ANSI/ASHRAE/IESNA Standard 90.1-2007

An Overview of the Building Envelope Requirements

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Building Envelope Chapter & Appendices

- Chapter 5: Building Envelope
- Appendix A: Rated R-value of Insulation and 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 F: Addenda Description Information
- Appendix G: Performance Rating Method

ASHRAE Standard 90.1-2007
Appendix F: Addenda to 90.1-2004

- Overall addenda: 44
- Building envelope addenda:
  - 90.1c: revise vestibule applications (5.4.3.4)
  - 90.1d: updating of references (12)
  - 90.1k & al: add metal bldg roof U-factors (A2.3)
  - 90.1n & av: glass/slatted overhangs (5.5.4.4.1)
  - 90.1o: add 368 China & 38 Taiwan sites (App D)
  - 90.1y, ad & aj: cool roof stds, labels (5.5.3.1)
  - 90.1as: update opaque criteria (Table 5.5-1 to 8)
  - 90.1at: update fenestration criteria (T 5.5-1 to 8)

Section 5: Building Envelope, General Requirements

Space-Conditioning Categories(§5.1.2)

- 5.1.2.1(a) nonresidential conditioned space:
  "all occupancies other than residential"
- (b) residential conditioned space:
  "spaces in buildings used primarily for living and sleeping. Residential spaces include, but are not limited to, dwelling units, hotel/motel guest rooms, dormitories, nursing homes, patient rooms in hospitals, lodging houses, fraternity/sorority houses, hostels, prisons, and fire stations"
- (c) semi-heated space:
  "heated by a heating system whose output capacity is greater than or equal to 3.4 Btu/h·ft^2 of floor area but is not a conditioned space"

Space-Conditioning Definition (§3.2)

- Conditioned space:
  "a cooled space, heated space, or indirectly conditioned space defined as follows:
  - cooled space: an enclosed space within a building that is cooled by a cooling system whose sensible output capacity exceeds 5 Btu/h·ft^2 of floor area
  - heated space: an enclosed space within a building that is heated by a heating system whose output capacity relative to the floor area is greater than or equal to the criteria in Table 3.1"

- Comment:
  - "conditioned" does not mean air-conditioned, it includes heated-only spaces
  - very few spaces qualify as semiheated

Section 5: Building Envelope, General Requirements

Space-Conditioning Categories(§5.1.2)

- 5.1.2.2: Assumption of conditioned space:
  "Spaces shall be assumed to be conditioned space and shall comply with the requirements for conditioned space at the time of construction, regardless of whether mechanical or electrical equipment is included in the building permit application or installed at that time."
  except "…if approved by the building official"

- - meant to address problem of non-compliance in speculative buildings like warehouses where owners want to pass cost to tenants and it is more expensive to insulate later
  - example exception would be lumber storage

Section 5: Building Envelope, General Requirements

Climate (§5.1.4)

- 5.1.4.1: United States locations:
  - Use Figure B-1 or Table B-1 in Appendix B to determine the required climate zone (climate zones are specified by county)
- 5.1.4.2: Canada and international locations:
  - For Canada, use Table B-2 in Appendix B,
  - For international, use Table B-3,
  - For locations not listed, use Table B-4

- ***Later examples show the criteria for nonresidential spaces using these climate zones***

Climate Zones and Climatic Data
Normative Appendices B and D

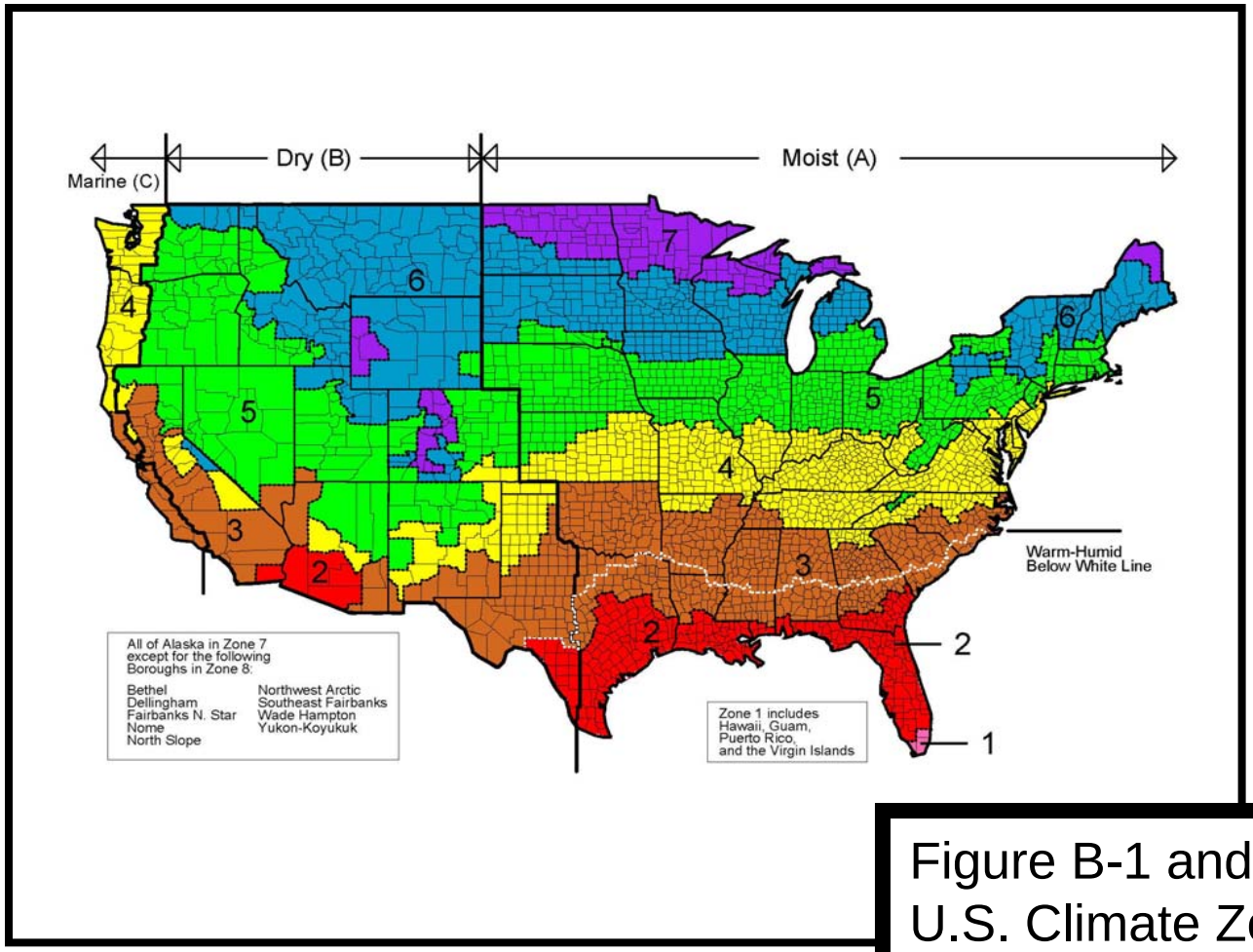


Figure B-1 and Table B-1
U.S. Climate Zones

Section 5: Building Envelope

Mandatory Provisions (§5.4)

- Insulation (§5.4.1, 5.8.1)
  to be discussed with Prescriptive Option
- Fenestration and Doors (§5.4.2, 5.8.2)
  to be discussed with Prescriptive Option
- Air Leakage (§5.4.3)

- ***Note: Standard 90.1 and LEED require compliance with these mandatory provisions regardless of how energy-efficient the building is or how great the energy savings are.***

Section 5: Building Envelope, Mandatory Provisions

Air Leakage (§5.4.3)

- Building Envelope Sealing (§5.4.3.1)
  - seal, caulk, gasket, weatherstrip all openings
- Fenestration and Doors (§5.4.3.2)
  - air leakage < 1.0 cfm/ft^2 for glazed swinging doors & revolving doors, < 0.4 cfm/ft^2 for others
- Loading Dock Weatherseals (§5.4.3.3)
  - in CZ 4-8 to limit leakage when truck parked

Section 5: Building Envelope, Mandatory Provisions

Air Leakage (§5.4.3)

- Vestibules (§5.4.3.4)
  - exceptions for doors into spaces < 3,000 ft^2, doors that are not building entrances, revolving doors, climate zones 1-2
  - *(revised)* exception for CZ 3-4 for buildings < 4 stories above grade and < 10,000 ft^2
  - *(revised)* exception for CZ 5-8 for buildings < 1,000 ft^2

- Comments
  - previous 4-story exemption was for all climates and all building sizes,
  - vestibules now required for big-box retail, supermarkets, etc. in CZ 3-8

Section 5: Building Envelope

Prescriptive Option (§5.5)

- Opaque assemblies (§5.5.3)
  - roofs (3 categories)
  - walls, above grade (4 categories)
  - walls, below grade (1 category)
  - floors (3 categories)
  - slab-on-grade floors (2 categories)
  - opaque doors (2 categories)
- Fenestration (§5.5.4)
  - vertical glazing (4 categories)
    (were 2 different categories in 90.1-2004)
  - skylights (3 categories)

Section 5: Building Envelope, Prescriptive Option

Opaque Assemblies (§5.5.3)

- Two compliance options (§5.5.3)
- R-value of insulation alone:
  "R-values of insulation for the thermal resistance of the added insulation in framing cavities and continuous insulation only"
  - does not include air films or building materials
  - sometimes only continuous insulation (ci)
- U-factor, C-factor, or F-factor for the entire assembly:
  "The values … listed in Normative Appendix A shall be used to determine compliance"

Section 5: Building Envelope, Prescriptive Option

Opaque Roofs (§5.5.3.1)

- Roof w/ insulation above deck:

  "all insulation installed above (outside of) the roof structure and continuous"

Changes: CZ 2-7	
1:	R-15 ci, U-0.063
2-8:	R-20 ci, U-0.048

- Comments:
  - insulation R-value is a minimum for all locations, not acceptable to "average" R-values for tapering
  - assembly U-factors in Appendix A Table A2.2
  - exception allows reduction for cool roof
    - *(new)* SRI 82 per ASTM E1980 as alternate
    - *(new)* must use accredited lab and must be labeled

Section 5: Building Envelope, Prescriptive Option

Opaque Roofs (§5.5.3.1)

- Metal building roof:
  "metal, structural, weathering surface, no ventilated cavity, steel framing members"

Changes: none
1-7: R-19, U-0.065
8: R-13 + R-19, U-0.049

- Comments:
  - exception to 5.8.1.2 allows metal building insulation to be compressed between roof skin and structure
  - assembly U-factors in Appendix A Table A2.3 *(revised)* expanded options for screw down roofs
  - exception allows reduction for cool roof

  - addendum under review for metal buildings

Section 5: Building Envelope, Prescriptive Option

Opaque Roofs (§5.5.3.1)

- Attic and all other roofs:
  "all other roofs"

Changes: CZ 2-5, 8	
1:	R-30, U-0.034
2-7:	R-38, U-0.027
8:	R-49, U-0.021

- Comments:
  - 5.8.1.8 prohibits installing roof insulation on suspended ceiling with removable ceiling tiles
  - 5.8.1.6 prohibits recessing light fixtures into insulation unless area is < 1%
  - 5.8.1.4 requires baffles around eave vents
  - assembly U-factors in Appendix A in Tables A2.4 for wood joists, A2.5 for steel joists
  - possible reduction for single-rafter roofs

Section 5: Building Envelope, Prescriptive Option

Opaque Walls Above Grade (§5.5.3.2)

- Wall above grade, mass:
  "with a heat capacity exceeding 7 Btu/ft^2·°F or a material unit weight of 5 Btu/ft^2·°F if <120 lb/ft^3"

Changes:	CZ 2-8
1:	NR, U-0.058
2:	R-5.7 ci, U-0.151
3:	R-7.6 ci, U-0.123
4:	R-9.5 ci, U-0.104
5:	R-11.4 ci, U-0.090
6:	R-13.3 ci, U-0.080
7-8:	R-15.2 ci, U-0.071

- Comments:
  - "ci" (§3.2 definitions) means insulation must be "continuous across all structural members without thermal bridges other than fasteners"
  - if metal or wood studs, then must use U-factor
  - assembly U-factors in Appendix A Table A3.1A
  - heat capacity in A3.1B, A3.1C, option in A3.1D

Section 5: Building Envelope, Prescriptive Option

Opaque Walls Above Grade (§5.5.3.2)

- Wall above grade, metal building:
  "metal spanning members supported by steel structural"

	Changes: none	
1-6:	R-13,	U-0.113
7-8:	R-13 + R-13,	U-0.057

- Comments:
  - exception to 5.8.1.2 allows metal building insulation to be compressed between wall skin and structure
  - assembly U-factors in Appendix A Table A3.2
  - addendum under review for metal buildings

Section 5: Building Envelope, Prescriptive Option

Opaque Walls Above Grade (§5.5.3.2)

- Wall above grade, steel-framed:
  "typical steel stud walls and curtain wall systems"

Changes: CZ 3-6		
1-2:	R-13,	U-0.124
3:	R-13 + R-3.8 ci,	U-0.084
4-8:	R-13 + R-7.5 ci,	U-0.064

- Comments:
  - cavity insulation must also be accompanied by continuous insulation due to thermal bridging
  - assembly U-factors in Appendix A Table A3.3
  - Table A9.2B shows that R-13 insulation only achieves an effective R-6.0 in metal studs (R-19 in 6" stud only achieves R-7.1)

Section 5: Building Envelope, Prescriptive Option

Opaque Walls Above Grade (§5.5.3.2)

- Wall above grade, wood-framed:
  "all other wall types, including wood stud walls"

Changes: CZ 5-8	
1-4:	R-13, U-0.089
5:	R-13 + R-3.8 ci, U-0.064
6-7:	R-13 + R-7.5 ci, U-0.051
8:	R-13 + R-15.6 ci, U-0.036

- Comments:
  - while wood studs perform better thermally than steel, continuous insulation is still beneficial
  - assembly U-factors in Appendix A Table A3.4
  - compressing insulation reduces R-value, Table A9.4C shows that R-19 insulation only has an effective R-13 when forced into 4" studs

Section 5: Building Envelope, Prescriptive Option

Opaque Walls Below Grade (§5.5.3.3)

- Wall below grade:
  "that portion of a wall …that is entirely below the finish grade and in contact with the ground"

Changes:	CZ 5-6
1-4:	NR, C-1.140
5-8:	R-7.5 ci, C-0.119

- Comments:
  - insulation must be continuous across the wall
  - if metal or wood studs, then must use C-factor
  - assembly C-factors in Appendix A Table A4.2
    (C-factor does not include R-values for exterior or interior air films or for soil)

Section 5: Building Envelope, Prescriptive Option

Opaque Floors (§5.5.3.4)

- Mass floor:
  "with a heat capacity exceeding 7 Btu/ft^2·°F or a material unit weight of 5 Btu/ft^2·°F if <120 lb/ft^3"

Changes:	CZ 2, 4-8
1:	NR, U-0.322
2-3:	R-6.3 ci, U-0.107
4:	R-8.3 ci, U-0.087
5:	R-10.4 ci, U-0.074
6-7:	R-12.5 ci, U-0.064
8:	R-14.6 ci, U-0.057

- Comments:
  - waffle-slab floors shall be insulated either on the interior above the slab or on all exposed surfaces of the waffle (A5.2.2.3)
  - similar for concrete beams (A5.2.2.4)
  - assembly U-factors in Appendix A Table A5.2

Section 5: Building Envelope, Prescriptive Option

Opaque Floors (§5.5.3.4)

- Steel joist floors:
  "steel joist members supported by structural members"

Changes: CZ 4-5, 8

1:	NR, U-0.350
2-3:	R-19, U-0.052
4-7:	R-30, U-0.038
8:	R-38, U-0.032

- Comments:
  - 5.8.1.5 requires floor insulation be installed "in substantial contact with the inside surface"
  - assembly U-factors in Appendix A Table A5.3
  - Table A9.2A shows that R-30 insulation only achieves an effective R-23.7 when installed between metal framing 4 feet on center

Section 5: Building Envelope, Prescriptive Option

Opaque Floors (§5.5.3.4)

- Wood framed and other floors:
  "all other floor types, including wood joist floors"

Changes: CZ 4	
1:	NR, U-0.282
2-3:	R-19, U-0.051
4-8:	R-30, U-0.033

- Comments:
  - 5.8.1.5 requires floor insulation have "supports no greater than 24 in. on center"
  - assembly U-factors in Appendix A Table A5.4

Section 5: Building Envelope, Prescriptive Option

Opaque Slab-on-Grade (§5.5.3.5)

Slab-on-grade floor:

"a slab floor…in contact with the ground and that is either above grade or is ≤ 24 in. below the final elevation of the nearest exterior grade"

- Unheated slab-on-grade:

  "a slab-on-grade that is not a heated slab-on-grade floor"

Changes: CZ 6-8

1-5: NR, F-0.730
6: R-10 for 24 inches, F-0.540
7-8: R-15 for 24 inches, F-0.520

- Heated slab-on-grade:

  "a slab-on-grade with a heating source either within or below it"

Changes: CZ 3-8

1-2: R-7.5 for 12 inches, F-0.102
3: R-10 for 24 inches, F-0.900
4-6: R-15 for 24 inches, F-0.860
7: R-20 for 24 inches, F-0.843
8: R-20 for 48 inches, F-0.688

Section 5: Building Envelope, Prescriptive Option

Opaque Door (§5.5.3.6)

Door:

"all operable opening areas (which are not fenestration) …including swinging and roll-up doors, fire doors, and access hatches. Doors …more than one-half glass are…fenestration."

- Swinging:
  "all operable opaque panels with hinges on one side and opaque revolving doors"

Changes: CZ 7
1-6: U-0.700
7-8: U-0.500

- Non-swinging:
  "roll-up, sliding, and…doors that are not swinging doors"

Changes: CZ 4-5
1-3: U-1.450
4-8: U-0.500

Fenestration Definition (§3.2)

- Fenestration:
  "all areas (including the frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, glass doors that are more than one-half glass, and glass block walls"

- Comments:
  - if it is not insulated roof, wall, or floor, then it is fenestration

Fenestration Ratings (§5.8.2)

- U-factor (§5.8.2.4)

  "U-factors shall be determined in accordance with NFRC 100.

  U-factors for skylights shall be determined for a slope of 20 degrees above the horizontal."

- Comments:

  - ratings are for overall product including glass, sash, and frame (not center of glass)
  - the overall product U-factor w/frame can be twice as high as the center-of-glass U-factor
  - higher U-factor for products at a slope

Fenestration Ratings (§5.8.2)

- NFRC 100
  - first published in 1991
  - certified by U.S. DOE as EPAct-compliant
  - specifies standard rating conditions and sizes for apples-to-apples comparison
  - includes all product types: glazed wall systems (i.e. curtainwalls/storefronts), sloped glazing, skylights, casement, awning, picture, slider, pivoted, swinging doors, sliding doors, etc.
  - ratings are based on simulation, not testing (limited testing is done for validation)
  - further information at www.nfrc.org

Fenestration Ratings (§5.8.2)

- Solar Heat Gain Coefficient (§5.8.2.5)

  "SHGC for the overall fenestration area shall be determined in accordance with NFRC 200."

- Exceptions to 5.8.2.5:

  (a) allowable to use shading coefficient (SC) for the center of the glass multiplied by 0.86 provided that SC is from a spectral data file determined in accordance with NFRC 300

Fenestration Ratings (§5.8.2)

- Exceptions to 5.8.2.5 (cont.):
  (b) allowable to use SHGC for the center of the glass (instead of for the overall product)

- Comments:
  - using the exceptions does not give the full credit that the NFRC-certified SHGC does
  - though the SHGC for the frame is not zero (ranges from 0.11-0.14 for metal frames and from 0.02 to 0.07 for wood/vinyl/ fiberglass), the SHGC for the frame is almost-always lower than the SHGC for the glass

Section 5: Building Envelope, Mandatory Provisions

Fenestration Ratings (§5.8.2)

- Visible Light Transmittance (§5.8.2.6)
  "Visible light transmittance shall be determined in accordance with NFRC 200."

- Comments:
  - only necessary if using the EnvStd compliance option in §5.6
  - however, NFRC requires products to be rated for visible light transmittance as well as U-factor and SHGC, so information available
  - important for daylighting, can now find products with VT more than twice as high as SHGC

Section 5: Building Envelope, Mandatory Provisions

Fenestration Ratings (§5.8.2)

- Ratings (§5.8.2.1)
  "U-factor, solar heat gain coefficient (SHGC)… shall be determined by a laboratory accredited by a nationally recognized accreditation organization, such as the National Fenestration Rating Council "

- - ratings done by a qualified, independent party (though software is helpful for designers and is used by manufacturers for product design)
  - Appendices A8.1 & A8.2 provide some limited default values for unlabeled products

Section 5: Building Envelope, Mandatory Provisions

Fenestration Labeling (§5.8.2)

- Labeling (§5.8.2.2-3)
  "All manufactured fenestration products shall have a permanent nameplate, installed by the manufacturer, listing the U-factor, solar heat gain coefficient (SHGC)"
  OR
  "…certification for the installed fenestration listing the U-factor, SHGC"

- NFRC labeling for inspectors:
  - manufactured products, 4" x 4" label at factory
  - site-built products, 8-1/2" x 11" label certificate

Section 5: Building Envelope, Mandatory Provisions

Fenestration Labeling (§5.8.2)

Section 5: Building Envelope, Mandatory Provisions
Fenestration Ratings (§5.8.2)

NFRC PRODUCT CERTIFICATION PROGRAM

NFRC Label Certificate for Site-Built Products

Project Location

Street Address: _____

City: _____ State: _____ Zip Code: _____

Project Name (Optional): _____ Designer (Optional): _____

Product Line Information

Operator Type (per Table 4-3 of NFRC 100) _____

Product Line ID No. _____ Individual Product ID No. _____

How many of this individual product _____ Location in building _____

Elevation drawing page _____ Fenestration (window & door) schedule page _____

Frame Material Supplier Company name: _____

City: _____ State: _____ Zip Code: _____

Street Address: _____

Contact: _____ Phone: _____ Fax: _____

Glazing Material Supplier Company name: _____

City: _____ State: _____ Zip Code: _____

Street Address: _____

Contact: _____ Phone: _____ Fax: _____

Glazing Contractor/Installer Comp. name: _____

City: _____ State: _____ Zip Code: _____

Street Address: _____

Contact: _____ Phone: _____ Fax: _____

Certification Authorization

Independent Certification & Inspection Agency (IA): _____

Date Certification Authorization Issued: _____

Section 5: Building Envelope, Prescriptive Option

Fenestration General (§5.5.4.1)

- Calculation methodology:

  "Gross wall areas and gross roof areas shall be calculated separately for each space-conditioning category for the purposes of determining compliance."

- - for mixed-use buildings, must do separate calculations for nonresidential, residential, and semiheated spaces.
  - within these subcategories, an exception allows area-weighted averaging for U-factor, SHGC

Fenestration Area Definition (§3.2)

Fenestration area:

"total area of the fenestration measured using the rough opening and including the glazing, sash, and frame. For doors where the glazed vision area is less than 50% of the door area, the fenestration area is the glazed vision area. For all other doors, the fenestration area is the door area."

- - must use rough opening, not glass area

Fenestration Area Definition (§3.2)

- Vertical glazing:
  "all fenestration other than skylights"
- Skylights:
  "a fenestration surface having a slope of less than 60 degrees from the horizontal plane. Other fenestration, even if mounted on the roof of a building, is considered vertical fenestration"

- - clerestories and roof monitors are considered vertical fenestration

Section 5: Building Envelope, Prescriptive Option

Fenestration Area (§5.5.4.2)

- Vertical:
  "total vertical fenestration area shall be less than 40% of the gross wall area"

Changes: CZ 1-8

1-8: 40% maximum

- Skylights:
  "total skylight area shall be less than 5% of the gross roof area"

Changes: none

1-8: 5% maximum

- - exception allows up to 75% area for the street-side of street-level retail provided it has projection factor (overhang) > 0.5

Section 5: Building Envelope, Prescriptive Option

Fenestration U-factor (§5.5.4.3)

- Vertical, nonmetal framing:
  wood/vinyl/fiberglass frames, fixed/operable windows/doors

Changes: CZ 1-8
1: U-1.20; **2:** U-0.75;
3: U-0.65; **4:** U-0.40;
5-8: U-0.35 max.

- Vertical, curtainwall/ storefront:
  metal frame

Changes: CZ 1-8
1: U-1.20; **2:** U-0.70;
3: U-0.60; **4:** U-0.50;
5-6: U-0.45; **7-8:** U-0.40 max.

- Vertical, entrance door:
  metal frame

Changes: CZ 1-8
1: U-1.20; **2:** U-1.10;
3: U-0.90; **4:** U-0.85;
5-8: U-0.80 max.

- Vertical, other metal:
  fixed/operable, non-entrance doors

Changes: CZ 1-8
1: U-1.20; **2:** U-0.75;
3: U-0.65; **4-6:** U-0.55;
7-8: U-0.45 max.

Section 5: Building Envelope, Prescriptive Option

Fenestration SHGC (§5.5.4.4)

- Vertical, all:
  same for all areas,
  same for all orientations

Changes: CZ 1-8
1-3: SHGC-0.25 max.
4-6: SHGC-0.40 max.
7-8: SHGC-0.45 max.

- - credit for fenestration “shaded by permanent projections that will last as long as the building itself”
  - *(new)* partial credit for glass/slatted overhangs

Section 5: Building Envelope, Prescriptive Option

Fenestration U-factor (§5.5.4.3)

- Skylight, glass with curb and plastic with curb:

Changes: none

1-2: U-1.98/1.90 max.
3-4: U-1.17/1.30 max.
5: U-1.17/1.10 max.
6-7: U-1.17/0.87 max.
8: U-0.98/0.61 max.

- Skylight, all materials without curb:

Changes: none

1-2: U-1.36 max.
3-7: U-0.69 max.
8: U-0.58 max.

- - skylights with curbs can have a surface area that is double the rough opening area
  - skylights without curbs are sloped glazing like curtainwalls but higher heat loss due to slope

Section 5: Building Envelope, Prescriptive Option

Fenestration SHGC (§5.5.4.4)

- Skylight, glass with curb and plastic with curb:

Changes: none

1:	SHGC-0.19/0.27 max.
2-3:	SHGC-0.19/0.34 max.
4:	SHGC-0.39/0.34 max.
5:	SHGC-0.39/0.62 max.
6:	SHGC-0.49/0.58 max.
7:	SHGC-0.64/0.71 max.
8:	NR

- Skylight, all materials without curb:

Changes: none

1-3:	SHGC-0.19 max.
4:	SHGC-0.34 max.
5:	SHGC-0.39 max.
6:	SHGC-0.49 max.
7:	SHGC-0.64 max.
8:	NR

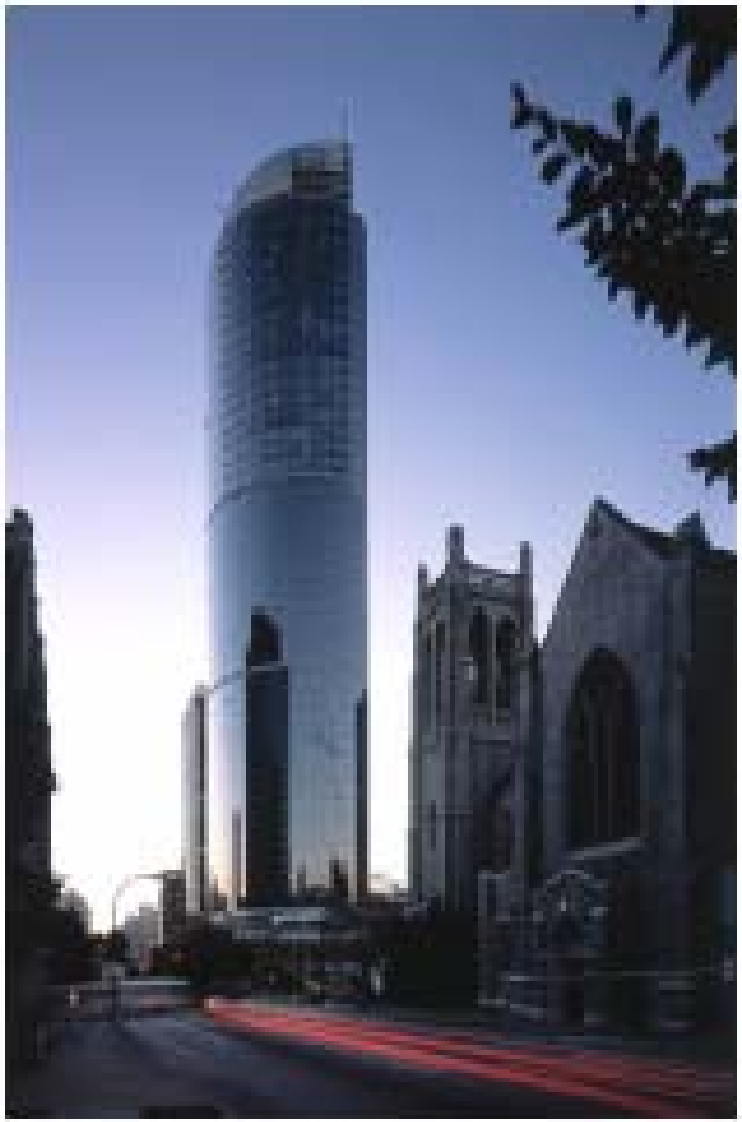
- - for 90.1-2010, may require skylights with automatic daylighting control

EnvStd Trade-Off Option (§5.6)

- More flexibility, but more work
- Trade-offs limited to envelope components
  - no lighting or HVAC
- Includes daylighting – need good VT
- Methodology and assumptions in Appendix C
- See Users Manual with EnvStd

More Building Envelope Energy Efficiency

48-story hotel/condo, U-0.21 (3-layer)



More Building Envelope Energy Efficiency

19-story office, U-0.14 (4-layer)

More Information?

- Standard 90.1-2007, and the Users Manual are expected to be available this fall.
- For more information, contact:

www.ashrae.org