Low Slope Roofing Systems
The University of Wisconsin Madison
Madison, Wisconsin – December 2-4, 2015

Cool and Green Roofs

presented by

Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association
Rosemont, Illinois

Cool roofs

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For example…

NRCA-tested initial solar reflectivity values

EPDM membrane (black)

SR = 0.08

TPO membrane (white)

SR = 0.78

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Reflective roof ≈ "Cool" roof

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Benefits of cool roofs

- Energy savings
- Improved occupant comfort
- Reduction of urban heat islands effect and smog
- Global warming mitigation
- Comply with codes and green building programs

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What is a cool roof?

A cool roof's surface reflects and emits the sun's heat back to the sky instead of transferring it to the building below.

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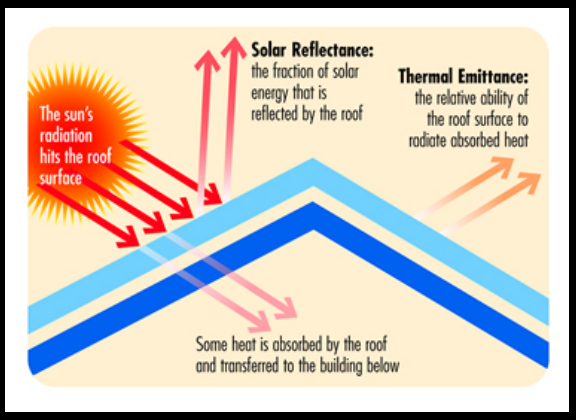

Courtesy of the Cool Roofs Rating Council

What is cool…?

"Coolness" is measured by two properties:

- Solar reflectivity
- Thermal emittance

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Definitions

Solar reflectance: The fraction of solar flux reflected by a surface expressed within the range of 0.00 and 1.00.

Thermal emittance: The ratio of radiant heat flux emitted by a surface to that emitted by a black body radiator at the same temperature expressed within a range of 0.00 to 1.00.

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Definitions – cont.

Solar reflectance index (SRI): The relative steady-state surface temperature of a surface with respect to the standard white (SRI = 100) and standard black (SRI = 0) under standard solar and ambient conditions.

--ASTM E 1980

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"Cool" recognition programs

- Energy Star® roof products program
- Cool Roofs Rating Council (CRRC)

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Energy Star® roof products program

www.energystar.gov

U.S. Environmental Protection Agency (EPA)
U.S. Department of Energy (DOE)

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Program criteria

Version 3.0

ENERGY STAR® Program Requirements for Roof Products

Partner Commitments

Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture and labeling of ENERGY STAR qualified products. The ENERGY STAR Partner must adhere to the following partner commitments:

Table 1 – Specifications for Low-Slope Roof Products	
Characteristic	**Performance Specification**
Solar Reflectance	
Initial Solar Reflectance	Greater than or equal to 0.65.
Maintenance of Solar Reflectance	Greater than or equal to 0.50 three years after installation under normal conditions.
Reliability	
Manufacturer warranty for defects in materials and manufacturing	Each company's warranty for ENERGY STAR qualified roof products shall be equal in all material respects to the product warranty offered by the same company for comparable non-ENERGY STAR qualified roof products. A company that sells only ENERGY STAR qualified roof products shall offer a warranty that is equal in all material respects to the standard industry warranty for comparable non-ENERGY STAR qualified roof products.

Verifying Ongoing Product Qualification

6. Participate in third-party verification testing through a Certification Body recognized by EPA for roof products, providing full cooperation and timely responses. EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR qualified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

Providing Information to EPA

7. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:

Program criteria

Version 3.0

ENERGY STAR® Program Requirements for Roof Products

Partner Commitments

Following are the terms of the ENERGY STAR Partnership Agreement as it pertains to the manufacture and labeling of ENERGY STAR qualified products. The ENERGY STAR Partner must adhere to the following partner commitments:

Table 2 – Specifications for Steep-Slope Roof Products	
Characteristic	**Performance Specification**
Energy Efficiency Levels	
Initial Solar Reflectance	Greater than or equal to 0.25.
Maintenance of Solar Reflectance	Greater than or equal to 0.15 three years after installation under normal conditions.
Reliability	
Manufacturer warranty for defects in materials and manufacturing	Each company's warranty for ENERGY STAR qualified roof products shall be equal in all material respects to the product warranty offered by the same company for comparable non-ENERGY STAR qualified roof membrane products. A company that sells only ENERGY STAR qualified roof products shall offer a warranty that is equal in all material respects to the standard industry warranty for comparable non-ENERGY STAR qualified roof products.

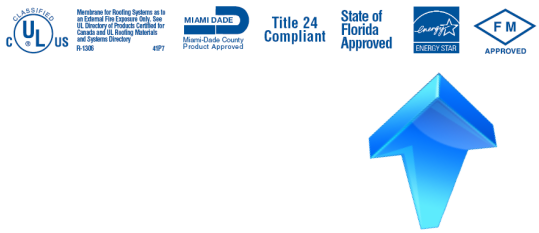
Verifying Ongoing Product Qualification

6. Participate in third-party verification testing through a Certification Body recognized by EPA for roof products, providing full cooperation and timely responses. EPA/DOE may also, at its discretion, conduct tests on products that are referred to as ENERGY STAR qualified. These products may be obtained on the open market, or voluntarily supplied by Partner at the government's request.

Providing Information to EPA

7. Provide unit shipment data or other market indicators to EPA annually to assist with creation of ENERGY STAR market penetration estimates, as follows:

Products complying with the Energy Star® criteria are eligible to use the Energy Star ® logo



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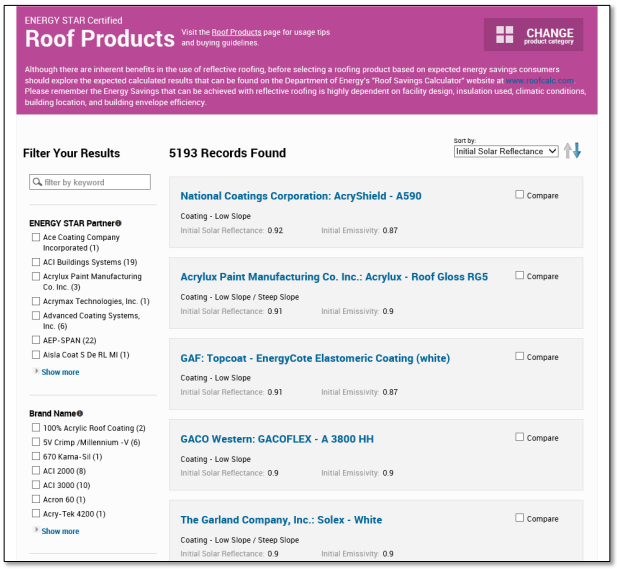
Energy Star® roof products program

www.energystar.gov/productfinder



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Cool Roof Rating Council (CRRC)

www.coolroofs.org

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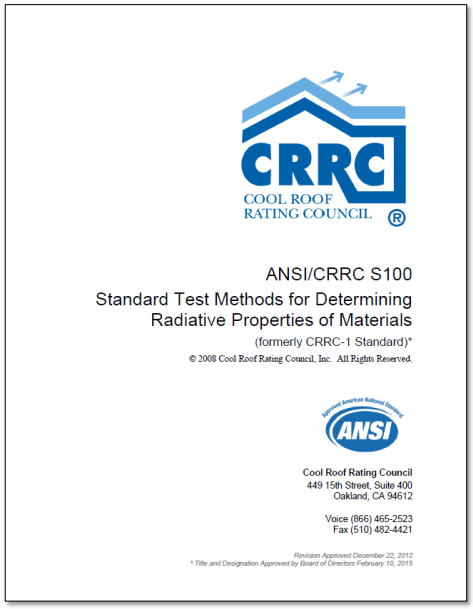
CRRC documents



ANSI/CRRC S100

Standard Test Methods for Determining Radiative Properties of Materials

(formerly CRRC-1 Standard)*

Cool Roof Rating Council
449 15th Street, Suite 400
Oakland, CA 94612

Voice (866) 465-2523
Fax (510) 482-4421

Revision Approved December 22, 2012
* Title and Designation Approved by Board of Directors February 10, 2015

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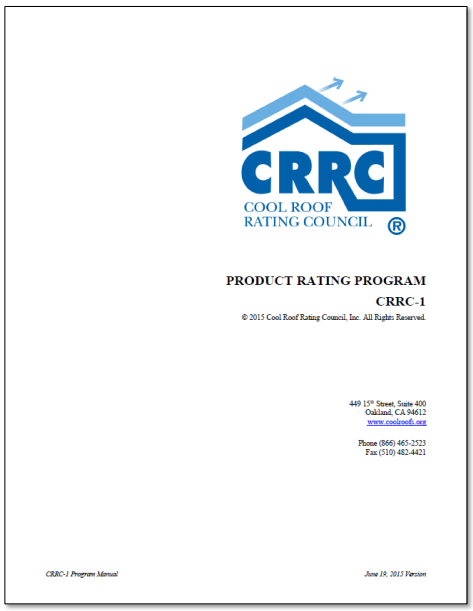
CRRC documents



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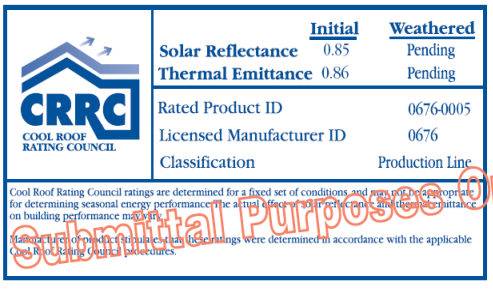
Cool Roofs Rating Council

www.coolroofs.org

Products complying with CRRC's criteria are eligible to use their label



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CRRC-rated products directory

www.coolroofs.org/

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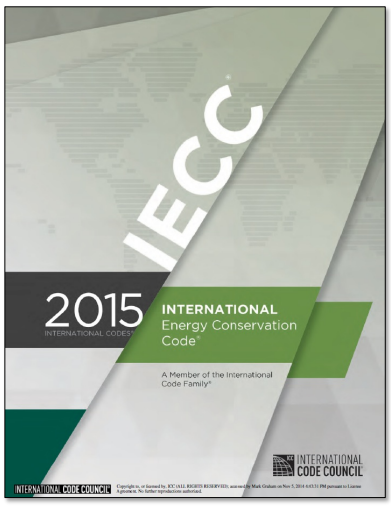
Code requirements for cool roofs



Energy code:

- Commercial (non-Residential) buildings
- Climate Zones 1-3

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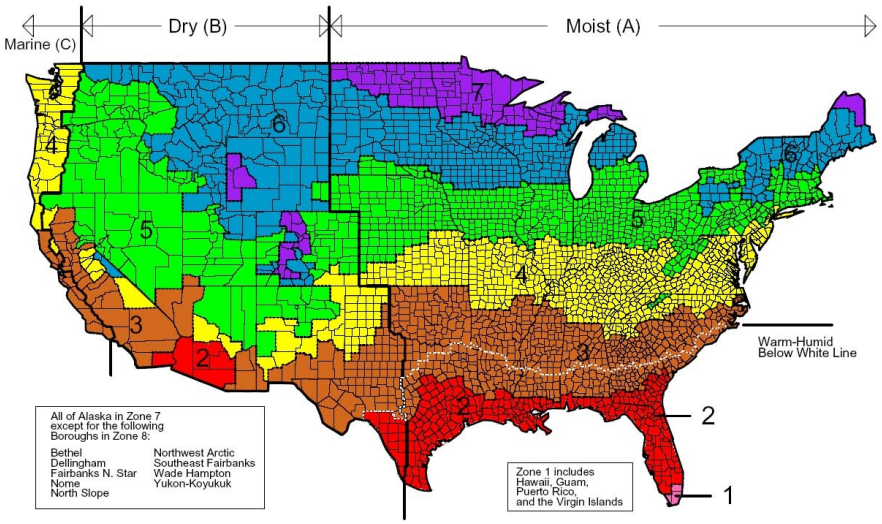
IECC 2015, Fig. C301.1-Climate zones

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



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Ch. 4[CE]-Commercial energy efficiency

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: [next slide]

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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Ch. 4[CE]-Commercial energy efficiency

Exceptions: The following roofs and portions of roofs are exempt from the requirements of Table C402.3:

1. Portions of the roof that include or are covered by the following:
   - 1.1. Photovoltaic systems or components.
   - 1.2. Solar air or water-heating systems or components.
   - 1.3. Roof gardens or landscaped roofs.
   - 1.4. Above-roof decks or walkways.
   - 1.5. Skylights.
   - 1.6. HVAC systems and components, and other opaque objects mounted above the roof.
2. Portions of the roof shaded during the peak sun angle on the summer solstice by permanent features of the building or by permanent features of adjacent buildings. [Continued…]

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Ch. 4[CE]-Commercial energy efficiency

3. Portions of roofs that are ballasted with a minimum stone ballast of 17 pounds per square foot [74 kg/m^2] or 23 psf [117 kg/m^2] pavers.
4. Roofs where not less than 75 percent of the roof area complies with one or more of the exceptions to this section.

C402.3.1 Aged roof solar reflectance. Where an aged solar reflectance required by Section C402.3 is not available, it shall be determined in accordance with Equation 4-3.

$$R_{aged} = [0.2+0.7(R_{initial} - 0.2)] \quad \textbf{(Equation 4-3)}$$

where:

R_{aged} = The aged solar reflectance.

$R_{initial}$ = The initial solar reflectance determined in accordance with CRRC-1.

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Some cool roofs research

- ASHRAE Cool Roofs Conference
- SIUE rooftop thermal comparison study
- ASTM Symposium/Chicago 5-year study

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ASHRAE cool roofs conference

May 13, 2005 – Atlanta, GA

Table 1: Solar Reflectance (SR) of Existing Chicago Roofs*

Age (years)	Description	SR (percentage)
15	Aggregate-surfaced BUR	25.3
22+	Aggregate-surfaced BUR w/ Heavy Ponding	16.3
22+	Aggregate-surfaced BUR w/ Blisters	15.5
10+	Aggregate-surfaced BUR	27.8
15+	Aggregate-surfaced BUR	17.1
10-15	Aggregate-surfaced BUR	19.7
10-15	Aggregate-surfaced BUR	19.3
3 Months	Smooth-surfaced APP – Fibrated AL 2:12 slope	57.7
13	Slate-surfaced APP	14.4
13	Slate-surfaced APP w/ 50 percent granule loss	8.7
13	Slate-surfaced APP w/ 90 percent granule loss	5.5
3	AL coated APP w/4:12 slope	25.9
1	45-mil Reinforced EPDM	10.3
1	45-mil Reinforced EPDM at dust in ponded areas	29.5
10	Ballasted EPDM	26.9
10	Beige concrete pavers	44.5
1 Week	White-coated CSPE	72.6
1	White granule-surfaced modified bitumen	30.5
4	Smooth-surfaced SBS – Fibrated AL coating	54.7
4	Smooth-surfaced SBS – Fibrated thin AL coating	39.7
6	Smooth-surfaced APP – Non-fibrated AL coating	45.6
8	Smooth-surfaced APP – Tan granules 3:12 slope	25.1
8	Smooth-surfaced APP – Tan granules at laps	16.2

* Measured by the D & S method, known as ASTM C1549, "Standard Test Method for Determination of Solar Reflectance Near Ambient Temperature Using a Portable Solar Reflectometer".

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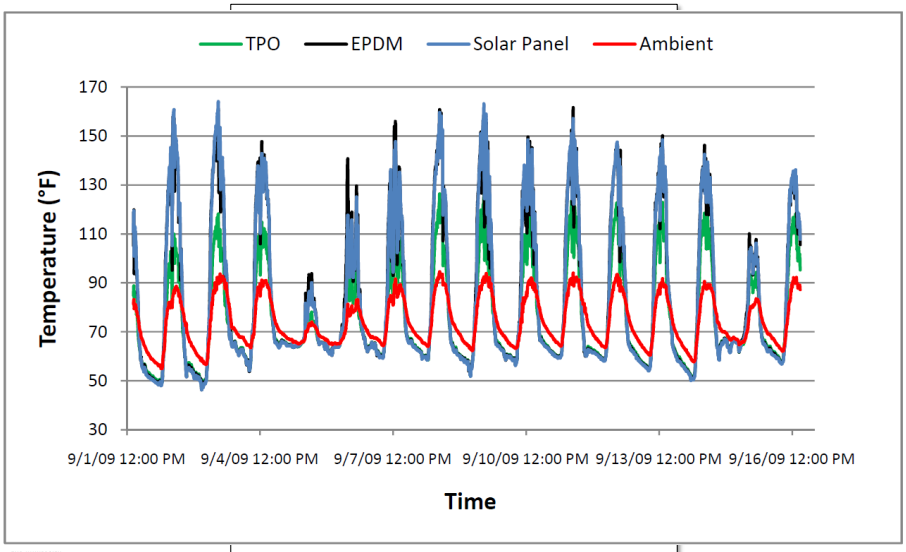
SIUE rooftop thermal comparison study

2008-09 – Edwardsville, IL



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Chicago roof reflectivity study

- Funded by the Roofing Industry Alliance for Progress
- Conducted by NRCA with assistance from the Chicago Roofing Contractors Association (CRCA)
- Annual reflectivity measurements on 34 roofs over a five year period
  - 36 other roofs with partial measurement histories
- Report to be presented as a peer-reviewed paper at an ASTM Committee D08 symposium (STP 1590)

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Vegetative Roof Systems

Sometimes called "green roofs"

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Definition

The NRCA Vegetative Roof Systems Manual, Second Edition

Vegetative roof system: A roof area of planting/landscaping installed above a waterproofed substrate at any building level that is over habitable space.

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Ford
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Benefits of vegetative roofs

- Aesthetic improvement
- Storm water management
- Mitigation of heat island effect
- Energy efficiency
- Air quality improvement
- Noise reduction
- Increased roof system durability
- LEED® credit
- Rebates and other incentives

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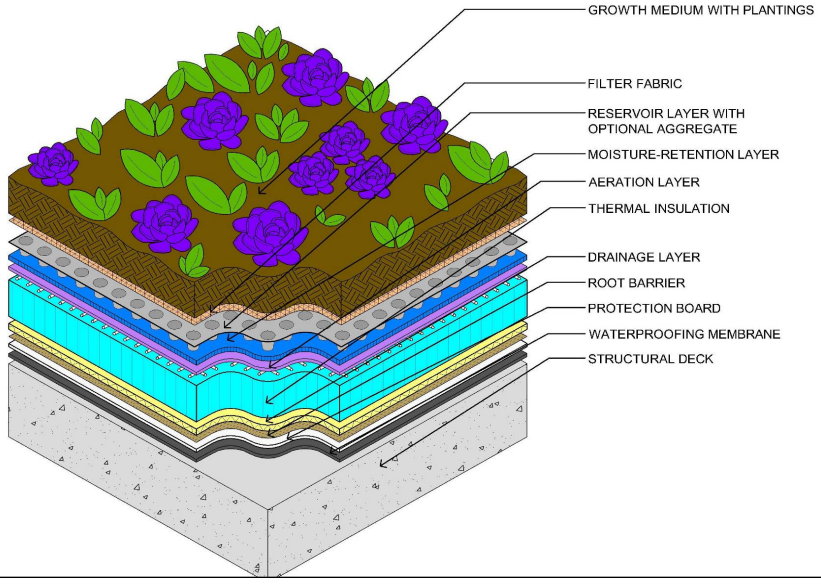
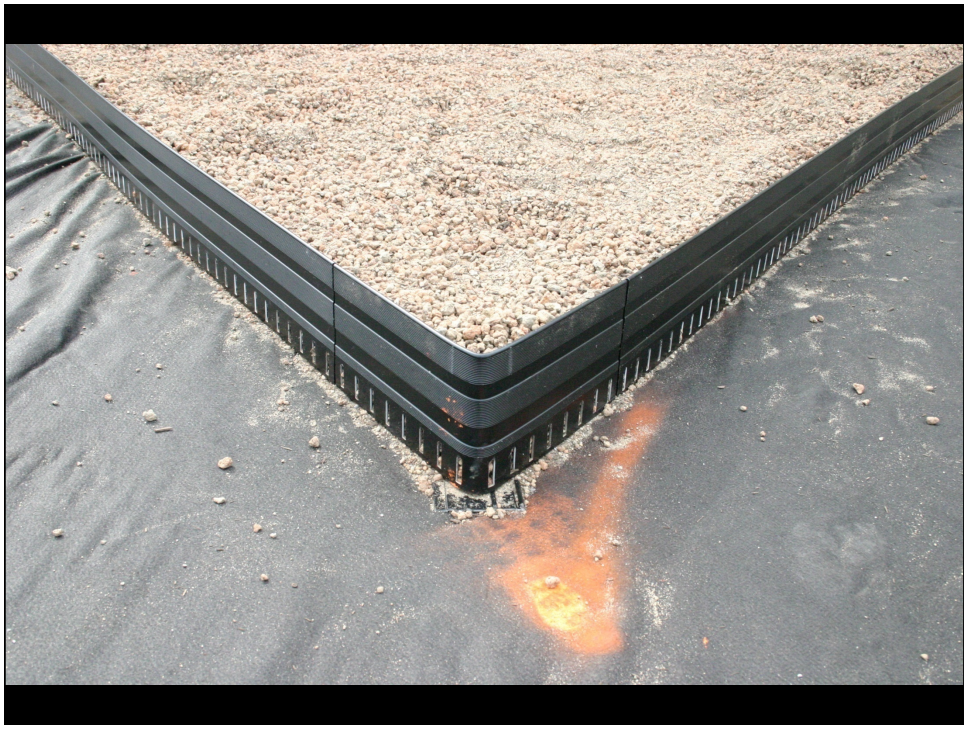
Basic configurations

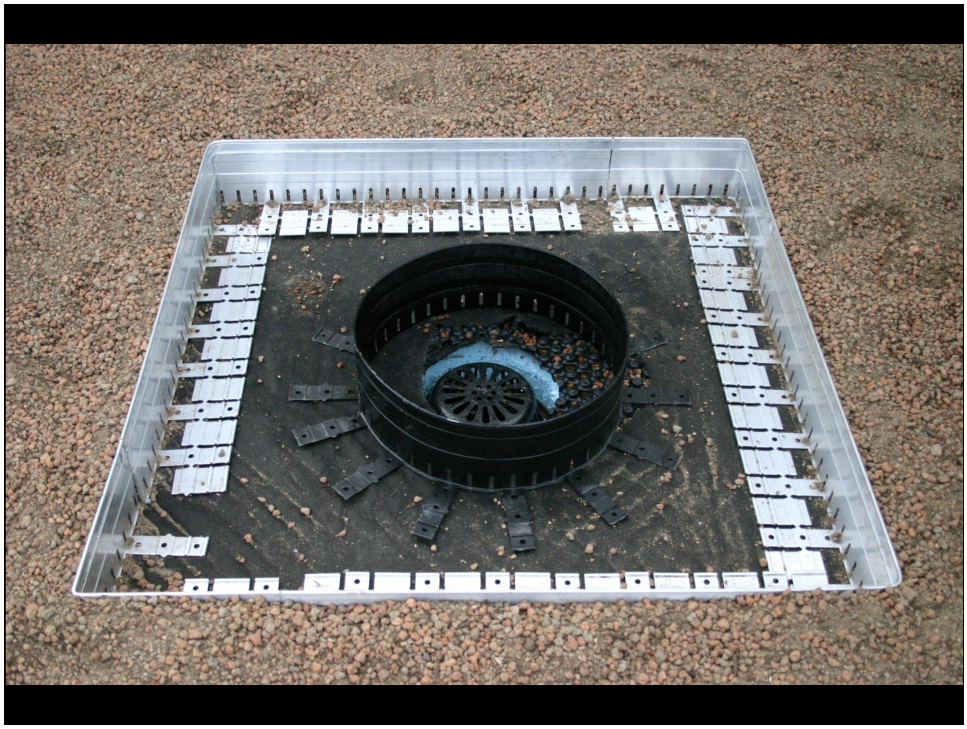
- Modular systems
- Built-in-place systems

Built-in-place System



Construction Details for Vegetative Roof Systems





Membrane Integrity Testing

- Flood test
- Flowing water test
- Electronic field vector mapping

Vegetative roof systems
require regular maintenance

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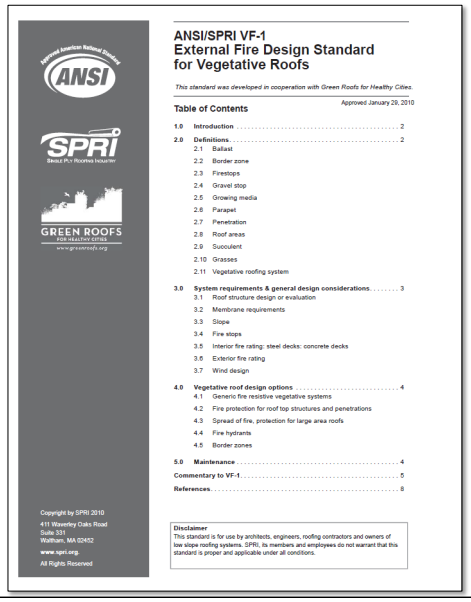
Deign standards -- ANSI/SPRI VF-1

www.spri.org



ANSI/SPRI VF-1
External Fire Design Standard for Vegetative Roofs

This standard was developed in cooperation with Green Roofs for Healthy Cities.

Approved January 29, 2010

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Disclaimer
This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

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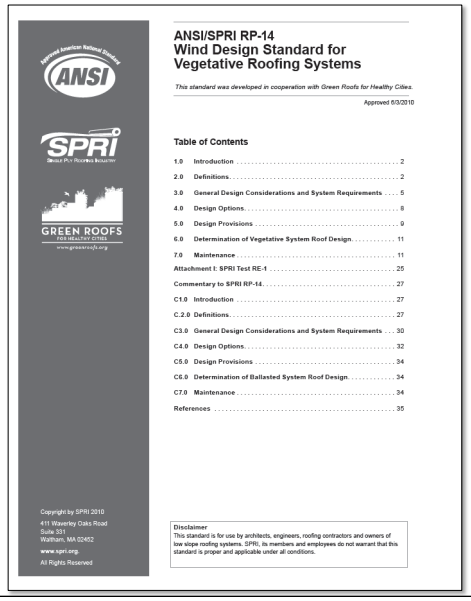
Design standards -- ANSI/SPRI RP-14

www.spri.org



ANSI/SPRI RP-14
Wind Design Standard for Vegetative Roofing Systems

This standard was developed in cooperation with Green Roofs for Healthy Cities.

Approved 6/3/2010

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Disclaimer
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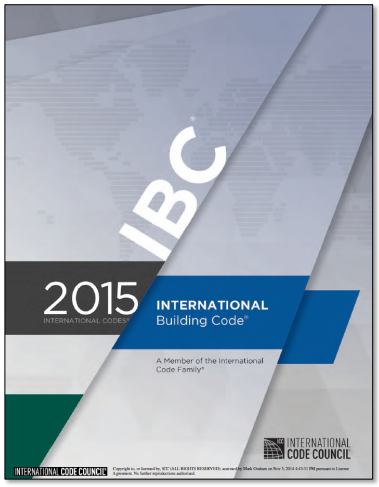
Code requirements for vegetative roofs



IBC 2015:

Ch. 15: Roofing

- Sec. 1511: Reroofing

Ch. 13: Energy efficiency

- References IECC 2015

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Code requirements

International Building Code, 2015 Edition

1507.16 Vegetative roofs, roof gardens and landscaped roofs. *Vegetative roofs*, roof gardens and landscaped roofs shall comply with the requirements of this chapter, Sections 1607.12.3 and 1607.12.3.1 and the *International Fire Code*.

[BF] 1507.16.1 Structural fire resistance. The structural frame and roof construction supporting the load imposed upon the roof by the *vegetative roof*, roof gardens or landscaped roofs shall comply with the requirements of Table 601.

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Code requirements

International Building Code, 2015 Edition

Sec. 202-Definitions

VEGETATIVE ROOF. An assembly of interacting components designed to waterproof and normally insulate a building's top surface that includes, by design, vegetation and related landscape elements.

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Code requirements

International Building Code, 2015 Edition

Sec. 1505-Fire Classification

1505.10 Roof gardens and landscaped roofs. Roof gardens and landscaped roofs shall comply with **[IBC 2018: Section 1505.1,]** Section 1507.16 and shall be installed in accordance with ANSI/ SPRI VF-1.

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Code requirements

International Building Code, 2015 Edition

1607.12.3 Occupiable roofs. Areas of roofs that are occupiable, such as *vegetative roofs*, roof gardens or for assembly or other similar purposes, and marquees are permitted to have their uniformly distributed live loads reduced in accordance with Section 1607.10.

1607.12.3.1 Vegetative and landscaped roofs. The weight of all landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil as determined in accordance with ASTM E 2397. The uniform design live load in unoccupied landscaped areas on roofs shall be 20 psf (0.958 kN/m^2). The uniform design live load for occupied landscaped areas on roofs shall be determined in accordance with Table 1607.1.

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Code requirements

International Building Code, 2015 Edition

1607.12.3 Occupiable roofs. Areas of roofs that are occupiable, such as *vegetative roofs*, roof gardens or for assembly or other similar purposes, and marquees are permitted to have their uniformly distributed live loads reduced in accordance with Section 1607.10.

1607.12.3.1 Vegetative and landscaped roofs. The weight of all landscaping materials shall be considered as dead load and shall be computed on the basis of saturation of the soil as determined in accordance with ASTM E 2397. The uniform design live load in unoccupied landscaped areas on roofs shall be 20 psf (0.958 kN/m^2). The uniform design live load for occupied landscaped areas on roofs shall be determined in accordance with Table 1607.1.

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Code requirements

International Building Code, 2015 Edition

Excerpts from TABLE 1607.1

MINIMUM UNIFORMLY DISTRIBUTED LOADS, L_o,

AND MINIMUM CONCENTRATED LIVE LOADS[g]

OCCUPANCY OR USE	UNIFORM (psf)	CONCENTRATED (psf)
26. Roofs		
[some text omitted for clarity]		
Ordinary flat, pitched, and curved roofs (that are not occupiable)		
[some text omitted for clarity]	20	
Occupiable roofs:		
Roof gardens	100	
Assembly areas	100[m]	
All other similar areas	Note 1	Note 1

[Footnotes omitted for clarity]

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Code compliance for vegetative roof systems is a challenge

--Mark Graham

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Some useful references...

Vegetative roof systems

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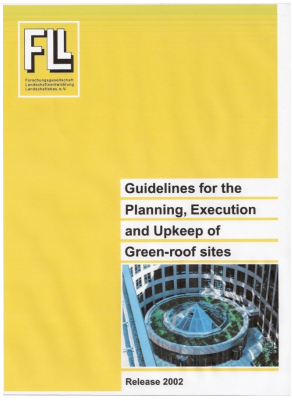
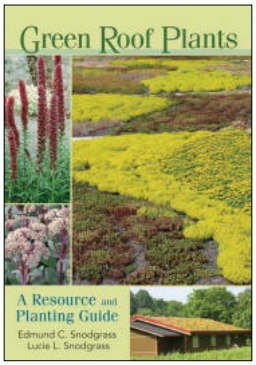
FLL, "Guidelines for the Planning, Execution and Upkeep of Green-roof sites"



The NRCA Vegetative Roof Systems Manual, Second Edition

Green Roof Plants

Authors: Edmund C. Snodgrass & Lucie L. Snodgrass



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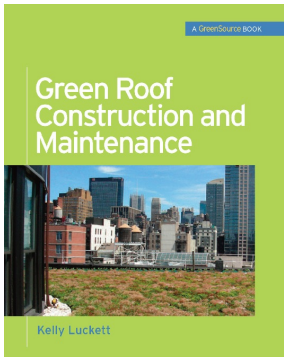
Green Roof Construction and Maintenance

Author: Kelly Luckett



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www.greenroofs.com

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Incentive programs

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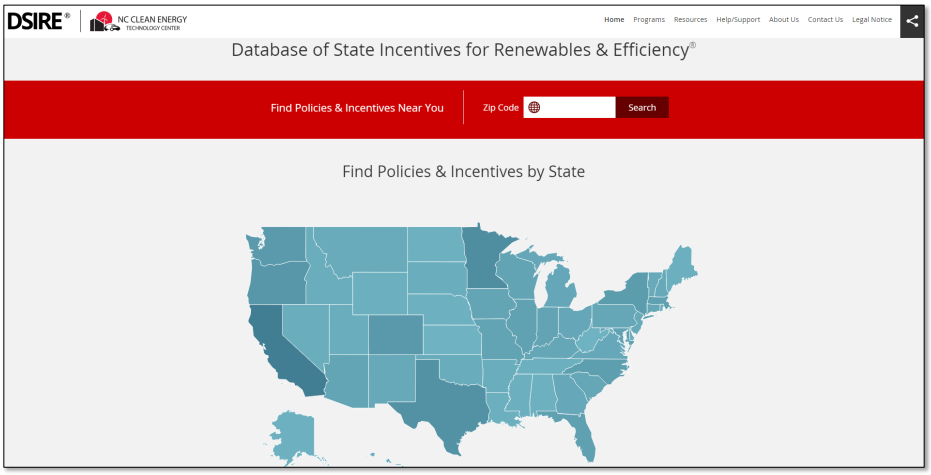
www.dsireusa.org



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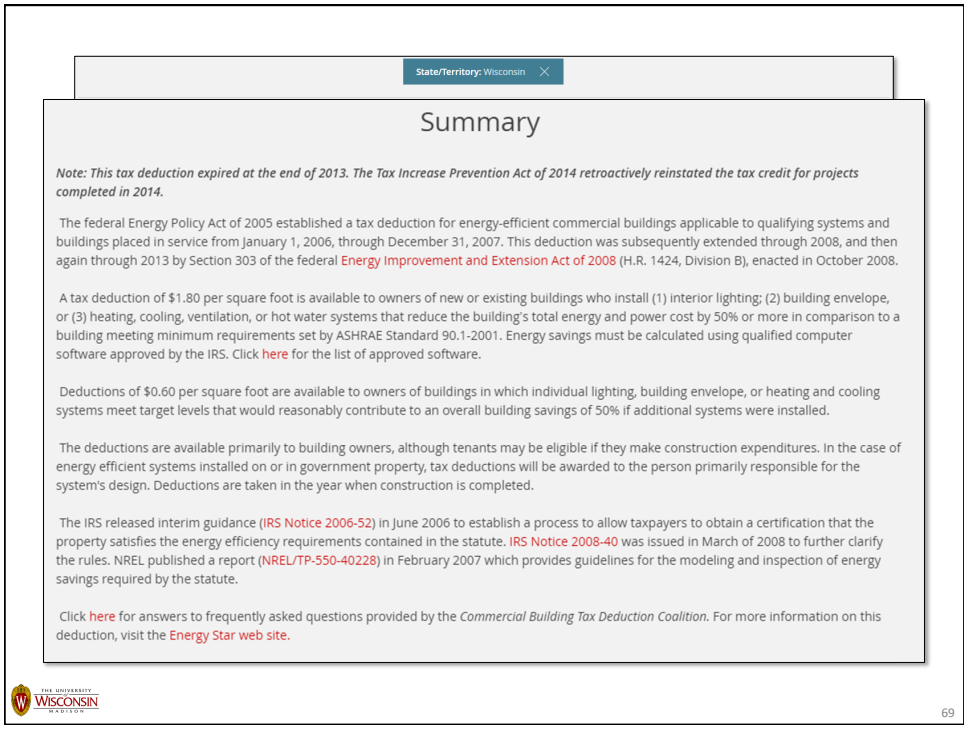

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