Presentation to

Appalachian State University

Boone, NC

NC Commercial Energy Code Overview

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Department of Commerce

January 10, 2013

btu/sf
Utility Savings Initiative

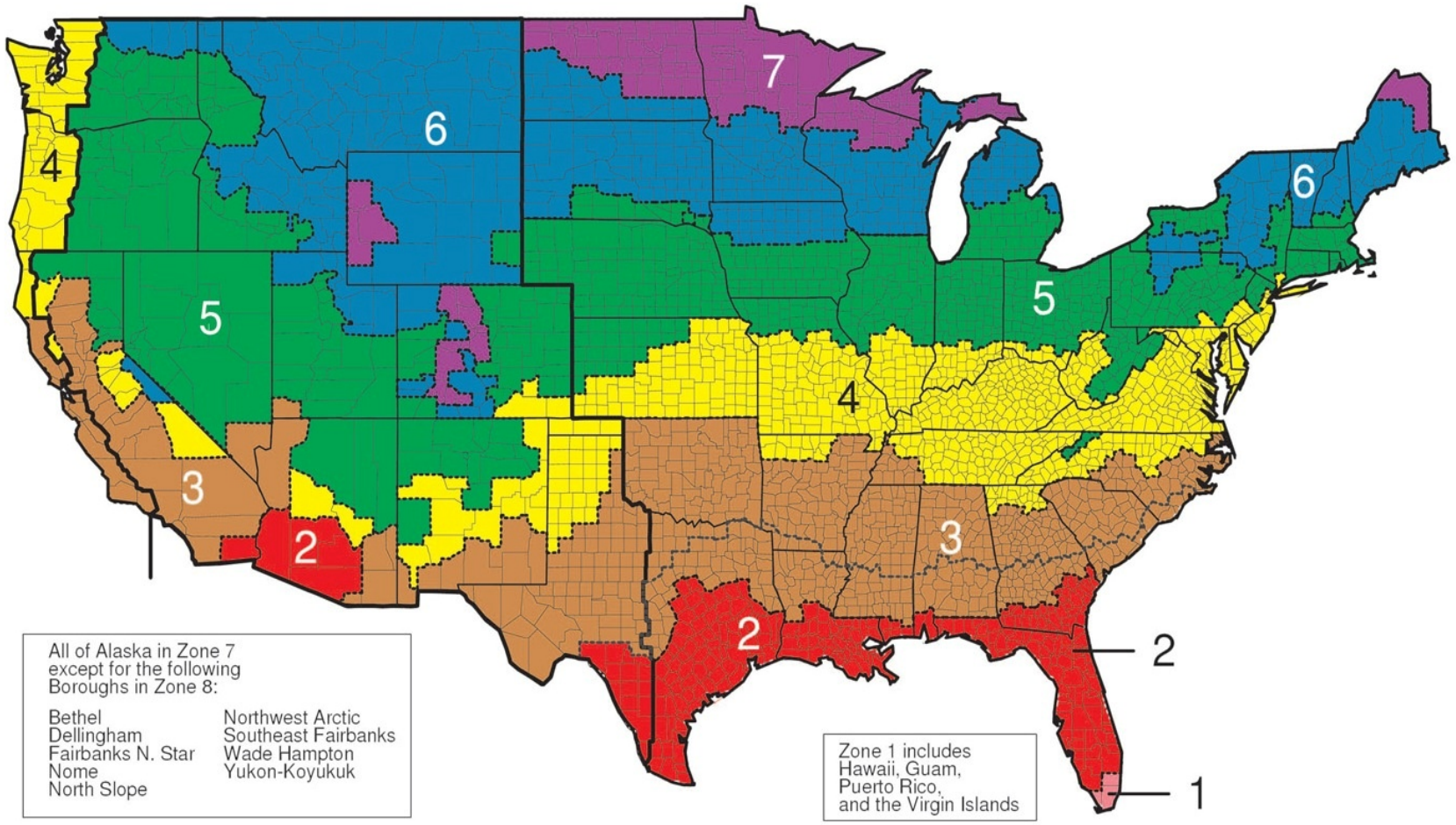
Commercial Code

Commercial code excludes one and two-family dwellings and multiple single-family dwellings not more than three stories above grade plane.

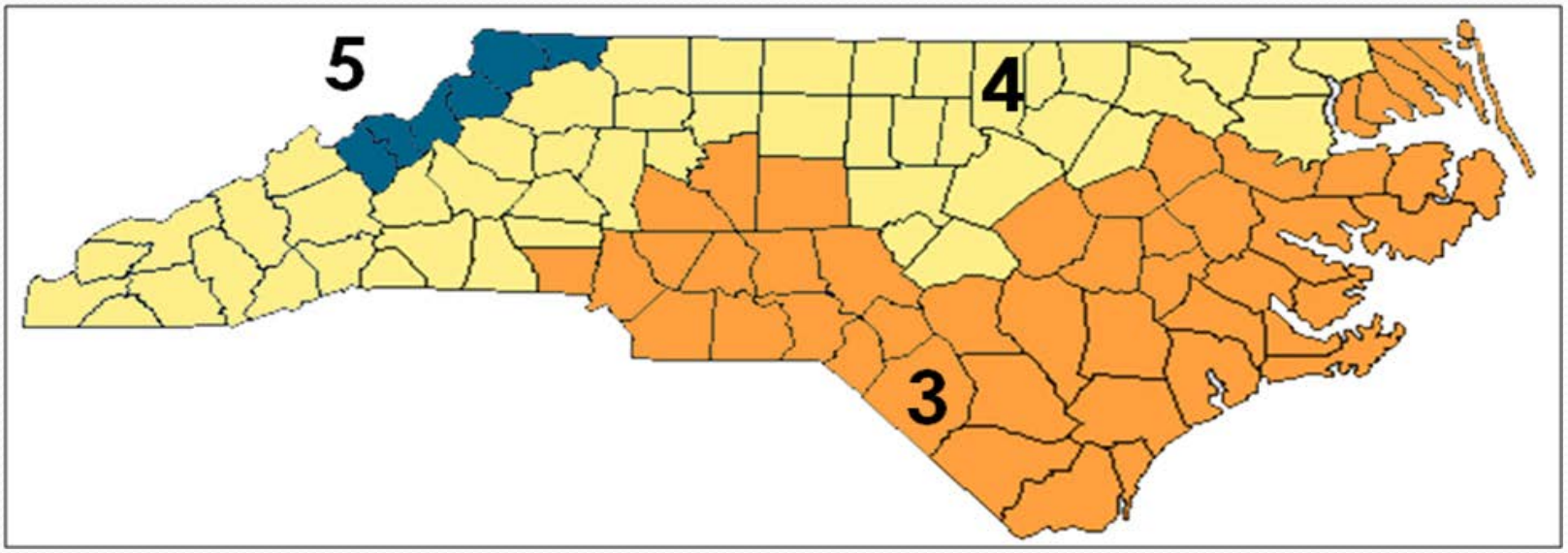
2012 NC Commercial Energy Code

Chapters	Subjects
1–2	Administration and definitions
3	Climate zones and general materials requirements
4	Energy efficiency for residential buildings
5	**Energy efficiency for commercial buildings**
6	Referenced standards

Section 301 2012 IECC

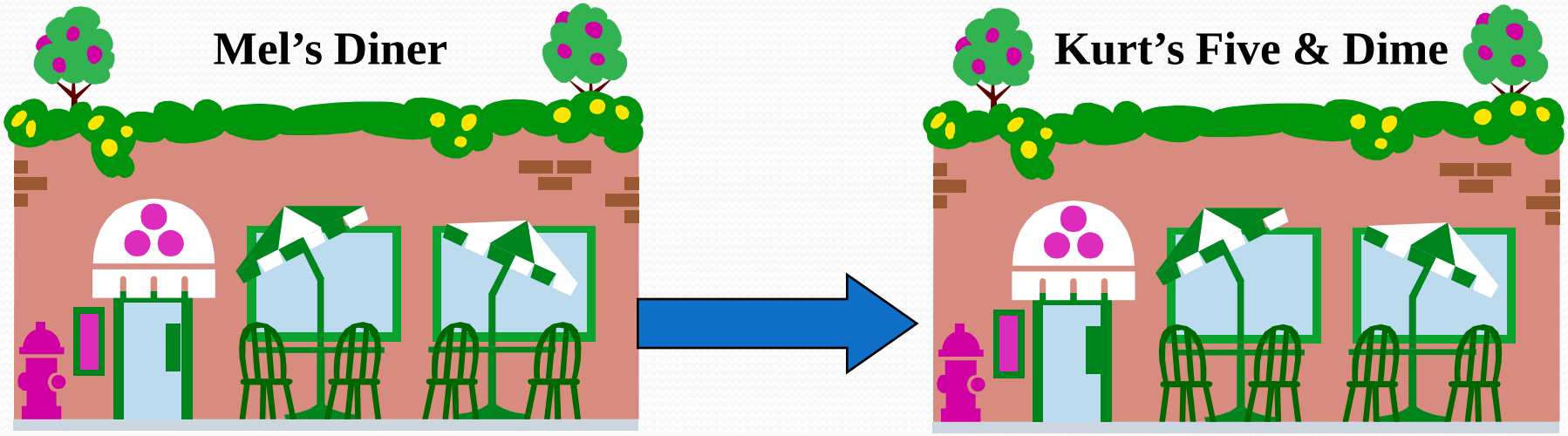


NC Climate Zones: 3, 4, 5



101.4.4 Change in occupancy or use

Spaces undergoing a change in occupancy that would result in an increase in demand for either fossil fuel or electrical energy shall comply with this code. Where the use in a space changes from one use in Table 505.5.2 to another use in Table 505.5.2, the installed lighting wattage shall comply with Section 505.5.



Additions and Alterations

- Additions
  - Shall conform to this code
- Alterations and Renovations to Existing Spaces
  - Applies to only portions of the systems being altered
  - New systems in the Alterations must comply
- Exceptions:
  - See 101.4.3

101.4.5 Change in space conditioning

Any non-conditioned space that is altered to become *conditioned space* shall be required to be brought into full compliance with this code.

Exception: See 101.4.3, exception 2.

Definition:

Conditioned Space – Building provided with heating and/or cooling equipment or system capable of maintaining 50°F for heating and 85°F for cooling.

101.4.6 Mixed occupancy

Where a building includes both *residential* and *commercial* occupancies, **each occupancy shall be separately considered** and meet the applicable provisions of Chapter 4 for *residential* and Chapter 5 for *commercial*.

101.5.2 Low energy buildings

Exemption from meeting the building thermal envelope provisions:

Peak design rate of energy use less than 3.4 Btu/h / ft^2
Or 1.0 watt / ft^2 of floor area for space conditioning purposes.

Compliance Paths:

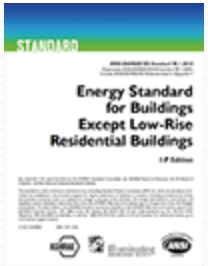
- **Option 1:** Prescriptive using this code (Sections 502-506)

- **Option 2:** Performance path outlined in Section 507: Total Building Performance. Uses annual energy cost of proposed building against standard building. (COMcheck)

- **Option 3:** Comply with the mandatory provisions of **2007 ASHRAE Standard 90.1** and **exceed the minimum level of energy efficiency it prescribes by 20%** following the procedure in ASHRAE/IESNA Standard 90.1, Appendix G.

Compliance Paths:

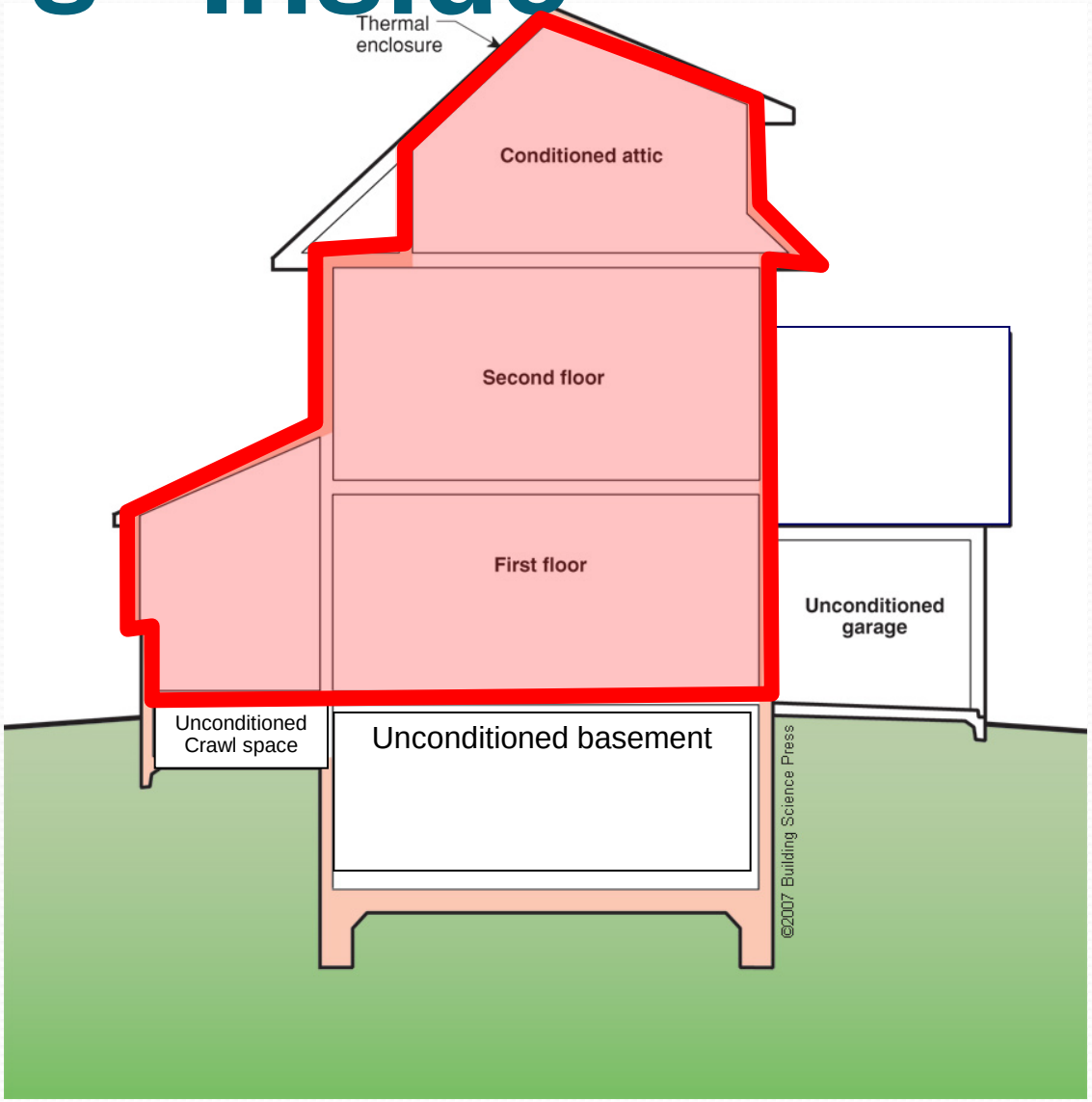
- **State Construction Office – SB668 Buildings**
- Passed as ASHRAE 90.1 – 2004 + 30% better
- **Alternate:** Comply with the mandatory provisions of **ASHRAE Standard 90.1 – 2007** and **exceed the minimum level of energy efficiency it prescribes by 24%** following the procedure in ASHRAE/IESNA Standard 90.1, Appendix G.



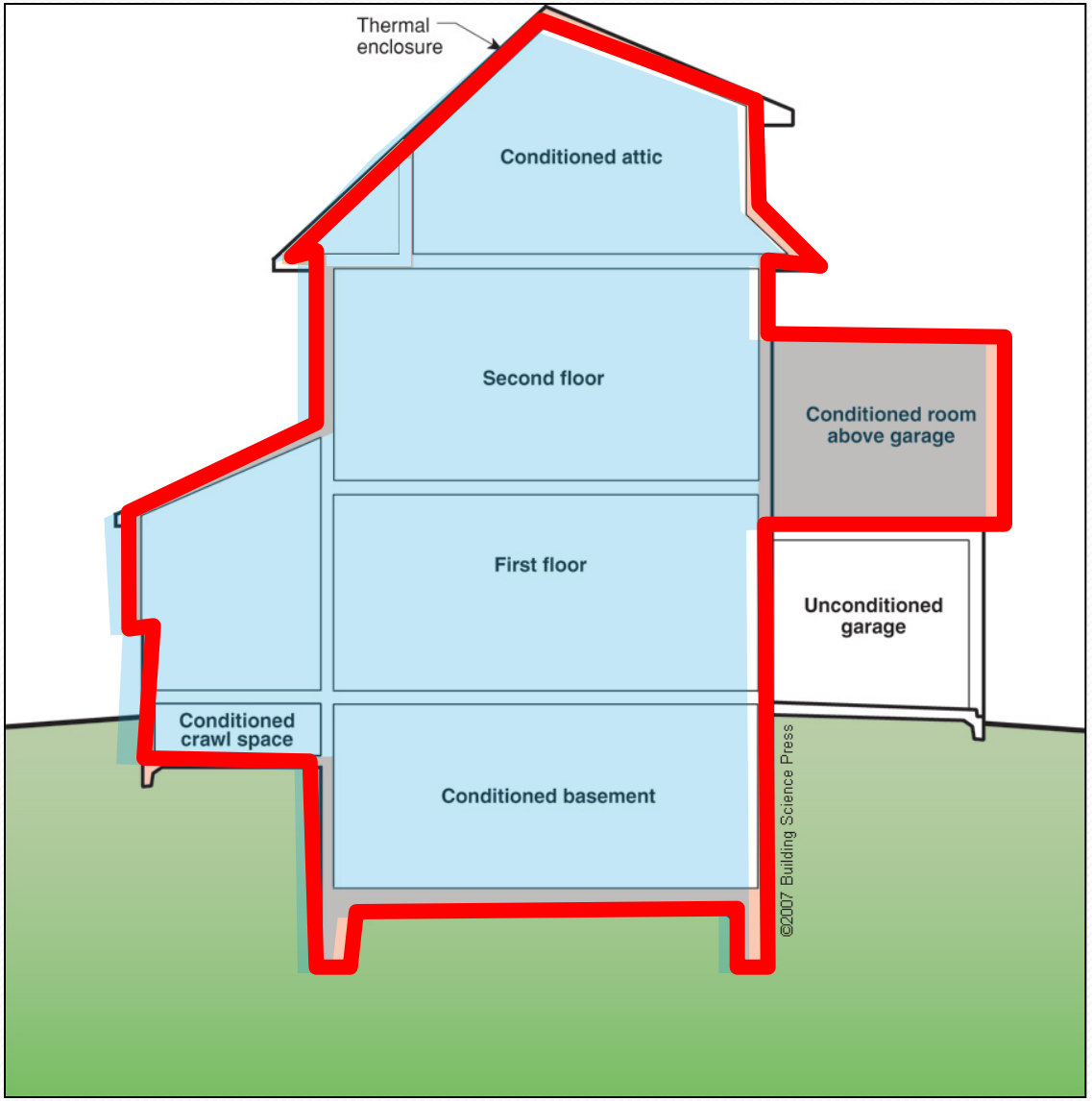
Concrete Block Walls

- Concrete Masonry Units
  - The insulation inside CMU no longer counts

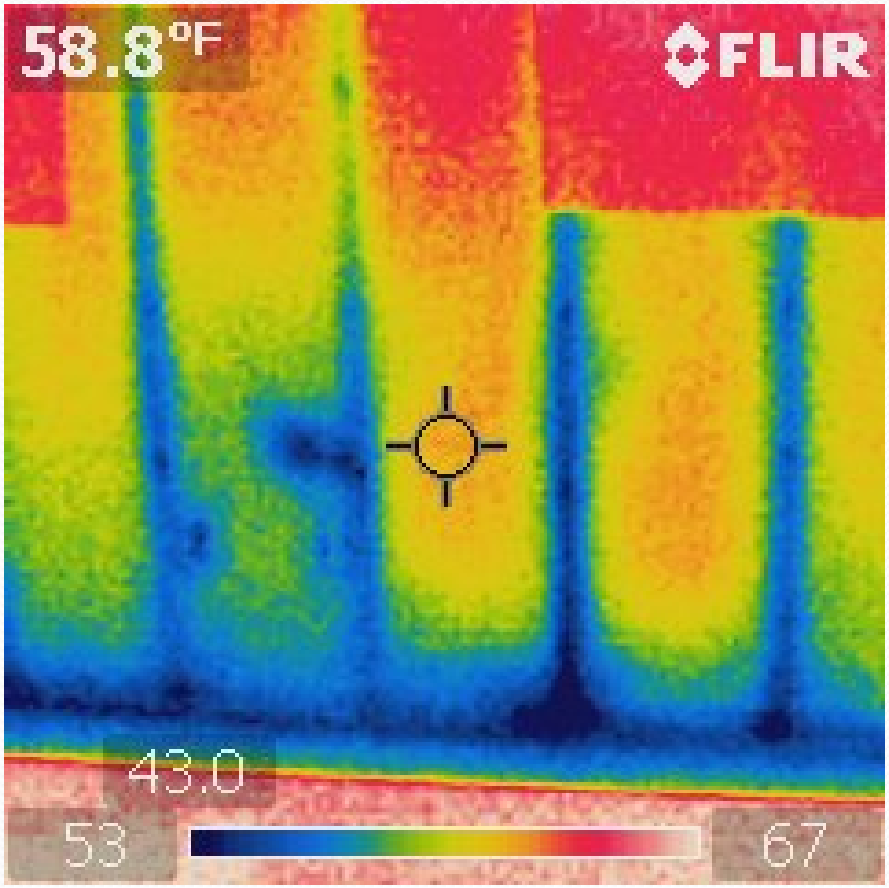
What's "Inside"

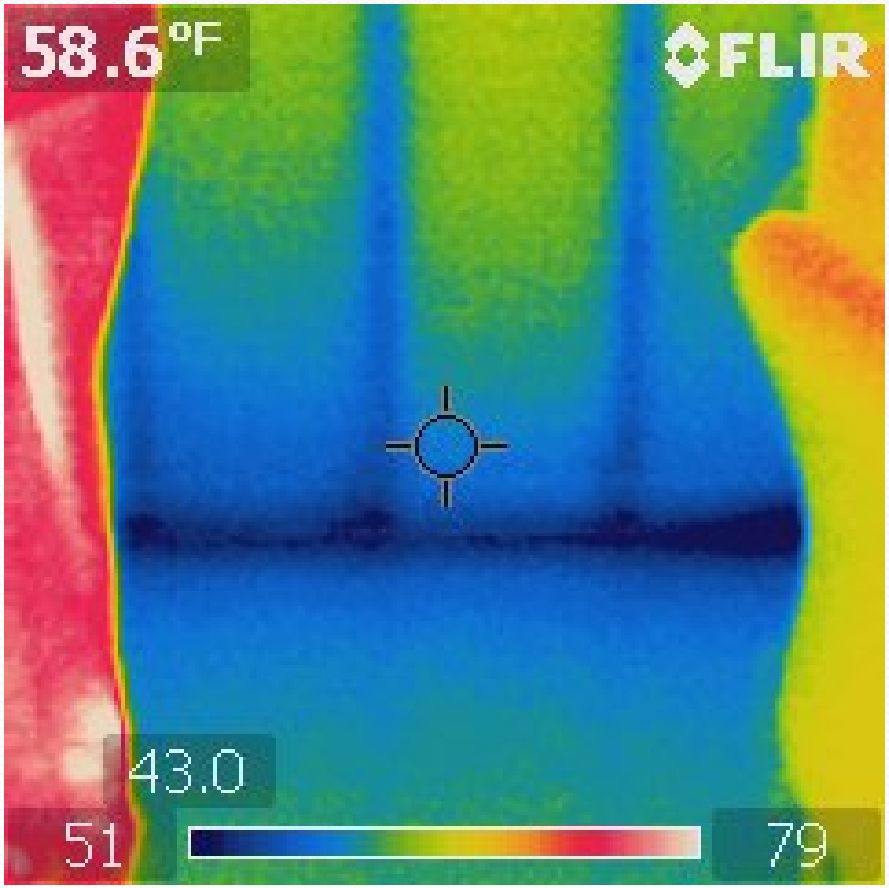


What's "Inside" #2: Redefined Building Envelope



Steel Framing and Insulation





Foam Sheathing Provides Thermal Break

- Provides thermal break
- Can serve as moisture barrier and rain screen
- Can also serve as exterior air barrier if seams are sealed

502.4.3 Sealing of the building envelope

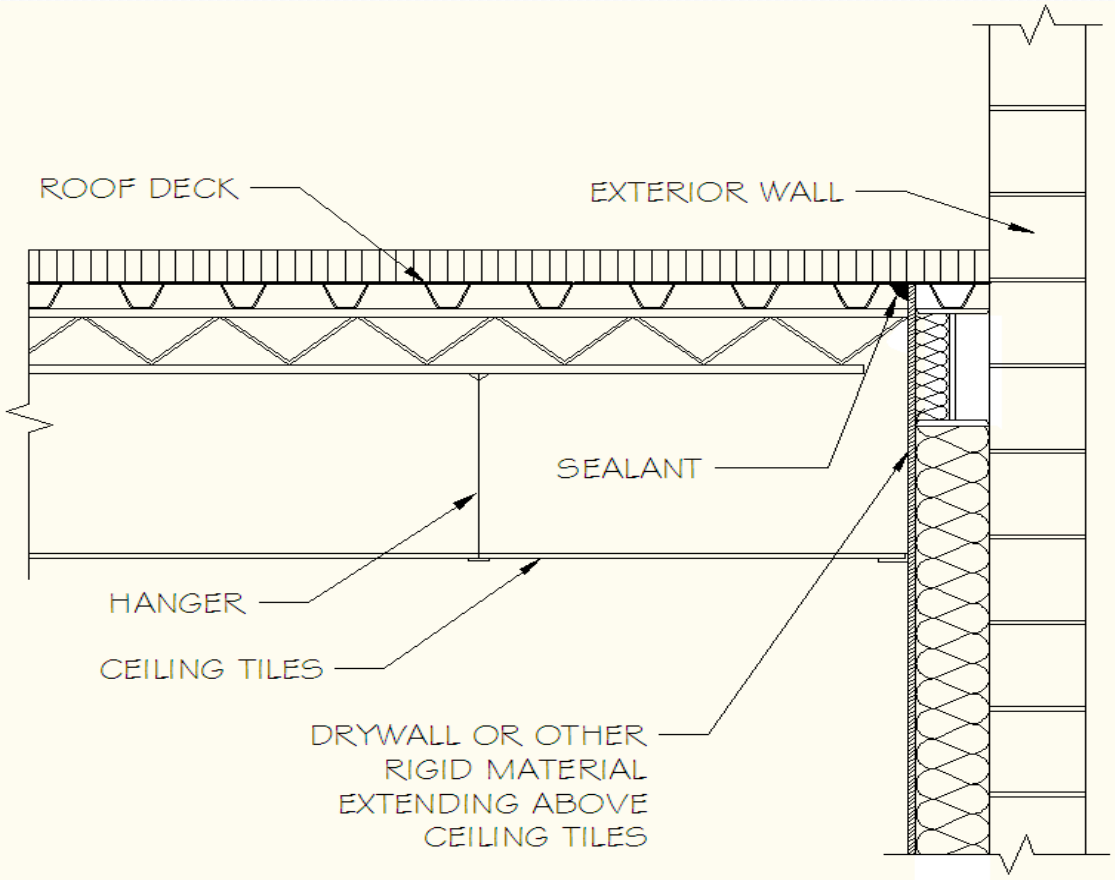


TABLE 502.2(1) : OPAQUE ASSEMBLIES –

Climate Zone	3		4		5	
	All Other	Group R	All Other	Group R	All Other	Group R
Walls, Above Grade						
Mass	R-7.6 ci	R-9.5 ci	R-9.5 ci	R-11.4 ci	R-11.4 ci	R-15 ci
Metal building[b]	R-0+R-13 ci	R-0 + R-19 ci	R-0 + R-15.8 ci	R-0 + R-19 ci	R-0 + R-19 ci	R-0 + R-19 ci
Metal framed	R-13 + 7.5 ci	R- 13 + R-7.5 ci	R-13 + R-10 ci	R-13 + R-12.5 ci	R-13 + R-12.5 ci	R- 13 + R-15 ci
Wood framed and other	R-13 + R-3.8 ci	R-19, R-13+ R-5, or R-15 + $R\text{-}3_g$	R-13 + R-7.5 ci	R-19, R-13+ R-5, or R-15 + $R\text{-}3_g$	R-13 + R-10 ci	R-19, R-13+ R-5, or R-15 + $R\text{-}3_g$
Walls, Below Grade						
Below-grade wall[c]	R-7.5 ci	R-7.5 ci	R-7.5 ci	R-10 ci	R-7.5 ci	R-10 ci

Group R = Residential 4 stories and above; ci = continuous insulation

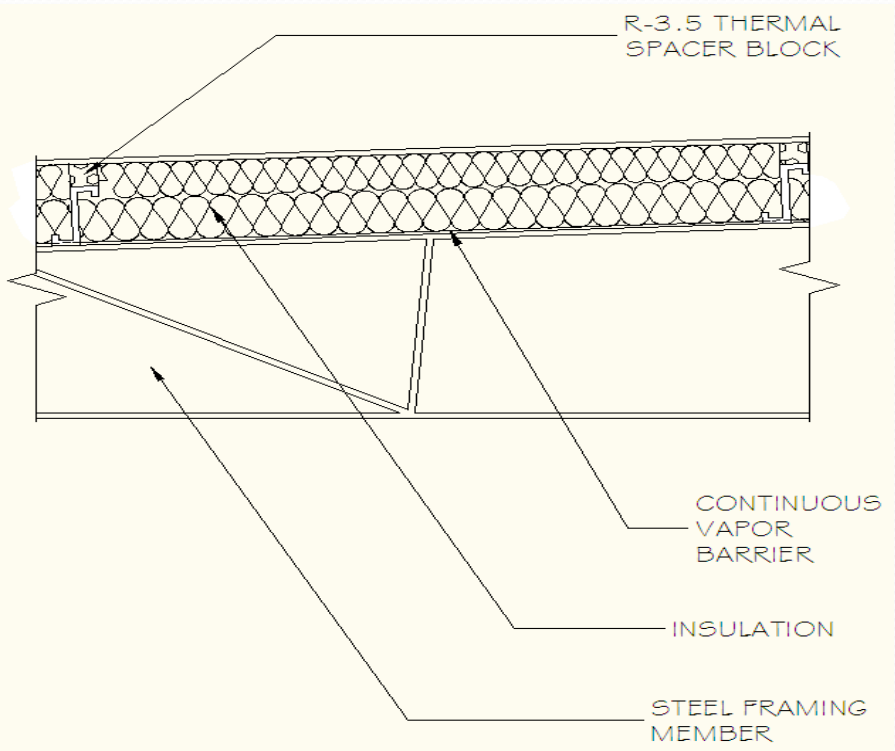
TABLE 502.2(2) (*OTHER*) OPAQUE ASSEMBLIES

ROOFS	DESCRIPTION
R-10 + R-19FC	**Filled cavity fiberglass insulation.** A continuous vapor barrier is installed below the purlins and uninterrupted by framing members. Both layers of uncompressed, unfaced fiberglass insulation rest on top of the vapor barrier and are installed parallel, between the purlins. A minimum R-3.5 thermal spacer block is placed above the purlin/batt, and the roof deck is secured to the purlins. Drawings of typical details are shown in Appendix 2.2.
R-19 + R11 Ls	**Liner System with minimum R-3.5 thermal spacer block.** A continuous membrane is installed below the purlins and uninterrupted by framing members. Uncompressed, unfaced insulation rests on top of the membrane between the purlins. Drawings of typical details are shown in Appendix 2.2.
WALLS	
R-0 + R-13 ci R-0 + R-19 ci	The second rated R-value is for continuous rigid insulation installed between the metal wall panel and steel framing, or on the interior of the steel framing. Drawings of typical details are shown in Appendix 2.2.

Metal Buildings

Insulate outside of the metal structure without compressing insulation if at all possible

Table 502.2(2) Roofs.



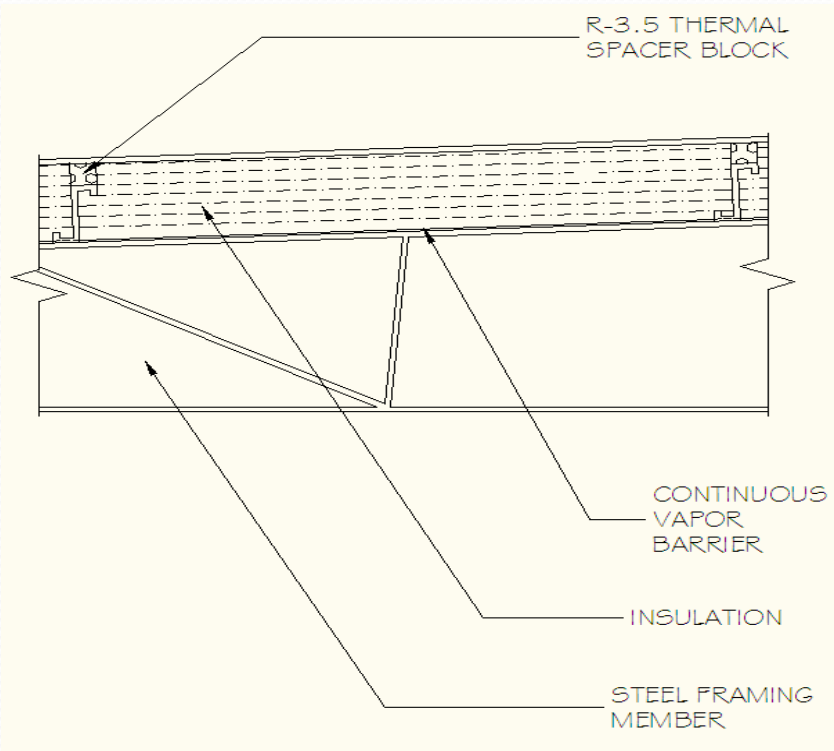


TABLE 502.2(1) : OPAQUE ASSEMBLIES – FLOORS/ DOORS

Climate Zone	3		4		5	
	All Other	Group R	All Other	Group R	All Other	Group R
Floors						
Mass	R-12.5 ci	R-12.5 ci	R-14.6 ci	R-16.7 ci	R-14.6 ci	R-16.7 ci
Joist / Framing	R-30[e]	R-30[e]	R-38	R-38	R-38	R-38
Slab-on-Grade Floors[d]						
Unheated slabs	NR	R-10 for 24 in.	R-15 for 24 in.	R-15 for 24 in.	R-15 for 24 in.	R-20 for 24 in.
Heated slabs	R-15 for 24 in.	R-15 for 24 in.	R-20 for 24 in.	R-20 for 48 in.	R-20 for 48 in.	R-20 for 48 in.
Opaque Doors						
Swinging	U – 0.70	U – 0.50	U – 0.50	U – 0.50	U – 0.50	U – 0.50
Roll-up or sliding	U - 0.50	U - 0.50	U - 0.50	U - 0.50	U - 0.50	U - 0.50

TABLE 502.3: FENESTRATION (30% maximum of above-grade wall)

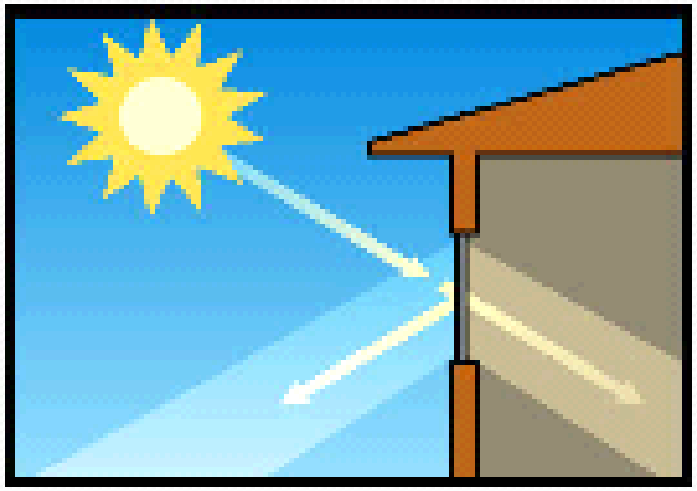
CLIMATE ZONE	3	4	5
Framing materials other than metal with or without metal reinforcement or cladding			
U-Factor	0.32	0.32	0.30
Metal framing with or without thermal break			
Curtain Wall/Storefront U-Factor	0.45	0.45	0.38
Entrance Door U-Factor	0.77	0.77	0.77
All Other U-Factor[a]	0.45	0.45	0.45
SHGC-All Frame Types			
SHGC: PF < 0.25	0.25	0.25	0.40
SHGC: 0.25 ≤ PF < 0.5	0.33	0.33	NR
SHGC: PF ≥ 0.5	0.40	0.40	NR

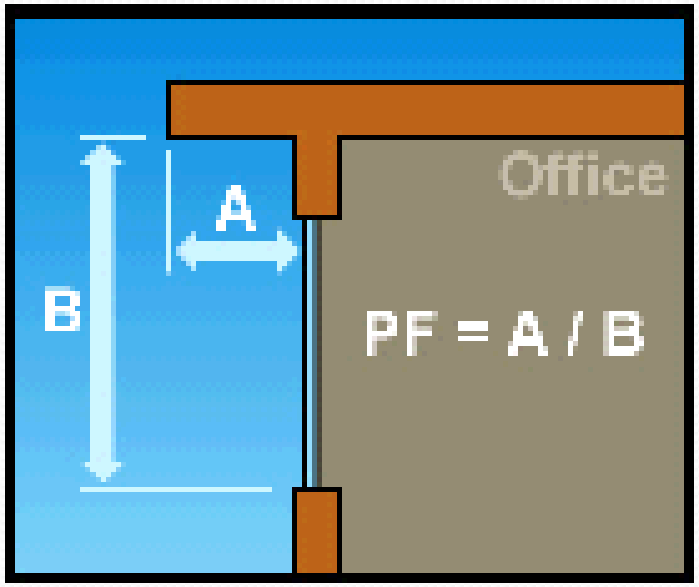
PF = Projection factor for window overhang; SHGC = Solar Heat Gain Coefficient

Windows - SHGC

Solar Heat Gain Coefficient

- Requirements dependent on projection factor (PF)
- National Fenestration Rating Council (NFRC) tested
- SHGC = SC x .87 where SC is the Shading Coefficient, a former window shading term





NFRC Label


NFRC
National Fenestration Rating Council®
CERTIFIED
World's Best Window Co.
Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing • Argon Fill • Low E
Product Type: Vertical Slider
ENERGY PERFORMANCE RATINGS
U-Factor (U.S./I-P)
0.35
Solar Heat Gain Coefficient
0.32
ADDITIONAL PERFORMANCE RATINGS
Visible Transmittance
0.51
Air Leakage (U.S./I-P)
0.2
Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information.
www.nfrc.org

Windows – Requirements

- Maximum of 30% of vertical wall area or must use Energy Modeling option
- Use assembly U-value
- All windows must meet or exceed

502.4.7 Vestibules.

A door that separates *conditioned space* from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices.

Exceptions:

- **Non- entrance doors**
- **Directly from a sleeping unit or dwelling**
- **Directly from a space less than 3,000 sq. ft.**
- **Revolving doors**
- **Doors for vehicular movement**
- **Buildings less than 4 stories and less than 10,000 sq. ft.**

SECTION 503
BUILDING MECHANICAL SYSTEMS

503.1 General. Mechanical systems and equipment serving the building heating, cooling or ventilating needs shall comply with Section 503.2 (referred to as the mandatory provisions) and either:

1. Section 503.3 (Simple systems), or
2. Section 503.4 (Complex systems).

503.2.4.1 Thermostatic controls.

The supply of heating and cooling energy to **each zone** shall be **controlled by individual thermostatic controls** capable of responding to temperature within the zone.

Where humidification or dehumidification or both is provided, **at least one humidity control device** shall be provided for **each humidity control system**.

503.2.4.1.1 Heat pump supplementary heat.

Restrictions on when supplementary electric resistance heat can come on**.**

• cooling capacity of less than 65,000 Btuh, a **heat strip outdoor temperature lockout shall be set no lower than 35°F and no higher than 40ºF.**

503.2.4.4 Shutoff damper controls.

Outdoor air supply and exhaust ducts, fans or openings in the building thermal envelope shall be equipped with **motorized dampers** that will automatically shut when the systems or spaces served are not in use.

Exceptions:

1. Gravity dampers shall be permitted in buildings less than three stories in height.
2. Gravity dampers shall be permitted for outside air intake or exhaust airflows of 300 cfm (0.14m3/s) or less.

Objective of 503.2.5.1 Demand-controlled ventilation

- Reduce unnecessary fan energy use when ventilation is not needed due to low building occupancy
- Reduce humidity and thermal gain from outside when outside air is not needed for occupants
- Result – save $ thousands in energy costs and improve control over summer humidity gains

503.2.5.1 Demand-controlled ventilation.

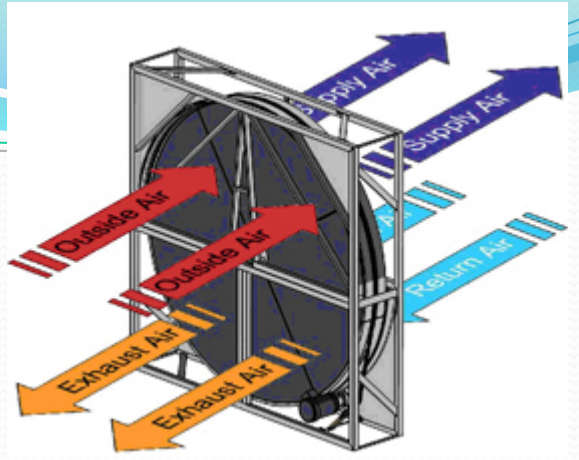
Ventilation systems in **buildings over 10,000 ft²** of conditioned area shall have **demand controls**.

In spaces larger than 500 ft² with a maximum occupant load of 40 or more people per 1,000 ft² of floor area, **ventilation supply air flow shall be controlled** by monitoring indoor air quality conditions, such as with CO2 sensors or thermostats.

Demand controlled ventilation systems shall be capable of **reducing outside supply air to at least 50%** below design ventilation rates.

Note: Table 403.3 in Mechanical Code is source for occupancy loads.

503.2.5.1Cont.



Exceptions:

1. **Systems with energy recovery** that provide a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions.
2. Building spaces where the **primary ventilation needs are for process loads**, including laboratories and hospital.
3. **Individual units with less than 65,000 Btu/h** of cooling capacity.

503.2.6 Energy recovery ventilation systems.

Individual fan systems that have both a design supply **air capacity of 5,000 cfm** or greater **and a minimum outside air supply of 70 percent** or greater of the design supply air quantity **shall have an energy recovery system** that provides a change in the enthalpy of the outdoor air supply of 50 percent or more of the difference between the outdoor air and return air at design conditions.

503.2.6 outlines exceptions to the energy recovery requirement

503.2.9 HVAC System Completion (prior to issuance of CO)

Exception: A temporary certificate of occupancy shall be allowed to be issued when requested prior to the completion of this section.

503.2.9.1 System balancing.

All HVAC systems shall be balanced by contractor. Test and balance activities shall include as a minimum the following items:

503.2.9.1.1 Air systems balancing

Each supply air outlet and zone terminal device shall be equipped with means for air balancing in accordance with the requirements of Chapter 6 of the North Carolina Mechanical Code. Discharge dampers are prohibited on constant volume fans and variable volume fans with motors 10 hp (7.5kW) and larger.

Exceptions:

1. Fan with fan motors of 1 hp or less.

503.2.9.1.2 Hydronic systems balancing

503.2.9 HVAC System Completion (cont.)

503.2.9.1.2 Hydronic systems balancing

Individual **hydronic heating and cooling coils** shall be equipped with **means for balancing and pressure testing connections**. Hydronic systems shall be balanced in a manner to **first minimize throttling losses**, then the pump impeller shall be **trimmed or pump speed shall be adjusted to meet design flow conditions**. Each hydronic system shall have either the ability to measure pressure across the pump, or test ports at each side of each pump.

Exceptions:

1. Pumps with pump motors of 5 hp or less.

2. When throttling of an individual pump results in no greater than 5% of the nameplate horsepower draw above that required if the impeller were trimmed.

503.2.9.2 Manuals (System Completion, cont.)

An **operating and maintenance manual** shall be **provided to the building owner by the contractor**. The manual shall include:

1. **Submittal data** stating equipment model number and capacity (input and output) and selected options.

2. **Manufacturer's operation manuals and maintenance manuals** for each piece of equipment requiring maintenance, except equipment not furnished as part of the project. **Required routine maintenance** actions shall be clearly identified.

3. **Name and address of at least one service agency.**

4. **HVAC controls system maintenance and calibration information, including wiring diagrams, schematics, and control sequence descriptions.** Desired or field-determined set points shall be permanently recorded on control drawings at control devices or, for digital control systems, in programming comments.

5. A complete narrative of how each system is intended to operate.

6. Names and addresses of designers of record, contractors, major subcontractors and equipment suppliers.

503.2.9.3 System installation statement (System Completion, cont.)

A **North Carolina licensed design professional** shall prepare and sign the ***Statement of Compliance – HVAC System Installation (Appendix C).*** This statement shall be submitted to the code official and the facility owner.

Exception:

1. The HVAC contractor will be allowed to prepare the *Statement of Compliance* when a building permit is issued for a project without the seal of a licensed design professional as allowed by an exception under NC State Building Administrative Code and Policies: 204.3.5.

503.2.9.3 System installation statement (System Completion, cont.)

503.2.9.3.1 Equipment

Equipment installation and operation shall be verified, to the extent feasible, to be in accordance with approved plans and specifications. Verification shall include demonstration of **operation of components, systems and system-to-system interfacing relationships**.

503.2.9.3.2 Controls

Controls installation and operation shall be verified, to the extent feasible, to be in accordance with approved plans and specifications. Verification shall include demonstration of operation of control devices, systems and system-to-system interfacing relationships. Control sequences shall be functionally verified, to the extent feasible, to demonstrate operation in accordance with the intent of the approved plans and specifications.

APPENDIX C
Statement of Compliance – HVAC System Installation

Project Name:_____

Project Location:_____

In my professional opinion, the HVAC systems have been installed and are in substantial compliance with the intent of the approved project plans and specifications based on a site observation performed on _____ and upon review of the following:

Yes	No	Not Required	Items	Comments
			Testing and balancing report	
			Operations and maintenance manuals	
			HVAC Equipment	
			Control sequences	

Name:_____

Signature:_____

Date:_____

Seal:_____

503.3.1 Economizers.

Supply air economizers shall be provided on each cooling system as shown in Table 503.3.1(1).

Economizers shall be capable of providing 100-percent outdoor air, even if additional mechanical cooling is required to meet the cooling load of the building. Systems shall provide a means for pressure relief; the relief air outlet shall be located to avoid recirculation into the building.

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B, 2A, 7, 8	No requirement
2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B	**Economizers on all cooling systems ≥ 65,000Btu/h$_a$**

SECTION 505 ELECTRICAL POWER AND LIGHTING SYSTEMS

505.1 General (Mandatory Requirements). This section covers lighting system controls, the connection of ballasts, the maximum lighting power for interior applications, and minimum acceptable lighting equipment for exterior applications

Exception: Lighting within dwelling units where 75 percent or more of the permanently installed interior light fixtures are fitted with high-efficacy lamps.

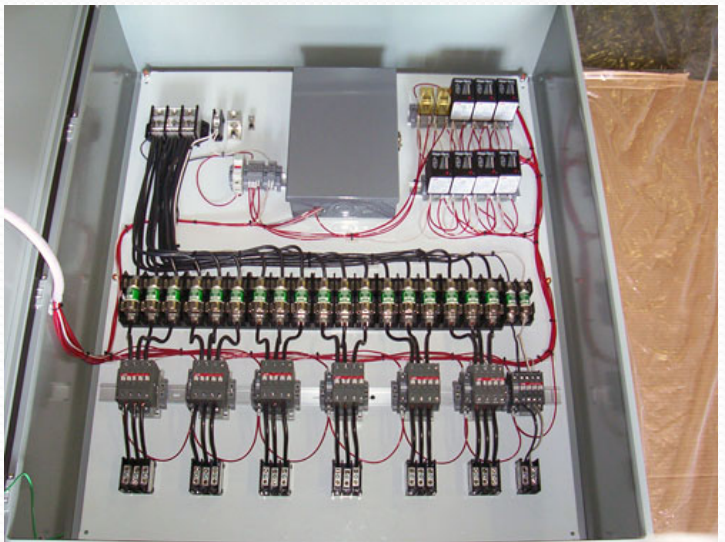


TABLE 505.5.2 Example INTERIOR LIGHTING POWER ALLOWANCES

LIGHTING POWER DENSITY		
	Whole Building	Space by Space
Building Area Type[a]	(W/ft2)	
Common Space Types		
Active Storage		0.63
Atrium - First Three Floors		0.63
Atrium - Each Additional Floor		0.16
Automotive Facility		0.91
Bank / Office, Bank Activity Area		1.38
Classroom / Lecture / Training		1.25
Conference / Meeting / Multipurpose		1.29
Corridor / Transition		0.65
Education Laboratory		1.28
Electrical / Mechanical		0.95
Food Preparation		0.99
Lobby		0.60
Locker Room		0.78
Medical / Industrial Research Lab		1.62
Parking Garage - Garage Area		0.21
Restroom		0.84
Stairway		0.69
Convention Center	1.05	

505.2.1 Interior lighting controls.

Each area enclosed by walls or floor-to-ceiling partitions shall have at least one manual control for the lighting serving that area. The required controls shall be located within the area served by the controls or be a remote switch that identifies the lights
served and indicates their status.

Exceptions:

1. Areas designated as security or emergency areas that must be continuously lighted.
2. Lighting in stairways or corridors that are elements of the means of egress.

505.2.2.1 Light reduction controls.

Each area that is required to have a manual control shall also allow the occupant to reduce the connected lighting load in a reasonably uniform illumination pattern by at least 50 percent. Methods (other approved are possible):

1. Controlling all lamps or luminaires;
2. Dual switching
3. Switching the middle lamp luminaires independently of the outer lamps; or
4. Switching each luminaire or each lamp.

Exceptions:

1. Areas that have only one luminaire.
2. Areas that are controlled by an occupant-sensing device.
3. Corridors, storerooms, restrooms or public lobbies.
4. *Sleeping units* (see Section 505.2.3).
5. Spaces that use less than 0.6 watts per square foot (6.5 W/m2).

505.2.2.2.2 Occupancy sensors

All buildings shall have occupancy sensors in all of the following spaces:

- Classrooms
- Conference/meeting rooms
- Employee lunch and break rooms
- Private offices
- Storage rooms over 100 s.f.
- Computer rooms over 100 s.f.

505.5 Interior lighting power requirements (Prescriptive).

505.5.1 Total connected interior lighting power

See exceptions listed.

Building Area Method
or
Space-by-Space Method

SECTION 506
ADDITIONAL PRESCRIPTIVE COMPLIANCE REQUIREMENTS

506.1 Requirements. Commercial buildings are required to comply with **one of the following sections:**

a. 506.2.1 **More Efficient Mechanical Equipment**
b. 506.2.2 **Reduced Lighting Power Density**
c. 506.2.3 **Energy Recovery Ventilation Systems**
d. 506.2.4 **Higher Efficiency Service Water Heating**
e. 506.2.5 **On-Site Supply of Renewable Energy**
f. 506.2.6 **Automatic Daylighting Control System**

Gotta do one of them!

SECTION 507 TOTAL BUILDING PERFORMANCE

507.1 Scope.

This section establishes criteria for compliance using total building performance. The following systems and loads shall be included in determining the total building performance: heating systems, cooling systems, service water heating, fan systems, lighting power, receptacle loads and process loads.

507.3 Performance-based compliance.

- Compliance based on total building performance requires that a proposed building (*proposed design*) be shown to have an **annual energy cost that is less than or equal to the annual energy cost of the *standard reference design***.
- **Energy prices** shall be taken from a source *approved* by the *code official*, such as the Department of Energy, Energy Information Administration's *State Energy Price and Expenditure Report*.
- *Code officials* shall be **permitted to require time-of-use pricing** in energy cost calculations.
- **Nondepletable energy** collected off site shall be treated and priced the same as purchased energy.
- **Energy from nondepletable energy sources** collected on site shall be omitted from the annual energy cost of the *proposed design*.

Exception: Jurisdictions that require site energy (1 kWh = 3413 Btu) rather than energy cost as the metric of comparison.

507.4.1 Compliance report.

Compliance software tools shall generate a report that documents that the *proposed design* has annual energy costs less than or equal to the annual energy costs of the *standard reference design*. The compliance documentation shall include the following information:

- Address of the building;
- An inspection checklist documenting the building component characteristics of the *proposed design* as *listed* in Table 507.5.1(1) and a comparison of the estimated annual energy cost for *standard reference design* and *proposed design*;
- Name of individual completing the compliance report; and
- Name and version of the compliance software tool.

Appendices of Building Details

- Appendix 1 – Residential Requirements
- Appendix 2 – Commercial Building Requirements
- Appendix 3 – Samples Worksheets (Residential)
- Appendix 4 – High Efficiency Residential Option **(HERO)** Additional Voluntary for achieving additional 15 – 20% efficiency
- Appendix 5 – Statement of Compliance – HVAC System Installation

Comments/ Questio

Energy Savings Analysis

- Simulate selected DOE Baseline Building Models
- Reference ASHRAE 90.1 Appendix G for HVAC selection
- Use eQUEST, Carrier HAP, Energy Plus Modeling Software

Research performed by Mathis Consulting Company and Appalachian State Dept. of Technology and Environmental Design under a special project grant from DOE and NC State Energy Office

Models

3 Story Office Building

- 90,000 sq.ft.

Stand Alone Retail

- 50,000 sq.ft.

Small Office Building

- 5,500 sq.ft.

Construction Costs @ $150 / sq. ft.

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Case Study Building Model Features

- Proposed package includes the following changes from IECC ’09
  - Insulation and fenestration measures
  - Occupancy lighting controls
  - Demand controlled ventilation
  - Reduced lighting power density
  - 10% Higher Efficiency HVAC as Additional Measure

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Electricity Use
90,000 sq ft Office

Charlotte	90,000 sq ft Office Building		
ELECTRICITY (1,000 kwh)	**NC 2009**	**2009 IECC**	**Package**
Space Cool	176	128	90
Vent. Fans	26	25	21
Pumps & Aux.	6	6	6
Misc. Equip.	177	177	177
Area Lights	247	247	198
Total Minus Misc. Equip.	**455**	**407**	**315**
Cost of Electricity	**$ 39,538**	**$ 35,921**	**$ 30,094**

NATURAL GAS (MMBtu)	**NC 2009**	**2009 IECC**	**Package**
Space Heat	652	635	220
Hot Water	229	228	228
Total Gas MMBtu	**880**	**863**	**449**
Cost of Natural Gas	**$ 10,233**	**$ 10,039**	**$ 5,291**

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Estimated Energy Savings (Million Btu/ year)

3-Story Office Building (90,000 sq ft)				
	Natural Gas	Electricity	Total	% of Total
Charlotte	432	479	910	37%
Raleigh	458	480	938	38%

Stand-Alone Retail (50,000 sq ft)				
Charlotte	458	480	938	38%

Small Office Building (5,500 sq ft)				
Charlotte	24	25	49	30%

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Estimated Costs

	3-Story Office Building	Retail Strip Mall	Small Office
Added Insulation	$ 40,110	$ 47,600	$ 5,373
Systems Verification	11,759	13,540	2,830
DCV	30,000	9,000	2,000
Occupancy Controls	45,000	5,000	3,000
Glazing	8,190	2,000	624
Lighting	11,250	9,375	689
Additional Requirements	44,098	50,774	4,717
Reduced A/C Tonnage	(12,750)	(11,250)	(750)
Reduced Boiler Capacity	(2,484)	(10,235)	(253)
Total Additional Cost	**$ 181,053**	**$ 122,573**	**$ 18,229**
Rough Building Cost	$ 13,500,000	$ 7,500,000	$ 826,200
	1.3%	1.6%	2.2%

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Cost Impact for 30% Improvement

Residential – Average 1,800 sq. ft. home

- Additional Construction:
  - Material and Labor $2,500
  - Overhead & Profit @ 20% = $ 500
  - Total (no credit counted for reduced HVAC equipment) $3,000

  - Additional monthly mortgage $16
  - Reduction in monthly energy bills $25

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Cost Impact for 30% Improvement

Residential – Additional Costs	
Lighting	$ 75
Air Sealing Details	$ 250
Duct Sealing Details	$ 100
Heat Pump & T-Stat	$ 130
Testing (both duct and air leakage)	$ 350
Framing and Wall Insulation	
Upgrade for R-18 Wall	$1,100

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Cost Impact for 30% Improvement

Residential – Additional Costs (con't.)	
Insulation (foundation)	$ 300
Windows ($0.75 / sq. ft. 11 at 3' x 5')	$ 124
Doors (2 at $15)	$ 30
Total	**$2,459**

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