ANSI/ASHRAE/IESNA Standard 90.1-2004

U.S. Department of Energy
Building Energy Codes Program

Why is Standard 90.1-2004 important?

- It replaces ANSI/ASHRAE/IESNA Standard 90.1-2001
- It proposed to be the reference standard for the 2006 ICC IECC
- It is proposed to be the commercial building energy reference in NFPA 5000, NFPA's family of building codes
- It is the professional "standard of care" set by ASHRAE consensus

How have requirements changed?

- Envelope and mechanical requirements expressed using new climate zones
- Lighting requirements more stringent by about 25%
- Entire document has been reformatted

How can I find out more about the differences?

- Detailed comparisons of Standards 90.1-1989 and 90.1-1999 may be found at http://www.energycodes.gov/implement/determinations_com.stm
- Preliminary comparisons of Standards 90.1-1999 and 90.1-2001 may be found at http://www.energycodes.gov/news/2003_workshop/presentations.stm#ashrae
- DOE will be formally comparing Standards 90.1-2001 and 90.1-2004 in 2005

How can I get a copy?

- Standard 90.1-2004 and the Standard 90.1-2004 Users Manual are available from ASHRAE

ASHRAE
Engineering for the World We Live In

www.ashrae.org

404-636-8400

Standard 90.1-2004

- 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

Standard 90.1-2004

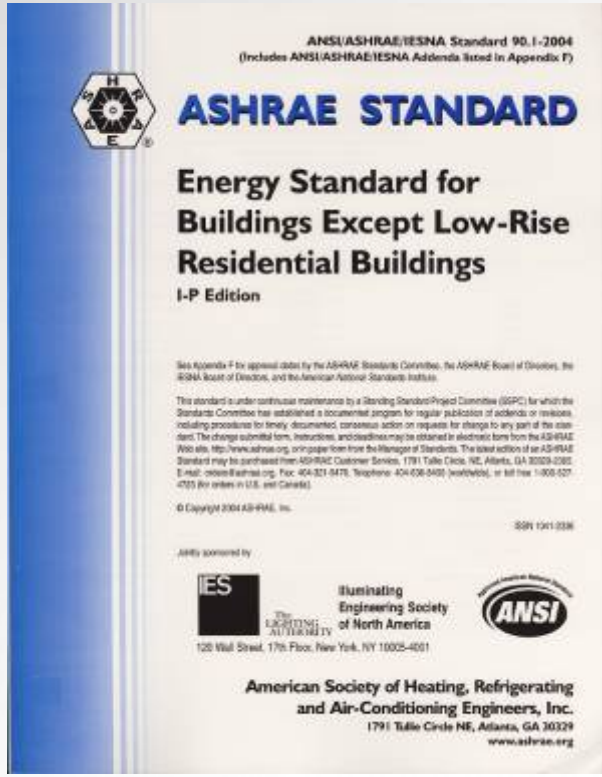
- Section 7 - Service Water Heating
- Section 8 - Power
- Section 9 - Lighting
- Section 10 - Other Equipment
- Section 11 - Energy Cost Budget Method
- Section 12 - Normative References

Standard 90.1-2004 Appendices

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

Section 1 - Purpose

The purpose of this standard is to provide minimum requirements for the energy-efficient design of buildings except low-rise residential buildings



Section 2 - Scope

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

Section 2 – Scope *(cont'd)*

- Envelope
  - if heated by a heating system with an output capacity ≥ 3.4 btu/h-ft^2 or
  - if cooled by a cooling system with a sensible output ≥ 5 btu/h-ft^2
- Virtually all mechanical and lighting systems are covered

Scope Exceptions

- 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 purposes

Section 3 - Definitions, Abbreviations, and Acronyms

- 10 pages of definitions
- 1 page of abbreviations and acronyms
- Defined terms are italicized in text of standard

Section 4 – Administration and Enforcement

- Addresses new buildings, additions to existing buildings, and alterations to existing buildings
- Addresses replacement of portions of existing buildings
- Discusses changes in space conditioning

Section 4 – Administration and Enforcement

- Addresses compliance documentation
- Addresses labeling of materials and equipment
  - Fenestration, doors, insulation, mechanical equipment, and packaged terminal air conditioners
- Addresses alternative materials and methods of construction
- Addresses inspections

Section 4 – Administration and Enforcement

- 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”

Section 4 – Administration and Enforcement

- Important Exceptions for Alterations of Existing Buildings
  - Buildings that are specifically designated as historic 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 the building's annual energy consumption is the same as a building that meets the requirements of Sections 5-10 and such compliance is verified by a design professional using methods acceptable to the authority having jurisdiction

Building System

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

Mandatory Provisions

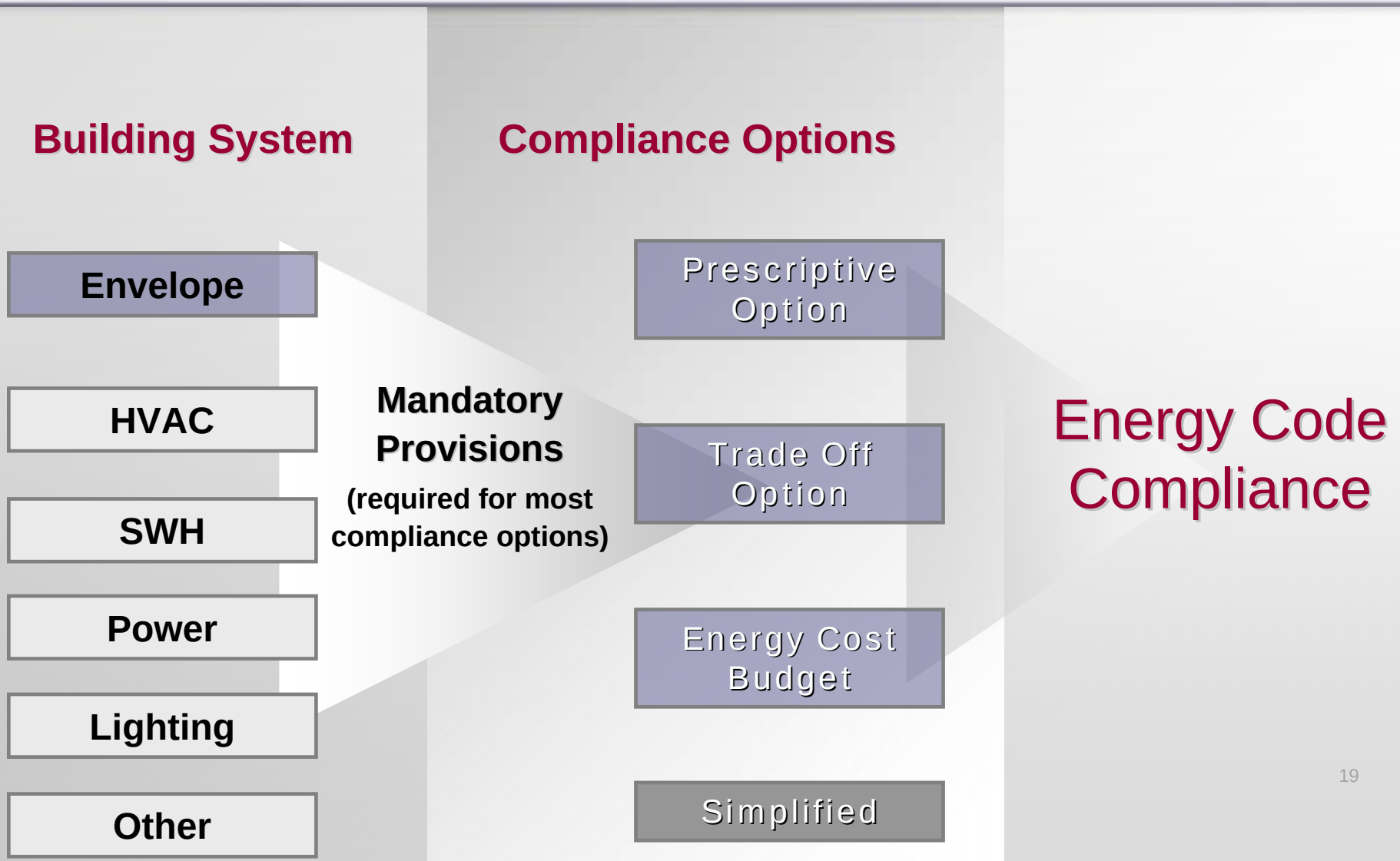
(required for most compliance options)

Compliance Options

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

Energy Code Compliance

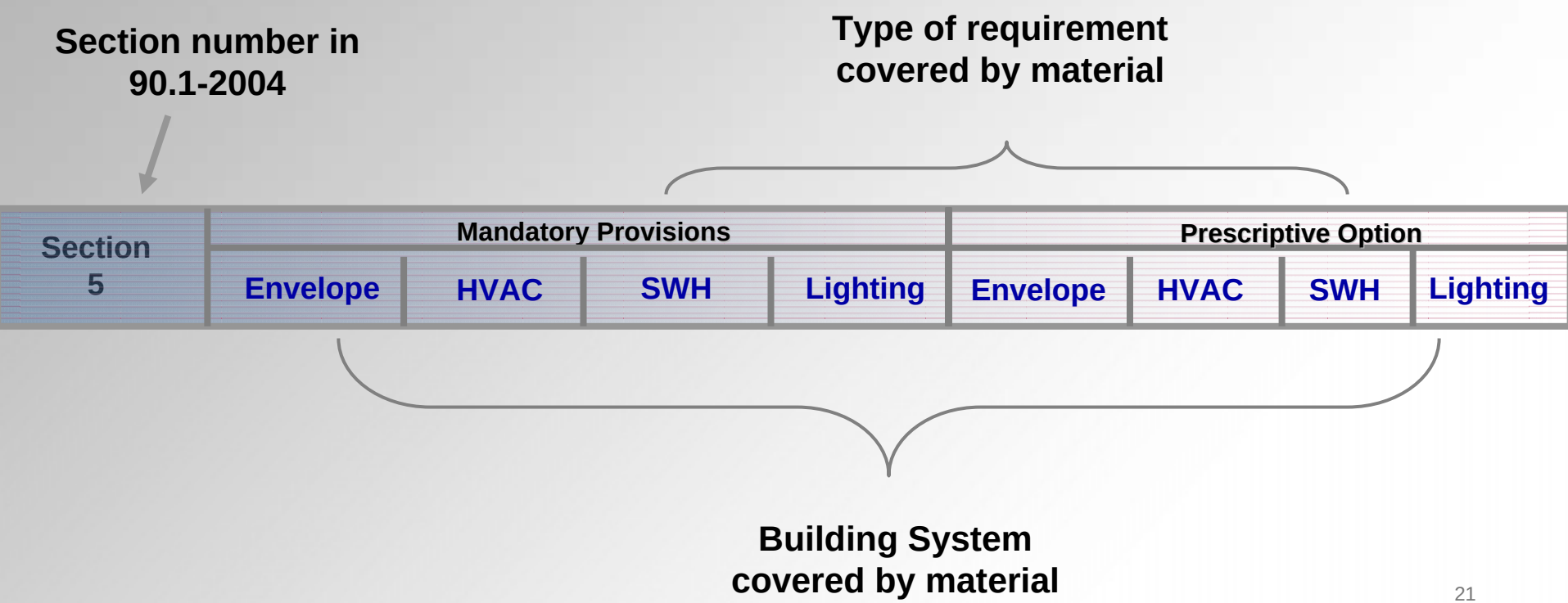
Envelope Compliance



Section 5 – Building Envelope

- General *(Section 5.1)*
  - Scope
  - Space-Conditioning Categories
  - Envelope Alterations
  - Climate
- Compliance Methods *(Section 5.2)*
- Simplified Building Option *(Section 5.3)* Not Used
- Mandatory Provisions *(Section 5.4)*
  - Insulation
  - Fenestration and Doors
  - Air Leakage

Presentation Reference



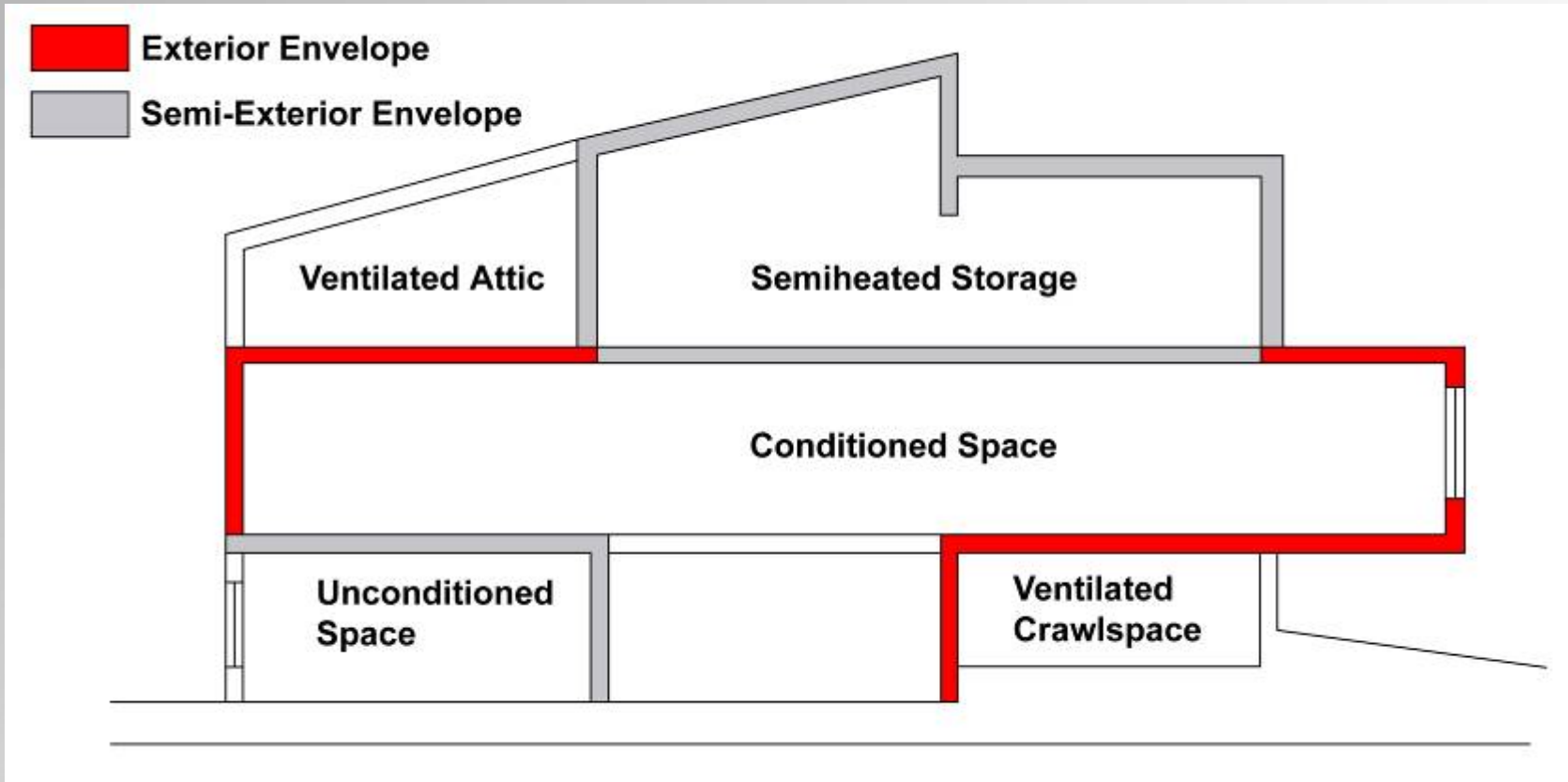
Section 5 – Building Envelope *(cont'd)*

- Prescriptive Building Envelope Option *(Section 5.5)*
  - Opaque Areas
  - Fenestration
- Building Envelope Trade-Off Options *(Section 5.6)*
- Submittals *(Section 5.7)*
- Product Information and Insulation Requirements *(Section 5.8)*

Scope

- Envelope components that enclose
  - Conditioned space
  - Semi-heated space
    - Has a heating system with a capacity > 3.4 Btu/h·ft^2 of floor area but is not conditioned space
- Requirements apply to three types of spaces
  - Nonresidential
  - Residential
  - Semi-heated
- Exceptions

Building Envelope



Space-Conditioning Categories and Basis

Envelope Requirements Are Specified by Space-Conditioning Categories

- Each space to be included in a category
  - Nonresidential conditioned space
  - Residential conditioned space
  - Semiheated space
- Spaces in climates > 1800 HDD65 assumed to be conditioned space unless
  - Space will only be semiheated or unconditioned and
  - Approved as such by the building official

Semi-heated Space

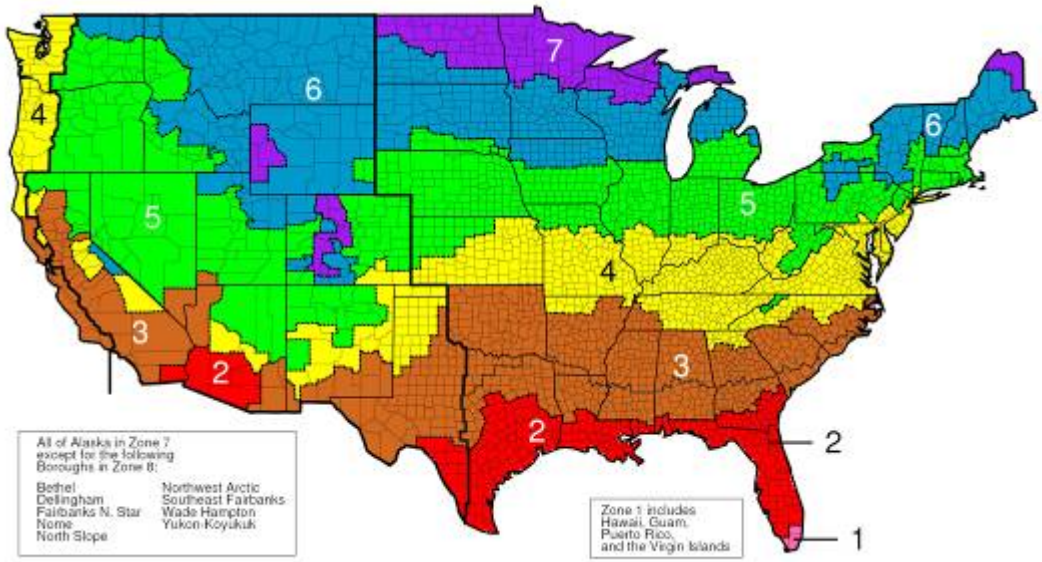
- Has a heating system with a capacity > 3.4 Btu/h.ft^2 (10W/m^2) of floor area but is not conditioned space
- Space is not cooled at all

Envelope Alterations

- Alterations to the building envelope shall comply with the requirements of Section 5
  - Exceptions that 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 based on several climatic parameters and expressed in map shown in Figure B-1.
  - Locations listed in Appendix B on county-by-county basis for United States

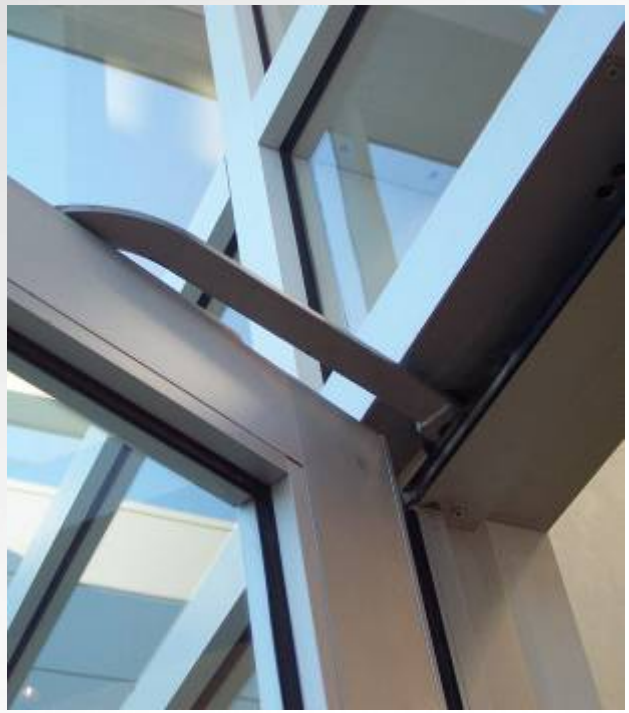


Envelope Compliance Paths

- Section 5.2
- You have to follow Sections 5.1, 5.4, 5.7, and 5.8, and then you can either follow Section 5.5 or Section 5.6
- Alternatively, you can follow Section 11 (ECB), in which case Section 5.4 is mandatory
  - However, Section 5.4 merely refers to Section 5.8

Mandatory Provisions

- Insulation *(Section 5.8.1)*
  - Installation *(Section 5.8.1.1)*
  - Substantial Contact *(Section 5.8.1.5)*
  - Recessed Equipment *(Section 5.8.1.6)*
  - Insulation Above Suspended Ceilings *(Section 5.8.1.8)*
  - Insulation Protection *(Section 5.8.1.7)*
- Fenestration and Doors *(Section 5.8.2)*
- Air Leakage *(Section 5.4.3)*



Air Leakage

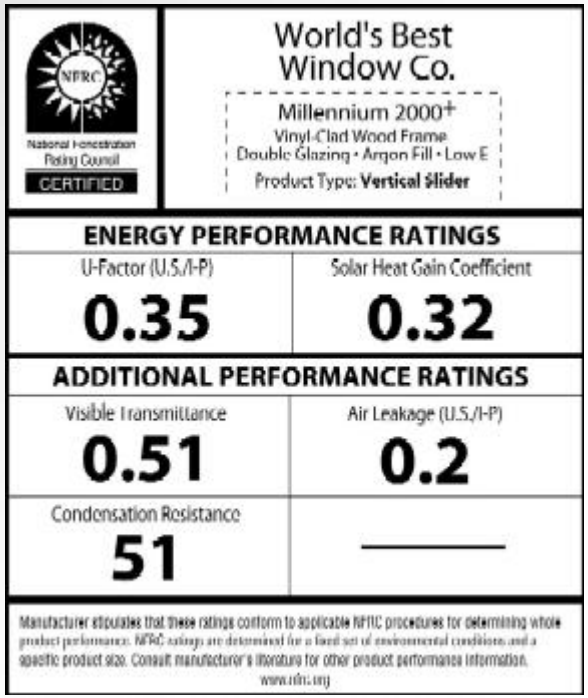
- Seal, caulk, gasket, or weather-strip
  - Openings and joints in building envelope
  - Fenestration and doors per NFRC 400
  - Loading docks in climates in climate zones 4-8
  - Vestibules and doors separating conditioned space from exterior

Building Envelope Sealing

- Joints around fenestration and door frames
- Junctions between walls
  - and foundations
  - at building corners
  - and structural floors or roofs
  - and roof or wall panels
- Openings for utility services through roofs, walls, and floors
- Site-built fenestration and doors
- Building assemblies used as ducts or plenums
- Joints, seams, and penetrations of vapor retarders
- All other openings in the building envelope

Fenestration and Doors

- 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

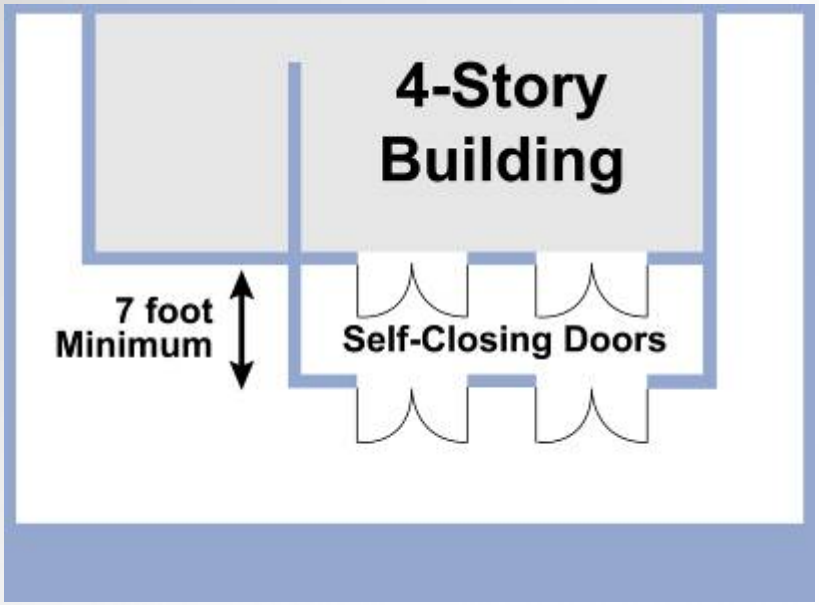


Loading Dock Weatherseals

- In climate zones 4-8
  - Cargo doors and loading dock doors equipped with weatherseals
    - To restrict infiltration when vehicles are parked in the doorway

Vestibules

- All exterior doors in tall buildings in climate zones 3-8 must have a vestibule with
  - Self-closing doors
  - Interior and exterior doors must not be open at the same time
  - Distance between interior and exterior doors not < 7 ft when in closed position (remember ADA!)



Vestibule Exceptions

- Non-entrance doors (mechanical/electrical rooms)
- Vehicle and material handling doors and adjacent personnel doors **OR** revolving doors
- All doors in climate zones 1 and 2 **OR** in buildings < 4 stories
- All doors that open into spaces < 3000 ft^2 **OR** into dwelling units

Prescriptive Building Envelope Option

WWR ≤ 50% of gross wall area
Skylight-roof ratio ≤ 5% of roof area
Each envelope component must separately meet requirements

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

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

Opaque Areas

- 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

Roof Insulation

- Meet or exceed minimum R-value in table for climate zone
- 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

Roof Insulation *(cont'd)*

- 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

Roof Insulation Exceptions

- Roofs with a minimum total solar reflectance of 0.70 and a minimum thermal emittance of 0.75, other than roofs with ventilated attics or roofs of semiheated spaces may adjust their roof U-factors as shown in Equation 5-1 and Table 5.5.3.1.

- Basically, “cool roofs” are allowed to have less insulation.

Above-Grade Wall Insulation

- Meet or exceed R-value in appropriate table for climate zone
- Four types of walls are defined:
  - Mass walls
    - heat capacity determined from Table A-6 or A-7
    - 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

Above-Grade Wall Insulation *(cont'd)*

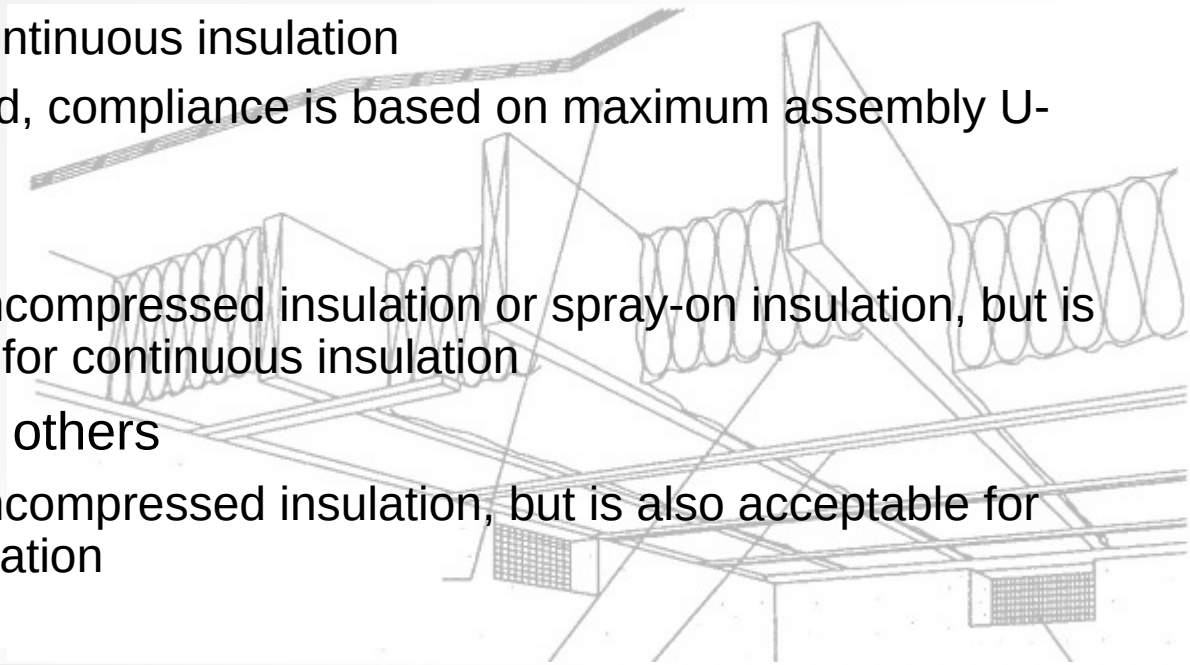
- Metal building wall R-value is for insulation compressed between metal wall panels and the steel structure
- Steel-framed wall R-value is for uncompressed insulation installed in the cavity between steel studs
- Wood-framed and other R-value is for uncompressed insulation installed in the cavity between wood studs; also acceptable to be continuous insulation uninterrupted by studs

Below-Grade Wall Insulation

- 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

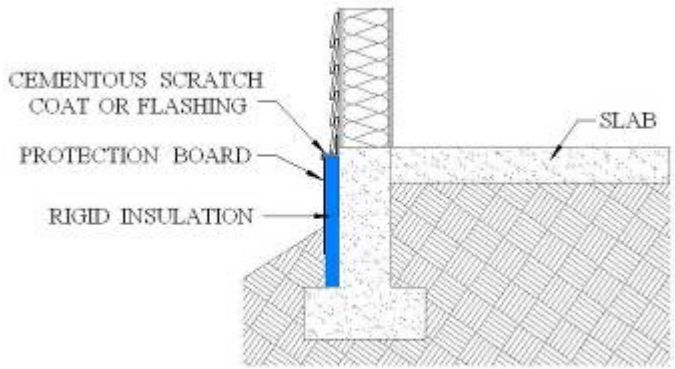
Floor Insulation

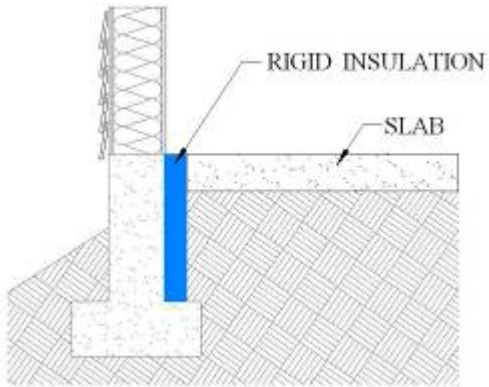
- Meet or exceed values in appropriate table for climate zone
- Floors over unconditioned space:
  - Mass floors
    - R-value is for continuous insulation
    - If framing is used, compliance is based on maximum assembly U-factor
  - Steel joist floors
    - R-value is for uncompressed insulation or 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

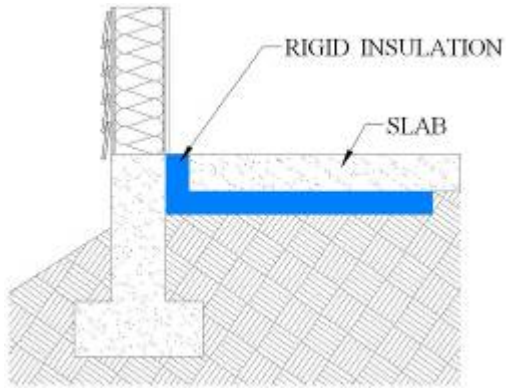


Slab-on-Grade Floor Insulation

- 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







Opaque Doors

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

TABLE B-1
Building Envelope Requirements (HDD65: 0-900, CDD50: 10801+)

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.048	R-20 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.055	R-13.0 + R-13.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above Grade						
Mass	U-0.580	NR	U-0.151*	R-5.7 ci*	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel Framed	U-0.124	R-13.0	U-0.084	R-13.0 + R-3.8 ci	U-0.352	NR
Wood Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below Grade						
Below Grade Wall	C-1.140	NR	C-1.140	NR		
Floors						
Mass	U-0.322	NR	U-0.322			
Steel Joist	U-0.350	NR	U-0.350			
Wood Framed and Other	U-0.282	NR	U-0.2			
Slab-On-Grade Floors						
Unheated	F-0.730	NR				
Heated	F-1.020	R-7.5 for 1				
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	

Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Non-Swinging	U-1.450	U-1.450	U-1.450

Fenestration

- 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

Fenestration Area

- Total vertical fenestration area to be < 50% of gross wall area
  - Including both fixed and operable vertical fenestration
- Total skylight area to be < 5% of gross roof area
  - Including glass skylights, plastic skylights with a curb, and all skylights without a curb

Fenestration U-Factor

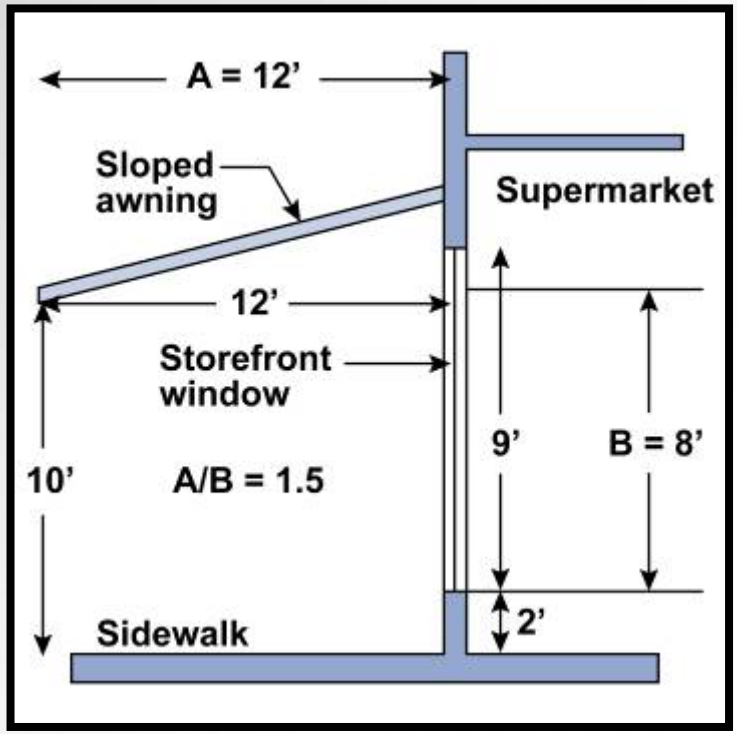
- NFRC or meet or exceed maximum U-factors in A-17
- Exception
  - Vertical fenestration complying with Exception (c) to 5.5.4.4.1 to have a U-factor ≤ U-factor specified for 40% of the gross wall area
  - The exception essentially allows a building to have street side, street-level glazing between 40% and 75% of the wall area while only meeting the requirement for 40%, subject to having a story height of 20 feet or less and an overhang

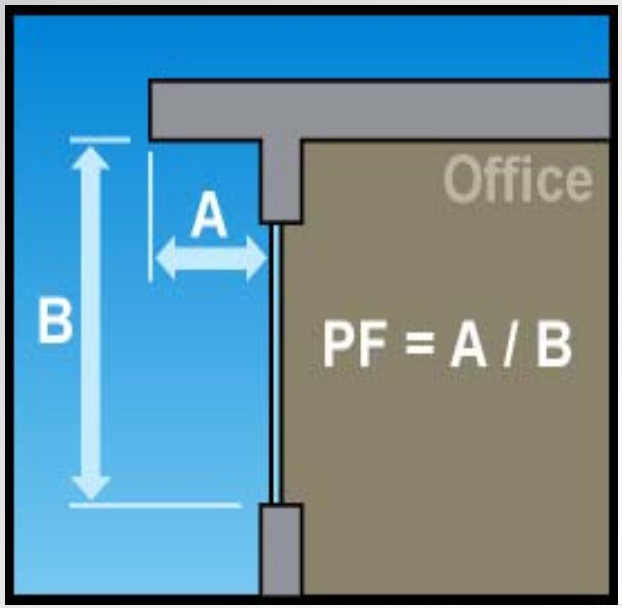
Fenestration SHGC

- Vertical fenestration
  - SHGC values < Table value for appropriate total vertical fenestration area
- Skylights
  - SHGC values < Table value for appropriate total skylight area
- No SHGC requirements for semiheated spaces or for buildings in climates > 10800 HDD65
- No criteria in the for Visible Light Transmittance in Prescriptive Building Envelope Option, but there are minimum criteria in the Trade-Off Option (Details in Appendix C)

Overhangs

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





Building Envelope Trade-Off Option

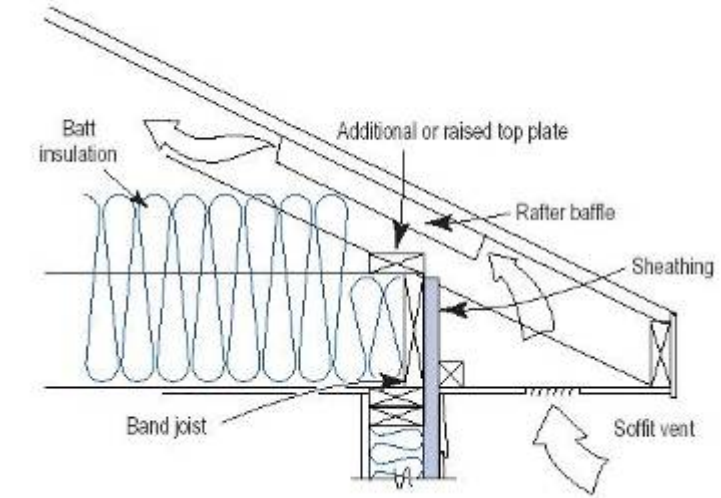
- Building complies if
  - It satisfies the provisions of 5.1, 5.4, 5.7, and 5.8
  - Envelope performance factor (EPF) of proposed building is ≤ EPF of budget building
  - EPF considers only the building envelope components and is calculated using procedures in Normative Appendix C
  - Schedules of operation,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

Product Information and Installation Requirements

- Labeling of Building Envelope Insulation *(Section 5.8.1.1)*
- Compliance with Manufacturer's Requirements *(Section 5.8.1.2)*
- Loose-Filled 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)*

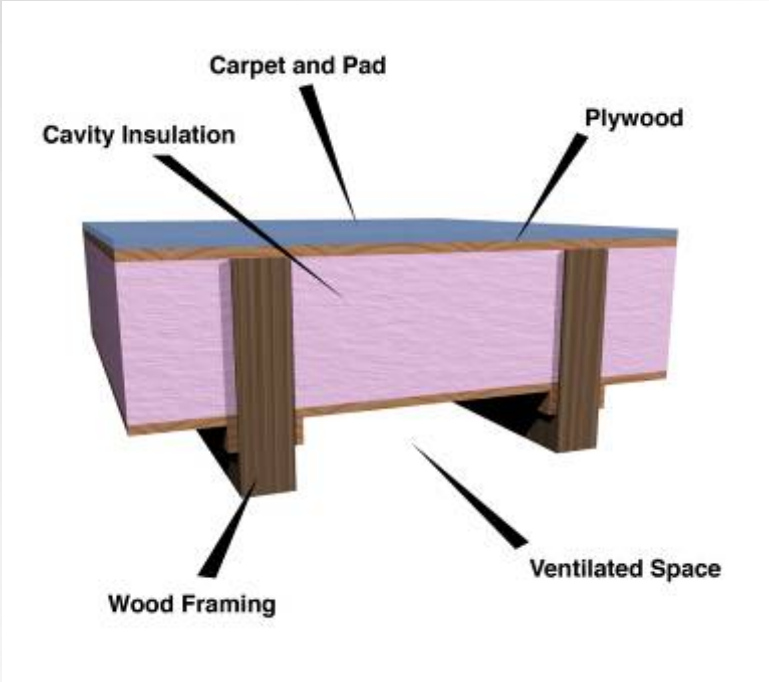
Insulation Installation

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



Insulation - Substantial Contact

- Install insulation in a permanent manner in substantial contact with inside surface
- Flexible batt insulation in floor cavities
  - To be supported in a permanent manner by supports no more than 24 in. o.c.



Recessed Equipment

- 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

- Insulation Protection
  - Cover exterior insulation with protective material
    - Sunlight
    - Moisture
    - Landscaping operations
    - Equipment maintenance
    - Wind
  - Access to attics and mechanical rooms without damaging or compressing insulation
  - Insulation materials in ground contact to have a water absorption rate ≤ 0.3% (ASTM C272)

Roof Insulation

- Roof Insulation
  - Not installed on a suspended ceiling with removable ceiling panels

Fenestration and Doors

- U-factors
  - NFRC 100 or
  - Assemblies listed in Appendix A
- SHGC
  - NFRC 200 or
  - Assemblies listed in Appendix A
- Visible Light Transmittance
  - NFRC 200 when building envelope trade-off option is used

U-Factor

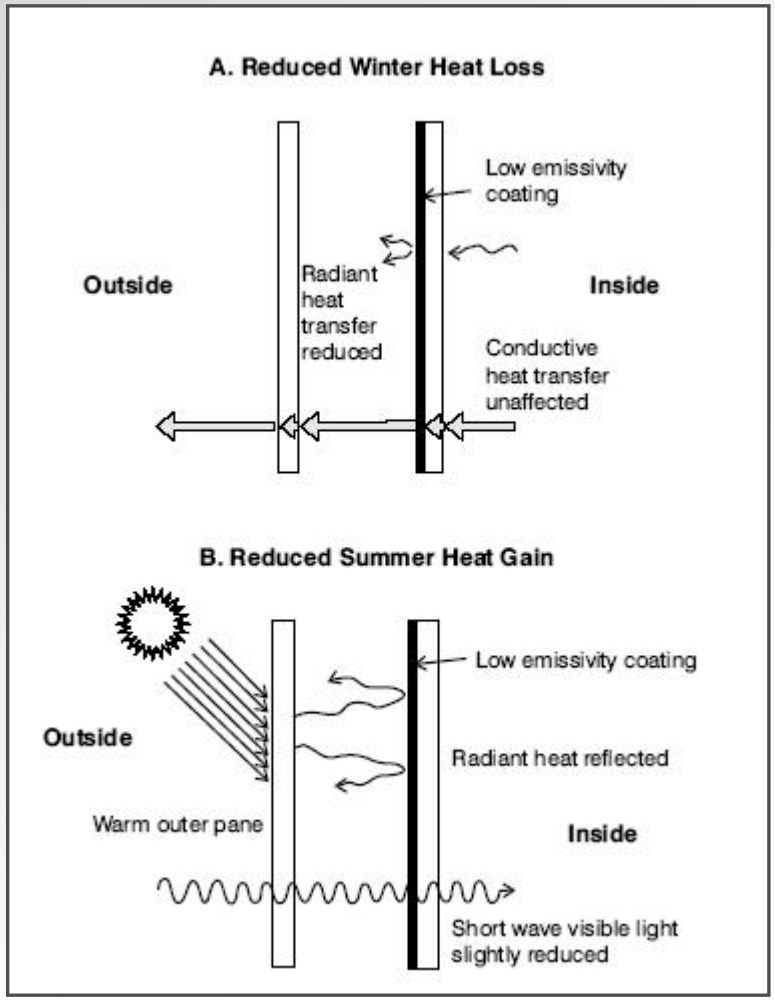
- Skylights – determine for a slope of 20° above the horizontal
- Labeled and certified by manufacturer
- Exceptions
  - Glazed wall systems in vertical fenestration and skylights – may use U-factors in A.8.1
  - A.8.2 acceptable for other vertical fenestration
  - A.7 acceptable for opaque doors
  - ANSI/DASMA 105 acceptable for garage doors

Solar Heat Gain Coefficient *(SHGC)*

- 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 A.8.1 for glazed wall systems in vertical fenestration and skylights
  - SHGC from A.8.2 for other vertical fenestration
- The glazing's effectiveness in rejecting solar heat gain

SHGC *(cont'd)*

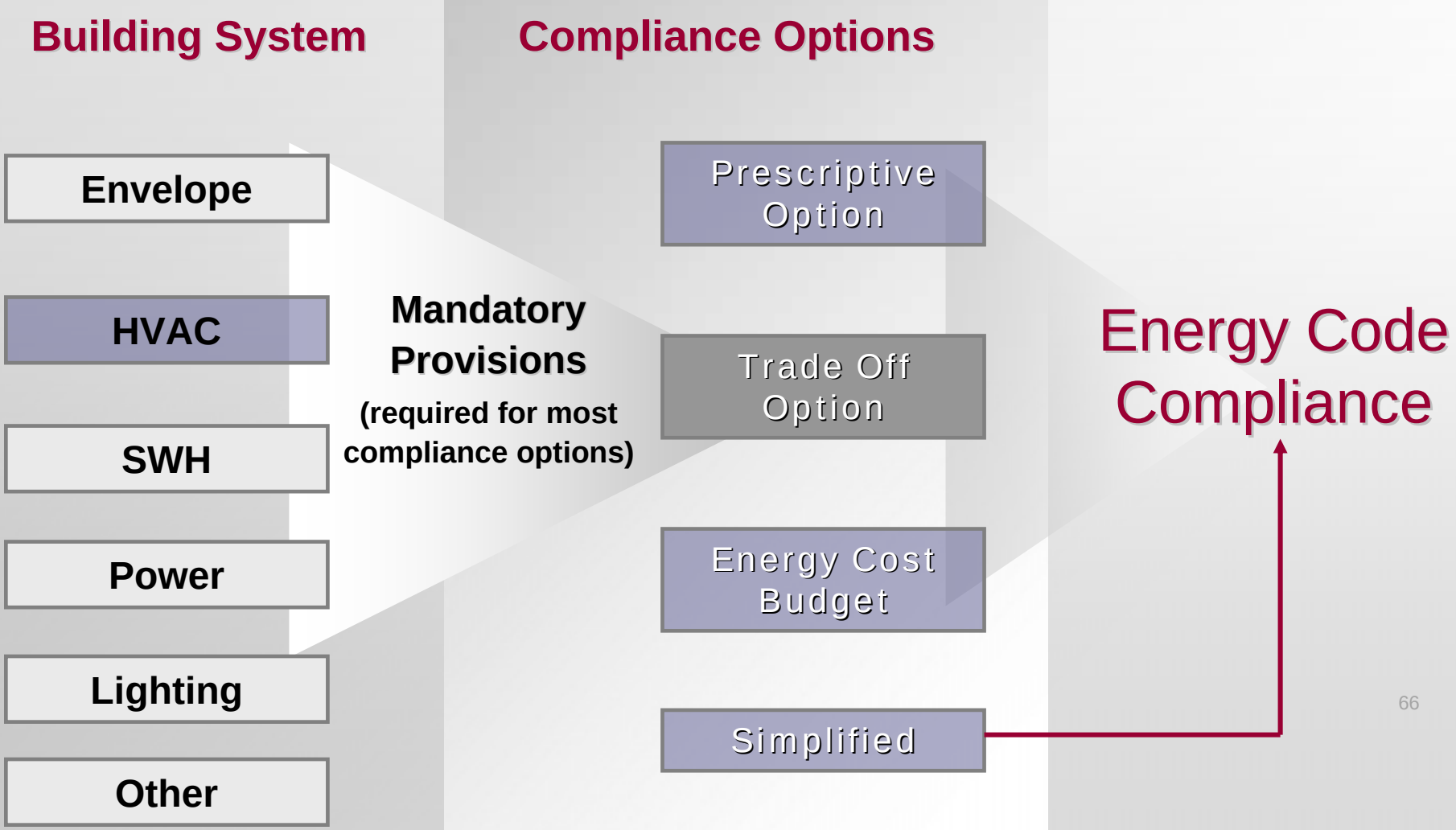
- The glazing's effectiveness in rejecting solar heat gain
- Part of a system for rating window performance
  - used by the National Fenestration Rating Council (NFRC)
- Gradually replacing shading coefficient (SC) in product literature and design standards
  - convert SC to SHGC by multiplying the SC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



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

HVAC Compliance



HVAC Alterations

- New equipment shall meet the minimum efficiency requirements
- New cooling systems installed to serve previously uncooled spaces shall comply with this section
- Alterations to existing cooling systems shall not decrease economizer capacity (unless economizer tradeoff is used)
- New and replacement duct work shall comply with applicable requirements
- New and replacement piping shall comply with applicable requirements

HVAC Alterations

- Alterations to the building HVAC system shall comply with the requirements of Section 6
  - Exceptions that are allowed:
    - For equipment being modified or repaired, but not replaced, provided such modifications will not result in an increase in the annual energy consumption
    - Where a replacement or alteration of equipment requires extensive revisions to other systems and such replacement or altered equipment is a like-for-like replacement
    - For refrigerant change of existing equipment
    - For the relocation of existing equipment
    - For ducts and pipes where there is insufficient space or access to meet these requirements

HVAC Compliance Paths

- Section 6.2
- You have to follow Sections 6.1, 6.7, and 6.8, and then you can follow either

  Section 6.3

  OR

  Sections 6.4 and 6.5

- Alternatively, you can follow Section 11 (ECB), in which case Section 6.4 is mandatory

Simplified Approach Option

- Limited to…
  - Buildings with 1 or 2 stories
  - Buildings < 25,000 ft^2
  - Each HVAC system in the building meets the following requirements
- Requirements
  - Single-zone systems
  - Cooling - Unitary packaged or split-system AC
  - Air-cooled or evaporatively cooled only

Simplified Approach Option *(cont'd)*

- The system shall have an economizer, unless the economizer Trade-off Option is used
  - Limited to unitary systems
  - Requires higher minimum cooling efficiency (EER)
  - Trade-off EER by
    - System size
    - Climate zone

Table 6.3.2

Section 6.3	Mandatory Provisions				Prescriptive Option			
	Envelope	HVAC	SWH	Lighting	Envelope	HVAC	SWH	Lighting

Simplified Approach Option *(cont'd)*

- Requirements
  - Manual changeover or dual set-point thermostat
  - Heat pump supplementary control
  - No reheat or simultaneous heating and cooling for humidity control
  - Time clocks (except hotel/motel guest rooms and systems requiring continuous operation
  - Pipe and ductwork insulated

Simplified Approach Option *(cont'd)*

- Requirements
  - Ducted system to be air balanced in accordance with industry accepted procedures
  - Interlocked thermostats to prevent simultaneous heating and cooling when separate heating and cooling systems are used
  - Non-manually operated dampers required on exhaust systems with capacity > 300 cfm unless continuous operation
  - Optimum start controls (design supply air capacity > 10,000 cfm)

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)*

Equipment Covered

- Package air conditioners and condensing units
- Heat pumps (air, water, and ground source)
- Packaged terminal and room air conditioners
- Chillers including absorption chillers
- Furnaces and unit heaters
- Boilers
- Heat rejection equipment

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
- 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

Load Calculations

- Determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority

Controls

- Zone Thermostatic controls
  - Required for each zone
  - Dead Band controls
  - Set Point Overlap Restrictions
  - Thermostats must have a 5°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

Controls

- Set Point Overlap Restriction
  - 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 controls (*Section 6.4.3.3*)
  - automatic shutdown
  - setback controls
  - optimum start controls
  - shutoff damper controls
  - zone isolation
- Exceptions, HVAC systems
  - with heating/cooling capacity < 15,000 Btu/h
  - serving hotel/motel guestrooms
  - intended to operate continuously

Automatic Shutdown

- Controls to operate on different time schedules for seven different day-types per week and retain programming and time setting during loss of power for at least 10 hrs and a manual override
- Each control to have
  - Occupant sensor, **OR**
  - Manually-operated timer with maximum two hour duration, **OR**
  - Interlock to security system
- Exception – Residential occupancies may use controls with two different time schedules per week

Setback Controls

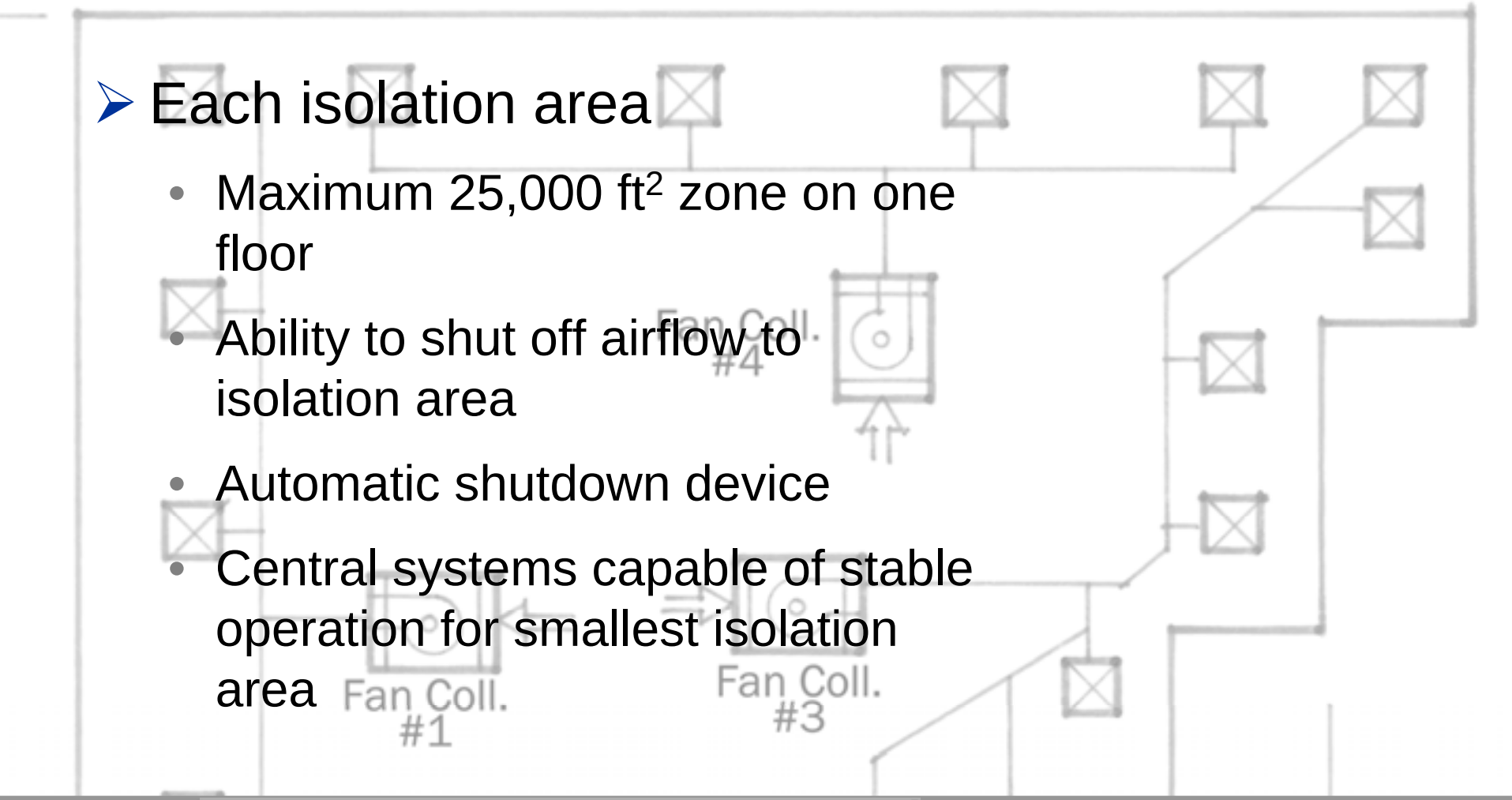
- For heating systems in climate zones 2-8, the heating set point must be adjustable down to ≤ 55°F
- For cooling systems in zones 1b, 2b, and 3b, cooling set point must be adjustable up to ≥ 90°F or to prevent high space humidity levels
- Exception
  - Radiant floor and ceiling heating systems

Optimum Start Controls

- 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

Zone Isolation

- Each isolation area
  - Maximum 25,000 ft^2 zone on one floor
  - Ability to shut off airflow to isolation area
  - Automatic shutdown device
  - Central systems capable of stable operation for smallest isolation area



Controls *(cont'd)*

- Ventilation System Controls *(Section 6.4.3.4)*
  - Stair and Shaft Vent dampers
  - Gravity Hoods, Vents, and Ventilator Dampers
- Heat Pump Auxiliary Heat Control *(Section 6.4.3.5)*

Stair and Shaft Vents

- 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

- Motorized dampers to automatically shut when spaces served are not in use
- Exceptions
  - Gravity dampers okay in buildings
    - < 3 stories in height
    - Of any height in climate zones 1 – 3
  - Ventilation systems serving unconditioned spaces

Shutoff Damper Controls

- 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)

Shutoff Damper Controls

- Exceptions:
  - Gravity dampers okay in buildings
    - < 3 stories in height
    - Of any height in climate zones 1-3
  - Gravity dampers are acceptable in systems with design outside air intake or exhaust capacity ≤ 300 cfm
- Table 6.4.3.3.4 provides maximum leakage rates for outdoor air supply and exhaust dampers

Heat Pump Auxiliary Heat Control

- Controls to prevent supplementary heat when heat pump can handle the load
- Exception
  - Heat pumps
    - With minimum efficiency regulated by NAECA
    - With HSPF rating meeting Table 6.8.1B

    (Includes all usage of internal electric resistance heating)

Controls *(cont'd)*

- Humidifier Preheat Controls *(Section 6.4.3.6)*
- Humidification and Dehumidification Controls *(Section 6.4.3.7)*
- Freeze Protection and Ice Melting Systems Controls *(Section 6.4.3.8)*
- Ventilation Controls for High-Occupancy Areas *(Section 6.4.3.9)*

Humidifier Preheat

- Automatic valve to shut off preheat when humidification isn't required

Humidification and Dehumidification

- 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
    - Computer rooms, museums, and hospitals

Freeze Protection and Snow/Ice

- 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

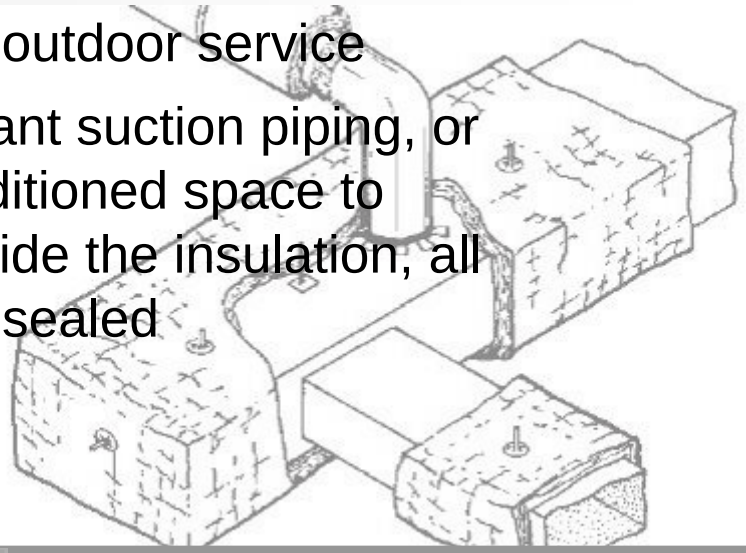
- Automatic controls for reduction of outdoor air for systems with >3000 cfm outdoor air design capacity and greater than 100 person/1000 sf
  - Exception for systems with heat recovery

HVAC System Construction and Insulation

- Insulation installed in accordance with industry accepted standards
- Insulation protection
- Duct and plenum insulation
- Duct sealing
- Duct leakage testing
- Piping insulation

General

- 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



Duct and Plenum Insulation

- 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 ft^2 need not exceed R-2; those ≤ 5 ft^2 need not be insulated

Piping Insulation

- 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)

Duct Sealing

- Table 6.4.4.2A
- Requirements of 6.4.4.2
- Based on standard industry practice and definitions

Table 6.4.4.2A

Minimum Duct Seal Level

Duct Location	Duct Type			
	Supply			
	≤2 in. w.c.†	>2 in. w.c.†	Exhaust	Return
Outdoors	A	A	C	A
Unconditioned Spaces	B	A	C	B
Conditioned Spaces**	C	B	B	C

* See Table 6.2.4.3B definition of Seal Level.
† Duct design static pressure classification.
** Includes indirectly conditioned spaces such as return air plenums.

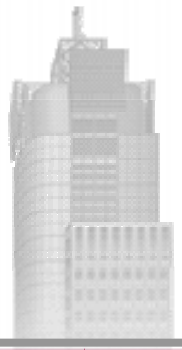
Duct Leakage Tests

- 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
    - $L_{max} = C_L P^{0.65}$

Where L_{max} = maximum permitted leakage in cfm/100 ft^2 duct surface area

Completion Requirements

- Refers to Section 6.7 for Submittal and Completion Requirements including
  - Record drawings
  - Operating and maintenance manuals
  - System balancing
  - System commissioning



HVAC Prescriptive Path

- 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

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

Design Capacity

- 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

Control Signal

- 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)

High Limit Shutoff

- Automatically reduce outside air intake to minimum outdoor air quantify when outside 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

Dampers

- Return air and outside air dampers to meet the damper leakage specified in 6.4.3.3.4

Relief of Excess Outside Air

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

Design Capacity

- 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

Maximum Pressure Drop

- Precooling coils and water-to-water heat exchangers to have either
  - Water-side pressure drop of < 15 ft of water **OR**
  - Create a secondary loop so the coil or heat exchanger pressure drop isn't seen by the circulating pumps when the system is in normal cooling mode

Integrated Economizer Control

- Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required
- Some exceptions to this

Economizer Heating System Impact

- Designed so economizer operation doesn't increase the building heating energy use during normal operation
- Exception
  - Economizers on VAV systems that cause zone level heating to increase due to a reduction in supply air temperature

Simultaneous Heating and Cooling Limitation

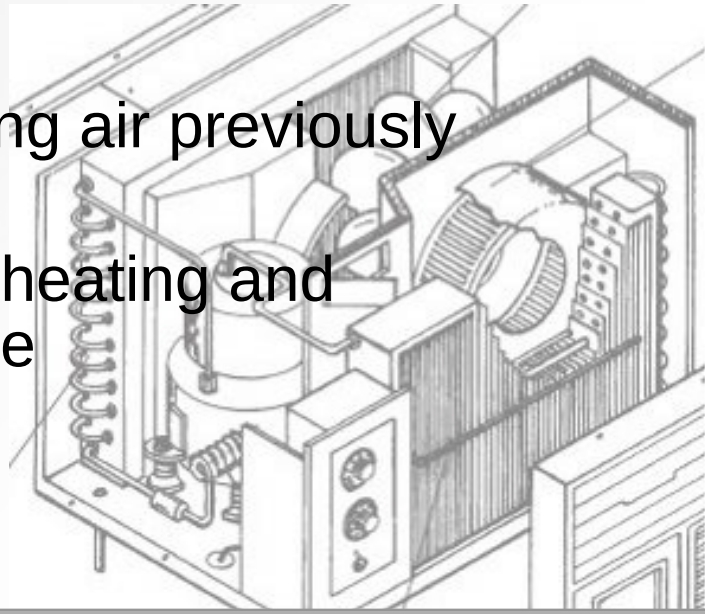
- Zone controls capable of operating in sequence the supply of heating and cooling energy to the zone to prevent reheating, recooling, mixing or simultaneously supplying air previously heated or cooled
- Hydronic system controls to prevent reheating or recooling of fluids

Simultaneous Heating and Cooling Limitation *(cont'd)*

- Dehumidification controls
- Humidification controls

Zone Controls

- Capable of operating in sequence the supply of heating and cooling energy to the zone
- Controls prevent
  - Reheating
  - Recooling
  - Mixing or simultaneously supplying air previously heated or cooled
  - Other simultaneous operation of heating and cooling systems to the same zone



Zone Controls - Exceptions

- 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 6.1.3 of ASHRAE 62 for the zone
  - 0.4 cfm/ft^2 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

Hydronic System Controls

- Limit heating and cooling of fluids previously heated or cooled mechanically per 6.5.2.2.1 through 6.5.2.2.3

Three-Pipe System

- No common return system for both hot and chilled water

Two-Pipe Changeover System

- Common distribution system acceptable if
  - Deadband from one mode to another is ≥ 15°F outside air temperature
  - Controls to allow operation of ≥ 4 hours before changing over
  - Reset controls so heating and cooling supply temperatures at changeover point no more than 30°F apart

Hydronic (Water Loop) Heat Pump Systems

- 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
- A two-position valve at each hydronic heat pump for hydronic systems having a total pump system power > 10 hp
- Exception
  - If system loop temperature optimization controller is used, deadband < 20°F is allowed

Dehumidification

- Humidistatic controls to prevent
  - Reheating
  - Mixing of hot and cold air streams
  - Heating and cooling of same air stream

Dehumidification Exceptions

- 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

Humidification

- Systems with hydronic cooling and humidification systems designed to maintain inside humidity at > 35°F dewpoint temperature shall use a water economizer if required by 6.5.1

Air System Design and Control

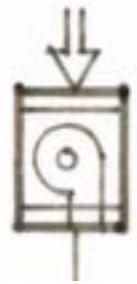
- HVAC systems with total fan system power > 5 hp to meet 6.5.3.1 through 6.5.3.2
  - Fan Power Limitation
  - VAV Fan Control
    - Part Load Fan Power Limitation
    - Static Pressure Sensor location
    - Set Point Reset

Fan Power Limitation

- Table 6.5.3.1
- Allowable fan system power may be adjusted if
  - Air systems require air treatment or filtering systems with pressure drops > 1 in. w.c. when filters are clean, or heat recovery coils or devices, or direct evaporative humidifiers/coolers, or other devices to serve process loads in the airstream
- If
  - design room temperature – supply air temp at cooling design condition = > 20°F, allowable fan system power may be adjusted

Part-Load Fan Power Limitation

- Individual VAV fans with motors ≥ 15 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 ≤ 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

- Placed so controller set point is ≤ 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

- 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

Hydronic System Design and Control

- HVAC hydronic systems with total pump system power > 10 hp shall meet 6.5.4.1 – 6.5.4.4
  - Hydronic Variable Flow Systems
  - Pump Isolation
  - Chilled and Hot Water Temperature Reset
  - Hydronic (water-loop) Heat Pump Systems

Hydronic Variable Flow

- 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

- 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

Pump Isolation

- 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

Chilled and Hot Water Temperature Reset Controls

- 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

Hydronic Heat Pump

- For heat pump loops with total pump system power > 10 hp
  - 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 6.3.4.1

Heat Rejection Equipment

- 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

Fan Speed Control

- Each 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

Exhaust Air Energy Recovery

- Incorporate exhaust air energy recovery in systems with
  - ≥ 70% outside air and ≥ 5000 cfm total
  - 50% energy recovery effectiveness

Exhaust Air Energy Recovery Exceptions

- Lab systems meeting 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

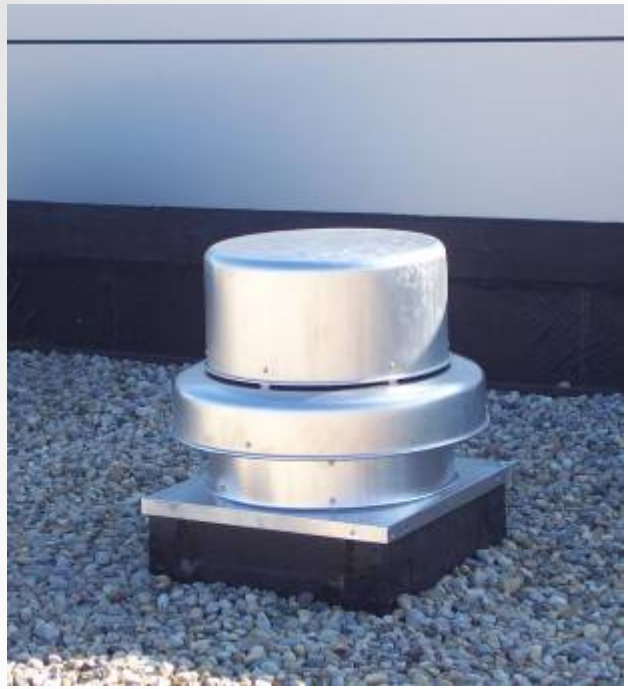
- Condenser recovery required if
  - 24 hrs per day **and**
  - Heat rejection > 6,000,000 Btu/h **and**
  - SWH load > 1,000,000 Btu/h

Kitchen Hoods (Exhaust)

- 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 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

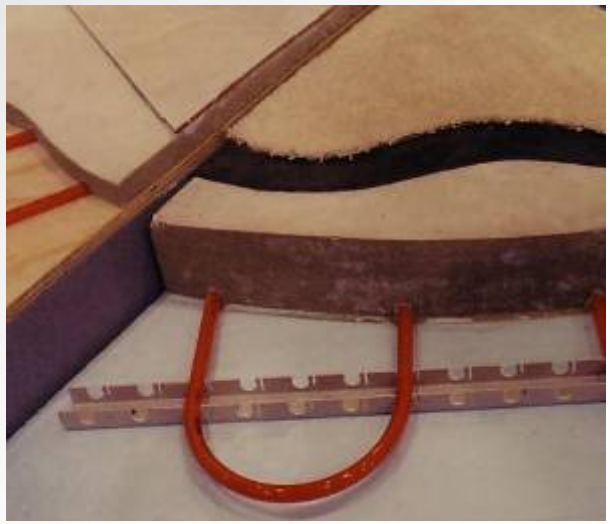
Fume Hoods

- 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



Radiant Heating Systems

- Required for unenclosed spaces except loading docks with air curtains
- “Radiant heating systems that are used as primary or supplemental enclosed space heating must be in conformance with the governing provisions of the standard”



Hot Gas Bypass Limitation

- 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
- Operating and maintenance manuals
- System balancing
- System commissioning

Drawings

- 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

Manuals

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

System Balancing

- Systems shall be balanced in accordance with accepted engineering standards
- Written report for conditioned spaces > 5000 ft^2
- Minimize throttling losses
- For fans with system power > 1 hp
  - Adjust fan speed to meet design flow conditions

Hydronic System Balancing

- 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 $\leq$ 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

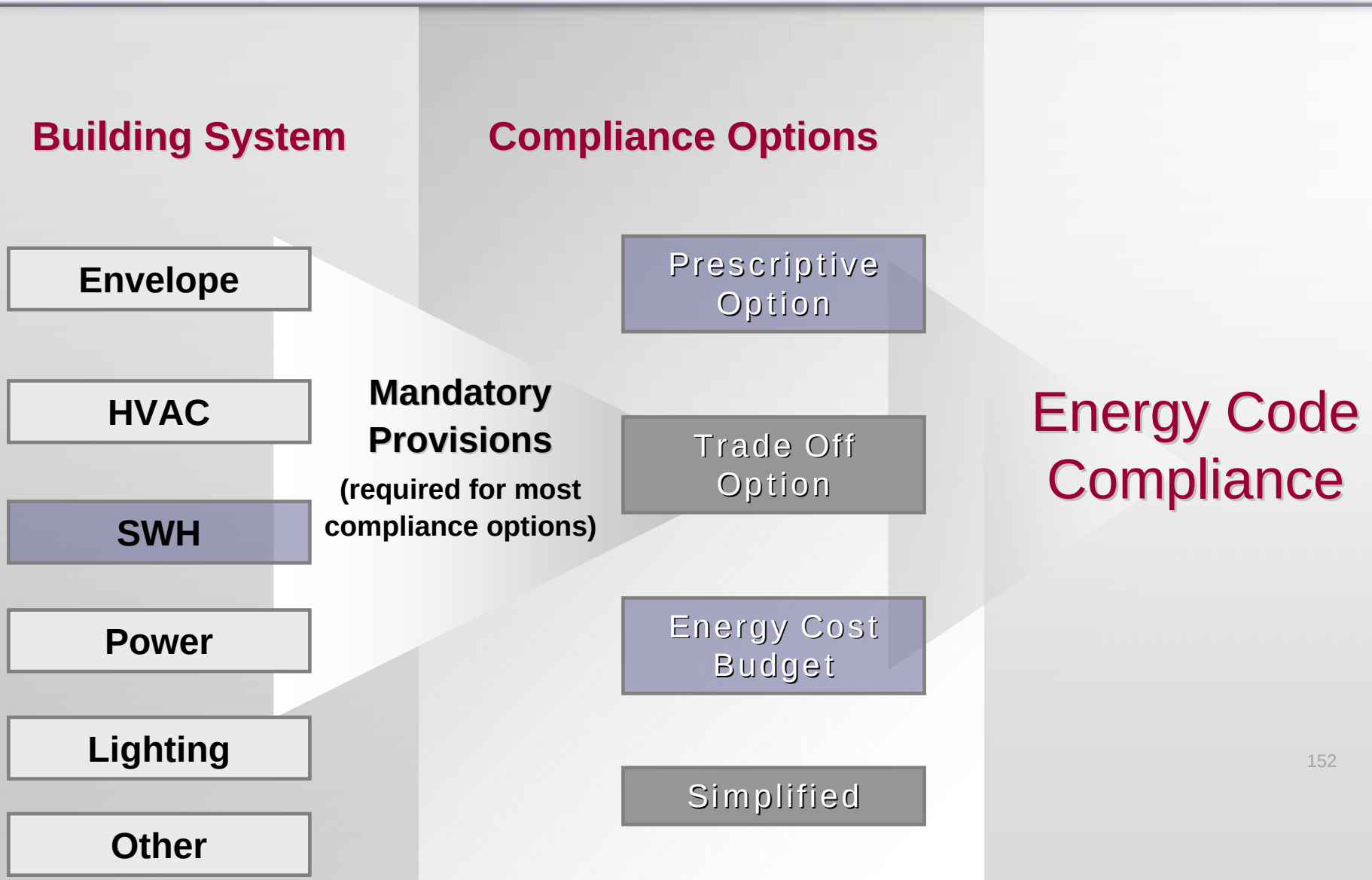
System Commissioning

- Control elements are calibrated, adjusted, and in proper working condition
- > 50,000 ft^2 conditioned area
  - Except warehouses and semiheated spaces
  - Requires commissioning instructions

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



Section 7 - Service Water Heating

- 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)*

Section 7	Mandatory Provisions				Prescriptive Option			
	Envelope	HVAC	SWH	Lighting	Envelope	HVAC	SWH	Lighting

SWH Alterations

- 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

- In accordance with manufacturer's published sizing guidelines or generally accepted engineering standards and handbooks

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
- Heat pump pool heaters added to Table 7.8 in Standard 90.1-2004

Service Hot Water Piping Insulation

- Table 6.8.3, Section 6
- Circulating water heater
  - Recirculating system piping, including supply and return piping
- Nonrecirculating storage system
  - First 8 ft of outlet piping
  - Inlet pipe between storage tank and heat trap
- Externally-heated pipes (heat trace or impedance heating)

Service Water Heating System Controls

- Temperature Controls
- Temperature Maintenance Controls
- Outlet Temperature Controls
- Circulating Pump Controls

Temperature Controls

- 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

- 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

- Controls provided
  - To limit maximum temperature of water delivered from lavatory faucets in public facility restrooms to 110°F

Circulating Pump Controls

- To limit operation to a period from the start of the heating cycle to a maximum of five minutes after the end of the heating cycle

Pools

- Pool heaters to have readily accessible on-off switch
- Pool heaters fired by natural gas can NOT have continuously burning pilot lights
- Vapor retardant pool covers required (unless recovered or solar heat)
- Time switches required

Heat Traps

- Noncirculating 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

Space Heating and Water Heating

- 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 x *pmd* + 400) / *n*; where *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

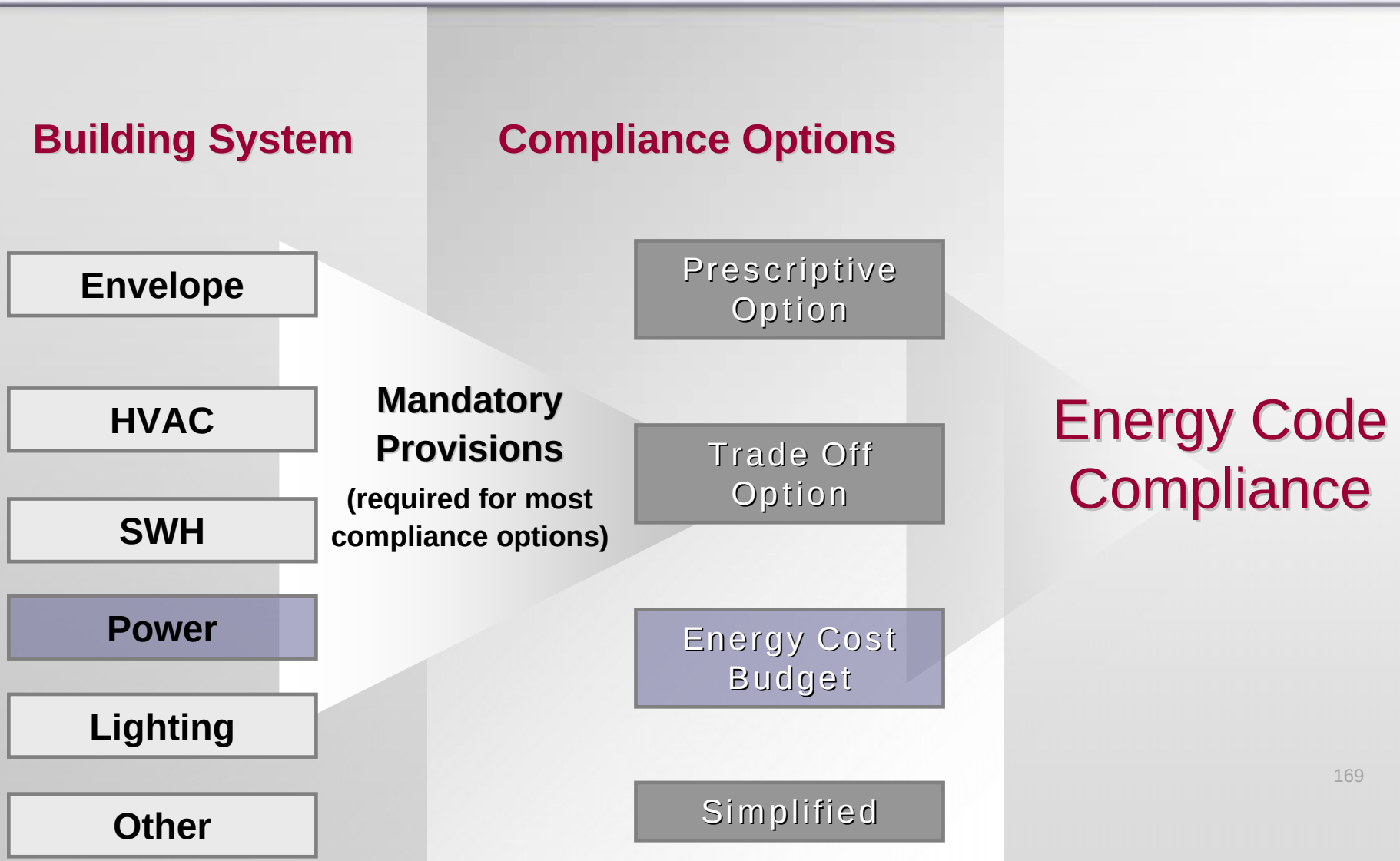
Service Water Heating Equipment

- 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

Service Water Heating Submittals

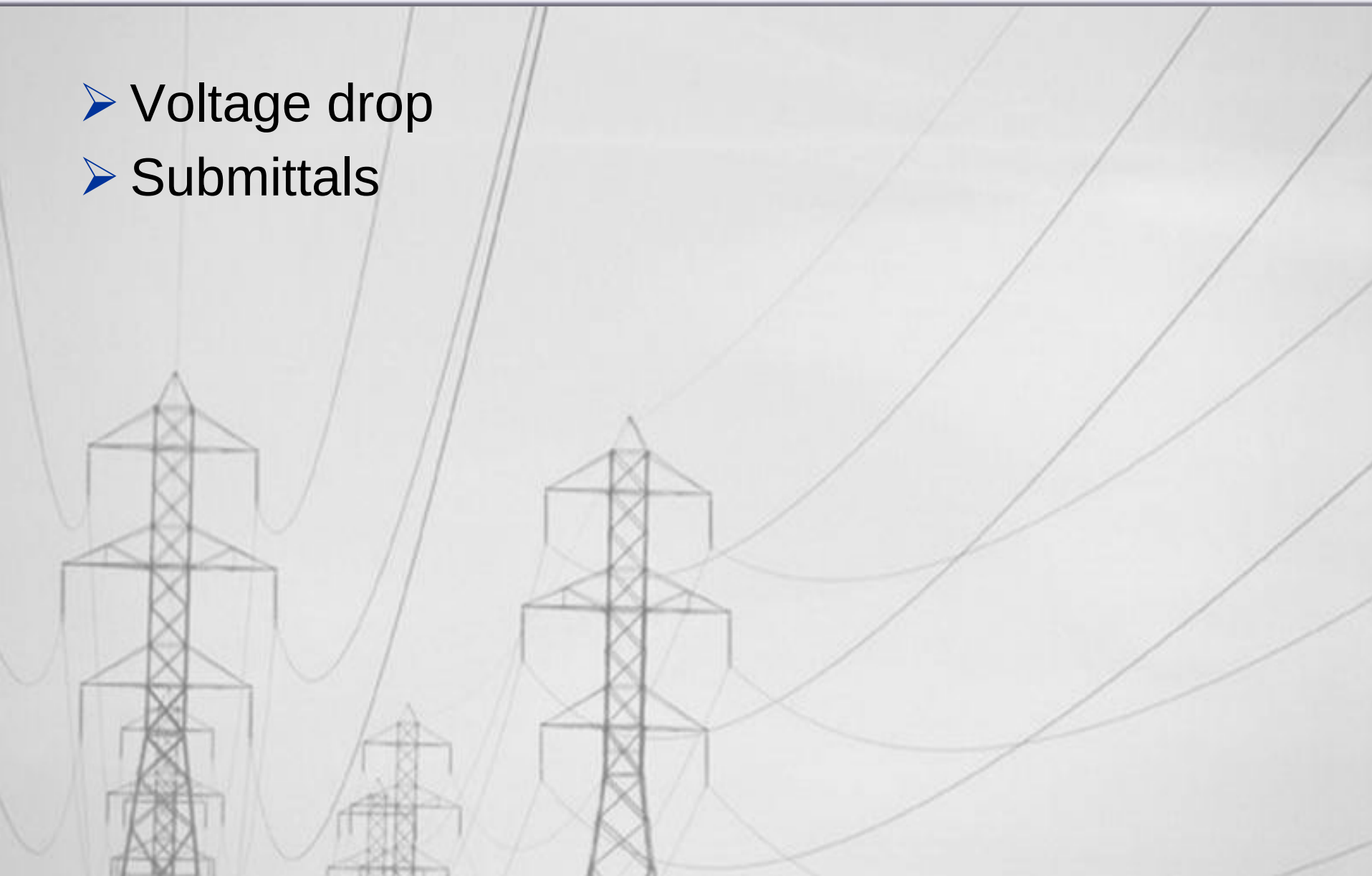
- Authority having jurisdiction may require submittal of compliance documentation and supplemental information in accord with Section 4.2.2 of this standard.

Power Compliance



Section 8 - Power

- Voltage drop
- Submittals



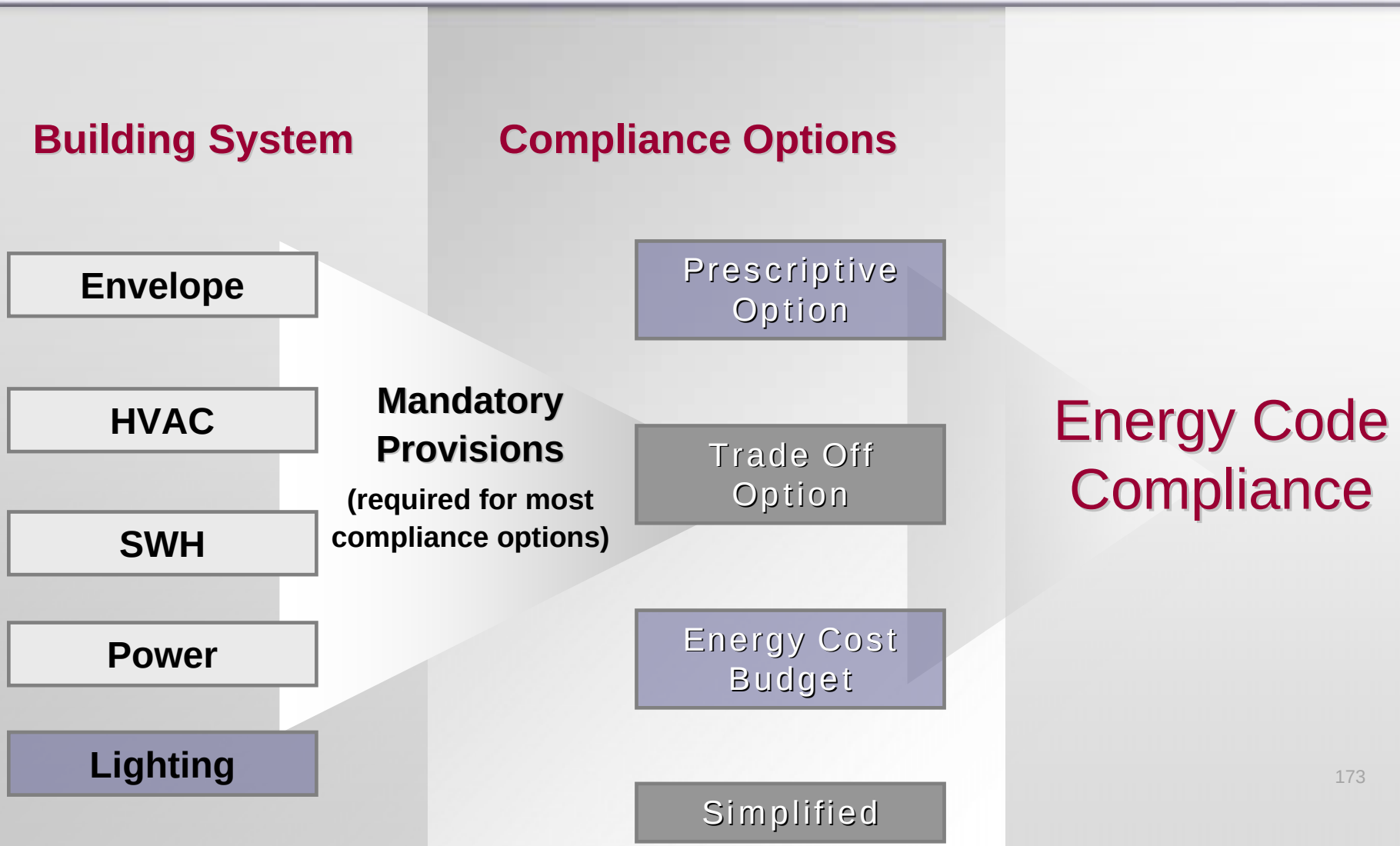
Voltage Drop

- Two types of conductors
  - Feeder conductors
    - Run between the service entrance equipment and the branch circuit distribution equipment
    - 2% maximum voltage drop allowed at design load
  - Branch circuit conductors
    - 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)

Power Submittals

- Owner gets information about the building's electrical system
  - Record drawings of actual installation within 30 days
    - Single-line diagram of electrical distribution system
    - Floor plans showing location and areas served for all distribution
  - Manuals
    - Submittal data stating equipment rating
    - O&M manuals for equipment
    - Qualified service agency
    - Complete narrative of system as it's normally intended to operate

Lighting Compliance



Section 9 - Lighting

- 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 grounds lighting
- Building Area Method Compliance Path (*Section 9.5)*
- Alternative Compliance Path: Space-by-Space Method *(Section 9.6)*

Section 9	Mandatory Provisions				Prescriptive Option			
	Envelope	HVAC	SWH	Lighting	Envelope	HVAC	SWH	Lighting

Lighting General

- Scope
  - Interior spaces of buildings
  - Exterior building features
  - Exterior grounds lighting powered through building
    - Exceptions
      - Emergency lighting
      - Lighting required by life safety statute
      - Lighting within living units of buildings
      - Decorative gas lighting

- Lighting Alterations – 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

Lighting General

- Installed Interior Lighting Power shall include all power used by the luminaires, including lamps, ballasts, current regulators, 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
- Luminaire Wattage for various systems shall determined in accordance with details in Section 9.1.4

Lighting Alterations

- Interior spaces of buildings
- Exterior building features
- Exterior grounds lighting powered through building
- Exceptions
  - Emergency lighting
  - Lighting required by life safety statute
  - Lighting within living units of buildings
  - Decorative gas lighting

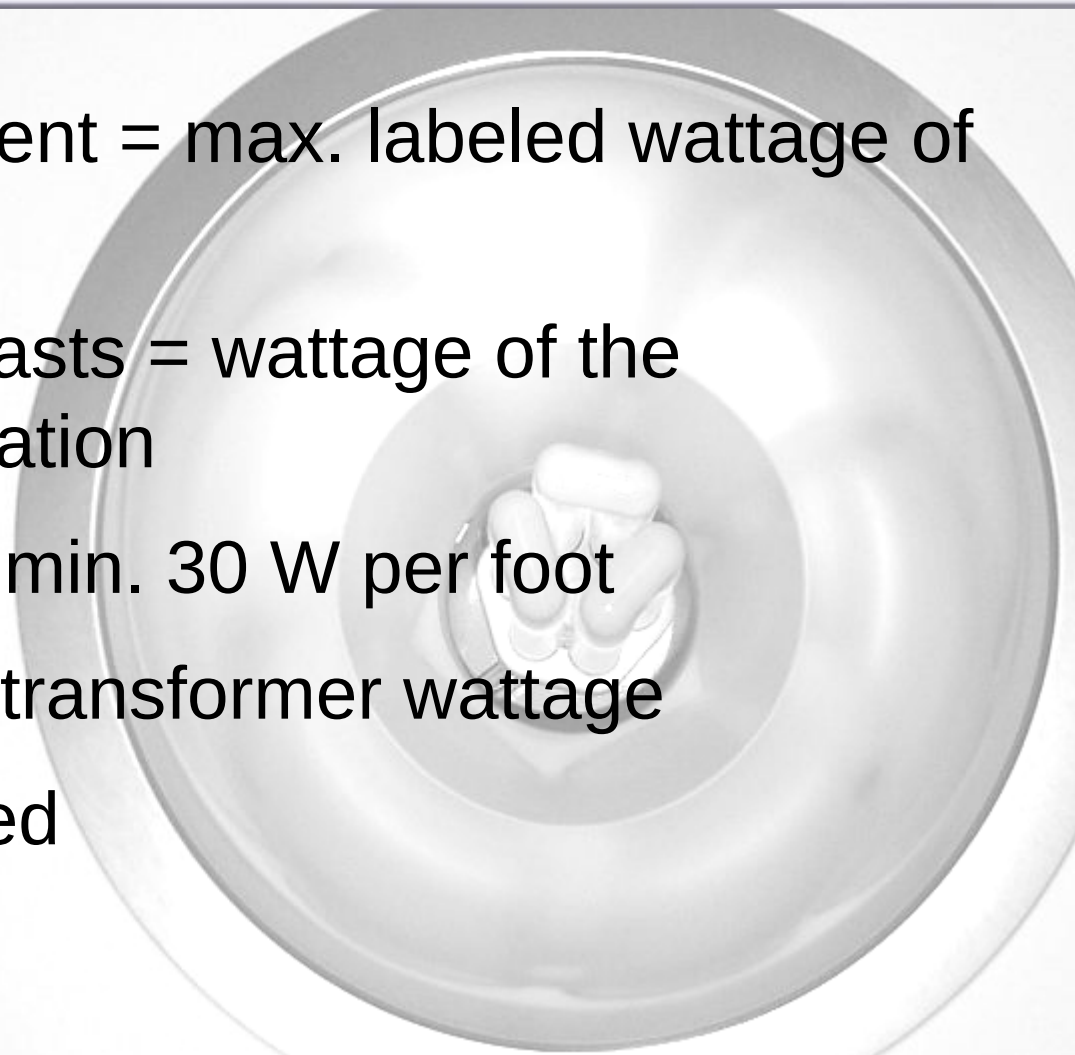
Lighting Scope

- New construction
- Existing nonresidential and high-rise residential
  - If ≥ 50% of existing luminaires are replaced
  - If renovation increases lighting power
- Control devices can't control
  - > 2500 ft^2 in spaces < 10,000 ft^2
  - > 10,000 ft^2 in spaces > 10,000 ft^2
- Control must be readily accessible and located so occupants can see the controlled lighting

Installed Interior Lighting Power

- Includes all permanent and portable interior lighting intended for general, ambient, or task illumination
- Includes lamp, power used by ballast, the control (when applicable), current regulators, and any other power draws associated with the lighting system
- Exception
  - If 2 or more independently operating lighting systems in a space can be controlled to prevent simultaneous operation, can base IILP on lighting system with highest wattage

Luminaire Wattage



- Standard incandescent = max. labeled wattage of the luminaire
- Luminaires with ballasts = wattage of the lamp/ballast combination
- Line voltage track = min. 30 W per foot
- Low voltage track = transformer wattage
- All others as specified

Lighting Control

- Automatic lighting shutoff
  - Applies to buildings > 5000 ft^2
    - Time-scheduling devices
      - Accommodate separate schedules for each floor or each space > 25,000 ft^2
    - Occupant-sensing devices
      - All general lighting controlled by one or more occupant sensors
      - Must turn off lights in each controlled space within 30 minutes of last occupant detection
    - A signal from another control or alarm system that indicates the area is unoccupied

Space Control 1

- At least one for each room or space enclosed by ceiling-height partitions
- Readily accessible to occupants, unless there are safety or security issues

Space Control 2

- For classrooms, conference/meeting rooms, and employee lunch and break rooms:
  - The control device shall automatically turn lighting off within 30 minutes of sensing that all occupants have left the space:
    - Exceptions
      - Spaces with multi-scene control
      - Shop classrooms, laboratory classrooms, and preschool through 12th grade classrooms
  - These spaces are not required to be connected to other automatic lighting shutoff controls

Space Control 3

- For all other spaces:
  - In spaces ≤ 10,000 ft^2, each control can serve a maximum of 2500 ft^2
  - In spaces > 10,000 ft^2, each control can serve a maximum of 10,000 ft^2

Exterior Lighting Control

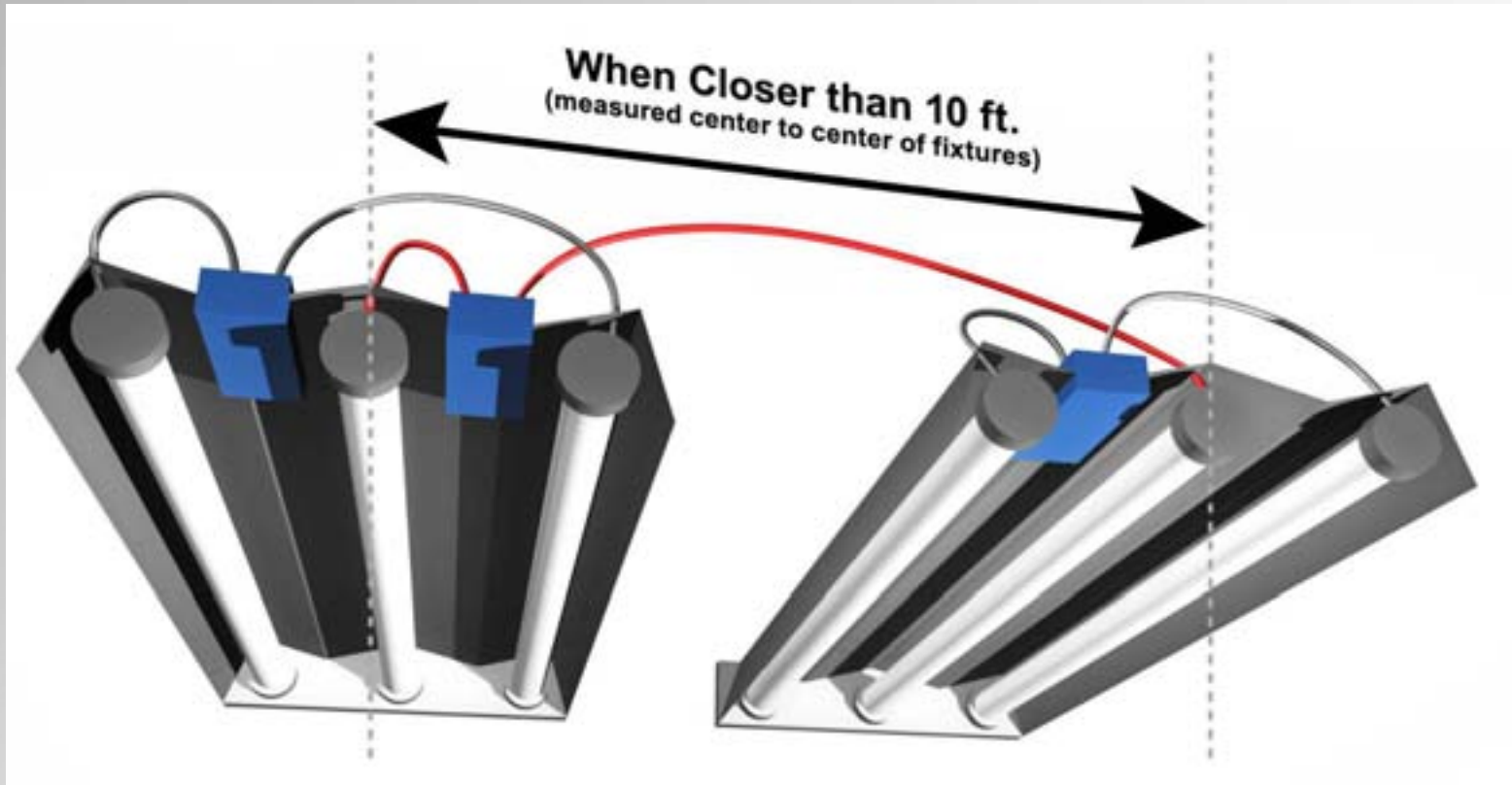
- Lighting for all exterior applications not exempted in 9.1 shall have automatic controls capable of turning off exterior lighting when sufficient daylighting is available or when the lighting is not required during nighttime hours.
  - Lighting not designated”dusk-to-dawn - astronomical time switch required
  - Lighting designated “dusk-to-dawn” – astronomical time switch or photosensor
- Astronomical time switches shall be capable of and time setting during loss of power for a perio
- Exceptions – lighting for
  - Covered vehicle entrances
  - Exits from buildings or parking structures

  (where required for safety, security, or eye adaptation)

Additional Control

- Many special lighting applications must be controlled separately
  - Display/accent lighting
  - Case lighting
  - Hotel/motel guest room lighting
  - Task lighting
  - Nonvisual lighting
  - Demonstration lighting

Tandem Wiring



Tandem Wiring Exceptions

- 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

Exit Signs

- Internally illuminated exit signs shall not exceed 5 watts per face

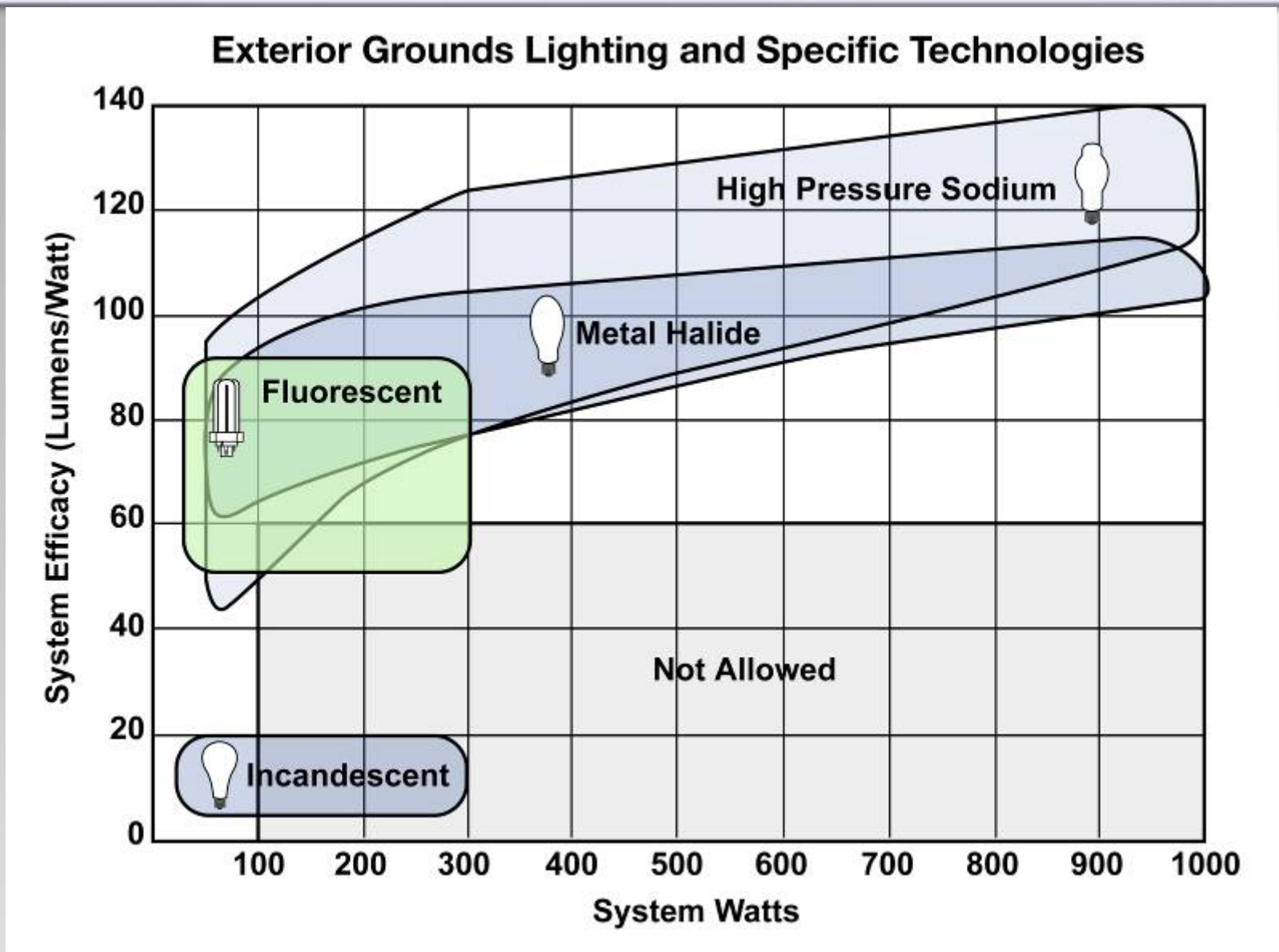
Efficacy

- 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
  - 40 watt fluorescent = 2640 lumens

Exterior Building Grounds Lighting

- Luminaires that operate at > 100 W = efficacy > 60 lumens/W
- Exceptions
  - Traffic signals
  - Lighting within outdoor signs
  - Lighting used to illuminate public monuments or registered historic landmarks
  - If an occupancy sensor or motion sensor controls the lighting application

Efficacy


Exterior Grounds Lighting and Specific Technologies
System Efficacy (Lumens/Watt)
140
120
100
80
60
40
20
0
High Pressure Sodium
Metal Halide
Fluorescent
Not Allowed
Incandescent
100
200
300
400
500
600
700
800
900
1000
System Watts

Exterior Building Lighting Power

- In 2003 the ASHRAE 90.1 lighting subcommittee undertook re-writing of the 90.1-2001 Exterior Lighting Requirements
  - Reviewed existing exterior lighting documents including
    - the Outdoor Lighting Research proposal for California Outdoor Lighting Standards
    - IESNA RP-33, RP-02, RP-20, RP-10 (draft), DG-5, and the 9th Edition Handbook
  - Multiple lighting solution models were created and analyzed for; parking areas, walkways, plazas, building entries, canopies, façade lighting, and outdoor sales
  - Metal halide was used as the base case!

Exterior Building Lighting Power

- The total exterior lighting power allowance for all exterior building applications is the sum of the individual lighting power densities permitted in Table 9.4.5 for these applications plus an additional unrestricted allowance of 5% of that sum
- Trade-offs are allowed only among exterior lighting applications listed in “Tradable Surfaces” section

Exterior Building Lighting Power

- 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 Building Lighting Power

- Tradable Building Surface Requirements

Uncovered Parking Areas	0.15 W/ft^2
Building Grounds	0.2 – 1 W/ft^2
Building Entrances and Exits	20 – 30 W/lf of door width
Canopies and Overhangs	1.25 W/ft^2
Outdoor Sales	0.5 W/ft^2

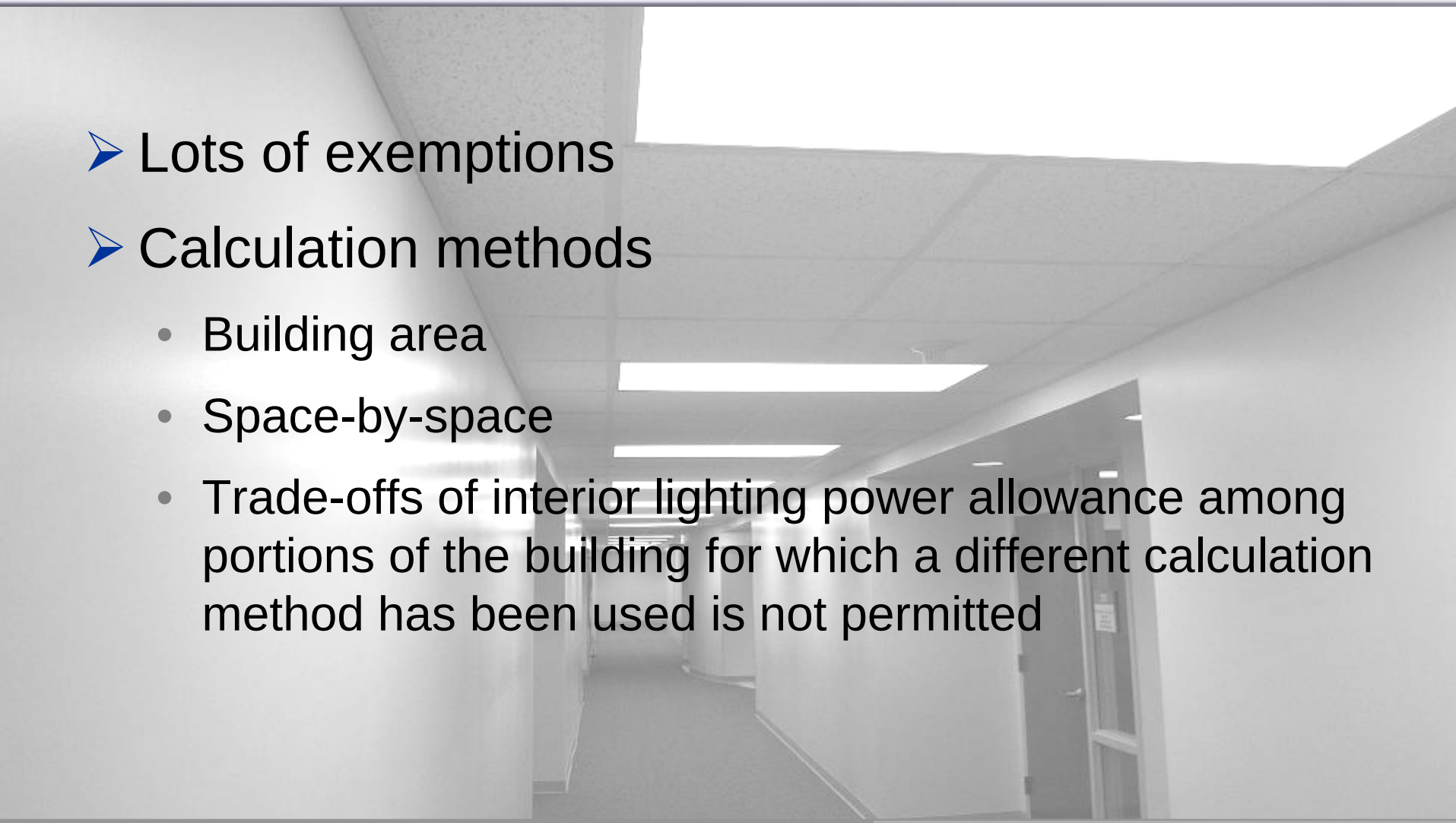
Exterior Building Lighting Power

- Non-Tradeable Surfaces
  - Building Facades – 0.2 w/ft^2 or 5.0 W/linear foot
  - Automated teller machines and night depositories
  - Entrances and gatehouses
  - Loading areas for law enforcement and public safety
  - Drive-up windows at fast food restaurants
  - Parking near 24-hour retail entrances

Lighting Power Development Concept

- Create building space models to calculate power densities with:
  - Current product performance data
  - Updated efficacy and loss factors
  - New building construction data
  - IES-recommended light levels
  - Professional lighting design consensus

Interior Lighting Power

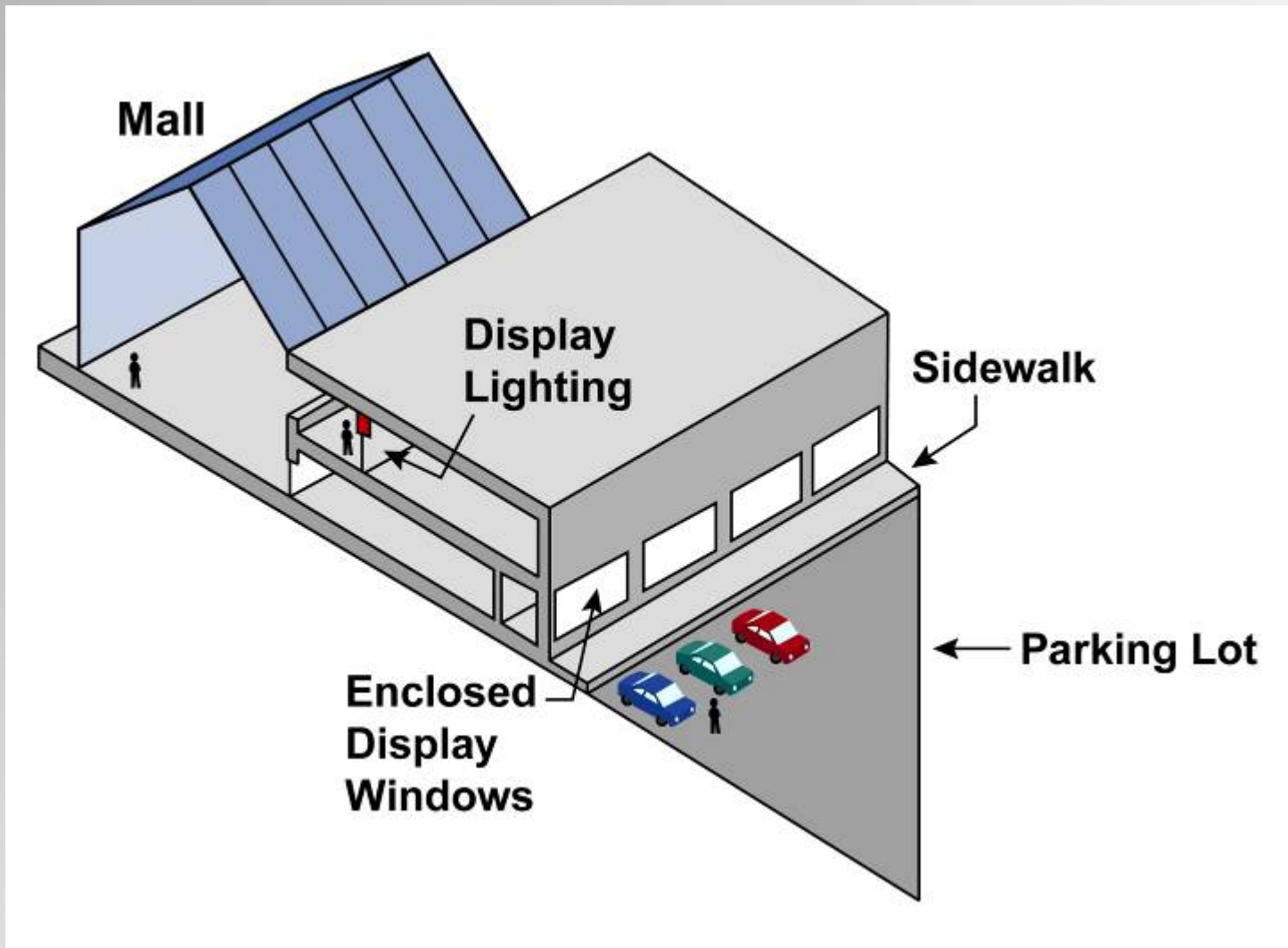


- Lots of exemptions
- Calculation methods
  - Building area
  - Space-by-space
  - Trade-offs of interior lighting power allowance among portions of the building for which a different calculation method has been used is not permitted

Lighting Power Allowance Exemptions

- 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
- 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
- For use in areas specifically designed for the visually impaired

Exemption Example



Building Area Method of Calculating Interior Lighting Power Allowance

- 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

Gross Lighted Area

- 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

Building Area Allowances

- Table 9.5.1

Building Type	Lighting Power Density (W/ft^2)
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
➢ ➢ ➢	➢ ➢ ➢

Space-by-Space Method of Calculating Interior Lighting Power Allowance

- 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)

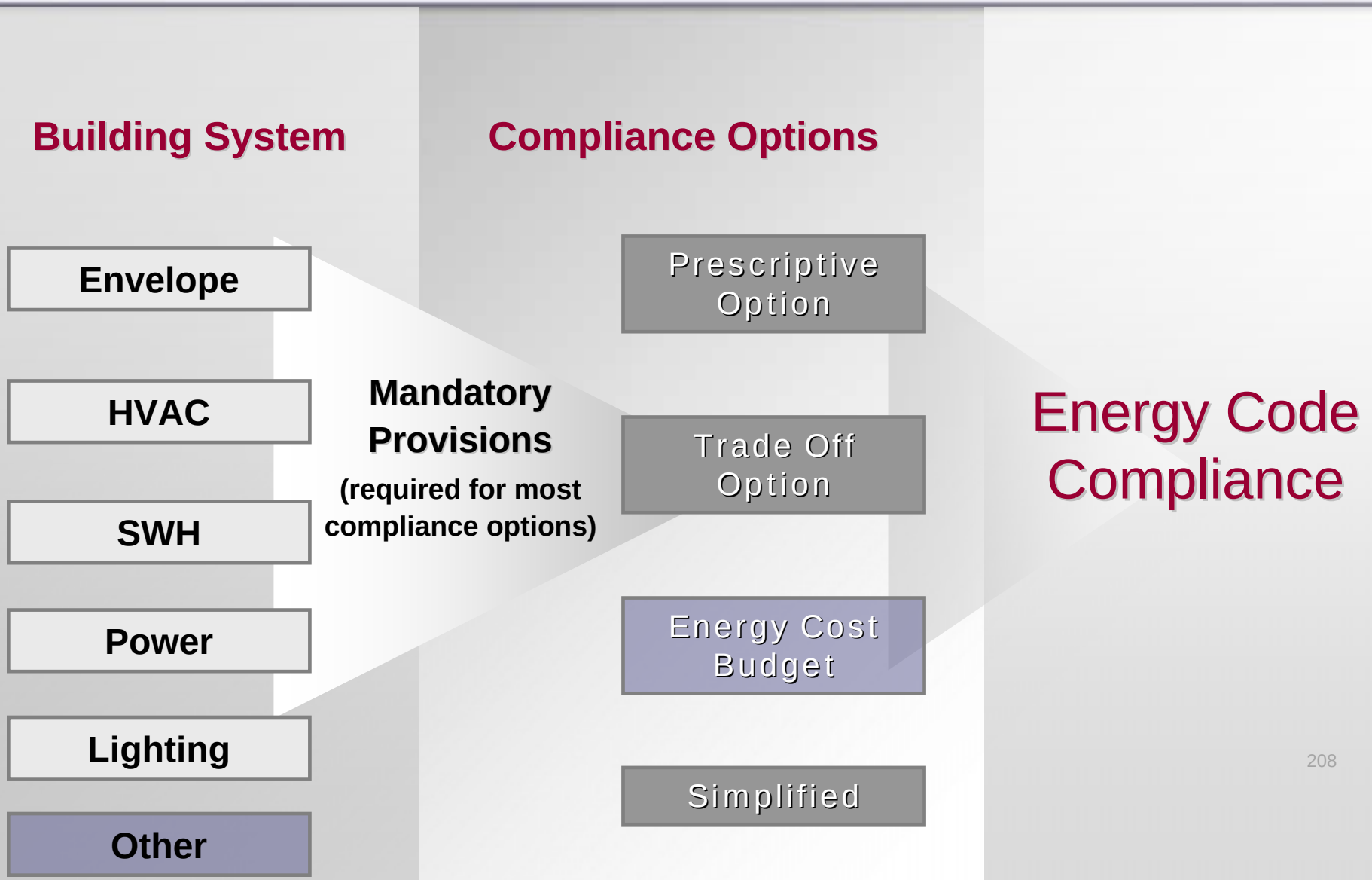
Additional Interior Lighting Power

- An increase in the ILPA is allowed for specific space functions when using the space-by-space method
  - Decorative – 1.0 W/ft^2 in space used
  - Fluorescent designed to eliminate glare – .35 W/ft^2
  - Lighting equipment installed in retail spaces specifically to highlight merchandise in specific space used
    - Additional 1.6 W/ft^2 times the area of specific display, or
    - Additional 3.9 W/ft^2 times the area of specific display for fine merchandise

Submittals

- There are no submittals associated with the lighting requirements

Other Compliance



Section 10 - Other Equipment

- Motor efficiency levels correspond to Energy Policy Act of 1992 manufacturing standards
- Mandatory provisions are for General Purpose Design A and Design B motors only
- Motors in new buildings, additions to existing buildings, and alterations to existing buildings must comply
  - Relocated or reused existing motors do not have to meet these requirements
- No small building option, no prescriptive compliance path, no alternative compliance paths, no submittals

Section 11 - Energy Cost Budget Method

- 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)

Section 11 - Energy Cost Budget Method

- Tradeoff limited to building permit
- You have to have an approved building envelope design prior to ECB submittal
- 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
- You must document all this in great detail

Section 11 - Energy Cost Budget Method

- You must use a good and approved simulation program
- You must use appropriate and approved climate data
- You must use appropriate and approved purchased energy rates
- You must use the same simulation program, climate data, and purchased energy rates for both the design energy cost and energy cost budget
- You must get approval to deal with exceptional calculations that aren't covered in the simulation program

Section 11 - Energy Cost Budget Method

- You must develop your proposed building design and budget building design in accordance with Table 11.3.1
  - This table “locks down” a number of building design parameters
- You must choose your budget building HVAC system from Figure 11.3.2 and Table 11.3.2A

Section 11 - 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

Section 12 - Normative References

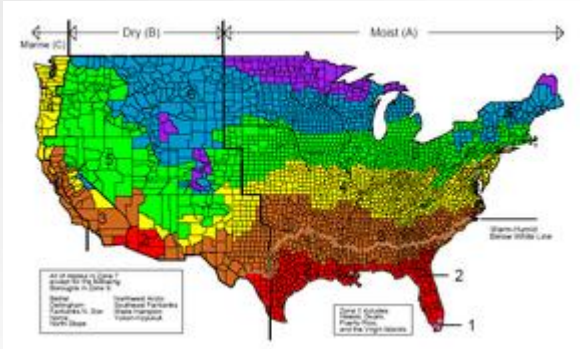
- Normative (read “mandatory”) reference documents
- Includes test methods, rating procedures, and other standards

Rated R-Value of Insulation and Assembly U-Factor, C-Factor, and F-Factor Determinations

- Includes pre-calculated U-factors, C-factors, and F-factors
  - Above-grade walls
  - Below-grade walls
  - Floors
  - Slab-on-grade floors
  - Opaque doors
  - Fenestration

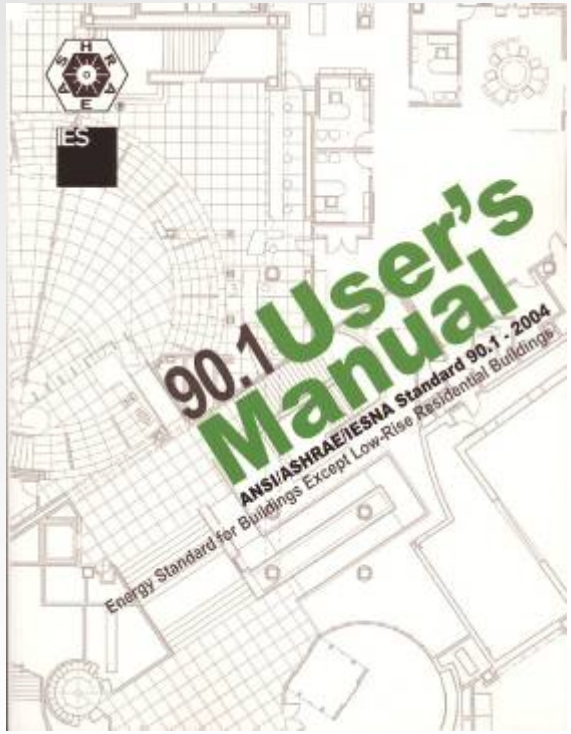
Building Envelope Climate Criteria

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



Methodology for Building Envelope Trade-Off Option in Subsection 5.6

- 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



Normative Appendix C	Mandatory Provisions				Prescriptive Option			
	Envelope	HVAC	SWH	Lighting	Envelope	HVAC	SWH	Lighting

Climate Data

- 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

- Other useful references that are not mandatory, but are useful as examples for the user of Standard 90.1-2004
- In general, these are not consensus documents so ASHRAE procedures do not allow them to be mandatory references

Addenda Description Information

- Information on addenda to ANSI/ASHRAE/IENSA Standard 90.1-2001 (the predecessor to Standard 90.1-2004)
- ASHRAE issued 31 addenda to Standard 90.1-2001
- Standard 90.1-2001 plus these addenda plus the reformat forms the basis of Standard 90.1-2004

Performance Rating Method

- Instructions for using the ANSI/ASHRAE/IESNA Standard 90.1-2004 Energy Cost Budget Method in conjunction with the U.S. Green Buildings Council (USGBC) Leadership in Energy and Environmental Design (LEED) program

Informative Appendix G	Mandatory Provisions				Prescriptive Option			
	Envelope	HVAC	SWH	Lighting	Envelope	HVAC	SWH	Lighting