td>
</tr>
<tr>
<td>Office (2014 sq.ft.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>95</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>32</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>100</td>
</tr>
</tbody>
</table>

Total Proposed Watts = 1765
Section 4: Requirements Checklist

Lighting Wattage:
☐ 1. Total proposed watts must be less than or equal to total allowed watts.

<table>
<thead>
<tr>
<th>Allowed Watts</th>
<th>Proposed Watts</th>
<th>Complies</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>1765</td>
<td>YES</td>
</tr>
</tbody>
</table>

Step 6: Verify the Proposed Wattage is less than or equal to the Allowed Wattage.
Commercial Plan Review

Step 7: Verify all mandatory requirements have been met. For example, verify switching for each interior space is shown on the lighting plans and is applicable to the space type.

Controls, Switching, and Wiring:

- 2. Daylight zones under skylights more than 15 feet from the perimeter have lighting controls separate from daylight zones adjacent to vertical fenestration.
- 3. Daylight zones have individual lighting controls independent from that of the general area lighting.

Exceptions:
- Contiguous daylight zones spanning no more than two orientations are allowed to be controlled by a single controlling device.
- Daylight spaces enclosed by walls or ceiling height partitions and containing two or fewer light fixtures are not required to have a separate switch for general area lighting.
- 4. Independent controls for each space (switch/occupancy sensor).

Exceptions:
- Areas designated as security or emergency areas that must be continuously illuminated.
- Lighting in stairways or corridors that are elements of the means of egress.
- 5. Master switch at entry to hotel/motel guest room.
- 6. Individual dwelling units separately metered.
- 7. Medical task lighting or art/history display lighting claimed to be exempt from compliance has a control device independent of the control of the nonexempt lighting.
- 8. Each space required to have a manual control also allows for reducing the connected lighting load by at least 50 percent by either controlling all luminaires, dual switching of alternate rows of luminaires, alternate luminaires, or alternate lamps, switching the middle lamp luminaires independently of other lamps, or switching each luminaire or each lamp.
Commercial Plan Review

Section 5: Compliance Statement

Compliance Statement: The proposed lighting design represented in this document is consistent with the building plans, specifications and other calculations submitted with this permit application. The proposed lighting system has been designed to meet the 2009 IECC requirements in COMcheck Version 3.8.0 and to comply with the mandatory requirements in the Requirements Checklist.

Name - Title | Signature | Date

Step 8: Verify the Interior Lighting complies with the code by +0% or greater.
Commercial Plan Review

COMcheck Software Version 3.8.0

Exterior Lighting Compliance Certificate

2009 IECC

Section 1: Project Information

Project Type: New Construction
Project Title: Sample Office Building
Exterior Lighting Zone: 2 (Neighborhood business district)

Construction Site:
2222 Redwood Road
Salt Lake City, UT 22262
Permit No. 10-463
Permit Date: August 19, 2010

Owner/Agent:
ABC Property Company
1677 2nd Street
Salt Lake City, UT 22311

Designer/Contractor:
Designs Are Us
1453 McMinnion Street
Park City, UT 96422

Step 1: Verify the [highlighted text]
Information matches the information on the building plans. The code, location, and project type will impact compliance.
Commercial Plan Review

Section 2: Exterior Lighting Area/Surface Power Calculation

Step 2: Verify the lighting application(s) (Exterior Area/Surface), Quantity, and Totals match lighting specifications.

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior Area/Surface</td>
<td>Quantity</td>
<td>Allowed Watts / Unit</td>
<td>Tradable Wattage</td>
<td>Allowed Watts (B x C)</td>
<td>Proposed Watts</td>
</tr>
<tr>
<td>Parking area</td>
<td>40360 ft²</td>
<td>0.06</td>
<td>Yes</td>
<td>2422</td>
<td>2040</td>
</tr>
<tr>
<td>Walkway &lt; 10 feet wide</td>
<td>355 ft of walkway length</td>
<td>0.7</td>
<td>Yes</td>
<td>248</td>
<td>320</td>
</tr>
<tr>
<td>Walkway ≥ 10 feet wide</td>
<td>4320 ft²</td>
<td>0.14</td>
<td>Yes</td>
<td>605</td>
<td>800</td>
</tr>
<tr>
<td>Main entry</td>
<td>12 ft of door width</td>
<td>20</td>
<td>Yes</td>
<td>240</td>
<td>160</td>
</tr>
<tr>
<td>Other door (not main entry)</td>
<td>12 ft of door width</td>
<td>20</td>
<td>Yes</td>
<td>240</td>
<td>160</td>
</tr>
</tbody>
</table>

Total Tradable Watts* = 3756
Total Allowed Watts = 3755
Total Allowed Supplemental Watts** = 600

* Wattage tradeoffs are only allowed between tradable areas/surfaces.
** A supplemental allowance equal to 600 watts may be applied toward compliance of both non-tradable and tradable areas/surfaces.
Commercial Plan Review

Step 3: Verify the **Fixture Description**, **Lamps per Fixture**, **Ballast Type**, and **Number of Fixtures** shown in the documentation is consistent with the lighting plans/fixture schedule.

Step 4: Verify the **Fixture Wattage** is accurate. Default values can be from COMcheck or from manufacture literature. However, careful attention to overall wattage installed against the proposed should be reviewed.

### Section 3: Exterior Lighting Fixture Schedule

<table>
<thead>
<tr>
<th>Fixture ID</th>
<th>Description</th>
<th>Lamp / Wattage Per Lamp / Ballast</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E (C X D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Parking area (40380 ft²): Tradable Wattage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HID 1: Metal Halide 250W / Pulse start</td>
<td>1</td>
<td>8</td>
<td>255</td>
<td>2040</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Walkway &lt; 10 feet wide (355 ft of walkway length): Tradable Wattage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HID 2: Metal Halide 75W / Pulse start</td>
<td>1</td>
<td>4</td>
<td>80</td>
<td>320</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Walkway &gt;= 10 feet wide (4320 ft²): Tradable Wattage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HID 2 copy 1: Metal Halide 75W / Pulse start</td>
<td>1</td>
<td>10</td>
<td>80</td>
<td>800</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Main entry (12 ft of door width): Tradable Wattage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HID 2 copy 2: Metal Halide 75W / Pulse start</td>
<td>1</td>
<td>2</td>
<td>80</td>
<td>160</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Other door (not main entry) (12 ft of door width): Tradable Wattage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HID 2 copy 3: Metal Halide 75W / Pulse start</td>
<td>1</td>
<td>2</td>
<td>80</td>
<td>160</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Tradable Proposed Watts =</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3480</td>
</tr>
</tbody>
</table>

Commercial Plan Review

Section 4: Requirements Checklist

Lighting Wattage:
☐ 1. Within each non-tradable area/surface, total proposed watts must be less than or equal to total allowed watts. Across all tradable areas/surfaces, total proposed watts must be less than or equal to total allowed watts.

  Compliance: Passes.

Controls, Switching, and Wiring:
☐ 2. All exemption claims are associated with fixtures that have a control device independent of the control of the nonexempt lighting.
☐ 3. Lighting not designated for dusk-to-dawn operation is controlled by either a photosensor (with time switch), or an astronomical time switch.
☐ 4. Lighting designated for dusk-to-dawn operation is controlled by an astronomical time switch or photosensor.
☐ 5. All time switches are capable of retaining programming and the time setting during loss of power for a period of at least 10 hours.
Exterior Lighting Efficacy:

☐ 8. All exterior building grounds luminaires that operate at greater than 100W have minimum efficacy of 60 lumen/watt.

Exceptions:

- Lighting that has been claimed as exempt and is identified as such in Section 3 table above.
- Lighting that is specifically designated as required by a health or life safety statute, ordinance, or regulation.
- Emergency lighting that is automatically off during normal building operation.
- Lighting that is controlled by motion sensor.

**Exterior Lighting PASSES: Design 20% better than code.**

## Section 5: Compliance Statement

**Compliance Statement:** The proposed exterior lighting design represented in this document is consistent with the building plans, specifications and other calculations submitted with this permit application. The proposed lighting system has been designed to meet the 2009 IECC requirements in COMcheck Version 3.8.0 and to comply with the mandatory requirements in the Requirements Checklist.

<table>
<thead>
<tr>
<th>Name - Title</th>
<th>Signature</th>
<th>Date</th>
</tr>
</thead>
</table>

**Step 6:** Verify the Exterior Lighting complies with the code by +0% or greater.
Commercial Plan Review

COMcheck Software Version 3.8.0

Mechanical Compliance Certificate

2009 IECC

Section 1: Project Information

Project Type: New Construction
Project Title: Sample Office Building

Construction Site:
2222 Redwood Road
Salt Lake City, UT 22262
Permit No. 10-483
Permit Date: August 19, 2010

Owner/Agent:
ABC Property Company
1677 2nd Street
Salt Lake City, UT 22311

Designer/Contractor:
Designs Are Us
1453 McMinion Street
Park City, UT 99432

Step 1: Verify the Project Information matches the information on the building plans. The code, location, and project type will impact compliance.

Section 2: General Information

Building Location (for weather data):
Salt Lake City, Utah
Climate Zone:
5b
**Commercial Plan Review**

**Section 3: Mechanical Systems List**

<table>
<thead>
<tr>
<th>Quantity</th>
<th>System Type &amp; Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HVAC System 1: Cooling: Cooling equipment (Rooftop Package Unit), Capacity Unknown, Efficiency: 12.10, Evaporatively Cooled Condenser / Multiple-Zone</td>
</tr>
<tr>
<td>1</td>
<td>HVAC System 3: Cooling: Cooling equipment (Rooftop Package Unit), Capacity Unknown, Evaporatively Cooled Condenser / Multiple-Zone</td>
</tr>
<tr>
<td>1</td>
<td>Plant 1: Heating: Hot Water Boiler, Capacity 1038 kBtu/h, Gas, Efficiency: 75.00 % Et</td>
</tr>
</tbody>
</table>

**Section 4: Requirements Checklist**

Requirements Specific To: HVAC System 1:

- 1. Equipment minimum efficiency: Rooftop Package Unit: 12.1 EER
- 2. Minimum one temperature control device per zone
- 3. Leak testing > 3 per in. static pressure - report submitted showing CL < 6.0
- 4. Balancing and pressure test connections on all hydronic terminal devices
- 5. Systems serving more than one zone must be VAV systems
  - Exception: Where pressure relationships must be maintained
  - Exception: Zones or supply air systems with at least 75% of reheating/recooling energy site recovered or site solar
  - Exception: Zones with humidity requirements for special processes
  - Exception: Zones with cfm <300 and flow rate <10% of total design flow rate
  - Exception: Outside air needed to meet IMC Chapter 4
Commercial Plan Review

- 14. Demand control ventilation (DCV) present for high design occupancy areas (>40 person/1000 ft² in spaces >500 ft²) and served by systems with any one of 1) an air-side economizer, 2) automatic modulating control of the outdoor air damper, or 3) a design outdoor airflow greater than 3000 cfm.
  - Exception: Systems with heat recovery.
  - Exception: Multiple-zone systems without DDC of individual zones communicating with a central control panel.
  - Exception: Systems with a design outdoor airflow less than 1200 cfm.
  - Exception: Spaces where the supply airflow rate minus any makeup or outgoing transfer air requirement is less than 1200 cfm.
- 15. Motorized, automatic shutoff dampers required on exhaust and outdoor air supply openings
  - Exception: Gravity dampers acceptable in buildings <3 stories
  - Exception: Gravity dampers acceptable in systems with outside or exhaust air flow rates less than 300 cfm where dampers are interlocked with fan
- 16. Automatic controls for freeze protection systems present
- 17. Three-pipe systems not used
- 18. Exhaust air heat recovery included for systems 5,000 cfm or greater with more than 70% outside air fraction or specifically exempted
  - Exception: Hazardous exhaust systems, commercial kitchen and clothes dryer exhaust systems that the International Mechanical Code prohibits the use of energy recovery systems.
  - Exception: Systems serving spaces that are heated and not cooled to less than 60°F.
  - Exception: Where more than 60 percent of the outdoor heating energy is provided from site-recovered or site solar energy.
  - Exception: Heating systems in climates with less than 3600 HDD.
  - Exception: Cooling systems in climates with a 1 percent cooling design wet-bulb temperature less than 64°F.
  - Exception: Systems requiring dehumidification that employ energy recovery in series with the cooling coil.
  - Exception: Laboratory fume hood exhaust systems that have either a variable air volume system capable of reducing exhaust and makeup air volume to 50 percent or less of design values or, a separate make up air supply meeting the following makeup air requirements: a) at least 75 percent of exhaust flow rate, b) heated to no more than 2°F below room setpoint temperature, c) cooled to no lower than 3°F above room setpoint temperature, d) no humidification added, e) no simultaneous heating and cooling.

Section 5: Compliance Statement

Compliance Statement: The proposed mechanical design represented in this document is consistent with the building plans, specifications and other calculations submitted with this permit application. The proposed mechanical systems have been designed to meet the 2009 IECC requirements in COMcheck Version 3.8.0 and to comply with the mandatory requirements in the Requirements Checklist.

Name - Title

Signature

Date
Commercial Plan Review

COMcheck Software Version 3.8.0

Mechanical Requirements Description

2009 IECC

The following list provides more detailed descriptions of the requirements in Section 4 of the Mechanical Compliance Certificate.

Requirements Specific To: HVAC System 1:
1. The specified heating and/or cooling equipment is covered by the ASHRAE 90.1 Code and must meet the following minimum efficiency:
   - Rooftop Package Unit: 12.1 EER
2. Each zone of a multiple-zone system must have its own temperature control device.
3. The specified distribution system is designed to operate at static pressure over 3 in. water column. The system must be leak tested in accordance with SMACNA standards. The contractor or engineer must submit a report to the enforcing jurisdiction documenting that a minimum of 25% of all duct surfaces have been tested and that tested ducts have a SMACNA rated air leakage class of under 0.0.
4. Hydronic heating and cooling coils must be equipped with a way to pressure test connections and measure and balance water flow and pressure.
5. Systems serving multiple thermostatic control zones must be variable-flow systems. Zone terminal controls must reduce the flow of primary supply air before reheating, recooling, or mixing air streams to one of the following:
   a) 30% of the maximum supply air to each zone,
   b) 300 cfm or less where the maximum flow rate is less than 10% of the total fan system supply airflow rate, or
   c) minimum ventilation requirements of Chapter 4 of the International Mechanical Code.

Exception: VAV controls are not required for zones with special pressurization or cross-contamination requirements. These zones must be called out in the construction documents for easy identification during field inspection.

Exception: VAV controls are not required for zones or supply air systems where at least 75% of the reheating and recooling energy is made available through the use of site-recovered or site solar energy. These zones must be called out in the construction documents for easy identification during field inspection.

Exception: VAV controls are not required for zones with special humidity control requirements for specialized processes. These zones must be called out in the construction documents for easy identification during field inspection.

Exception: VAV controls are not required for zones that require less than 300 cfm of supply air provided the total airflow to these zones does not exceed 10% of the total design flow rate for the system.

Exception: VAV controls are not required where constant volume supply air is necessary to meet the minimum outside air requirements of Chapter 4 of the International Mechanical Code. These zones must be called out in the construction documents for easy identification during field inspection.
REScheck software also available for residential projects:

http://www.energycodes.gov/rescheck/download.stm
U.S. Department of Energy

DOE Homepage: [www.energy.gov](http://www.energy.gov)

- National Security
- Energy Sources
- Energy Efficiency
- Environment
- Energy Prices and Trends
- Science and Technology
- Health
- Safety and Security
- Program Offices
- Staff Offices
- Energy Information Administration
- National Laboratories and Technology Centers
- Operations Offices and Field Organizations

Date visited: 3/14/2011
# Building Energy Codes Program

**BECP Homepage:**

http://www.energycodes.gov/

<table>
<thead>
<tr>
<th>Free Code Downloads</th>
<th>Building Energy Codes University (BECU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (REScheck)</td>
<td>Training Presentations</td>
</tr>
<tr>
<td>Commercial (COMcheck)</td>
<td>State Training Events</td>
</tr>
<tr>
<td>Compliance Tools</td>
<td>Consumer Education</td>
</tr>
<tr>
<td>Federal Building Codes</td>
<td>Energy Codes Glossary</td>
</tr>
</tbody>
</table>

[Image of the BECP homepage]

Date visited: 3/14/2011
Welcome to the Building Energy Codes Resource Center

This system has been developed to provide users with information about energy codes and beyond code technologies. You can SEARCH by keyword, or BROWSE the available topics. Start your research using the toolbar at the top of the page.

Resources are available in a variety of different media types, including Articles, Graphics, Online Tools, Presentations, and Videos. The BECP Resource Center gathers content not only from our own archives, but also provides links to energy code resources from around the web. Learn more about the Resource Center.

Something missing? Send us your materials if you see something outdated, or let us know if you have requests for information we don’t have.
Building Energy Codes University (BECU)

Training Hard to Save Energy

The Building Energy Codes University provides a one-stop shop for all of your building energy codes training needs — whether you are new to the world of energy codes or are a seasoned veteran.

Course Offerings

BECU offers training in a variety of formats and media types; from self-paced online training to live webcast events to tailored on-site training. Course topics cover the entire spectrum of building energy codes at all levels. Course topics include:

- Compliance with the American Recovery and Reinvestment Act
- The 2009 International Energy Conservation Code
- The ASHRAE 90.1-2007 standard
- REScheck and COMcheck basics
- and much more...

A Continuing Education Provider

BECU, through the Building Energy Codes Program, is a continuing education provider for the American Institute of Architects.
General Information

- Building Energy Codes 101 - An Introduction

Webcasts On-Demand

- Comply! Energy Code Tools You May Be Missing
- Duct Testing

Self-Paced Training

- Codes 101
- Area Takeoffs 101

Instructions

- Webcasts On-Demand
- Self-Paced Courses
Online Learning Modules:

http://www.energycodes.gov/becu/

REScheck Basics

Course Description:
This training covers the basics of using REScheck software and is geared toward the beginning user.

Original Webcast Date
February 19, 2009

Presented by:
Rosemarie Bartlett and Pam Cole
Pacific Northwest National Laboratory

Downloads:
Video (1 hour, 8 minutes)
Video Transcript
Presentation Slides

ASHRAE 90.1—2007 Download

Through funding from the U.S. Department of Energy (DOE), the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) had offered the Standard 90.1-2007 Inch Pound Edition (I-P Edition) available to download at no-cost for a limited time.

Due to overwhelming popularity, no-cost copies of 90.1-2007 are no longer available.

ASHRAE is now offering the digital version of the Standard at a reduced price of $19.00 for a limited time.

Visit ASHRAE’s website to purchase a copy of Standard 90.1-2007 at this reduced price now.

http://www.energycodes.gov/publications/code_books.stm
REScheck and COMcheck
Welcome to the Building Codes Assistance Project (BCAP)

BCAP's home site is undergoing revisions!

While we're working on improving the site, please visit our energy code resource and community site, the Online Code Environment and Advocacy Network (OCEAN). Launched in November 2009, OCEAN offers users the chance to browse a comprehensive energy codes library, interact with a network of energy code stakeholders, catch the latest energy code news and events, and, of course, check out BCAP's various energy code status maps and other helpful tools.

You may notice that a page you are used to looking at is no longer available here. However, we have provided re-directs for all of our most popular pages that are now on OCEAN.

Visit OCEAN at www.bcap-ocean.org
Why Energy Codes Matter

What Consumers Need to Know

We don’t often think about how much energy used in buildings impacts society. Yet buildings account for over 40 percent of total energy use in the United States—more than either the transportation or industrial sectors.

Building energy codes matter because they:

Save Consumers Money

For most people, buying a home is the most expensive investment they will ever make. It is surprising, then, that so many of us don’t look at the operational costs of our homes when making a purchase. Most homes waste energy needlessly, and those costs add up. In 2008, US households spent about $2,225 on average for energy bills. Energy efficient buildings use less energy, which reduces utility bills and puts money back into consumers’ pockets. Millions of additional dollars are now available to...

Help Stimulate the Economy and Create Green Jobs

Consumers spend the money they save from reduced energy bills on other goods and services, which bolsters the local economy. Businesses can then invest in other areas of need, such as production, investment, and employee retention, as well as provide more work for local inspection departments. Setting new standards for efficiency also creates a growing market for energy audits, retrofits, and weatherization. In short, investing in energy efficiency projects creates or sustains a wide-range of green jobs. Of course, at their most basic level, building codes are designed to...

Ensure Health and Safety

First, energy codes reduce heating and cooling costs, helping protect millions of low-income Americans who can now afford to stay warm in the winter and cool in the summer. Second, they reduce pollution from electricity generation and improves indoor air quality, both of which keep us healthier. Finally, they reduce greenhouse gas emissions, which mitigates the impacts of global climate change. Finally, energy codes...

Provide Comfort

An important advantage of energy-efficient homes is that they receive a higher rate of homeowner satisfaction. Lower air infiltration rates, along with lower utility bills and higher potential resale values, lead to happy customers with comfortable homes. Energy efficient construction also cuts back the time and money that may be spent in the future on home improvement projects to make living spaces more comfortable.

OCEAN is an online resource of the Building Codes Assistance Project

For more information, please visit us at: www.bcap-ocean.org

http://bcap-ocean.org/why-energy-codes-matter
BCAP: OCEAN

Energy efficiency is in! But as demand for more stringent energy codes grows, so does the complexity of the codes process and the need for a broad coalition of stakeholders. For anyone new to codes, simply identifying the many actors involved can be a daunting task, much less finding opportunities for involvement. Even veteran code experts must stay up-to-date with the changing landscape.

To help make sense of it all, BCAP is proud to introduce the Energy Codes Universe!

Disclaimer: The intent of this resource is to include all participants in the energy codes process. However, BCAP acknowledges the possibility of excluding deserving organizations. All omissions are inadvertent. If you believe that your organization merits recognition in the Energy Codes Universe, please contact us at bcap-ocean@ase.org.

ASHRAE Standard 90.1 -- Energy Standard for Buildings Except Low-Rise Residential Buildings

Training and Resources

Professional Development Seminars (Full-Day)

Complying with Standard 90.1:2007

This course is targeted at design professionals, code officials and building owners. ASHRAE Standard 90.1-1999, 90.1-1999, and 90.1-2001 have been the benchmarks for commercial building energy codes in the United States and a key basis for standards in more than 15 countries around the world. The 2004 version of Standard 90.1 includes significant changes from the previous versions, such as reducing the number of climate zones from 20 to 8, refining a number of HVAC provisions, improving the stringency of lighting power requirements, and adding an appendix with new, more flexible rules when using 90.1 for LEED certification. This course presents an overview of the 2004 standard, the addenda that are added in the 2007 version, the standard’s requirements, and methods for compliance.

Exceeding the Requirements of Standard 90.1:2007

This course is targeted at design professionals and building owners. Appendix G, a new informative appendix in 90.1 since 2004, provides specific guidance on the rules and procedures to use to simulate building energy use when the objective is to substantially exceed the requirements of 90.1. Appendix G is especially useful for energy simulations connected with LEED credits and with energy tax credits. This course presents an overview of Appendix G and explains its use through a number of examples using EnergyStar.

Short Courses (Half-Day)

Complying with Standard 90.1:2007: HVAC Mechanical

This course presents the HVAC mechanical and methods of compliance from ASHRAE Standard 90.1-2007. Standard 90.1 is the benchmark for commercial building energy codes in the United States and in countries around the world. States are currently in the process of adopting elements of the Standard. The U.S. Department of Energy is also reviewing it in preparation for adoption as the new benchmark for state energy codes. This course presents an overview of the Standard and describes changes to the new 2004 mechanical section that are part of the 2007 Standard. Design professionals, code officials and building owners will benefit from this seminar.

Exceeding Standard 90.1:2007

This course explains Appendix G, a new informative appendix in 90.1 since 2004, provides specific guidance on the rules and procedures to use to simulate building energy use when the objective is to substantially exceed the requirements of 90.1. Appendix G is especially useful for energy simulations connected with LEED credits and with energy tax credit.
ICC Training Resources

http://www.iccsafe.org/Edu-Cert/Pages/default.aspx  Date visited: 3/14/2011
Training Workshops

Energy Codes 2010
http://www.energycodes.gov/events/energycodes/agenda_presentations.stm

Energy Codes 2011
http://www.energycodes.gov/events/energycodes

BEST3 Conference 2012
http://www.thebestconference.org/program.php

Efficiency Vermont 2011 Conference Presentations
http://www.efficiencyvermont.com/for_our_partners/bbd/conference_schedule.aspx

Greenbuild International Conference and Expo
http://www.greenbuildexpo.org/Home.aspx
Upcoming Workshops

For a list of upcoming energy related conferences, workshops and events:

State of Michigan Resources

Michigan Bureau of Construction Codes (BCC):
http://www.michigan.gov/dleg/0,1607,7-154-10575---,00.html

http://www.michigan.gov/dleg/0,1607,7-154-25676---,00.html

Energy Efficiency for Small Businesses:

Energy Star Homes Brochure:

Home Maintenance and Operations:
U.S. EPA Energy Star Homes Program®

Energy Star is a government-backed program helping businesses and individuals protect the environment through superior energy efficiency

For more information:  http://www.energystar.gov/
Video Resource: Weatherization TV

Training America's Wx Workforce

WxTV will take a look inside eight weatherization training centers around the country to see what they're doing to train the weatherization workforce. The technology and techniques in training have come a long way.

Running length: 20:48  Date added: 2/11/11

Attic Prep & Insulation

Insulating an attic is one of the cornerstones of weatherization. On a six degree day in Fargo, ND, Doug Bakke and crew will show us what to look for when prepping and sealing an attic and then blowing in cellulose to reach an R50 target.

Running length: 17:33  Date added: 1/24/11

Health & Safety Series: Mold & Moisture

WxTV jumps back into our Health & Safety Series with this episode dealing with mold and moisture problems. We'll travel to the states of Washington and Maryland to look at three homes with existing mold problems and listen to how these crews handled this challenging health issue.

Running length: 14:23  Date added: 1/14/11

U.S. Green Building Council (USGBC)

Education & Training
USGBC is the source for LEED and green building knowledge. With the most innovative and highest-quality LEED and green building knowledge and training, a USGBC education helps green building professionals across all market sectors build the capacity to build their careers.

USGBC’s LEED Curriculum
Browse through the essential LEED trainings developed and delivered by USGBC at www.usgbc.org/LEEDcurriculum. See what’s available at all learning levels for every rating system track from the organization that knows LEED best.

E-Learning
From webinars to podcasts, online courses to videos and case studies (coming soon!), USGBC is your source for excellence in online, green building education. Browse through the expert online resources developed and delivered by USGBC at www.usgbc.org/ELearning.

Find Courses
Your interactive source for all the LEED and green building courses, trainings and resources offered by USGBC and approved third-party courses. Find what you need, when and how you need it.

Find Resources & Experts
Connect to hundreds of free third-party resources on a variety of green building topics, listen to USGBC podcasts, find an industry expert to speak at your next event, and browse a library of great green building reads.

Education Providers
USGBC’s broad network of Education Providers equips professionals with advanced green
California's Energy Efficiency Standards for Residential and Nonresidential Buildings

Title 24, Part 6, of the California Code of Regulations

The Energy Efficiency Standards for Residential and Nonresidential Buildings were established in 1978 in response to a legislative mandate to reduce California's energy consumption. The standards are updated periodically to allow consideration and possible incorporation of new energy efficiency technologies and methods.

2008 Standards - Effective January 1, 2010

2008 Standards - Went into effect January 1, 2010, and supersede the 2005 Standards. Projects that apply for a building permit on or after this date must comply with the 2008 Standards.

California's building efficiency standards (along with those for energy efficient appliances) have saved more than $56 billion in electricity and natural gas costs since 1978. It is estimated the standards will save an additional $23 billion by 2013.

The current 2003 standards may be downloaded from the Web pages listed above, or to obtain a hard copy, contact the Energy Commission's publications unit at +1-916-654-5200.

If you have questions about Title 24:

Energy Standards Hotline
E-mail: title24@energy.ca.gov
Phone: +1-916-654-5106 or
Phone: +1-800-772-5286 (toll free in Calif.)

http://www.energy.ca.gov/title24/ Date visited: 3/15/2011
City of Seattle: DIY Energy Audit


Date visited: 3/15/2011
The Code College Initiative is designed to address the building and energy code and building science training needs of the building industry, including code officials, state agencies, builders, and trade groups across the nation. Code College presents objective, industry-sponsored online training from national experts that brings the audience to the field with our "online job site" approach available 24/7 for the ultimate convenience of the building professionals.

Learn more about...

Advertising on the Code College Network

Want to reach 1000's of people in the construction industry with information about your product? BCAP's Cosmina Panatiul explains the concept behind the code college network and highlights the many reasons why product manufacturers and industry professionals should take advantage of this exceptional marketing venue. Double click on the video for a full scene version of this 3 minute video.

Code College Online Video Training Offerings

To watch a video, click on thumbnails.

RESIDENTIAL VIDEOS

BUILDING ENVELOPE > Insulation: Rigid Foam Insulation

Overview of Rigid Foam Insulation

Doug Bilbee, Residential Technical Specialist, Dow Building Materials, explains the benefits of using insulated foam sheathing in order to increase energy efficiency and help prevent moisture/mold problems.

Exterior Wall Sheathing

Wood framing typically represents 25% of the surface area of walls, so the proper installation of insulated foam sheathing can prevent thermal bridging and increase energy efficiency in a house.

Exterior Basements and Slabs

Insulating the exterior foundation walls helps the concrete stay warm and uses thermal mass properties to help keep the basement warmer. Find out how to install exterior insulated foam sheathing.

http://www.codecollegenetwork.com/video_center/
Alliance to Save Energy (ASE)

The Latest in Energy Efficiency

President Obama's Conference on Rising Oil, Gas Prices Prompts Renewed Call for Increased Energy Efficiency by Alliance to Save Energy
March 11, 2011

The Alliance to Save Energy echoed President Obama's call at today's White House news conference for bipartisan cooperation by members of Congress to advance energy efficiency as oil and gas prices continue to rise.

Can I Get a Tax Credit for That?
March 11, 2011

No one likes filling out their taxes. But, for consumers making energy-efficient choices, tax season might help you keep a little extra cash in your wallet.

Alliance to Save Energy Says Greater U.S. Energy Efficiency Can Counter Spiking Oil, Gas Prices That Threaten Economic

http://ase.org/ Date visited: 3/15/2011
ASE: Building Energy Efficient Codes Network

Topics: Homes and Buildings, Policy, Codes and Standards

The Building Energy Efficient Codes Network is the Alliance’s coalition to influence national public policy and public opinion on energy efficient codes.

Overview:

The Building Energy Efficient Codes Network (BEECN) engages Congress and other elected officials, industry leaders, code officials, and the media in support of set energy code targets for homes and commercial buildings. The broad-based coalition also advocates adequate resources for the adoption and enforcement of energy codes for all new buildings.

BEECN unites key stakeholders in an integrated campaign of lobbying, media, and grassroots advocacy in support of federal legislation that will set America on a path of continuous improvement that will lead to net zero energy buildings by 2030.

What’s New

Policy Summit on Capitol Hill: Energy Efficiency Across the Smart Grid
September 17, 2010

EE Global Forum Attracts International Energy Efficiency Leaders
February 17, 2011

Energy Efficiency Global Forum 2011: In Brussels in April
January 31, 2011

Poll: Energy Efficiency Key to Reducing Costs in Federal Government Buildings
November 5, 2010

Code to Vastly Improve Energy Efficiency of Home, Commercial Building Construction
November 4, 2010

Welcome to the

Michigan Bureau of Construction Codes
Online Code Training Series

As our statewide construction codes are revised and updated, we are providing this e-learning programming to educate the industry on building product information, installation details and performance standards guidance to meet the revised codes. Through the kind support of our industry sponsors, Building Media, Inc. (www.buildingmedia.com) is working in partnership with the Bureau of Construction Codes to develop and provide this unique Internet-based training approach for building and design communities to disseminate and communicate these new and revised construction codes.

The purpose of this online building academy is to provide readily accessible training to building department personnel, builders and architects. The goal of this training program is to:

1. Educate building department personnel to have a greater knowledge and understanding of the codes so they can effectively enforce and inspect for building code regulations
2. Assist builders to construct better buildings that are in compliance with the new state building codes
3. Instruct architects and engineers on understanding the new codes that will be reflected in their designs and engineering.

Click on the buttons on the left to enter the learning modules.

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National Association of State Energy Officials (NASEO)

On Capitol Hill, NASEO Advocates for Full Funding of U.S. State Energy Program

With debate on the FY '11 federal budget in full swing, the National Association of State Energy Officials is urging the Senate to fully fund the U.S. State Energy Program (SEP), the only Department of Energy program that provides cost-shared formula funds directly to states for energy-related economic development. SEP allows states to determine which energy priorities to target.

The State Energy Program has maintained bipartisan support from governors and Congress for 30 years and focuses on energy efficiency and renewable energy projects that address each state's unique energy priorities and opportunities. Each dollar of federal SEP funding is matched with an estimated $10.71 of state and private funds, and yields $7.22 in annual energy cost savings, according to a Department of Energy national lab study.
Home Energy Rating System (HERS)

For More Information:

• Residential Energy Services Network
  
  http://resnet.us
  
  - Mission: establish and maintain the standards of quality for evaluating building energy performance and increase the opportunity for ownership of high performance buildings

• Energy Efficient Homes Midwest
  
  http://www.eehmidwest.com/
  
  - Midwest agency
  - Certifies most raters in Michigan
Additional Training Resources

U. S. Department of Energy
Building Energy Codes Program

Additional Training Resources:
http://www.energycodes.gov/events/other_resources.stm

- Several additional training resources
- ICC and ASHRAE links
- Professional and trade organizations
- State-specific resources
Interesting Web Links

ASHRAE Building Science Article

California Title 24: Online Learning
http://www.energy.ca.gov/title24/

City of Seattle, WA: DIY Home Energy Audit

Efficient Windows Collaborative
http://www.efficientwindows.org/

EPA Energy Star Program
http://www.energystar.gov/

Michigan Code Watch: Online Code Training
http://www.michigancodes.com/

MIT Open Courseware
http://ocw.mit.edu/index.htm

Montana Weatherization Training Center
http://weatherization.org/
Interesting Web Links

Oak Ridge National Laboratory: Building Envelope Research
http://www.ornl.gov/sci/roofs+walls/insulation/ins_01.html

Southface Learning Center
www.southface.org/learning-center/trainings/

Southface Online Training
www.southfaceonlinetraining.org/

U. S. Energy Information Administration: Key Terms Glossary
http://www.eia.doe.gov/a-z_index/Energya-z_a.html

U. S. Green Building Council (LEED Rating System)
www.usgbc.org

USGBC: Education
http://www.usgbc.org/education

U.S. DOE: Building Energy Codes Program
http://www.energycodes.gov

U.S. DOE: Energy Savers Blog
Appendix
Important Terminology

Heat Flow Terms:

- R-value
- U-value
- C-factor
- F-factor
R-value

A measure of thermal resistance, or how well a material or series of materials resist the flow of heat. R-value is the reciprocal of U-value. Materials with higher R-values resist better than those with lower R-values.

Unit of measure: hr ft$^2$ °F / BTU

$R = 1 / U$-value
U-value

A measure of how well a material or series of materials conduct heat. U-values for window and door assemblies are the reciprocal of the assembly R-value. Materials with lower U-values resist heat better than those with higher U-values.

Unit of measure: BTU / hr ft²°C

\[ U = \frac{1}{R\text{-value}} \]
C-factor

C-factor is also a rate of heat flow through a homogenous material, but could be for any given thickness.

Unit: BTU / hr ft² °F

C-factor does not include soil or air films
The perimeter heat loss factor for slab-on-grade floors, expressed in **BTU / hr ft. °F**
Glazing/Fenestration

- Fenestration
- Solar Heat Gain Coefficient
- Shading Coefficient
Fenestration

The terms "fenestration", "window", and "glazing" are often used interchangeably. However, fenestration refers to the design and position of windows, doors and other structural openings in a building (including frames).
Fenestration

- U-values for windows can be measured at the center of the glass or can be expressed as a whole unit U-value
- National codes such as IECC and IRC require a unit U-value
- Codes have specific requirements for testing and labeling of window U-values
Solar Heat Gain Coefficient (SHGC)

SHGC is the glazing's effectiveness in rejecting solar heat gain. It is a part of a system for rating window performance used by the National Fenestration Rating Council (NFRC).

It is the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed, then subsequently released inward. It is expressed as a number between 0 and 1. The lower a window's SHGC, the less solar heat it transmits.

SHGC is gradually replacing the older index, Shading Coefficient (SC), in design standards.


Date Visited: 3/15/2011
Shading Coefficient

The ratio of solar heat gain through fenestration, with or without integral shading devices, to that occurring through un-shaded 1/8-in thick double-strength glass.

If you are using glass whose performance is listed in terms of SC, you may convert to SHGC by multiplying the SC value by 0.87
Climate Zone / Degree Days

- Climate Zone
- Heating Degree Days
- Cooling Degree Days

Heating Degree Days

A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load of a building in winter. For any one-day, when the mean temperature is less than 65°F (18.3°C), there exists as many degree-days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65°F (18.3°C).

Example for any given day:
High Temp = 50° F
Low Temp = 20° F
Average Temperature = 50° + 20° F = 70/2 = 35° F
Degree Day = 65°F - 35° F = 30° F
Therefore, the day was a 30° HDD

Totaling the degree-days generated each day for the entire year represents the annual Heating Degree Days which is abbreviated as HDD
Cooling Degree Days

For any one-day when the mean temperature is more than 50°F (10°C), there are as many degree-days as degrees Fahrenheit temperature difference between the mean temperature for the day and 50°F (10°C).

Example for any given day:
High Temp = 80°F
Low Temp = 40°F
Average Temperature = \(80°\,F + 40°\,F = 120/2 = 60°\,F\)
Degree Day = \(60°F - 50°F = 10°F\)
Therefore, the day was a 10°F CDD

Totaling the degree-days generated each day for the entire year represents the annual Cooling Degree Days which is abbreviated as CDD.

http://www.climatesource.com/us/fact_sheets/excdd_us.gif

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Other Key Terms

• Air Barrier
• Mass Wall
• Semi-heated Space
Air Barrier

The principal function of the air barrier is to prevent both the infiltration of outdoor air into a building and the exfiltration of indoor air to the outside.

Air leakage can cause problems such as loss of energy and deposition of moisture in the walls.
Mass Walls

Wall with thermal heat sinking capacity exceeding 7 BTU/ft\(^2\)ºF or 5 BTU/ft\(^2\)ºF provided that the wall has material unit weight not greater than 120 lb/ft\(^3\).

It is generally constructed of masonry or heavy wood and serves as a heat sink.
Semi-Heated Space

An enclosed space within a building that is heated by a heating system whose output capacity is greater than or equal to 3.4 BTU/hr.ft$^2$ of floor area, but is not a conditioned space.
Equipment Efficiency Terms

- Energy Efficiency
- Coefficient of Performance (COP)
- Energy Efficiency Ratio (EER)
- Seasonal Energy Efficiency Ratio (SEER)
- Annual Fuel Utilization Efficiency (AFUE)
Energy Efficiency

Energy Efficiency = Useful Energy OUTPUT / energy INPUT

**Example:** The IRC requires the heating appliances to be 78% energy efficient or 0.78.

Practically, efficiency cannot be 100% or 1 because energy is always lost in appliances in the form of sound or light energy.
Coefficient of Performance (COP)

The ratio of the rate of heat exchange to the rate of energy input in consistent units for a complete cooling/heating system as tested under a nationally recognized standard or designated operating conditions.
Energy Efficiency Ratio (EER)

The ratio of net cooling capacity of an equipment item in Watts (1 BTU / hr = 0.29 Watts) to the total rate of power input (in Watts) under designed operating conditions.

\[
EER = \frac{\text{Net cooling capacity (in Watts)}}{\text{Power input (Watts)}}
\]
Seasonal Energy Efficiency Ratio (SEER)

The ratio of the total cooling output of an air conditioner during its annual usage period of cooling to the energy input during the same period.

SEER = Cooling output / Energy input

• New equipment ranges from about 10 to 16 SEER
• Higher SEER ratings indicate more efficient equipment
Annual fuel utilization efficiency is the combustion heating equipment efficiency and is abbreviated as AFUE. AFUE typically ranges from about 78 to 96% AFUE.

*Higher AFUE ratings indicate more efficient equipment*
Basic Energy Units

• **British Thermal Unit (BTU):**
  - 1 BTU is the amount of heat energy required to raise the temperature of one pound of water by 1°F, at sea level (It takes about 2,000 BTUs to make a pot of coffee).

• **Joules:**
  
  1,000 joules = 1 Kilojoules = 1 BTU

  So, 2 million joules to make a pot of coffee!!

• **Other measures such as CALORIES**
Heat Energy and Heat Flow

• Heat is a form of energy

• Flows in 3 ways:
  – CONDUCTION
  – CONVECTION
  – RADIATION

http://www.savenrg.com/norbs.jpg
https://www.cresis.ku.edu/iceicebaby/?m=201010

Date visited: 3/15/2011
CONDUCTION

• Higher to lower temperature (higher $\rightarrow$ lower energy)
• Transfer of heat through a substance, resulting from a difference in temperature between different parts
• Rate of heat flow between 2 regions is directly proportional to:
  – The temperature difference between them and
  – Conductivity of the substance
  – Contact area
• Example: Heat flowing from inside conditioned space to outside unconditioned space through walls
CONVECTION

• Warmer air rises

• Convection is the mode of heat transfer in fluids (air and liquids)
  – Air expands when heated—density decreases
  – Warmer air rises through the surrounding cooler air
  – Cooler air that flows in to replace the rising warmer air gets heated and also rises
  – Thus, a current called a convection current, becomes established in the air
  – The same principle causes land and sea breezes
RADIATION

Radiant energy is energy that comes from a source and travels through space (example: solar radiation)

- The Sun: The most common source of radiant energy
- The Sun's light and heat cannot reach us by conduction or convection because space is almost completely empty (VACUUM)

When sunlight hits the earth, its radiant energy is absorbed or reflected
Energy in Building Science

• A building’s energy performance is closely related to other aspects of building science such as:
  – MOISTURE
  – MOLD
  – VENTILATION

• Changes in construction details for one purpose can have unintended effects

• When designing for energy one should consider moisture and ventilation simultaneously

• In some states successful training programs for builders have been developed, which address these interrelationships
Moisture in Buildings

Excessive moisture in buildings, combined with favorable temperature conditions, can foster:

- Mold growth
- Air quality problems
- Health problems
- Decay of building materials and failure of the envelope

According to EPA:

*The key to mold control is moisture control*
Envelope Air/Moisture Flows

Source: Building Science Primer by Patrick Huelman, University of Minnesota, July 2004
Envelop Moisture Formation

Moisture condenses on the cold underside of the plywood sheathing.

Warm, moist air enters the roof assembly through openings around the recessed light fixture.

Condensed moisture drips down into the space.

Source: Building Science Primer by Patrick Huelman, University of Minnesota, July 2004
# Moisture Control

## Key Components of a Cold Climate House

<table>
<thead>
<tr>
<th>Component</th>
<th>Energy Saving</th>
<th>Moisture Control</th>
<th>Improving Air Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous, warm-side air barrier</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Full-coverage, warm-side vapor retarder</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Full-coverage, optimal thermal insulation</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Continuous, exterior-side weather barrier</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Energy-efficient &amp; condensation-resistant windows</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Effective ground-moisture/soil gas control</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Safe, efficient space heating &amp; cooling</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Managed mechanical ventilation</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Low-toxicity materials, finishes &amp; furnishings</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
<tr>
<td>Efficient &amp; safe appliances &amp; lighting</td>
<td>![Primary Benefit of Measure]</td>
<td>![Secondary Benefit]</td>
<td>![Minor Effect]</td>
</tr>
</tbody>
</table>

**Source:** Building Science Primer by Patrick Huelman, University of Minnesota, July 2004
Ventilation

• Outdoor air ventilation addresses most indoor air quality issues:
  − Sick Building Syndrome
  − Moisture and Mold Problems
  − Second-hand Tobacco Smoke
  − Material Out-gassing
  − Multiple Chemical Sensitivity

• Good ventilation dilutes pollutants

• Ventilation can increase energy consumption, which can be mitigated by the use of heat exchangers

Source: ‘Ventilation Basics and Beyond’, Presentation made by Jeff Tiller at 2004 National State Building Energy Codes Conference
Why Ventilate?

• **Moisture control**
  - Reduce excessive moisture harmful to the building structure
  - Reduce excessive moisture that is a source of mold and mildew growth

• **Eliminate odors and pollutants** that are harmful to human health

*Source: ‘Ventilation Basics and Beyond’, Presentation made by Jeff Tiller at 2004 National State Building Energy Codes Conference*