



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



For example...

NRCA-tested initial solar reflectivity values



EPDM membrane (black)

SR = 0.08



TPO membrane (white)

SR = 0.78



3

Reflective roof ≈ “Cool” roof



4

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



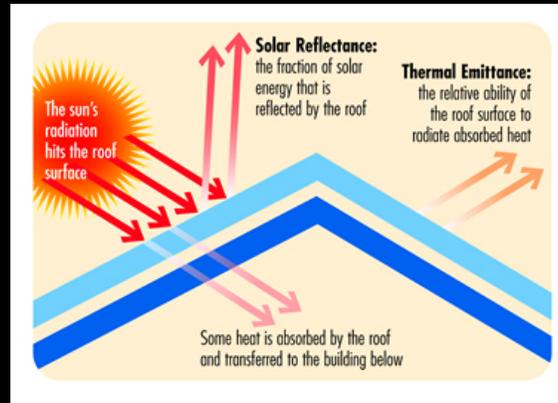
5

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.



6



Courtesy of the Cool Roofs Rating Council

What is cool...?

“Coolness” is measured by two properties:

- Solar reflectivity
- Thermal emittance

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.



9

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



10

“Cool” recognition programs

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



11

Energy Star® roof products program

www.energystar.gov



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



12

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:

ENERGY STAR Program Requirements for Roof Products – Partner Commitments 1


13

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:

ENERGY STAR Program Requirements for Roof Products – Partner Commitments 1


14

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



15

Energy Star® roof products program

www.energystar.gov/productfinder

ENERGY STAR Certified
Roof Products Visit the Roof Products page for usage tips and buying guidelines. CHANGE product category

Although there are inherent benefits in the use of reflective roofing, before selecting a roofing product based on expected energy savings consumers should explore the expected calculated results that can be found on the Department of Energy's "Roof Savings Calculator" website at www.doehp.nc.gov. Please remember the Energy Savings that can be achieved with reflective roofing is highly dependent on facility design, insulation used, climatic conditions, building location, and building envelope efficiency.

Filter Your Results **5193 Records Found** Sort by: Initial Solar Reflectance

filter by keyword

ENERGY STAR Partner®

- Ace Coating Company Incorporated (1)
- ACI Buildings Systems (19)
- Acrylox Paint Manufacturing Co. Inc. (3)
- Acrymax Technologies, Inc. (1)
- Advanced Coating Systems, Inc. (5)
- AEP-SPAN (23)
- Asia Coat S De RL MI (1)

[Show more](#)

Brand Name®

- 100% Acrylic Roof Coating (2)
- 5V Crimp/Millennium -V (6)
- 670 Karma-Sil (1)
- ACI 2000 (8)
- ACI 2000 (19)
- Acron 60 (1)
- Acry-Tek 4200 (1)

[Show more](#)

National Coatings Corporation: AcryShield - A590	<input type="checkbox"/> Compare
Coating - Low Slope Initial Solar Reflectance: 0.92 Initial Emissivity: 0.87	
Acrylux Paint Manufacturing Co. Inc.: Acrylux - Roof Gloss RG5	<input type="checkbox"/> Compare
Coating - Low Slope / Steep Slope Initial Solar Reflectance: 0.91 Initial Emissivity: 0.9	
GAF: Topcoat - EnergyCote Elastomeric Coating (white)	<input type="checkbox"/> Compare
Coating - Low Slope Initial Solar Reflectance: 0.91 Initial Emissivity: 0.87	
GACO Western: GACOFLEX - A 3800 HH	<input type="checkbox"/> Compare
Coating - Low Slope Initial Solar Reflectance: 0.9 Initial Emissivity: 0.9	
The Garland Company, Inc.: Solex - White	<input type="checkbox"/> Compare
Coating - Low Slope / Steep Slope Initial Solar Reflectance: 0.9 Initial Emissivity: 0.9	



16

Cool Roof Rating Council (CRRC)
www.coolroofs.org



17

CRRC documents



ANSI/CRRC S100
Standard Test Methods for Determining
Radiative Properties of Materials
(formerly CRRC-1 Standard)*
© 2008 Cool Roof Rating Council, Inc. All Rights Reserved.



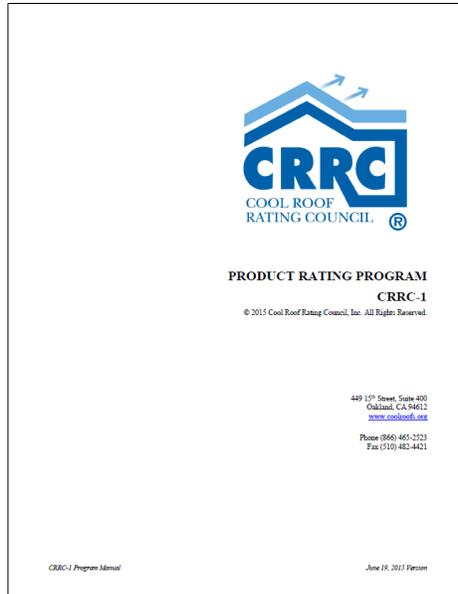
Cool Roof Rating Council
449 15th Street, Suite 400
Oakland, CA 94612
Voice (866) 465-2523
Fax (510) 462-4421

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



18

CRRC documents



Cool Roofs Rating Council

www.coolroofs.org

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

	<u>Initial</u>	<u>Weathered</u>	
	Solar Reflectance	0.85	Pending
	Thermal Emittance	0.86	Pending
	Rated Product ID	0676-0005	
	Licensed Manufacturer ID	0676	
Classification	Production Line		
Cool Roof Rating Council ratings are determined for a fixed set of conditions and are not representative for determining seasonal energy performance. The actual effect on energy performance and thermal emittance on building performance may differ. Manufacturer of product should ensure that their ratings were determined in accordance with the applicable Cool Roof Rating Council procedures.			

For Submittal Purposes Only



CRRC-rated products directory

www.coolroofs.org/

The screenshot shows the CRRC-rated products directory website. It features a navigation menu with options like HOME, ABOUT CRRC, RESOURCES, MEMBERS, PRODUCT RATING, and RATED PRODUCTS DIRECTORY. A search bar is at the top left. Below it are several filter categories: Product Type, Color, Minimum Radiative Properties, Slope (All, Low, Steep), Manufacturer, Brand, Model, and Product Market. A list of product types is displayed, including Asphalt Shingles, Built-Up and Modified Bitumen, Sheet Roofing, Concrete/Clay Tile and Slates, Field-Applied Coatings, Fluid Applied Membrane Roofing, Metal Products, Metal Shakes/Shingles (including Granular Coated Metal), Polymer/Composite Steep-Slope Products, Roof Pavers, Single Ply Thermoplastic and Thermoset Roofing, Spray Polyurethane Foam Roof Products, Stone Aggregate/Ballast Products, and Wood Shakes/Shingles. Below the filters, it shows '2608 SEARCH RESULTS' and a table of results.

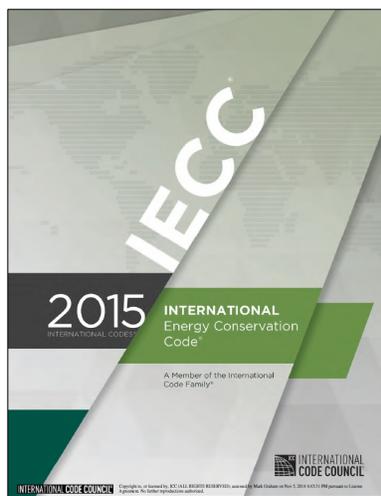
2608 SEARCH RESULTS
Selected filters

*CRRC Rapid Ratings: These are interim laboratory-aged values that simulate weathered values. These values will be replaced with the measured three-year aged values upon completion of the weathering process. SRI values calculated using Rapid Ratings may change once the aged rating replaces the Interim rating.

CRRC PROD. ID	MANUFACTURER, BRAND MODEL	PRODUCT TYPE	COLOR	SOLAR REFLECTANCE		THERMAL EMITTANCE		SRI		MORE INFO
				Initial	3 year	Initial	3 year	Initial	3 year	
0986-0004	A-1 Grl Company, Arctic White	Other Roof Products:	Bright White	0.73	0.56	0.92	0.90	91	67	

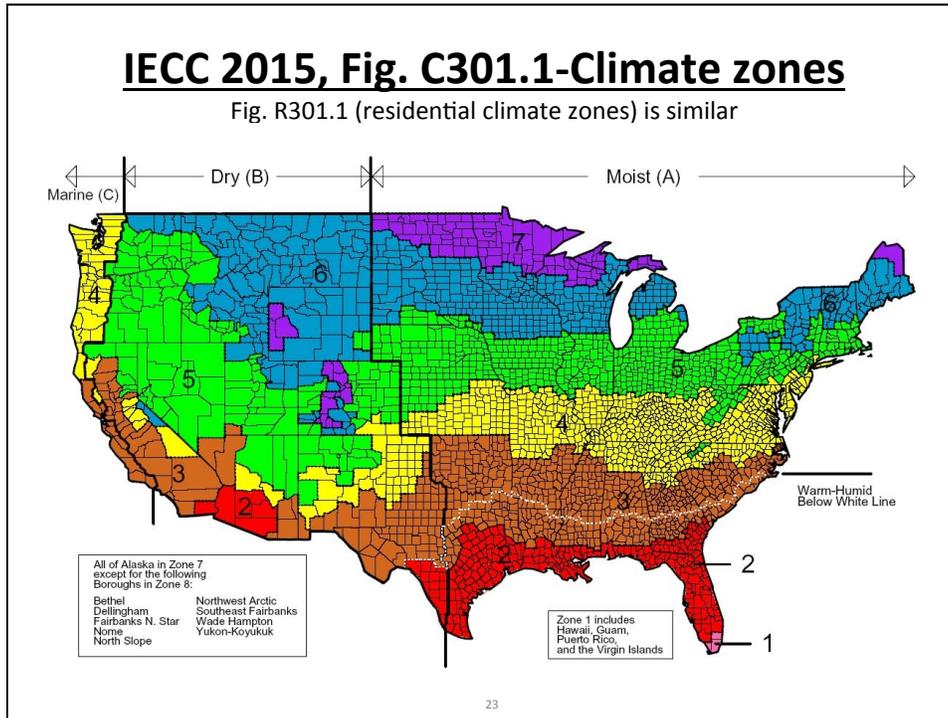


Code requirements for cool roofs



Energy code:

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



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 EMITTANCE 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]

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...]



25

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/m²] or 23 psf [117 kg/m²] 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.

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

where:

R_{aged} = The aged solar reflectance.

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



26

Some cool roofs research

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



27

ASHRAE cool roofs conference

May 13, 2005 – Atlanta, GA

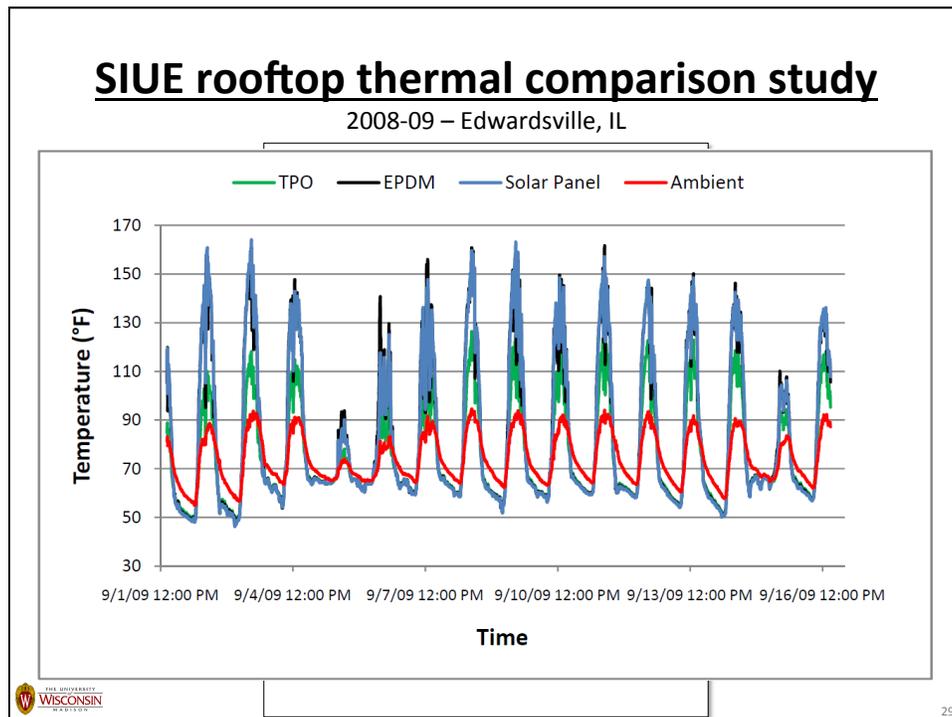
Table 1: Solar Reflectance (SR) of Existing Chicago Roofs*

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-ml Reinforced EPDM	10.3
1	45-ml 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".



28



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)

Vegetative Roof Systems
Sometimes called “green roofs”



31

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.



32







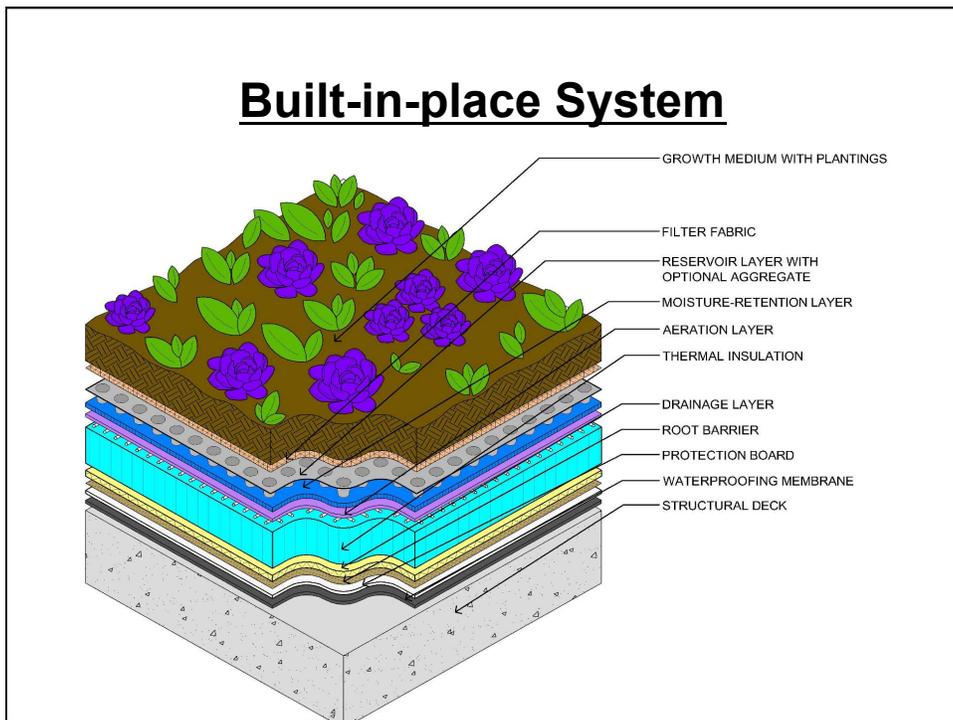
Benefits of vegetative roofs

- 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

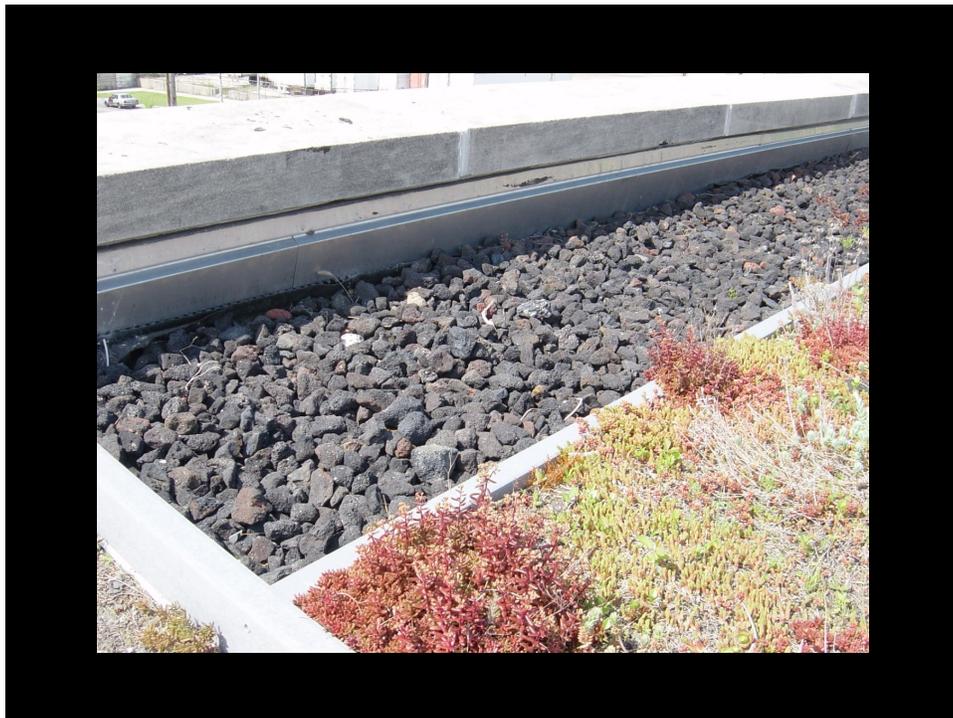
Basic configurations

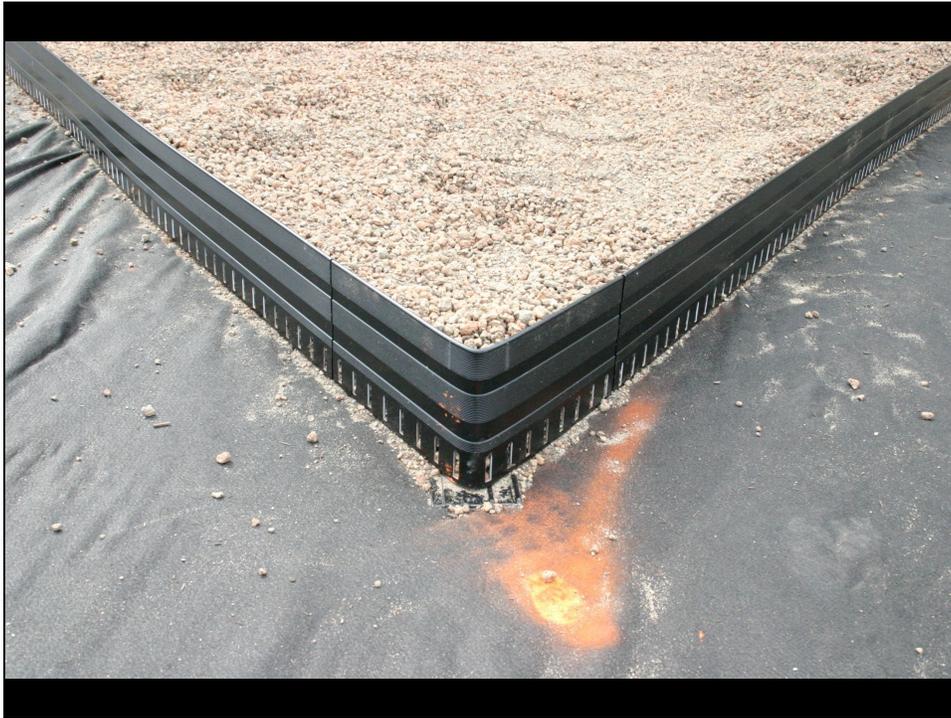
- Modular systems
- Built-in-place systems

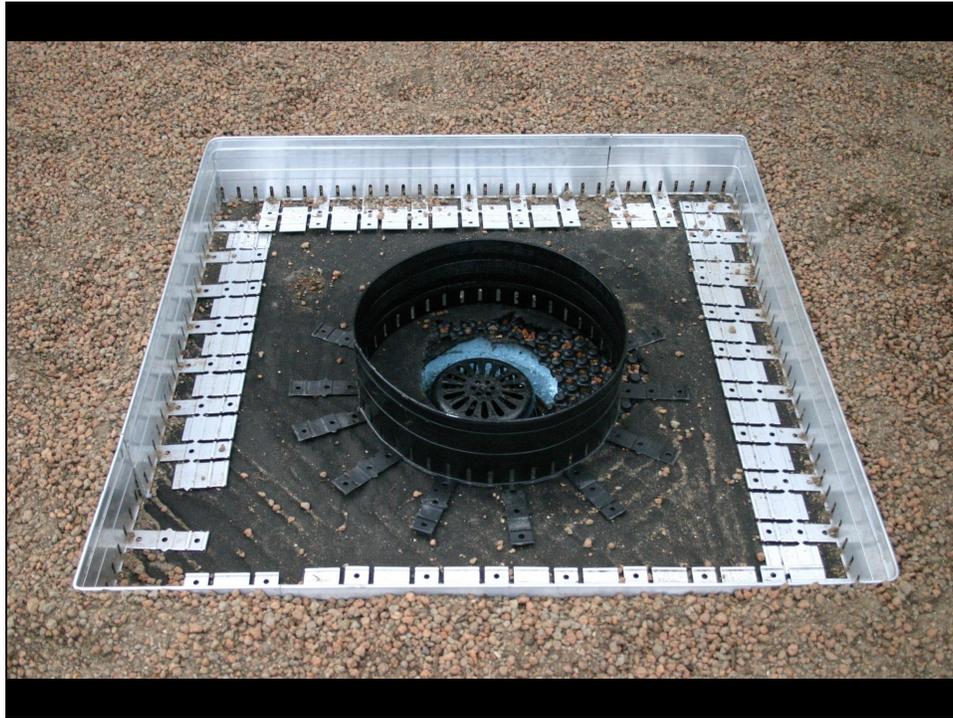




Construction Details
for Vegetative Roof Systems







Membrane Integrity Testing

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



Vegetative roof systems
require regular maintenance



Design standards -- ANSI/SPRI VF-1

www.spri.org





Copyright by SPRI 2010
411 Waverly Oaks Road
Suite 201
Waltham, MA 02452
www.spri.org
All Rights Reserved

**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 26, 2010

Table of Contents

1.0 Introduction	2
2.0 Definitions	2
2.1 Balises	2
2.2 Border zone	2
2.3 Firestops	2
2.4 Gravel stop	2
2.5 Growing media	2
2.6 Parapet	2
2.7 Penetration	2
2.8 Roof areas	2
2.9 Succulent	2
2.10 Grasses	2
2.11 Vegetative roofing system	2
3.0 System requirements & general design considerations	3
3.1 Roof structure design or evaluation	3
3.2 Maintenance requirements	3
3.3 Slope	3
3.4 Fire stops	3
3.5 Interior fire rating: steel decks; concrete decks	3
3.6 Exterior fire rating	3
3.7 Wind design	3
4.0 Vegetative roof design options	4
4.1 Generic fire resistive vegetative systems	4
4.2 Fire protection for roof top structures and penetrations	4
4.3 Spread of fire, protection for large area roofs	4
4.4 Fire hydrants	4
4.5 Border zones	4
5.0 Maintenance	4
Commentary to VF-1	5
References	8

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.

51

Design standards -- ANSI/SPRI RP-14

www.spri.org





Copyright by SPRI 2010
411 Waverly Oaks Road
Suite 201
Waltham, MA 02452
www.spri.org
All Rights Reserved

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

This standard was developed in cooperation with Green Roofs for Healthy Cities.
Approved 9/3/2010

Table of Contents

1.0 Introduction	2
2.0 Definitions	2
3.0 General Design Considerations and System Requirements	5
4.0 Design Options	8
5.0 Design Provisions	9
6.0 Determination of Vegetative System Roof Design	11
7.0 Maintenance	11
Attachment I: SPRI Test RE-1	25
Commentary to SPRI RP-14	27
C.1.0 Introduction	27
C.2.0 Definitions	27
C.3.0 General Design Considerations and System Requirements	30
C.4.0 Design Options	32
C.5.0 Design Provisions	34
C.6.0 Determination of Ballasted System Roof Design	34
C.7.0 Maintenance	34
References	35

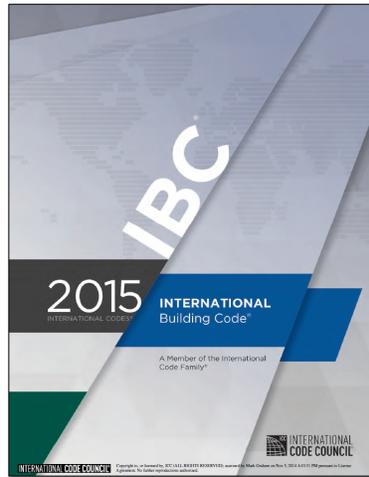
Disclaimer
This standard is for use by architects, engineers, roofing contractors and owners of low slope roofing systems. SPRI, its members and employees do not warrant that this standard is proper and applicable under all conditions.

52

UW-Madison--Low Slope Roofing Systems

December 2-4, 2015

Code requirements for vegetative roofs



IBC 2015:

Ch. 15: Roofing

- Sec. 1511: Reroofing
- Ch. 13: Energy efficiency
- References IECC 2015

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.

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.



55

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.



56

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/m²). The uniform design live load for occupied landscaped areas on roofs shall be determined in accordance with Table 1607.1.



57

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/m²). The uniform design live load for occupied landscaped areas on roofs shall be determined in accordance with Table 1607.1.



58

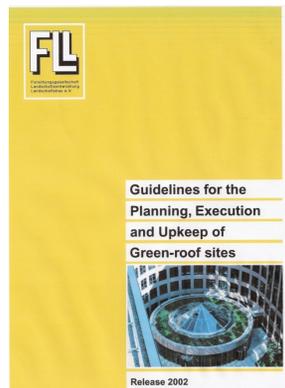
Some useful references...

Vegetative roof systems

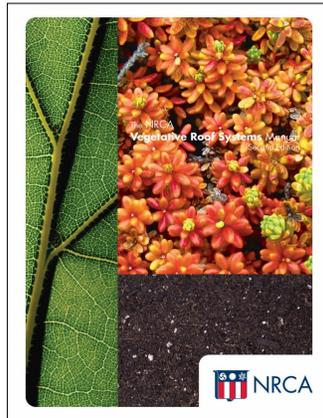


61

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

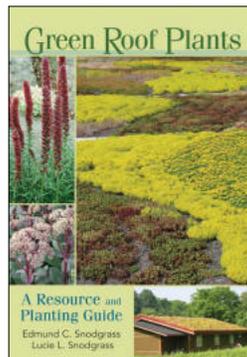


The NRCA Vegetative Roof Systems Manual, Second Edition



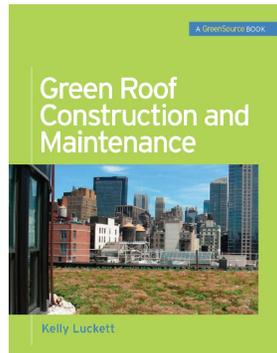
Green Roof Plants

Authors: Edmund C. Snodgrass & Lucie L. Snodgrass



Green Roof Construction and Maintenance

Author: Kelly Lockett



65

www.greenroofs.com



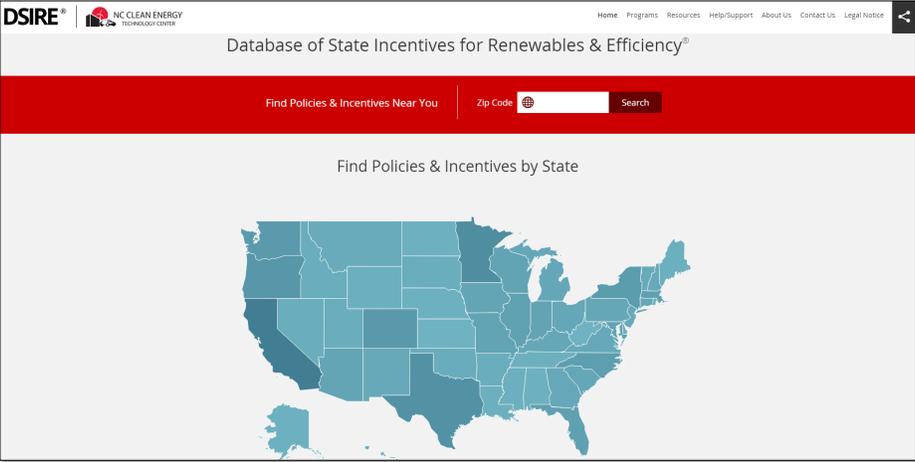
66

Incentive programs



67

www.dsireusa.org



The screenshot shows the DSIRE website interface. At the top, there are logos for DSIRE and NC Clean Energy Technology Center. A navigation menu includes Home, Programs, Resources, Help/Support, About Us, Contact Us, and Legal Notice. The main heading is "Database of State Incentives for Renewables & Efficiency®". Below this is a red search bar with the text "Find Policies & Incentives Near You", a "Zip Code" input field with a globe icon, and a "Search" button. Underneath the search bar is a section titled "Find Policies & Incentives by State" which contains a map of the United States with state boundaries outlined in dark blue.



68

State/Territory: Wisconsin X

Summary

Note: This tax deduction expired at the end of 2013. The Tax Increase Prevention Act of 2014 retroactively reinstated the tax credit for projects completed in 2014.

The federal Energy Policy Act of 2005 established a tax deduction for energy-efficient commercial buildings applicable to qualifying systems and buildings placed in service from January 1, 2006, through December 31, 2007. This deduction was subsequently extended through 2008, and then again through 2013 by Section 303 of the federal [Energy Improvement and Extension Act of 2008](#) (H.R. 1424, Division B), enacted in October 2008.

A tax deduction of \$1.80 per square foot is available to owners of new or existing buildings who install (1) interior lighting; (2) building envelope, or (3) heating, cooling, ventilation, or hot water systems that reduce the building's total energy and power cost by 50% or more in comparison to a building meeting minimum requirements set by ASHRAE Standard 90.1-2001. Energy savings must be calculated using qualified computer software approved by the IRS. Click [here](#) for the list of approved software.

Deductions of \$0.60 per square foot are available to owners of buildings in which individual lighting, building envelope, or heating and cooling systems meet target levels that would reasonably contribute to an overall building savings of 50% if additional systems were installed.

The deductions are available primarily to building owners, although tenants may be eligible if they make construction expenditures. In the case of energy efficient systems installed on or in government property, tax deductions will be awarded to the person primarily responsible for the system's design. Deductions are taken in the year when construction is completed.

The IRS released interim guidance ([IRS Notice 2006-52](#)) in June 2006 to establish a process to allow taxpayers to obtain a certification that the property satisfies the energy efficiency requirements contained in the statute. [IRS Notice 2008-40](#) was issued in March of 2008 to further clarify the rules. NREL published a report ([NREL/TP-550-40228](#)) in February 2007 which provides guidelines for the modeling and inspection of energy savings required by the statute.

Click [here](#) for answers to frequently asked questions provided by the *Commercial Building Tax Deduction Coalition*. For more information on this deduction, visit the [Energy Star web site](#).


69



Mark S. Graham
Vice President, Technical Services
National Roofing Contractors Association
10255 West Higgins Road, 600
Rosemont, Illinois 60018-5607

(847) 299-9070
1-800-323-9545
FAX: (847) 299-1183

www.nrca.net
mgraham@nrca.net

Twitter: @MarkGrahamNRCA or www.twitter.com/MarkGrahamNRCA
Personal website: www.MarkGrahamNRCA.com