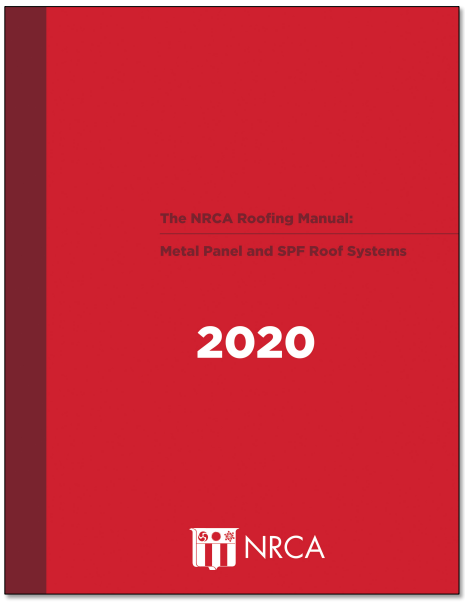
Project Managers Meeting
Oglebay Resort, Wheeling, WV
February 20, 2020

Emerging Technical Issues and Risks

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

1

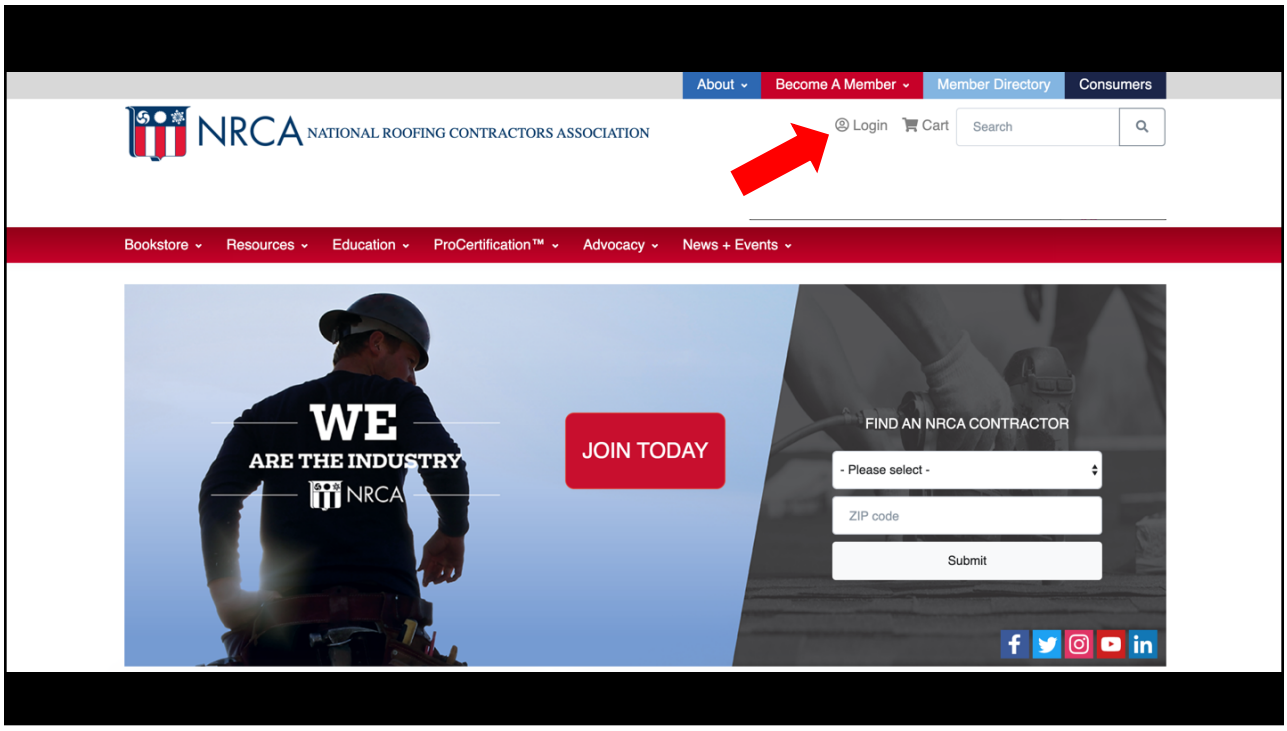


The NRCA Roofing Manual:
Metal Panel and SPF Roof Systems-2020

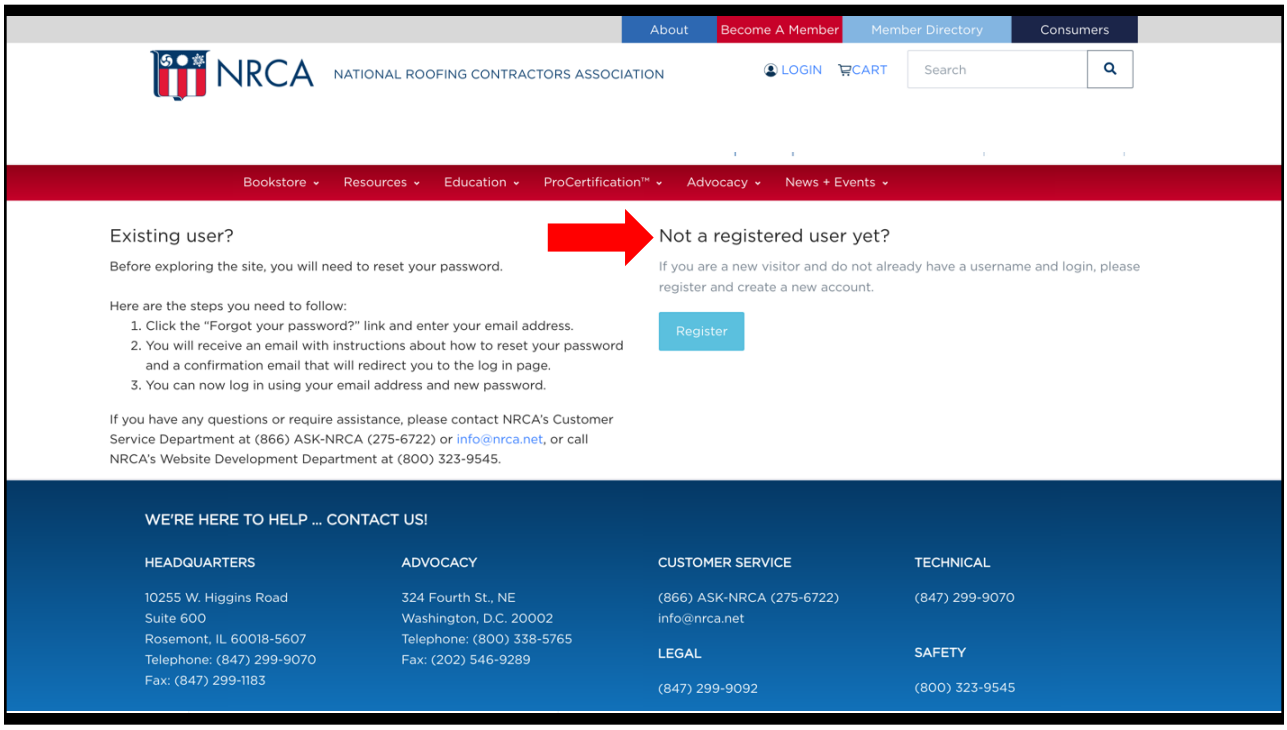
2

The NRCA Roofing Manual

3

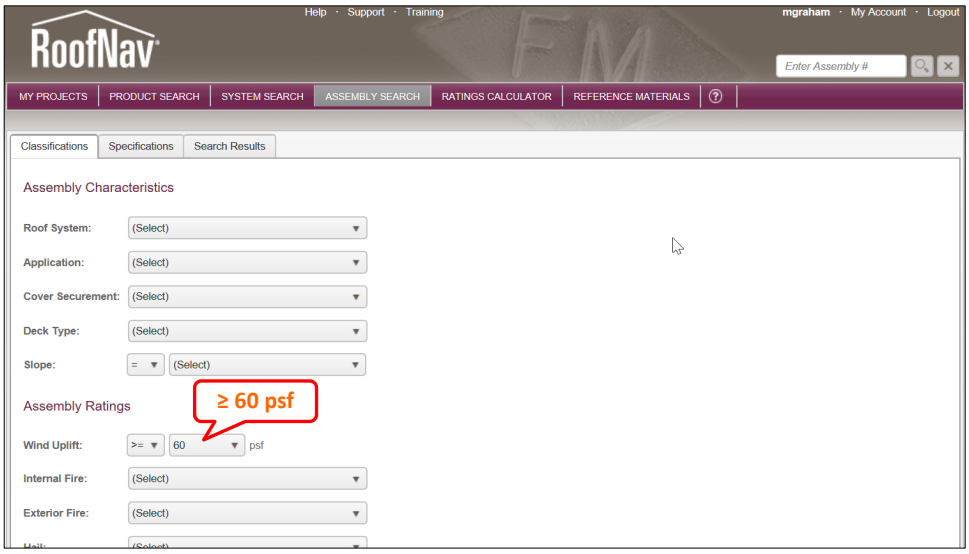


4

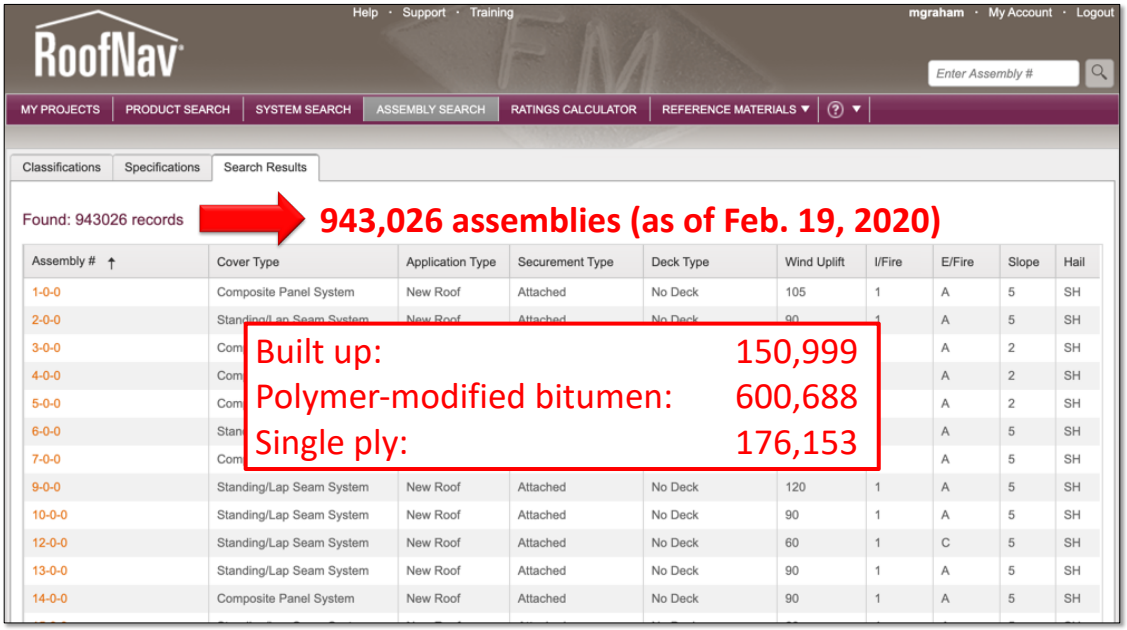


5

Some "fun" with RoofNav



6



7

Moisture in concrete roof decks

8

PORTLAND CEMENT ASSOCIATION
RESEARCH AND DEVELOPMENT LABORATORIES
Development Department • Bulletin D89

Table 1

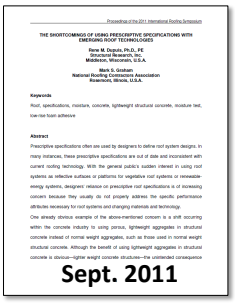
Drying time in days at 73 F and 50% relative Humidity for a 4-inch-thick specimen to reach 3 lbs/1,000 sq. ft./24 hrs.

Water-Cement Ratio	Bottom Sealed	Bottom Exposed to Water Vapor	Bottom in Contact with Water
0.4	46	52	54
0.5	85	144	199
0.6	117	365	>>365
0.7	130	>>365	>>365
0.8	148	>>365	>>365
0.9	166	>>365	>>365
1.0	190	>>365	>>365

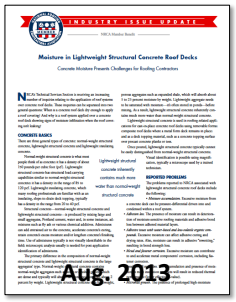
9

Moisture in concrete roof decks

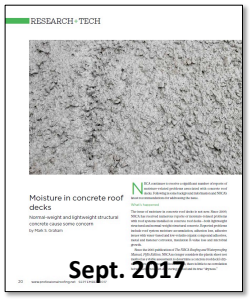

Feb. 2010


Sept. 2011

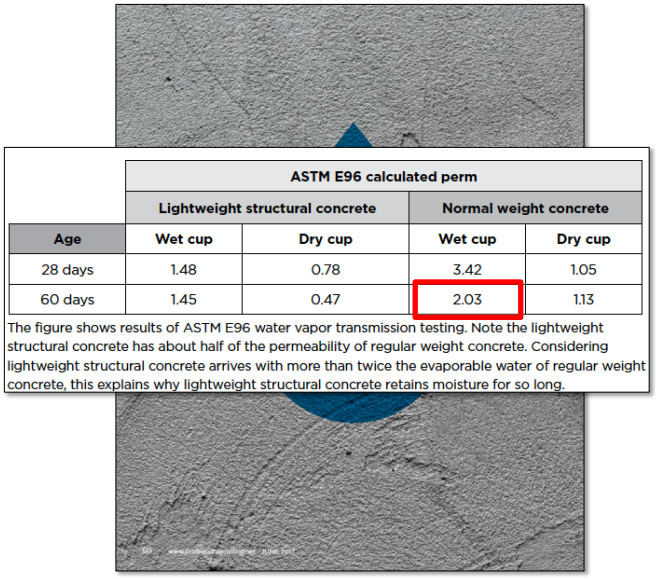

Dec. 2012


Aug. 2013


Dec. 2013


Sept. 2017

10



	ASTM E96 calculated perm			
	Lightweight structural concrete		Normal weight concrete	
Age	Wet cup	Dry cup	Wet cup	Dry cup
28 days	1.48	0.78	3.42	1.05
60 days	1.45	0.47	2.03	1.13

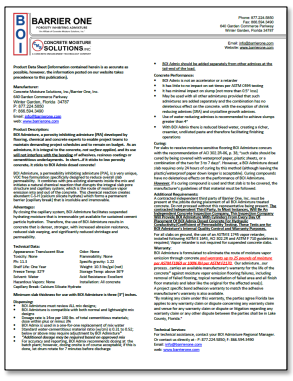
The figure shows results of ASTM E96 water vapor transmission testing. Note the lightweight structural concrete has about half of the permeability of regular weight concrete. Considering lightweight structural concrete arrives with more than twice the evaporable water of regular weight concrete, this explains why lightweight structural concrete retains moisture for so long.

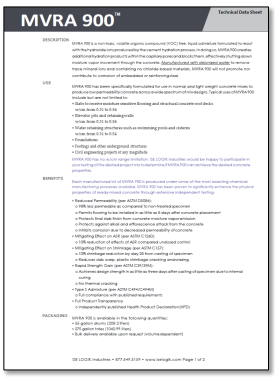
Professional Roofing, June 2017

Professional Roofing, December 2018

11

Moisture vapor reduction admixtures (MVRAs)





NRCA still has not seen an MVRA perform successfully in concrete <u>roof deck</u> applications

12

RESEARCH+TECH

	Deck 1 (no MVRA)		Deck 2 (with an MVRA)		Deck 3 (with an MVRA)	
Specimen No.	1-1	1-2	2-1	2-2	3-1	3-2
Permeability (U.S. perm)	1.9	1.8	3.7	3.4	3.7	3.8

Table: Average tested permeability values

Putting it to the test

NRCA conducts testing of moisture vapor reduction admixtures

by Mark S. Graham

tion admixture intended to minimize a concrete roof deck's ability to pass and release moisture vapor. Some background and an overview of NRCA's testing and results follow.

What's an MVRA?

Concrete admixtures intended as MVRAs are specific chemicals added during concrete's batching and mixing to provide an additional chemical reaction during the concrete's hydration and curing process. MVRAs use the concrete mix's excess water and chlorides to create a calcium silicate hydrate gel within the concrete. The gel is said to fill the small pores and capillary openings in curing concrete, minimizing the concrete's ability to pass and release moisture vapor. The gel is intended to be permanent and integral throughout the concrete thickness.

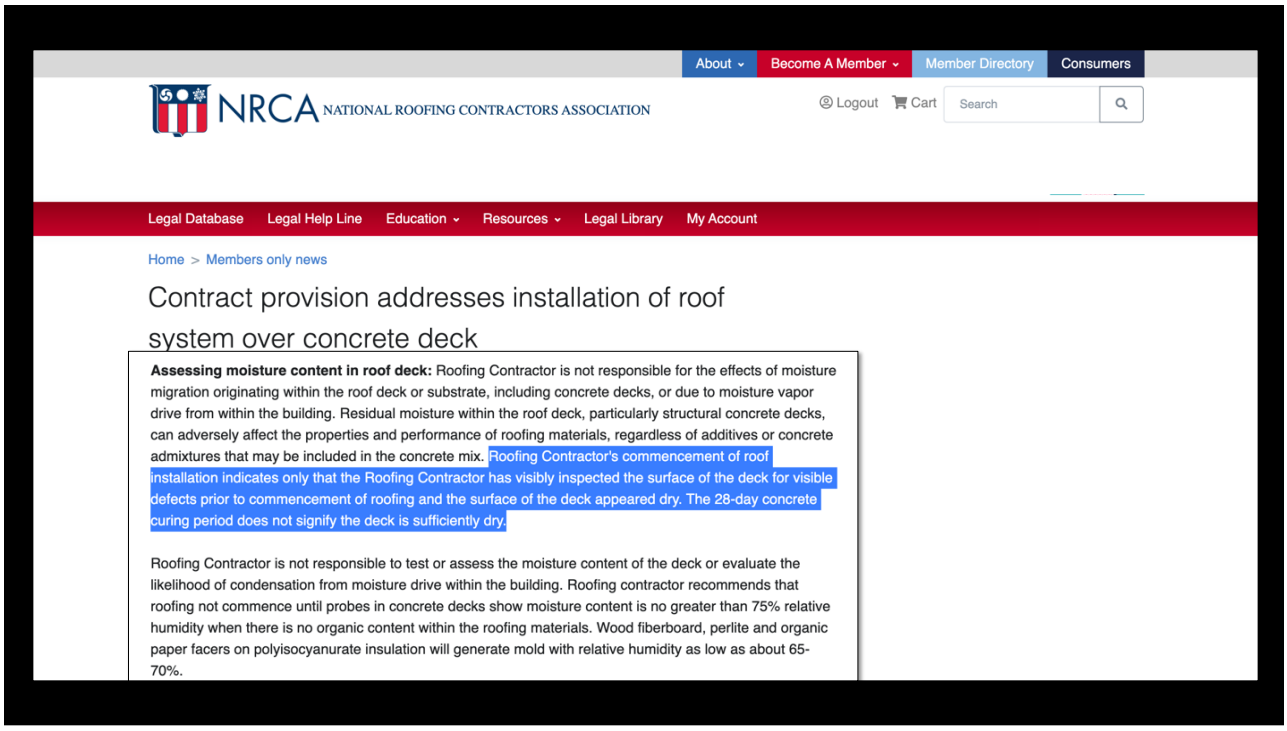
MVRAs are available from numerous suppliers and typically added to a concrete mix at the concrete batch plant separately from any other admixtures. Some MVRA suppliers permit their MVRAs to be added to concrete mixers at job sites provided the concrete mixer's drum is rotated for a supplier's recommended minimum amount of time after dosage and before concrete discharge and placement.

26 www.professionalroofing.net FEBRUARY 2020

Professional Roofing
February 2020

"…These test results contradict claims an MVRA minimizes concrete's ability to pass and release moisture vapor…"

13



14

Coming soon...

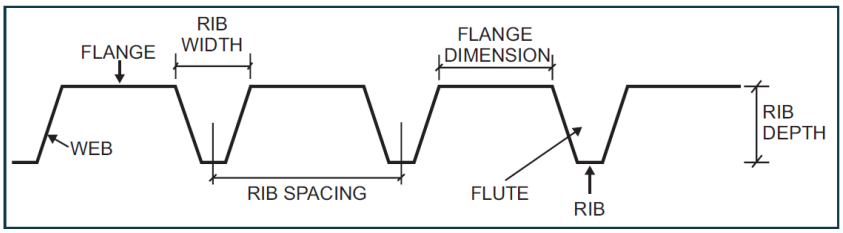
- Publication of the final report on SRI's industry-sponsored concrete moisture research
- Research summary article written by Matt Dupuis in the March issue of *Professional Roofing*
- NRCA "Industry Issue update," which will summarize the research to date and provide NRCA latest recommendations

15

Fastener pull-out testing in steel roof decks

16

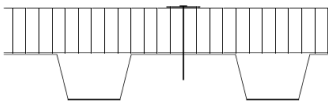
Terminology -- Steel roof decks



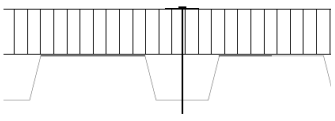
17

Tested fastener locations

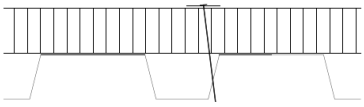
Fastener in flange



Fastener in rib



Fastener in web



18

Other test parameters

Steel deck types:

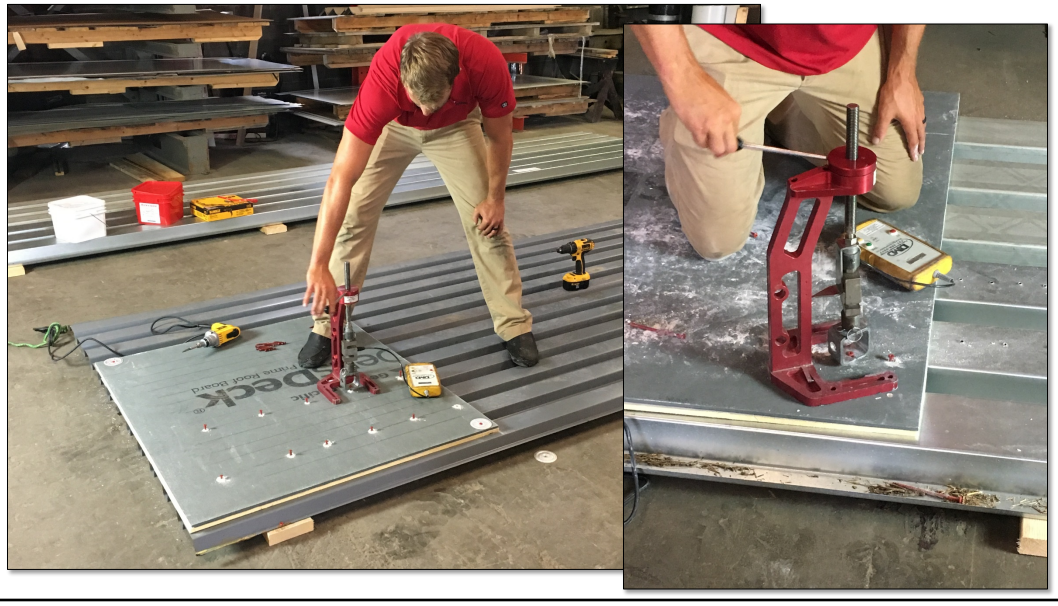
- 22 ga., 1½-in.-thick, Type B-deck
- 20 ga., 3-in.-thick, Type N-deck (Type 3DR)

Fastener types:

- All-purpose fastener (#14)
  - Published pull-out values:
    - 22 ga.: 315 lbf at 33 ksi and 480 lbf at 80 ksi
    - 20 ga.: 420 lbf at 33 ksi and 615 lbf at 80 ksi
- Heavy duty fastener (#15)
  - Published pull-out values:
    - 22 ga.: 595 lbf at 33 ksi and 650 lbf at 80 ksi

19

Test set-up and equipment



20

Test data

22 ga., 1½-in.-thick, Type B deck
All-purpose Fastener (#14)
Average value 10 pull-out tests

Fastener in flange	Fastener in rib	Fastener in web
637.4 lbf	561.1 lbf	556.2 lbf

Published pull-out value is 315-480 lbf

Tested fastener in rib value is 88 % of fastener in flange value
Tested fastener in web value is 87% of fastener in flange value

21

Test data

22 ga., 1½-in.-thick, Type B deck
Heavy Duty Fastener (#15)
Average value 10 pull-out tests

Fastener in flange	Fastener in rib	Fastener in web
761 lbf	680.9 lbf	674.8 lbf

Published pull-out value is 595-650 lbf

Tested fastener in rib value is 89 % of fastener in flange value
Tested fastener in web value is 89% of fastener in flange value

22

Test data

20 ga., 3-in.-thick, Type3DR deck
All-purpose Fastener (#14)
Average value 10 pull-out tests

Fastener in flange	Fastener in rib	Fastener in web
848.8 lbf	732.8 lbf	733.0 lbf

Published pull-out value is 420-615 lbf

Tested fastener in rib value is 86% of fastener in flange value
Tested fastener in web value is 86% of fastener in flange value

23

Test data

20 ga., 3-in.-thick, Type3DR deck
Heavy Duty Fastener (#15)
Average value 10 pull-out tests

Fastener in flange	Fastener in rib	Fastener in web
1,044 lbf	1,037 lbf	978.2 lbf

No published pull-out value

Tested fastener in rib value is 99% of fastener in flange value
Tested fastener in web value is 94% of fastener in flange value

24

Conclusions

Fastener pull-out testing

- Tested pull-out values are greater than published values
- "Fastener in web" or "Fastener in rib" placement results in a less than 15% reduction in pull-out load versus "Fastener in flange" placement
- Actual deck gauge, deck yield strength and fastener selection have larger impacts on fastener pull-out values
- A safety factor is typically applied to fastener pull-out loads which more than covers this reduction
- This test data applies to insulation fasteners' performances, not necessarily membrane fasteners' (e.g, fastener "rocking" due to membrane fluttering)

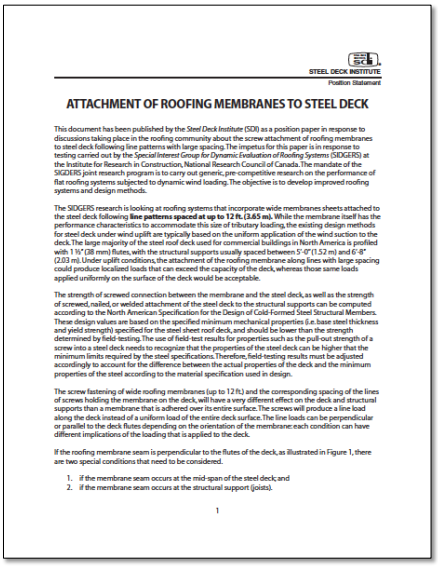
25

Steel roof decks/seam-fastened systems

26

SDI bulletin

2009



STEEL DECK INSTITUTE
Position Statement

ATTACHMENT OF ROOFING MEMBRANES TO STEEL DECK

This document has been published by the *Steel Deck Institute* (SDI) as a position paper in response to discussions taking place in the roofing community about the screw attachment of roofing membranes to steel deck following line patterns with large spacing. The impetus for this paper is in response to testing carried out by the *Special Interest Group for Dynamic Evaluation of Roofing Systems* (SIDGERS) at the Institute for Research in Construction, National Research Council of Canada. The mandate of the SIGDERS joint research program is to carry out generic, pre-competitive research on the performance of flat roofing systems subjected to dynamic wind loading. The objective is to develop improved roofing systems and design methods.

The SIDGERS research is looking at roofing systems that incorporate wide membranes sheets attached to the steel deck following **line patterns spaced at up to 12 ft. (3.65 m).** While the membrane itself has the performance characteristics to accommodate this size of tributary loading, the existing design methods for steel deck under wind uplift are typically based on the uniform application of the wind suction to the deck. The large majority of the steel roof deck used for commercial buildings in North America is profiled with 1 ½" (38 mm) flutes, with the structural supports usually spaced between 5'-0" (1.52 m) and 6'-8" (2.03 m). Under uplift conditions, the attachment of the roofing membrane along lines with large spacing could produce localized loads that can exceed the capacity of the deck, whereas those same loads applied uniformly on the surface of the deck would be acceptable.

The strength of screwed connection between the membrane and the steel deck, as well as the strength of screwed, nailed, or welded attachment of the steel deck to the structural supports can be computed according to the North American Specification for the Design of Cold-Formed Steel Structural Members. These design values are based on the specified minimum mechanical properties (i.e. base steel thickness and yield strength) specified for the steel sheet roof deck, and should be lower than the strength determined by field-testing. The use of field-test results for properties such as the pull-out strength of a screw into a steel deck needs to recognize that the properties of the steel deck can be higher that the minimum limits required by the steel specifications. Therefore, field-testing results must be adjusted accordingly to account for the difference between the actual properties of the deck and the minimum properties of the steel according to the material specification used in design.

The screw fastening of wide roofing membranes (up to 12 ft.) and the corresponding spacing of the lines of screws holding the membrane on the deck, will have a very different effect on the deck and structural supports than a membrane that is adhered over its entire surface. The screws will produce a line load along the deck instead of a uniform load of the entire deck surface. The line loads can be perpendicular or parallel to the deck flutes depending on the orientation of the membrane: each condition can have different implications of the loading that is applied to the deck.

If the roofing membrane seam is perpendicular to the flutes of the deck, as illustrated in Figure 1, there are two special conditions that need to be considered.

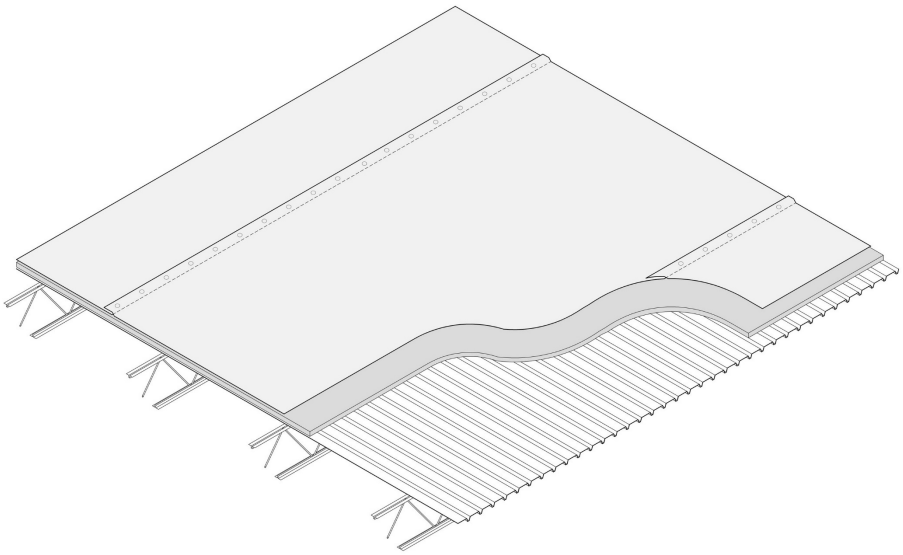
1. if the membrane seam occurs at the mid-span of the steel deck; and
2. if the membrane seam occurs at the structural support (joists).

1

- Decks designed for joist spacing between 5’ and 6’ 8” o.c.
- Deck designed for uniform loading
- Seam-fastened single-ply membranes are a concern

27

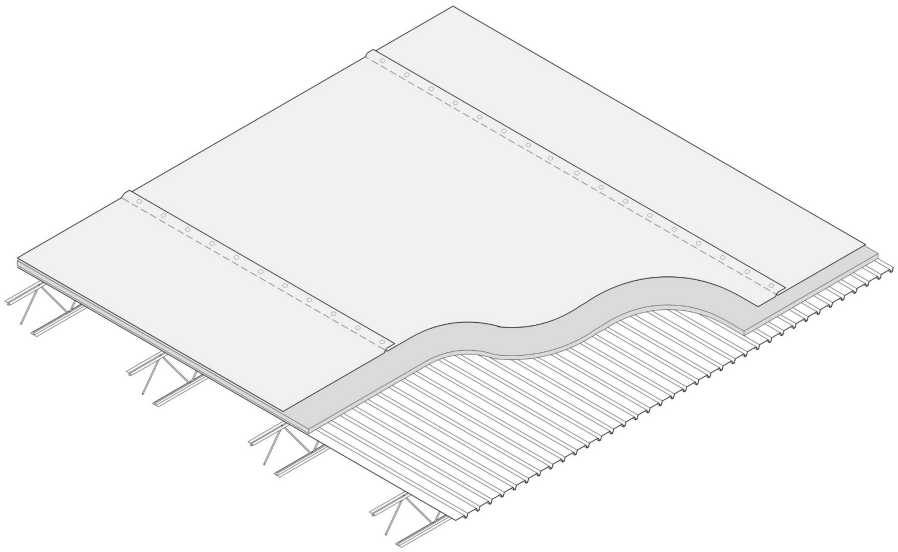
Membrane seams across deck flutes



SDI: 3.8 X moment (deck); 2 X load (joists)

28

Membrane seams in deck flute direction



SDI: 12 X bending moment and shear (deck)

29

SDI bulletin – Conclusion

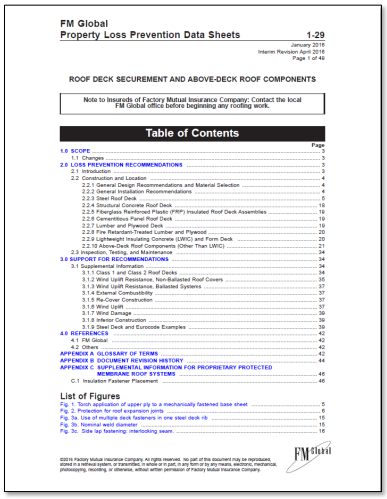
2009 bulletin

"…SDI does not recommend the use of roofing membranes attached to the steel deck using line patterns with large spacing unless a structural engineer has reviewed the adequacy of the steel deck and the structural supports to resist to wind uplift loads transmitted along the lines of attachment. Those lines of attachment shall only be perpendicular to the flutes of the deck."

30

FM Global's Loss Prevention Data Sheet 1-29

April 2016



FM Global
Property Loss Prevention Data Sheets 1-29
January 2016
Interim Revision April 2016
Page 1 of 46

ROOF DECK SECUREMENT AND ABOVE-DECK ROOF COMPONENTS

Note to Insureds of Factory Mutual Insurance Company: Contact the local FM Global office before beginning any roofing work.

Table of Contents

Page

1.0 SCOPE ... 3
1.1 Changes ... 3
2.0 LOSS PREVENTION RECOMMENDATIONS ... 3
2.1 Introduction ... 3
2.2 Construction and Location ... 4
2.2.1 General Design Recommendations and Material Selection ... 4
2.2.2 General Installation Recommendations ... 4
2.2.3 Steel Roof Deck ... 5
2.2.4 Structural Concrete Roof Deck ... 18
2.2.5 Fiberglass Reinforced Plastic (FRP) Insulated Roof Deck Assemblies ... 18
2.2.6 Gypsum Roof Deck and Roof Deck ... 19
2.2.7 Lumber and Plywood Decks ... 19
2.2.8 Fire Retardant-Treated Lumber and Plywood ... 20
2.2.9 Lightweight Insulating Concrete (LWIC) and Form Deck ... 20
2.2.10 Above-Deck Roof Components (Other Than LWIC) ... 21
2.3 Inspection, Testing, and Maintenance ... 34
3.0 SUPPORT FOR RECOMMENDATIONS ... 34
3.1 Supplemental Information ... 34
3.1.1 Class 1 and Class 2 Roof Decks ... 34
3.1.2 Wind Uplift Resistance, Non-Ballasted Roof Covers ... 35
3.1.3 Wind Uplift Resistance, Ballasted Systems ... 37
3.1.4 External Combustibility ... 37
3.1.5 Re-Cover Construction ... 37
3.1.6 Wind Uplift ... 37
3.1.7 Wind Damage ... 39
3.1.8 Interior Construction ... 39
3.1.9 Steel Deck and Eurocode Examples ... 39
4.0 REFERENCES ... 42
4.1 FM Global ... 42
4.2 Others ... 42
APPENDIX A GLOSSARY OF TERMS ... 42
APPENDIX B DOCUMENT REVISION HISTORY ... 44
APPENDIX C SUPPLEMENTAL INFORMATION FOR PROPRIETARY PROTECTED MEMBRANE ROOF SYSTEMS ... 46
C.1 Insulation Fastener Placement ... 46

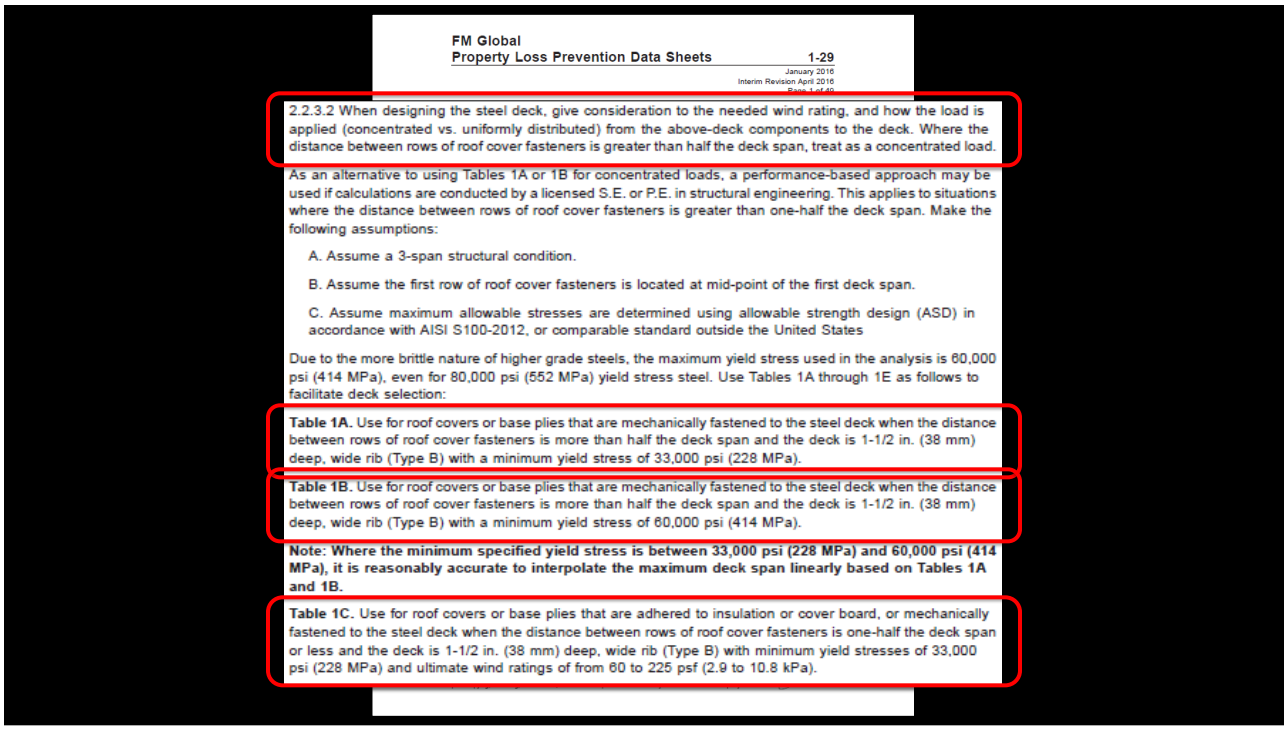
List of Figures

Fig. 1. Torch application of upper ply to a mechanically fastened base sheet ... 5
Fig. 2. Protection for roof expansion joints ... 6
Fig. 3a. Use of multiple deck fasteners in one steel deck rib ... 15
Fig. 3b. Nominal weld diameter ... 15
Fig. 3c. Side lap fastening: interlocking seam ... 16

Revised/new criteria:

- Steel roof decks:
  - Uniformly-distributed loading
  - Concentrated loading
- Lightweight structural concrete

31



FM Global
Property Loss Prevention Data Sheets 1-29
January 2016
Interim Revision April 2016
Page 1 of 46

2.2.3.2 When designing the steel deck, give consideration to the needed wind rating, and how the load is applied (concentrated vs. uniformly distributed) from the above-deck components to the deck. Where the distance between rows of roof cover fasteners is greater than half the deck span, treat as a concentrated load.

As an alternative to using Tables 1A or 1B for concentrated loads, a performance-based approach may be used if calculations are conducted by a licensed S.E. or P.E. in structural engineering. This applies to situations where the distance between rows of roof cover fasteners is greater than one-half the deck span. Make the following assumptions:

A. Assume a 3-span structural condition.

B. Assume the first row of roof cover fasteners is located at mid-point of the first deck span.

C. Assume maximum allowable stresses are determined using allowable strength design (ASD) in accordance with AISI S100-2012, or comparable standard outside the United States

Due to the more brittle nature of higher grade steels, the maximum yield stress used in the analysis is 60,000 psi (414 MPa), even for 80,000 psi (552 MPa) yield stress steel. Use Tables 1A through 1E as follows to facilitate deck selection:

Table 1A. Use for roof covers or base plies that are mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is more than half the deck span and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with a minimum yield stress of 33,000 psi (228 MPa).

Table 1B. Use for roof covers or base plies that are mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is more than half the deck span and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with a minimum yield stress of 60,000 psi (414 MPa).

Note: Where the minimum specified yield stress is between 33,000 psi (228 MPa) and 60,000 psi (414 MPa), it is reasonably accurate to interpolate the maximum deck span linearly based on Tables 1A and 1B.

Table 1C. Use for roof covers or base plies that are adhered to insulation or cover board, or mechanically fastened to the steel deck when the distance between rows of roof cover fasteners is one-half the deck span or less and the deck is 1-1/2 in. (38 mm) deep, wide rib (Type B) with minimum yield stresses of 33,000 psi (228 MPa) and ultimate wind ratings of from 60 to 225 psf (2.9 to 10.8 kPa).

32

FM Global
Property Loss Prevention Data Sheets 1-29

Table 1C. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, Wide Rib (Type B) Steel Deck with an Adhered Roof Cover, for Wind Ratings from 60 to 225 psf (2.9 to 10.8 kPa)
(NOTE: Use this table when the distance between rows of roof cover fasteners is one-half the deck span or less. Green font indicates that deflection governs over bending stress.)

Yield Stress psi	Deck Gauge	Ultimate Wind Rating per RoofNav (psf) Maximum Span (ft)											
		60	75	90	105	120	135	150	165	180	195	210	225
33,000	22	7.10	7.10	7.10	7.10	7.07	6.67	6.33	6.03	5.78	5.55	5.35	5.17
	20	7.78	7.78	7.78	7.78	7.78	7.43	7.05	6.72	6.44	6.18	5.96	5.76
	18	9.08	9.08	9.08	9.08	9.08	8.66	8.22	7.84	7.50	7.21	6.95	6.71
	16	10.36	10.36	10.36	10.36	10.36	9.89	9.38	8.94	8.56	8.23	7.93	7.66
40,000	22	7.10	7.10	7.10	7.10	7.10	7.10	6.96	6.64	6.35	6.10	5.88	5.68
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.76	7.40	7.08	6.80	6.56	6.33
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.04	8.62	8.25	7.93	7.64	7.38
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.32	9.84	9.42	9.05	8.72	8.43
45,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.04	6.74	6.48	6.24	6.03
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.51	7.22	6.95	6.72
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	8.76	8.41	8.11	7.83
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	9.99	9.60	9.25	8.94
50,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.93	6.66	6.42	6.20
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.72	7.42	7.15	6.91
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.00	8.65	8.33	8.05
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.28	9.87	9.51	9.19
55,000	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.90	6.67
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.69	7.43
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	8.97	8.66
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.24	9.89
60,000 +	22	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	7.10	6.97
	20	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.78	7.77
	18	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.08	9.06
	16	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.36	10.34

Green font indicates that deflection governs over bending stress.

33

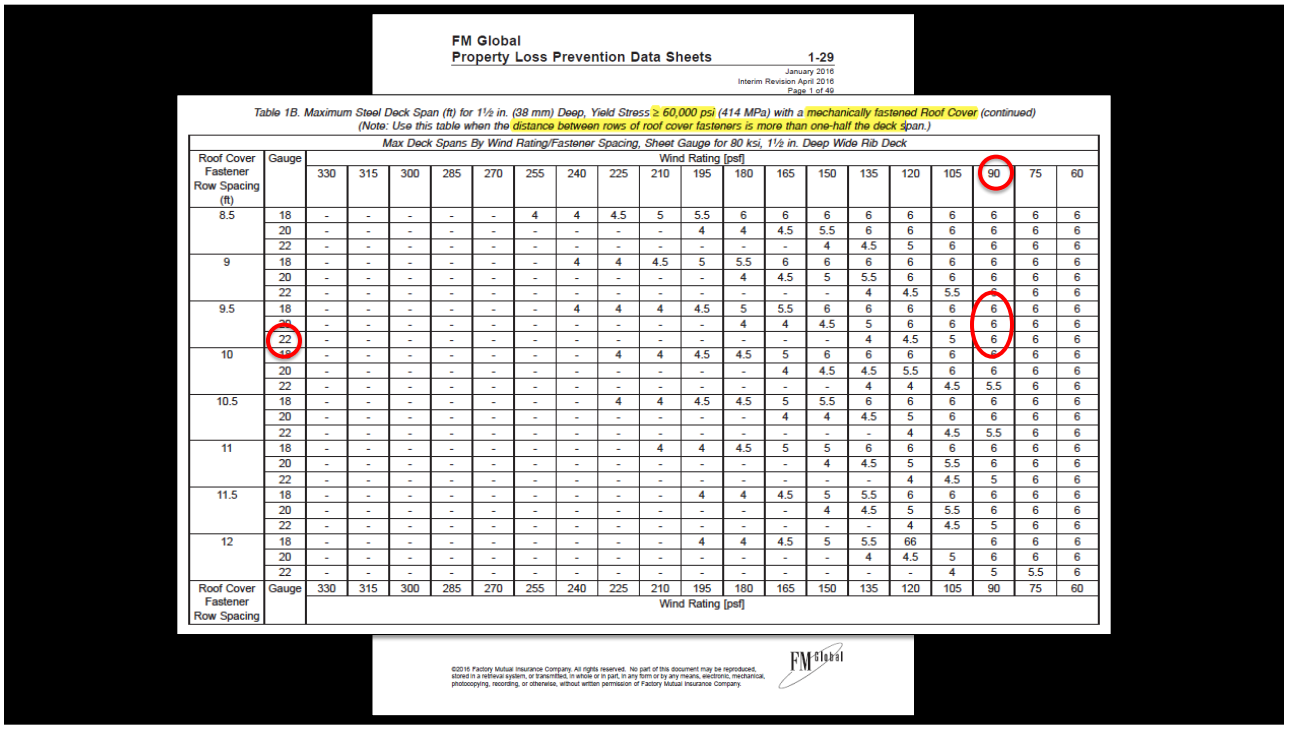
FM Global
Property Loss Prevention Data Sheets 1-29
January 2016
Interim Revision April 2016

Table 1A. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, 33,000 psi (228 MPa) Yield Stress with a Mechanically Fastened Roof Cover
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 33 ksi, 1½ in. Deep Wide Rib Deck

Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf] 330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
3.5	18	4.5	5.5	5.5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	4	4	4.5	4.5	4.5	5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	4	4	4.5	4.5	4.5	5.5	5.5	5.5	6	6	6	6	6	6
4	18	4.5	4.5	5	5	5	6	6	6	6	6	6	6	6	6	6	6		6	6
	20	-	-	-	-	4	4.5	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	4	4.5	5	5	6	6	6	6	6	6	6
4.5	18	-	4	4	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	4	4	5	5	5.5	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6
5	18	-	-	-	4	4	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6	6
	20									4	4.5	5	5.5	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6	6
5.5	18	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5	6	6	6	6
6	18	-	-	-	-	-	-	-	-	4	5	5.5	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6	6
6.5	18	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	5.5	6	6
7	18	-	-	-	-	-	-	-	-	-	-	-	4	5.5	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	6	6
7.5	18	-	-	-	-	-	-	-	-	-	-	-	-	4	5.5	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	6

34



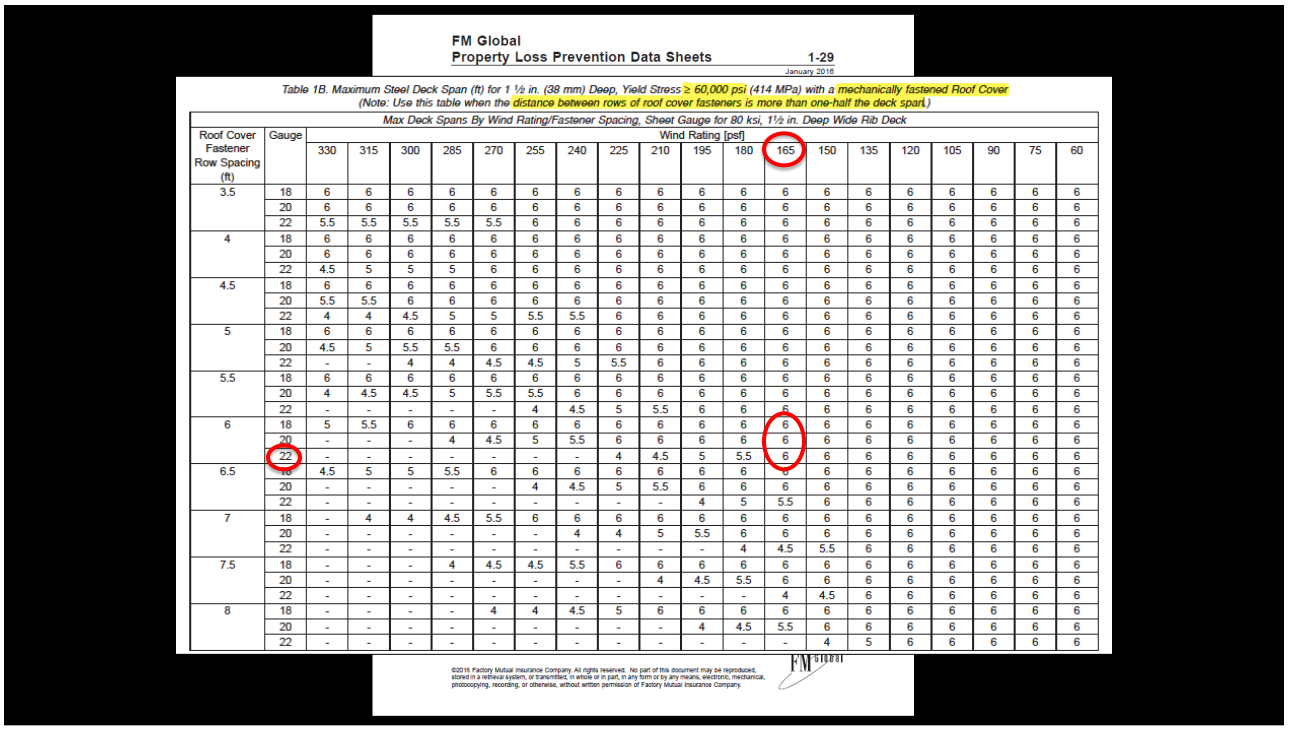
FM Global
Property Loss Prevention Data Sheets 1-29
January 2016
Interim Revision April 2016
Page 1 of 49

Table 1B. Maximum Steel Deck Span (ft) for 1½ in. (38 mm) Deep, Yield Stress ≥ 60,000 psi (414 MPa) with a mechanically fastened Roof Cover (continued)
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 80 ksi, 1½ in. Deep Wide Rib Deck

Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf]																		
		330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
8.5	18	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	4	4	4.5	5.5	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6	6
9	18	-	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6
9.5	18	-	-	-	-	-	-	4	4	4	4.5	5	5.5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6
10	18	-	-	-	-	-	-	-	4	4	4.5	4.5	5	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	4	4.5	4.5	5.5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5.5	6	6
10.5	18	-	-	-	-	-	-	-	4	4	4.5	4.5	5	5.5	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	4	4	4.5	5	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6
11	18	-	-	-	-	-	-	-	-	4	4	4.5	5	5	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6
11.5	18	-	-	-	-	-	-	-	-	-	4	4	4.5	5	5.5	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6
12	18	-	-	-	-	-	-	-	-	-	4	4	4.5	5	5.5	66		6	6	6
	20	-	-	-	-	-	-	-	-	-	-	-	-	-	4	4.5	5	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	5.5	6
Roof Cover Fastener Row Spacing	Gauge	330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
		Wind Rating [psf]																		

35



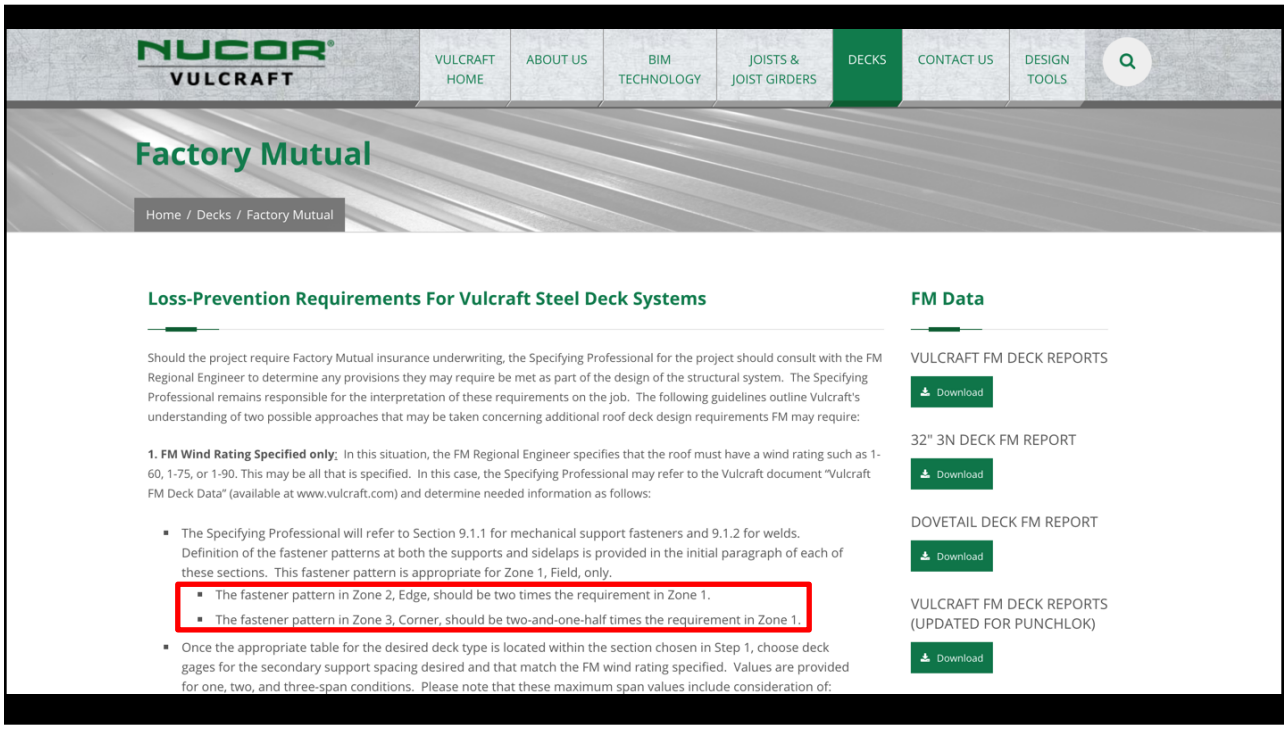
FM Global
Property Loss Prevention Data Sheets 1-29
January 2016

Table 1B. Maximum Steel Deck Span (ft) for 1 ½ in. (38 mm) Deep, Yield Stress ≥ 60,000 psi (414 MPa) with a mechanically fastened Roof Cover
(Note: Use this table when the distance between rows of roof cover fasteners is more than one-half the deck span.)

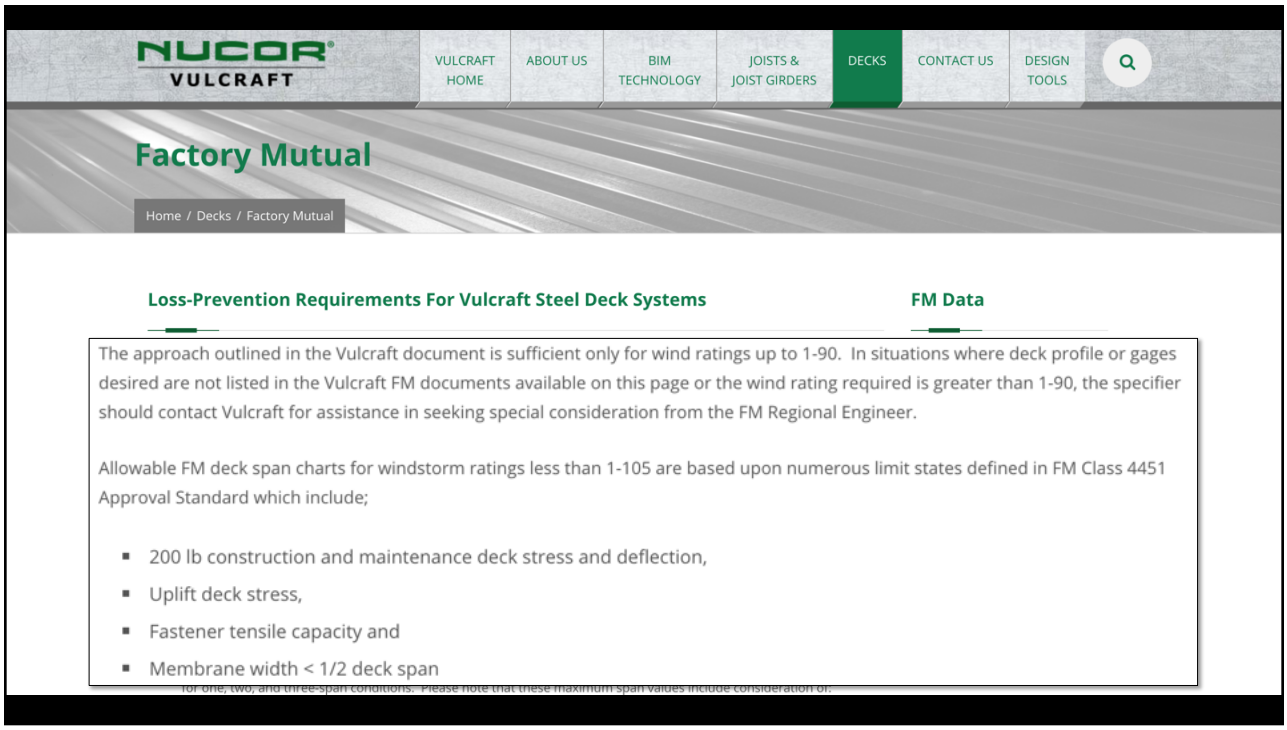
Max Deck Spans By Wind Rating/Fastener Spacing, Sheet Gauge for 80 ksi, 1½ in. Deep Wide Rib Deck

Roof Cover Fastener Row Spacing (ft)	Gauge	Wind Rating [psf]																		
		330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60
3.5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	5.5	5.5	5.5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	4.5	5	5	5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
4.5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	4	4	4.5	5	5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	4.5	5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	-	-	4	4	4.5	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6	6
5.5	18	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	4	4.5	4.5	5	5.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6
6	18	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6
6.5	18	4.5	5	5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	4	4.5	5	5.5	6	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	4	5	5.5	6	6	6	6	6	6	6
7	18	-	4	4	4.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	4	4	5	5.5	6	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6
7.5	18	-	-	-	4	4.5	4.5	5.5	6	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	4	4.5	6	6	6	6	6	6
8	18	-	-	-	-	4	4	4.5	5	6	6	6	6	6	6	6	6	6	6	6
	20	-	-	-	-	-	-	-	-	-	4	4.5	5.5	6	6	6	6	6	6	6
	22	-	-	-	-	-	-	-	-	-	-	-	-	4	5	6	6	6	6	6

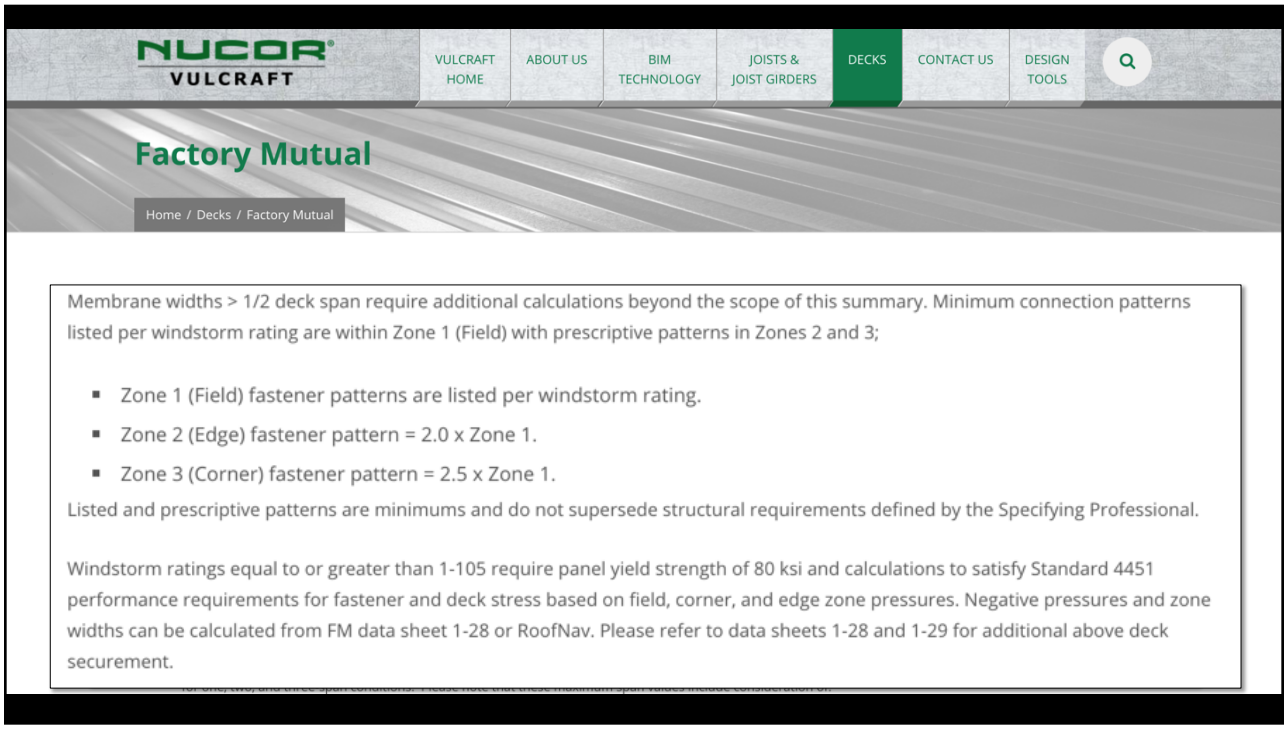
36


NUCOR VULCRAFT
VULCRAFT HOME
ABOUT US
BIM TECHNOLOGY
JOISTS & JOIST GIRDERS
DECKS
CONTACT US
DESIGN TOOLS
Factory Mutual
Home / Decks / Factory Mutual
Loss-Prevention Requirements For Vulcraft Steel Deck Systems
Should the project require Factory Mutual insurance underwriting, the Specifying Professional for the project should consult with the FM Regional Engineer to determine any provisions they may require be met as part of the design of the structural system. The Specifying Professional remains responsible for the interpretation of these requirements on the job. The following guidelines outline Vulcraft's understanding of two possible approaches that may be taken concerning additional roof deck design requirements FM may require:
1. FM Wind Rating Specified only: In this situation, the FM Regional Engineer specifies that the roof must have a wind rating such as 1-60, 1-75, or 1-90. This may be all that is specified. In this case, the Specifying Professional may refer to the Vulcraft document "Vulcraft FM Deck Data" (available at www.vulcraft.com) and determine needed information as follows:
The Specifying Professional will refer to Section 9.1.1 for mechanical support fasteners and 9.1.2 for welds. Definition of the fastener patterns at both the supports and sidelaps is provided in the initial paragraph of each of these sections. This fastener pattern is appropriate for Zone 1, Field, only.
The fastener pattern in Zone 2, Edge, should be two times the requirement in Zone 1.
The fastener pattern in Zone 3, Corner, should be two-and-one-half times the requirement in Zone 1.
Once the appropriate table for the desired deck type is located within the section chosen in Step 1, choose deck gages for the secondary support spacing desired and that match the FM wind rating specified. Values are provided for one, two, and three-span conditions. Please note that these maximum span values include consideration of:
FM Data
VULCRAFT FM DECK REPORTS
Download
32" 3N DECK FM REPORT
Download
DOVETAIL DECK FM REPORT
Download
VULCRAFT FM DECK REPORTS (UPDATED FOR PUNCHLOK)
Download

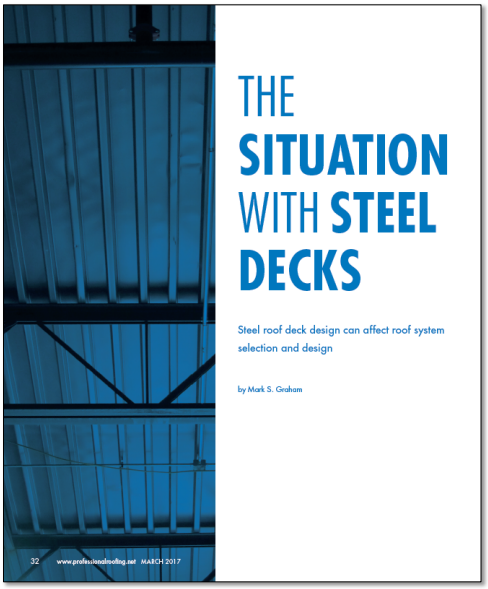
37


NUCOR VULCRAFT
VULCRAFT HOME
ABOUT US
BIM TECHNOLOGY
JOISTS & JOIST GIRDERS
DECKS
CONTACT US
DESIGN TOOLS
Factory Mutual
Home / Decks / Factory Mutual
Loss-Prevention Requirements For Vulcraft Steel Deck Systems
FM Data
The approach outlined in the Vulcraft document is sufficient only for wind ratings up to 1-90. In situations where deck profile or gages desired are not listed in the Vulcraft FM documents available on this page or the wind rating required is greater than 1-90, the specifier should contact Vulcraft for assistance in seeking special consideration from the FM Regional Engineer.
Allowable FM deck span charts for windstorm ratings less than 1-105 are based upon numerous limit states defined in FM Class 4451 Approval Standard which include;
200 lb construction and maintenance deck stress and deflection,
Uplift deck stress,
Fastener tensile capacity and
Membrane width < 1/2 deck span

38



39



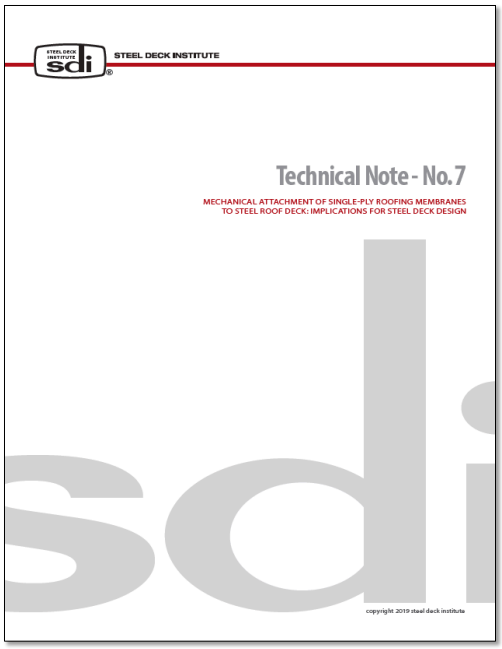
Professional Roofing
March 2017
www.professionalroofing.net

40

Fastener pull-out tests…

There is little correlation between fastener pull-out resistance and a steel roof deck's yield strength and uplift (bending) strength

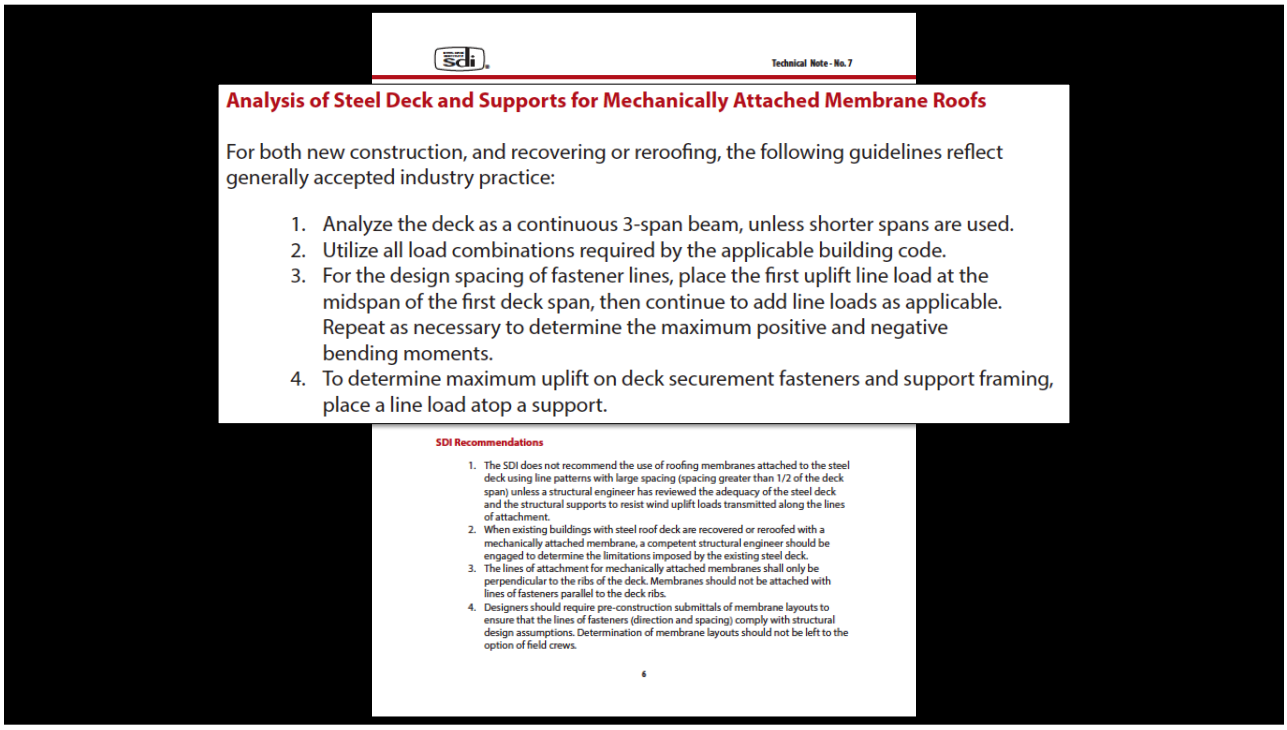
41



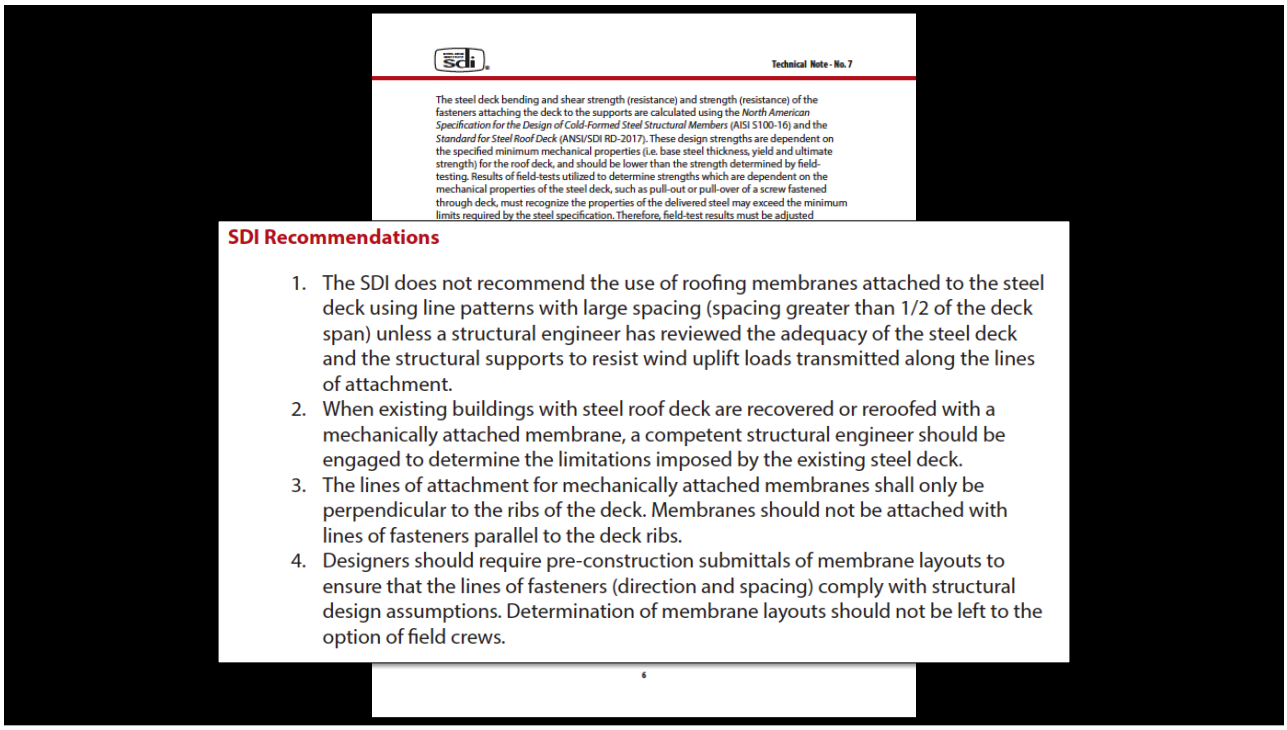
SDI Technical Note-No. 7 (Nov. 2019)

Mechanical attachment of single-ply roofing membranes to steel roof deck: Implications for steel deck design

42


Technical Note - No. 7
Analysis of Steel Deck and Supports for Mechanically Attached Membrane Roofs
For both new construction, and recovering or reroofing, the following guidelines reflect generally accepted industry practice:
1. Analyze the deck as a continuous 3-span beam, unless shorter spans are used.
2. Utilize all load combinations required by the applicable building code.
3. For the design spacing of fastener lines, place the first uplift line load at the midspan of the first deck span, then continue to add line loads as applicable. Repeat as necessary to determine the maximum positive and negative bending moments.
4. To determine maximum uplift on deck securement fasteners and support framing, place a line load atop a support.
SDI Recommendations
1. The SDI does not recommend the use of roofing membranes attached to the steel deck using line patterns with large spacing (spacing greater than 1/2 of the deck span) unless a structural engineer has reviewed the adequacy of the steel deck and the structural supports to resist wind uplift loads transmitted along the lines of attachment.
2. When existing buildings with steel roof deck are recovered or reroofed with a mechanically attached membrane, a competent structural engineer should be engaged to determine the limitations imposed by the existing steel deck.
3. The lines of attachment for mechanically attached membranes shall only be perpendicular to the ribs of the deck. Membranes should not be attached with lines of fasteners parallel to the deck ribs.
4. Designers should require pre-construction submittals of membrane layouts to ensure that the lines of fasteners (direction and spacing) comply with structural design assumptions. Determination of membrane layouts should not be left to the option of field crews.
6

43


Technical Note - No. 7
The steel deck bending and shear strength (resistance) and strength (resistance) of the fasteners attaching the deck to the supports are calculated using the North American Specification for the Design of Cold-Formed Steel Structural Members (AISI S100-16) and the Standard for Steel Roof Deck (ANSI/SDI RD-2017). These design strengths are dependent on the specified minimum mechanical properties (i.e. base steel thickness, yield and ultimate strength) for the roof deck, and should be lower than the strength determined by field-testing. Results of field-tests utilized to determine strengths which are dependent on the mechanical properties of the steel deck, such as pull-out or pull-over of a screw fastened through deck, must recognize the properties of the delivered steel may exceed the minimum limits required by the steel specification. Therefore, field-test results must be adjusted
SDI Recommendations
1. The SDI does not recommend the use of roofing membranes attached to the steel deck using line patterns with large spacing (spacing greater than 1/2 of the deck span) unless a structural engineer has reviewed the adequacy of the steel deck and the structural supports to resist wind uplift loads transmitted along the lines of attachment.
2. When existing buildings with steel roof deck are recovered or reroofed with a mechanically attached membrane, a competent structural engineer should be engaged to determine the limitations imposed by the existing steel deck.
3. The lines of attachment for mechanically attached membranes shall only be perpendicular to the ribs of the deck. Membranes should not be attached with lines of fasteners parallel to the deck ribs.
4. Designers should require pre-construction submittals of membrane layouts to ensure that the lines of fasteners (direction and spacing) comply with structural design assumptions. Determination of membrane layouts should not be left to the option of field crews.
6

44

Expect additional scrutiny of seam-fastened, mechanically-attached, single-ply membrane roof systems

45

The roofing industry needs to re-think the concept of "deck acceptance."

Deck acceptance should be limited to:
- Its physical presence
- Top surface is visually dry
- Surface is broom clean

If we do not limit deck acceptance, we do nothing other than incur someone else's liability (and not get paid for it).

46

RESEARCH+TECH

Consider the deck

SDI provides additional guidance for steel roof deck designers

by Mark S. Graham

In November 2019, the Steel Deck Institute issued new guidance for steel roof decks that features seam-fastened, mechanically attached, single-ply membranes. Although this guidance is directed toward roof deck designers, single-ply membrane manufacturers and suppliers, roof system designers and roofing contractors also should be aware of SDI's latest guidelines.

Previous guidance

In May 2009, SDI issued a position statement, "Attachment of Roofing Membranes to Steel Deck," indicating seam-fastened, mechanically attached, single-ply membrane roof systems apply wind-uplift loads to roof decks differently than adhered membrane roof systems. Although adhered membrane roof systems apply uplift loads uniformly across a roof deck, seam-fastened membrane systems result in concentrated line loads along the deck. Such line loads can result in excess bending moment and shear applied to the deck or a doubling of uplift loads on specific structural supports (joists) depending on the orientation of the membrane sheets relative to the deck flutes and joists.

SDI's document goes on to recommend structural engineers should review the adequacy of steel roof decks and their underlying

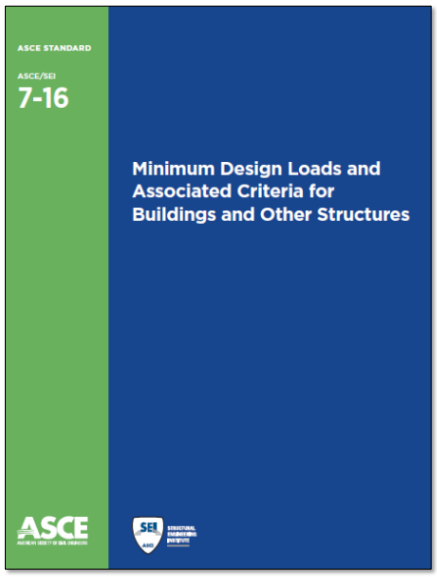
20 www.professionalroofing.net JANUARY 2020

Professional Roofing
January 2020

47

ASCE 7-16 implementation

48



American Society of Civil Engineers Standard 7, "Minimum design loads and associated criteria for buildings and other structures" (ASCE 7-16)

49

Noteworthy changes in ASCE 7-16

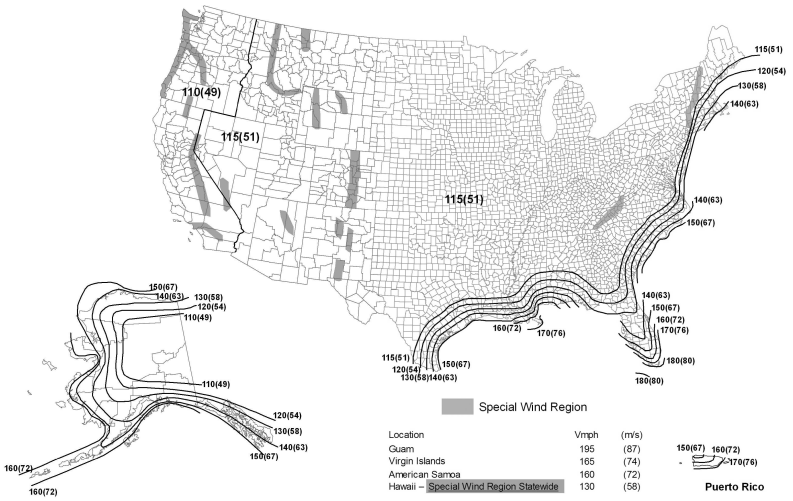
Compared to ASCE 7-10

- Revised basic wind speed map
- Changes (and new) pressure coefficients
- Revised perimeter and corner zones

50

ASCE 7-10 basic wind speed map

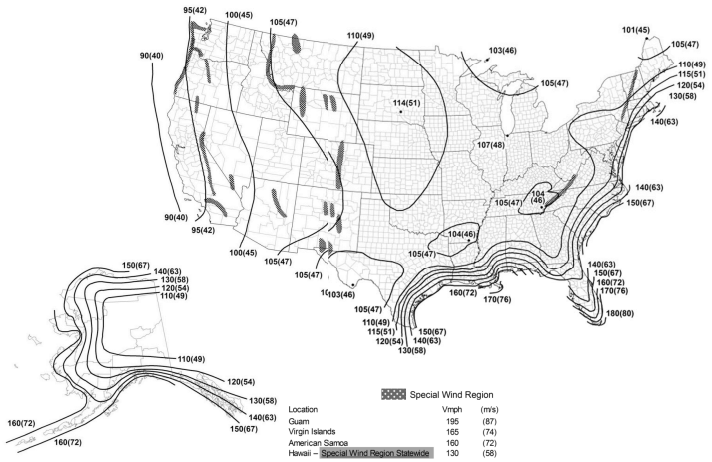
Fig. 1607A--V_{ult} for Risk Category II Buildings



51

ASCE 7-16 basic wind speed map

Risk Category II Buildings



52

Comparing GC_p pressure coefficients

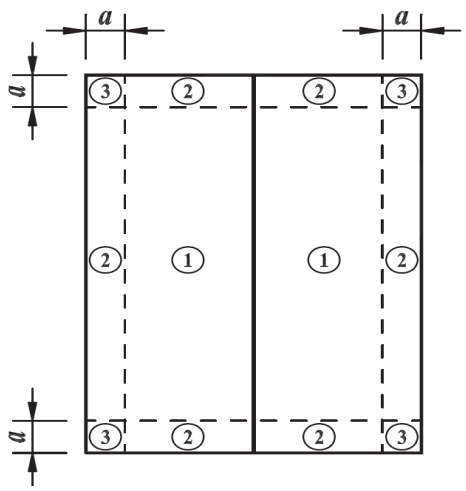
h ≤ 60 ft., gable roofs ≤ 7 degrees

Zone	ASCE 7-10	ASCE 7-16	Change
1' (center field)	n/a	0.9	-10%
1 (field)	-1.0	-1.7	+70%
2 (perimeter)	-1.8	-2.3	+28%
3 (corners)	-2.8	-3.2	+14%

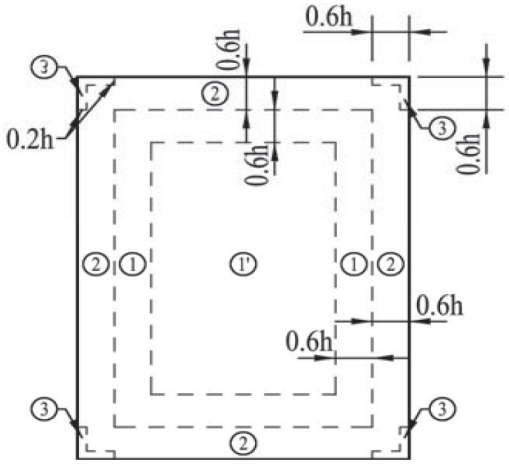
53

Zones

h ≤ 60 ft., gable roofs ≤ 7 degrees



ASCE 7-10



ASCE 7-16

54

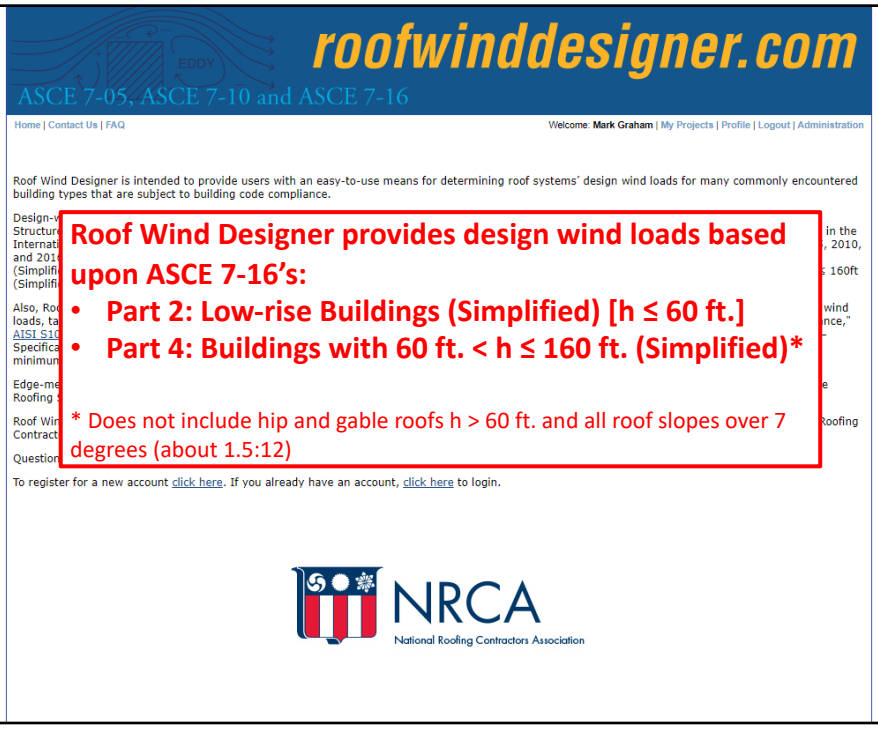
Noteworthy changes in ASCE 7-16

Compared to ASCE 7-10

- Revised basic wind speed map
- Changes (and new) pressure coefficients
- Revised perimeter and corner zones

While center field pressures may be slightly lower, field, perimeter and corner uplift pressures will generally be greater

55



56

Comparing ASCE 7-05, FM 1-28, ASCE 7-10 and ASCE 7-16

Example: A office building (Risk Category II) is located in Baltimore, MD. The building is an enclosed structure with a mean roof height of 40 ft. The building is located in an open terrain area that can be categorized as Exposure Category C. An adhered, membrane roof systems is to be installed.

Document	Basic wind speed (mph)	Design wind pressure (psf)			
		Zone 1' (Center)	Zone 1 (Field)	Zone 2 (Perimeter)	Zone 3 (Corners)
ASCE 7-05	90	--	22	36	55
FM 1-28	90	--	25	42	63
ASCE 7-10 Ult.	115	--	36	60	90
ASCE 7-10 ASD	90	--	21	36	54
ASCE 7-16 Ult.	115	33	57	75	102
ASCE 7-16 ASD	90	20	34	45	61

57

This comparison illustrates why it is important for Designers to include wind design loads in their Construction Documents (per IBC Sec. 1603.1)…

…It also illustrate why specifying a wind warrantee can create an uneven playing field. Unless the Designer indicates the wind design loads, which design method will the manufacturer use (e.g., in a competitive environment)?

58

FM Global has indicated they will update their Loss Prevention Data Sheet FM 1-28 and RoofNav Ratings Calculator to be based upon ASCE 7-16 (with modifications) this month.

59

TECH TODAY

Considering the winds

Properly specifying wind design is key to roof system performance

by Mark S. Graham

With increasing frequency, NRCA has been receiving reports of roof system designs that include inadequate provisions for wind loads and resistances. Designs that only specify wind speeds, wind warranties or disproportionately high (or low) uplift-resistance classifications are telltale signs of insufficient design considerations for high winds.

Where it appears designers have not properly addressed wind design, contractors are encouraged to seek further guidance from designers

Code requirements

Building codes typically provide minimum requirements for determining and reporting design wind loads on a project-specific basis.

For example, in the *International Building Code, 2015 Edition,*[1] (IBC), design wind loads should be determined according to Chapter 16—Structural Design. This chapter specifically references the 2010 edition of ASCE Standard 7, "Minimum Design Loads for Buildings and Other Structures." ASCE 7-10 also is referenced in IBC 2012.

With ASCE 7-10, roof systems typically are considered components and cladding elements, and design wind loads are determined using one of two methods: strength design or allowable stress design (ASD). Most roof systems are designed using the ASD method. IBC 2006 and IBC 2009 reference ASCE 7-05, which results in design wind loads near those derived using ASCE 7-10's ASD method.

IBC 2015's Section 1603—Construction Documents indicates a building's design loads, including a roof system's live load, snow load data, wind design and any special loads be noted in construction documents. Code-required wind design data include identifying the ultimate design wind speed, nominal design wind speed, risk category, wind exposure and applicable internal pressure coefficient. For component and cladding systems not specifically designed by a registered design professional, design wind pressures in terms of pounds per square foot (psf) also are required. Design wind pressures for the field, perimeter and corner regions of roof areas should specifically be noted.

A building's design loads most commonly will be identified on the structural drawings in the project drawing set for new construction projects. For reroofing projects without specific structural drawings, design loads may be provided on the architectural drawings or in the project specifications.

IBC 2012 and previous editions include similar construction document requirements for indicating building design loads.

IBC 2015 also has specific requirements for designing roof systems' abilities to resist design wind loads. For built-up, polymer-modified bitumen, and adhered and mechanically fastened single-ply membrane roof systems, for example, IBC 2015's Section 1504—Performance Requirements specifies laboratory testing according to one of the following:

- FM 4474, "American National Standard for Evaluating the Simulated Wind Uplift Resistance of Roof Assemblies Using Static Pressure and/or Negative Pressure"
- UL 580, "Tests for Uplift Resistance of Roof Assemblies"
- UL 1897, "Uplift Tests for Roof Covering Systems"

These tests provide the basis for FM Approvals' and Underwriters Laboratories' (UL) approval classifications for roof systems.

Roof Wind Designer

NRCA's Roof Wind Designer application can help roof system designers properly determine and specify design wind loads on roof systems. Roof Wind Designer allows users to input specific project information and determine design wind loads using ASCE 7-05 or ASCE 7-10's strength design and ASD methods for many commonly encountered building types. The application also determines minimum-recommended tested wind-resistance load capacities, taking into consideration a safety factor that allows designers to select appropriate uplift resistance-classified roof systems. Roof Wind Designer generates a project-specific report, which can be used for project documentation and submittal purposes.

Roof Wind Designer is free and can be accessed at www.roofwinddesigner.com. To date, the application has been used on more than 17,750 roofing projects.

In situations where it appears roof system designers have not properly addressed code-required considerations for wind design, contractors are encouraged to seek further guidance from designers. Referring designers to Roof Wind Designer is one possible approach to helping designers provide code-required documentation of design wind loads in contract documents.

MARK S. GRAHAM is NRCA's vice president of technical services.

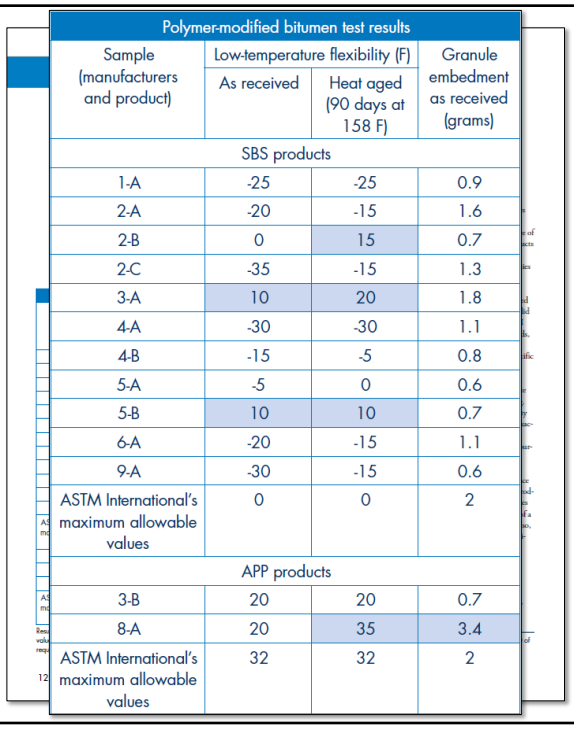
12 www.professionalroofing.net APRIL 2016

Professional Roofing
April 2016

60

Polymer-modified bitumen sheet testing

61



Polymer-modified bitumen test results

Sample (manufacturers and product)	Low-temperature flexibility (F)		Granule embedment as received (grams)
	As received	Heat aged (90 days at 158 F)	
SBS products			
1-A	-25	-25	0.9
2-A	-20	-15	1.6
2-B	0	15	0.7
2-C	-35	-15	1.3
3-A	10	20	1.8
4-A	-30	-30	1.1
4-B	-15	-5	0.8
5-A	-5	0	0.6
5-B	10	10	0.7
6-A	-20	-15	1.1
9-A	-30	-15	0.6
ASTM International's maximum allowable values	0	0	2
APP products			
3-B	20	20	0.7
8-A	20	35	3.4
ASTM International's maximum allowable values	32	32	2

Professional Roofing
February 2016

Nine of 13 products tested complied…

62

2011 testing

Only six of the 16 products tested complied….

63

2019 MB testing

- ASTM D5147 -- Low-temperature flexibility (as received)
- ASTM D4977 -- Granule embedment (as received)
- ASTM D3461 -- Softening point (as received)

64

Products tested

2019 MB testing

- 18 products tested:
  - 7 APP
  - 9 SBS
  - 15 products with granules
  - 3 products without granules (granule embedment doesn't apply)
- Manufacturers:
  - 10 (CertainTeed, Derbigum, Firestone, GAF, Garland, JM, Polyglass, Siplast, Soprema and Tremco)

65

Results – SBS products

2019 testing

Sample ID	Modifier	ASTM designation	Low-temp. flex. (F)	Granule loss (g)
1-A	SBS	ASTM D6164, Type I, Grade G	-13	0.56
3-A	SBS	ASTM D6164, Type I, Grade S	-27	NA
3-B	SBS	ASTM D6164, Type II, Grade G	-15	0.48
4-A	SBS	ASTM D6164, Type II, Grade G	-16	1.13
5-A	SBS	ASTM D6162, Type III, Grade G	-15	2.05
6-A	SBS	ASTM D6164, Type I, Grade G	-13	0.34
6-B	SBS	ASTM D6164, Type II, Grade G	-13	0.53
6-C	SBS	ASTM G6164, Type I, Grade G	-9	0.55
8-A	SBS	ASTM D6163, Type I, Grade G	-20	0.09
9-A	SBS	ASTM D6164, Type I, Grade G	-8	0.53
10-A	SBS	ASTM D6163, Type III, Grade G	Less than -40	1.16
		ASTM spec.	0 (max.)	2.0 (max)

66

Results – APP products

2019 testing

Sample ID	Modifier	ASTM designation	Low-temp. flex. (F)	Granule loss (g)
2-A	APP	ASTM D6223, Type I, Grade G	21	0.95
2-B	APP	ASTM D6223, Type I, Grade S	10	NA
2-C	APP	D6223, Grade G	14	0.60
2-D	APP	ASTM D6222, Type II, Grade G	10	0.65
2-E	APP	D6223, Grade G	9	NA
7-A	APP	D6222, Grade G	Greater than 41	0.10
7-B	APP	D6222, Type I, Grade G	Greater than 41	0.88
		ASTM spec.	32 (max.)	2.0 (max)

67

Summary of results

- 15 of the 18 products tested comply
- Results notably are better than 2015 and 2011
- Still some reason(s) for concern

68

Softening point testing

- Tested sheet backside (bottomside) coating material and parting media (sand, film)
- Tested using ASTM D3461 (ring and ball)

APP products: 309 F to 330 F

SBS products: 239 F to 293 F

69

Recommendations

2019 MB testing

- Select MB products carefully
- Consider seeking out products with third-party verification of compliance:
  - UL product certification
  - PRI Product Validation
  - Dade County Approval
- As always, call NRCA Technical Services if you see anything unusual

70

“Fully” adhered

71


TECH TODAY

The fully adhered misnomer

Terminology can create unrealistic expectations within the roofing industry

by Mark S. Graham

NRCA recommends the term “fully adhered” be avoided

12 www.professionalroofing.net JANUARY 2017

Professional Roofing,
January 2017

72

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

(847) 299-9070
mgraham@nrca.net
www.nrca.net

Twitter: @MarkGrahamNRCA
Personal website: www.MarkGrahamNRCA.com

73