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SPRI Wind Design Seminar
Introduction to ASCE 7

SPRI
SINGLE PLY ROOFING INDUSTRY

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Low-slope Roofing Market

- Estimated to be about $35 to $45 Billion annually*
- Roughly 5% of the construction industry
- Approximately 10% the cost of the building, but approximately 2/3 – 3/4 of construction industry litigation

*NRCA, Reid Ribble, February 2017

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Codes and Standards

Roofing and Reroofing is address in:

- **International Building Code**
  - Fire Resistance
  - Material Performance
  - Impact Resistance/Rooftop Traffic
  - Wind Resistance
  - Platform for PV Systems & Garden Roofs

2021 International Building Code (IBC)

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Adoption by State

International Code Council (February 2024)

FBC / IBC edition	ASCE 7 edition	States
FBC 2024	2022	FL*
2018 & 2021	2016	AL, AK, AR, CA, CT, FL, GA, HI, ID, LA, MD, MN, MS, MT, NE, NH, NJ, NY, ND, OH, OK, OR, PA, RI, SC, SD, UT, VA, WA, WV, & WY **Total 31 States**
2012 & 2015	2010	IN, IA, KY, ME, MA, MI, NM, NC, TN, TX, VT, & WI **Total 12 States & DC****
2006 & 2009	2005	0
Adopted by Local Governments	??	AZ, CO, DE, IL, KS, MO, & NV **Total 7 States**

*Florida 8th Edition = IBC 2021

**District of Columbia

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Section 1503 Weather Protection

1503.1 General
Roof decks shall be covered with approved roof coverings secured to the building or structure in accordance with this code and the approved manufacturers' instructions such that eh roof coverage shall serve to protect the building or structure.

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Section 1505 Fire Classification

1505.1 General
Roof assemblies shall be divided into the classes defined below. Class A, B and C roof assemblies and roof coverings required to be listed by this section, shall be tested in accordance with ASTM E 108 or UL 790.

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UL – External Fire Rating

Exterior Fire Test Exposure: Class A; UL 790 & ASTM E108, assemblies and roof slopes

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Section 1508 Roof Insulation

1508.1 General
The use of above-deck thermal insulation shall be permitted provided such insulation is covered with an approved roof covering and passes the test of FM 4450 or UL 1256 when tested as an assembly.

This test clarifies if a thermal barrier is necessary with specific foam plastic insulation

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Performance Section

International Building Code Chapter 15: Physical Properties

Roofing shall meet the following:

Accelerated Weathering (covering)

Impact Resistance (Assembly)

Uplift (Assembly)

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Accelerated Weather

Roofing system shall withstand 2000 hours of exposure when tested according to ASTM G 152 (Carbon Arc), ASTM G 154 (Fluorescent Ultraviolet Lamp) or ASTM G 155 (Xenon-Arc testing)

Impact Resistance

Roofing system shall resist impact damage when tested according to ASTM D 3746, ASTM D 4272 or FM 4470 (Resistance to Foot Traffic Test)

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Impact Resistance

FM 4470 (Resistance to Foot Traffic Test)

Foot Traffic Resistance Tests
Testing for foot traffic resistance shall be as follows:
A 3 in. (76 mm) square steel plate with rounded corners is placed on the sample. A 200 lb (91 kg) load is imposed on the plate five times.

Conditions of Acceptance for Foot Traffic
Resistance Roof Cover - There shall be no sign of tearing or cracking of the roof cover causing exposure of the substrate.

Insulation - The top surface of the roof insulation shall resist puncture. Under this same loading the roof insulation shall not fracture over rib openings of the steel deck.

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Section 1507
Requirements for Roof Coverings

1507.11.2
Modified bitumen roof coverings shall comply with CGSB 37-GP-56M, ASTM D6162, ASTM D6163, ASTM D6164, ASTM D6222, ASTM D6223, ASTM D6298 or ASTM D6509

1507.12.2
Thermoset single-ply roof covering shall comply with ASTM D4637, or ASTM D5019

1507.13.2
Thermoplastic single-ply roof coverings shall comply with ASTM D4434, ASTM D6754, or ASTM D6878

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Wind Resistance

IBC - Chapters 15 and 16

SECTION 1504
PERFORMANCE REQUIREMENTS

1504.1 Wind resistance of roofs. Roof decks and roof coverings shall be designed for wind loads in accordance with Chapter 16 and Sections 1504.2, 1504.3 and 1504.4.

1609.1.4 Wind design data. The following information related to wind loads shall be shown, regardless of whether wind loads govern the design of the lateral force-resisting system of the structure:

1. Basic design wind speed, V, miles per hour and allowable stress design wind speed, F_{asd}, as determined in accordance with Section 1609.3.1.
2. *Risk category*.
3. Wind exposure. Applicable wind direction if more than one wind exposure is utilized.
4. Applicable internal pressure coefficient.
5. Design wind pressures to be used for exterior component and cladding materials not specifically designed by the *registered design professional* responsible for the design of the structure, psf (kN/m^2).

Results are in lbs/sqft

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ASCE 7

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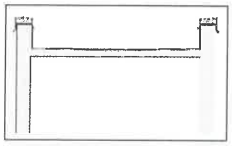
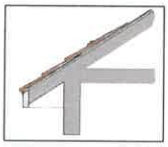
Roof Assemblies

Low-slope
- Weatherproof
- < 2:12 slope

Steep-slope
- Water shedding
- ≥ 2:12





Today's discussion is focusing on low-slope

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Standard

ASCE 7 (American Society of Civil Engineers)

- 1988- first edition of the ASCE 7 was published
- In use updated: 2005, 2010, 2016, & 2022
- Latest publication is 889-pages
- Roof Systems uplift, approximate 100-pages, explains method on how to calculate wind loads (lbs./sqft.)

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Background

ASCE 7 (American Society of Civil Engineers)

Provides method to calculate building pressure loads (lbs./sqft.) due to:

- Soil
- Hydrostatic Pressure
- Floods
- Snow
- Rain
- Earthquake
- Wind
- Etc.

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ASCE 7 Similarities

ASCE-7 edition	2010	2016	2022
Chapter(s)	Chapters 26-31	Chapters 26-31	Chapters 26-32
General Requirements	X	X	X
MWFRS* (Directional Procedure)	X	X	X
MWFRS* (Envelope Procedure)	X	X	X
Appurtenances and Other Structures (Directional Procedure)	X	X	X
Components and Cladding	X	X	X
Wind Tunnel Procedure	X	X	X
Tornado			X

*MWFRS: Main Wind Force Resistance System

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ASCE 7

Chapter 26 – General Requirements

ASCE-7 edition	2010	2016	2022
Scope	X	X	X
Definitions	X	X	X
Ultimate Wind Speed Maps	X	X	X
Wind Directionality Factor	X	X	X
Exposure	X	X	X
Gust Factor	X	X	X
Topographic Factor	X	X	X
Elevation Above Sea Level Factor		X	X

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ASCE 7

Chapter 30 – Components & Cladding

ASCE-7 edition	2010	2016	2022
Analytical Method (h <= 60-ft)	X	X	X
Simplified Method (h<= 60-ft)	X	X	Removed
Analytical Method (h> 60-ft)	X	X	X
Simplified Method (h <= 160-ft)	X	X	Removed
Internal Pressure Coefficient (GCpi)	X	X	X
External Pressure Coefficient (GCp)	X	X	X

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Analytical Method: Basic Formula

Velocity Pressure (qz)

ASCE 7-10: $q_z = 0.00256 \times K_z \times K_{zt} \times K_d \times V^2 \times 0.6$

ASCE 7-16: $q_z = 0.00256 \times K_z \times K_{zt} \times K_e \times K_d \times V^2 \times 0.6$

ASCE 7-22: $q_z = 0.00256 \times K_z \times K_{zt} \times K_e \times K_d \times V^2 \times 0.6$

- 0.00256 = numerical coefficient, unless sufficient climatic data are available
- Kz = velocity pressure exposure coefficient evaluated at height z = h
- Kzt = Topographic factor
- Kd = wind directionality factor
- V² = basic ultimate wind speed
- I = Importance Factor
- Ke = Elevation Factor

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Factors to Determine Uplift

Basic Criteria for all ASCE 7 Versions

Building location
- Terrain
- Wind

Building use
- Risk Category

Building physical parameters
- Height
- Openings

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Building Location

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Building Location

Terrain & Wind

Terrain

- Exposure
  - "B" = urban/suburban
  - "C" = open terrain
  - "D" = close to a large body of water
- Hills & Escarpments

Wind

- ASCE 7 Basic Ultimate Wind Maps
  - Risk Category I
  - Risk Category II
  - Risk Category III
  - Risk Category IV

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Kz: Height and Terrain
Exposure "B"

Surface Roughness "B":
Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the same size of single-family dwellings or larger.

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Kz: Height and Terrain
Exposure "C"

Surface Roughness "C":
Open terrain with scattered obstruction having heights less than 30-ft. This includes flat open country and grasslands.

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Kz: Height and Terrain
Exposure "D"

Surface Roughness "D":
Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice.

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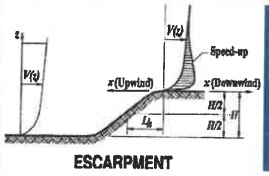
Kzt: Hills & Escarpments

Special calculations are required for hills and escarpments:



ESCARPMENT

Note: No calculations available for intensified winds at the end of valleys. Local authorities would need to offer assistance.

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V^2: Basic Ultimate Wind Speed

Determine from applicable ASCE 7:

ASCE 7-2010 Risk Category III/IV

ASCE 7-2016 Risk Category IV

ASCE 7-2022 Risk Category IV

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Risk Category

Building Use

Risk Category I = Low hazard to human life	Agricultural, minor storage (golf cart shed), and certain temporary facilities
Risk Category II = Most typical buildings	All buildings except those listed in Category I, III or IV
Risk Category III = Substantial hazard to human life	Facilities for more than 300 persons (schools, health care, power generation, toxic chemicals)
Risk Category IV = Essential Facilities	Surgery, fire & rescue, communications, emergency shelters, and national defense.

Note: Importance Factor has been renamed to Risk Categories and this factor has been rolled into the wind speed

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Building Physical Parameters

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Building Physical Parameters
Characteristics

Roof Area
- Height & Slope
- Parapets Heights

Building Structure
- On a hill or precipices
- Building Openings
  - Open, Partial Enclosed, Enclosed
- Building Overhangs
- Interior Pressurized

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Building Physical Parameters
Parameters Affects

Increase uplift
- The higher the roof area
- Building on hill
- Building openings
- Pressures from interior mechanical

Reduce uplift
- Parapet heights greater than 3-ft

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Building Openings

Opening Types	Amount of Openings
Enclosed	Less than 10%
Partially Enclosed	10% to 20%
Partially Open	Does not comply with the others
Open	80% or greater

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Basic Information to Calculate Uplift Pressures

Check List

- ✓ Applicable Code and Standard
- ✓ Building Location for:
  - ✓ ASCE 7 ultimate winds
  - ✓ Topography
  - ✓ Surrounding Terrain
  - ✓ Wind Direction
- ✓ Building Use
- ✓ Building Physical Parameters
  - ✓ Height
  - ✓ Openings
  - ✓ Roof Dimensions

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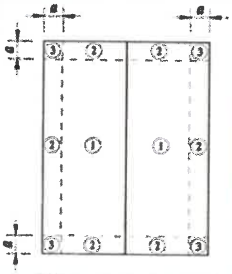
ASCE 7-10 Roof Zone Layout

Figure 30.4-2A h ≤ 60-ft Slope ≤ 7°



Design Pressures (Zonal Pressures)

$$P \text{ (pressure)} = q_z [(GC_p) - (GC_{pi})]$$

Note:

Zone 2 and 3 areas are 0.4 x height or 0.1 x the width whichever is smaller but cannot be less than 0.04 x width or 3-ft.

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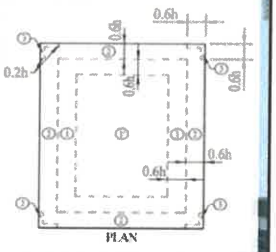
ASCE 7-16 & 7-22 Roof Zone Layout

Figure 30.3-2A $h \leq 60$-ft Slope $\leq 7°$



Design Pressures (Zonal Pressures)

(7-16) $P = q_z [(GC_p) - (GC_{pi})]$

(7-22) $P = q_z \times K_d \times [(GC_p) - (GC_{pi})]$

Note:

Zone 1 & 2 area 0.6 x building height

Zone 3 is "L" shaped with legs 0.6 x building height and width 0.2 x building height

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Example Results ASCE 7

Concord, NC

40-ft high

Exposure "C"

Enclosed Bldg

Category IV

	ASCE 7-10	ASCE 7-16	ASCE 7-22
Ultimate Winds	120-mph	124-mph	122-mph
Zone 1'		23 psf	22 psf
Zone 1	24 psf	40 psf	38 psf
Zone 2	39 psf	52 psf	51 psf
Zone 3	59 psf	71 psf	69 psf

Net Wind Loads are increasing (66% field)

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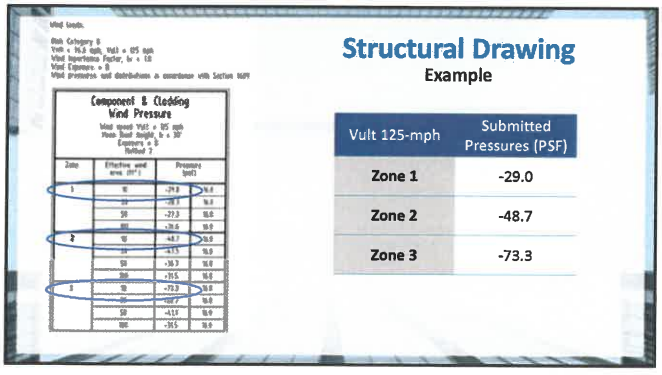

Structural Drawing

Example

Vult 125-mph	Submitted Pressures (PSF)
Zone 1	-29.0
Zone 2	-48.7
Zone 3	-73.3

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Laboratory Testing of Roofing Assemblies

Tested Assemblies ≥ Uplift Pressures

Manufacturer assembly tests:
These tests certify the uplift rating for the specified assembly from lab testing

- UL 580
- ANSI/FM 4474
- UL 1897

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Certification of Compliance

Uplift Rating Test (ANSI/FM 4474)

Test panel exposed to air pressure from below

15 psf levels, each level held for 1 minute.

Increased until failure.

Ratings:

60 psf; 75 psf; 90 psf; 105 psf...

ANSI/FM 4474
(12'x24' size testing table)

Results are in lbs/sqft

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ANSI/FM 4474

12'x24' Testing Table

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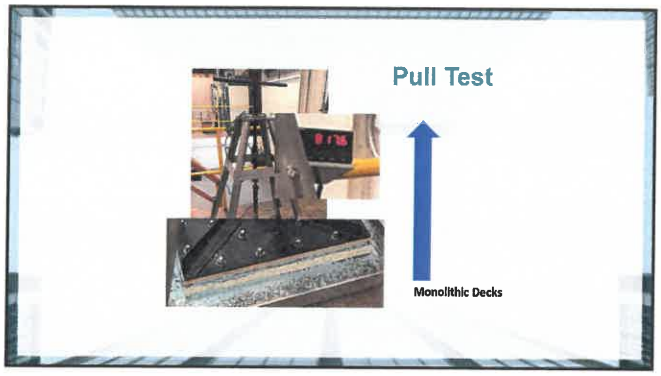
Pull Test
Monolithic Decks

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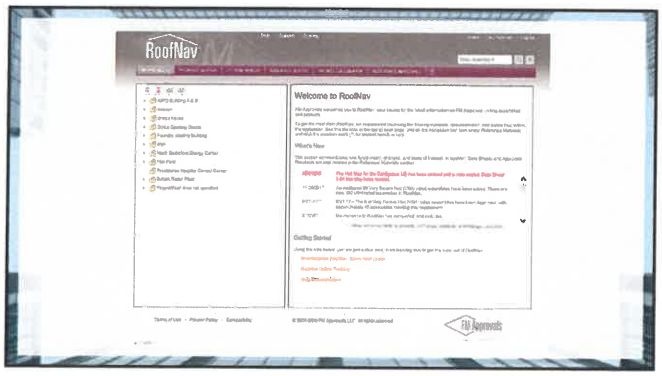
RoofNav
Welcome to RoofNav

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SPRI developed DORA, "Directory of Roof Assemblies"
www.dora-directory.com
dora
Let's Find a Listing
DORA addresses:
• Modified Bitumen and Single-ply membranes
• All deck types (including wood & cementitious wood fiber)
• Wind resistance (will soon be adding fire resistance)

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Ballasted Systems & Overburden

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International Code Council (ICC)

International Building Code (IBC)	Chapter 15
Wind Uplift Requirement	**1504 Adhered or Mech. Fast:** ASCE 7
	1504 Ballasted System: ANSI/SPRI RP-4

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Ballast – ANSI / SPRI RP-4

C. For Parapet Heights From 12.0 to Less Than 18.0 Inches
Maximum Allowable Wind Speed (MPH)

Bldg. Ht. Ft.	System 1 Exposure		System 2 Exposure		System 3 Exposure	
	B*	C*	B*	C*	C*	D*
0 - 15	125	140	140	140	140	140
>15 - 30	115	130	140	140	140	140
>30 - 45	105	120	130	140	140	140
>45 - 60	95	110	120	140	140	140
>60 - 75	90	105	115	135	140	140
>75 - 90	85	100	110	130	140	140
>90 - 105	80	100	110	125	140	140
>105 - 120	80	100	105	125	125	140
>120 - 135	No	No	No	125	125	140
>135 - 150	No	No	No	125	125	140

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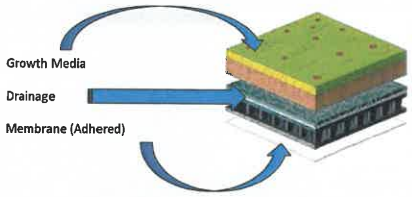
Overburden: Vegetated Roofs

The Concept



2" to 4" – Shallow (12 - 24psf) (Approx. 80% of Garden Roof Market)

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Overburden: Patio / Terraces

Concrete Pavers

The structural system must be designed to carry the extra weight.

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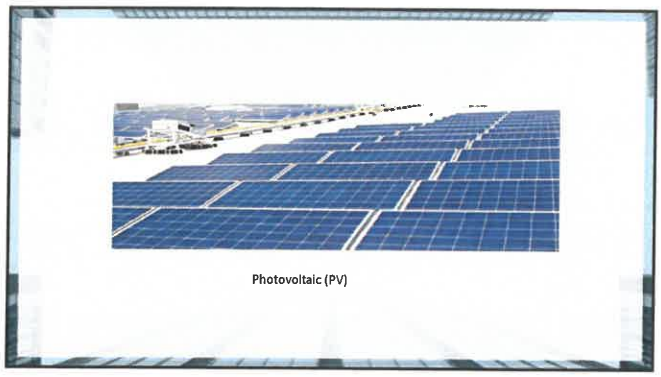

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Metal Edging & Gutters

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Roof Edge Failure Examples

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Roof Edge Failure Examples

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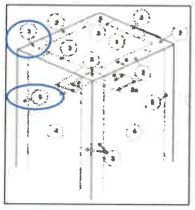
Roof Edge Design Pressures Calculations

Need:

- Local Wind Based on ASCE 7 & Risk Category
- Building Height
- Building Exposure (B, C or D)
- Edging must be enclosed
- ASCE 7 Building Zones: 3 & 5



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SPRI Standards

- ANSI/SPRI/FM 4435/ES-1 Test Standard for Edge Systems Used with Low Slope Roofing Systems *
- ANSI/SPRI GT-1 Test Standard for Gutter Systems*
- ANSI/SPRI RP-4 Wind Design Standard for Ballasted Single Ply Roofing Systems*
- ANSI/SPRI VF-1 External Fire Design Standard for Vegetative Roofs*

*referenced in the International Building Code

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Thank you for Your Attention!

SPRI
SINGLE PLY ROOFING INDUSTRY

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