American National Standards Institute

ANSI/SPRI Standards

- ANSI/SPRI WD-1 Design Standard Practices for Roofing Assemblies
- ANSI/SPRI RP-4*
- ANSI/SPRI RP-14
- ANSI/SPRI IA-1
- ANSI/SPRI FX-1

*referenced in the International Building Code

ANSI/SPRI WD-1 - Wind Design Standard Practice for Roofing Assemblies

Document assists in verifying the process to meet the building code associated to uplift pressures for roofing:

ASCE 7 Calculations (PSF) ≤ Tested Assembly (PSF)

Includes rational analysis methods for determining enhancement of perimeter and corner fastening (if necessary)

Select an appropriate roofing system

Assemblies are tested by following

- ANSI/FM 4474
- UL 580
- UL 1897

Consider a Factored Tested Load Capacity

- Tested load capacity ÷ safety factor (1.0 to 2.0)

Rationale Analysis Method for Perimeters and Corners of Adhered Assemblies

Rationale analysis method can be used when:

- Insulation secured with fasteners / adhesive ribbons
- The tested wind uplift was determined using equipment of sufficient size to allow side-by-side positioning of three full size boards (12’x24’ testing table)
- Securement pattern can be converted to a sqft area
- The tested wind uplift load capacity (not factored) of the system selected must be greater than the corner design load

Rationale Analysis Method for Adhered Assemblies with Mechanically Attached Insulation

Mechanically attached insulation

Increase fasteners per the following formula

$$F_n = (F_t \times L_d)/L_t$$

Where:

- F_n = fasteners to meet design load
- F_t = Number of fasteners used to achieve tested load
- L_d = Design load for perimeter or corner
- L_t = Factored tested load capacity

Adhered assembly with mechanically attached insulation

Building Height, ft.	Field Design Load, psf	Perimeter Design Load, psf	Corner Design Load, psf
60	**-25.6**	**-42.9**	**-64.6**

Roof Assembly “Tested Load Capacity” is 75psf

Factored load = 75psf ÷ 2 = 37.5psf

System uses 2-inch foam plastic insulation mechanically attached to the deck using 1 fastener every 4 ft² [8 fasteners per 4’x8’ size board]

Adhered assembly with mechanically attached insulation

Fn = (Ft x Ld)/Lt

Perimeter

- $F_n = (F_t \times L_d)/L_t$
- F_n = (8 fasteners x 42.9 psf) ÷ 37.5 psf
- = 9 fasteners per board

Corner

- $F_n = (F_t \times L_d)/L_t$
- F_n = (8 fasteners x 64.6 psf) ÷ 37.5 psf
- = 14 fasteners per board

Rational Analysis Method—
Adhered Membrane with Ribbon/Bead Adhesive Attached Insulation/Substrates

Ribbons/beads of an adhesive spacing equation:

Rn = Rt/(Ld/Lt):

Where:

- Rn = the ribbon spacing to meet the calculated design load, inches (cm).
- Rt = the ribbon spacing used to achieve the tested load capacity, inches (cm).
- Ld = the calculated design load for the perimeter or corner area of a roof, psf.
- Lt = the Factored Tested Load Capacity, psf.

Rationale Analysis Method for Perimeters and Corners of Mechanically Attached Assemblies

Rationale Analysis method for mechanically attached assemblies when:

- For linearly-attached (rows) assemblies the test chamber used must be of sufficient size to allow positioning of at least three attachment rows on the test frame. The minimum frame width shall be 8 feet.

- For spot attached assemblies the test chamber used must be of sufficient size to allow positioning of a minimum of nine attachment locations on the test frame. The minimum frame width shall be 8 feet.

Rationale Analysis Method for Mechanically Attached Systems

Increase the number of fasteners to resist the greater wind loads at the perimeter and corner using the following formula:

$$\mathbf{IA_n = (L_t \times IA_t)/L_d:}$$

Where:

- IA_n = Max. area of membrane held in place to meet design load
- L_t = The factored load
- IA_t = Area of membrane held in place by one fastener for the tested assembly (fastener row spacing x fastener spacing along the row)
- L_d = the calculated design load for the perimeter or corner

IBC: Ballast & Aggregate

Insulation

Membrane

Ballast

IBC and Ballast

Chapter 1504

- Ballast 1504.4
  - ANSI/SPRI RP-4
- Aggregate 1504.8
  - Charts

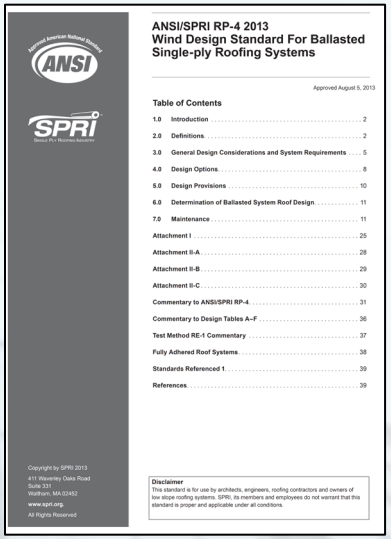
International Code Council (ICC)

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

- Adhered and Mech. Fastened are tested in a lab following ANSI/FM 4474, UL 1987 or UL 580. Tests involve introducing an uplift load on the assembly to achieve ratings in pounds per square foot.
- Ballasted systems cannot be tested based on the nature of the assembly, loose laid materials head down by ballast.

Wind Design Standards

- Scouring of ballast could occur in corner and perimeter areas as a result of high wind loading
- IBC has a procedure which limits location and height of building for ballasted systems
- Once this has been completed the ANSI/SPRI Wind Design Standard RP-4 would be used to determine final enhancements if any.


ANSI/SPRI RP-4 2013
Wind Design Standard For Ballasted Single-ply Roofing Systems

Approved August 5, 2013

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411 Waverley Oaks Road
Suite 331
Waltham, MA 02452
www.spri.org

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.

Ballast

1504.4 – Ballasted low-slope (roof slop < 2:12) single-ply roof system coverings installed in accordance with Sections 1507.12 and 1507.13 shall be designed in accordance with Section 1504.8 and ANSI/SPRI RP-4

1507.12 – **Thermoset** Single-ply Roofing ballasted with stone that complies with ASTM D448 or ASTM D7655

1507.13 – **Thermoplastic** Single-ply Roofing ballasted with stone that complies with ASTM D448 or ASTM D7655

Ballast

Standard sizes of coarse aggregate – Based on ASTM D7655

Size Number	#1	#2	#3	#4
Nominal Size Square Openings	**3-½" to 1-½"**	**2-½" to 1-½"**	**2" to 1"**	**1-½" to ¾"**
	Amounts Passing Each Lab Sieve (Square Opening), Percent (%)			
4"	100			
3-½"	90 to 100			
3"		100		
2-½"	25 to 60	90 to 100	100	
2"		35 to 70	90 to 100	100
1-½"	0 to 15	0 to 15	35 to 70	90 to 100
1"			0 to 15	20 to 55
¾"	0 to 5	0 to 5		0 to 15
½"			0 to 5	
⅜"				0 to 5

Ballast Limitation

1504.8
Surfacing and ballast materials in hurricane-prone regions

For a building located in a hurricane-prone region as defined in **Section 202**, or on any other building with a mean roof height exceeding the permitted by **Table 1504.8** based on the exposure category and basic wind speed at the site, the following material shall not be used on the roof:

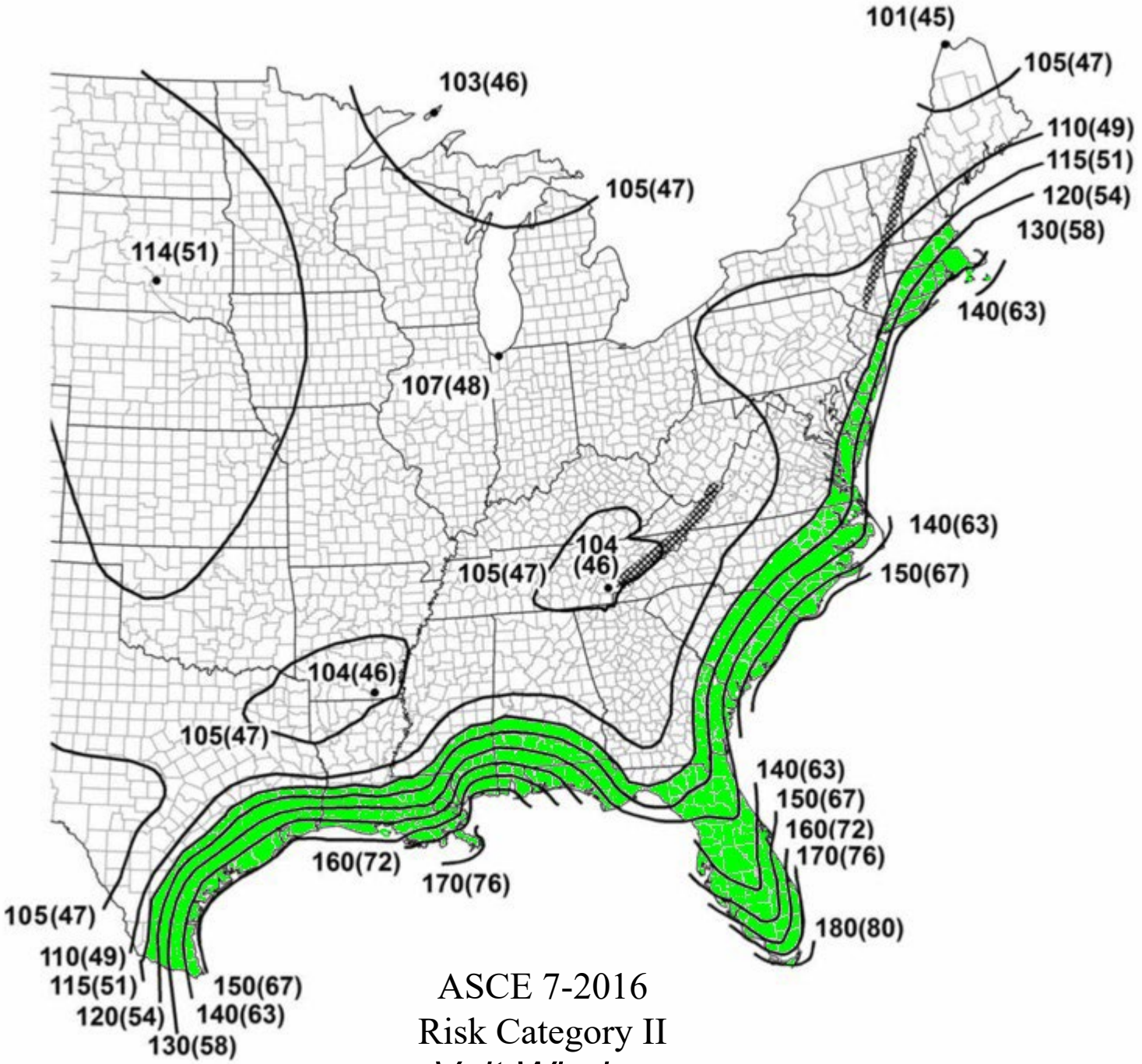
1. Aggregate used as surfacing for roof coverings.
2. Aggregate, gravel or stone used as ballast

Definition

Section 202
Hurricane-Prone Regions

Areas vulnerable to hurricanes defined as:

1. The U.S. Atlantic Ocean and Gulf of Mexico coasts where the ultimate design wind speed, *Vult*, for *(ASCE 7-10 & 7-16)* Risk Category II building in greater than 115-mph.
2. Hawaii, Puerto Rico, Guam, Virgin Islands and American Samoa



ASCE 7-2016
Risk Category II
Vult Winds

Table 1504.8

Maximum Allowable Mean Roof Height Permitted for Buildings with Aggregate on the Roof in Areas Outside Hurricane-Prone Regions

Nominal Design Wind Speed, *Vasd mph*	Maximum Mean Roof Height (ft)		
	Exposure Category		
	B	C	D
85	170	60	30
90	110	35	15
95	75	20	NP
100	55	15	NP
105	40	NP	NP
110	30	NP	NP
115	20	NP	NP
120	15	NP	NP
Greater than 120	NP	NP	NP

Vasd shall be determined in accordance with Section 1609.3.1

ASCE 7-10 & 7-16 Wind Maps

Vult to *Vasd*

1609.3.1 Wind speed conversion. When required, the ultimate design wind speeds of Figures 1609A, 1609B and 1609C shall be converted to nominal design wind speeds, V_{asd}, using Table 1609.3.1 or Equation 16-33.

$$V_{asd} = V_{ult}\sqrt{0.6} \qquad \textbf{(Equation 16-33)}$$

TABLE 1609.3.1
WIND SPEED CONVERSIONS[a, b, c]

V_{ult}	100	110	120	130	140	150	160	170	180	190	200
V_{asd}	78	85	93	101	108	116	124	132	139	147	155

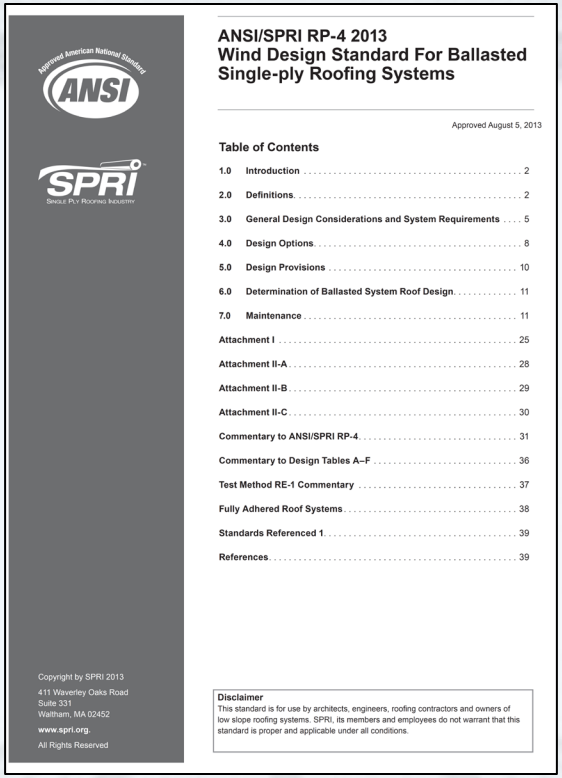
Table 1504.8

Maximum Allowable Mean Roof Height Permitted for Buildings with Aggregate on the Roof in Areas Outside Hurricane-Prone Regions

Nominal Design Wind Speed, Vasd mph	Maximum Mean Roof Height (ft)		
	Exposure Category		
	B	C	D
85	170	60	30
90	110	35	15
95	75	20	NP
100	55	15	NP
105	40	NP	NP
110	30	NP	NP
115	20	NP	NP
120	15	NP	NP
Greater than 120	NP	NP	NP

Wind Design Standards

Once this has been completed the ANSI/SPRI Wind Design Standard RP-4 would be used to determine final enhancements if any.



Approved American National Standard
ANSI
SPRI
Single Ply Roofing Industry

ANSI/SPRI RP-4 2013
Wind Design Standard For Ballasted Single-ply Roofing Systems

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As of IBC 2021, previous steps to this point unnecessary

Aggregate is used with BUR material to protect the material
Nom. 1/2-inch diameter

Ballast on membrane is used to hold the roof assembly down.
Nom. 1.5-inch diameter

IBC 2021: Ballast

1504.5 – Ballasted low-slope (roof slop < 2:12) single-ply roof system coverings installed in accordance with Sections 1507.12 shall be designed in accordance with ANSI/SPRI RP-4

1507.12 – (All Single-ply) Roofing ballasted with stone that complies with ASTM D7655

2” Gravel Stop to 6” Parapet

Bldg. Height	System 1 Exp. A/C	System 1 Exp. B	System 2 Exp. A/C	System 2 Exp. B	System 3 Exp. A/C	System 3 Exp. B
0-15’	100 mph	105	115	115	130	140
15-30’	100	105	110	115	130	140
30-45’	90	100	100	115	130	140
45-60’	No	No	95	115	120	140

ANSI/SPRI RP-4

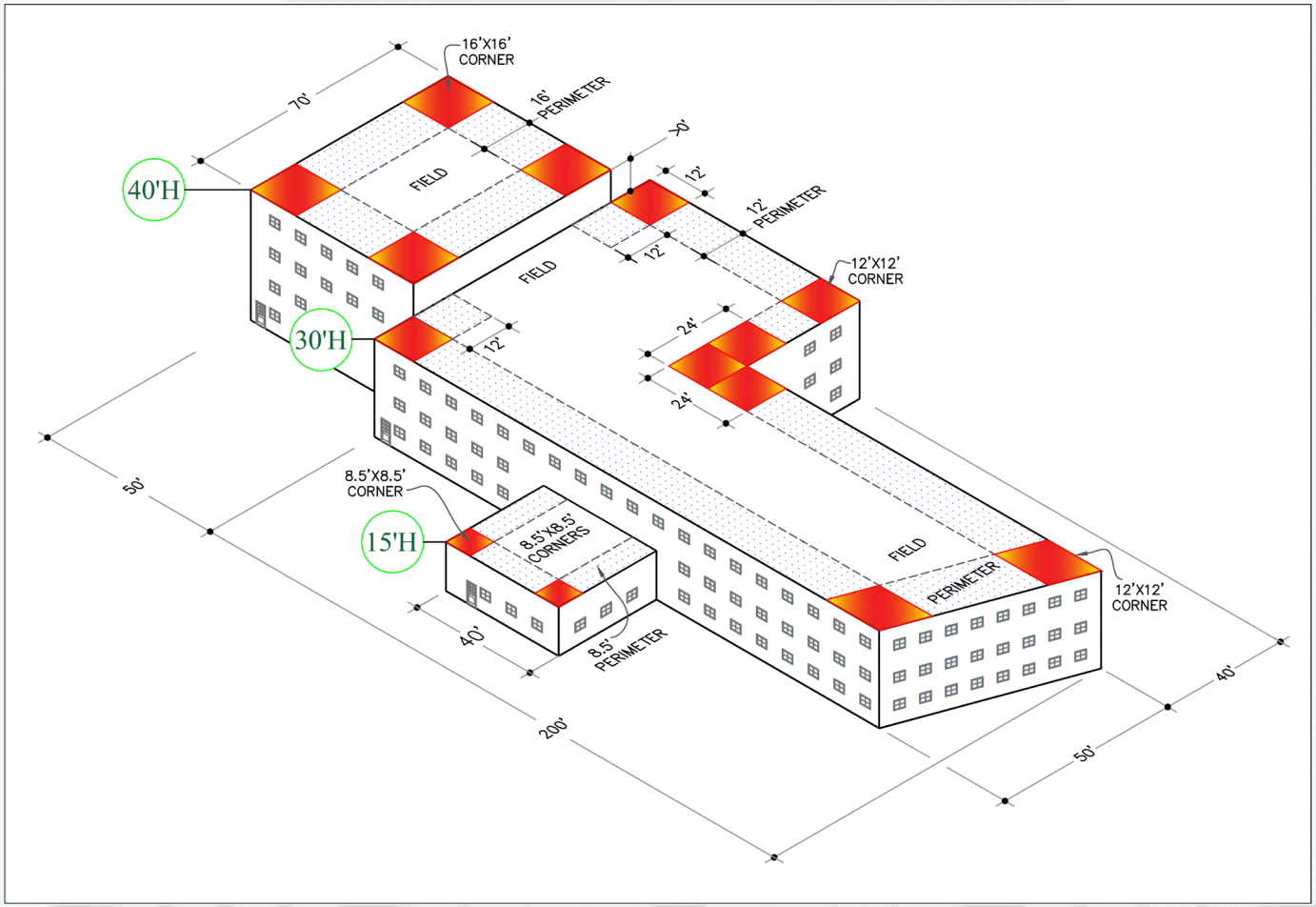
Ballast Requirements

System 1
The installed membrane shall be ballasted with #4 ballast.

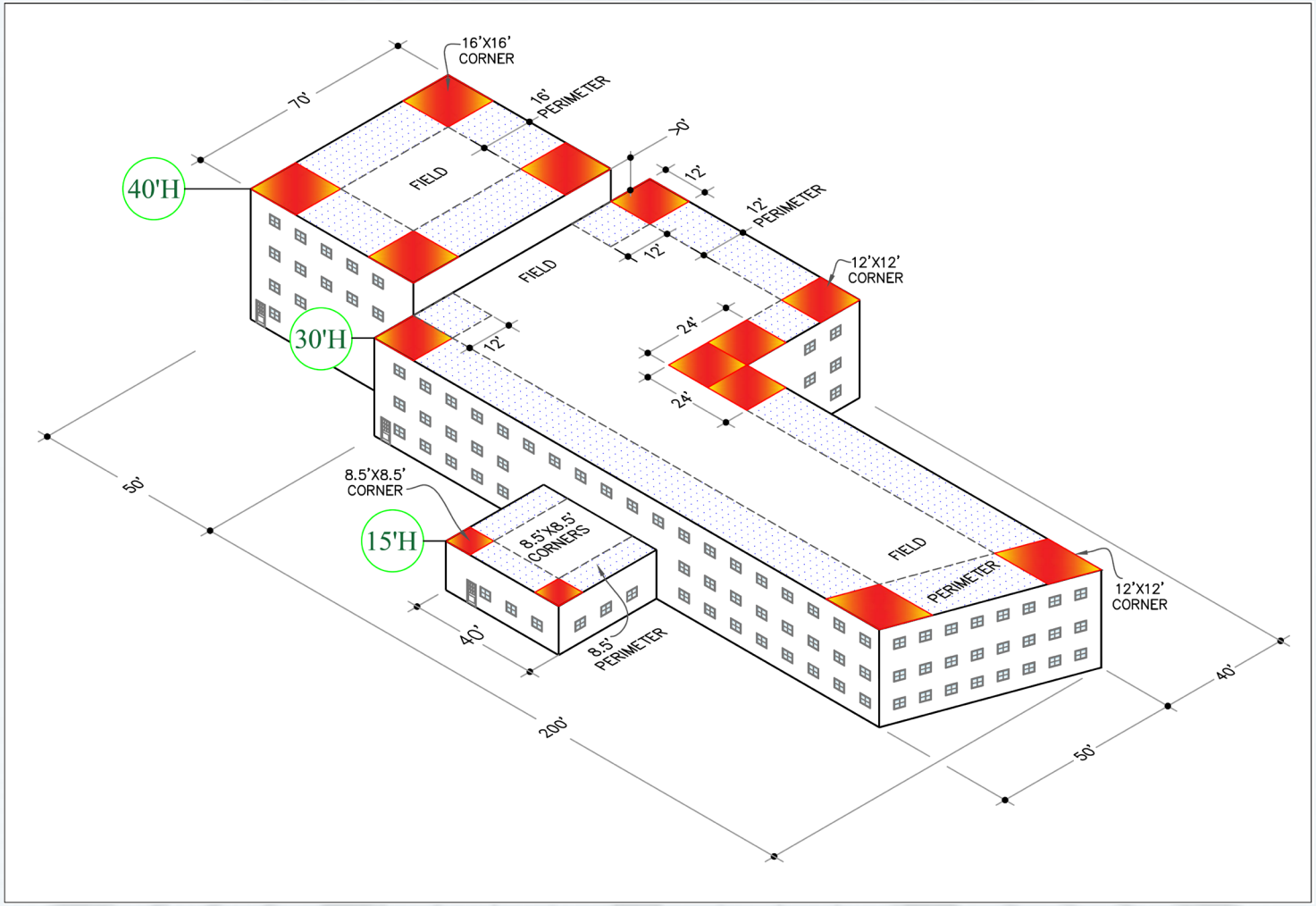
System 2
- Corner Zone shall be ballasted with #2 ballast
- Perimeter Zone shall be ballasted with #2 ballast
- Field shall be ballasted with #4 ballast

System 3
- Corner zone, an adhered or mechanically attached roof system designed
- Perimeter Zone, an adhered or mechanically attached roof system designed
- Field shall be ballasted with #2 ballast

Roof Layout System 2



Roof Layout System 3



ANSI/SPRI RP-14 - 2016 Wind Design Standard for Vegetative Roofing Systems

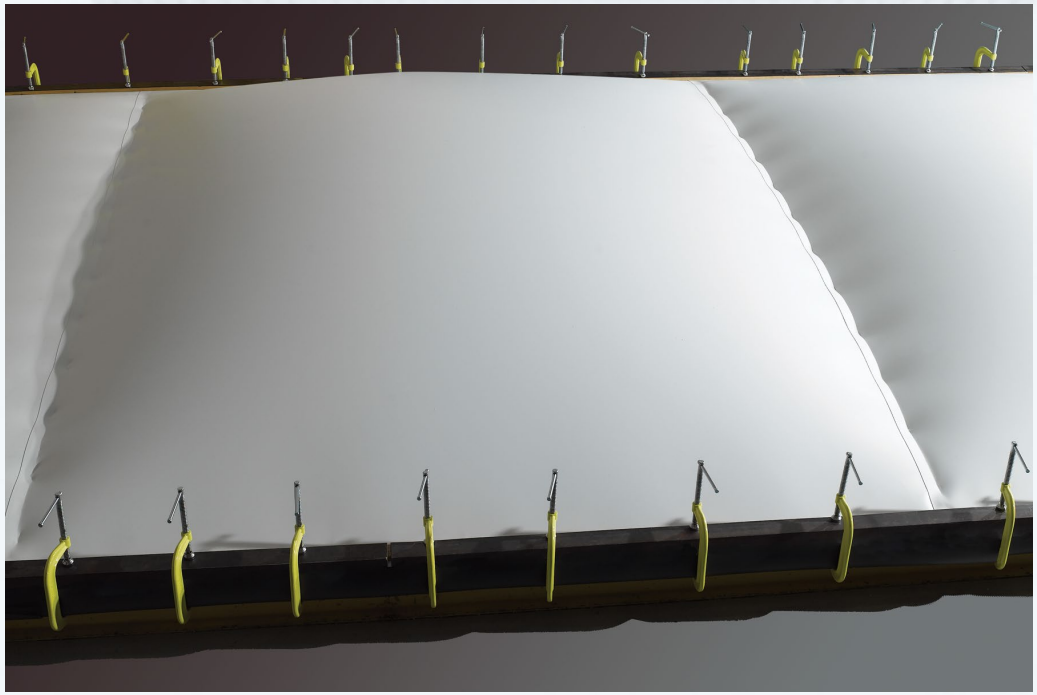
Wind Testing Challenge

Site Built

Tray systems

Vegetative mats

How to Test for Wind Resistance?



- 15 PSF of soil media on the roof
- When pressure exceeds 15 PSF membrane and growth media “floats”

Wind Resistance of Vegetative Roofs

- ANSI.SPRI RP-14 Wind Design Standard for Vegetative Roofing Systems
- Similar to ANSI/SPRI RP-4 Ballast Design Guide
- Defines design parameters that prevent scour of the vegetation and growing media

Vegetative Roofing Systems Wind Performance

Wind Resistance of Vegetative Roofs

ANSI/SPRI RP-14 was revised in 2016

- Now for use only with adhered membrane assemblies
- Requirements are designed to keep the vegetative roof components in place

ANSI/SPRI RP-14 Restrictions

Restrictions to the use of vegetative roof systems in ANSI/SPRI RP-14

- Requires licensed design professional when:
  - building height exceeds 150 feet
  - maximum 3-second gust wind speed exceeds 140 miles per hour
  - Located in a windborne debris region
  - Slopes greater than 1.5”

Nominal Vegetation Coverage Required

- Exposed growth media may be no greater than a 4" (100 mm) diameter

ANSI/SPRI RP-14 Ballast Designs

System #1

- Growth media installed (minimum rate of 10 lbs/ft^2)
- Modular pre-planted or pre-grown vegetative roof trays that are independently set (minimum 18 lbs/ft2)
- Interlocking, contoured fit or strapped together (minimum 10 lbs/ft^2)
- Weights are based on dry weight
- Gravel ballast or concrete pavers may also be used

ANSI/SPRI RP-14 Ballast Designs

System #2 (Field same as System 1)

Perimeters and corners ballasted as follows:

- Growth media installed (minimum rate of 13 lbs/ft^2)
- Independently set modular pre-planted or pre-grown vegetative roof trays containing 22 lbs/ft^2 dry weight inorganic material plus organic material or
- Modular pre-planted or pre-grown vegetative roof trays; which are interlocking, contoured fit or strapped together containing 13 lbs/ft^2 dry weight inorganic material plus organic material
- Gravel ballast or concrete pavers may also be used

ANSI/SPRI RP-14 Ballast Designs

System #3 (Field same as System 2)

Perimeter and corner areas ballasted as follows:

- Mechanically attached or adhered assembly designed to resist the uplift force
- No soil media, modular vegetative roof trays or gravel may be used in these areas
- If a protective covering is desired, minimum 22 psf pavers over an adhered assembly no mechanically attached systems permitted

Selecting the Proper Design

Vegetative roof design parameters

- Basic wind speed
- Building height
- Parapet height
- Exposure

C. For parapet heights from 12.0 to less than 18.0 inches

Maximum Wind Speed (MPH)

Roof height feet	System 1		System 2		System 3	
	Exposure C	Exposure B	Exposure C	Exposure B	Exposure C	Exposure B
0–15	110	115	125	125	140	140
15–30	110	115	120	125	140	140
30–45	100	115	115	125	140	140
45–60	No	100	105	125	140	140
60–75	No	100	100	120	130	140
75–90	No	No	100	120	120	130
90–105	No	No	100	110	120	120
105–120	No	No	95	110	110	120
120–135	No	No	No	110	110	120
135–150	No	No	No	105	110	120

[3] Wind speed reference see Section 2.5

Wind speeds in above tables are “3 second gust” measured at 10 meters (33 feet).

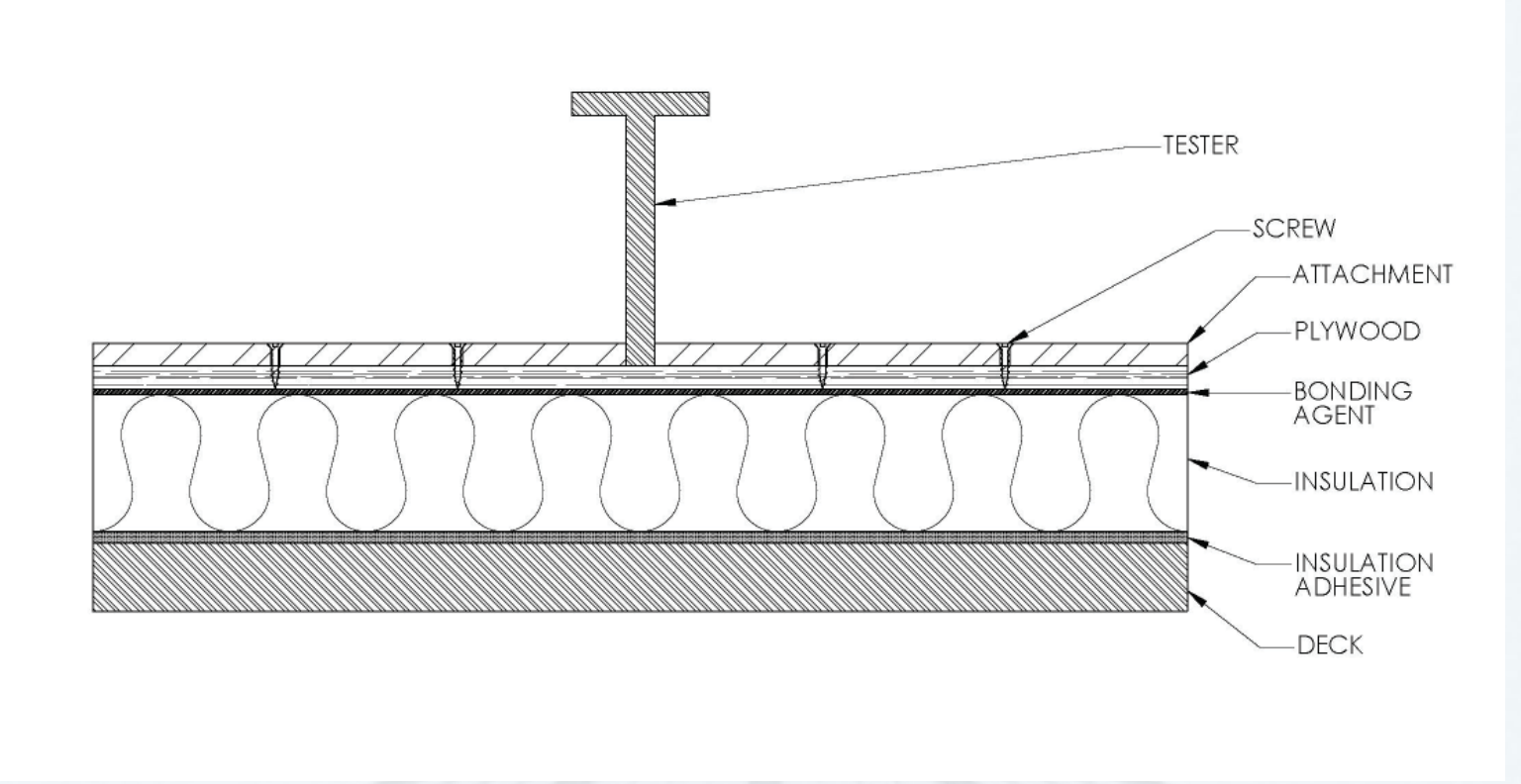
ANSI/SPRI IA-1 2015
Standard Field Test Procedure for Determining the Uplift Resistance of Insulation and Insulation Adhesive Combinations over Various Substrates

ANSI/SPRI IA-1 - 2015

Scope

This standard specifies a field-testing procedure to determine the uplift resistance of a specific roof insulation/adhesive combination. This testing procedure encompasses various types of insulation adhesives and roof decks.

Test Assembly



ANSI/SPRI IA-1

4 pulls for up to 50,000-sqft
+2 for each additional 50,000-sqft

Pullouts should be completed in various areas of the deck, including corners, perimeter, and field.

Locations should not be in close proximity to each other

Testing of adhered Vapor Retarder to a concrete deck (515-lbs/sqft)


Atomic Cafe
ATM
COSI
Hands-on science
museum & planetarium
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20

Test Procedure

- The sample size shall be 24” x 24” (0.6096m x 0.6096m) with the insulation adhesive applied according to the adhesive manufacturer’s specifications
- A 24” x 24” (0.6096m x 0.6096m) piece of CDX grade plywood minimum 23/32” (18.2mm) thick shall be adhered to the top of the insulation or cover-board
- The load shall be applied perpendicularly to the roof deck
- The test shall begin when the load equals 120 lbf plus the tare weight

Test Procedure

- Increase the load in 60 lbf (.2669kN) increments
- Hold each incremental load for 60 seconds. Continue until failure occurs
- Failure occurs when any component of the assembly fails

ANSI/SPRI FX-1 2016 American National Standard Standard Field Test Procedure for Determining the Withdrawal Resistance of Roofing Fasteners

ANSI/SPRI FX-1 Test Apparatus

ANSI/SPRI FX-1 Test Procedure

- Remove any roofing material above the deck (i.e. waterproofing membrane, existing insulation) before the test is performed
- The fastener shall be installed using the same method and tools as will be used during actual installation
- The fastener shall be pulled out perpendicular to the deck
- The load shall be applied at 2.0 +/- 1.0 in/min
- Record the results of all pullout tests

Pull Test Report

Job Name	COSI
Job Location	Columbus, OH
Roof Area (sqft)	100,000
Building Height (ft)	60 FT
Project Type	Tear-off
Thickness of Existing Roof Assembly	6"
Roof Cover Type	F/A Single Ply
New System Manufacturer	Carlisle
Fastener(s) Tested	InsulFast, HP

Report Number	PT-04969
Test Date / Time	9/4/2019 10:00:00 AM
Ambient Temperature	75°F
Tester Manufacturer	DMD Force-2000
Max Cap of Tester (lbs)	2,000
Test Performed By	Conor Hartnett
Test Cut Area Repaired By	Pete Luka
Test Witnessed By	Pete Luka

Insulation Manufacturer	Insulation Type	Thickness
Unknown	ISO	Unknown
Unknown	Cover Board	Unknown

Deck Type	Thickness
Steel	Unknown

Disclaimer: Manufacturer's installation requirements shall be followed when using any of the tested fasteners or adhesives. Neither the technician performing the pullout tests, nor his/her company is responsible for the waterproofing integrity of the repairs. This test report does not certify the structural integrity of the roof deck.

Test Results

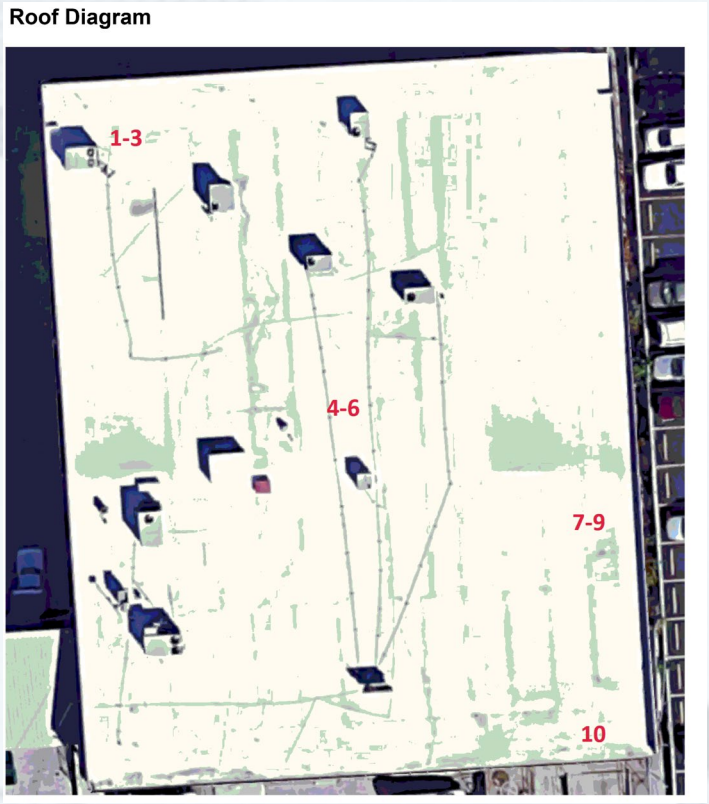
Test Location Number	Pull Value (lbf)	Fastener Tested	Penetration (in)	Bit Diameter (in)	Comments
1	499	Carlisle InsulFast	1"		
2	607	Carlisle InsulFast	1"		
3	512	Carlisle InsulFast	1"		
4	570	Carlisle InsulFast	1"		
5	671	Carlisle InsulFast	1"		
6	565	Carlisle HP	1"		
7	362	Carlisle HP	1"		
8	450	Carlisle HP	1"		
9	638	Carlisle HP	1"		
10	900	Carlisle HP	1"		
11	463	Carlisle InsulFast	1"		
12	546	Carlisle InsulFast	1"		
13	544	Carlisle InsulFast	1"		
14	507	Carlisle InsulFast	1"		
15	553	Carlisle InsulFast	1"		
16	681	Carlisle HP	1"		
17	567	Carlisle HP	1"		
18	609	Carlisle HP	1"		
19	594	Carlisle HP	1"		
20	712	Carlisle HP	1"		

ANSI/SPRI FX-1

10 pullouts for up to 50,000-sqft
+5 for each additional 50,000-sqft

Pullouts should be completed in various areas of the deck, including corners, perimeter, and field.

50% should be performed in the corners and perimeters



ANSI/SPRI FX-1 Test Procedure

- Design test program to quantify special conditions
- Test each roof section separately
  - Different elevation
  - Different deck type