BUILDING ENERGY CODES UNIVERSITY

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ANSI/ASHRAE/IES Standard 90.1-2010 Envelope

Edited & Presented by Donald Vigneau AIA
Additional editing by Kevin Rose

April 2011 – PNNL-SA-80142

Delaware ENERGY OFFICE

Compliance Approaches

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

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

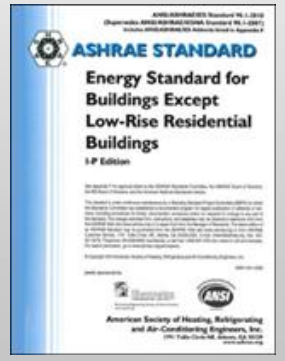
Mandatory Provisions

(required for most compliance options)

Compliance Options

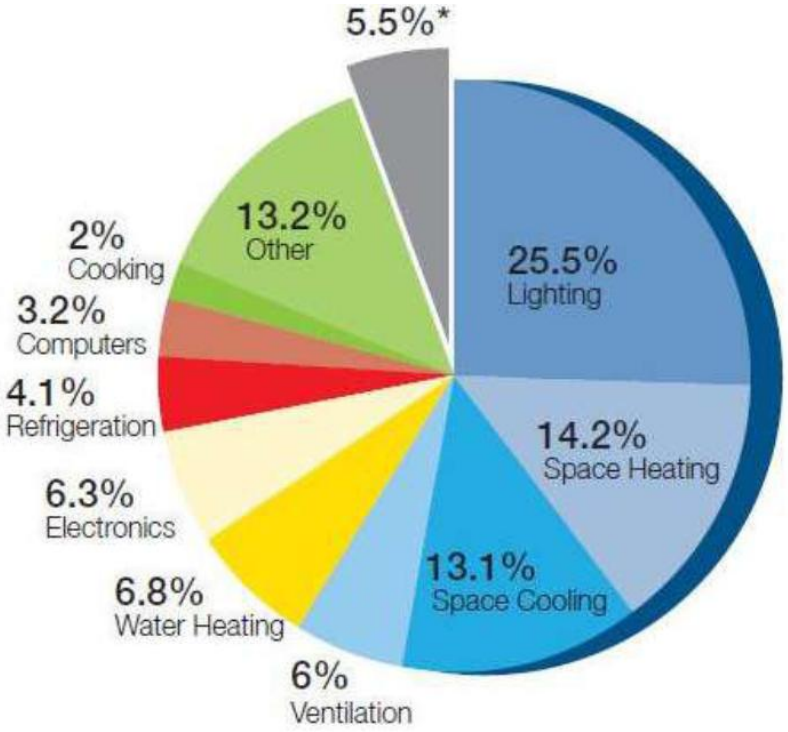
- ***Prescriptive Option***
- ***Trade Off Option***
- ***Energy Cost Budget***
- ***Simplified***

Energy Code Compliance

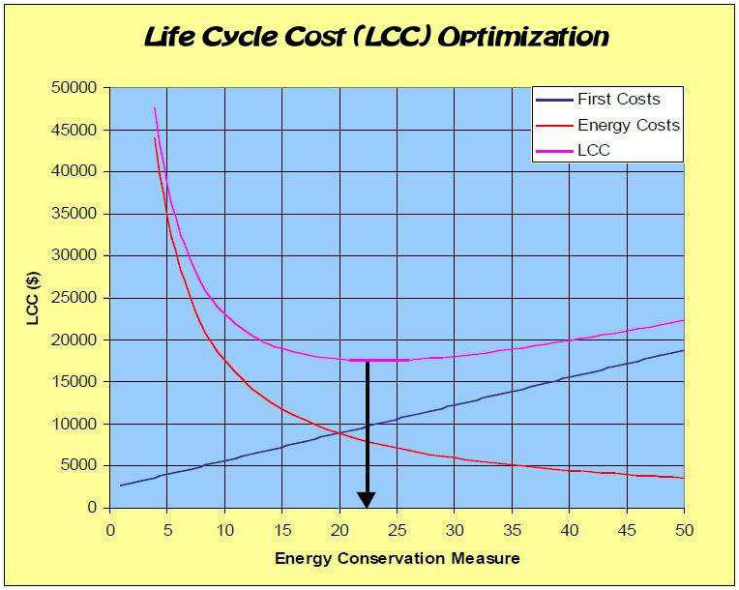


Buildings Today

- Responsible for roughly 48% of our energy use and 70% of electricity consumption
  - The scope of energy codes cover about 67% of a building's energy use
- The average consumer spends $2,175 on energy bills every year



- 90.1-2010 savings vs. 90.1-2004
- ~25% with plug loads
- ~31% without plug loads



General *(Section 5.1)*

- ✓ Scope
- ✓ Space-Conditioning Categories
- ✓ Envelope Alterations
- ✓ Climate

Compliance Paths *(Section 5.2)*

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

Mandatory Provisions *(Section 5.4)*

- ✓ Insulation
- ✓ Fenestration and Doors
- ✓ Air Leakage

2012 Delaware Energy Codes

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Commercial

90.1-2010

1,2,4. Scope and Application / ***use [CE] C 103 for CDs***

3. Definitions, Acronyms

4. Building Envelope

5-11 Commercial Energy Efficiency

12. Referenced Standards

Residential

Section [RE]

Ch. 1 Scope and Application / Administrative and Enforcement

Ch. 2 Definitions

Ch. 3 General Requirements

Ch. 4 Residential Energy Efficiency

Ch. 5 Referenced Standards

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
  - – Approved by local official

Requirements apply to three space conditioning categories

- ✓ Nonresidential
- ✓ Residential
- ✓ Semi-heated (no A/C)

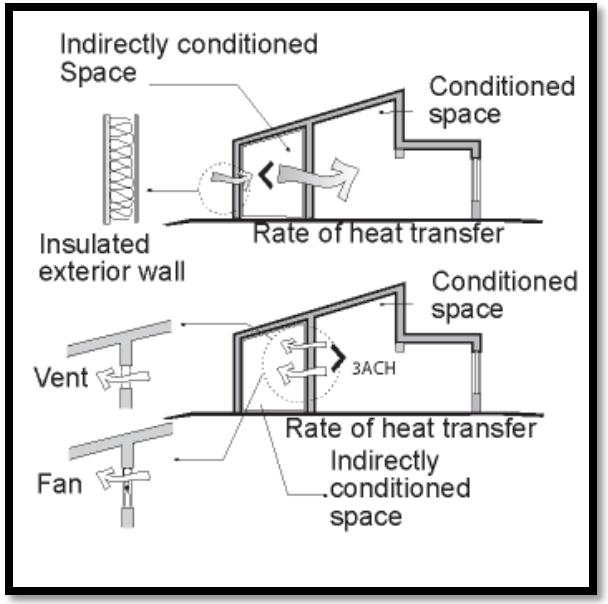


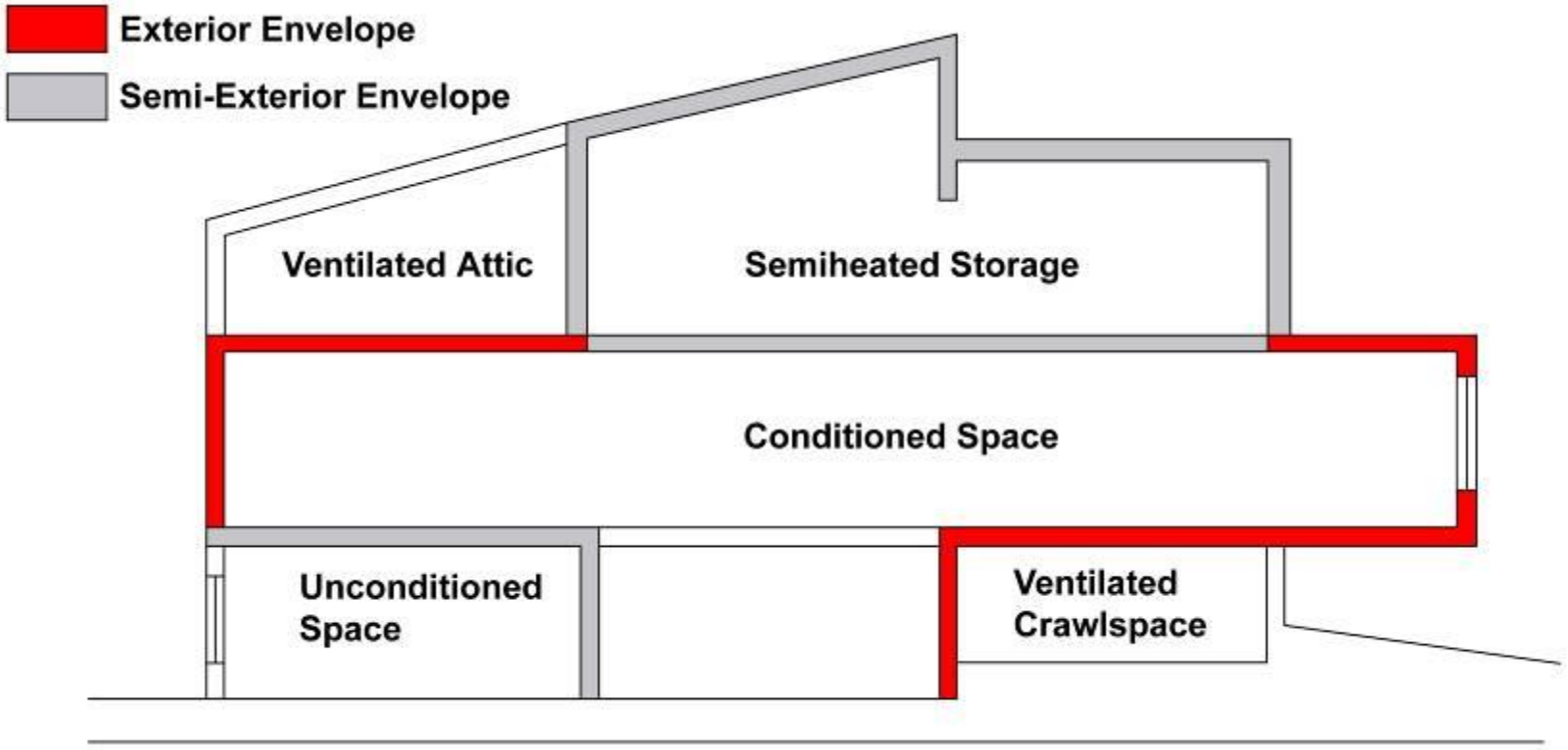
Figure 5-A

Examples of Indirectly Conditioned Spaces

(User's Manual – 90.1.-2010)

COM*check* Option

- This Option can be used to demonstrate compliance with 2012 IECC or ASHRAE Standard 90.1-2010
- User inputs all the building data
- Will show if building can meet performance or tradeoff based compliance
- When used, report shall be submitted with construction documents. New changes will use checklists from SCORE+STORE


Exterior Envelope
Semi-Exterior Envelope
Ventilated Attic
Semiheated Storage
Conditioned Space
Unconditioned Space
Ventilated Crawlspace

Compliance Approach
Building Envelope

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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

- ✓ Fenestration and Doors *(Section 5.8.2)*
- ✓ Air Leakage *(Section 5.4.3)*

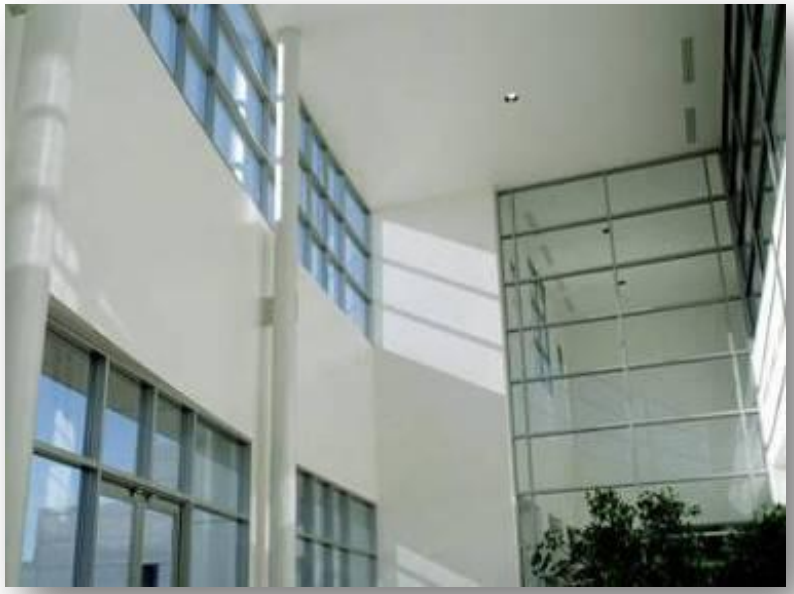


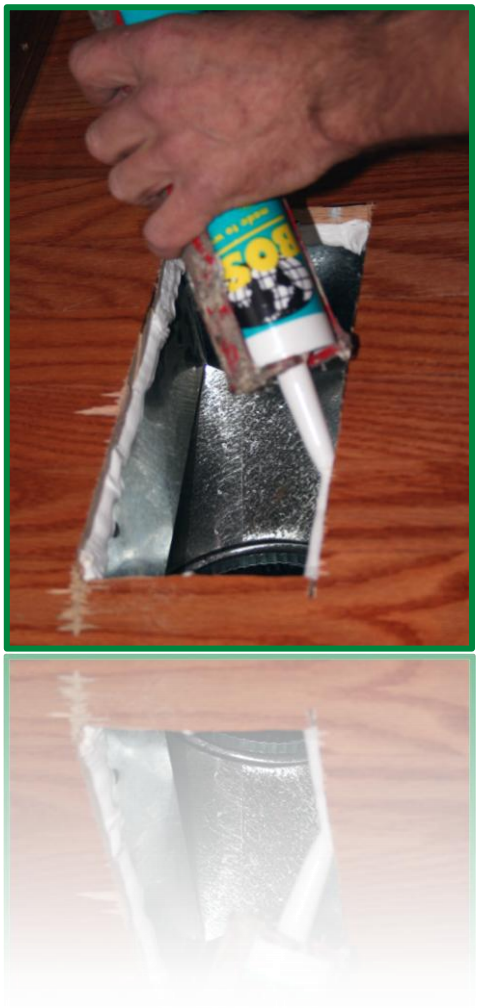
Photo courtesy of Ken Baker, K energy

Continuous air barrier required except in semi-heated spaces

- Plans
  - Air barrier components identified or noted in construction documents
  - Joints, intersections, and penetrations of air barrier components (incl. lighting fixtures) detailed
- Extends over all surfaces of thermal envelope
  - From lowest floor, exterior walls, to ceiling or roof
- Resists positive and negative pressures
  - Wind, stack effect, and mechanical ventilation

Wrap, seal, caulk, gasket, or tape:

- Joints around fenestration and door frames (both manufactured and site-built)
- Junctions between walls
  - And foundations
  - At building corners
  - And roofs or ceilings
- Penetrations for roofs, walls, and floors
- Building assemblies used as ducts or plenums
- Joints, seams, connections between planes, and other changes in air barrier materials



Material	Thickness (minimum)
Plywood	3/8 in.
Oriented strand board	3/8 in.
Extruded polystyrene insulation board	½ in.
Foil-faced urethane insulation board	½ in.
Exterior gypsum sheathing or interior gypsum board	½ in.
Cement board	½ in.
Built up roofing membrane	
Modified bituminous roof membrane	
Fully adhered single-ply roof membrane	
A Portland cement / sand parge, stucco, or gypsum plaster	½ in.
Cast-in-place and precast concrete sealed w/grout or paint	
Sheet metal	
Closed cell 2 lb/ft3 nominal density spray polyurethane foam	1 in.

Materials air permeance tested in accordance with ASTM E 2178 using ≤ 0.004 cfm/ft^2 at a pressure differential of 0.3 in. w.g.;
Sealants/tapes tested in accordance with ASTM E 2357, 1677, 1680, or 283

Moisture Diffusion in Materials

MATERIAL	PERM RATING	VAPOR RETARDER(?)
½" GWB	38 -42	NO
EPS, FIBERGLASS INSULATION	??-??	NO
TYVEK	52	NO
Latex Primer	7.0 – 10.0	NO
7/16" OSB (*w/exterior glue)	0.77* – 3.48	SOMETIMES
1" XPS	0.40 – 1.60	SOMETIMES
7/16" Plywood (exterior glue)	0.70	YES
Kraft Paper Facing	1.0	YES
2 mil polyethylene	0.06 – 0.22	YES
Alkyd-base or V/R paint	< 0.05	YES
1 mil aluminum foil laminate	< 0.05	YES
½" GWB + VWC	0.05 – 0.80	YES

Product	cfm/ft^2	Procedure	psf
Glazed swinging entrance doors and revolving doors	1.0	AAMA/WDMA/CSA 101/I.S.2/A440, NFRC 400, or ASTM E283	1.57
Curtainwall and storefront glazing	0.06	NFRC 400 or ASTM E283	1.57
Unit skylights with condensation weepage openings	0.3	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400	1.57
Unit skylights with condensation weepage openings	0.5	AAMA/WDMA/CSA 101/I.S.2/A440	6.24
Non-swinging opaque doors	0.4	ANSI/DASMA 105, NFRC 400, or ASTM E283	1.57
All other products	0.2	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400	1.57
All other products	0.3	AAMA/WDMA/CSA 101/I.S/A440	6.24

- ✓ **Exceptions**
  - Field-fabricated fenestration and doors
  - Metal coiling doors in semi-heated spaces in Climate Zones 1-6

Cargo doors and loading dock doors equipped with weather seals

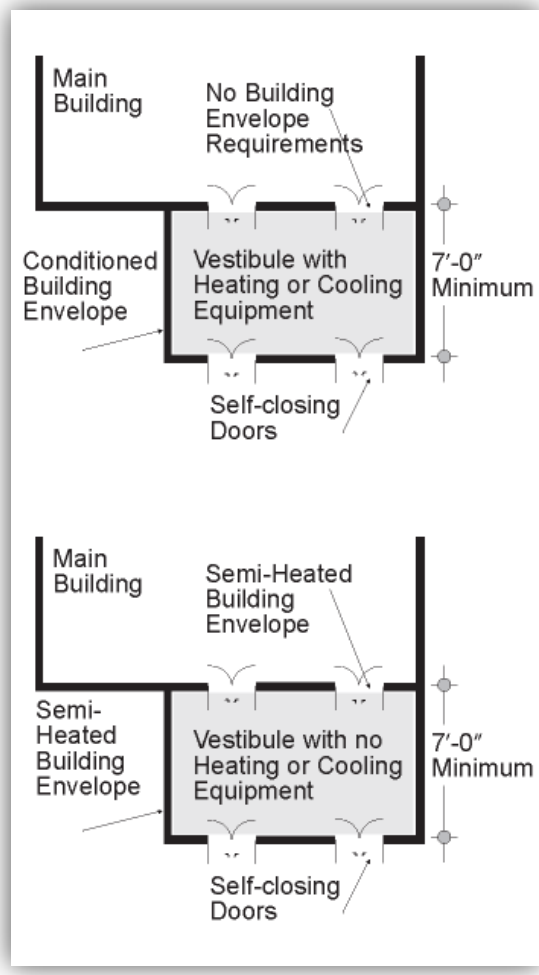
- To restrict infiltration when vehicles are parked in the loading dock/doorway
- What about dock levelers?

Required in

- ✓ Climate Zones 4 for entrances in buildings > 1000 ft^2

Vestibules must have

- ✓ Self-closing doors
- ✓ Interior and exterior doors not open at the same time
- ✓ Distance between interior and exterior doors not < 7 ft when in closed position *(remember ADA!)*



- ✓ Non-entrance doors
- ✓ Building entrances with revolving doors
- ✓ All entrances in buildings < 1000 ft^2 **in Climate Zone 4**
- ✓ All doors that open from spaces < 3000 ft^2 *(separate from building entrance)*
- ✓ Doors from dwelling units

Compliance Approach
Building Envelope

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building System

- Envelope
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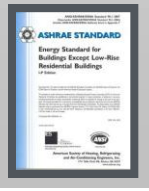
- Other

Mandatory Provisions
(required for most compliance options)

Compliance Options

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

Energy Code Compliance



Rules

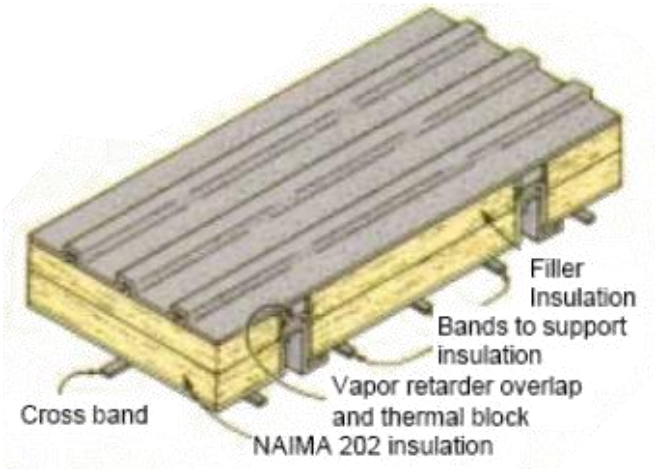
- ✓ Window/Wall Ratio ≤ 40% of gross wall area (IECC 30%)
- ✓ Skylight-roof Ratio ≤ 5% of roof area
- ✓ Each envelope component must separately meet requirements

Criteria sets for 8 different climate types

- ✓ Z4 = single page that summarizes all prescriptive requirements
  - Insulation levels for roofs, walls, floors
  - Fenestration criteria

Envelope: Zone 4 Insulation

Only changes are for nonresidential metal buildings



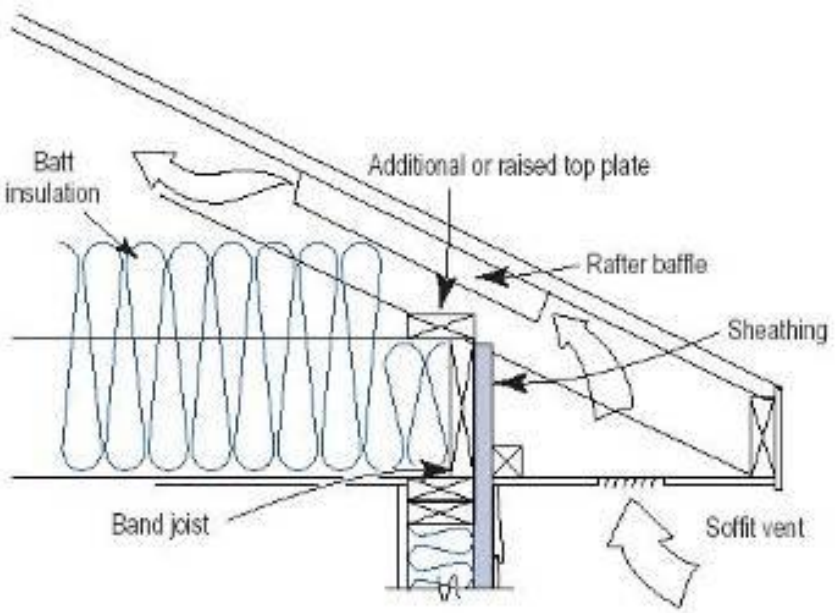
New requirements:

ASHRAE Standard 90.1 Version	Metal Roof R-Value	Metal Above-Grade Wall R-Value	Above-Grade Wood Frame Wall R-Value
90.1-2007	**19**	**13**	13
90.1-2010	**13+13**	**19**	13

- ✓ 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



Section 5
High Albedo Roof – *(not required in Zone 4A)*

Four types of walls are defined

- ✓ Mass walls
  - heat capacity: Table A3.1B or A3.1C
  - R-value is for continuous insulation
- ✓ Metal building wall R-value
  - insulation compressed between metal wall panels and the steel structure
- ✓ Steel-framed wall R-value
  - uncompressed insulation installed in the cavity between steel studs
- ✓ Wood-framed and other R-value
  - uncompressed insulation installed in the wood stud cavities; also continuous insulation uninterrupted by studs

Meet or exceed values in appropriate table for climate zone

R-value is for continuous insulation

Exception

- ✓ If framing is used, compliance is based on maximum assembly C-factor

Photo courtesy of Dow Building Solutions

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

Criteria apply to fenestration, including windows, glass doors, glass block, plastic panels, skylights and ***rooftop monitors***

Compliance

- ✓ ≤ maximum U-factors in table
- ✓ ≥minimum SHGC in table
- ✓ Use NFRC ratings or default values in Appendix A

Section 5 – 5.5-1 *(cont'd)*
Opaque

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TABLE 5.5-1 (Cont'd)

Fenestration	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC	Assembly Max. U	Assembly Max. SHGC
Vertical Glazing, 0%–40% of Wall						
Nonmetal framing (all)[c]	U-1.20	SHGC-0.25 all	U-1.20	SHGC-0.25 all	U-1.20	SHGC-NR all
Metal framing (curtainwall/storefront)[d]	U-1.20		U-1.20		U-1.20	
Metal framing (entrance door)[d]	U-1.20		U-1.20		U-1.20	
Metal framing (all other)[d]	U-1.20		U-1.20		U-1.20	
Skylight with Curb, Glass, % of Roof						
0%–2.0%	U_{all}–1.98	$SHGC_{all}$–0.36	U_{all}–1.98	$SHGC_{all}$–0.19	U_{all}–1.98	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.98	$SHGC_{all}$–0.19	U_{all}–1.98	$SHGC_{all}$–0.16	U_{all}–1.98	$SHGC_{all}$–NR
Skylight with Curb, Plastic, % of Roof						
0%–2.0%	U_{all}–1.90	$SHGC_{all}$–0.34	U_{all}–1.90	$SHGC_{all}$–0.27	U_{all}–1.90	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.90	$SHGC_{all}$–0.27	U_{all}–1.90	$SHGC_{all}$–0.27	U_{all}–1.90	$SHGC_{all}$–NR
Skylight without Curb, All, % of Roof						
0%–2.0%	U_{all}–1.36	$SHGC_{all}$–0.36	U_{all}–1.36	$SHGC_{all}$–0.19	U_{all}–1.36	$SHGC_{all}$–NR
2.1%–5.0%	U_{all}–1.36	$SHGC_{all}$–0.19	U_{all}–1.36	$SHGC_{all}$–0.19	U_{all}–1.36	$SHGC_{all}$–NR

"The following definitions apply: c.i. = continuous insulation (see Section 3.2), NR = no (insulation) requirement.
[a] When using R-value compliance method, a thermal spacer block is required; otherwise use the U-factor compliance method. See Table A2.3.
[b] Exception to Section A3.1.3.1 applies.
[c] Nonmetal framing includes framing materials other than metal with or without metal reinforcing or cladding.
[d] Metal framing includes metal framing with or without thermal break. The "all other" subcategory includes operable windows, fixed windows, and non-entrance doors.

Skylights are required in enclosed spaces that are:

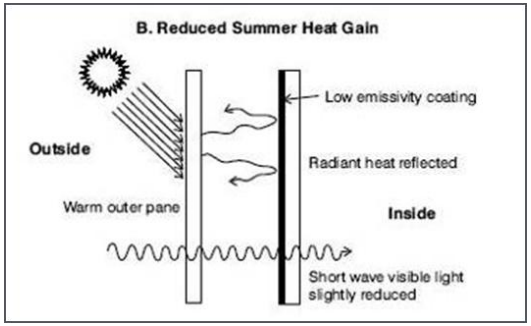
- ≥ 5,000 ft^2 area and
- > 15 ft Ceiling height and
- One of these space types
  - Office
  - Lobby
  - Atrium
  - Concourse
  - Corridor
  - Storage
  - Gymnasium/Exercise Center
  - Convention Center
  - Automotive Service
  - Manufacturing
  - Non-refrigerated Warehouse
  - Retail
  - Distribution/Sorting Area
  - Transportation
  - Workshop

The glazing's effectiveness in rejecting solar heat gain

- NFRC 200 Standard
- Replaces shading coefficient (SC) in product literature and design standards

Exceptions

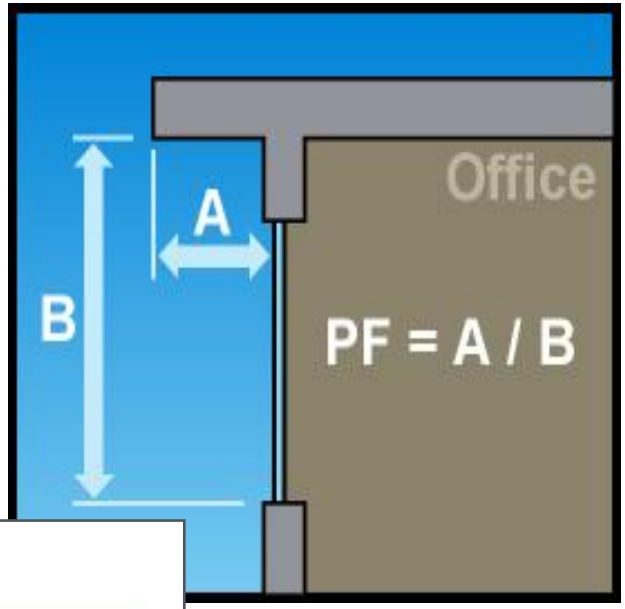
- ✓ SC x 0.86 is acceptable for overall fenestration area (NFRC 300)
- ✓ SHGC of center-of-glass is acceptable (NFRC 300) for overall fenestration area
- ✓ SHGC from A8.1 for glazed wall systems vertical fenestration and skylights
- ✓ SHGC from A8.2 for other vertical fenestration

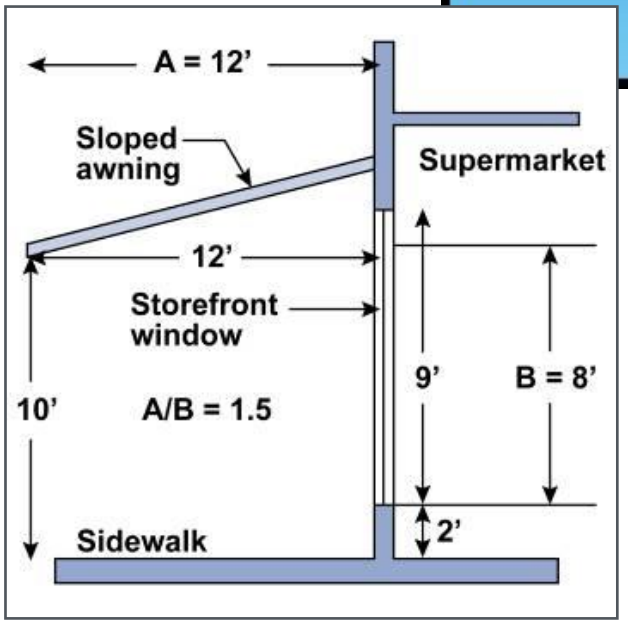


Information – 5.5.4.4.1 Overhangs

90.1 credits permanent overhangs by adjustment to SHGC

Size of overhang is determined by projection factor





Skylights

- ✓ SHGC values < Table value for appropriate total skylight area

Exceptions, if skylights:

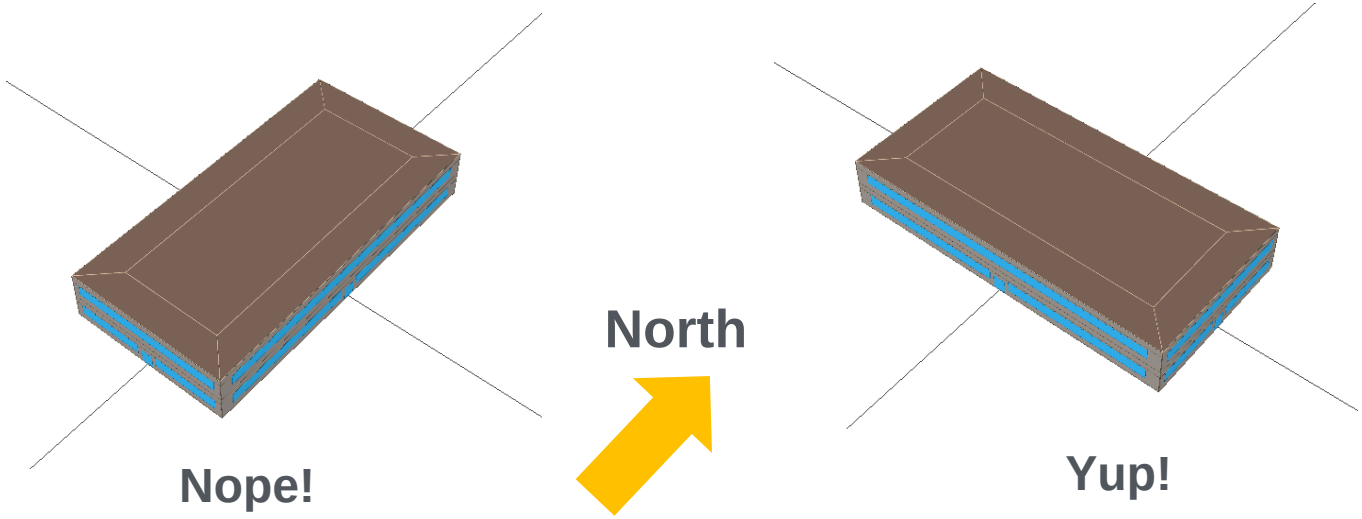
- Have a glazing material or diffuser with measured haze value > 90% when tested according to ASTM D1003
- Have a skylight VT > 0.40, and
- Have all general lighting in daylight area under skylights controlled by multilevel photo-controls per Section 9.4.1.5

Dynamic Glazing

- **Minimum SHGC is used to demonstrate compliance**
- **Considered separately from other vertical fenestration**
- **Area-weighted averaging with other vertical fenestration that isn't dynamic glazing isn't allowed**

Vertical fenestration area to meet this requirement:

Area South ≥ Area West and Area South ≥ Area East



Exceptions:

- Buildings shaded by other buildings within 20 ft to the south which is at least ½ as tall as the proposed building
- Buildings with shade on 75% of the west and east
- Alterations and additions that don't increase vertical fenestration area

Determined in accordance with ASTM E972

A measure of the amount of visible light that passes through fenestration

Affected by

- ✓ composition of the glass
- ✓ coatings
- ✓ internal shading devices

Relationship between VT and SHGC

- ✓ Daylighting without excessive solar gain– VT at least 1.2 x SHGC

Exception

- ✓ For skylights not within scope of NFRC 200, VT to be the solar photometric transmittance of the skylight glazing material in accordance with ASTM E972

Compliance Approaches

Building System

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- HVAC
- SWH
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- Lighting
- Other

Mandatory Provisions
(required for most compliance options)

Compliance Options

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

Energy Code Compliance

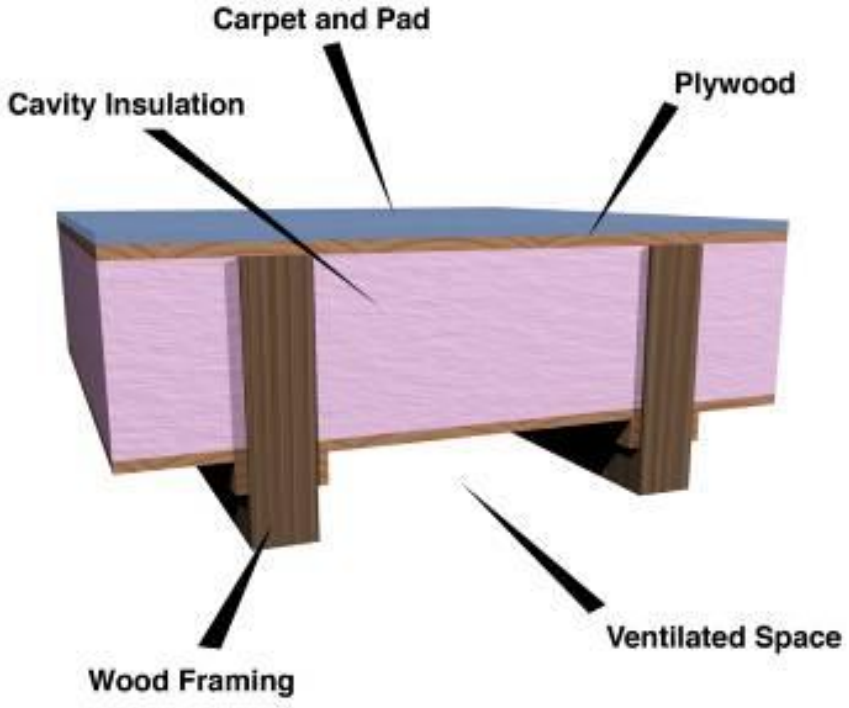
Building complies if

- ✓ 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

Install insulation in a permanent manner in substantial contact with inside surface

Flexible batt insulation in floor cavities

- ✓ Supported in a permanent manner by supports no more than 24 in. on center (o.c.)



Do not recess equipment that affects insulation thickness

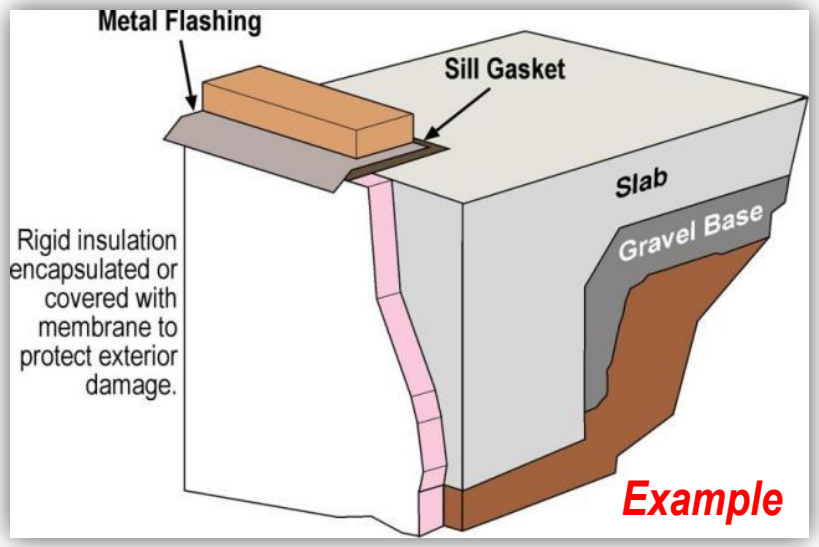
- ✓ Lighting fixtures
- ✓ HVAC equipment (wall heaters, ducts, plenums)
- ✓ Other

Except when

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

Insulation Protection

- ✓ Cover exterior insulation with protective material
  - 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

- ✓ Not installed on a suspended ceiling with removable ceiling panels
- ✓ Non-compliant

Standard 90.1-2010 Appendices and Addenda

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

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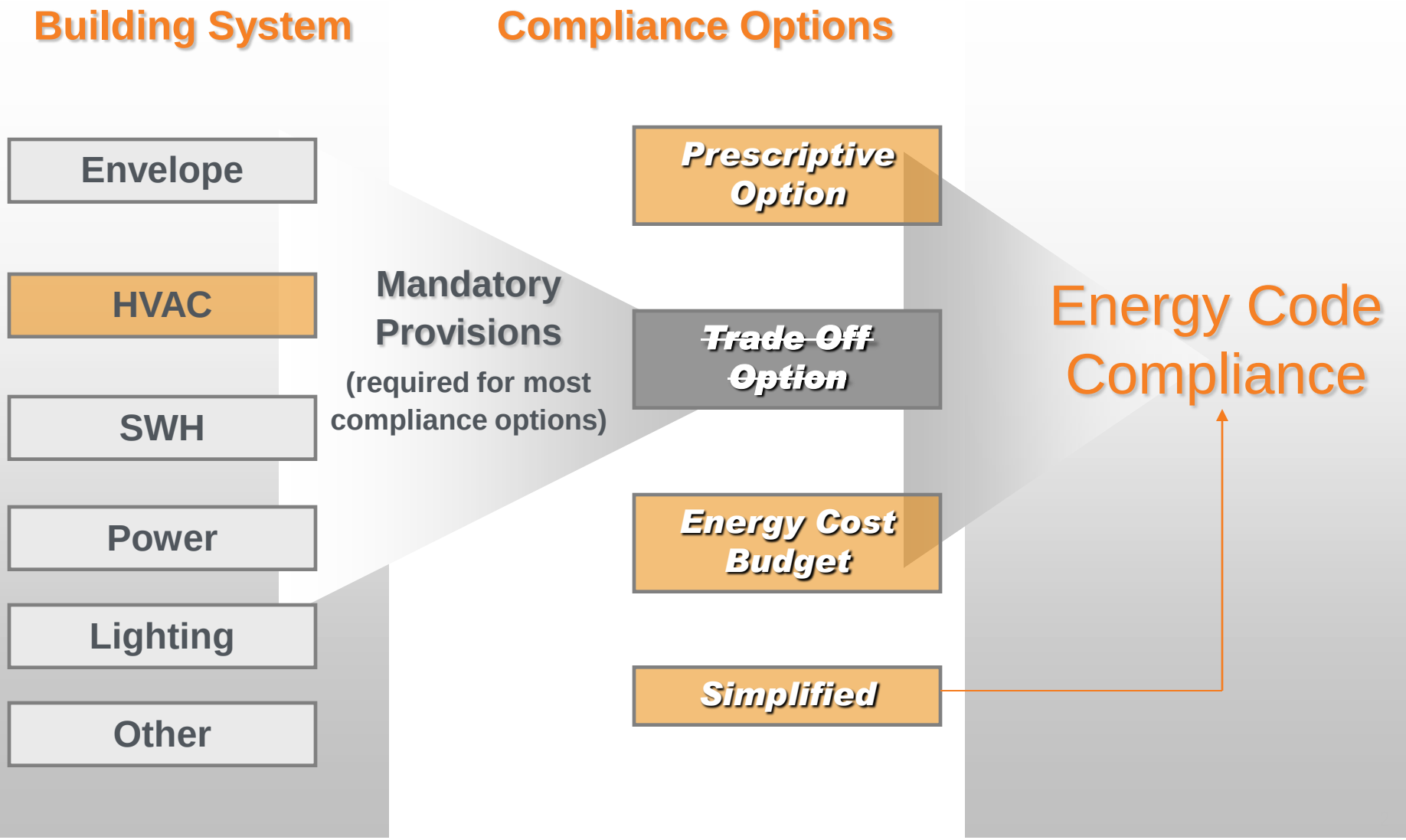
Delaware ENERGY OFFICE

HVAC Compliance



5.1.2 and DEFINITIONS - *Space*

- Each *space* to be categorized as:
- ➢ Nonresidential *conditioned space*, or
- ➢ Residential *conditioned space*
- ➢ *Unconditioned space*
- ▪ Spaces are assumed to be *conditioned spaces* at time of construction regardless of presence of HVAC in the building permit application, or not installed.
- ▪ Spaces in climate zone 4 may be designated as ***semi-heated or unconditioned*** only when approved as such by the ***building official***.
- ➢ *Semi-heated space*: > 3.4 and < 15 Btu/h

New Buildings and Additions

- ✓ All HVAC requirements apply to new equipment & systems
- ✓ Existing equipment may remain in use, with some modifications

Alterations Compliance in Existing Buildings

- ✓ **Equipment**
  - Replacement equipment: meet new minimum efficiencies
- ✓ **Cooling systems**
  - New systems serving previously uncooled spaces
  - Alterations to existing systems shall not decrease economizer capacity (unless tradeoff exception can be used)
- ✓ **Ductwork**
  - New and replacement ductwork : meet requirements for new
- ✓ **Piping**
  - New and replacement piping: meet requirements for new

HVAC: Equipment Efficiencies

Significant Efficiency Rating Increases:

- Packaged Heat Pumps/Air Conditioners
- Air-cooled and water-cooled chillers
  - Changes for part-load chillers
- Air-cooled Air Conditioners and Heat Pumps
- Water-cooled Air Conditioners and Heat Pumps
- 6.5.9 Hot gas bypass limits
- Table 6.8.1 **IPLV/IEER** ratings

New 450-Ton Step Chiller w/ Turbomodulator

Alterations to existing building HVAC systems

✓ Exceptions allowed:

- Equipment being **modified or repaired** (not replaced)
  - provided such modifications will not result in an increase in the annual energy consumption
- Equipment being **replaced or altered** which requires extensive revisions to other systems, equipment, or building elements, and such replaced or altered equipment is a like-for-like replacement
- **Refrigerant** change for existing equipment
- **Relocation** of existing equipment
- **Ducts and pipes** where insufficient space or access exists to meet these requirements

- ✓ Must follow Sections
  - 6.1 **General**,
  - 6.7 **Submittals**,
  - 6.8 **Minimum Equipment Efficiency**
- ✓ Then choose either
  - 6.3 **Simplified Approach** (must meet limitations)

    OR
  - 6.4 **Mandatory Provisions**

    and either
  - 6.5 **Prescriptive Path**

    OR
  - Ch.11 **Energy Cost Budget (ECB) Method**

The simplified approach is an optional path for compliance when the following are met:

- ✓ Buildings < 3 stories
- ✓ Gross floor area < 25,000 ft^2
- ✓ Single zone HVAC system
- ✓ Unitary packaged or split air conditioners (air-cooled or evaporatively cooled)
- ✓ 17 Criteria **(2 new)**
- ✓ **Mandatory provisions do not apply**

- ✓ Balancing of ducted systems
- ✓ Outdoor air intake and exhaust systems
- ✓ Interlocked thermostats for separate heating and cooling
- ✓ System > 10,000 cfm:
  - optimum start controls
- ✓ Demand control ventilation

HVAC: Economizers and ERVs

- Economizers are now required for all systems with cooling capacities over 33,000 Btu/h (6.3.2/6.5.1)
- Economizer exception: **tradeoffs increase from 9 to 11 (6.5.1)**
- Energy Recovery (ERV) systems (6.5.6) now required for all systems with greater than 30% outside air
  - Sizing based on **new Table 6.5.6.1/6.3.2**
  - **One new Exception (j)**

Economizer Exceptions – Table 6.3.2

Addendum "cy" introduces an updated Table 6.3.2. The Table exempts the requirement for economizers through the use of higher efficiency HVAC equipment.

Table 6.3.2 is based on the new benchmark building models, and was expanded to allow use for any type of HVAC system, not just for unitary air-cooled equipment in the current table.

Table 6.3.2 Eliminate Required Economizer for Comfort Cooling by Increasing Cooling Efficiency

Climate Zone	Efficiency Improvement[a]
2a	17%
2b	21%
3a	27%
3b	32%
3c	65%
4a	42%
4b	49%
4c	64%
5a	49%
5b	59%
5c	74%
6a	56%
6b	65%
7	72%
8	77%

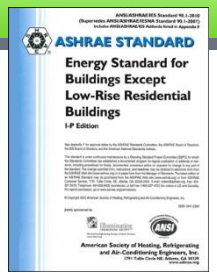
[a] If a unit is rated with an IPLV, IEER or SEER then to eliminate the required air or water economizer, the minimum cooling efficiency of the HVAC unit must be increased by the percentage shown. If the HVAC unit is only rated with a full load metric like EER or COP cooling then these must be increased by the percentage shown.

- ✓ 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)*

Piping and ductwork/plenum insulated

Reference Tables 6.8.2A and B on page 68 in 90.1-2010

Pipe Sizing and Insulation



- Maximum allowable flow rates for chilled and condensed water
  - Based on nominal pipe size
- New requirements for pipe insulation for heating systems
  - Increases 0.5”-2” depending on tube size and temp range
  - Four Exceptions to Tables

Tables 6.8.3A and 6.8.3B

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 fossil fuels or electricity 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
- ✓ Piping ≤ 1 in.
  - No insulation required for strainers, control values, and balancing values

Required if:

- ✓ Supply air capacity ≥ value listed in Table 6.5.6.1
  - – Values are based on climate zone and 70% of outdoor air flow rate at design conditions

Recovery system effectiveness ≥ 50%

Ten Exceptions: one new

Performance testing: new requirement

Climate Zone 4

• Exterior	R-6
• Vented Attic	R-6
• Unvented Attic	R-6
• Conditioned Attic	R-3.5
• Unconditioned Space	R-3.5
• Indirect conditioned Space	N/R

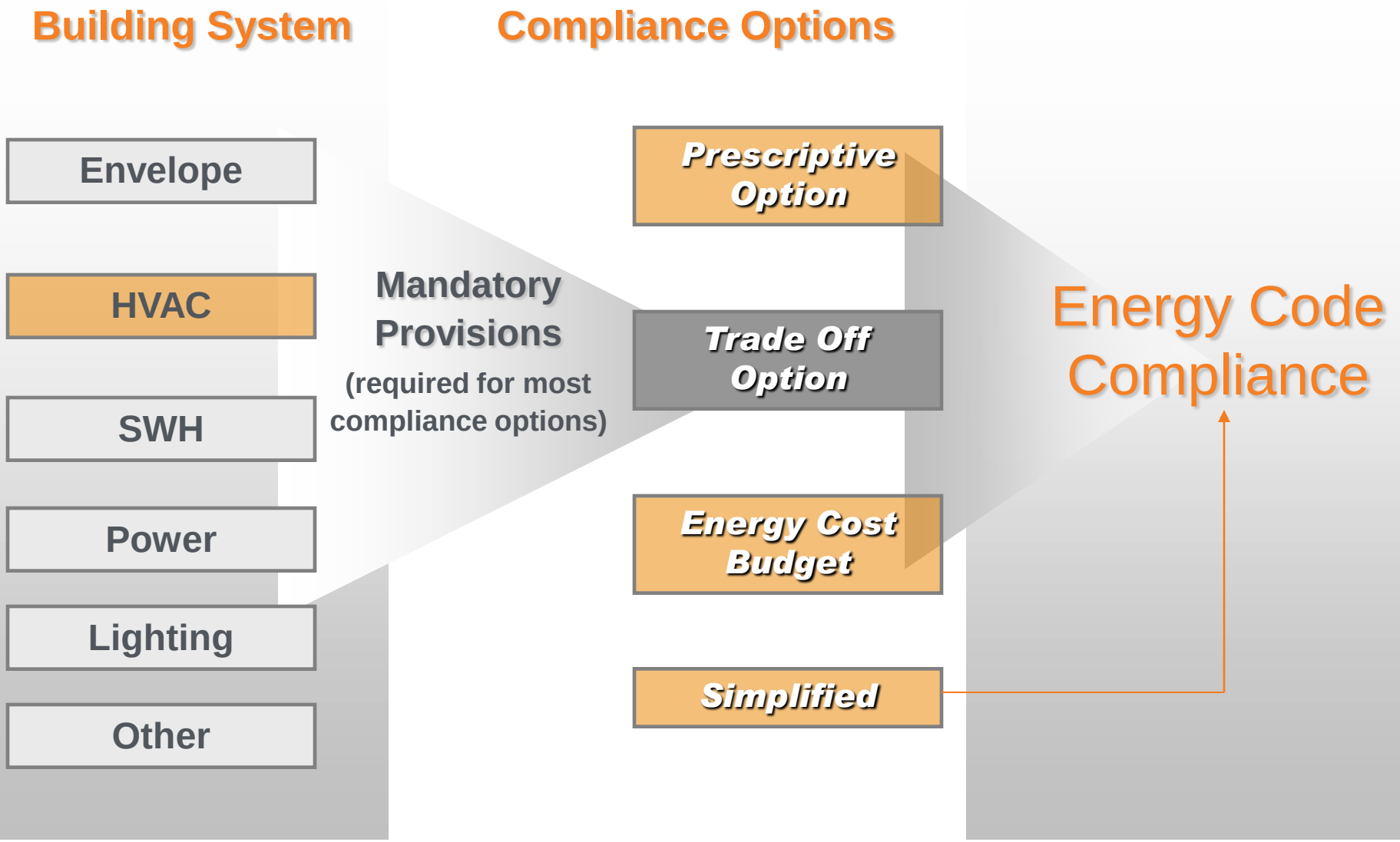
Reference Table 6.8.2B on page 68 in 90.1-2010

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

- ✓ An air-side economizer,
- ✓ Automatic modulating control of the OSA dampers, or
- ✓ A design outdoor airflow > 3,000 cfm

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

HVAC Compliance



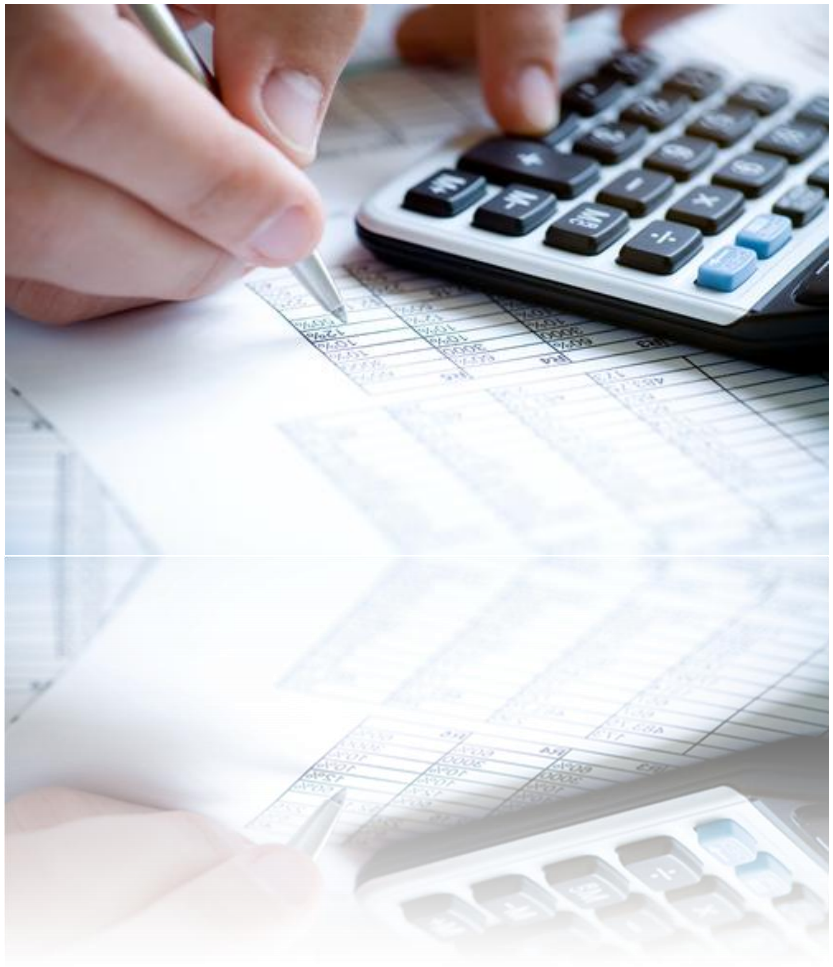
- ✓ Minimum Equipment Efficiency *(Section 6.4.1)*
- ✓ Calculations *(Section 6.4.2)*
- ✓ Controls *(Section 6.4.3)*
- ✓ HVAC System Construction and Insulation *(Section 6.4.4)*

HVAC Equipment Covered in Tables 6.8.1 (A) to (K)

- ✓ Air conditioners and condensing units
- ✓ Heat pumps (air, water, and ground source)
- ✓ Water-chilling packages (chillers)
- ✓ Packaged terminal and room air conditioners and heat pumps
- ✓ Furnaces, duct furnaces and unit heaters
- ✓ Boilers
- ✓ Heat rejection equipment (cooling towers)
- ✓ Heat transfer equipment (heat exchangers)
- ✓ Variable refrigerant flow (VRF) air conditioners
- ✓ VRF air-to-air and applied heat pumps
- ✓ Air conditioners serving computer rooms

Must calculate heating and cooling system design loads

Must determine calculations with ANSI/ASHRAE/ACCA Standard 183-2007



Required for each zone

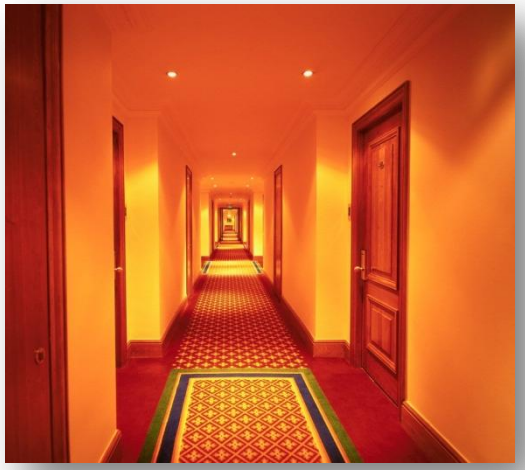
- ✓ Perimeter can be treated differently

Dead band controls

- ✓ Thermostats must have at least 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

Temperature Control off-hour requirements

- ✓ Automatic shutdown
- ✓ Setback controls
- ✓ Optimum start
- ✓ Zone isolation
- ✓ **Exceptions**, HVAC systems
  - with heating/cooling capacity < 15,000 Btu/h
  - intended to operate continuously



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

Applies to

- ✓ Each floor in a multistory building
- ✓ Maximum 25,000 ft^2 zone on one floor

Requirements

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

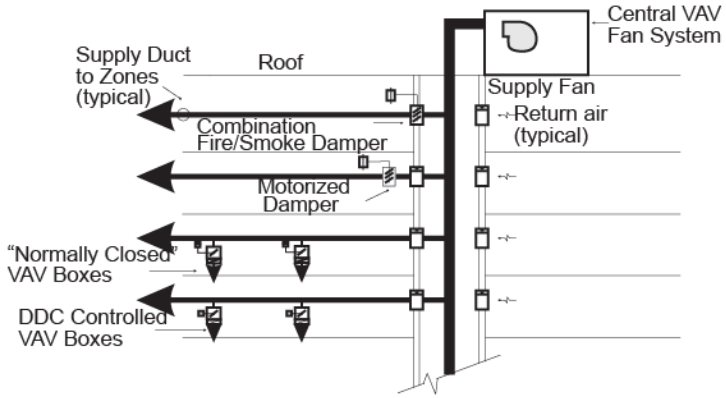


Figure 6-E

Isolation Methods for a Central VAV System

(User's Manual – 90.1.-2007)

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

Exception

- ✓ HVAC systems intended to operate continuously

Ventilation systems in enclosed parking garages

- ✓ automatically detect contaminant levels and stage fans or
- ✓ modulate fan airflow rates to ≤ 50%, provided acceptable contaminant levels are maintained

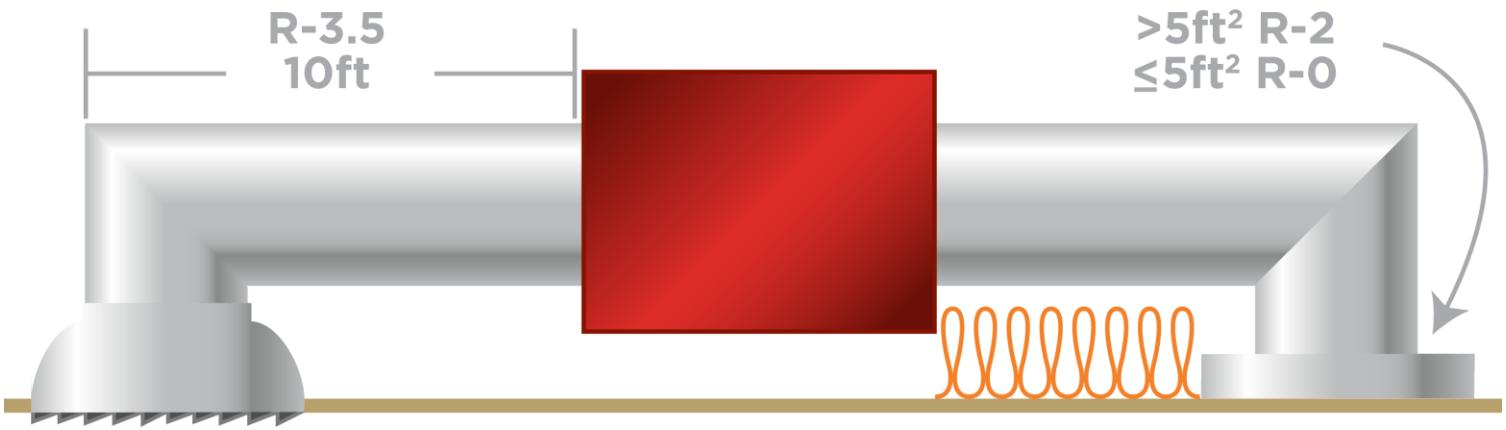
Exception

- ✓ Garages < 30,000 ft^2 with ventilation systems that use mechanical cooling or heating
- ✓ Garages with a garage area to ventilation system motor nameplate hp ratio > 1500 ft^2/hp and don't use mechanical cooling or heating
- ✓ **Where permitted by AHJ**

Insulate all supply & return ducts & plenums per Tables 6.8.2A and 6.8.2B

Exceptions

- ✓ HVAC factory-installed plenums, casings, or ductwork in equipment
- ✓ Ducts located in heated, semi-heated, or cooled spaces
- ✓ R-value ≤ 3.5 for runouts < 10 ft long to air terminals or air outlets
- ✓ Insulation for backs of air outlets and outlet plenums exposed to unconditioned or indirectly conditioned spaces:
- ✓ R-2 with face areas > 5 ft^2
- ✓ No insulation with face areas ≤ 5 ft^2

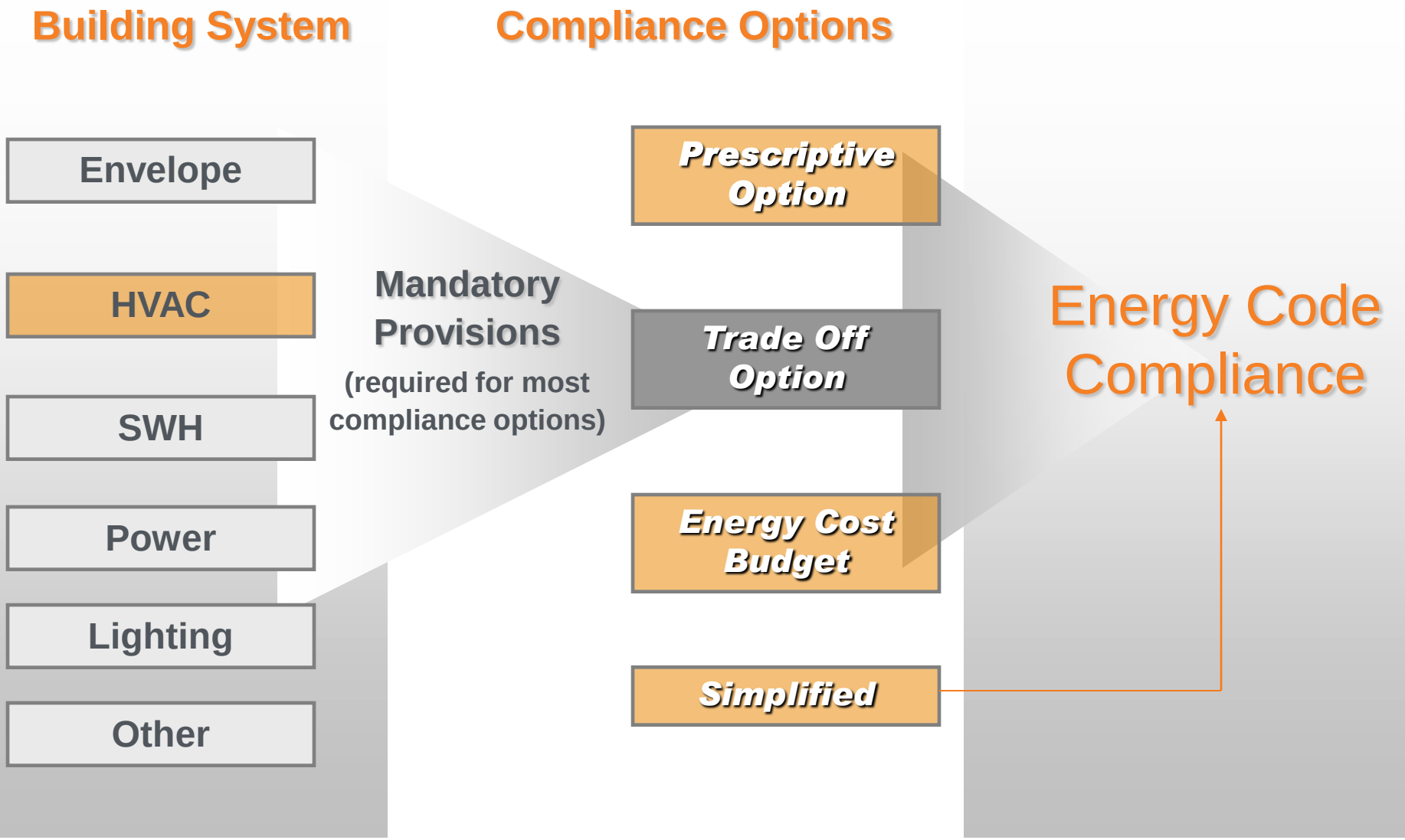


- ***Duct Sealing (cq)***
- Ductwork and plenums with pressure ratings shall be seal class A
- Shaft openings require bushings
- 25% of duct systems over 3” w.c. and ALL outdoor ducts shall be leak tested
- Tested sections chosen by owner
- Leakage class = 4 for all ducts

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

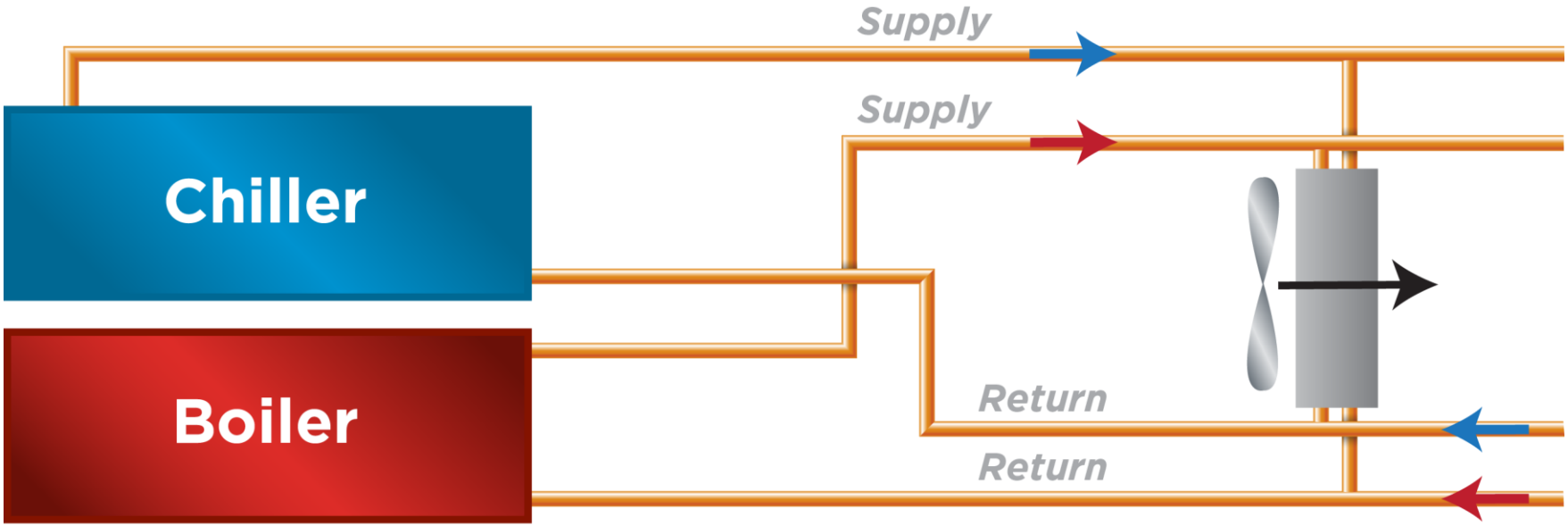
HVAC Compliance - Prescriptive



- ✓ Economizers ***(6.5.1Two new exceptions)***
- ✓ Simultaneous Heating and Cooling Limitation ***(6.5.2 – several exception additions/clarifications)***
- ✓ Air System Design and Control ***(6.5.3 New Ventilation Optimization and supply air controls)***
- ✓ Hydronic System Design and Control *(6.5.4 DDC controls)*
- ✓ Heat Rejection Equipment *(6.5.5.3 Cooling tower limits)*
- ✓ Energy Recovery ***(6.5.6 New Exception 'j')***
- ✓ Exhaust Systems ***(6.5.7 New kitchen & lab requirements)***
- ✓ Radiant Heating Systems *(Section 6.5.8)*
- ✓ Hot Gas Bypass Limitation *(Section 6.5.9)*

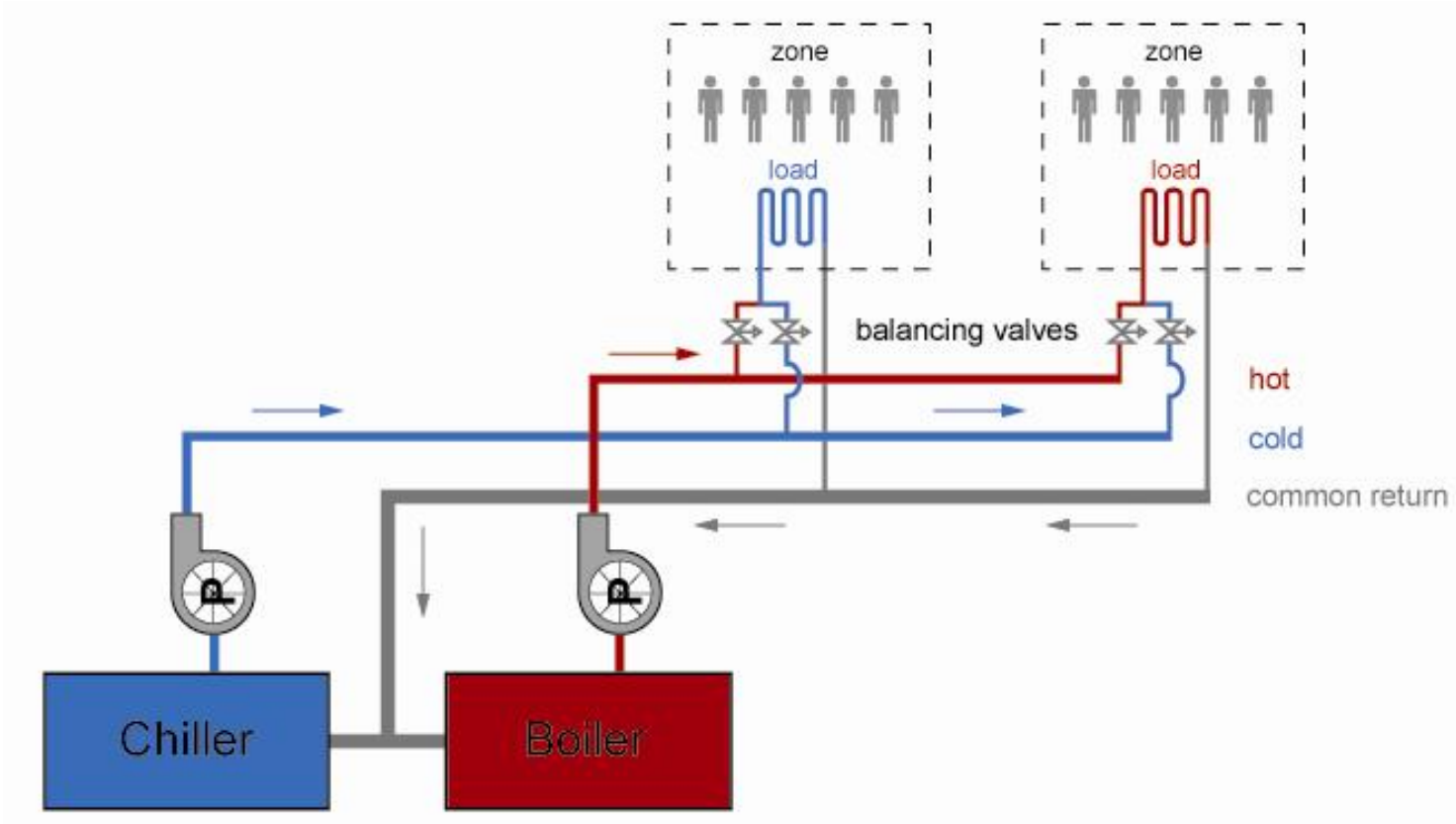
- 2007 None required Zone 4A
  - (65,000Btu/h IECC)
- 2010 **54,000Btu/h**
  - None required for computer rooms
- Requires water economizer for some zones to be humidified
- Run cooling towers in the winter
- Hospitals & some labs
  - Economizers must be integrated with mechanical cooling systems and be capable of providing partial cooling even when additional mechanical cooling is required

To prevent the simultaneous heating and cooling in hydronic systems



Four Pipe System

A common return hydronic system for both hot and chilled water is still prohibited



Two options:

- nameplate hp (Option 1)
- fan system brake hp (Option 2)
- Table 6.5.3.1.1B sets forth adjustments

Exceptions

✓ Hospital, vivarium and laboratory systems utilizing flow control devices on exhaust and/or return to maintain space pressure relationships necessary for occupant health and safety or environmental control may use variable-volume fan power limitation

✓ Individual exhaust fans with motor nameplate hp ≤ 1 hp

✓ **Fans exhausting air from fume hoods (new)**

(New) In multiple-zone VAV systems with ***DDC*** of individual zone boxes reporting to central control panel

- ✓ Include means to automatically reduce outdoor air intake flow below design rates in response to changes in system ventilation efficiency as per Standard 62.1, Appendix A

Exceptions

- ✓ VAV systems with zonal transfer fans that recirculate air from other zones without directly mixing it with outdoor air, dual-duct dual-fan VAV systems, and VAV systems with fan-powered terminal units
- ✓ Systems required to have exhaust air energy recovery complying with 6.5.6.1
- ✓ Systems where total design exhaust airflow is > 70% of total outdoor air intake flow requirements

(NEW) Multiple zone HVAC systems to have controls to automatically reset supply-air temperature in response to building loads or outdoor air temperature

Controls to be capable of resetting supply air temperature at least 25% of difference between design supply-air temperature and design room air temperature. Controls that adjust the reset based on zone humidity are okay

Zones expected to experience relatively constant loads to be designed for fully reset supply temperature

Exceptions

- ✓ Systems that prevent reheating, recooling or mixing of heated and cooled supply air
- ✓ 75% of energy for reheating is from site-recovered or site solar energy sources

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

- ✓ Hydronic Variable Flow Systems – pumps > 5hp (50hp - 2007)
- ✓ Pump Isolation
- ✓ Chilled and Hot Water Temperature Reset
- ✓ Hydronic (water-loop) Heat Pumps and **Water-Cooled Unitary Air-Conditioners – Exception for water economizers**
- ✓ **Pipe Sizing - added**

- ✓ Kitchen exhaust **(expanded requirements)**
  - **Field testing requirement (new)**

- ✓ Laboratory exhausts
  - Reduced airflow limit to 5,000 cfm (from 15,000 cfm)
  - **Three air volume reduction options**

Service Water Heating *(SWH)*

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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

BUILDING ENERGY CODES UNIVERSITY

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ANSI/ASHRAE/IES Standard 90.1-2010 Power and Lighting

April 2011 – PNNL-SA-79907

neep

Delaware ENERGY OFFICE

Building System

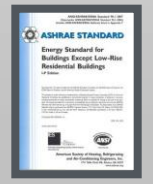
- Envelope
- HVAC
- SWH
- **Power**
- Lighting
- Other

Mandatory Provisions
(required for most compliance options)

Compliance Options

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

Energy Code Compliance



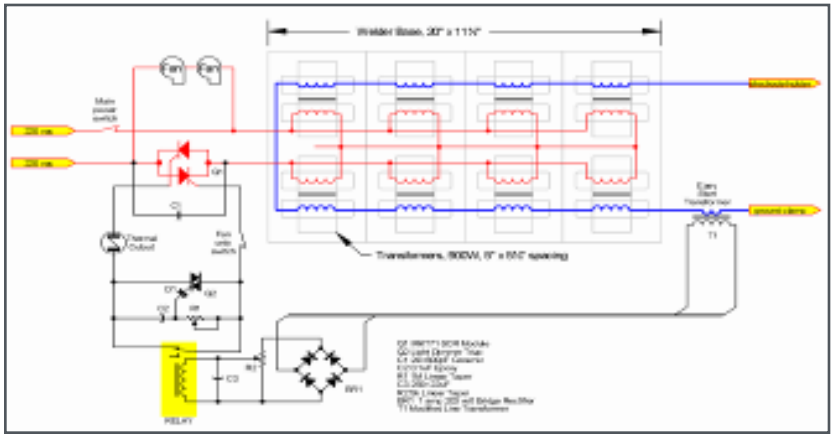
- ✓ Low-Voltage Dry Type Distribution Transformers
- ✓ New Buildings
- ✓ Additions
- ✓ Alterations
- ✓ Mandatory Provisions
  - ✓ Voltage drop
  - ✓ Automatic receptacle control
- ✓ Submittals: Drawings & Manuals

Two types of conductors

- ✓ Feeder conductors
  - – Connect service equipment to the branch circuit breaker panels
  - – 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)

Exception

Feeder conductors and branch circuits dedicated to emergency services



≥ 50% of all 125 volt 15- and 20-amp receptacles (including those in modular partitions) must be controlled by an automatic control device in these space types

- ✓ Private offices
- ✓ Open offices
- ✓ Computer classrooms

Exceptions

- ✓ Receptacles designated for equipment requiring 24 hr operation
- ✓ Spaces with security or safety concerns

- **Exceptions:**
- Receptacles specifically designated for equipment requiring 24 hour operation
- Spaces where patient care is rendered
- Spaces where an automatic shutoff would endanger the safety or security of the room or building occupant(s).

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

Building System

- Envelope
- HVAC
- SWH
- Power
- Lighting

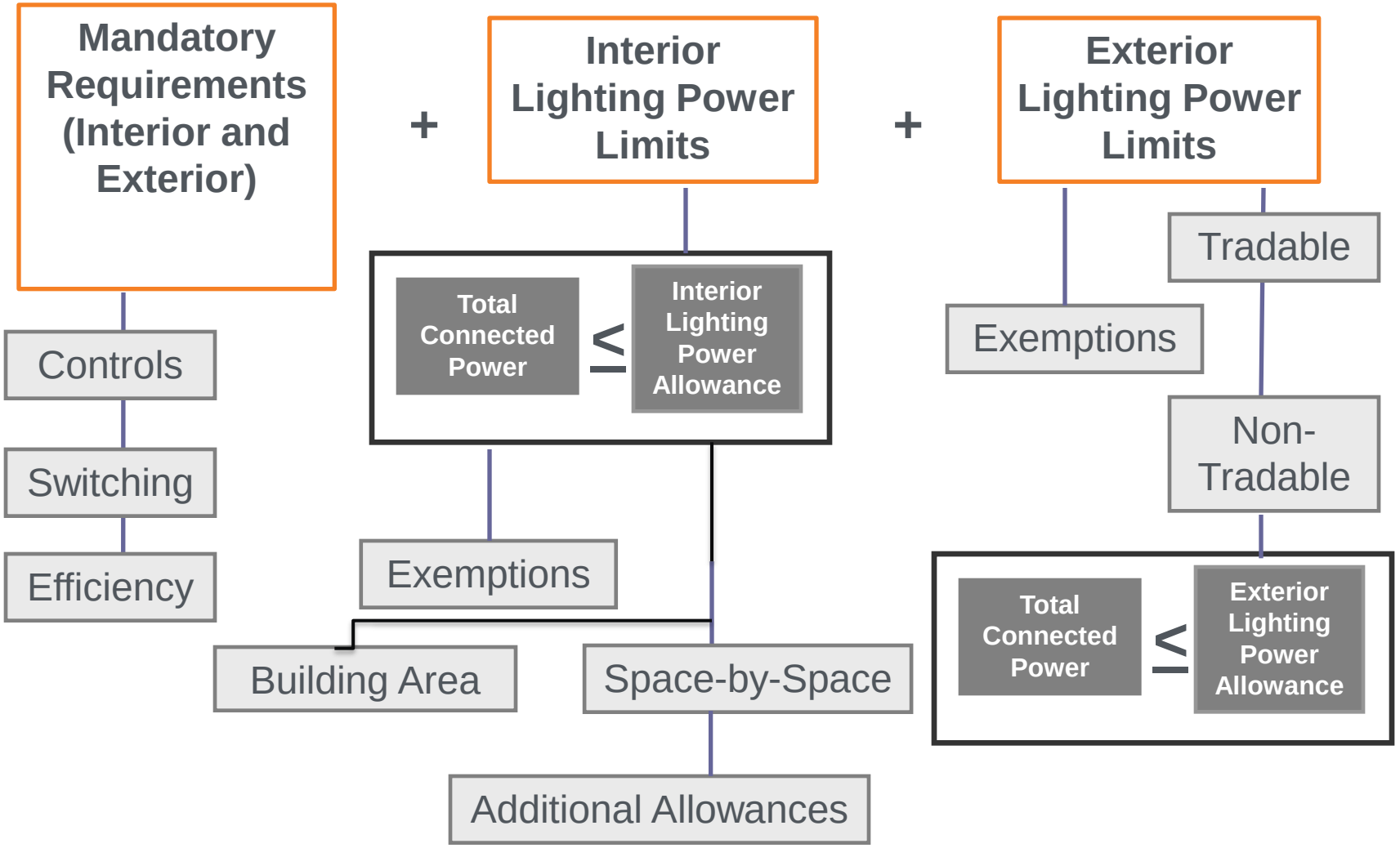
Mandatory Provisions
(required for most compliance options)

Compliance Options

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

Energy Code Compliance

Basic Lighting Requirements



- ✓ 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
  - Exit signs
  - Exterior building lighting power
  - Functional testing
- ✓ Building Area Method Compliance Path *(Section 9.5)*
- ✓ Space-by-Space Method Alternative Compliance Path: *(Section 9.6)*
- ✓ Submittals *(Section 9.7)*

- ✓ Interior spaces of buildings
- ✓ Exterior building features
- ✓ Exterior grounds lighting powered through building

Exceptions

- Emergency lighting
- Lighting required by life safety statute
- Lighting within dwelling units of buildings
- Decorative gas lighting

Lighting: Retrofits / Oversight

- **Any project/retrofit which alters 10% of the connected lighting load must comply with 90.1-2010.**
- All lighting controls must be tested and documented by a 3rd party that the equipment has been installed to manufacturer's specifications and meet performance criteria. Applies to these retrofits:
- Where luminaires are added, replaced, or removed
- Includes lamp plus ballast

Lots of exemptions (2 new categories)

Calculation methods

- ✓ Building area
- ✓ Space-by-space

Trade-offs of interior lighting power allowance aren't allowed when both allowed methods are used in different portions of the building

Part of Table 9.5.1

Building Type	Lighting Power Density (W/ft^2)
Automotive Facility	~~0.90~~ 0.82
Convention Center	~~1.20~~ 1.08
Court House	~~1.20~~ 1.05
Dining: Bar Lounge/Leisure	~~1.30~~ 0.99
Dining: Cafeteria/Fast Food	~~1.40~~ 0.90
Dining: Family	~~1.60~~ 0.89
Dormitory	~~1.00~~ 0.61
Exercise Center	~~1.00~~ 0.88

Lighting: Light Power Density

- Across-the-board reductions in Light Power Density (LPD) in watts/sf.
- **Introduction of Room Cavity Ratio (RCR) Adjustment**, allows 20% increase in LPD for unusually tall or wide spaces.

- **Addendum "by" changes:**
- • For most building types, the LPDs are reduced.
- Table shows samples.
- Average LPDs:
- • 90.1-2007…… avg.=1.09
- • 90.1-2010…….. Avg.=0.906
- • Difference …….. -16.9%

TABLE 9.5.1 Lighting Power Densities Using the Building Area Method

Building Area Type[a]	LPD (W/ft^2)	
Automotive facility	~~0.9~~	0.82
Convention center	~~1.2~~	1.08
Courthouse	~~1.2~~	1.05
Dining: bar lounge/leisure	~~1.3~~	0.99
Dining: cafeteria/fast food	~~1.4~~	0.90
Dining: family	~~1.6~~	0.89
Dormitory	~~1.0~~	0.61
Exercise center	~~1.0~~	0.88
Gymnasium	~~1.1~~	1.00
Health-care clinic	~~1.0~~	0.87
Hospital	~~1.2~~	1.21
Hotel	~~1.0~~	1.00
Library	~~1.3~~	1.18
Manufacturing facility	~~1.3~~	1.11
Motel	~~1.0~~	0.88
Motion picture theater	~~1.2~~	0.83
Multifamily	~~0.7~~	0.60
Museum	~~1.1~~	1.06
Office	~~1.0~~	0.90
Parking garage	~~0.3~~	0.25

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 uses. (See Standard).

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

9.6.3 - Added LPD Adjustment

Room Cavity Ratio Adjustment for relief in unusual spaces

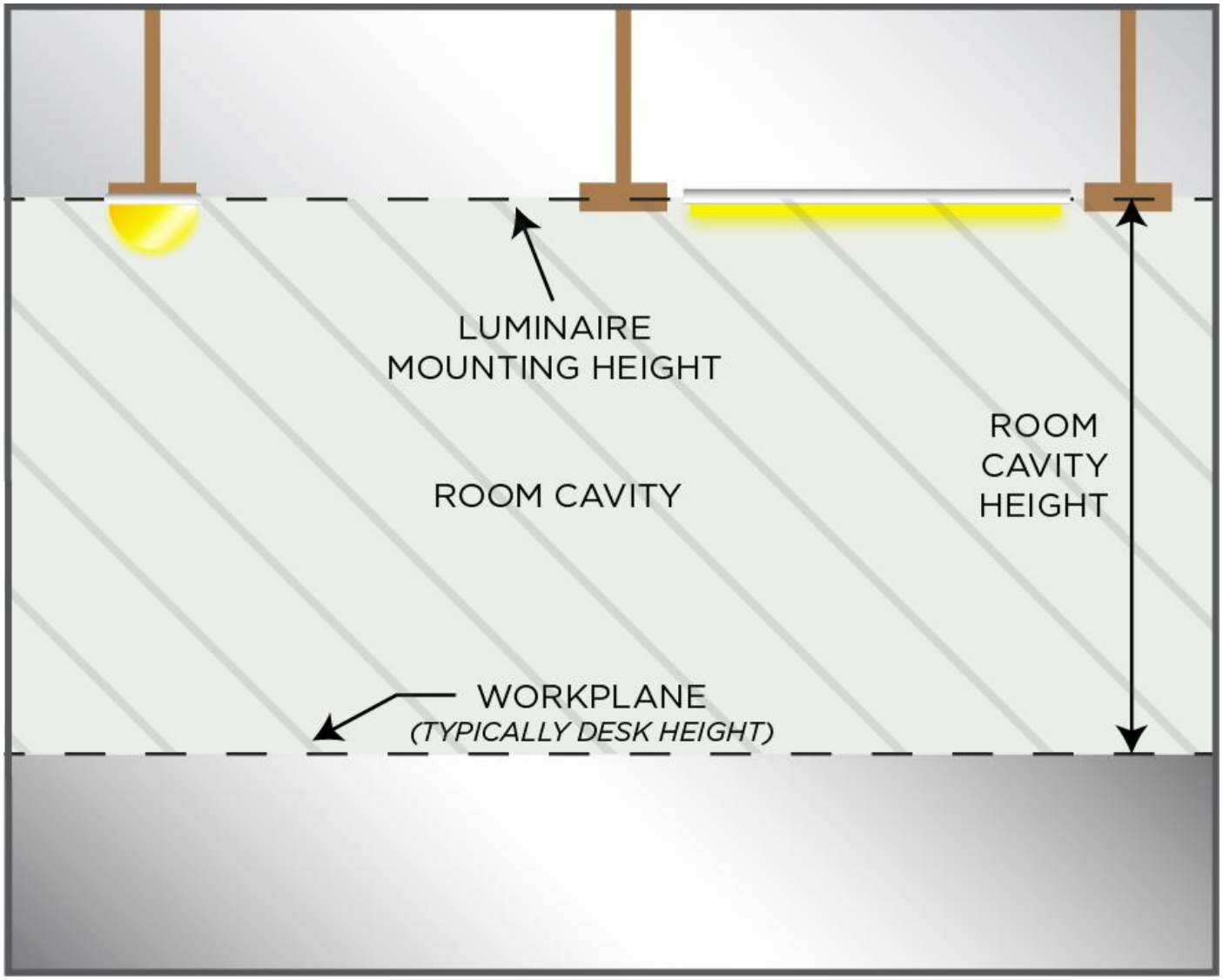
- Use only when applying the space by space method
- Calculate the *Room Cavity Ratio* (RCR) for the empty room:

$$RCR = \frac{2.5 \times \text{Room Cavity Height} \times \text{room perimeter length}}{\text{room area}}$$

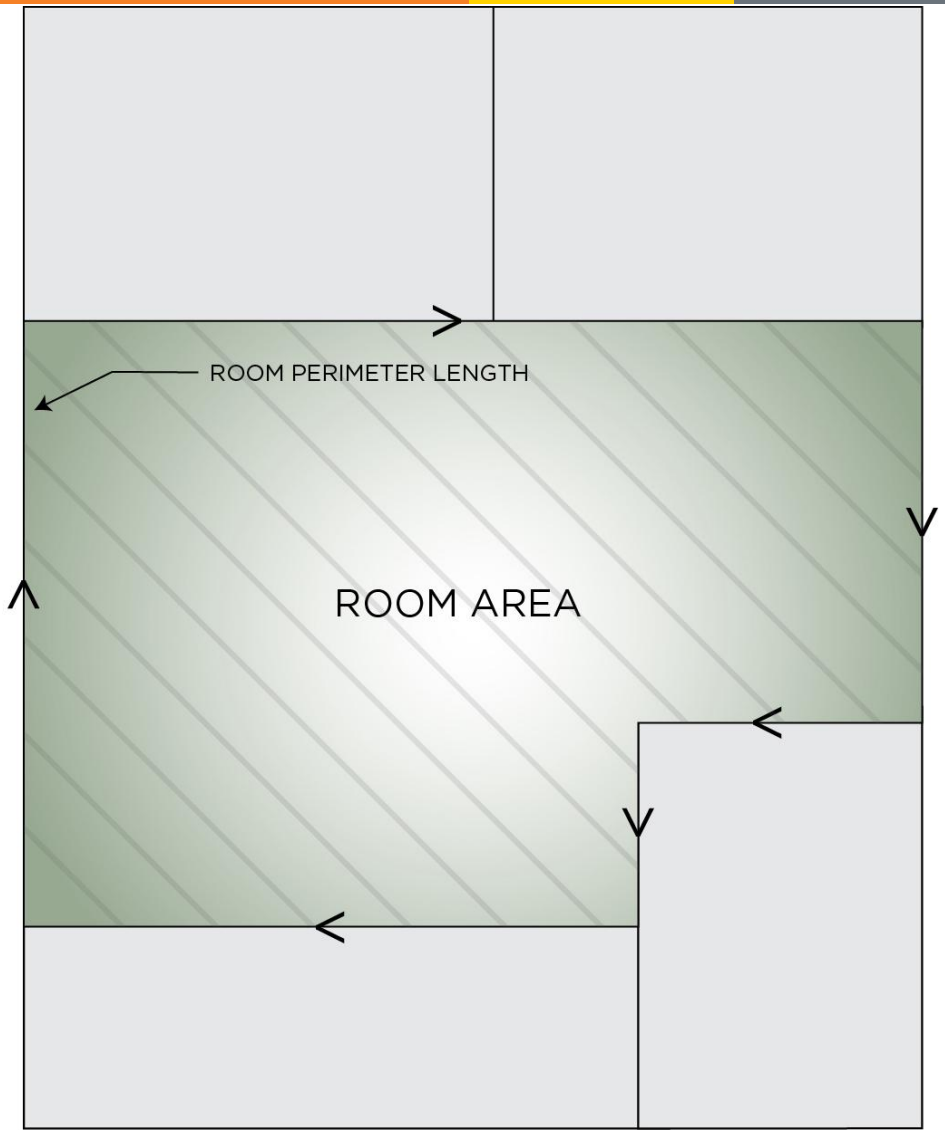
(Room Cavity Height = Luminaire mounting height – Workplane)

- If RCR is greater than the RCR threshold for that space type, a 20% increase is allowed
- For corridor/transition spaces, this adjustment is allowed when less than 8 feet wide, regardless of the RCR

Added LPD Adjustment



Added LPD Adjustment



9.6.2 Merchandise Lighting

- Addendum “bq” reduces the allowance for specific lighting to highlight merchandise
- This shows proposed reductions for the additional interior Lighting Power Allowance (LPA):
- Example: LPA = 1000 watts general space lighting
- + (Retail area 1 x ~~1.0~~ 0.6 W/ft2 – all other except 2, 3, 4 below)
- + (Retail area 2 x ~~1.7~~ 0.6 W/ft2 – vehicles, sporting goods …)
- + (Retail area 3 x ~~2.6~~ 1.4 W/ft2 – furniture, clothing, artwork…))
- + (Retail area 4 x ~~4.2~~ 2.5 W/ft2 – jewelry, crystal, china)

If all mandatory control requirements are met for a space AND advanced controls are installed in that space, THEN additional limited lighting power is allowed:

- ✓ Additional power can be used anywhere in the building
- ✓ Additional Interior Lighting Power Allowance is calculated as

Lighting Power Under Control x Control Factor

Partial Table 9.6.2 Control Factors Used in Calculating Additional Interior Lighting Power Allowance

Additional Control Method (in Addition to Mandatory Requirements).	Space Type				
	Open Office	Private Office	Conference Room, Meeting Room, Classroom (Lecture/ Training)	Retail Sales Area	Lobby, Atrium, Dining Area, Corridors/ Stairways, Gym/ Pool, Mall Concourse, Parking Garage
Manual, continuous dimming control or Programmable multi-level dimming control	0.05	0.05	0.10[1]	0.10	0
Programmable multi-level dimming control using programmable time scheduling	0.05	0.05	0.10[1]	0.10	0.10
Multi-level occupancy sensors	0.05	0.05	0.05	0	0

Lighting: Controls

- Automatic shutoff controls required in **nearly all spaces**.
- All lighting controls must be “manual-on” or “automatic-on” to only 50% power.
- **Multi-level** automatic daylighting controls required when
  - primary sidelighted area exceeds 250sf
  - primary toplighted area exceeds 900sf
- Requirements for “auto-off” plug load receptacles

- *Occupancy Sensors*
- Added training rooms, lecture halls, storage 50-1000sf
- Manual on
- Exceptions – restrooms, public corridors and stairs
- Bi-level control for most spaces
- Not corridors

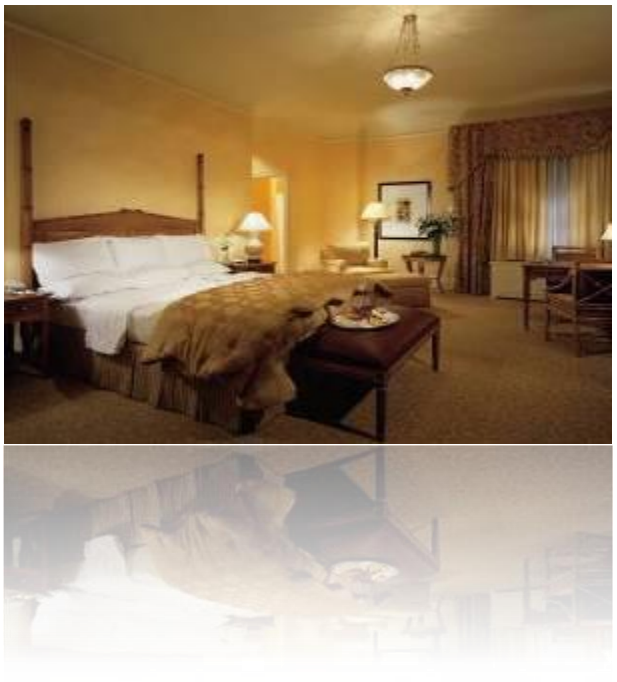
- *Parking Garage*
- Reduce power 30% if no activity in >3,600sf area

Additional space control required for

- ✓ Display/accent lighting
- ✓ Case lighting
- ✓ Task lighting
- ✓ **Nonvisual** lighting
- ✓ Demonstration lighting
- ✓ Stairwell lighting

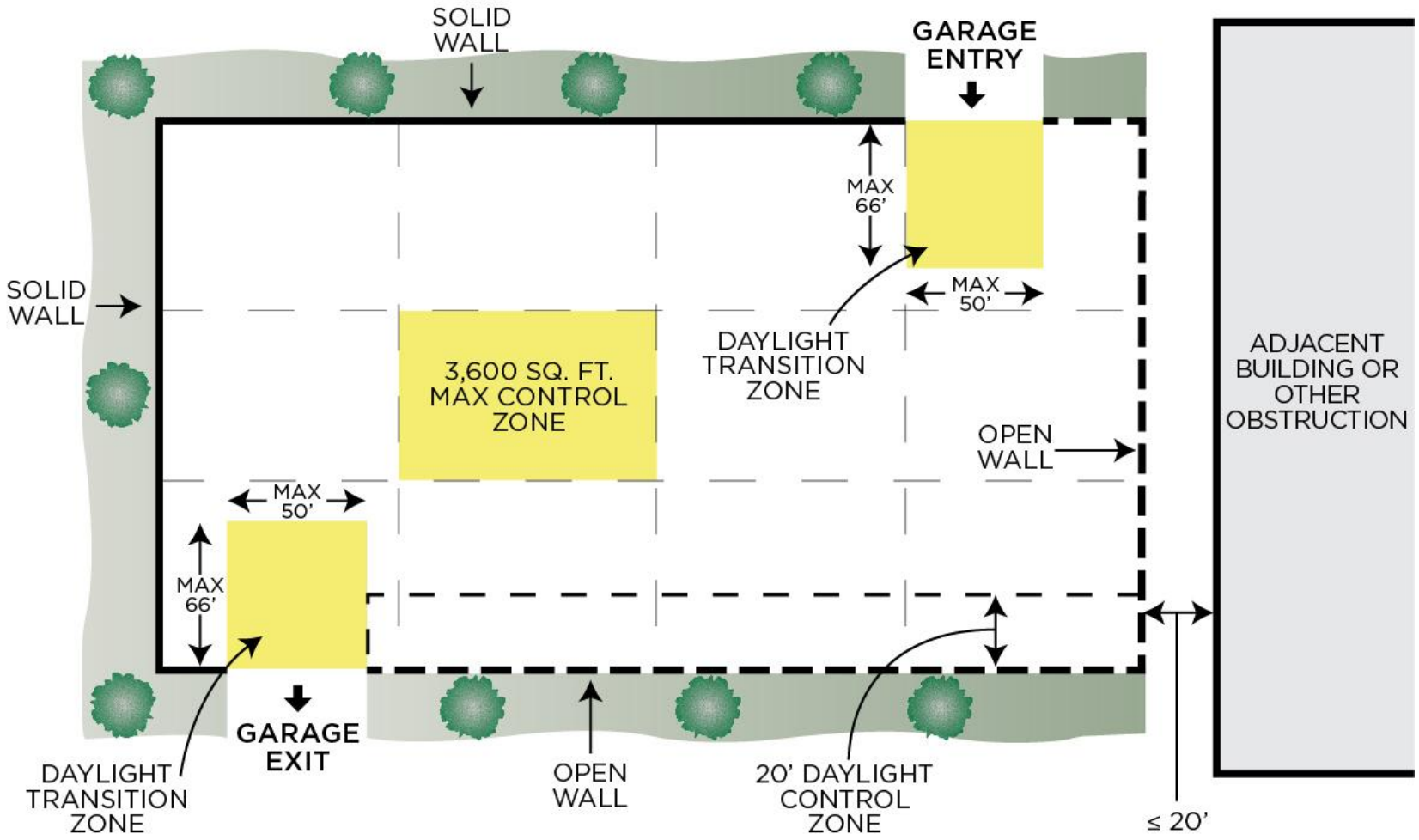
Guestroom lighting must be controlled at room entry

- Suites must be controlled at entry to each room or primary entry
- Bathrooms controlled to automatically turn off lighting within 60 minutes of occupant leaving space
  - Exception: night lighting not > 5W



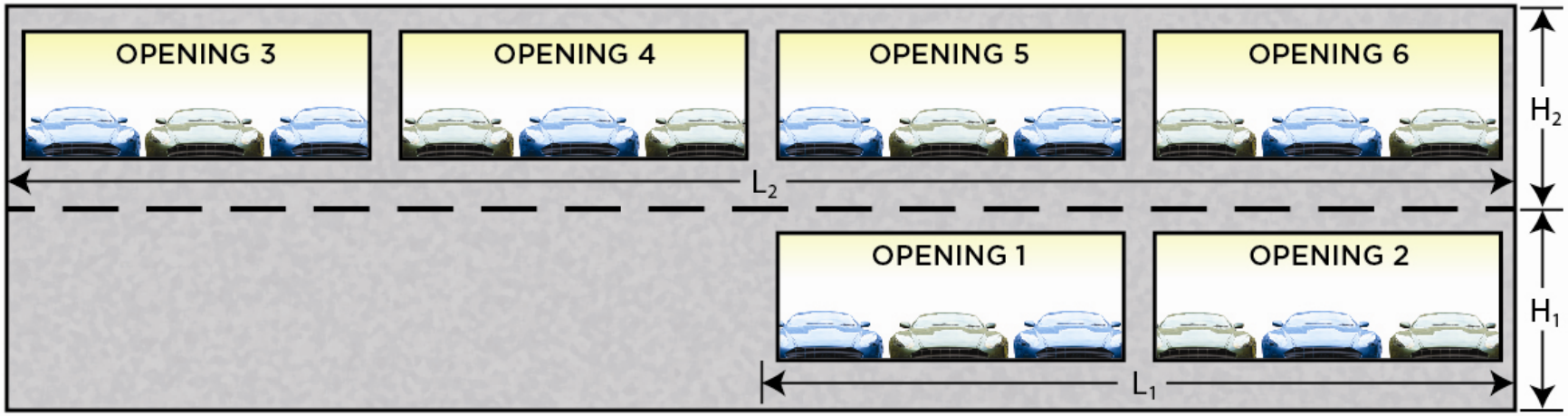
Stairwells

- Automatic reduction control for lighting in enclosed stairwells to
  - Automatically reduce lighting power in any control zone by at least 50% within 30 minutes of all occupants leaving the zone



THERE ARE CONTROL EXCEPTIONS

PARKING GARAGE SIDE VIEW (ELEVATION)



Daylighting control required if the total area of all openings in a wall section (i.e. openings 1-2) are greater than or equal to 40% of the total wall area (HxL).

Example: $\frac{\text{Opening 1 + Opening 2}}{H_1 \times L_1}$

Example: $\frac{\text{Opening 3 + Opening 4 + Opening 5 + Opening 6}}{H_2 \times L_2}$

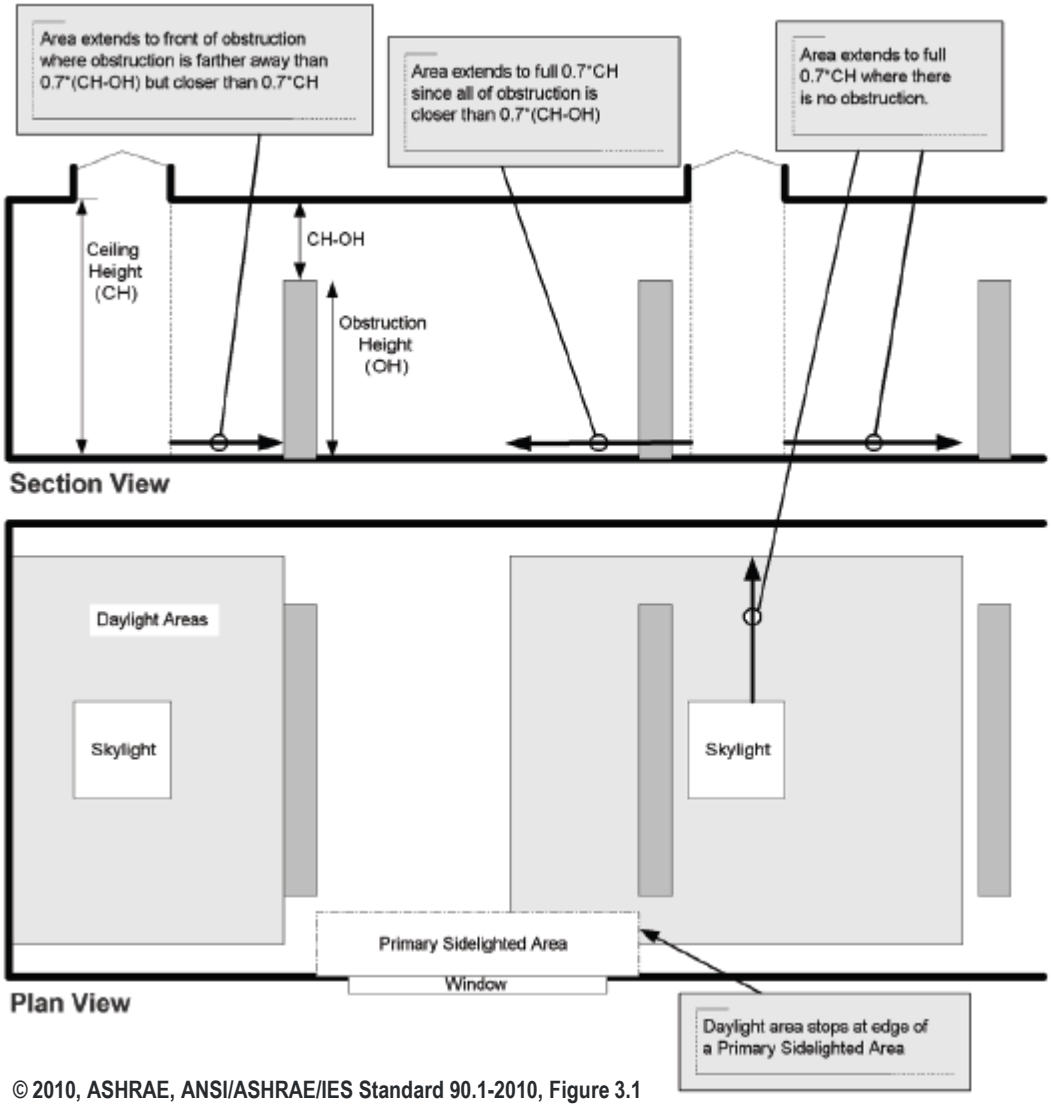
LPD W/SF)	1989	1999	2001	2004	2010
Clinic	1.44	1.60	1.60	1.00	0.87
Hospital	1.44	1.60	1.60	1.20	1.21

- *Lighting Controls - daylighting*
- Rules first added 2010
- Addenda: **d, ab, al, ct**
- Opaque obstacles >5’ tall cut off areas

Controls required for daylighted spaces

- Primary sidelighted area
- Secondary sidelighted area
- Toplighting
- Daylighted area (under skylights)

Section 9 – 9.4.1.4
Daylight Zone Definition – Under Skylights



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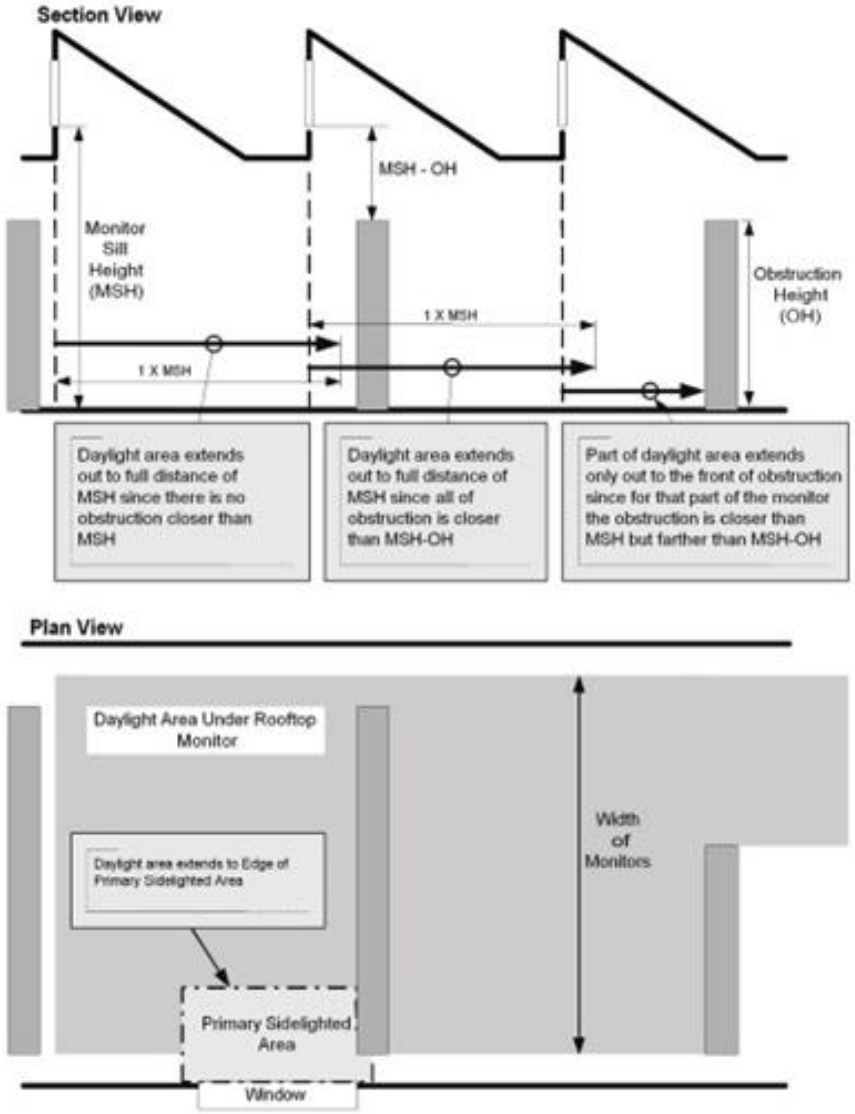
Section 9 – 9.4.1.4
Daylight Zone Definition – Under Rooftop Monitors



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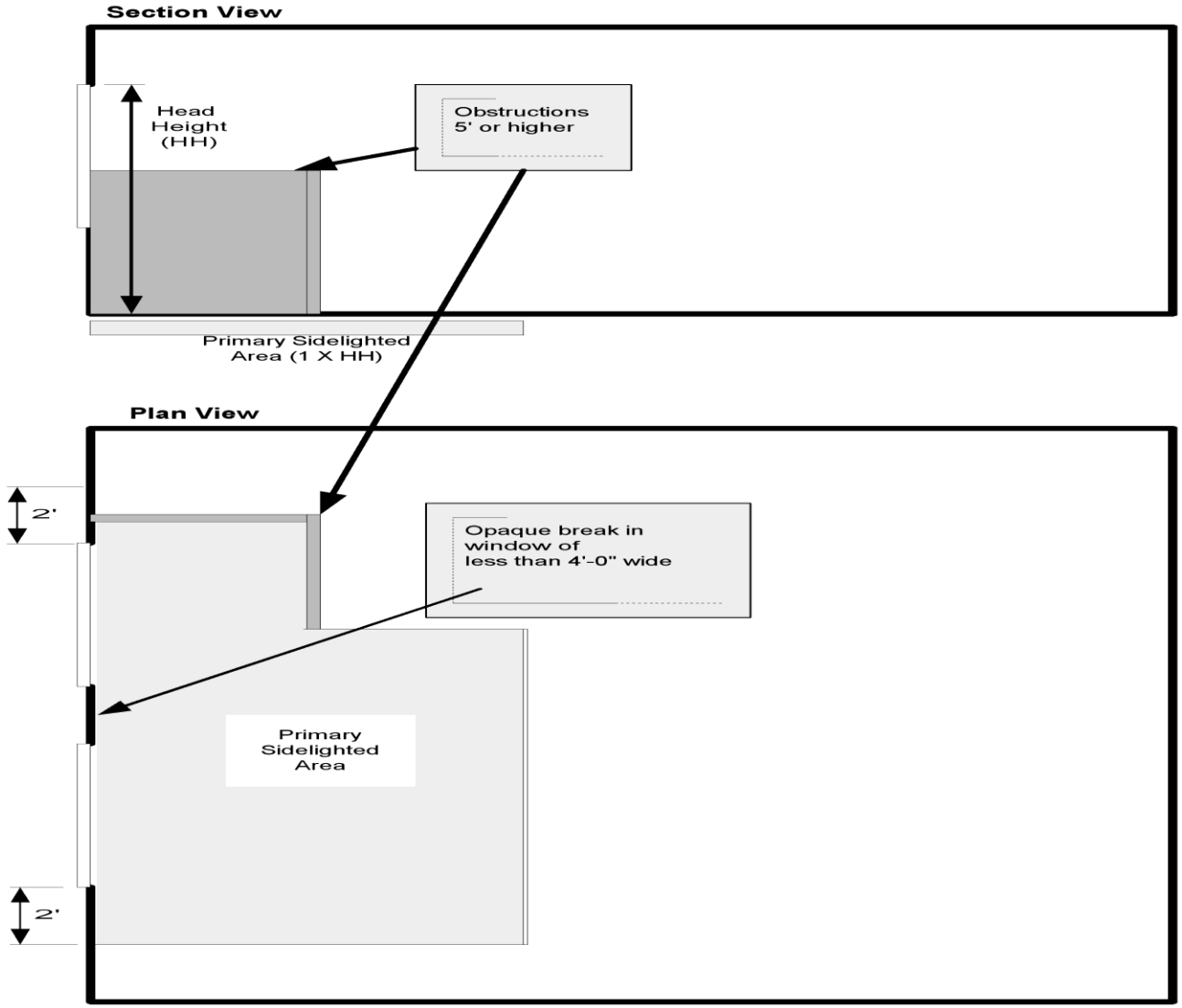
Section 9 – 9.4.1.4
Automatic Daylighting Controls for Primary Sidelighted Area



Exterior Building Lighting Power (ELP) must meet prescribed wattage limits.

- ✓ Exterior applications divided into 2 categories:
  - **Tradable**: allowed wattage may be traded among these applications
  - **Non-Tradable**: allowed wattage **cannot** be traded between surfaces or with other exterior lighting
- ✓ **Three new ELP exemptions**

Section 9.4.5
Exterior Lighting Power Zones

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

ZONE 1
Developed areas of parks, forest, and rural areas.

ZONE 2
Residential and mixed use, neighborhood business, light industrial with limited night use.

ZONE 3
All other.

ZONE 4
High activity commercial in major metro as designated by AHJ.

In 2010, Zone 0 was introduced to represent undeveloped areas within national parks, forest land, and rural areas as defined by AHJ.

Lighting: Exterior

- Exterior lighting now uses a Zone System to set LPD allowances.
- New exterior lighting controls:
  - Lighting must be off during daytime
  - Lighting must be turned off 12 AM – 6 AM, or building opening – closing
  - Advertising must be reduced by at least 30% after hours or when area is unoccupied

Exterior Control *(cd)* and Incentives

- MUST turn off exterior lighting when sufficient daylight is available
- Use astronomical timer or daylight sensor
- Façade and landscape lighting off from midnight or closing to 6am or opening
- Addendum AC allows more LPD if more controls are added
- Most options allow 5-10% increase

Section 9.4.4 Functional Testing (az)

- Functional testing (calibrated/adjusted/programmed) of lighting control devices and systems required within 90 days of occupancy
  - Must be performed by individuals NOT involved in design, manufacture, or installation
  - For occupant sensors, time switches, programmable controls, or photosensors, verify:
    - All performance criteria met
    - Occupant sensor time-out and sensitivity settings
    - Timers and programs set to turn lights off
    - Photosensor controls effectively control lighting in response to daylight

- ✓ Record drawings for each piece of lighting equipment:
  - ✓ Location
  - ✓ Luminaire identifier
  - ✓ Control
  - ✓ Circuiting
- ✓ Operation and maintenance manuals

Credits

Content and images in this presentation provided by resources from:

Building Codes Assistance Project	DOE Building Energy Codes Program	National Renewable Energy Laboratory
energycodesocean.org	energycodes.gov	nrel.gov/data/pix

Thank you for your time!

QUESTIONS??

Delaware ENERGY OFFICE

This concludes this American Institute of Architects Continuing Education Systems Program

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