



Listing and Technical Evaluation Report™

A Duly Authenticated Report from an Approved Agency

Report No: 2303-06



Issue Date: August 13, 2018

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Subject to Renewal: July 1, 2026

Versico VacuSeal™ Vent System

Trade Secret Report Holder:

Versico Roofing Systems

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CSI Designations:

DIVISION: 07 00 00 - THERMAL AND MOISTURE PROTECTION

Section: 07 05 00 - Membrane Roofing

Section: 07 07 00 - Roof Accessories

1 Innovative Product Evaluated¹

1.1 VacuSeal™ Roof Vent

2 Product Description and Materials

2.1 The innovative product evaluated in this report is shown in **Figure 1**.







2.2 VacuSeal Roof Vent Description

- 2.2.1 VacuSeal Roof Vent is a roof anchoring system for single-ply roof membranes.
- 2.2.2 VacuSeal Roof Vent is a patented technology under U.S. Patent Nos. 7001266 and 7607974.
- 2.2.3 VacuSeal Roof Vent draws air from under the roof membrane to create a negative pressure (suction) that prevents the membrane from lifting off the roof deck.
- 2.2.4 VacuSeal Roof Vent uses the Bernoulli Principle and the Venturi effect, as shown in **Figure 1**, to create the negative pressure beneath the roof membrane.
 - 2.2.4.1 The Bernoulli Principle states that an increase in the speed of a fluid (air) causes a decrease in the fluid pressure.
 - 2.2.4.2 The Venturi effect is an application of the Bernoulli Principle, which states that a fluid flowing through a constricted section of a tube undergoes an increase in velocity and a decrease in pressure.
- 2.2.5 The VacuSeal Roof Vent consists of two hollow, hemispherical domes separated by a gap (see **Figure 2**).
- 2.2.6 As the wind blows through the narrow gap, it accelerates which lowers the pressure and creates suction.
- 2.2.7 The three hollow legs, which support the upper dome above the lower dome, allow the suction to draw air from under the roof membrane to a port located on the bottom of the upper dome, as shown in **Figure 1**.
- 2.2.8 Distribution strips are placed immediately beneath the roofing membrane to allow airflow to the VacuSeal Roof Vent. The strips connect the vents to the perimeter and corners of the roof to ensure air under the membrane can be removed (see **Figure 2**).
- 2.2.9 VacuSeal Roof Vents are placed over the intersection of distribution pathways at openings cut in the membrane (**Figure 2**).
- 2.2.10 The lower hemisphere of the VacuSeal Roof Vent has a flange for attaching the roof membrane to the vent (see **Figure 2**).
- 2.2.11 VacuSeal Roof Vents are located according to a layout plan provided for each project. To achieve the highest level of efficiency, the VacuSeal Roof Vents should be positioned a sufficient distance from perimeter edge to ensure that they receive airflow at a wind velocity value that is high enough to enable the adequate operation of the VacuSeal Roof Vent (**Figure 2**).







Figure 2. Photos of VacuSeal Roof Vent System

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2.3 Materials

- 2.3.1 VacuSeal Roof Vents:
 - 2.3.1.1 VacuSeal Roof Vents are manufactured from UV-resistant PVC.
- 2.3.2 Distribution Strips:
 - 2.3.2.1 The distribution strip is a 10" wide polypropylene mesh mat that allows unrestricted airflow under the membrane.
- 2.3.3 Roofing Membrane:
 - 2.3.3.1 VacuSeal Roof Vents are used with Versico Roofing Systems approved membranes.
- 2.3.4 Termination Bar:
 - 2.3.4.1 The termination bar used for securing the edges of the roof membrane shall be tested for resistance in accordance with Test Methods RE-1, RE-2, and RE-3 of ANSI/SPRI ES-1 per <u>IBC Section 1504.6.</u>²
- 2.4 As needed, review material properties for design in **Section 6** and the regulatory evaluation in **Section 8**.

3 Definitions³

- 3.1 <u>New Materials</u>⁴ are defined as building materials, equipment, appliances, systems, or methods of construction, not provided for by prescriptive and/or legislatively adopted regulations, known as alternative materials.⁵ The <u>design strength</u> and permissible stresses shall be established by tests⁶ and/or engineering analysis.⁷
- 3.2 <u>Duly authenticated reports</u>⁸ and <u>research reports</u>⁹ are test reports and related engineering evaluations that are written by an <u>approved agency</u>¹⁰ and/or an <u>approved source</u>.¹¹
 - 3.2.1 These reports utilize intellectual property and/or trade secrets to create public domain material properties for commercial end-use.
 - 3.2.1.1 This report protects confidential Intellectual Property and trade secretes under the regulation, <u>18.US.Code.90</u>, also known as <u>Defend Trade Secrets Act of 2016</u> (DTSA).¹²
- 3.3 An approved agency is *"approved"* when it is <u>ANAB ISO/IEC 17065 accredited</u>. DrJ Engineering, LLC (DrJ) is accredited and listed in the <u>ANAB directory</u>.
- 3.4 An <u>approved source</u> is *"approved"* when a professional engineer (i.e., <u>Registered Design Professional</u>, hereinafter <u>RDP</u>) is properly licensed to transact engineering commerce. The regulatory authority governing approved sources is the <u>state legislature</u> via its professional engineering regulations.¹³
- 3.5 Testing and/or inspections conducted for this <u>duly authenticated report</u> were performed by an <u>ISO/IEC 17025</u> <u>accredited testing laboratory</u>, an <u>ISO/IEC 17020 accredited inspection body</u>, and/or a licensed <u>RDP</u>.
 - 3.5.1 The <u>Center for Building Innovation</u> (CBI) is <u>ANAB¹⁴ ISO/IEC 17025</u> and <u>ISO/IEC 17020</u> accredited.
- 3.6 The regulatory authority shall <u>enforce¹⁵</u> the specific provisions of each legislatively adopted regulation. If there is a non-conformance, the specific regulatory section and language of the non-conformance shall be provided in <u>writing¹⁶</u> stating the nonconformance and the path to its cure.
- 3.7 The regulatory authority shall accept <u>duly authenticated reports</u> from an <u>approved agency</u> and/or an <u>approved</u> <u>source</u> with respect to the quality and manner of use of new materials or assemblies as provided for in regulations regarding the use of alternative materials, designs, or methods of construction.¹⁷
- 3.8 ANAB is an <u>International Accreditation Forum</u> (IAF) <u>Multilateral Recognition Arrangement</u> (MLA) signatory. Therefore, recognition of certificates and validation statements issued by conformity assessment bodies accredited by all other signatories of the IAF MLA with the appropriate scope shall be approved.¹⁸ Thus, all ANAB ISO/IEC 17065 <u>duly authenticated reports</u> are approval equivalent,¹⁹ and can be used in any country that is an MLA signatory found at this link: <u>https://iaf.nu/en/recognised-abs/</u>
- 3.9 Approval equity is a fundamental commercial and legal principle.²⁰





4 Applicable Local, State and Federal Approvals; Standards; Regulations²¹

- 4.1 Local, State, and Federal
 - 4.1.1 Approved in all local jurisdictions pursuant to ISO/IEC 17065 <u>duly authenticated report</u> use, which includes the following featured local jurisdictions and is not limited to: Austin, Baltimore, Broward County, Chicago, Clark County, Dade County, Dallas, Detroit, Denver, DuPage County, Fort Worth, Houston, Kansas City, King County, Knoxville, Las Vegas, Los Angeles City, Los Angeles County, Miami, Nashville, New York City, Omaha, Philadelphia, Phoenix, Portland, San Antonio, San Diego, San Jose, San Francisco, Seattle, Sioux Falls, South Holland, Texas Department of Insurance, and Wichita.²²
 - 4.1.2 Approved in all state jurisdictions pursuant to ISO/IEC 17065 duly authenticated report use, which includes the following featured states, and is not limited to: California, Florida, New Jersey, Oregon, New York, Texas, Washington, and Wisconsin.²³
 - 4.1.3 Approved by the Code of Federal Regulations Manufactured Home Construction: Pursuant to Title 24, Subtitle B, Chapter XX, Part 3282.14²⁴ and Part 3280²⁵ pursuant to the use of ISO/IEC 17065 <u>duly</u> <u>authenticated reports</u>.
 - 4.1.4 Approved means complying with the requirements of local, state, or federal legislation.
- 4.2 Standards
 - 4.2.1 ASCE/SEI 7: Minimum Design Loads and Associated Criteria for Buildings and Other Structures
 - 4.2.2 UL 1897: Uplift Tests for Roof Covering Systems

4.3 Regulations

- 4.3.1 IBC 15, 18, 21, 24: International Building Code®
- 4.3.2 IRC 15, 18, 21, 24: International Residential Code®
- 4.3.3 IECC 15, 18, 21, 24: International Energy Conservation Code®
- 4.3.4 FBC-B—20, 23: Florida Building Code Building²⁶ (FL 42724)
- 4.3.5 FBC-R—20, 23: Florida Building Code Residential²⁶ (FL 42724)

5 Listed²⁷

5.1 Equipment, materials, products, or services included in a List published by a <u>nationally recognized testing</u> <u>laboratory</u> (i.e., CBI), an <u>approved agency</u> (i.e., CBI and DrJ), and/or and <u>approved source</u> (i.e., DrJ), or other organization(s) concerned with product evaluation (i.e., DrJ), that maintains periodic inspection (i.e., CBI) of production of listed equipment or materials, and whose listing states either that the equipment or material meets nationally recognized standards or has been tested and found suitable for use in a specified manner.

6 Tabulated Properties Generated from Nationally Recognized Standards

- 6.1 Structural Applications
 - 6.1.1 The VacuSeal Roof Vent is used as a hold-down device to resist wind uplift forces on single-ply membrane systems and has been tested in accordance with UL 1897 per <u>IBC Section 1504.4.1</u>.²⁸
 - 6.1.2 The VacuSeal Roof Vent is used as an alternative attachment method to a mechanically attached or fully adhered roof membrane.
 - 6.1.3 VacuSeal Roof Vent can also be used for recovering existing roof or as a reroofing application in accordance with **Section 6.2**.





6.1.4 Design:

6.1.4.1 **Table 1** lists the allowable uplift resistance for the VacuSeal Roof Vent.

Table 1. Nominal Uplift Resistance for the VacuSeal Roof Vent^{1,2,3}

Model	Nominal Wind Uplift Resistance (psf)					
VacuSeal Roof Vent	195					
SI: 1 psf = 0.0479 kN/m² 1. Tested in accordance with UL 1897. 2. Design wind loads shall be in accordance with ASCE 7. 3. Perimeter enhancements are additive to the allowable wind uplift resistance in a	accordance with Section 6.1.4.2.					

- 6.1.4.2 The uplift resistance provided by the fasteners in the termination bar (see **Figure 3**) around the roof perimeter and at penetrations can be added to the uplift resistance of the VacuSeal Roof Vent given in **Table 1**.
- 6.1.4.3 The total allowable uplift resistance provided by the VacuSeal Roof Vent and the mechanical fasteners shall be greater than the design wind pressures calculated in accordance with Section 6.1.6.
- 6.1.4.4 The factor of safety for the VacuSeal Roof Vent shall be calculated as the total nominal uplift resistance provided by the VacuSeal Roof Vents and the mechanical fasteners in pounds divided by the total wind uplift force in pounds.
 - 6.1.4.4.1 The nominal (ultimate) uplift resistance for the VacuSeal Roof Vent in pounds is determined by multiplying the nominal uplift resistance of the VacuSeal Roof Vent in **Table 1** by the total area of the roof.
 - 6.1.4.4.2 The nominal uplift resistance for the mechanical fasteners is determined as the number of fasteners in the termination bar around the roof perimeter and at penetrations times the nominal uplift capacity per fastener given in the manufacturer literature.
 - 6.1.4.4.3 The total wind uplift force in pounds is calculated as the sum of the design wind pressures for the field, perimeter, and corners of the roof calculated in accordance with **Section 6.1.6** multiplied by the area of the field, perimeter, and corners of the roof, respectively.
- 6.1.5 The layout of the VacuSeal Roof Vents must meet the following minimum requirements:
 - 6.1.5.1 The first row of VacuSeal Roof Vents around the perimeter of the roof shall be staggered.
 - 6.1.5.2 The first row of VacuSeal Roof Vents from the perimeter edge shall be located, at a minimum, in accordance with the following:
 - 6.1.5.2.1 **Table 2** for roofs with a 10,000 ft² area
 - 6.1.5.2.2 **Table 3** for roofs with a 25,000 ft² area
 - 6.1.5.2.3 **Table 4** for roofs with a 50,000 ft² area
 - 6.1.5.2.4 **Table 5** for roofs with a 100,000 ft² area
 - 6.1.5.2.5 For roofs over 100,000 ft² and/or greater than 150 ft in height, the minimum placement distance from the parapet wall to the vent is 9'.
 - 6.1.5.2.6 For roof areas less than what is shown in the tables, use of the next highest value in the table is permitted (i.e., for a 20,000 ft² roof, use 25,000 ft²).
 - 6.1.5.2.7 *"Max"* values listed in the following tables represent the distance from the roof perimeter where the wind velocity approaches a maximum speed.





6.1.5.3 See **Figure 3** for an example of VacuSeal Roof Vent layout.

Table 2. Minimum Required Distance From Perimeter Edge to VacuSeal Roof Vent and Distance From the Roof

 Perimeter Where Wind Velocity Approaches its Maximum Speed, 10,000 Ft² Roof Area

	Parapet Height	Ultimate Wind Speed ^{1,2} (mph)											
Building Height ³ (ft)		70		100		120		160		2	00		
	(ft)	Min Distance from Perimeter to Vent / Distance for Max Wind Speed (ft)											
		Min	Мах	Min	Max	Min	Мах	Min	Мах	Min	Max		
	0	9	45	9	45	9	45	9	45	9	45		
	1	9	27	9	27	9	27	9	27	9	27		
75	3	9	36	9	36	9	36	9	36	9	36		
	6	9	36	9	36	9	36	9	36	9	36		
	10	9	45	9	45	9	45	9	45	9	45		
100	0	9	45	9	45	9	45	9	45	9	45		
	1	9	36	9	36	9	36	9	36	9	36		
	3	9	45	9	45	9	45	9	45	9	45		
	6	9	54	9	54	9	54	9	54	9	54		
	10	9	54	9	54	9	54	9	54	9	54		
	0	9	36	9	36	9	36	9	36	9	36		
	1	9	36	9	36	9	36	9	36	9	36		
125	3	9	36	9	36	9	36	9	36	9	36		
	6	9	45	9	45	9	45	9	45	9	45		
	10	9	45	9	45	9	45	9	45	9	45		
150	0	9	45	9	45	9	45	9	45	9	45		
	1	9	36	9	36	9	36	9	36	9	36		
	3	9	45	9	45	9	45	9	45	9	45		
	6	9	63	9	63	9	63	9	63	9	63		
	10	9	54	9	54	9	54	9	54	9	54		

SI: 1" = 25.4 mm, 1 mph = 1.61 km/h

1. Linear interpolation is permitted.

2. Ultimate wind speeds are based on ASCE 7-16 and ASCE 7-22. Ultimate wind speeds, V_{ult} , can be converted to nominal wind speeds, V_{asd} , using the equation, $V_{asd} = V_{ult} \sqrt{0.6}$.





 Table 3. Minimum Required Distance From Perimeter Edge to VacuSeal Roof Vent and Distance From the Roof

 Perimeter Where Wind Velocity Approaches its Maximum Speed, 25,000 Ft² Roof Area

	Parapet Height	Ultimate Wind Speed ^{1,2} (mph)										
Building Height ³ (ft)		70		100		120		1	60	2	00	
	(ft)	Min Distance from Perimeter to Vent / Distance for Max Wind Speed (ft)										
		Min	Мах	Min	Мах	Min	Мах	Min	Мах	Min	Мах	
	0	9	54	9	54	9	54	9	54	9	54	
	1	9	27	9	27	9	27	9	27	9	27	
75	3	9	45	9	45	9	45	9	45	9	45	
	6	9	18	9	18	9	18	9	18	9	18	
	10	9	63	9	63	9	63	9	63	9	63	
100	0	9	45	9	45	9	45	9	45	9	45	
	1	9	36	9	36	9	36	9	36	9	36	
	3	9	45	9	45	9	45	9	45	9	45	
	6	9	72	9	72	9	72	9	72	9	72	
	10	9	27	9	27	9	27	9	27	9	27	
	0	9	72	9	72	9	72	9	72	9	72	
	1	9	114	9	114	9	114	9	114	9	114	
125	3	9	81	9	81	9	81	9	81	9	81	
	6	9	18	9	18	9	18	9	18	9	18	
	10	9	72	9	72	9	72	9	72	9	72	
	0	9	54	9	54	9	54	9	54	9	54	
150	1	9	54	9	54	9	54	9	54	9	54	
	3	9	63	9	63	9	63	9	63	9	63	
	6	9	81	9	81	9	81	9	81	9	81	
	10	9	36	9	36	9	36	9	36	9	36	

SI: 1" = 25.4 mm, 1 mph = 1.61 km/h

1. Linear interpolation is permitted.

2. Ultimate wind speeds are based on ASCE 7-16 and ASCE 7-22. Ultimate wind speeds, V_{ult} , can be converted to nominal wind speeds, V_{asd} , using the equation, $V_{asd} = V_{ult} \sqrt{0.6}$.





Table 4. Minimum Required Distance From Perimeter Edge to VacuSeal Roof Vent and Distance From the Roof Perimeter Where Wind Velocity Approaches its Maximum Speed, 50,000 Ft² Roof Area

	Parapet Height	Ultimate Wind Speed ^{1,2} (mph)										
Building Height ³ (ft)		70		100		120		160		2	00	
	(ft)	Min Distance from Perimeter to Vent / Distance for Max Wind Speed (ft)										
		Min	Мах	Min	Мах	Min	Max	Min	Мах	Min	Мах	
	0	9	45	9	45	9	45	9	45	9	45	
	1	9	45	9	45	9	45	9	45	9	45	
75	3	9	72	9	72	9	72	9	72	9	72	
	6	9	27	9	27	9	27	9	27	9	27	
	10	9	36	9	36	9	36	9	36	9	36	
100	0	9	111	9	111	9	111	9	111	9	111	
	1	9	135	9	135	9	135	9	135	9	135	
	3	9	81	9	81	9	81	9	81	9	81	
	6	9	99	9	99	9	99	9	99	9	99	
	10	9	72	9	72	9	72	9	72	9	72	
	0	9	99	9	99	9	99	9	99	9	99	
	1	9	135	9	135	9	135	9	135	9	135	
125	3	9	63	9	63	9	63	9	63	9	63	
	6	9	36	9	36	9	36	9	36	9	36	
	10	9	36	9	36	9	36	9	36	9	36	
150	0	9	63	9	63	9	63	9	63	9	63	
	1	9	135	9	135	9	135	9	135	9	135	
	3	9	72	9	72	9	72	9	72	9	72	
	6	9	54	9	54	9	54	9	54	9	54	
	10	9	45	9	45	9	45	9	45	9	45	

SI: 1" = 25.4 mm, 1 mph = 1.61 km/h

1. Linear interpolation is permitted.

2. Ultimate wind speeds are based on ASCE 7-16 and ASCE 7-22. Ultimate wind speeds, V_{ult} , can be converted to nominal wind speeds, V_{asd} , using the equation, $V_{asd} = V_{ult} \sqrt{0.6}$.





 Table 5. Minimum Required Distance From Perimeter Edge to VacuSeal Roof Vent and Distance From the Roof

 Perimeter Where Wind Velocity Approaches its Maximum Speed, 100,000 Ft² Roof Area

	Parapet Height	Ultimate Wind Speed ^{1,2} (mph)										
Building Height ³ (ft)		70		100		120		160		2	00	
	(ft)	Min Distance from Perimeter to Vent / Distance for Max Wind Speed (ft)										
		Min	Мах	Min	Мах	Min	Мах	Min	Мах	Min	Мах	
	0	9	54	9	54	9	54	9	54	9	54	
	1	9	27	9	27	9	27	9	27	9	27	
75	3	9	54	9	54	9	54	9	54	9	54	
	6	9	102	9	102	9	102	9	102	9	102	
	10	9	72	9	72	9	72	9	72	9	72	
100	0	9	102	9	102	9	102	9	102	9	102	
	1	9	54	9	54	9	54	9	54	9	54	
	3	9	36	9	36	9	36	9	36	9	36	
	6	9	54	9	54	9	54	9	54	9	54	
	10	9	54	9	54	9	54	9	54	9	54	
	0	9	54	9	54	9	54	9	54	9	54	
	1	9	54	9	54	9	54	9	54	9	54	
125	3	9	54	9	54	9	54	9	54	9	54	
	6	9	54	9	54	9	54	9	54	9	54	
	10	9	81	9	81	9	81	9	81	9	81	
	0	9	36	9	36	9	36	9	36	9	36	
150	1	9	102	9	102	9	102	9	102	9	102	
	3	9	54	9	54	9	54	9	54	9	54	
	6	9	54	9	54	9	54	9	54	9	54	
	10	9	81	9	81	9	81	9	81	9	81	

SI: 1" = 25.4 mm, 1 mph = 1.61 km/h

1. Linear interpolation is permitted.

2. Ultimate wind speeds are based on ASCE 7-16 and ASCE 7-22. Ultimate wind speeds, V_{ult} , can be converted to nominal wind speeds, V_{asd} , using the equation, $V_{asd} = V_{ult} \sqrt{0.6}$.





- 6.1.5.4 The maximum spacing between the VacuSeal Roof Vents along the perimeter of the roof is 50' o.c (see **Figure 3**).
- 6.1.5.5 If the roof spans 200' or more between perimeter edges in both directions, a second row of VacuSeal Roof Vents around the perimeter of the roof must be provided.
- 6.1.5.5.1 The maximum spacing between the VacuSeal Roof Vents in the second row is 125' o.c.
- 6.1.5.6 The dimensions of the roof shall be sufficient to allow a minimum of two (2) VacuSeal Roof Vents to be placed along each side.
- 6.1.5.7 If the roof is separated by interior parapets, expansion joints, roof area dividers, etc., each portion of the roof shall be designed as a separate roof.
- 6.1.6 Wind load pressures on the roof membrane that are to be resisted by the VacuSeal Roof Vent system shall be determined in accordance with ASCE 7 per <u>IBC Section 1504.4</u>²⁹ and <u>IBC Section 1609.6</u>.³⁰
 - 6.1.6.1 The roof membrane shall be designed to resist the design wind load pressures for components and cladding in accordance with ASCE 7 Chapter 30.
 - 6.1.6.2 The design wind speeds shall be for the Risk Category determined from the applicable building code, unless a higher Risk Category is specified on the Construction Documents.
 - 6.1.6.2.1 For roofs designed in accordance with the recommendations of FM LPDS 1-28, the design wind speeds shall be for Risk Category III-IV, regardless of the actual Risk Category for the building.
 - 6.1.6.3 The effective wind area of the roof membrane shall be determined in accordance with ASCE 7, unless a smaller effective wind area is specified on the construction documents.
 - 6.1.6.3.1 For roofs designed in accordance with the recommendations of FM LPDS 1-28, the wind pressures shall be based on a maximum 10 ft² effective wind area, regardless of the actual effective area of the roof membrane.
- 6.1.7 See **Appendix A. Example Design Layout** of this report for a design example with the wind pressure and factor of safety calculations, along with a roof layout for the VacuSeal Roof Vents.

6.2 Roof Recovering

- 6.2.1 The VacuSeal Roof Vent may be installed without first removing the existing layers of roof coverings in accordance with Exception 3 of <u>IBC Section 1512.2</u>.³¹
 - 6.2.1.1 VacuSeal Roof Vents create a suction force, which transmits the wind uplift forces directly to the structural system of the roof without relying on attachment to the existing roof or roof covering by means of adhesives or mechanical fasteners.
 - 6.2.1.2 Since mechanical fasteners are not used by the VacuSeal Roof Vent, the ability of the existing roof deck to serve as a nailing base and the depth of the existing layers of roof coverings are not of concern.
- 6.2.2 The VacuSeal Roof Vent may be used to recover an existing roof without first removing the existing layers of roof coverings if the following conditions are met:
 - 6.2.2.1 The existing roof deck and structural components shall be capable of supporting the additional uplift and/or gravity loads due to added layers of roof covering material in accordance with <u>IBC Section</u> <u>3301.3.³²</u>
 - 6.2.2.2 The existing roof deck and structural components shall also be capable of supporting the additional loads due to the construction activities.
 - 6.2.2.3 The existing roof covering shall not be wood shake, slate, clay, cement, or asbestos-cement tile.





6.3 Where the application falls outside of the performance evaluation, conditions of use, and/or installation requirements set forth herein, alternative techniques shall be permitted in accordance with accepted engineering practice and experience. This includes but is not limited to the following areas of engineering: mechanics or materials, structural, building science, and fire science.

7 Certified Performance³³

- 7.1 All construction methods shall conform to accepted engineering practices to ensure durable, livable, and safe construction and shall demonstrate acceptable workmanship reflecting journeyman quality of work of the various trades.³⁴
- 7.2 The strength and rigidity of the component parts and/or the integrated structure shall be determined by engineering analysis or by suitable load tests to simulate the actual loads and conditions of application that occur.³⁵

8 Regulatory Evaluation and Accepted Engineering Practice

- 8.1 VacuSeal Roof Vent complies with the following legislatively adopted regulations and/or accepted engineering practice for the following reasons:
 - 8.1.1 This report examines the ability of the VacuSeal Roof Vent to resist wind uplift forces for the following conditions:
 - 8.1.1.1 Performance of VacuSeal Roof Vent used with single-ply roof membranes installed on low-slope roofs.
- 8.2 Any building code, regulation and/or accepted engineering evaluations (i.e., <u>research reports</u>, <u>duly</u> <u>authenticated reports</u>, etc.) that are conducted for this Listing were performed by DrJ, which is an <u>ISO/IEC</u> <u>17065 accredited certification body</u> and a professional engineering company operated by <u>RDP</u> or <u>approved</u> <u>sources</u>. DrJ is qualified³⁶ to practice product and regulatory compliance services within its <u>scope of</u> <u>accreditation and engineering expertise</u>,³⁷ respectively.
- 8.3 Engineering evaluations are conducted with DrJ's ANAB <u>accredited ICS code scope</u> of expertise, which is also its areas of professional engineering competence.
- 8.4 Any regulation specific issues not addressed in this section are outside the scope of this report.

9 Installation

- 9.1 Installation shall comply with the approved construction documents, the manufacturer installation instructions, this report, and the applicable building code.
- 9.2 In the event of a conflict between the manufacturer installation instructions and this report, contact the manufacturer for counsel on the proper installation method.
- 9.3 A copy of the published manufacturer installation instructions shall be available at all times on the jobsite during installation.
- 9.4 All contractors using the VacuSeal Roof Vent must be certified by Versico Roofing Systems.
- 9.5 Installation of the roofing membrane shall be in accordance with the roofing membrane manufacturer specifications and the approved construction documents.
- 9.6 The roof shall have flashing installed in accordance with <u>IBC Section 1503.2</u> and the flashing manufacturer installation instructions.





9.7 Installation Procedures

- 9.7.1 Depending on the roof application, the roof surface may need to be sealed to ensure that air infiltration is minimized in all areas of the roof.
 - 9.7.1.1 All equipment, curb, and parapet wall penetrations in the roofing deck structure need to be sealed for optimal performance of the VacuSeal Roof Vent.
- 9.7.1.2 Openings in the deck shall be air sealed with appropriate materials to achieve the intended purpose.
- 9.7.2 If two (2) layers of insulation are installed over the roof deck, the joints should be staggered in both directions to decrease air movement. Roof cover boards should be applied when appropriate.
- 9.7.3 Distribution strips shall be installed over the roof deck or insulation board to create a pathway for airflow under the roofing membrane. The strips shall be tacked into position with bonding adhesive or fastened using plates and screws. The layout of the distribution strip shall be as shown on the drawings provided for the project.
 - 9.7.3.1 Around the roof perimeter, three (3) distribution strips shall connect each VacuSeal Roof Vent to the perimeter edge: one (1) distribution strip shall run perpendicular to the perimeter edge to the VacuSeal Roof Vent, and the other two (2) distribution strips shall run diagonally from the VacuSeal Roof Vent to the point on the perimeter edge midway between the VacuSeal Roof Vents.
 - 9.7.3.2 See **Figure 3** for an example of the distribution strip layout for the perimeter VacuSeal Roof Vents.



Figure 3. Distribution Strip Layout for VacuSeal Roof Vents





- 9.7.3.3 At re-entrant roof corners, three (3) distribution strips shall radiate from the corner.
 - 9.7.3.3.1 The center strip shall be at an angle of approximately 45° to each of the perimeter edge and connect directly to the VacuSeal Roof Vent. The remaining two (2) distribution strips shall radiate from the corner at an angle of approximately 17° 22° to the perimeter edge.
 - 9.7.3.3.1.1 Where obstructions occur on the roof such as HVAC equipment locations, place the vents and strips so that the angle of the center strip is as close to 45° to each of the perimeter edge as possible, and the angle of the remaining distribution strips are as close to 17° 22° to the perimeter edge as possible.
- 9.7.3.4 At interior vent locations, two (2) 25' long distribution strips shall be laid out in an "X" pattern with the VacuSeal Roof Vent at the center, as shown in **Figure 3**.
- 9.7.3.5 The distribution strips shall be routed around any openings/obstructions in its path.
- 9.7.4 All intersections of the distribution strips where the VacuSeal Roof Vents are to be located shall be marked by placing an object at the intersection to create a rise in the membrane once it is rolled out.
- 9.7.5 The roofing membrane is loose laid on top of the roof deck or insulation boards and distribution strips. During placement, edges of the roofing membrane can be welded temporarily to keep rain or external elements from getting beneath the roofing membrane.
- 9.7.6 A 10" diameter opening is cut in the membrane at the locations identified by the markers, and the objects used as markers are removed.
- 9.7.7 VacuSeal Roof Vents are located over the intersection of distribution pathways at the openings cut in the membrane. A skirt on the VacuSeal Roof Vent is welded or adhered with pressure sensitive butyl adhesive, to the roofing membrane.

10 Substantiating Data

- 10.1 Testing has been performed under the supervision of a professional engineer and/or under the requirements of ISO/IEC 17025 as follows:
 - 10.1.1 Full-scale building testing at the Institute for Business and Home Safety (IBHS) Research Center
 - 10.1.2 Uplift resistance testing in accordance with UL 1897
 - 10.1.3 Full-scale wind tunnel testing at NASA Langley Research Center
 - 10.1.4 Wind tunnel testing at Virginia Tech
- 10.2 Information contained herein may include the result of testing and/or data analysis by sources that are <u>approved agencies</u>, <u>approved sources</u>, and/or an <u>RDP</u>. Accuracy of external test data and resulting analysis is relied upon.
- 10.3 Where applicable, testing and/or engineering analysis are based upon provisions that have been codified into law through state or local adoption of regulations and standards. The developers of these regulations and standards are responsible for the reliability of published content. DrJ's engineering practice may use a regulation-adopted provision as the control. A regulation-endorsed control versus a simulation of the conditions of application to occur establishes a new material as <u>being equivalent</u> to the regulatory provision in terms of quality, <u>strength</u>, effectiveness, <u>fire resistance</u>, durability, and safety.
- 10.4 The accuracy of the provisions provided herein may be reliant upon the published properties of raw materials, which are defined by the grade mark, grade stamp, mill certificate, or <u>duly authenticated reports</u> from <u>approved</u> <u>agencies</u> and/or <u>approved sources</u> provided by the supplier. These are presumed to be minimum properties and relied upon to be accurate. The reliability of DrJ's engineering practice, as contained in this <u>duly</u> <u>authenticated report</u>, may be dependent upon published design properties by others.





10.5 Testing and Engineering Analysis

- 10.5.1 The strength, rigidity, and/or general performance of component parts and/or the integrated structure are determined by suitable tests that simulate the actual conditions of application that occur and/or by accepted engineering practice and experience.³⁸
- 10.6 Where additional condition of use and/or regulatory compliance information is required, please search for VacuSeal Roof Vent on the <u>DrJ Certification website</u>.

11 Findings

- 11.1 As outlined in **Section 6**, VacuSeal Roof Vent has performance characteristics that were tested and/or meet applicable regulations. In addition, they are suitable for use pursuant to its specified purpose.
- 11.2 When used and installed in accordance with this <u>duly authenticated report</u> and the manufacturer installation instructions, VacuSeal Roof Vent shall be approved for the following applications:
 - 11.2.1 Data and engineering analysis review has found that the VacuSeal Roof Vent, as described in this report, conforms to the requirements of the code references listed in **Section 4**.
- 11.3 Any application specific issues not addressed herein can be engineered by an <u>RDP</u>. Assistance with engineering is available from Versico Roofing Systems.
- 11.4 IBC Section 104.2.3 (IRC Section R104.2.2 and IFC Section 104.2.3³⁹ are similar) in pertinent part state:

104.2.3 Alternative Materials, Design and Methods of Construction and Equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative is not specifically prohibited by this code and has been approved.

- 11.5 Approved:⁴⁰ Building regulations require that the building official shall accept duly authenticated reports.⁴¹
 - 11.5.1 An approved agency is "approved" when it is ANAB ISO/IEC 17065 accredited.
 - 11.5.2 An <u>approved source</u> is *"approved"* when an <u>RDP</u> is properly licensed to transact engineering commerce.
 - 11.5.3 Federal law, <u>Title 18 US Code Section 242</u>, requires that, where the alternative product, material, service, design, assembly, and/or method of construction is not approved, the building official shall respond in writing, stating the reasons why the alternative was not approved. Denial without written reason deprives a protected right to free and fair competition in the marketplace.
- 11.6 DrJ is a licensed engineering company, employs licensed <u>RDP</u>s and is an <u>ANAB Accredited Product</u> <u>Certification Body</u> – <u>Accreditation #1131</u>.
- 11.7 Through the <u>IAF Multilateral Arrangement</u> (MLA), this <u>duly authenticated report</u> can be used to obtain product approval in any <u>jurisdiction</u> or <u>country</u> because all ANAB ISO/IEC 17065 <u>duly authenticated reports</u> are equivalent.⁴²





12 Conditions of Use

- 12.1 Material properties shall not fall outside the boundaries defined in **Section 6**.
- 12.2 As defined in **Section 6**, where material and/or engineering mechanics properties are created for load resisting design purposes, the resistance to the applied load shall not exceed the ability of the defined properties to resist those loads using the principles of accepted engineering practice.
- 12.3 When required by adopted legislation and enforced by the <u>building official</u>, also known as the Authority Having Jurisdiction (AHJ) in which the project is to be constructed:
 - 12.3.1 Any calculations incorporated into the construction documents shall conform to accepted engineering practice and, when prepared by an <u>approved source</u>, shall be approved when signed and sealed.
 - 12.3.2 This report and the installation instructions shall be submitted at the time of permit application.
 - 12.3.3 This innovative product has an internal quality control program and a third-party quality assurance program.
 - 12.3.4 At a minimum, this innovative product shall be installed per Section 9.
 - 12.3.5 The review of this report by the AHJ shall comply with IBC Section 104.2.3.2 and IBC Section 105.3.1.
 - 12.3.6 This innovative product has an internal quality control program and a third party quality assurance program in accordance with <u>IBC Section 104.7.2</u>, <u>IBC Section 110.4</u>, <u>IBC Section 1703</u>, <u>IRC Section R104.7.2</u>, and IRC Section R109.2.
 - 12.3.7 The application of this innovative product in the context of this report is dependent upon the accuracy of the construction documents, implementation of installation instructions, inspection as required by <u>IBC</u> <u>Section 110.3</u>, <u>IRC Section R109.2</u>, and any other regulatory requirements that may apply.
- 12.4 The approval of this report by the AHJ shall comply with <u>IBC Section 1707.1</u>, where legislation states in part, "the <u>building official</u> shall make, or cause to be made, the necessary tests and investigations; or the <u>building</u> <u>official</u> shall accept duly authenticated reports from <u>approved agencies</u> in respect to the quality and manner of use of new materials or assemblies as provided for in <u>Section 104.2.3</u>", all of <u>IBC Section 104</u>, and <u>IBC Section 105.3</u>.
- 12.5 <u>Design loads</u> shall be determined in accordance with the regulations adopted by the jurisdiction in which the project is to be constructed and/or by the building designer (i.e., <u>owner</u> or <u>RDP</u>).
- 12.6 The actual design, suitability, and use of this report for any particular building, is the responsibility of the owner or the authorized agent of the <u>owner</u>.

13 Identification

- 13.1 The innovative product listed in **Section 1.1** is identified by a label on the board or packaging material bearing the manufacturer name, product name, this report number, and other information to confirm code compliance.
- 13.2 Additional technical information can be found at <u>www.versico.com</u>.

14 Review Schedule

- 14.1 This report is subject to periodic review and revision. For the latest version, visit <u>www.drjcertification.org</u>.
- 14.2 For information on the status of this report, please contact <u>DrJ Certification</u>.





Appendix A Example Design Layout

The roof Layout for VacuSeal Roof Vent:







Issue Date: October 16, 2023 Subject to Renewal: July 1, 2026

FBC Supplement to Report Number 2303-06

REPORT HOLDER: Versico Roofing Systems

1 Evaluation Subject

1.1 VacuSeal Roof Vent

2 Purpose and Scope

- 2.1 Purpose
 - 2.1.1 The purpose of this Report Supplement is to show VacuSeal Roof Vent, recognized in Report Number 2303-06, has also been evaluated for compliance with the codes listed below as adopted by the Florida Building Commission.
- 2.2 Applicable Code Editions
 - 2.2.1 FBC-B—20, 23: Florida Building Code Building (FL 42724)
 - 2.2.2 FBC-R—20, 23: Florida Building Code Residential (FL 42724)

3 Conclusions

- 3.1 VacuSeal Roof Vent, described in Report Number 2303-06, complies with the FBC-B and FBC-R and is subject to the conditions of use described in this supplement.
- 3.2 Where there are variations between the IBC and IRC and the FBC-B and FBC-R applicable to this report, they are listed here:
 - 3.2.1 FBC-B Section 104, Section 110.4 are reserved.
 - 3.2.2 FBC-R Section R104 and Section R109 are reserved.
 - 3.2.3 FBC-B Section 104.6 is reserved and replaces IBC Section 104.4.
 - 3.2.4 FBC-B Section 104.11 replaces IBC Section 104.2.3 and Section 104.2.3.2.
 - 3.2.5 FBC-B Section 105.3 replaces IBC Section 105.3.
 - 3.2.6 FBC-B Section 105.3.1 replaces IBC Section 105.3.1.
 - 3.2.7 FBC-B Section 110.3 replaces IBC Section 110.3.
 - 3.2.8 FBC-B Section 1503.2 replaces IBC Section 1503.2.
 - 3.2.9 FBC-B Section 1504.4 replaces IBC Section 1504.4.
 - 3.2.10 FBC-B Section 1504.3.1 replaces IBC Section 1504.4.1.
 - 3.2.11 FBC-B Section 1504.5 replaces IBC Section 1504.6.
 - 3.2.12 FBC-B Section 1511.3.1 is reserved and replaces IBC Section 1512.2.
 - 3.2.13 FBC-B Section 1707.1 replaces IBC Section 1707.1.
 - 3.2.14 FBC-B Section 2306.1 replaces IBC Section 2306.1.
 - 3.2.15 FBC-B Section 2306.3 replaces IBC Section 2306.3.





4 Conditions of Use

- 4.1 VacuSeal Roof Vent, described in Report Number 2303-06, must comply with all of the following conditions:
 - 4.1.1 All applicable sections in Report Number 2303-06.
 - 4.1.2 The design, installation, and inspections are in accordance with additional requirements of FBC-B Chapter 16 and Chapter 17, as applicable.





Notes

¹ For more information, visit <u>dricertification.org</u> or call us at 608-310-6748.

- ³ Capitalized terms and responsibilities are defined pursuant to the applicable building code, applicable reference standards, the latest edition of <u>TPI1</u>, the <u>NDS</u>, <u>AISI S202</u>, <u>US</u> professional engineering law, <u>Canadian building code</u>, <u>Canada professional engineering law</u>, <u>Qualtim External Appendix A: Definitions/Commentary</u>, <u>Qualtim External Appendix B:</u> <u>Project/Deliverables</u>, <u>Qualtim External Appendix C: Intellectual Property and Trade Secrets</u>, definitions created within Design Drawings and/or definitions within Reference Sheets. Beyond this, terms not defined shall have ordinarily accepted meanings as the context implies. Words used in the present tense include the future; words stated in the masculine gender include the feminine and neuter; the singular number includes the plural and the plural, the singular.
- 4 <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1702</u>
- ⁵ Alternative Materials, Design and Methods of Construction and Equipment: The provisions of any regulation code are not intended to prevent the installation of any material or to prohibit any design or method of construction not specifically prescribed by a regulation. Please review <u>https://www.justice.gov/atr/mission</u> and https://up.codes/viewer/mississippi/ibc-2024/chapter/1/scope-and-administration#104.2.3
- 6 <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1706.2:~:text=the%20design%20strengths%20and%20permissible%20stresses%20shall%20be%20established%20by%20tests</u>
- ⁷ The <u>design strengths</u> and permissible stresses of any structural material shall conform to the specifications and methods of design of accepted engineering practice. <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1706.1:~:text=Conformance%20to%20Standards-</u>, The%20design%20strengths%20and%20permissible%20stresses,-of%20any%20structural
- 8 <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1707.1;~:text=the%20building%20official%20shall%20make%2C%20or%20to%20be%20made%2C%20the%20necessary%20tests%20and%20investigations%3B %20or%20the%20building%20official%20shall%20accept%20duly%20authenticated%20reports%20from%20approved%20agencies%20in%20respect%20to%20the%20quality%2 0and%20manner%20off%20use%20off%20new%20materials%20or%20assemblies%20as%20provided%20for%20in%20Section%20104.2.3.</u>
- 9 https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1703.4.2
- ¹⁰ <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/2/definitions#approved_agency</u>
- 11 https://up.codes/viewer/mississippi/ibc-2024/chapter/2/definitions#approved_source
- https://www.law.comell.edu/uscode/text/18/1832 (b) Any organization that commits any offense described in subsection (a) shall be fined not more than the greater of \$5,000,000 or 3 times the value of the stolen trade secret to the organization, including expenses for research and design and other costs of reproducing the trade secret that the organization has thereby avoided. The <u>federal government</u> and each state have a <u>public records act</u>. To follow DTSA and comply state public records and trade secret legislation requires approval through <u>ANAB ISO/IEC 17065 accredited certification bodies</u> or <u>approved sources</u>. For more information, please review this website: <u>Intellectual Property and Trade Secrets</u>.
- 13 <u>https://www.nspe.org/resources/issues-and-advocacy/professional-policies-and-position-statements/regulation-professional AND https://apassociation.org/list-of-engineeringboards-in-each-state-archive/</u>
- 14 https://www.cbitest.com/accreditation/

15 https://up.codes/viewer/mississippi/ibc-2024/chapter/1/scope-and-administration#104.1:~:text=directed%20to%20enforce%20the%20provisions%20of%20this%20code

- 16 https://up.codes/viewer/mississippi/ibc-2024/chapter/1/scope-and-administration#104.2.3 AND https://up.codes/viewer/mississippi/ibc-2024/chapter/1/scope-and-
- administration#105.3.1
- ¹⁷ https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1707.1
- 18 https://iaf.nu/en/about-iaf-

mla/#:~:text=Once%20an%20accreditation%20body%20is%20a%20signatory%20of%20the%20IAF%20MLA%2C%20it%20is%20required%20to%20recognise%20certificates%20 and%20validation%20and%20verification%20statements%20issued%20by%20conformity%20assessment%20bodies%20accredited%20by%20all%20other%20signatories%20of %20the%20IAF%20MLA%2C%20with%20the%20appropriate%20scope

- ¹⁹ True for all ANAB accredited product evaluation agencies and all International Trade Agreements.
- 20 https://www.justice.gov/crt/deprivation-rights-under-color-law AND https://www.justice.gov/atr/mission
- ²¹ Unless otherwise noted, the links referenced herein use un-amended versions of the <u>2024 International Code Council (ICC)</u> 2024 International Code Council (ICC) model codes as foundation references. Mississippi versions of the <u>IBC 2024</u> and the <u>IRC 2024</u> are un-amended. This material, product, design, service and/or method of construction also complies with the 2000-2012 versions of the referenced codes and the standards referenced therein. As pertinent to this technical and code compliance evaluation, CBI and/or DrJ staff have reviewed any state or local regulatory amendments to assure this report is in compliance.
- ²² See <u>Adoptions by Publisher</u> for the latest adoption of a non-amended or amended model code by the local jurisdiction. <u>https://up.codes/codes/general</u>
- ²³ See <u>Adoptions by Publisher</u> for the latest adoption of a non-amended or amended model code by state. <u>https://up.codes/codes/general</u>
- ²⁴ https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3282/subpart-A/section-3282.14
- ²⁵ <u>https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280</u>
- ²⁶ All references to the FBC-B and FBC-R are the same as the 2024 IBC and 2024 IRC unless otherwise noted in the Florida Supplement at the end of this report.
- 27 <u>https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280#p-3280.2(Listed%20or%20certified); https://up.codes/viewer/mississippi/ibc-2024/chapter/2/definitions#listed AND https://up.codes/viewer/mississippi/ibc-2024/chapter/2/definitions#labeled</u>
- ²⁸ <u>2018 IBC Section 1504.3.1</u>
- 29 2018 IBC Section 1504.3
- 30 2021 IBC Section 1609.5
- ³¹ 2018 IBC Section 1511.3.1.1
- ³² 2021 IBC Section 3301.2.1, 2018 IBC Section 1511.2
- ³³ <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1703.4</u>

^{2 2018} IBC Section 1504.5





- ³⁴ <u>https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-</u>
 - 3280#:~:text=All%20construction%20methods%20shall%20be%20in%20conformance%20with%20accepted%20engineering%20practices%20to%20insure%20durable%2C%20liv able%2C%20and%20safe%20housing%20and%20shall%20demonstrate%20acceptable%20workmanship%20reflecting%20journeyman%20quality%20of%20work%20of%20the% 20various%20trades
- 35 <u>https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280#:~:text=The%20structure%20shall%20be%20determined%20by%20 engineering%20and/or%20the%20integrated%20structure%20shall%20be%20determined%20by%20 engineering%20analysis%20or%20by%20suitable%20load%20tests%20to%20simulate%20the%20and/or%20the%20and%20conditions%20of%20application%20that%20occur</u>
- ³⁶ Qualification is performed by a legislatively defined <u>Accreditation Body</u>. <u>ANSI National Accreditation Board (ANAB)</u> is the largest independent accreditation body in North America and provides services in more than 75 countries. <u>DrJ</u> is an ANAB accredited <u>product certification body</u>.
- ³⁷ https://anabpd.ansi.org/Accreditation/product-certification/AllDirectoryDetails?prgID=1&orgID=2125&statusID=4#:~:text=Bill%20Payment%20Date-,Accredited%20Scopes_-13%20ENVIRONMENT.%20HEALTH
- 38 See Code of Federal Regulations (CFR) Title 24 Subtitle B Chapter XX Part 3280 for definition: https://www.ecfr.gov/current/title-24/subtitle-B/chapter-XX/part-3280
- 39 2018: <u>https://up.codes/viewer/wyoming/ifc-2018/chapter/1/scope-and-administration#104.9</u> AND 2021: <u>https://up.codes/viewer/wyoming/ibc-2021/chapter/1/scope-and-administration#104.11</u>
- ⁴⁰ Approved is an adjective that modifies the noun after it. For example, Approved Agency means that the Agency is accepted officially as being suitable in a particular situation. This example conforms to IBC/IRC/IFC Section 201.4 (<u>https://up.codes/viewer/mississippi/ibc-2024/chapter/2/definitions#201.4</u>) where the building code authorizes sentences to have an ordinarily accepted meaning such as the context implies.
- ⁴¹ <u>https://up.codes/viewer/mississippi/ibc-2024/chapter/17/special-inspections-and-tests#1707.1</u>
- ⁴² Multilateral approval is true for all ANAB accredited product evaluation agencies and all International Trade Agreements.