Low Slope Roofing Systems
The University of Wisconsin Madison
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Roof Insulation and Code Compliance

presented by

Mark S. Graham
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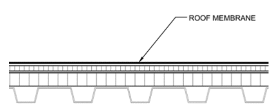
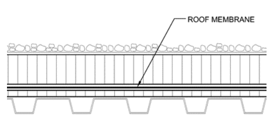
Rosemont, Illinois

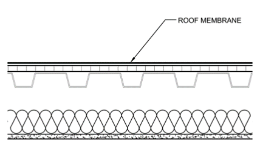
Roof assembly configurations



Conventional
Insulation above deck



Protected membrane
Insulation above membrane



Attic (or "other")
Insulation below deck

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Purpose(s) for insulation

Low-slope roof systems

- Thermal performance
- Condensation control
- Smooth substrate
- Deck stability
  - Reduce temperature variations
  - Control thermal expansion and contraction
- Fire resistance
- Roof slope
  - Above-deck tapered insulation

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Principles of thermal insulation

British thermal unit (Btu): the energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit (F).

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Principles of thermal insulation

Thermal conductivity (k): the amount of heat is transmitted by conduction through 1 square foot of 1-inch-thick homogenous material in 1 hour where there is a difference of 1 degree Fahrenheit (F) across the two surfaces of the material.

$$k = Btu \bullet inch / ft^2 \bullet hr \bullet F$$

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Principles of thermal insulation

Thermal conductance (C): the amount of heat is transmitted by conduction through 1 square foot of a specified thickness of material in 1 hour where there is a difference of 1 degree Fahrenheit (F) across the two surfaces of the material.

$$C = Btu / ft^2 \bullet hr \bullet F$$

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Principles of thermal insulation

Thermal transmittance (U): the amount of heat is transmitted by conduction through 1 square foot of an assembly and its boundary layers in 1 hour where there is a difference of 1 degree Fahrenheit (F) across the two surfaces of the assembly.

$$U = Btu / ft^2 \bullet hr \bullet F$$

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Principles of thermal insulation

Thermal resistance: a relative measure of a material's or an assembly's resistance to heat flow; the reciprocal of the material's thermal conductance (C) or an assembly's thermal transmittance (U).

$$R = 1 / C \text{ or } R = 1 / U$$

R-values are readily additive (unlike k-values and C-values). Therefore $R_T = R_1 + R_2 + R_3 = \ldots$

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R-values of boundary layer air films

Applicable to the inside and outside surfaces of assemblies

Surface	Condition	Resistance
Outside air film (f_o)	15 mph wind (winter) 7.5 mph wind (summer)	0.17 °F•ft²•h/Btu 0.25 °F•ft²•h/Btu
Inside air film (f_i)	Still air—horizontal surface[3] Heat flow upward (winter) Heat flow downward (summer)	 0.61 °F•ft²•h/Btu 0.92 °F•ft²•h/Btu

1. Values derived from Table 1, *2001 ASHRAE Handbook—Fundamentals,* page 25.4.
2. Surface air films exist on every surface. They are invisible layers of air that cling to the surface on a material and have some resistance to heat flow. Outside air films vary in thickness according to wind velocity; inside air films vary in effectiveness according to the direction of heat flow.
3. Inside air film values listed are for horizontal inside surfaces only. If the inside surface being evaluated is sloping or vertical, other thermal resistance values may apply; refer to Table 1, *2001 ASHRAE Handbook—Fundamentals,* page 25.4.

Figure 3-1: Thermal resistance values for air films

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R-values of enclosed spaces

Position of Air Space[3]	Condition[3]	Thickness of Air Space[4]	Thermal Resistance of Air Space[5]		
			Highly Reflective Roof Surface[6]	Moderately Reflective Roof Surface[7]	Non-Reflective Roof Surface[8]
Horizontal	Heat flow upward (winter)	0.75 inch 1.5 inches 3.5 inches	1.70°F•ft²•h/Btu 1.81°F•ft²•h/Btu 1.95°F•ft²•h/Btu	1.16°F•ft²•h/Btu 1.21°F•ft²•h/Btu 1.28°F•ft²•h/Btu	0.87°F•ft²•h/Btu 0.89°F•ft²•h/Btu 0.93°F•ft²•h/Btu
Horizontal	Heat flow downward (summer)	0.75 inch 1.5 inches 3.5 inches	2.41°F•ft²•h/Btu 3.27°F•ft²•h/Btu 4.09°F•ft²•h/Btu	1.45°F•ft²•h/Btu 1.73°F•ft²•h/Btu 1.93°F•ft²•h/Btu	1.02°F•ft²•h/Btu 1.15°F•ft²•h/Btu 1.24°F•ft²•h/Btu

1. Values derived from Tables 2 and 3, *2001 ASHRAE Handbook—Fundamentals,* pages 25.2 and 25.4.
2. Any air space where the air is not ventilated or otherwise allowed to freely move has some thermal resistance to heat flow. If the air space is ventilated or if the space is used as a plenum, the thermal resistance of the space and inside air film must be considered zero.
3. The thermal resistance values listed are for horizontal air spaces with the direction of heat flow either in an upward (winter) or downward (summer) direction. If the air space being evaluated is oriented in a sloping or vertical direction, other thermal resistance values may apply; refer to Tables 2 and 3, *2001 ASHRAE Handbook—Fundamentals,* pages 25.2 and 25.4.
4. Interpolation and moderate extrapolation for air spaces other than those listed is permissible.
5. Thermal resistance values based on 50 F mean temperature and 10 F temperature difference.
6. Values based on an Effective Emittance (ϵ_{eff}) of 0.20 with one surface with a reflectivity of 75-84 percent and the other surface with ϵ=0.90 (e.g., foil-surfaced modified bitumen membrane, mill finish aluminum panels).
7. Values based on an ϵ_{eff} of 0.50 with one surface with a reflectivity of 30-70 percent and the other surface with ϵ=0.90 (e.g., white membranes, smooth-surfaced membrane with a reflective coating).
8. Values based on an ϵ_{eff} of 0.82 with surfaces with a reflectivity of 5-15 percent (e.g., most aggregate-surfaced roofs, smooth-surfaced built-up roofs).

Figure 3-2: Thermal resistance values for enclosed air spaces

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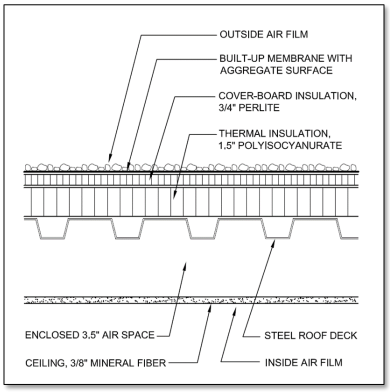
R-value calculations



Component	Heating Condition R-value	Cooling Condition R-value
Outside air film	0.17	0.25
Built-up membrane, aggregate surfaced	0.33	0.33
Insulation cover board, ¾-inch perlite board	2.08	2.08
Primary insulation, 1½-inch polyisocyanurate	7.50	8.40
Roof deck, steel	0.00	0.00
Enclosed air space, 3½ inches	0.93	1.24
Ceiling, ⅜-inch mineral fiber	1.56	1.56
Inside air film	0.61	0.92
Total (R_T):	13.18	14.78

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Desirable properties for roof insulation

- Attachment capability
- Compatible with adhesives
- Compatible with other roof assembly components
- Compressive strength
- Dimensionally stable
- Fire resistant
- Impact resistance
- Moisture resistant
- Thermal resistant (low k-value or C-value/high R-value)
- Thermal resistance stability

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So, what is the "ideal" roof insulation?

There is no "ideal" roof insulation…

roof insulation selection and use is a compromise

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Roof insulation types

Rigid board insulation

- Cellular glass
- Expanded polystyrene (EPS)
- Extruded polystyrene (XPS)
- Faced gypsum
- Fiber-reinforced gypsum
- Mineral fiber (stone wool)
- Perlite
- Polyisocyanurate
- High-density polyisocyanurate
- Wood fiberboard

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Cellular glass

- Crushed glass and hydrogen sulfide gas heated to 950 F
- ASTM C552, Type IV
- 12” x 18”, 18” x 24” and 2’ x 4’
- 1½” to 6” and tapered
- R = 3.44 per inch

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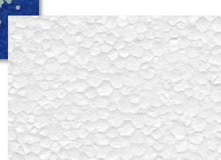
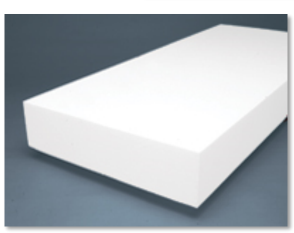
Expanded polystyrene (EPS)





- Polystyrene polymer, foaming agent and heat
- ASTM C578 (many types)
- 4’ x 4’ and 4’ and 8’
- ⅜” to 24”and tapered
- R = 3.1 to 4.3 per inch based upon density

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EPS types

ASTM C578, Type __

EPS type	Density, min. (pounds per cubic foot)	Compressive strength, min. (psi)	R-value
Type I*	0.90 (1.0 nominal)	10.0	3.6
Type II	1.35 (1.5 nominal)	15.0	4.0
Type VIII	1.15 (1.25 nominal)	13.0	3.8
Type IX	1.80 (2.0 nominal)	25.0	4.2
Type XI*	0.70 (0.75 nominal)	5.0	3.1
Type XIV	2.40 (2.5 nominal)	40.0	4.2
Type XV	2.85 (3.0 nominal)	60.0	4.3

* Type I and Type XI are generally not intended to be used in roofing applications

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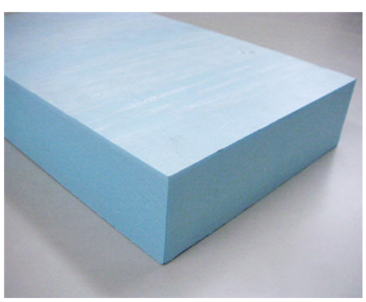
Extruded polystyrene (XPS)



- Polystyrene polymer is heated and extruded
- ASTM C578 (many types)
- 2’ x 4’ and 2’ x 8’
- 1”, 1½”, 2”, 2½”, 3” & 4”
- R = 4.6 to 5.0 per inch

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XPS types

ASTM C578, Type __

XPS type	Density, min. (pounds per cubic foot)	Compressive strength, min. (psi)	R-value
Type IV	1.45	25.0	5.0
Type V	3.00	100.0	5.0
Type VI	1.80	40.0	5.0
Type VII	2.20	60.0	5.0
Type X	1.30	15.0	5.0
Type XII*	1.20	15.0	4.6
Type XIII*	1.60	20.0	3.9

* Type XII and Type XIII are generally not intended to be used in roofing applications

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Faced gypsum

- Gypsum core between paper or fiberglass-mat facers
- ASTM C1396 (paper)
- ASTM C1177 (glass-mat)
- 4' x 4' and 4' x 8'
- ¼", ½" and ⅝" thick
- R = 1.12 per inch

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Fiber-reinforced gypsum

- Cellulose-fiber reinforced gypsum
- ASTM C1278
- 4’ x 4’ and 4’ x 8’
- ¼”, ⅜”, ½” and ⅝” thick
- R = 1.0 per inch

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Mineral fiber (stone wool)

- Rock, slag or glass heated and spun into fibers with a binding agent
- ASTM C726 or ASTM C612
- 4’ x 4’
- Up to 6” thick
- R = 4 per inch (10 pcf density)

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Perlite

- Expanded volcanic minerals, organic fibers and binders
- ASTM C728 (various types)
- 2' x 4' and 4' x 4'
- ½", ¾", 1", 1½", 2" and tapered
- R = 2.78 per inch

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Perlite types

ASTM C728, Type __

- Type 1: Roof insulation board
- Type 2: Recover board
- Type 3: Recover board (higher physical properties)

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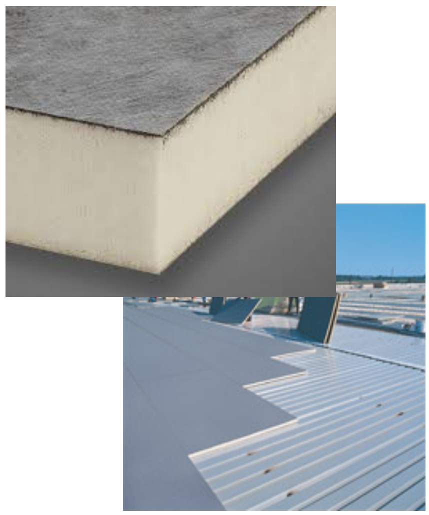
Polyisocyanurate



- Polyisocyanurate foam and facers
- ASTM C1289 (multiple types, grades and classes)
- 4’ x 4’ and 4’ x 8’
- Thicknesses range from 1” to 4”
- R = 5.0-6.0 per inch
- LTTR = 5.6 to 5.9 per inch

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Polyiso. type, grades and classes

ASTM C1289, Type II, Class __, Grade __

- Type II:
  - Class 1: organic/glass facer:
    - Grade 1: 16 psi (min.) compressive strength
    - Grade 2: 20 psi (min.) compressive strength
    - Grade 3: 25 psi (min.) compressive strength
  - Class 2: coated glass facer
  - Class 3: uncoated glass facer

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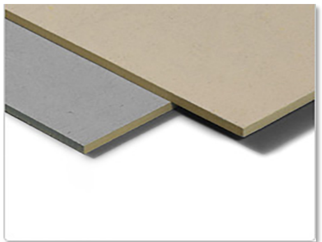
High density polyisocyanurate



- Polyisocyanurate foam and facers
- ASTM C1289, Type II, Class 4 (multiple grades)
- 4' x 4' and 4' x 8'
- ¼" and ½" thick
- R = 1.0 for ¼" thick

  R = 2.0 for ½" thick

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HD polyiso. type, class and grades

ASTM C1289, Type III, Class 4, Grade __

- Type II:
  - Class 4: coated or uncoated glass mats:
    - Grade 1: 80 psi (min.) compressive strength
    - Grade 2: 110 psi (min.) compressive strength
    - Grade 3: 140 psi (min.) compressive strength

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Wood fiberboard

- Wood or cane fibers and binders; may be coated
- ASTM C208, Type II (two grades)
- 2' x 4', 4' x 4' and 4' x 8'
- ½", 1" and 2' thick
- R = 2.78 per inch

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Wood fiberboard grades

ASTM C208, Type II, Grade __

- ASTM C208, Type II:
  - Grade 1: For BUR and MB systems
  - Grade 2: For single-ply systems

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Composite boards

- EPS and plywood/OSB
- Polyiso. and perlite, wood fiberboard, plywood/OSB or glass-mat-faced gypsum

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Board joints

Heat loss through gaps at the joints between insulation boards can represent up to a 10% reduction in effective R-value

A two-layer application rigid board insulation with staggered and offset board joints is recommended

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Mechanical fasteners

Mechanical fasteners through the cross-section of rigid board insulation can represent 3% to 8% losses in effective R-values.

Mechanically-attach the bottommost layer and adhere subsequent layers is preferred.

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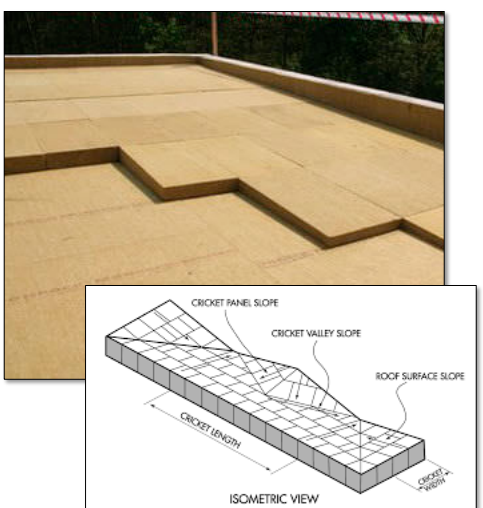
Tapered roof insulation



- Common materials:
  - EPS
  - XPS
  - Perlite
  - Polyisocyanurate
- Common slopes:
  - ⅛” per foot
  - ¼” per foot
  - ½” per foot

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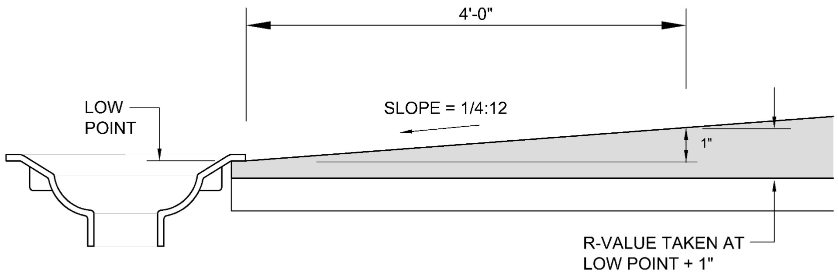
What about tapered insulation…?

IBC 2012, Sec. C402.2-Roof Assembly , Exception 1
allows a 1-inch insulation thickness variation



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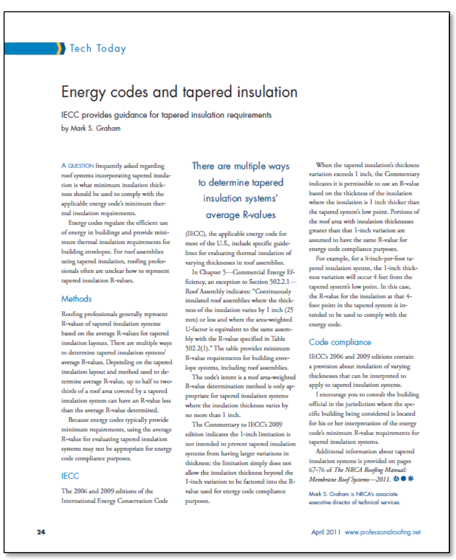
Tapered insulation



Tech Today

Energy codes and tapered insulation

IECC provides guidance for tapered insulation requirements

by Mark S. Graham

A QUESTION frequently asked regarding roof systems incorporating tapered insulation is what minimum insulation thickness should be used to comply with the applicable energy code's minimum thermal insulation requirements.

Energy codes regulate the efficient use of energy in buildings and provide minimum thermal insulation requirements for building envelopes. For roof assemblies using tapered insulation, roofing professionals often are unclear how to represent tapered insulation R-values.

Methods

Roofing professionals generally represent R-values of tapered insulation systems based on the average R-values for tapered insulation layouts. There are multiple ways to determine tapered insulation systems' average R-values. Depending on the tapered insulation layout and method used to determine average R-value, up to half to two-thirds of a roof area covered by a tapered insulation system can have an R-value less than the average R-value determined.

Because energy codes typically provide minimum requirements, using the average R-value for evaluating tapered insulation systems may not be appropriate for energy code compliance purposes.

IECC

The 2006 and 2009 editions of the International Energy Conservation Code (IECC), the applicable energy code for most of the U.S., include specific guidelines for evaluating thermal insulation of varying thicknesses in roof assemblies.

There are multiple ways to determine tapered insulation systems' average R-values

In Chapter 5—Commercial Energy Efficiency, an exception to Section 502.2.1—Roof Assembly indicates: "Continuously insulated roof assemblies where the thickness of the insulation varies by 1 inch (25 mm) or less and where the area-weighted U-factor is equivalent to the same assembly with the R-value specified in Table 502.2(1)." The table provides minimum R-value requirements for building envelope systems, including roof assemblies.

The code's intent is a roof area-weighted R-value determination method is only appropriate for tapered insulation systems where the insulation thickness varies by no more than 1 inch.

The Commentary to IECC's 2009 edition indicates the 1-inch limitation is not intended to prevent tapered insulation systems from having larger variations in thickness; the limitation simply does not allow the insulation thickness beyond the 1-inch variation to be factored into the R-value used for energy code compliance purposes.

When the tapered insulation's thickness variation exceeds 1 inch, the Commentary indicates it is permissible to use an R-value based on the thickness of the insulation where the insulation is 1 inch thicker than the tapered system's low point. Portions of the roof area with insulation thicknesses greater than that 1-inch variation are assumed to have the same R-value for energy code compliance purposes.

For example, for a ¼-inch-per-foot tapered insulation system, the 1-inch thickness variation will occur 4 feet from the tapered system's low point. In this case, the R-value for the insulation at that 4-foot point in the tapered system is intended to be used to comply with the energy code.

Code compliance

IECC's 2006 and 2009 editions contain a provision about insulation of varying thicknesses that can be interpreted to apply to tapered insulation systems.

I encourage you to consult the building official in the jurisdiction where the specific building being considered is located for his or her interpretation of the energy code's minimum R-value requirements for tapered insulation systems.

Additional information about tapered insulation systems is provided on pages 67-76 of *The NRCA Roofing Manual: Membrane Roof Systems—2011.*

Mark S. Graham is NRCA's associate executive director of technical services.

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April 2011 www.professionalroofing.net

Professional Roofing,
April 2011

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Code compliance for roof systems

Some background

- The I-Codes are "model codes" developed by the International Code Council (ICC)
- Model codes serve as the technical basis for state or local code adoption
- The code provides the minimum legal requirements for building construction…and operation
- The code is enforced by the "authority having jurisdiction" (AHJ)
- The code can also provide a basis for construction claims-related litigation

Code enforcement

- Code official
- Construction litigation

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Legal considerations

"In most states, a building code violation is considered to be evidence of negligence. In some situations, a building code violation may be considered *negligence per se…"*

--Stephen M. Phillips
Hendrick, Phillips, Salzman & Flatt

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Who is responsible?

- The building owner
- And, everyone else involved

AIA General Conditions

AIA A201 – General Conditions of The Contract for Construction

Article 3 Contractor

3.2.3 The Contractor is not required to ascertain that the Contract Documents are in accordance with applicable laws, statues, ordinances, codes, rules and regulations, or lawful orders of public authorities, but the Contractor shall promptly report to the Architect any nonconformity discovered by and made known to the Contractor as a request for information in such a form as the Architect may require.

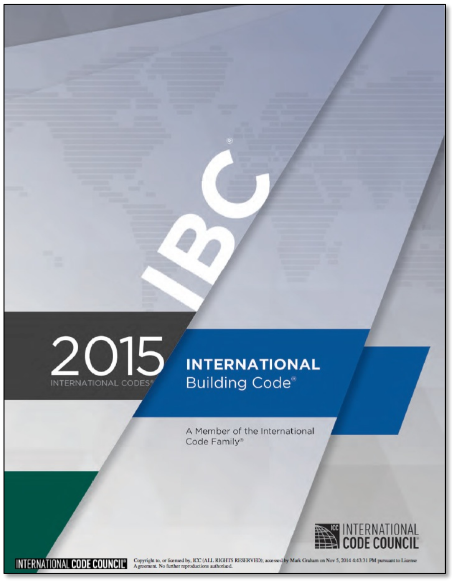
AIA General Conditions

AIA A201 – General Conditions of The Contract for Construction

3.2.4 …If the Contractor fails to perform the obligations of Sections 3.2.2 or 3.2.3, the Contractor shall pay the costs and damages to the Owner as would have been avoided if the Contractor had performed such obligations. If the Contractor performs those obligations, the Contractor shall not be liable to the Owner or Architect for damages …for nonconformities of the Contract Documents to… codes…

So, it pays to know...

or, it can cost you if you don't know.



Roof requirements

- Wind resistance
- Fire classification
- Installation requirements
- Prescriptive requirements
- Reroofing

Wind resistance

International Building Code, 2015 Edition, Sec. 1504-Performance Requirements

Built-up, modified bitumen, fully-adhered and mechanically attached single ply and metal panel roof systems applied over a deck:

- FM 4474: Class 60, Class 90, Class 120, etc.
- UL 580 or UL 1897: Class 30, Class 60, Class 90

FM classifications include a safety factor or 2.0, UL's classifications do not.

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Wind resistance

International Building Code, 2015 Edition, Sec. 1504-Performance Requirements

Ballasted single-ply membrane roof systems:

- ANSI/SPRI RP-4 and Table 1504.8 (windborne debris)

Structural metal panel roof systems applied over open framing:

- Concealed clips: FM 4474 or ASTM E1592
- Through-fastened: FM 4474, UL 580 or ASTM E1592

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Wind loads

International Building Code, 2015 Edition, Chapter 16—Structural Design

Design wind loads:

- IBC Chapter 16
- ASCE 7-10

IBC requires design wind loads to be shown in the Contract Documents (Sec. 1603)

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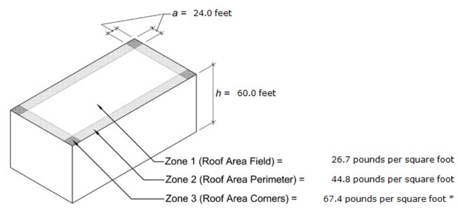
Design wind load determination

www.roofwinddesigner.com

Allowable Stress Design (ASD) Method:

Because ASD results sometimes are used to determine wind-uplift resistance values, a designer using ASCE 7-10 may want to adjust the strength design values to ASD values. In order to do so, applying a wind load factor of 0.6 to the strength design values may be appropriate. The ASD values determined for the roof area defined by this report are as follows:



* ASCE 7-10, Part 3: Buildings with h > 60 ft., permits the design wind loads in Zone 3 (roof area corners) to be reduced to the value for Zone 2 (roof area perimeter) when a minimum 36-inch high parapet occurs at the two outside edges of the specific corner area where the design wind load is being reduced.

Minimum Recommended Design Wind-resistance Loads

Accepted engineering principles provide for adding a reasonable "safety factor" to design wind-uplift loads in determining the minimum recommended design wind-resistance loads. This safety factor is intended to address normally anticipated variances in the materials and construction of the building, including the roof system, and any normally anticipated deterioration of the materials' physical properties because of aging.

Roof Wind Designer determines roof systems' minimum recommended design wind-resistance loads, which are derived from the building's design wind loads, taking into consideration a safety factor using ASTM D6630, "Standard Guide for Low Slope insulated Roof Membrane Assembly Performance." This recognized consensus standard indicates design wind-resistance loads shall have a minimum 2.0 safety factor from the design wind uplift loads determined using ASCE 7. However, for a roof assembly with a steel deck and a steel or aluminum metal panel roof system, Roof Wind Designer applies a safety factor of 1.67. This safety factor is recommended in AISI S100, "North American Specification for the Design of Cold-formed Steel Structural Members" and "Aluminum Design Manual: Part 1—Specification for Aluminum Structures" for bending.

On this basis, taking into consideration the ASD design wind-uplift loads, the minimum recommended design wind-resistance loads for the specific roof area and building identified in this report are as follows:

Zone 1 (roof area field):	53.4 pounds per square foot

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Fire classification

International Building Code, 2015 Edition, Sec. 1505-Fire Classification

Roof assemblies shall be tested and listed:

- Class A: Severe fire-exposure

  Exceptions: Brick, masonry, exposed concrete deck; metal shingles or sheets, tile or slate on non-combustible decks; and copper or slate on non-combustible decks

- Class B: Moderate fire-test exposure
- Class C: Light fire-test exposure

TABLE 1505.1[a, b]
MINIMUM ROOF COVERING CLASSIFICATION FOR TYPES OF CONSTRUCTION

IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB
B	B	B	C[c]	B	C[c]	B	B	C[c]

[Footnoted omitted for clarity]

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Installation requirements

International Building Code, 2015 Edition, Sec. 1506-Materials

"…Roof coverings shall be applied in accordance with this chapter and the manufacturer's installation instructions...."

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Prescriptive requirements

International Building Code, 2015 Edition, Sec. 1507-Requirements for Roof Coverings

- Deck
- Slope: ¼" per ft., ⅛" per ft. for coal tar BUR
- Material standards: Typically ASTM standards
- Installation

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Reroofing

International Building Code, 2015 Edition, Sec. 1511-Reroofing
IBC's previous editions: Sec. 1510-Reroofing

"…recovering or replacing an existing roof covering shall comply with the requirements of Chapter 15…."

Exceptions:

- Roof slope: "positive drainage" instead of ¼"per ft.
- Secondary roof drains: Not required

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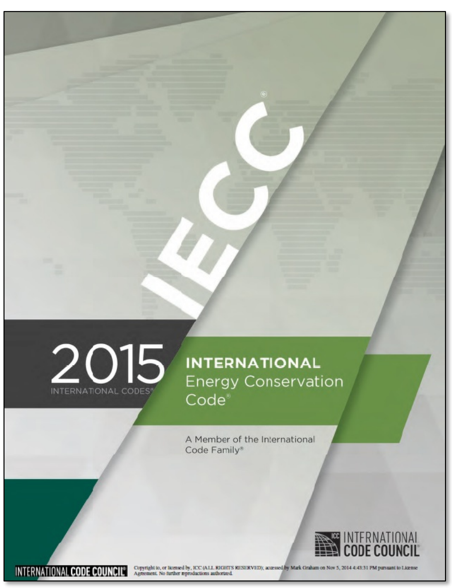
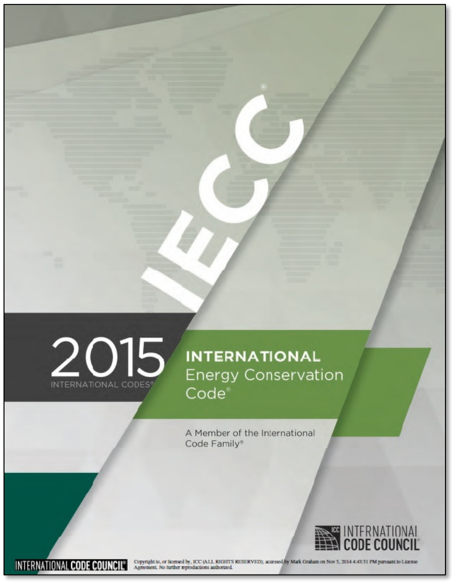


Roof requirements:

- R-value
- Roof reflectivity
- Air retarder



IECC 2015:

Commercial buildings:

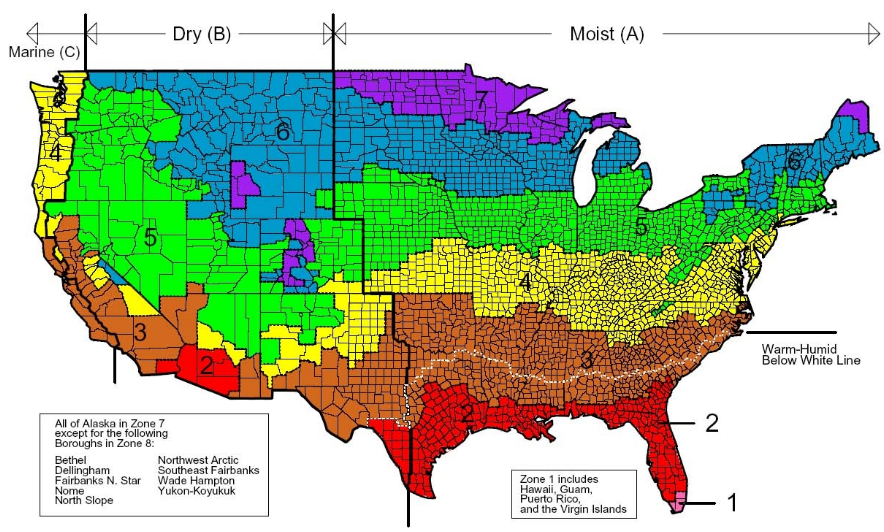
- All except "Residential Buildings"

Residential buildings:

- One- and two-family dwellings, multiple single-family dwellings and Group R-2, R-3 and R-4 buildings three stories or less

IECC 2015, Fig. C301.1-Climate zones

Fig. R301.1 (residential climate zones) is similar



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Minimum R-value

IECC 2015: Commercial Buildings (Insulation component R-value-based method)

<table>
<tr><th rowspan="2">Climate zone</th><th colspan="3">Assembly description</th></tr>
<tr><th>Insulation entirely above deck</th><th>Metal buildings</th><th>Attic and other</th></tr>
<tr><td>1</td><td>R-20ci (all other)
R-25ci (Group R)</td><td rowspan="5">R-19 + R-11 LS</td><td rowspan="3">R-38</td></tr>
<tr><td>2</td><td rowspan="2">R-25ci</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td rowspan="3">R-30ci</td><td>R-38
(except Marine 4)</td></tr>
<tr><td>5</td><td>R-38 (all other)
R-49 (Group R, Marine 4)</td></tr>
<tr><td>6</td><td>R-25 + R-11 LS</td><td rowspan="3">R-49</td></tr>
<tr><td>7</td><td rowspan="2">R-35ci</td><td rowspan="2">R-30 + R-11 LS</td></tr>
<tr><td>8</td></tr>
</table>

ci = Continuous insulation; LS = Liner system

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Comparison of IECC's various editions

Commercial Buildings (Insulation component R-value-based method)

<table>
<tr><th>Climate Zone</th><th>IECC 2006</th><th>IECC 2009</th><th>IECC 2012*</th><th>IECC 2015*</th></tr>
<tr><td>1</td><td rowspan="4">R-15 ci</td><td>R-15 ci</td><td rowspan="3">R-20 ci</td><td>R-20 ci</td></tr>
<tr><td>2</td><td rowspan="5">R-20ci</td><td rowspan="2">R-25 ci</td></tr>
<tr><td>3</td></tr>
<tr><td>4</td><td rowspan="3">R-25 ci</td><td rowspan="3">R-30 ci</td></tr>
<tr><td>5</td><td rowspan="2">R-20 ci</td></tr>
<tr><td>6</td></tr>
<tr><td>7</td><td rowspan="2">R-25 ci</td><td rowspan="2">R-25 ci</td><td rowspan="2">R-30 ci</td><td rowspan="2">R-35 ci</td></tr>
<tr><td>8</td></tr>
</table>

* Applies to roof replacement projects
ci = continuous insulation

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Reflectivity

International Energy Conservation Code, 2015 Edition (Commercial)

C402.3 Roof solar reflectance and thermal emittance. Low-sloped roofs directly above cooled conditioned spaces in Climate Zones 1, 2 and 3 shall comply with one or more of the options in Table C402.3.

Exceptions: [Refer to earlier "Cool and Green Roofs" presentation]

TABLE C402.3
MINIMUM ROOF REFLECTANCE AND EMITTNCE OPTIONS

Three-year solar reflectance of 0.55 and 3-year aged thermal emittance of 0.75
Three-year-aged solar reflectance index of 64

[Footnotes omitted for clarity]

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Air barrier

International Energy Conservation Code, 2015 Edition (Commercial), Sec. C402.5

"A continuous building envelope air barrier shall be provided throughout the building envelope…." (Except 2B)

Test methods:

- Whole building: Not greater than 0.40 cfm/ft^3
- Assembly: Not greater than 0.04 cfm/ft^3
- Material: Not greater than 0.004 cfm/ft^3
  - Deemed to comply: BUR, MB, adhered single ply and SPF

Air barrier not required in reroofing projects unless also recladding (IECC 2015 only: Sec. C502.4)

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Code compliance is becoming increasingly challenging and presents significant liability risks

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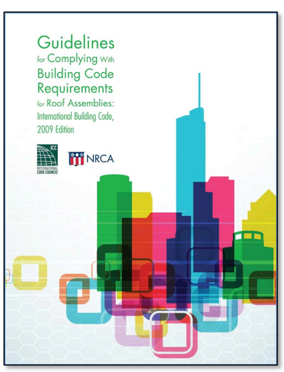
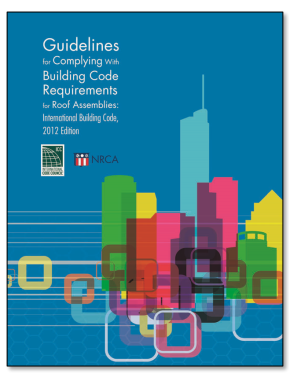
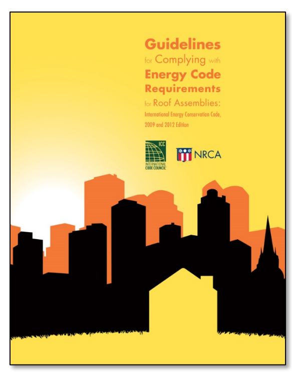
NRCA code manuals

shop.nrca.net or (866) ASK-NRCA







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