	Tuesday, July 12	
	Ocean A-D	Patriot
8:00 AM	Codes & Standards 8:00 - 9:00 Ober	
8:15 AM		
8:30 AM		
8:45 AM		
9:00 AM	Code Development 9:00 - 10:00 Hickman	
9:15 AM		
9:30 AM		Digital Content & Communications 9:30 - 10:00 Montoya
9:45 AM		
10:00 AM	VOC Reg Monitoring 10:00 - 11:00 Bates	ES-1 Review 10:00 - 10:45 Patel
10:15 AM		
10:30 AM		
10:45 AM		
11:00 AM	DORA Listing Service 11:00 - 11:30 Darsch/Holloway/Jones	SPPI 11:00-11:30, Van Dam
11:15 AM		
11:30 AM	D6878 TPO Considerations for Revision 11:30 - 12:00, Sanborn	RP-14 Revision 11:30 - 12:00 Mader
11:45 AM		
12:00 PM	**Member Services Update** 5-G Tower Safety	
12:15 PM		
12:30 PM		
12:45 PM	Rooftop Attachments 12:45 - 1:15 Blasini	
1:00 PM		
1:15 PM	Lightning Protection 1:15 - 2:15 Van Dam	VF-1 1:15 - 1:45, Ober
1:30 PM		
1:45 PM		Membrane / Plate Standard Development 1:45 - 2:30 Childs/Shyti
2:00 PM		
2:15 PM	Education 2:15 - 2:45 Chamberlain	
2:30 PM		NT-1 2:30 - 3:00, Hawn
2:45 PM		
3:00 PM	Technical Committee 3:00 - 3:45 O'Neal	
3:15 PM		
3:30 PM		
3:45 PM		
4:00 PM	Annual SPRI BBQ Eisenhower House sponsored by OMG Roofing Products and the SPRI Member Services Committee	
4:15 PM		

	Wednesday, July 13
	Bristol
8:00 AM	Board of Directors 8:00 - 11:00 Approximate end time All SPRI Members Welcome
8:15 AM	
8:30 AM	
8:45 AM	
9:00 AM	
9:15 AM	
9:30 AM	
9:45 AM	
10:00 AM	
10:15 AM	
10:30 AM	
10:45 AM	

SPRI
Codes & Standards
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
8:00 a.m.

AGENDA

I. Call to Order — R. Ober

II. Roll Call & Reading of SPRI Antitrust Statement

III. Codes
   a. ICC
   b. California
   c. EPA
   d. Factory Mutual

IV. Industry Associations
   a. ACC
   b. ASHRAE
   c. CEC
   d. CRRC
   e. Green Roofs for Healthy Cities
   f. IIBEC
   g. NRCA
   h. RICOWI
   i. USGBC

V. Standards
   a. ANSI activity
   b. ASTM activity
   c. SPRI standards
   d. EPD renewal

VI. State & Local Codes / Regulations

VII. Other Fun Facts

VIII. Adjournment

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Return to Schedule

SPRI
Code Development
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
9:00 a.m.

AGENDA

I.	Call to Order	Hickman
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Review Code Development Task Force Objectives	
IV.	ICC Code Development (2024 Edition) a. Group B b. IECC	
V.	ASHRAE Update (90.1 and 189.1)	
VI.	Florida Code Development Update	
VII.	Adjournment	

Return to Schedule

SPRI
VOC Monitoring
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
10:00 a.m.

AGENDA

I. Call to Order — Bates

II. Roll Call & Reading of SPRI Antitrust Statement

III. PCBTF Regulation Update

   a. Review SCAQMD PCBTF/tBAc analysis letter if necessary

IV. Rule 1168 Technology Assessment

   a. Review recommended subcategories, VOC limits, and definitions

   b. Note: AQMD vote ETA Q3 2022

V. SCAQMD Spray PUR Foam Testing Updates

VI. Other VOC issues

VII. Adjournment

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Return to Schedule

SPRI
DORA Listing Service Task Force
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
11:00 a.m.

AGENDA

I.	Call to Order	Darsch
II.	Roll Call & Reading of the SPRI Antitrust Statement*	
III.	Participation Overview (Intertek)	Holloway
IV.	Analytics (Intertek)	
V.	Outreach & Education (Intertek)	
VI.	Developing / Outstanding Topics	
VII.	Marketing Update	Jones
VIII.	Adjournment	

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Return to Schedule

SPRI
D6878 TPO Considerations for Revision
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
11:30 a.m.

AGENDA

I.	Call to Order	Sanborn
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Fleece Back Thickness Measurement Test Method Update	
IV.	Adjournment	

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Return to Schedule

SPRI
Rooftop Attachments
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
12:45 p.m.

AGENDA

I.	Call to Order	Blasini
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Review status of white paper (attached)	
IV.	Adjournment	

Return to Schedule

Rooftop Equipment Attachment
by
SPRI Trask Group on Rooftop Attachment with Anchors
and
Curtis L. Liscum. RRC. RRO

Suggested additional information:

Ballasted installations over mechanically fastened roof covers is not specifically addressed by this paper. That combination is dangerous and should be avoided.

ABSTRACT

Without proper attachment, rooftop equipment can become displaced during wind and seismic events. Displaced rooftop equipment can puncture and tear roof covering membranes allowing water direct access into your building causing interior finish damage, operational outages, loss of stored product and proliferation of biological growth. Most rooftop mounted equipment is tethered to the building by electrical and gas lines that when damaged due to movement will increase the likelihood of a rooftop fire. ~~Tragically,~~ D~~Tragically, d~~isplaced rooftop equipment can also be blown from a roof and injure people on the ground below.~~.~~ This paper will discuss the code related requirements for rooftop equipment attachment and review historical and current practices for equipment attachment.

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BACKGROUND

Proper attachment of rooftop equipment and utilities is paramount to long term roof performance. Rooftop equipment often forms an integral part of the building envelope. Frequently rooftop equipment becomes detached and displaced during wind and seismic events. Surprisingly, equipment displacement occurs at low wind speeds without occurrence of hurricanes, tornados, derechos, or other major windstorms. Displaced equipment can allow water into buildings and most often can no longer provide the service as intended. When dislodged, windblown equipment can puncture and tear roof covering membranes allowing water to saturate underlying components and enter the building. Equipment that is blown from the roof as wind-borne debris can damage buildings and other property and injure people. The equipment that was attached often times leaves active utility lines like gas and electrical that increase the fire risk once the equipment has been vacated. The most common causes of wind displacement are inadequate anchorage, inadequate strength of the equipment itself, and corrosion of equipment and connectors. Wind borne debris may include larger rooftop solar arrays, screen walls~~screenwalls~~, HVAC units such as exhaust fans, ventilation hoods, and unit compressors along with smaller units and utilities such as satellite dishes, lightning protection systems, electrical conduit, and piping. Some reference to rooftop fire fits here.

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Several recent significant wind events have prompted increased scrutiny on buildings, building enclosures and roofing performance. Hurricane Katrina was a large and destructive Category 5 Atlantic hurricane that caused over 1,800 fatalities and $125 billion in damage in late August 2005, especially in the city of New Orleans and the surrounding areas. After the initial recovery efforts, the Federal Emergency Management Agency (FEMA) issued “Attachment of Rooftop Equipment in High-Wind Regions' ' (Hurricane Katrina Recovery Advisory) in May 2006 and later revised it in July 2006. After Hurricane Irma, an extremely powerful Cape Verde hurricane and Hurricane Maria, a deadly Category 5 hurricane that devastated the northeastern Caribbean in September 2017, FEMA issued “Attachment of Rooftop Equipment in High-Wind Regions” (Hurricane IRMA and Maria in the US Virgin Islands Recovery Advisory 2) in March 2018. These documents jumpstarted revisions of the building code to include language concerning proper installation of rooftop equipment.

Return to Schedule

Additionally, several other organizations have issued guidelines and advisories such as Risk topics "Guide to securing rooftop equipment in hurricane prone regions" by Zurich in July 2008 and "Protecting Roof-Mounted HVAC Units FFrom Severe Weather" by Insurance Institute for Business & Home Safety in 2018. According to the USGS "More than 143 million Americans living in the forty-eight contiguous states are exposed to potentially damaging ground shaking from earthquakes. When the number of people living in the earthquake-prone areas of Alaska, Hawaii and U.S. territories are added, this number rises to nearly half of all Americans." With so many people living and working in a seismic zone, code and design officials have included rooftop equipment attachment requirements for earthquake prone areas.
This paper will specifically discuss rooftop equipment attachment for slopes less than 2:12 ~~(low slope roofs 9.5 degrees)~~ but has implications to all roofing types.

Commented [DB1]: Changing low slope to less than 2:12 for code and SPRI definition alignment

CODE REQUIREMENTS

The International Code Council (ICC) is the leading global source for developing a set of national model construction codes. The International Building Code (IBC) is the foundation of the family of codes that is an essential tool to preserve public health and safety. The IBC is in use or adopted in fifty states, the District of Columbia, Guam, Northern Marianas Islands, New York City, the U.S. Virgin Islands and Puerto Rico. Although these codes have given some guidance on rooftop attachment, more is needed to help outline best practices and eventually standardize installation of attachment systems.

As early as the 2015 IBC, Chapter 28 Mechanical Systems, Section 2801.1 Scope, references that *"Mechanical appliances, equipment and systems shall be constructed, installed and maintained in accordance with the International Mechanical Code"* (IMC). Chapter 3 General Regulations, Section 301.15 Wind Resistance, of the 2015 IMC states that *"Mechanical equipment, appliances and supports that are exposed to winds shall be designed and installed to resist the wind pressures determined in accordance with the International Building Code"*. In Chapter 16 of the IBC, Structural Design, Section 1609.1 Wind Loads Applications, it states that *"Buildings, structures and part thereof shall be designed to withstand the minimum wind loads prescribed herein."* Chapter 16 Section 1609.1.1 Determination of wind loads it states that "*Wind loads on every building or structure shall be determined in accordance with Chapters 26 and 30 of ASCE 7 or provisions of the alternate all-height method in Section 1609.6".* Chapter 35 of the 2015 IBC references the American Society of Civil Engineers / Structural Engineering Institute ASCE 7-10 *Minimum Design Loads for Buildings and Other Structures*.

In the 2018 IBC the ICC revised and clarified the requirements of Chapter 28 Mechanical Systems, Section 2801.1 Scope, to read *"The provisions of this chapter, The International Mechanical Code and the International Fuel Gas Code shall govern the design, construction, erection and installation of mechanical appliances, equipment and systems used in buildings and structures covered by this code."* Chapter 3 General Regulations, Section 301.15 Wind Resistance, of the 2018 IMC like in 2015 again states *"Mechanical equipment, appliances and supports that are exposed to winds shall be designed and installed to resist the wind pressures determined in accordance with the International Building Code".* And again, like in the 2015 IBC Chapter 16 Structural Design, Section 1609.1 Wind Loads Applications states that *"Buildings, structures and part thereof shall be designed to withstand the minimum wind loads prescribed herein."* But this is where we get more help, in Chapter 16 Section 1609.1.1 Determination of wind loads it states that *"Wind loads on every building or structure shall be determined in accordance with Chapters 26 and 30 of ASCE 7"*. Chapter 35 of the 2018 IBC references the American Society of Civil Engineers / Structural Engineering Institute ASCE 7-16.

Like in 2018, the 2021 IBC and IMC have similar language regarding the design, construction, erection and installation of mechanical appliances, equipment and systems used in buildings and structures. Chapter 16 Section 1609.1.1 Determination of wind loads of the 2021 IBC states that "*Wind loads on every building or structure shall be determined in accordance with Chapters 26 and 30 of ASCE 7".* Chapter 35 of the 2021 IBC again references the ASCE 7-16.

Regarding Earthquake (Seismic) Loads in the 2015 IBC Chapter 16 Structural Design, Section 1613.1 Earthquake Loads Scope, states that *"Every structure, and portion thereof, including nonstructural*

Return to Schedule

components that are permanently attached to structure and their supports and attachments shall be designed and constructed to resist the effects of earthquake motions in accordance with ASCE 7". In the 2018 IBC clarification was added by including "*in accordance with Chapters 11, 12, 13, 15, 17 and 18 of ASCE 7 as applicable"*. The 2021 IBC has similar language as the 2018 code.

Chapter 29 of ASCE 7-10 does provide some guidance for determination of wind loads on building appurtenances (such as rooftop structures and rooftop equipment) and other structures of all heights (such as solid freestanding walls and freestanding solid signs, chimneys, tanks, open signs, lattice frameworks, and trussed towers) using the directional procedure. However, in ASCE 7-16 Chapter 29 we get step by step directions required for the determination of wind loads on building appurtenances and other structures in Table 29.1-1. Additionally, there are several equations provided for calculating wind force (F), or pressure (p) on various rooftop equipment and utilities.:

- Eq. (29.3-1) for signs and walls
- Eqs. (29.4-2) and (29.4-3) for rooftop structures and equipment
- Eq. (29.4-1) for other structures
- Eq. (29.4-5) or (29.4-7) for rooftop solar panels

In ASCE 7-10 CHAPTER 13 Seismic Design Requirements For Nonstructural Components, Paragraph 13.4 Nonstructural Component Anchorage it reads that "Nonstructural components and their supports shall be attached (or anchored) to the structure in accordance with the requirements of this section" and "Component attachments shall be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity. A continuous load path of sufficient strength and stiffness between the component and the supporting structure shall be provided." Additional requirements include that "The design documents shall include sufficient information relating to the attachments to verify compliance with the requirements of this section." Paragraph 13.4 of ASCE 7-16 has similar requirements as ASCE 7-10.

The 2022 addition of ASCE-7 now includes a chapter on tornado loads and effects. The aspect of wind and its interaction with structures in tornadic storms are very different from traditional winds. Therefore, additional considerations for building design and rooftop equipment anchorage should be considered in areas prone to tornados, particularly for essential facilities (buildings with Risk Categories III or IV). Chapter 32 of ASCE-7 outlines the necessary requirements for tornado wind loads, along with relevant tornado resistant design standards and methodologies.

In the 2020 Florida Building Code (FBC) Chapter 15 Roof Assemblies and Rooftop Structures, Section 1522.1 High-Velocity Hurricane Zones - Rooftop Structures and Components states that "Rooftop structures shall be designed and constructed in accordance with the Florida Building Code" and in 1522.2 Rooftop-mounted equipment "All rooftop equipment shall be secured to the structure in compliance with the loading requirements of Chapter 16 (High Velocity Hurricane Zones). Typically, wood blocks or as commonly referred wood "sleepers" are used to support rooftop equipment or / utilities. They are placed between the roof membrane and equipment or / utilities. The use of such wood "sleepers" are not permitted based on language in the IBC. Also in the 2020 Florida Building Code, Mechanical Section 305.3 Piping Support, Structural Attachment states that "Hangers and anchors shall be attached to the building construction in an approved manner."

With the current code language, potential for property loss and the life safety concerns it can be argued that proper attachment of any rooftop equipment could be considered an appropriate "standard of care" for any roofing or reroofing project.

TRADITIONAL METHODS of INSTALLATION~~ATTACHMENT~~

Traditional~~ly,~~ methods of installation ~~attachment~~ for rooftop equipment includes~~dincluded~~ three ~~distinct~~ categories; ballasted, adhered, and positively attached. In many cases, these traditional methods of installation ~~attachment~~ were field fabricated, labor intensive, and relied significantly on sealants for long-

Commented [DB2]: Please Review language on ACSE 7-22 Chapter 32 as needed (eq relevant to rooftop equipment, etc.). Based on case study (M. Levitan, NIST) ASCE 7-16 vs. Tornado- Exposure B DFW school vs. Fire station (https://www.youtube.com/watch?v=XvjcW1y7x94)

Commented [DB3]: Rearranged the sentence to address request to explain the term "sleeper"

Commented [DB4]: Moved compression to new methods- back to 3-methods in this section

Return to Schedule

term watertightness. The In general, these traditional methods seemed to have less design intent and are more based upon on-the-roofspot fabrication, or "Roofer to Figure Out" (RFO) field methodology. A roofing professional is left to figure out the attachment method to the building roof assembly, as well as the long-term waterproofing of the attachment/equipment components. This on-the-roof fabricationRFO RFO process places unnecessary "design" burdens on an already overburdened professional workforce. Many of the traditional attachment methods require regular intensive maintenance to ensure performance and watertightness. The next three paragraphs will outline the differences between the three categories.

Commented [DB5]: Edited to clarify this is field fabricated

Ballasted installationattachments generally consisted of relying on the weight of the rooftop unit or require the applicationying ofapplying additional weight to the supported structure to increase the frictional resistance produced by the effects of gravity. As rooftop equipment got lighter, relying on their weight to resist wind forces became increasingly less secure. Sometimes an additional layer of membrane or a protection barrier was installed between the supported structure and roof covering, thereby minimizing membrane damage for the ballasting process. When selecting a material to be used as bBallast Ballast selection long term performance has not always beenbeen considered long term performance. Materials used such as bags of sand, dry bags of cement, and concrete masonry units (CMU) that were not freeze thaw resistant, have had less than stellar results. Long-term performance relies on the integrity of the ballast, ability of the substrate to withstand the increased loads without damage, and that sufficient weight was installed to withstand tipping or sliding forces.

Traditional Aadhered attachment methods refer to those where rooftop equipment is included the directly attachedment to direct attachment of the rooftop equipment to the roof covering or membrane. This was accomplished using mastics, adhesives, sealants, and and liquid bitumen. This method of attachment procedure would transfer any forces from or movement of the rooftop equipment (such as wood pipe sleepers) directly to the roof membrane and often cause membrane damage. The forces applied to the roof assembly may impart forces onto the roof assembly components they were not designed to handle. Insulation board facers and their attachment to the core of the insulation board are not designed to be point loaded in the manner they will be with this method of attachment. Long-term performance would be a direct correlation to the ability of the attachment adhesive to remain intact and attached to the membrane, the roofing materials' ability to stay intact and connected to one and other as originally installed, and the ability of the roof membrane to support and withstand any movement. In general, Tthe performance of the adhesive being employed typically degrades over time under normal roof UV and heat exposure conditions (heat and UV exposure), thus reducing the adhesive's resistance to vibrations or movement. In most cases the use of mastics and sealants requires maintenance and regular inspections to ensure long-term performance.

Commented [DB6]: Please review- Added to address Comment: What does performance of an adhesive look like?

The positively attached method generally consistsed of two different methods of attachment. The first method to positively attach rooftop equipment involved cutting through the roof assembly down to the structural roof deck and removing all roofing materials. The attachment point is installed into the roof deck or supporting structure. The roofing materials would then be placed back into position reinstalling them around the mount point incorporating it into the newly waterproofed finished result. The second method to positively attach rooftop equipment is much less complicated. The equipment is fastened to the roof deck or supporting structure through the roof assembly. The newly punched hole in the roof is then waterproofed using a layer of membrane, or in many cases the fastener is sealed using a liquid sealant.consisted of installing a fastener (screw, nail, tie-downs, or specialty fastener) through the rooftop equipment support, through the roof membrane, and directly into the supporting structure. This method is contrary to the cardinal rule of roofing "don't puncture through the roof membrane in the water way." At times, the fastener was sealed with a layer of membrane, but in most cases, the fastener head was sealed with a liquid sealant. Due to component shapes and irregularities, the watertight seal between the membrane cover and equipment support can be was problematic. Long-term performance generally relies on the flexibility of the sealant, the ability to maintain the sealants condition, sealant, and the watertightness between the cover, tie-down and equipment support.

Commented [DB7]: A.Changed per reviewer comment: water way. "The line, "don't puncture through the roof membrane in the water line", consider using "valley" or "water way" as those terms are used in the field."

Commented [DB8]: Added per review "What about tie-downs?"

MARKET OVERVIEW of ATTACHMENT METHODS

Return to Schedule

Current rooftop equipment attachment methods are like the traditional methods. however, there are some Next Generation (NextGen) methods available that are taking root in the industry and are worth exploring. These NextGen approaches tend to be minimally invasive to the roof membrane, have an intentional design philosophy (non RFO) and require minimal maintenance for long-term performance. These could be divided into two broad categories based on: attachment method to the roof assembly and waterproofing. The first category, “Compression Method” is mechanically attached to the roof assembly and relies on compression seals to achieved waterproofing. The second category, “Compression Free Technology” is also mechanically attached to the roof assembly and relies on an integrated and compatible roof flashing cover for the waterproofing. Both categories will be explored in the next paragraphs.

Many of the new NextGen attachment methods are in alignment with the current code requirements of:

- Nonstructural components and their supports shall be attached (or anchored) to the structure
- Component attachments shall be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity
- A continuous load path of sufficient strength and stiffness between the component and the supporting structure shall be provided
- The use of wood “sleepers” shall not be permitted – This

and can be installed using typical traditional roofing methods by experienced professional roofing mechanics.

The Compression Method of attachment generally occurs on vertical surfaces, such as termination bars with sealant., is also now widely used on horizontal planes and in many cases, the seal is placed within the “water way.” Compression includes the application of a compressible seal, which is generally a liquid sealant or sealant tape applied between a rigid framing member and substrate that is compressed using a fastener. The framing member could be metal or UV-resistant plastic. Long-term performance relies on the flexibility of the sealant, the ability to maintain the sealant, and the ability to tighten the fastener to maintain the compression.

The Compression Free Technology NextGen attachment methods include attachment of the rooftop equipment to the supporting structure and then covering the fasteners with a factory installed roofing membrane or component cover. The attachment support is first attached to the structure (roof deck or deck supporting structure) with the fasteners sealed using a sealed factory installed membrane or component cover. Any exposed fasteners are designed with integral sealing washers.

BEST PRACTICES – attachment frequency

Best practices for rooftop equipment attachment vary by attachment methodology and roof system type. The following is a general discussion of some of the typical practices. It is imperative that the roofing material manufacturer~~manufacture~~ be contacted for any specific requirements and that all the roofing material manufacturer's printed recommendations, guidelines and instructions be followed during the process. All installation work should be undertaken by a professional roofing contractor familiar and experienced with the installation of the attachment components. Fastener selection is dictated by what is being attached, the roof~~system~~ assembly, deck type, and the project engineer. Refer to manufacturer’s installation instructions and the specified roofing material manufacturer requirements before installing. Also, consider material/component compatibility and manufacturer’s warranty.

Prior to starting any rooftop equipment attachment project, a roof evaluation should be conducted by an experienced roofing professional such as an architect, engineer, consultant, manufacturer, or contractor. This entity should be knowledgeable in not only the roofing system type but in the attachment method proposed. The evaluation should not only focus on the attachment method but should look at the “bigger picture” and determine if the extent of attachment work is appropriate for the existing roof system. For example, it may not be appropriate to install an extensive solar panel project on an older or “aged” roof system. The remaining roof serviceable life may not be comparable with the proposed solar panels, a roof

Commented [DB9]: Added additional clarification on compression method and non-compression method. More focus on how it is attached to the roof and how is the waterproofing taking place separate the steps.

Commented [DB10]: Added example of vertical compression application

Commented [DB11]: SPRI Comment:
A.Consider putting in language about manufacturers’ warranties, similar to, “Consider material/component compatibility and manufacturer’s warranty.”

Return to Schedule

replacement may be appropriate prior to installing the solar panels. Additionally, it is important that the evaluation examines if the proposed attachment methods are right for the rooftop equipment attachment application and roof system type.

The next step is to develop a plan to minimize roof damage from construction activities. Damage by other trade workers and roofers can drastically reduce roof life, cause roof attachment concerns, and allow water to enter the roof system and building. Protection plans can include restricting travel areas and work areas, and protecting the existing membrane during construction in work, material staging plans to ensure safe and effective roof loading, and final requirements needed for the finished inspection travel areas.

Before installing any attachment method, the designer should consider the code required load path of the attachment method. Codes require that the applicable wind forces be transferred from the rooftop equipment to the attachment device to the roof deck or deck structural supporting members. One must be cautious when adhering any attachment method to the roof membrane. The roof membrane must be sufficiently adhered to the substrate and the substrate must have the appropriate characteristics to create a proper load path.

Regardless of the attachment method, the roof membrane should be clean and dry prior to application of the attachment. Any dirt, sand, debris or other foreign material between the attachment method and roof membrane could jeopardize adhesion of components and cause frictional damage to the roof membrane. Wet, damp, and frosty surfaces could also cause adhesion issues and promote long-term biological growth within the attachment method.

Any attachment method that is adhered to the roof membrane should consider membrane cleaning and material compatibility with the roof membrane. This would include sealants, mastics, adhesives, bonding agents, and liquid bitumen. Chemical cleaning and in some cases, priming of the roof membrane may be required to achieve adequate adhesion.

Commented [DB12]: Moved up for continuity on cleaning topic

Any attachment method that is supported on top of the roof system or fastened through a roof membrane should consider the compressive strength of the existing roof assembly. Installing a ballasted attachment method or through a fastened attachment method over a “soft” or low compressive strength roof assembly could cause significant membrane damage or create “depression”.

Outside the scope of this paper. Thermal bridging of attachment fasteners through the roof’s insulation layer allows for heat flow inward during warm periods and outward during cold periods. If insulation is not continuous, heat can flow into and out of buildings, reducing energy efficiency. In general, the thermal losses from these fastening elements could be in the range of 4% to 13% under the roof design thermal resistance (R-Value.) [Ref1] Some of the variables that affect thermal losses are climate zone, fastener density, fastener type and roof R-value. These key variables are similar between standard roof penetrations flashings, membrane, termination details, etc., and rooftop equipment anchors for securement. In all cases, thermal bridging could be mitigated by following standard roofing practices. For instance, the use of high-quality polyamide plastic sleeves (fastener/ sleeve combination) in conjunction with the anchoring fasteners could be used to decrease thermal bridging and improve heat resistance. Alternatively, the use of alternate fasteners fabricated with lower thermal conductivity material (e.g., austenitic stainless steel vs. carbon steel) or combination of material (e.g., bi-metal: austenitic stainless steel with carbon steel drill point) could also reduce thermal losses. [Ref 2] Depending on the rooftop equipment attachment method employed, thermal bridging may be a consideration and something a design professional should consider. Please consult current building code and standard requirements for roof design R-values, and account for potential reductions due to thermal bridging to establish the effective R-Value. The ASHRAE 90.1- *Energy Standard for Buildings Except Low-Rise Residential Buildings*, provides the minimum requirements for energy-efficient design of most buildings, except low-rise residential buildings. The standard offers the minimum energy efficiency requirements for design and construction of the roof, as well as criteria for determining compliance with these requirements.

Commented [DB13]: Section Added per SPRI Task group

Commented [DB14]: Please review added language to address SPRI TF comment:

This should be expanded on since the language is becoming codified. Reference to papers included at the end

CONCLUSIONS

Due to damage caused by rooftop equipment displaced by wind or seismic events, code professionals have included specific design and attachment criteria in the International Building and International Mechanical Codes. These criteria provide roofing professionals and designers guidance in the calculation of wind and seismic forces and in some cases specific attachment criteria. ANext Generation attachment methods on the market today are intentionally designed to be minimally invasive to the roof system and provide a continuous load path of sufficient strength and stiffness between the component and the supporting structure.

With the current code language, potential for property loss and life safety concerns, it can be argued that proper attachment of any rooftop equipment is considered an appropriate “standard of care” for any roofing or reroofing project.

Commented [DB15]: Given the creation of the document, aren't we saying that it is appropriate? Changed could be to is

The following check list highlights the key topics for Rooftop Equipment Attachment to consider:

*Consult manufacturer's instructions
*Restrict travel on areas of the roof to protect membrane
*Research appropriate building codes
*Clean and dry membrane prior to attachment
*Consider compressive strength of existing roof system
*Research membrane compatibility with bonding agent
*Analyze attachment system for possible thermal bridging
*Fire risk due to displaced units
*

References:

1: S. Molleti and B. Baskaran*, Towards Codification of Energy Losses From Fasteners on Commercial Roofing Assemblies,* IIBEC Interface 2/220, 14-24.

2: H. Wieland, *Heat Losses Through Flat Roof Fasteners?*, From Practice and Science: Building Fasteners, Nov. 2003.

PHOTOS NEEDED (with permission to use)

- Displaced rooftop equipment from a wind or seismic event
- Rooftop equipment using the ballasted method
- Schematic drawing of a NextGen attachment method
- Solar panel project installed on an aged roof system

Return to Schedule

SPRI
Lightning Protection
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
1:15 p.m.

AGENDA

I.	Call to Order	B. Van Dam
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Review Public Comment Edits from External Work with Coalition	
IV.	Agree on Comment Letter	
V.	Adjournment	

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Return to Schedule

S43-22

Proposed Change as Submitted

Proponents: Amanda Hickman, representing Single-Ply Roofing Industry (SPRI) (amanda@thehickmangroup.com)

2021 International Building Code

Revise as follows:

[BG] 1511.7 Other rooftop structures. *Rooftop structures* not regulated by Sections 1511.2 through 1511.6 shall comply with Sections 1511.7.1 through 1511.7.~~5~~ 6, as applicable.

Add new text as follows:

1511.7.6 Lightning Protection Systems. Lightning protection system components shall be installed in accordance with Section 1511.7.6.1. Lightning protection systems shall not be attached directly to metal edge systems, including gutters, where these roof assembly components are required to be tested to ANSI/SPRI/FM 4435-ES-1 or ANSI/SPRI GT-1 in accordance with Sections 1504.6 or 1504.6.1.

Exception: Where permitted by the manufacturer's installation instructions for the metal edge systems or gutters.

1511.7.6.1 Installation. Lightning protection system components directly attached to or through the roof covering shall be installed in accordance with this chapter and the roof covering manufacturer's installation instructions. Flashing shall be installed in accordance with the roof assembly manufacturer's installation instructions and Sections 1503.2 and 1507 where the lightning protection system installation results in a penetration through the roof plane.

Reason: Progress was made during the Group A cycle to include Lightning Protection Systems (LPS) and their appropriate installation standards in the IBC (G176-21). However, these standards (NFPA 780 and UL 96A) are currently silent on the impact the attachment of LPS have on the roof. In order to preserve the building envelope in a wind or weather event, it is critical to maintain the integrity of the roof components which are required by code to be tested and to ensure weatherproofing continuity.

Even in moderate wind events, there have been documented failures of code compliant and tested roof assembly components where LPS were attached.

Roof assembly components such as coping and gutters are required by code to be tested to specific wind loads. LPS attachments to these roof component systems not only alter the wind load on of these tested components, but also alter their performance by restricting thermal movement causing galvanic reaction, leak point, etc.

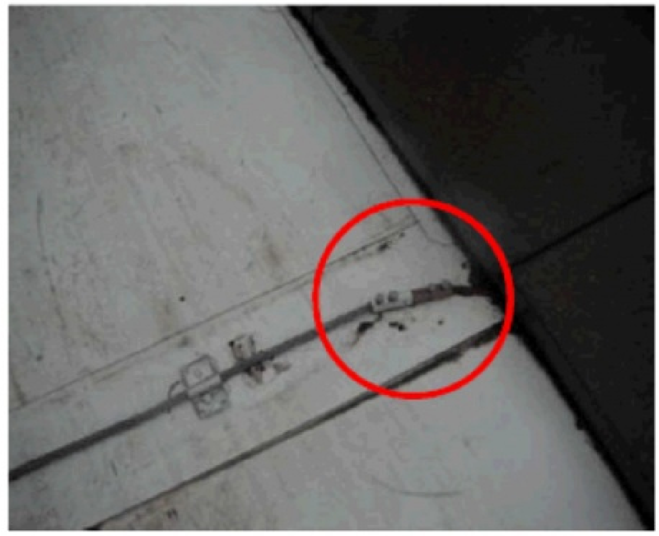
This proposal clarifies that attachment of LPS to any part of the roof needs to be done in accordance with the installation instructions for the roof assembly, roof covering, metal edge systems, or gutter. Where LPS components attach to or penetrate the roof, they must be properly flashed. Reasonable and readily available methods and details exist to attach LPS systems independent of coping, fascia, gutter and roof assembly components and for flashing of existing LPS attachment methods where penetrations are required. This proposal clarifies that regardless of sequencing challenges which may exist in new or retrofit applications of LPS, the integrity of tested components and the envelope shall be maintained.

Return to Schedule

Return to Schedule

Return to Schedule

Due to the installation of the Lightning Protection System components there may be certain details which require additional hot air welded patches installed under cable splices, frayed cable, and specific connections that could abrade the membrane. Hot air welded patches will provide sufficient protection to the field membrane from abrasion. Pictures below show examples of areas where additional hot air welded patches would be required.



Return to Schedule

Return to Schedule

Cost Impact: The code change proposal will not increase or decrease the cost of construction

This proposal just clarifies that LPS must be installed in accordance with the roofing component manufacturer's installation instructions. Flashing is already required for penetrations. There will, however, be a reduction in failure costs.

S43-22

Public Hearing Results

Return to Schedule

Committee Action: **Disapproved**

Committee Reason: Disapproved as adding an exception for the attachment is inappropriate. The committee stressed that the proposal needs additional coordination between disciplines. (Vote: 13-1)

S43-22

Individual Consideration Agenda

Public Comment HICKMAN-1:

IBC: [BG] 1511.7, 1511.7.6, 1511.7.6.1, 1511.7.6.2 (New)

Proponents: Amanda Hickman, representing Single-Ply Roofing Industry (SPRI) (amanda@thehickmangroup.com) requests As Modified by Public Comment

Modify as follows:

2021 International Building Code

[BG] 1511.7 Other rooftop structures. *Rooftop structures* not regulated by Sections 1511.2 through 1511.6 shall comply with Sections 1511.7.1 through 1511.7.6.2, as applicable.

1511.7.6 Lightning Protection Systems. Lightning protection system components shall be installed in accordance with Sections 1511.7.6.1, 1511.7.6.2 and 2703 of this code. ~~Lightning protection systems shall not be attached directly to metal edge systems, including gutters, where these roof assembly components are required to be tested to ANSI/SPRI/FM 4435-ES-1 or ANSI/SPRI GT-1 in accordance with Sections 1504.6 or 1504.6.1.~~

1511.7.6.1 Installation on metal edge systems or gutters. Lightning protection system components ~~directly~~ attached to ANSI/SPRI/FM 4435/ES-1 or ANSI/SPRI GT-1 tested metal edge systems or gutters shall be installed with compatible brackets, fasteners, or adhesives, in accordance with the metal edge systems or gutter manufacturer's installation instructions. When metal edge system or gutter manufacturer is unknown, installation shall be as directed by a registered design professional.~~or through the roof covering shall be installed in accordance with this chapter and the roof covering manufacturer's installation instructions. Flashing shall be installed in accordance with the roof assembly manufacturer's installation instructions and Sections 1503.2 and 1507 where the lightning protection system installation results in a penetration through the roof plane.~~

1511.7.6.2 Installation on roof coverings. Lightning protection system components directly attached to or through the roof covering shall be installed in accordance with this chapter and the roof covering manufacturer's installation instructions. Flashing shall be installed in accordance with the roof assembly manufacturer's installation instructions and Sections 1503.2 and 1507 where the lightning protection system installation results in a penetration through the roof covering. When the roof covering manufacturer is unknown, installation shall be as directed by a registered design professional.

Commenter's Reason:
Progress was made during the Group A cycle to include Lightning Protection Systems (LPS) and their appropriate installation standards in the IBC (G176-21). However, these standards (NFPA 780 and UL 96A) are currently silent on the impact the attachment of LPS have on the roof.

In order to preserve the building envelope in a wind or weather event, it is critical to maintain the integrity of the roof components which are required by code to be tested and to ensure weatherproofing continuity.

Roof assembly components such as coping, and gutters are required by code to be tested to specific wind loads. Any_attachments to these edge metal systems can alter the wind load on these tested components and therefore the performance of the systems.

This proposal clarifies that attachment of LPS needs to be done in accordance with the manufacturer installation instructions for the roof assembly, roof covering, metal edge systems, or gutter they are being attached to. Manufacturer is defined as a person or business that produced for sale or installation, the roof components referenced above (coping, gutters, roof membranes) and is often the roofing contractor, the roofing membrane manufacturer, or another manufacturing company responsible for the manufacturing of these tested components. Where LPS components attach to or penetrate the roof, they must be properly flashed. There are situations where the manufacturer of the metal edge system, gutter, or roof covering is unknown, or out of business. In these situations, a registered design professional can provide direction on an attachment method that will retain the integrity of the roof, while allowing a lightning protection system to be installed.

Cost Impact: The net effect of the public comment and code change proposal will not increase or decrease the cost of construction

If the Lightning protection system components are attached by adhesion or screw fasteners there will be no additional impact to costs. If the metal edge manufacturer’s installation instructions require the installation of a bracket or some other device not yet developed there will be an increase in the material and labor to install the lightning protection system and/or roofing system.

Public Comment# 3216

Return to Schedule

SPRI
Education Committee
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
2:15 p.m.

AGENDA

I. Call to Order — B. Chamberlain

II. Roll Call & Reading of SPRI Antitrust Statement

III. Discuss Wind Seminar

IV. Clarify methods to get more attendees outside our organization

V. BE Presentation

VI. Ideas and thoughts

VII. Adjournment

https://continuingeducation.bnpmedia.com/courses/multi-aia/roofing-technology-and-material-science-web-live/&Affiliate=speaker

Return to Schedule

SPRI
Digital Content & Communications
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
9:30 a.m.

AGENDA

I. Call to Order — Montoya

II. Roll Call & Reading of SPRI Antitrust Statement

III. Website update proposal options for the critical issues from audit:
   a. Current firm
   b. Adpearance

IV. Blog content – paid interviewer / writer next step discussion
   a. Adpearance proposal
   b. Sam Everett

V. Adjournment

Return to Schedule

SPRI
ES-1 Review
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
10:00 a.m.

AGENDA

I.	Call to Order	Patel
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Review of Comments Received (attached)	
IV.	Finalize Canvass List (draft attached)	
V.	Adjournment	

Originator	Comments/corrections not marked in the document	Committee actions	Conclusion
Phillip Smith (FM Approvals)	I think we need to revisit including loading on nailers in the standard.		
Phillip Smith (FM Approvals)	Due to the many changes on the loading side of the equation (ASCE 7, etc.) , the charts in the commentary should be removed.	Mark ups related to table values were removed with the tables	Accepted by the committee on May 10th (SPRI Q2 mtg)
Martin Moesgaard (Metal-Era)	Remove the tables in the commentary as they are also part of the design guide ED-1 which covers design of edge systems. ES-1 is now a test standard only.	Mark ups related to table values were removed with the tables	Accepted by the committee on May 10th (SPRI Q2 mtg)
David Hawn	**Comment re: P. Smith comment on nailers:** Nailers that the edge system tested may be attached to, require the structural attachment to the building with loads designated by the design professional. Those loads and requirements are the responsibility of the design professional required as part of the structural design of the building and, if not stated for a restoration project, must be provided by the entity seeking local jurisdiction approval prior to installation.		
Ryan Van Wert (FiberTite)	Commentary around previous comments and resistance calculations		
Martin Moesgaard (Metal-Era)	Change the Manufacture definition of 'An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set of rules'	To A person or company that produces finished goods from raw materials by using various tools, equipment, and processes.	

Return to Schedule

ANSI/SPRI/FM 4435/ES-1 ~~2017~~20XX
Test Standard for Edge Systems Used with Low Slope Roofing Systems

~~Approved January~~ XX~~24~~, XXXX~~2017~~

TABLE OF CONTENTS

Return to Schedule

1.0 Introduction

1.1 Scope

This Standard provides the basic requirements only for resistance testing for *roof edge system*s under simulated *wind load* conditions. This Standard is intended for use by those that design, specify, manufacturer, and test roofing materials and *roof edge system*s used in the roofing industry.

This Standard applies to low slope roof systems, with low slope defined here as roofs having a slope ≤ 9.5 degrees (2:12). The test methods found in this document address *copings* and *roof edge system*s.

1.2 Definitions

All words defined within this section are *italicized* throughout the standard.

ANSI
American National Standards Institute

Ballast
An anchoring material, such as ~~aggregate~~ stone or precast concrete pavers, which employs its mass and the force of gravity to hold (or assist in holding) single-ply roof *membranes* in place.

Commented [BL1]: Stone ballast is language used in code and other documents to differentiate from pea gravel and smaller aggregate.

Cleat
A continuous *metal* strip, or angled piece, used to secure *metal* components.

Clip
A non-continuous *metal* component or angle piece used to secure two or more *metal* components together.

Coping
The covering piece on top of a *parapet wall* exposed to the weather, ~~usually~~ often made of *metal*, and sloped to carry off water.

Deck
The uppermost structural component of the building immediately below the *roof system*. The *deck* must be capable of safely supporting the weight of the *roof system*, and the loads required by the governing building codes.

Design load
The total load on a structural system for the most severe combination of loads and forces which it is designed to sustain.

Drip edge
A *metal* flashing or other overhanging component with an ~~outward projecting~~ lower edge, intended to control the direction of dripping water, prevent capillary actions, and help protect underlying building components.

Commented [BL2]: Drip edges do not have to project out; a "blind drip" performs the same function

Return to Schedule

Fascia
The vertical or steeply sloped roof trim located at the perimeter of a building. Typically, it is a border for the *low-slope roof system*.

Fastener
Any of a wide variety of mechanical securement devices and assemblies, including nails, screws, *cleats, clips* and bolts, which may be used to secure various *roof edge system* components.

Fastener Pull-out
A type of failure mode in which a *fastener* pulls away from a *substrate* ~~(e.g.: nailer)~~ , e.g. nailer, or roof edge system component under load.

Fastener Pull-through
A type of failure mode in which a *fastener* head pulls through a *substrate, ~~clip or cleat~~roof edge system component* under load.

~~**Field of Roof Pressure**~~
~~The wind pressure (generally upwards) imparted on a central area of the roof.~~

Commented [MM3]: Committee agreed to remove this comment based on updates to ASCE-7 with new zones

Gravel stop
A flanged device, frequently metallic, designed to prevent loose aggregate from washing off the roof and to provide a continuous *roof edge system* for the roofing *membrane*.

Gutter
A channeled component installed along the down slope perimeter of a roof to convey runoff water from the roof to the drain leaders or downspouts.

Low-slope roof
A category of roofs that generally include weatherproof *membrane* types of *roof systems* installed on slopes at or less than 2:12 (9.5 degrees).

Manufacturer
An identification applied on a product by the manufacturer indicating that a product or material complies with a specified standard or set of rules

Commented [SP4]: You should not use the word in the definition. How about "The entity identified on the label as the supplier of the product.".

Commented [MM5]: Suggestion was accepted to add a definition of Manufacturer

Membrane
A flexible or semi-flexible roof covering or waterproofing whose primary function is to exclude water.

Metal
Any of a category of electropositive elements that usually have a shiny surface, are generally good conductors of heat and electricity, and can be melted or fused, hammered into thin sheets.

Parapet wall
The part of a perimeter wall that extends above the roof.

Return to Schedule

Roof Edge
The point of transition from a *low-slope roof* to a lower vertical or near vertical building element, including but not limited to walls, windows, *fascia* boards, and mansard roofs.

Roof edge system
A component or system of components at the perimeter of the roof that typically is integrated ~~in to~~into the *roof system* for the purpose of flashing and securing the roof *membrane*.

Roof slope
The angle a roof surface makes with the horizontal, expressed as a ratio of the units of vertical rise to the units of horizontal length (sometimes referred to as run), the amount or degree of such deviation. If the slope is given in inches, slope may be expressed as a ratio of rise of run, such as 2:12, or as an angle.

Roof system
A system of interacting roof components, generally consisting of a *membrane*, roof insulation and *roof edge systems* (not including the roof *deck*) designed to weatherproof and, sometimes, to improve the building's thermal resistance.

Soffit
The exposed undersurface of any exterior overhanging section of a roof eave.

Substrate
The upper surface of the roof *deck*, insulation, or other roofing structure upon which a roofing *membrane* or other component of the roofing system is placed or to which it is attached.

Wind load
Force exerted by the wind on a roof or any component of a roof system.

~~**2.0 Background Information**~~

~~**2.1 Wind Related Roofing Damage**~~

~~No area of the country is exempt from wind related roofing damage.~~

Commented [MM6]: Committee agreed this would be more useful in the comment section, so it is being deleted from this section

~~Public law 108-360, National Windstorm Impact Reduction Act of 2004, was signed into law by President Bush to reduce the risk wind hazards propose to life and property. It recommended improvements in and enhancements of, "standards and technologies that will enable cost effective, state of the art windstorm resistant provisions to be adopted as part of state and local building codes"~~

~~In addition, public law 114-52, National Windstorm Impact Reduction Act Reauthorization of 2015 2015, reauthorized the national windstorm impact reduction act and noted: SEC. 202. FINDINGS. NOTE: 42 USC 15701.~~

Return to Schedule

The Congress finds the following:
(1) Hurricanes, tropical storms, tornadoes, and thunderstorms can cause significant loss of life, injury, destruction of property, and economic and social disruption. All States and regions are vulnerable to these hazards.

A study of 145 FM Global losses involving built-up roof (BUR) systems showed 85 losses (59 percent) occurred because the roof perimeter failed[1]. The Roofing Industry Committee on Weather Issues (RICOWI) has issued several reports summarizing their findings regarding roof damage after significant wind events. The committee found "many examples of damage appeared to originate at failed edge details"[2]. RICOWI notes that their "studies reinforced the need for secure *roof edge systems*, and codes that require secure roof edging need to be enforced"[3].

3.0 Membrane Termination

Two types of *membrane* termination are industry accepted: dependently and independently terminated systems.

3.1 Dependently Terminated Systems

Ballasted systems, ribbon/spot adhered systems, or systems in which the mechanically attached roof cover is secured to the *substrate* at a distance greater than 12 in (305 mm) from the *roof edge* are considered dependently terminated by the *roof edge system*. For these systems the RE-1 and RE-2 tests are required.

3.2 Independently Terminated Systems

Systems in which the roof cover is fully adhered to the *substrate* or a mechanically attached roof cover is secured to the *substrate* at a distance less than or equal to 12 in (305 mm) from the *roof edge* are considered independently terminated. For these systems the RE-2 test or RE-3 test is required.

Commented [BL7]: Remove "fully", because it is almost impossible to install a truly fully adhered system.

4.0 Edge System Resistance

Roof edge systems shall be tested in accordance with tests RE-1, RE-2 or RE-3 as appropriate for the application. See Appendix A – Roof Edge System Testing.

4.1 Dependently Terminated Systems

Roof edge systems designed to act as *membrane* termination shall be tested according to tests RE-1 and RE-2.

4.2 Edge Flashing, Gravel Stops

For *roof edge systems* where the **exposed** horizontal component is 4 in (100 102 mm) or less, the exposed vertical component (face) area shall be tested according to test RE-2. For exposed horizontal components greater than 4 in, RE-3 test is required. See RE-2 test for more information.

4.3 Copings

Coping and other *roof edge systems* for which the **exposed** horizontal component exceeds 4 in (~~100~~ 102 mm) shall be tested according to test RE-3.

5.0 Packaging and Identification

Roof edge system components or packaging shall contain written documentation which identifies the components of a roof edge system which ~~have~~ has been ES-1 tested. Documentation, in the form of manufacturer's printed product literature or letter, shall be made available to the building owner or his/her representative.

6.0 Installation Instructions

Installation instructions shall be provided for all *roof edge systems* in compliance with the ES-1 test standard, and shall include *fastener* and *cleat* requirements.

7.0 References

1. Factory Mutual Approved Product News Vol. 21, No. 2, 2005
2. Roofing Industry Committee on Weather Issues (RICOWI), *Hurricane Katrina Wind Investigation Report*, 2007, pp. xiv
3. Roofing Industry Committee on Weather Issues (RICOWI), *Hurricanes Charley and Ivan Wind Investigation Report*, 2006, pp.xxiv

Return to Schedule

APPENDIX A
ROOF EDGE SYSTEM TESTING

RE-1 TEST
Test Method for Dependently Terminated Roof Membrane Systems

Note: This test is only required for systems described in 3.1, which do NOT contain a mechanical termination (commonly referred to as a "peel stop") within 12 in (~~300~~ 305 mm) of the *roof edge*.

RE1.1 Apparatus

The description of the apparatus is general in nature. Any equipment capable of performing the test procedure within the allowed tolerances shall be permitted. A schematic drawing of this apparatus is shown in Figure RE1.1. The test apparatus shall be constructed so that the performance of individual components ~~are~~is unaffected by end constraints on the test sample. Load shall be applied and measured with calibrated load cells, each accurate to within +/- 3% of ~~full scale~~full-scale load cell values. Calibration shall be performed annually (minimum) and should be performed and recorded at 5%, 25%, 50%, and 75% of the expected maximum test values.

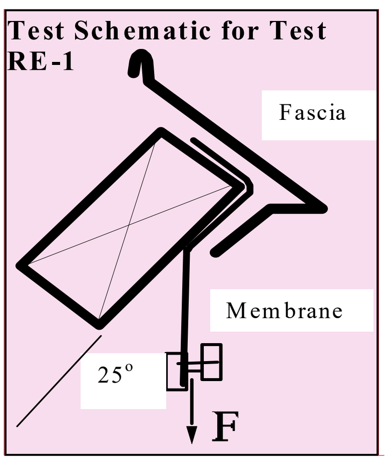


Figure RE1.1

Commented [BL8]: This detail could be drawn better, and is it even needed? RE1.2 shows the same thing.

Commented [MM9R8]:

RE1.2 Safety Precautions

Proper precautions shall be taken to protect the operating personnel and observers in case of any failure.

RE1.3 Test Method

To test the *roof edge system's* ability to restrain a *membrane* force, uniform tension shall be applied along the length of the *membrane* used in the test. The minimum length of the *membrane* and *roof edge system* shall be such that the *roof edge system* sample contains three (3) attachment *fasteners* at the design *fastener* spacing, or is 3 ft 0 in (915 mm) in

Return to Schedule

length, whichever is greater. The *roof edge system* shall be constructed and mounted on the base of a tensile testing device so the *membrane* is pulled at a 25° angle to the roof *deck* to simulate a billowing *membrane* (see Figure RE1.2).

Note that:

Applied Load = F * L

Where:

L = the length of the *roof edge system* sample, use 1 ft (~~300~~ 305 mm) to determine the load per linear foot.

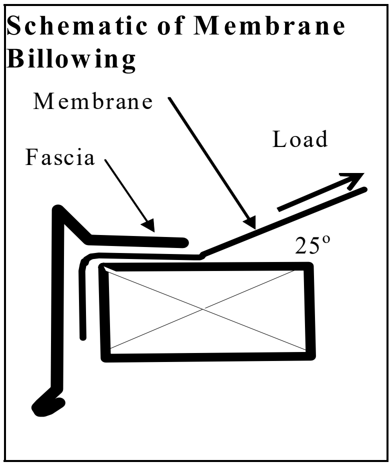


Figure RE1.2

The jaws of the tester shall be connected to two bars that clamp the *membrane* securely between them so that the load is distributed uniformly along the width of the *membrane* (see **Commentary for Test RE-1**). The tester is loaded at a rate of no less than 2 in/min (50 mm/min) until failure occurs or the desired *membrane* tension load is achieved. Failure is defined as any event that allows the *membrane* to come free of the *roof edge system* or the *roof edge system* to come free of its mount.

Commented [SP10]: 2in./min is correct. The test is conducted at a particular speed not a particular stress. IE constant strain test not aconstant stress test.

Commented [BL11]: Is this appropriate? Seems like lbs/min would make more sense.

RE1.4 Test Results

The results of the test shall be stated in pounds/lineal foot. The results are rounded down to the nearest pound/lineal foot.

Return to Schedule

RE-2 TEST
Test Method for Dependently or Independently Terminated *Roof edge systems*
(Exposed horizontal component 4 in. (~~100mm~~102mm) or less)

RE2.1 Apparatus

The description of the apparatus is general in nature. Any equipment capable of performing the test procedure within the allowed tolerances shall be permitted. A schematic drawing of this apparatus is shown in Figure RE2.1. The test apparatus shall be constructed so that the performance of individual components ~~are~~is unaffected by end constraints on the test sample. Load shall be applied and measured with calibrated load cells, each accurate to within +/- 3% of ~~full scale~~full-scale load cell values. Calibration shall be performed annually (minimum) and should be performed and recorded at 5%, 25%, 50%, and 75% of the expected maximum test values.

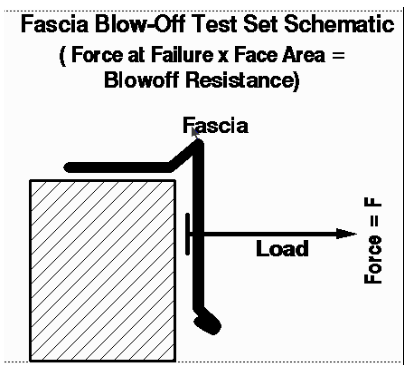


Figure RE2.1

RE2.2 Safety Precautions

Proper precautions shall be taken to protect the operating personnel and observers in case of any failure.

RE2.3 Test Specimens

All parts of the test specimen shall be full size in length, width and all other dimensions, using the same materials, details and methods of construction and anchoring devices (such as *clips, cleats*, and *fasteners*) as used on ~~the~~ an actual building. Sample length shall be a minimum of 8 ft (2.4 m). When the anchoring means at the ends of the *roof edge system* are normally used to restrain other additional lengths of the *roof edge system*, then the anchoring means shall be modified so that only that percentage that might restrain rotational movement in the test specimen is used.

Commented [BL12]: This may need more clarity. Do you use half cleats or splices, or do you only attach one side, etc.?

Commented [MM13R12]: Group discussion at SPRI May 10th resulted in agreement of keeping the wording It has been part of the standard since 1998

Return to Schedule

RE2.4 Procedure

RE2.4.1 Gravity

Any undue influence from gravity that does not occur during actual installation shall be omitted from the test specimen. If the test specimen is inverted, a gravity correction shall be made in the determination of the allowable superimposed loading. Tests run in an inverted position shall include data from pressure reversal or an upright specimen to show that unlatching of the *drip edges* at the *cleats* will not occur in the normal orientation.

RE2.4.2 Loading

Loading shall be applied uniformly on centers no greater than 12 in (~~300~~ 305 mm) to the centerline of the vertical face of the *roof edge system*. Loading shall be applied on the horizontal centerline of the face. Loads shall be applied incrementally and held for not less than 60 seconds after stabilization has been achieved at each incremental load. Between incremental loads, the load shall be reduced to zero until the specimen stabilizes (5 minutes maximum). After this stabilization period, initiate the next higher incremental load. Loading to the face of the *roof edge system* shall be applied in **increments** not to exceed 25-lb/ft^2 (120 kg/m^2) until approximately ½ of the expected failure load is obtained. Thereafter, increments of load shall not exceed 10-lb/ft^2 (50-kg/m2). Loading **speed** shall be such that each incremental load up to and including 150 psf (7.2 kPa) shall be achieved in 60 seconds or less. Above 150 psf (7.2 kPa), incremental loading shall be achieved in 120 seconds or less.

Loading shall proceed as indicated until the test specimen either fails or exceeds the required design pressure. The last 60-second load sustained without failure is the maximum load recorded.

RE2.4.3 Failure

Failure shall be loss of securement of a component of the *roof edge system***.**

RE2.4.4 Test Results

The data for the conditions described in 2.4.3 above shall be recorded. If this data is in units of force (pounds), the data shall be converted to pressure by dividing the force by the area of the face:

$$\text{Pressure} = \frac{\text{Outward Force}}{\text{Face Height x Face Length}}$$

- Pressure is measured in pounds per square foot
- Force is measured in Pounds Force
- Face Length is the test sample length in feet
- Face Height is in feet (inches÷12)

$$R = \frac{F}{H \times L}$$

Where:

$F = Force\ (lbf)$

$H = Height\ of\ Face\ (ft)$

$L = Length\ of\ sample\ (ft)$

Commented [LK14]: From RVW - Should "pressure" correspond with notation used in ED-1?

See section 6 - Edge System Resistance

Is resistance a better notation?

Commented [LK15]: From RVW - Purposed equation. (Similar to representation of water loads in 5.1 of ED-1)

$R = \ Resistance, maximum\ passing\ load\ in\ pounds\ per\ square\ foot\ (psf)$

Commented [RVW16]: Purposed equation. (Similar to representation of water loads in 5.1 of ED-1)

Return to Schedule

RE-3 Test for Copings

(Exposed horizontal component exceeds 4 inches (~~100~~ 102 mm))

RE3.1 Apparatus

This description of the apparatus is general in nature. Any equipment capable of performing the test procedure within the allowed tolerances shall be permitted. A schematic drawing of this apparatus is shown in Figures RE3.1 and RE3.2. The test apparatus shall be constructed so that the performance of individual components ~~are~~is unaffected by end constraints on the test sample. Load shall be applied and measured with calibrated load cells, each accurate to within +/- 3% of ~~full scale~~full-scale load cell values. Calibration shall be performed annually (minimum) and should be performed and recorded at 5%, 25%, 50%, and 75% of the expected maximum test values.

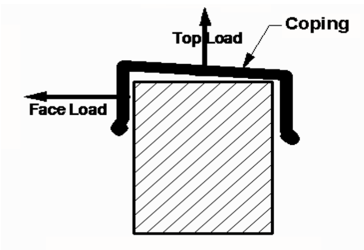


Figure RE3.1 RE3 Test- Face Leg Pull

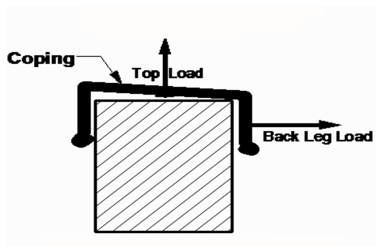


Figure RE3.2 RE3 Test- Back Leg Pull

RE3.2 Safety Precautions

Proper precautions shall be taken to protect the operating personnel and observers in case of any failure.

RE3.3 Test Specimens

All parts of the test specimen shall be full size in length, width and all other dimensions, using the same materials, details and methods of construction and anchoring devices (*fasteners*, *clips* and *cleats*) as used on the actual building. Sample length shall be a minimum of 8 ft. (2.4 m). When the anchoring means at the ends of the *roof edge system* are normally used to restrain other additional lengths of the *roof edge system*, then the anchoring means shall be modified so that only that percentage that might restrain rotational movement in the test specimen is used. A minimum of 1 face/top test and 1 top/back test shall be performed.

Commented [BL17]: This needs more clarity. If it is a clip system do you use half clips, or only attach one half: What about any splices or lapped joints?

Commented [MM18R17]: Group discussion at SPRI May 10th resulted in agreement of keeping the wording. It has been part of the standard since 1998

RE3.4 Procedure

RE3.4.1 Gravity

Any undue influence from gravity that does not occur during actual installation shall be omitted from the test specimen. If the test specimen is inverted, a gravity correction shall be made in the determination of the allowable superimposed loading. Tests run in an inverted position shall include data from pressure reversal or an upright specimen to show that unlatching of the *drip edges* at the *cleats* will not occur in the normal orientation.

Return to Schedule

RE3.4.2 Loading

Top and face loadings shall be applied simultaneously in the vertical and horizontal directions in the ratio of 1.73 lbs/sf top (vertical load) to 1 lb/sf face (horizontal load). Loading shall be applied uniformly on centers no greater than 12 in (300 mm) to the top of the *coping* and to one of the faces of the *coping* at the same time. Loads shall be applied on parallel horizontal centerlines of the surfaces tested.

Commented [BL19]: Ratios have changed in latest ASCE7 version, so maybe this needs to be changed; however, I would recommend it stay the same.

Commented [SP20R19]: Per new ASCE ratio could be as high as 2.5 we need to consider changing

Loads shall be applied incrementally and held for not less than 60 seconds after stabilization has been achieved at each incremental load. Between incremental loads, the load shall be reduced to zero until the specimen stabilizes (5 minutes maximum), before the next higher incremental load is initiated. Vertical loading to the top of the *roof edge system* shall be applied in **increments** not to exceed 25 ~~lb~~lbs/ft^2 (120 kg/m^2) until approximately ½ of the expected failure load is obtained. Thereafter, increments of load shall not exceed 10 ~~lb~~lbs/ft^2 (50 kg/m^2). Loading **speed** shall be such that each incremental load up to and including 150 psf (7.2 kPa) shall be achieved in 60 seconds or less. Above 150 psf (7.2k Pa), incremental loading shall be achieved in 120 seconds or less.

Commented [LK21]: RVW - Does RE-1 have the same loading sequence?

Loading shall proceed as indicated until the test specimen either fails or exceeds the required design pressure. The last 60-second load sustained without failure is the maximum load recorded.

Commented [LK22]: RVW - Should this be noted in RE-1 test?

Both face and back legs shall be tested in this manner using separate test samples. Thus, one sample to test the face while loading the top (Figure RE3.1), and the other to test the back leg while loading the top (Figure RE3.2).

RE3.4.3 Failure:

Failure shall be loss of securement of a component of the *roof edge system*.

RE3.4.4 Test Results:

The data for the conditions described in 3.4.3 above shall be recorded. If this data is units of force (in pounds), it shall be converted to pressure by dividing the force by the area of the face:

$$\text{Pressure} = \frac{\text{Outward Force}}{\text{Face Height * Face Length}}$$

Commented [LK23]: RVW - Should "pressure" correspond with notation sued in ED-1?

See section 6 - Edge System Resistance

Is resistance a better notation?

- Pressure is measured in pounds per square foot
- Force is measured in Pounds Force
- Face Length is the test sample length in feet
- Face Height is in feet (inches÷12)

$$R = \frac{F}{H \times L}$$

Where:

$F = Force\ (lbf)$

$H = Height\ of\ Face\ (ft)$

$L = Length\ of\ sample\ (ft)$

Return to Schedule

$R = Resistance, maximum\ passing\ load, in\ pounds\ per\ square\ foot\ (psf)$

Commented [LK24]: RVW - Purposed equation. (Similar to representation of water loads in 5.1 of ED-1)

Return to Schedule

APPENDIX B
COMMENTARY

This Commentary consists of explanatory and supplementary material designed to help designers, roofing contractors, manufacturers, testing facilities, and others in applying the requirements of the preceding Standard.

This Commentary is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements.

The sections of this Commentary are numbered to correspond to sections of the Standard to which they refer. Since having supplementary material for every section of the Standard is not necessary, not all sections are referenced in this Commentary.

C1.1 Scope

This test Standard was developed for use with Built-Up (BUR), Single-Ply and Modified Bitumen roofing systems.

The low slope value defined in this Standard comes from an industry accepted value of ≤ 9.5 degrees (2:12).

Roof edge systems serve aesthetic as well as performance functions for a building. Aesthetically, they provide an attractive finish and sometimes even a key feature to the exterior of a building. Of course, no matter how aesthetically pleasing, a *roof edge system* must act primarily as an effective mechanical termination and transition between the roof and other building components such as *parapet walls*, vertical walls, corners, *soffits*, *fascia* boards, etc.

A ~~high performance~~high-performance *roof edge system* provides many benefits. It acts as a water seal at the *roof edge*. When it is the means by which the *membrane* is attached to the building at the *roof edge*, it must also exhibit sufficient holding power to prevent the *membrane* from pulling out at the *roof edge* under design wind conditions. Furthermore, the *roof edge system* itself must not come loose ~~in~~ due to a design wind load. A loose component of a *roof edge system* not only endangers surrounding property or persons, but it also exposes the roofing to blow-off, starting at the *roof edge*.

C2.0 Background Information

The 1980s saw a dramatic increase in the popularity of single-ply *roof systems*. With this increase**,** *roof edge system*s began receiving additional attention. Throughout the 1980s into the early 1990s a variety of organizations developed *roof edge* termination recommendations and testing criteria. These standards, however, were not universal and each was focused on the specific needs or purpose of that organization. This created a challenge for design professionals in selecting the appropriate *roof edge system***,** which would perform to the needs of their particular project.

In 1995 the Single Ply Roofing Industry (SPRI) began the process of developing a consensus *roof edge* performance standard. The goal was to create a standard that would have real-world practicality and provide unified guidance to design professionals as well as those

Return to Schedule

that fabricate and install *roof edge systems*.

In 1998 the American National Standards Institute (*ANSI*) approved what was to become the ANSI/SPRI ES-1 Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems. In 2003 the ES-1 Standard was included in the International Building Code (IBC). 2006 and later versions of IBC all require *roof edge systems* to be tested per the test methods in this standard.

Today, the central role that *roof edge systems* play in protecting against *wind loads* is gaining increasing awareness due to renewed attention of significant wind events.

C2.1 Wind Related Roofing Damage

Commented [MM25]: Section moved to commentary as agreed to by the committee on May 10th

No area of the country is exempt from wind related roofing damage.

Public law 108-360, National Windstorm Impact Reduction Act of 2004, was signed into law by President Bush to reduce the risk wind hazards propose to life and property. It recommended improvements in and enhancements of, "standards and technologies that will enable cost effective, state of the art windstorm resistant provisions to be adopted as part of state and local building codes"

In addition, public law 114-52, National Windstorm Impact Reduction Act Reauthorization of 2015 2015, reauthorized the national windstorm impact reduction act and noted: SEC. 202. FINDINGS. NOTE: 42 USC 15701.

The Congress finds the following:
(1) Hurricanes, tropical storms, tornadoes, and thunderstorms can cause significant loss of life, injury, destruction of property, and economic and social disruption. All States and regions are vulnerable to these hazards.

A study of 145 FM Global losses involving built-up roof (BUR) systems showed 85 losses (59 percent) occurred because the roof perimeter failed[1]. The Roofing Industry Committee on Weather Issues (RICOWI) has issued several reports summarizing their findings regarding roof damage after significant wind events. The committee found "many examples of damage appeared to originate at failed edge details"[2]. RICOWI notes that their "studies reinforced the need for secure *roof edge systems*, and codes that require secure roof edging need to be enforced"[3].

C3.0 Membrane Termination Systems

The *roof edge system* may be the only restraint preventing a roof blow-off. Mechanically attached *membranes* may be attached only by the *roof edge system* at the building's *roof edge*. In *ballasted* systems, *ballast* may be scoured away from the *roof edge*. *Ballasted* roofs should be designed to meet ANSI/SPRI RP-4, *Wind Design Standard for Ballasted Single-Ply Roofing Systems*, to prevent excessive scour.

Consideration should be given to sealing the *roof edge* against air infiltration. Air infiltration may affect the loads on the roofing and the *roof edge system* by adding a positive pressure under the roofing, thus compounding the effect of negative pressure above the roofing.

BUR and most modified bitumen *membranes* are ~~fully~~ adhered to roof *deck* or insulation. When they are mechanically ~~attached~~attached, they shall follow the rules for all mechanically attached systems.

C3.1 Dependently terminated

Ballasted Systems or systems in which the mechanically attached roof cover is secured to the *substrate* at a distance greater than 12 in (~~300~~ 305 mm) from the *roof edge system* are considered dependently terminated by the *roof edge system*. For these systems Test RE-1 is applicable. Dependently Terminated *roof edge system*s are often called Edge Flashings or *Gravel Stops*. These products or designs complete the horizontal *deck* or *membrane* plane at its transition to a vertical wall drop, typically at a 90° angle.

Normally the roofing *membrane* is restrained at the *roof edge* by means of a mechanical gripping of the *membrane* by the *roof edge system* or by a bond between the *membrane* and *roof edge system*.

A *roof edge system* may also function as an air seal, when combined with an air retarder throughout the field of the roof, by preventing air infiltration under the roofing *membrane*. To resist air infiltration, nailers should be sealed to the building with appropriate sealant material. Where multiple courses of nailers are used, these nailer courses should also be sealed to each other. Butt joints should also be sealed.

Termination devices against higher vertical walls inboard of the *roof edge* are not considered by this Standard.

C3.2 Independently terminated

Systems in which the roof cover is ~~fully~~ adhered to the *substrate* or a mechanically attached roof cover that is secured the *substrate* at a distance less than or equal to 12 in (~~300~~ 305 mm) from the roof side of the *roof edge system* are considered independently terminated. For these systems Tests RE-2 or RE-3 are applicable.

Copings/Caps

Copings/Caps are independently terminated systems**:** These are *roof edge systems* that cover the tops of *parapet walls*, usually with the roofing *membrane* terminated under them.

Gutters

Gutters and other rain-carrying devices are beyond the scope of this Standard. However, the designer should be aware that their securement is important to the proper functioning of the building, and reference ANSI/SPRI GT-1 "*Test Standard for Gutter Systems*" for the testing of gutter systems.

C 4.0 Edge System Resistance

*Roof edge system*s may be selected from manufacturers who certify certain minimum performance to meet design requirements, based upon testing. Any *roof edge system* may be used provided that it is tested and certified by an independent testing laboratory to meet the wind design requirements.

The vertical face of an edge flashing (*gravel stop*) shall be tested according to Test RE-2 and provide a strength that meets or exceeds the required horizontal design pressure. The test shall be applicable to systems with exposed horizontal components less than 4 in (~~100~~ 102 mm) as detailed in the RE-2 Test Method; otherwise Test RE-3 is applicable.

The vertical and horizontal faces of *copings* (and like *roof edge systems*) shall be tested according to Test RE-3 and provide a strength that meets or exceeds the **horizontal and vertica**l pressures required.

The *roof edge system*, when used for securing dependently terminated *roofing systems*, shall be tested according to Test RE-1 to provide a strength that meets or exceeds the calculated *membrane* tension. See RE-1 Classification Tables in Commentary.

See Test Method RE-1, RE-2, and RE-3 for further information.

C5.0 Packaging and Identification

Because IBC requires that *roof edge systems* be tested per ES-1, owners and code officials need documentation packaged with the *roof edge system* to identify that it has been tested. Recognized or certified third party organizations may require additional auditing.

C6.0 Installation Instructions

In order for the *roof edge system* to perform as tested it must be installed in the same manner as the tested *roof edge system*. Installation instructions are required to assure the proper *cleats*, *clips*, *fasteners* and other components are installed in the correct location and at the correct spacing.

TEST METHOD RE-1 COMMENTARY

The *roof edge system* is a key anchor point holding the *membrane* in place. During high-speed wind loading, the *roof system* can create extreme loads on the *roof edge system***.**

Referring to Figure RE1.3 for a mechanically attached system, the loading depends upon the distance, r, of the first row of *fasteners* to the edge termination. The overall shape of the *membrane* is based upon previous tests indicating that the *membrane* deformation can be well approximated by a ~~25 degree~~25-degree angle[4, 5]. Figure RE1.4 shows a closer look at the *membrane* forces.

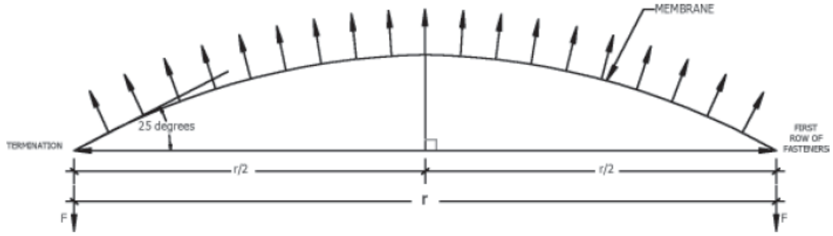


Figure RE1.3 – Mechanically Attached Roof Forces

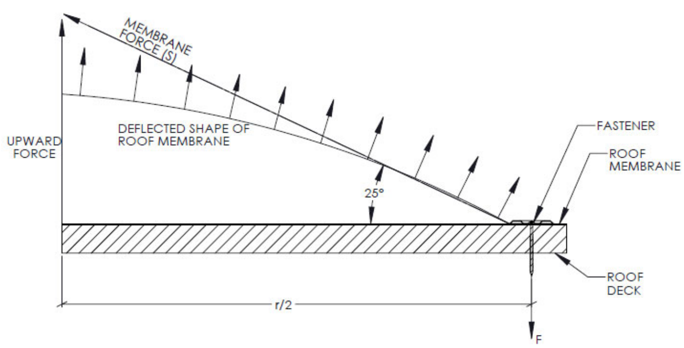


Figure RE1.4 – System of Forces, ½ of Membrane width between Fasteners

If an upward pressure (lb/ft^2) is applied to the *membrane*, then the upward force = upward pressure x r/2 for one half of the *membrane* width r (a single *fastener* will have a force, F, to resist this load). Assuming a 25° deflected shape, then the *membrane* force, S, can be found from the equations:

$$\sin 25^0 = \frac{UpwardForce}{S}$$

$$\sin 25^0 = \frac{Upwardpressure * \frac{r}{2}}{S}$$

Thus,

$$S = \frac{Upwardpressure * \frac{r}{2}}{sin\,25^0}$$

The precision and bias of this test measure has not been determined. ~~In the absence of third party witness testing/verification, the ES-1 committee recommends round robin testing of standard, pre-manufactured edge systems to establish lab-to-lab variability of individual test results.~~

Test Method RE-1 Commentary- ~~Fully~~ Adhered Roof Systems
~~Fully adhered~~ Adhered systems are assumed to apply no stress on the *roof edge system* under consideration, unless either the *metal* is loosened or the *membrane* is in peel from the pressure differential between the exterior and interior of the system; however, recent hurricane investigations have shown that both can occur.

Test Method RE-1 Commentary – Membrane Tension
The following tables are provided as a reference, when testing according to RE-1, for approximating *membrane* tension based upon the calculated Field of Roof or Vertical Perimeter Pressure, and the distance to the first row of *fasteners* in a mechanically attached system. For *ballasted* system 5 < r $\leq$ 6 is used. These tables are not intended to be used for design. *Design load* should be determined as required by the Authority Having Jurisdiction.

Return to Schedule

RE-1 Classifications - Dependently Terminated Systems
Occupancy Category II (Importance Factor, I=1.0)[1]
For $h \leq 60$ feet, Enclosed Buildings

Commented [MM26]: Committee agreed with the suggestion to remove the tables from ES-1 as they are duplicate of the tables in ASNI/SPRI/ED-1

Field of Roof Pressure q_{fz} psf (kPa)	Vertical Perimeter Pressure P_{vp} psf (kPa)	Membrane Tension lb/ft (kg/m)				
		Distance to first Row of Fasteners ft. (m)				
		1< r ≤ 2 (0.3< r ≤0.6)	2< r ≤3 (0.6 < r ≤ 0.9)	3< r ≤4 (0.9 < r ≤1.2)	4< r ≤5 (1.2 < r ≤0.5)	(note 2) 5< r ≤6 (1.5 < r ≤1.8)
q_{fz} ≤ 30.0	101 (4.83	23 (35	35 (53	47 (71	59 (88	71 (106
30.0< q_{fz} ≤37.5 (1.44< q_{fz} ≤1.8)	126 (6.03		44 (66	5 (88	74 (11	89 (133
37.5< q_{fz} ≤45.0 (1.8< q_{fz} ≤2.15)	151 (7.24	35 (53	53 (79	71 (10	89 (13	107 (159
45.0< q_{fz} ≤52.5 (2.15< q_{fz} ≤2.51)	176 (8.45	41 (2	6 (93	83 (12	10 (15	11 (186
52.5< q_{fz} ≤60.0 (2.51< q_{fz} ≤2.87)	202 (9.65	47 (71	71 (10	95 (14	11 (17	143 (213
60.0< q_{fz} ≤67.5 (2.87< q_{fz} ≤3.23)	227 (10.9	53 (79	8 (11	10 159	13 (19	161 (239
67.5< q_{fz} ≤75.0 (3.23< q_{fz} ≤3.59)	252 (12.1	59 (88	89 (13	11 (17	14 (22	178 (266
75.0< q_{fz} ≤82.5 (3.59< q_{fz} ≤3.95)	277 (13.3	65 (97	98 (14	13 (19	16 (24	196 (292
82.5< q_{fz} ≤90.0 (3.95< q_{fz} ≤4.31)	302 (14.5	71 (106	10 (15	14 (21	17 (26	214 (319
90.0< q_{fz} ≤97.5 (4.31< q_{fz} ≤4.67)	328 (15.7	77 (115	11 (17	15 (23	19 (28	232 (346
97.5< q_{fz} ≤105.0 (4.67< q_{fz} ≤5.03)	353 (16.9	83 (124	12 (18	16 (24	20 (31	250 (372
105< q_{fz} ≤112.5 (5.03< q_{fz} ≤5.39)	378 (18.1	89 (133	13 (19	17 (26	22 (33	268 (399
112.5< q_{fz} ≤120 (5.39< q_{fz} ≤5.75)	403 (19.3	95 (141	14 21	19 (28	23 (35	286 (425
120< q_{fz} ≤127.5 (5.75< q_{fz} ≤6.11)	428 (20.5	101 (150	15 (22	20 (30	25 (37	304 (452

Table Notes:

1. I = 1 so this table is also applicable when no importance factor is required. Adjust for other I values.

Return to Schedule

~~2. 5< r ≤ 6 column to be used for *ballasted* systems. See Appendix A- RE-1 test information.~~

RE-1 Classifications - Dependently Terminated Systems
Occupancy Category II (Importance Factor I=1.0)[1]
For h > 60 feet, Enclosed Buildings

Field of Roof Pressure q_{fz} psf (kPa)	Vertical Perimeter Pressure P_{vp} psf (kPa)	Membrane Tension lb/ft (kg/m)				
		Distance to first Row of Fasteners ft. (m)				
		1< r ≤ 2 (0.3< r ≤0.6)	2< r ≤ 3 (0.6 < r ≤ 0.9)	3< r ≤ 4 (0.9 < r ≤1.2)	4< r ≤ 5 (1.2 < r ≤0.5)	(note 2) 5< r ≤ 6 (1.5< r ≤1.8)
q_{fz} ≤ 30.0 (q_{fz} ≤ 1.44)	94 (4.51)	224 (333)	336 (498)	446 (664)	559 (830)	670 (997)
30.0< q_{fz} ≤37.5 (1.44< q_{fz} ≤1.8)	118 (5.64)	278 (415)	41 622)	559 (830)	698 (1037)	836 (1245)
37.5< q_{fz} ≤45.0 (1.8< q_{fz} ≤2.15)	141 (6.77	336 (498	50 (74	67 (99	83 (12	1004 (1494
45.0< q_{fz} ≤52.5 (2.15< q_{fz} ≤2.51)	165 (7.89	390 (581	58 (87	78 (11	97 14	1171 (1742
52.5< q_{fz} ≤60.0 (2.51< q_{fz} ≤2.87)	188 (9.02	446 (664	67 (99	89 (13	11 (16	1339 (1993
60.0< q_{fz} ≤67.5 (2.87< q_{fz} ≤3.23)	212 (10.2	502 (747	75 (11	10 (14	12 (18	1506 (2242
67.5< q_{fz} ≤75.0 (3.23< q_{fz} ≤3.59)	236 (11.3	559 (830	83 (12	11 (16	13 (20	1674 (2491
75.0< q_{fz} ≤82.5 (3.59< q_{fz} ≤3.95)	259 (12.4	613 (914	92 (13	12 (18	15 (22	1842 (2740
82.5< q_{fz} ≤90.0 (3.95< q_{fz} ≤4.31)	283 (13.5	670 (997	10 (14	13 (19	16 (24	2008 (2989
90.0< q_{fz} ≤97.5 (4.31< q_{fz} ≤4.67)	306 (14.7	725 (107	10 (16	14 (21	18 (26	2176 (3238
97.5< q_{fz} ≤105.0 (4.67< q_{fz} ≤5.03)	330 (15.8	78 (116	11 (17	15 (23	95 (29	2343 (3487
105< q_{fz} ≤112.5 (5.03< q_{fz} ≤5.39)	353 (16.9	836 (124	12 (18	16 (24	20 (31	2511 (3735
112.5< q_{fz} ≤120 (5.39< q_{fz} ≤5.75)	377 (18.0	893 (132	33 (19	17 (26	22 (33	28 (3985
120< q_{fz} ≤127.5 (5.75< q_{fz} ≤6.11)	400 (19.2)	948 (1412)	1424 (2118)	1896 (2823)	2371 (3528)	2846 (4235)

Return to Schedule

Table Notes:

1. I = 1 so this table is also applicable when no importance factor is required. Adjust for other I values.
2. 5< r ≤ 6 column to be used for *ballasted* systems. See Appendix A- RE-1 test information.

Test Methods RE-2 and RE-3 Commentary

Stabilization

Stabilization is necessary during loading to ensure that the specimen has reached equilibrium before considering a sustained load for a period of 60 seconds. As the specimen approaches its ultimate capacity, stabilization of the specimen will generally take longer to achieve.

Loading

These test methods consist of applying loads on surfaces of a test specimen and observing deformations and the nature of any failures of principal or critical elements of the *roof edge systems*. Loads are applied to simulate the static wind loading of the members. Test RE-2 requires horizontal loading on only the vertical face since the upward wind loading on an edge system member is considered to be negligible because of the small area exposed to uplift.

A recovery period between increases in incremental loading is allowed for the test specimen to attempt to assume its original shape prior to applying the next load level. The rate of sustained loading can be a critical issue when specimens are subjected to continuously increasing load until failure is achieved. Loading rate has little meaning in RE-2 and RE-3 because these methods employ incrementally increased loads sustained for long times followed by brief recovery periods. An incremental method is more stringent than continuous loading due to the requirement of a 60 second holding load.

The RE-2 and RE-3 Test procedures require full-length specimens because end conditions of discreet sections of *copings* and edge flashings can play a profound role in the failure mode of the materials. Furthermore, those products having *clips* (not continuous *cleats*) can exhibit different performance under testing than in the field if the *clips* do not act upon the products as they would in the field.

No special testing is required of fabricated miters. However, the *roof edge system* from which the miter has been fabricated shall have been tested to meet the calculated *design loads* of the corner region. The precision and bias of these test measures have not been determined. In the absence of third party witness testing/verification, the ES-1 committee recommends round robin testing of standard, pre-manufactured *roof edge systems* to establish lab-to-lab variability of individual test results.

The external Pressure Coefficients (GC_p) used to calculate horizontal and vertical pressures vary by building height (<u>≤</u>60 or >60') and location on the roof (perimeter or corner region). The ratio of top (vertical) pressure to face (horizontal) pressure ranges from 1.71 to 2.30 depending on the building height and roof location. To simplify testing and avoid having to test *roof edge systems* at

Return to Schedule

four different pressure ratios, the ratio for testing has been set at 1.73. This 1:73 ratio is deemed to be the most conservative as greater loads are applied to the face and back of the *coping* where failure most often occurs. 1.73 is also the ratio that was typically ~~was~~ used when testing per ANSI/SPRI ES-1 2003 and ANSI/SPRI/FM 4435/ES-1 2011; therefore, products tested in accordance with one of those previous versions should not require re-testing.

Failure

Some examples of component failure that will not enable the roof edge system to perform as designed would be:

- Full *fastener pull-out*
- *Fastener pull-through*
- Collapse of a *cleat*, *fascia* or cover
- Disengagement of cover from a *cleat* or *clip*

Consideration should be given to permanent deformation observed during testing. A *roof edge system* with no load being applied, which exhibits permanent deformation from its original shape, may allow water infiltration and be subjected to peeling wind forces that could compromise the intended performance of the *roof edge system*.

Test Method RE-2 and RE-3 Commentary – Horizontal and Vertical Edge Pressures

The following tables are provided as a reference, when testing according to RE-1 and RE-1RE-2 and RE-3, for approximating the Horizontal and Vertical Loads at the perimeter and corner based upon the calculated *Field of Roof pressure*. These tables are not intended to be used for design. *Design load* should be determined as required by the Authority Having Jurisdiction or project specifications, whichever is greater.

Horizontal and Vertical Edge Pressures
Enclosed Buildings
Occupancy Category II (I=1.0)[1]
$h \leq 60$ ft.

Field of Roof Pressure q_{fz} Psf (KPa)	Horizontal Load psf (KPa)		Vertical Load Psf (KPa)	
	Perimeter P_{hp}	Corner P_{hc}	Perimeter P_{vp}	Corner P_{vc}
30 (1.44)	58 (2.8)	73 (3.5)	101 (4.8)	152 (7.3)
37.5 (1.80)	73 (3.5)	91 (4.3)	126 (6.0)	190 (9.1)
45 (2.15)	87 (4.2)	109 (5.2)	151 (7.2)	228 (10.9)
52.5 (2.51)	102 (4.9)	127 (6.1)	176 (8.4)	266 (12.7)
60 (2.87)	116 (5.6)	145 (7.0)	202 (9.7)	304 (14.5)
67.5 (3.23)	131 (6.3)	163 (7.8)	227 (10.9)	342 (16.4)
75 (3.59)	146 (7.0)	182 (8.7)	252 (12.1)	380 (18.2)
82.5 (3.95)	160 (7.7)	200 (9.6)	277 (13.3)	417 (20.0)
90 (4.31)	175 (8.4)	218 (10.4)	302 (14.5)	455 (21.8)
97.5 (4.67)	189 (9.1)	236 (11.3)	328 (15.7)	493 (23.6)
X	1.94 * X	2.41 * X	3.36 * X	5.06 * X

Table Notes:

1. I = 1 so this table is also applicable when no importance factor is required. Adjust for other I values as required.
2. Horizontal and vertical load values are calculated directly using *field of roof pressure* given in column 1
3. Horizontal and vertical load values are calculated using External Pressure Coefficients (GC_p) of 0.97 horizontal perimeter, 1.21 horizontal corner, 1.68 vertical perimeter, and 2.53 vertical corner.
4. Horizontal and vertical load values contain a safety factor of 2.0.

Commented [MM27]: Committee agreed with the suggestion to remove the tables from ES-1 as they are duplicate of the tables in ASNI/SPRI/ED-1

Return to Schedule

Horizontal and Vertical Edge Pressures
Enclosed Buildings
Occupancy Category II (I=1.0)[1]
h > 60 ft.

Field of Roof Pressure	Horizontal Load psf (KPa)		Vertical Load Psf (KPa)	
q_{fz} Psf (KPa)	Perimeter P_{hp}	Corner P_{hc}	Perimeter P_{vp}	Corner P_{vc}
30 (1.44)	41 (2.0)	75 (3.6)	94 (4.5)	128 (6.1)
37.5 (1.80)	51 (2.4)	94 (4.5)	118 (5.6)	161 (7.7)
45 (2.15)	61 (2.9)	113 (5.4)	141 (6.8)	193 (9.2)
52.5 (2.51)	71 (3.4)	131 (6.3)	165 (7.9)	225 (10.8)
60 (2.87)	82 (3.9)	150 (7.2)	188 (9.0)	257 (12.3)
67.5 (3.23)	92 (4.4)	169 (8.1)	212 (10.1)	289 (13.8)
75 (3.59)	102 (4.9)	188 (9.0)	236 (11.3)	321 (15.4)
82.5 (3.95)	112 (5.4)	206 (9.9)	259 (12.4)	353 (16.9)
90 (4.31)	122 (5.9)	225 (10.8)	283 (13.5)	385 (18.4)
97.5 (4.67)	133 (6.3)	244 (11.7)	306 (14.7)	417 (20.0)
105 (5.03)	143 (6.8)	263 (12.6)	330 (15.8)	449 (21.5)
112.5 (5.39)	153 (7.3)	281 (13.5)	353 (16.9)	482 (23.1)
120 (5.75)	163 (7.8)	300 (14.4)	377 (18.0)	514 (24.6)
127.5 (6.10)	173 (8.3)	319 (15.3)	400 (19.2)	546 (26.1)
X	1.36 * X	2.5 * X	3.14 * X	3.28 * X

Table Notes:
1. I = 1 so this table is also applicable when no importance factor is required. Adjust for other I values as required.
2. Horizontal and vertical load values are calculated directly using *field of roof pressure* given

~~in column 1~~

~~3. Horizontal and vertical load values are calculated using External Pressure Coefficients (GC_p) of 0.97 horizontal perimeter, 1.21 horizontal corner, 1.68 vertical perimeter, and 2.53 vertical corner.~~

~~4. Horizontal and vertical load values contain a safety factor of 2.0.~~

~~[4] Allen, D.J., and Phalen, T.E., *Stress-Strain Characteristics for EPDM, CSPE, and PVC for the Development of Stresses in Membranes Utilized as Single-Ply Roof Systems*, 1991 International Symposium on Roofing Technology.~~

~~[5] Garrigus, P.C. The Stress-Strain, Stress-Thickness and Stress-Width Characteristics of Non-Reinforced, Glass Reinforced and Polyester Reinforced PVC Roofing Membrane, Graduate Thesis, NU Student School of Engineering Technology, March 1991.~~

urn to Schedule

2017 Canvass List				2[illegible]2 Revisions & Additions		
Affirmative	LeClare	Bob	Atas International			
Affirmative	~~Evans~~	~~Jeff~~	Benchmark	Reynolds	Andrew	Benchmark
Affirmative	~~Malpezzi~~	~~Joe~~	Carlisle Construction Materials	Chamberlain	Brian	Carlisle Construction Materials
Affirmative	~~Rew~~	~~Mike~~	Centimark Corp			
Affirmative	~~McQuillen~~	~~Tim~~	Firestone Building Products	O'Neal	Jenny	Firestone Building Products
Affirmative	Smith	Phil	FM Approvals			
Affirmative	Savoy	Tom	Insulfoam			
Affirmative	Van Dam	Brad	Metal-Era	Moesgaard	Martin	
Affirmative	Michelsen	Ted	Michelsen Technologies			
Affirmative	~~Patel~~	~~Karan~~	OMG Roofing Products	Childs	Stephen	OMG Roofing Products
Affirmative	~~Teitsma~~	~~Jerry~~	RCI, Inc	Lorenz	Emily	IIBEC
Affirmative	Dregger	Phil	Technical Roof Services, Inc.			
Negative	Resso	Frank	Innovative Metals Co.			
Negative	Smith	Tom	TL Smith Consulting			
Did not vote	Gardiner	Brian	Austech Roof Consultants, Inc.			
Did not vote	Baskaran	Bas	NRCC			
Did not vote	Wilen	Jason	NRCA	Graham	Mark	
				Lundquist	Eric	Metro Roofing & Metal Supply Co.
				Baker	Andy	Baker Roofing
				Sander	Chris	IBHS
				Hawn	David	Dedicated Roof & Hydro-Solutions

SPRI
RP-14 Revision
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
11:30 a.m.

SPRI
SINGLE PLY ROOFING INDUSTRY

AGENDA

I. Call to Order — Mader

II. Roll Call & Reading of SPRI Antitrust Statement

III. Review Results of Recirculation Ballot

IV. Determine Any Action Items

V. Adjournment

465 Waverley Oaks Road, Suite 421 – Waltham, MA 02452
t. 781.647.7026 f. 781.647-7222 e. info@spri.org

Return to Schedule

SPRI
VF-1 Revision
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
1:15 p.m.

AGENDA

I.	Call to Order	Ober
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Review Current VF-1 Document (attached)	
IV.	Discuss Need for Edits	
V.	Update Previous Canvass List (attached)	
VI.	Elect Task Force Chair	

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Return to Schedule

ANSI/SPRI VF-1
External Fire Design Standard for Vegetative Roofs

Approved May 11, 2017

Table of Contents

465 Waverley Oaks Road
Suite 421
Waltham, MA 02452

www.spri.org.

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

Return to Schedule

1.0 Introduction

This design standard provides a method for designing external fire spread resistance for *Vegetative Roofing System*s. It is intended to provide a minimum design and installation reference for those individuals who design, specify, and install *Vegetative Roofing System*s. It shall be used in conjunction with the installation specifications and requirements of the manufacturer of the specific products used in the *Vegetative Roofing System*. See Commentary C1.0.

2.0 Definitions

See Commentary C2.0.

The following definitions shall apply when designing a *Vegetative Roofing System*.

2.1 *Area Divider*
An area of the roof that meets Class A fire classification requirements when tested per ASTM E108.

2.2 *Ballast*
The weight provided by stones, pavers or light-weight interlocking paver systems to provide uplift resistance for roofing systems that are not adhered or mechanically attached to the roof deck. The inorganic portion of *Growing Media* can be considered *Ballast* if vegetation nominally covers the visible surface of the *Growing Media* or the *Growing Media* is protected by a system to prevent wind erosion.

2.3 *Border Zone*
The region around the edge of the vegetative plantings, where no vegetation exists. It is frequently the perimeter of the roof area, and areas around *Penetrations* and drains. See Commentary C2.3.

2.4 *Combustible Material*
Any material that does not comply with the requirements of Test Method E136.

2.5 *Fire Barrier*
A fire-resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained.

2.6 *Firebreak*
A *Firebreak* is a section of the roof that is covered with stone *Ballast* or concrete pavers and acts to slow or stop the progress of a rooftop fire.

2.7 *Growing Media*
An engineered formulation of inorganic and organic materials including, but not limited to, heat-expanded clays, slates, shales, aggregate, sand, perlite, vermiculite and organic material including but not limited to compost worm castings, coir, peat, and other organic material. See Commentary C2.7.

2.8 *Irrigation System*
A system which delivers moisture to the *Growing Media* making it available for plant use.

2.9 *Non-Combustible Material*
Any material that complies with the requirements of Test Method E136.

2.10 *Penetration*
An object that passes through the roof structure and rises above the roof deck/surface. *Penetrations* consist of, but are not limited to, mechanical buildings, penthouses, ducts, pipes, expansion joints and skylights. See Commentary C2.10.

2.11 *Vegetative Roofing System*
An assembly of interacting components designed to waterproof a building's top surface that includes, by design, vegetation and related landscape elements. See Commentary C2.11.

Return to Schedule

3.0 General Design Considerations

3.1 Roof Structure Design or Evaluation

The building owner shall consult with a licensed design professional to verify that the structure and deck will support fully-hydrated *Growing Media*, vegetation and other material or objects installed on the roof deck in combination with all other design loads.

3.2 Roof Deck Waterproofing Layer or Roof Cover Requirements

The roof cover specified for use in the vegetative system shall meet the recognized industry minimum material requirements for the generic membrane type, and shall meet the specific requirements of its manufacturer. When the roof cover is not impervious to root penetration a root barrier shall be installed. See Commentary C3.2.

3.3 Slope

This Design Standard is limited to roof slope designs up to 2:12. For slopes greater than 2:12, a licensed design professional experienced in vegetative roof design shall provide the design and the design shall be approved by the authority having jurisdiction. See Commentary C3.3.

3.4 *Firebreaks*

Where required *Firebreaks* shall be installed to provide a minimum 6-ft wide (1.8 m) continuous border.

3.5 *Area Divider*

Where required an *Area Divider* shall be installed to provide a minimum 13-ft wide (4 m) separation zone.

3.6 *Border Zone*

A minimum 3-ft wide (1 m) continuous border free of vegetation and *Growing Media*.

3.7 Other Design Considerations

The *Vegetative Roofing System* shall comply with all design requirements as determined by the Building Code or the authority having jurisdiction. See Commentary C3.7.

4.0 *Vegetative Roofing System* Requirements

See Commentary C4.0.

4.1 The waterproofing system below the vegetation shall be tested per ASTM E108 and meet the fire classification requirements of the authority having jurisdiction.

4.2 Fire Protection for Roof Top Structures, Joints and *Penetrations*

A *Border Zone* (See Section 3.6) shall be provided where *Vegetative Roofing Systems* abut *Non-Combustible* rooftop structures, or joints and *Penetrations*. See Commentary C4.2.

4.3 Spread of Fire, Protection for Large Area Roofs

An *Area Divider* as described in Section 3.5 shall be used to partition the roof area into sections not exceeding 15,625 ft^2 (1,450 m^2), with each section having no dimension greater than 125 ft (39 m). See Commentary C4.3.

4.4 Spread of Fire, Protection for combustible features that are part of the green roof design, but not part of the building structure

An *Area Divider* shall be installed around combustible features that are part of the vegetative roof design. See Commentary C4.4.

4.5 Fire Hydrants

Access to one or more fire hydrants or stand pipes shall be provided.

Return to Schedule

4.6 ***Firebreak***

Firebreaks (See Section 3.4) are required where *Vegetative Roofing Systems* abut combustible vertical surfaces and when terminating at a *Fire Barrier*.

5.0 Maintenance

Maintenance shall be provided as needed to sustain the system by keeping vegetative roof plants healthy and to keep dry foliage to a minimum; such maintenance includes, but is not limited to irrigation, fertilization, weeding. Excess biomass such as overgrown vegetation, leafs and other dead and decaying material shall be removed at regular intervals not less than two times per year. Provision shall be made to provide access to water for permanent or temporary irrigation. The requirement for maintenance shall be conveyed by the designer to the building owner, and it shall be the building owner's responsibility to maintain the *Vegetative Roof System*. See Commentary C5.0.

Return to Schedule

Commentary to VF-1

This Commentary consists of explanatory and supplementary material designed to assist designers and local building code committees and regulatory authorities in applying the requirements of the preceding standard.

The Commentary is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at them.

The sections of this Commentary are numbered to correspond to the sections of the VF-1 standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard, there are gaps in the numbering of the Commentary.

C1.0 Introduction

Green roofs, also known as vegetative roofs, eco-roofs, and rooftop gardens fall into three main categories:

- Extensive green roofs are installed with 6 inches (152 mm) of *Growing Media or less; generally weigh between 13 and 30 pounds per square foot (63 and 146 Kg/square meter); and support sedums, herbs and grasses;* and
- Intensive green roofs are installed with more than 6 inches (152 mm) of *Growing Media*, generally weigh between 35 and 100 pounds per square foot (171 and 488 Kg/square meter), and support greater plant diversity;
- **Semi-intensive** green roofs are roofs that have a mixture of extensive and intensive systems; generally weigh between 25 and 40 pounds per square foot (122 and 195 Kg/square meter); and support plantings seen on both extension and intensive green roof installations.

Vegetative roofs are complex systems consisting of many parts critical to the functioning of the system. To name a few of the components that are generally found in the system, but the system is not limited to these products: insulation, waterproofing membrane, protection mats/boards, root barrier, drainage layer that may include boards for water retention, aeration mat, filter fabric, *Growing Media*, and vegetation. A vegetative roof may consist of more than just *Growing Media* and vegetation, but include such things as walkways, water features, stone decoration, and benches.

A vegetative roof may cover the whole roof or share a portion of the surface with a conventional roofing system. They are versatile systems with many strong attributes including stormwater management, reduction of the heat island effect, and aesthetics.

VF-1 is a minimum standard. Manufacturers and/or designers requirements that exceed the standards minimum requirements can be incorporated into specifications for vegetative roof fire spread.

While the standard is intended as a reference for designers and roofing contractors, the design responsibility rests with the "designer of record."

C2.0 Definitions

Terms defined in this section appear capitalized and *italicized* throughout this document.

C2.3 *Border Zone*

For design and installation purposes, the roof surface is divided into the following areas:

Corners: The space between intersecting walls forming an angle greater than 45 degrees but less than 135 degrees.

Corner Areas: The corner area is defined as the roof section with sides equal to 40% of the building height. The minimum length of a corner is 8.5 ft (2.6 m).

Perimeter: The perimeter area has different size definitions depending upon the method of installing the roof. For Ballasted roof systems the perimeter area is defined as the outer boundary with a width measurement equal to 40% of the building height, but not less than 8.5 ft (2.6 m).

Return to Schedule

For adhered roof systems it is defined as the outer boundary of the roof width measurement equal to the least of the following measurements; 0.1 x the building width or 0.4 x the building width. The minimum width is 4 ft (1.2 m).

The perimeter area for a ballasted roof is larger due to a concern for *Ballast* blow-off.

Field: The field of the roof is defined as that portion of the roof surface, which is not included in the corner or the perimeter areas as defined above.

C2.7 *Growing Media*

Inorganic materials used as *Growing Media* are not combustible, however media with high concentrations of organic material can support combustion. Soils with high percentages of organic material can negatively affect the fire resistance of a system.

Sources for *Growing Media* specifications are as follows:

From ASTM:

C549-06	Standard Specification for Perlite Loose Fill Insulation
C330-05	Standard Specification for Lightweight Aggregates for Structural Concrete
C331-05	Standard Specification for Lightweight Aggregates for Concrete Masonry Units
C332-07	Standard Specification for Lightweight Aggregates for Insulating Concrete

Test Methods for classifying material:

C117-04	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
C136-06	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
D5975-96 (2004)	Standard Test Method for Determining the Stability of Compost by Measuring Oxygen Consumption
	US Composting Council: “TMECC” Test Methods for the Examination of Composting and Compost

Green roof *Growing Media* can be composed of a combination of inorganic and organic materials and should comply with ASTM or FLL performance standards. Different *Growing Media* can perform similar functions. As a result, the materials selected should be based on desired performance function, availability and cost.

C2.10 *Penetration*

Penetrations may consist of, but are not limited to, mechanical buildings, penthouses, ducts, pipes, expansion joints and skylights. These *Penetrations* may be combustible or fire may have a major impact on their performance. For these reasons, *Penetrations* need to be protected from fire exposure. Section 714 of the International Building Code provides descriptions of various types of *Penetrations* and the firestop requirements for those *Penetrations*.

C2.11 *Vegetative Roofing System*

Vegetative Roofing Systems are installed over adhered roof systems. There are several types of *Vegetative Roofing Systems* as noted below, and they can be interchanged without affecting the fire performance of the system.

Protected *Vegetative Roofing System*

A protected *Vegetative Roofing System* consists of vegetation, *Growing Media*, *Ballast* as defined in 2.2, a fabric that is pervious to air and water, insulation, and includes a membrane that provides waterproofing and substrate materials installed over a structural deck capable of supporting the system. Membranes are adhered to the roof deck or supporting insulation.

Return to Schedule

C2.11 *Vegetative Roofing System* Using a Fully Adhered Roof Membrane System

A *Vegetative Roofing System* using an adhered membrane system consists of vegetation, *Growing Media*, *Ballast* as defined in 2.2, and includes a membrane that provides waterproofing and is adhered to attached insulation, or adhered directly to a roof deck.

C3.2 Roof Deck Waterproofing Layer or Roof Cover Requirements

List of ASTM references for generic roofing types:

EPDM	ASTM D4637
PVC	ASTM D4434
TPO	ASTM D6878
Hypalon/CPE/PIB	ASTM D5019
KEE	ASTM D6754
SBS	ASTM D6164, 6163, 6162
APP	ASTM D6222, 6223, 6509
BUR	As defined by the standards referenced in the International Building Code
SEBS Hot Mopping Asphalt	ASTM D6152
Fully Adhered Hot-Applied Reinforced Waterproofing System	ASTM D6622

Building Height

Special consideration shall be given when the building height is greater than 150 ft (45.7 m). Vegetative roofs can be designed using Reference 1 (Kind Wardlaw study), consultation with a wind design engineer, or wind tunnel studies and fire design experience of the specific building and system.

Other Factors

There are other factors that affect the design of the vegetative roof for wind and fire. These include, but are not limited to, building height, building location, pressurized buildings, large openings, eaves and overhangs. See C3.7.

ANSI/SPRI VR-1 *Procedure for Investigating Resistance to Root Penetration on Vegetative Roofs provides a test method to evaluate* the resistance of vegetative roof coverings to normal root and rhizome *Penetration*.

C3.3 Slope

The roof should be sloped to shed water effectively or provide a minimum slope requirement, e.g., 1/4 inch.

C3.7 Other Design Considerations

While outside the scope of this standard, the following design considerations, must be considered by the designer of record and comply with the authority having jurisdiction.

Above Deck Thermal Insulation

The use of above deck thermal insulation is regulated by most building codes. For example, the International Building Code (IBC) only allows its use if it passes either NFPA 276 or UL 1256 when the entire assembly is tested. The designer of record is responsible for verifying that the *Vegetative Roofing System* being used meets the requirements of the authority having jurisdiction regarding the use of above deck thermal insulation.

Return to Schedule

Wind Design

Vegetative roofs are not recommended where the design wind speed is greater than 140 mph (62 m/s). However, they can be designed using Reference 1 (Kind Wardlaw study), consultation with a wind design engineer, or wind tunnel studies of the specific building and system. The "authority having jurisdiction" is the only source for approval of designs not covered in this document. ASCE 7 gives guidance on how non-standard conditions should be evaluated. See ANSI/SPRI RP-14 Wind Design Standard for *Vegetative Roof Systems*.

Given that wind standards may often require greater areas of non-vegetative roof, the wind standard will most often determine the size of the perimeter area or *Border Zones*.

C4.0 *Vegetative Roof System* Requirements

Effective with the 2018 Edition of the International Building Code, *Vegetative Roofing Systems* will be required to meet the same fire classification requirements as the roof covering and roof assembly. Due to the many variables (including plant type, plant condition, depth of *Growing Media*, combustibility of roofing assembly materials, and installation details) and the lack of sufficient experience and test data, classification of exterior fire exposure cannot be made with certainty at the present time. This standard requires that the roof system installed below the *Vegetative Roofing System* meet the fire classification requirements of the authority having jurisdiction. The standard then uses *Border Zones* and *Firebreaks* to protect roof top structures, *Penetrations* and joints that may be on the roof. It also uses roof divider areas consisting of ASTM E108 Class A approved systems to reduce fire spread potential of large vegetative roof areas.

C4.2. Fire Protection for Roof Top Structures and *Penetrations*

Pavers are often used as Class A or *Non-Combustible* separators. Care should be taken when installing pavers to avoid damaging the membrane. Some manufacturers require a separation material between the paver and the membrane.

C4.3 Spread of Fire, Protection for Large Area Roofs

This standard utilizes *Area Dividers* to reduce the potential for fire spread for large roof areas. Spread of flame for Class A fire is limited to 6 ft (1.8 m), if there is a 6 ft (1.8 m) break separating vegetative areas using Class A material or *Non-Combustible Material* the flame spread is not expected to ignite the nearby area. The dimensions chosen for large area roof limitations are based on FLL requirements and FM Global recommendations (FM Global Loss Prevention Data Sheet 1-35—*Green Roof Systems*, they also coincide with the International Building Codes Area limitations for Assembly buildings.

FM Global has used ASTM E108 to test *Vegetative Roofing Systems*. Modifications of the test standards may be able to provide a meaningful test for selected conditions. However, with all the plant types that could be used in a roof design, the varying weather conditions that occur through the year, and the effects of seasons generate many variables that limit the potential to classify a roof construction. For this reason, Class A classified assemblies are limited to succulent based systems at this time. Refer to Green Roof Plants and *Growing Media* course manual, by Green Roofs for Healthy Cities, for definitions related to vegetative roof plant types.

The FLL believes that a vegetative "hard roof" can be considered to be equivalent to an ASTM E108 Class A Fire Classified roof assembly. The FLL defines a vegetative "hard roof" as those that are:

- irrigated;
- regularly maintained;
- have a substrate no less than 30 mm (1.18 in);
- made of vegetation that is grasses, succulents and/or perennials;
- have a substrate with at least 80% inorganic content by mass.

The agreed minimal substrate thickness varies between 30 mm (1.18 in) and 80 mm (3.15 in).

Return to Schedule

C4.4 Spread of Fire

The intent of this Section is to provide protection for combustible green roof features that are not part of the building structure, such as wood or plastic planters and railings should be dealt with separately.

C5.0 Maintenance

The building owner needs to properly maintain a vegetative roof. One of the important ways of preventing fires is through the use of an *Irrigation System*. The need for irrigation will vary greatly due to climate and types of plants chosen. Designers should be aware that plantings are to be specific for the roof being installed and that rooftops are at best hostile places for vegetation. Dead foliage should be removed and the moisture level of the *Growing Media* should be checked at regular intervals depending upon specific conditions on the vegetative roof. By regularly removing excess biomass that could become fuel for a fire on the rooftop, the risk of fire spreading beyond the 6 ft (1.8 m) Class A fire rated separation is minimized.

Best management practices for maintenance include regular weeding, fertilization, and removal of dead/dormant vegetation in accordance with the recommendations of the green roof provider. Specific directions for the proper maintenance of the vegetative cover should be furnished by the green roof provider.

Return to Schedule

References

1. Kind, R.J. and Wardlaw, R.L., Design of Rooftops Against Gravel Blow-Off, National Research Council of Canada, Report No. 15544, September 1976.
2. FM Global: Property Loss Prevention Data Sheets 1-35 Green Roof Systems.
3. FM Global: Approval Standard for Vegetative Roof Systems Class Number 4477 June 2010.
4. FLL Standard “Guideline for the Planning, Execution and Upkeep of Green-Roof Sites”, Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau e.V.—FLL, Colmantstr, Bonn, Germany.
5. ANSI/SPRI RP-14, Wind Design Standard for Vegetative Roof Systems, June 2010.
6. Green Roof Plants and Growing Media course manual; Green Roofs for Healthy Cities.
7. ASTM E136 Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C.
8. ASTM E108 Standard Test Methods for Fire Tests of Roof Coverings.

Documentation

1. Breuning, Jörg, «Fire & Wind on Extensive Green Roofs», Conference Proceedings, Greening Rooftops for Sustainable Communities, Baltimore, MD, 2008.
2. Department for Communities and Local Government, «Fire Performance of Green Roofs and Walls», Government of the United Kingdom, 2013.
3. GRO, «The GRO Green Roof Code», United Kingdom, 2014.
4. Hydrotech Membrane Corporation, «Test inspired by Intermittent Flame Test as per ASTM E 108 Class A», 10 July 2015.
5. Living Roofs, «Green Roofs _ Fire and German Guidelines», www.igraworld.com.
6. RBQ, Critères techniques visant la construction de toits végétalisés, 2015.

Return to Schedule

First Name	Last Name	Company	Interest Category	Ballot 1	Ballot 2
Nicolette	Allen	Underwriters Laboratory	General Interest		
Timothy	Barrett	Barrett Co,	Producer		approve
Brian	Davis	GAF	Producer	approve	approve
Alex	Drescher	Carlisle Construction Materials Incorporated	Other Producer	negative	approve
Angie	Durhman	AD Green Roof	User	comment	
Mike	Ennis	SPRI, Inc.	---		
Doug	Fishburn	Fishburn Building Sciences Group	User		
T.W.	Freeman	TW Freeman Consultants	User		approve
Brian	Gardiner	Austech Roof Consultants Inc.	General Interest		
David	Hawn	Dedicated Roof & Hydro-Solutions, LLC	User	approve	approve
Jon	Jensen	Sika Sarnafil Inc.	Producer		
Kelly	Luckett	Green Roof Blocks	Producer		approve
Tim	McFarland	Mule-Hide Products Co., Inc.	Producer	abstain	approve
Ted	Michelsen	Michelsen Technologies	User		approve
Charles	Miller	Roofscapes	User	negative	approve
Steven	Nelson	Benchmark, Inc.	User		
Steve	Peck	Green Roofs for Healthy Cities	User		
Mike	Rew	Centimark Corporation	User	approve	approve
Owen	Rose	Rose Architecture	User	negative	approve
Tom	Savoy	Insulfoam LLC	Other Producer	approve	approve
Peter	Schmidt	Vitaroofs International Inc.	Producer	negative	
Phil	Smith	FM Approvals / FM Global	General Interest	negative	negative
Kurt	Sosinski	Tremco, Inc.	Other Producer		
Matthew	Barmore	Firestone Building Products Co, LLC	Producer	negative	
Todd	Taykowskie				approve
Jason	Wilen	National Roofing Contractors Association	General Interest	negative	approve
			approve	4	14
			negative	7	1
			abstain	1	

Return to Schedule

SPRI
Membrane/Plate Standard Development
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
1:45 p.m.

AGENDA

I.	Call to Order	S. Childs/F. Shyti
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Review FM Procedure	
IV.	Review Draft of Proposed Standard	
V.	Recommendations for Canvass Participants	
VI.	Interim Meetings	
VII.	Adjournment	

Return to Schedule

preliminary canvass list Membrane/Plate

Voter Email	Voter Name	Replacement
david.alves@fmapprovals.com	Alves, David	
davelee@ix.netcom.com	Roodvoets, David	
Flonja.Shyti@nrc-cnrc.gc.ca	Shyti, Flonja	
mikeg@flexmembranes.com	Giangiacomo, Michael	
~~joe.malpezzi@carlisleccm.com~~	~~Malpezzi, Joseph~~	
tim.mcquillen@jm.com	McQuillen, Tim	
cmeyer@seamancorp.com	Meyer, Chris	
tech@spri.org	Ober, Randall	
~~schwetz.joe@us.sika.com~~	~~Schwetz, Joseph~~	
alexanderbrian@bfusa.com	Alexander, Brian	
ajanni@duro-last.com	Janni, Al	
CMader@blueridgefiberboard.com	Mader, Christopher	
smoskowitz@atlasroofing.com	Moskowitz, Steven	
todd.burroughs@intertek.com	Burroughs, Todd	
stancconsult@comcast.net	Choiniere, Stan	
drhawn@drhroofsolutions.com	Hawn, David	
jthomas@trufast.com	Thomas, Jodi	
~~eyounkin@soprema.us~~	~~Younkin, Eric~~	

Return to Schedule

SPRI
NT-1 Review
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
2:30 p.m.

AGENDA

I. Call to Order — Hawn

II. Roll Call & Reading of SPRI Antitrust Statement

III. Review NT-1 (2017) with updates

IV. Review list of proposed Balloting participants

V. Review of Ballot timeline

VI. Discussion & Assignments as necessary

VII. Adjournment

Return to Schedule

BSR/SPRI/IIBEC NT-1

Detection and Location of Latent Moisture in Building Roofing Systems by Nuclear Radioisotopic Thermalization

Table of Contents

1.0 Scope

1.1 Radioisotopic thermalization, performed in accordance with this standard, can effectively be used in the roofing industry to:

1.1.1 Locate and quantify latent moisture contained in the roofing material and/or roof deck materials.

1.1.2 Locate hidden sources of moisture entry by tracing subsurface paths of moisture migration.

1.1.3 Provide a basis for investigating roofing material and/or roof deck material degradation over a period of years when used as part of a preventive maintenance program.

1.2. This standard provides a minimum set of procedures for conducting surveys of moisture in membrane roofing systems, and for analyses of the data obtained in such surveys. Included are operating, verification, and reporting procedures, as well as operator qualification criteria.

1.3 This standard addresses the effect of roof construction, material differences and roof conditions on the numerical data output provided by the nuclear equipment.

1.4 This standard addresses limitations in the use of radioisotopic thermalization.

1.5 This standard addresses the governmental control of the equipment used to conduct nuclear moisture surveys.

Return to Schedule

2.0 Terminology/Definitions

2.1 Agreement States

Certain States that have an agreement with the United States Nuclear Regulatory Commission (USNRC) which permits these States to control, within the State, those radioactive materials for which the USNRC is responsible.

2.2 Backscatter:

The number of neutrons reflected back in contrast to the number passing through a substance.

2.3 Film Badge

Photographic film used to measure exposure to ionizing radiation for purposes of personnel monitoring. See Commentary C2.3.

2.4 Radioisotopic Thermalization

The process undergone by high-energy (fast) neutrons as they lose energy by collision. Thermalization occurs when the energy of fast neutrons is partially absorbed by moderators of hydrogen atom collision.

2.5 United States Nuclear Regulatory Commission (USNRC)

The U.S. Nuclear Regulatory Commission (NRC) was created as an independent agency by Congress in 1974 to ensure the safe use of radioactive materials for beneficial civilian purposes while protecting people and the environment. The NRC has jurisdiction over licensing requirements for nuclear sources in the United States. Many other countries will have a similar agency with jurisdiction.

3.0 Survey Equipment and Licensing Requirements

3.1 The equipment shall be specifically designed for performing roof moisture surveys. An isotopic radioactive source consisting of Americum - 241, Radium 226, or Cesium 137 with a Beryllium target is required.

3.2 The possession and use of by-product radioactive material in the US requires a license issued by the United States Nuclear Regulatory Commission (USNRC) or the equivalent agency of a State which has entered into an agreement with USNRC to assume control over the distribution. The following applies within the US, and many foreign countries have similar regulations.

3.2.1 Certain States have an agreement with the USNRC which permits these States to control, within the State, those radioactive materials for which the USNRC is responsible. These States, known as “Agreement States,” have, in general, enacted laws and regulations for the control of radioactive material.

3.2.2 Most “Agreement States” have a reciprocity clause in their regulations that permits a user, licensed in his own State, to operate in another State for certain periods of time. Prior notification to the visited State is generally required.

3.2.3 Licensing requirements can differ depending upon the radioactive element being used in the equipment.

3.3 Commercially available equipment utilized for radioisotope thermalization shall be capable of meeting the requirements of the governing regulatory agency.

3.4 Since changes are continuously made governing regulation, the user shall stay current with the appropriate regulations. Responsibility for compliance with the regulations falls upon the owner of the equipment.

3.5 **Licensing Considerations**

3.5.1 **User Training**
The user shall complete an approved training program provided by the equipment manufacturer or other organization acceptable to the licensing authority.

3.5.2 **Manufacturer's Instruction Manual**
Each user shall have access to and be familiar with the equipment manufacturer's instruction manual.

3.5.3 **Storage, Transportation, and Use**
The equipment shall be stored in a locked area, base down, and in contact with shielding material such as concrete. Transportation shall be in an approved shipping container approved and labeled for use by the governing agency (typically provided by the equipment manufacturer), secured against removal by unauthorized personnel, and be accompanied by a current "Shipper's Certification for Radioactive Materials". During cleaning and use of the equipment, the operator shall avoid direct contact with the base of the equipment and shall instruct others to do likewise.

3.5.4 **Radiation Leak Testing**
Radiation leak tests shall be performed in accordance with the manufacturer's specifications, at prescribed intervals, and in accordance with the procedures designated by the licensing authority.

3.5.5 **Maintenance and Servicing:**
The user shall not be authorized to remove the source or perform any maintenance on the source or source holder. These services shall be performed by the equipment manufacturer or other persons specifically licensed to perform these operations.

3.5.6 **Personal Protection**
Unless otherwise allowed by the Governing Agency having jurisdiction, all users shall be provided with film badge type dosimeters to be worn when handling or using the equipment. Authorized personnel, meeting the requirements of part 4 below, shall see to it that other persons are kept away from the equipment

during use, transportation, or storage.

3.5.7 **Waste Disposal**

The equipment containing radioactive material shall be disposed of by either:

3.5.7.1 Transfer to another specifically licensed user or disposal agency.

3.5.7.2 Return to equipment manufacturer.

3.6. Moisture Detection

3.6.1 Fast neutrons from the radioactive source are involved with moisture content measurements. Fast neutrons from the radioactive source enter the material being surveyed and are both scattered and slowed down by collision with the nuclei of the atoms composing the material. Nuclei of all materials slow down the neutrons by momentum exchange, but the speed reduction is greatest for collisions with hydrogen nuclei, which have about the same mass as the neutrons. When water or moisture is present more hydrogen atoms exist for collisions. Some of the slow neutrons or thermal neutrons are scattered in such a way that they reach the slow neutron detector and are counted for a specified period of time.

3.6.2 In general, the detector measures the backscattering of slow neutrons that have collided with hydrogen nuclei. The resulting numerical readout displayed by the equipment is a relative measurement of hydrogen present in the material at the point of survey. It is important to note that elevated readings can be influenced by sources of hydrogen other than moisture content, i.e., bitumen thickness, wood deck, etc.

4.0 Survey Personnel

4.1 The moisture survey shall be performed under the supervision of a Survey Director. The Survey Director shall be thoroughly trained in the operation of the equipment and radiation safety, and have a thorough understanding of modern roofing technology, including knowledge of:

4.1.1 Types of roofing membrane material and the aging process.

4.1.2 Construction procedures.

4.1.3 Types of roofing insulations.

4.1.4 Types of roofing decks.

4.1.5 Types of roof assemblies.

4.1.6 Equilibrium moisture contents.

4.1.7 Effects of structural building components on moisture survey results.

4.1.8 Moisture migration in buildings.

4.2 The Survey Director shall have completed the following training:

4.2.1 Operational and radiological Safety training conducted by the manufacturer of the equipment being used.

4.2.2 Previous field experience in this surveying discipline with "hands on application," for a period of not less than two (2) years.

4.3 All other personnel involved in the survey shall have been instructed in radiological safety, equipment operation, rooftop safety, and basic roofing technology.

5.0 Survey and Analysis Procedures

5.1 **Preparation**

5.1.1 Prior to or as part of the nondestructive nuclear evaluation, a physical roof survey is required to visually determine areas that are not safe for access by persons required to perform the survey. To assist with the physical roof survey secure architectural or structural drawings (if possible), verify composition of existing roof materials, and solicit historical information pertaining to the roof system performance. See Commentary C5.1.1.

5.2 **Execution**

5.2.1 Establish a reference point for each roof section to be surveyed. A roof section is an area of homogeneous roof construction. The reference point shall be located to permit horizontal (x-axis) measurements to the right of the reference point when facing the reference point and vertical (y-axis) measurements toward the viewer when facing the reference point. All measurements relating to x-y coordinates and the location of structural elements of the building rising above the roof surface, roof penetration(s), and/or membrane defects shall be made from this reference point.

5.2.2 The entire roof area to be surveyed shall be laid out with a grid based upon the x-y coordinates. Distance between the x-y coordinates shall be determined by the Survey Director and shall be consistent in each direction resulting in a pattern best suited to provide an adequate number of equipment readings to permit a thorough evaluation. Grid size will be influenced by the size and configuration of the roof section being surveyed and the material make up of the roof system (see Table 1).

5.2.2.1 Equal x-y coordinates [e.g., 10 ft X 10 ft US or 3 m X 3 m Metric, 6 ft X 6 ft US or 2 m X 2 m Metric, , or 3 ft X 3 ft US or 1 m X 1 m Metric] in even increments and whole or half units of measure (US or Metric applied) shall be used. The distance between x-y coordinates shall not be greater than ten (10) feet US or three (3) meters Metric). Five feet US or 1.5 meters Metric is typically recommended. The distance between x-y coordinates used shall be consistent throughout the roof section being tested. A smaller increment between readings does improve the results by reducing the distance between readings but also increases the work required to provide the results. See Commentary C5.2.2.1.

5.2.2.2 x-y coordinates shall be located such that readings will not be required on the increased material thickness at perimeters and penetration flashings. One method of avoiding the extra material thickness is to come off the exterior perimeters and away from all penetration flashings a distance of two (2) to three (3) feet (one meter). In the field of the roof, areas of increased material thickness that cannot be avoided shall be treated as a separate roof section for analysis purposes.

5.2.2.3 x-y coordinate markings shall be made on the roof surface and on wall flashings around the perimeter of the area being surveyed to allow for identification of readings obtained for sampling and further investigation. Obtain permission from the building owner prior to the use of permanent marking material. Ensure that marking material is compatible with the surface being marked.

5.2.2.4 All structural elements of the building rising above the roof surface, penetrations, and obvious patched areas shall be accurately recorded on the recording sheet.

5.2.2.5 Prior to taking nuclear readings the device shall be tested on the roof to confirm it is functioning properly by taking ten readings in the same location without moving the equipment and recording them. When the equipment is functioning properly 99.7% of the readings recorded will fall between the plus or minus three (3) standard deviation limits established by the manufacturer for the equipment.

5.2.2.6 Nuclear readings shall be taken and recorded at each x-y coordinate or grid point. See Commentary C5.2.2.6.

5.3 **Limitations**

5.3.1 In order for this technique to be useful in detecting moisture, the material thickness is required to be constant (+/- 10 percent). Extra thickness of material, that normally occurs at flashings, penetrations, walkway layers, and patches, can alter the material thickness or reference level of the material composition being surveyed.

5.3.1.1 Over a deck or above-deck materials of varying thickness, the reference level can be altered (e.g., significantly tapered insulation material, precast tees, or waffle form decks).

5.3.1.2 A change in material below the roof membrane surface (e.g., metal deck vs. concrete deck; isocyanurate (polyisocyanurate) vs. fiberboard; additional plies of roofing material) can alter the reference level.

5.3.1.3 Heavy, moist, and dirty gravel can alter the reference level.

5.3.1.4 Equipment readings shall not be taken as part of a roof section survey in areas covered with standing water, ice, or snow. If nuclear readings must be taken in these areas, they shall be analyzed as a separate roof section, and must include a uniform covering of water, ice, or snow.

5.3.1.5 Roof assemblies composed of multiple layers of various materials derived from roof recover operations can alter the reference level.

5.3.2 For ballasted membranes and protected membrane roof (PMR) assemblies, the aggregate or paver ballast shall be removed in appropriate x-y coordinate spacing throughout the roof area in order to obtain equipment readings directly against the roof membrane and underlying insulation layers (if any). If the protective insulation layer of a PMR is left in place for the equipment reading, the core samples shall include this layer, since its moisture absorption level could adversely affect the overall survey.

5.3.3 Nuclear radioisotopic thermalization techniques for determining moisture contents of materials shall not be used over metal roof systems.

6.0 Verification and Quantification

6.1 General

6.1.1 The field data (numeric readout) is only relative and shall be quantified by core cuts. Three or more cores shall be extracted, with a core extracted at a general low (but not the lowest) reading, intermediate reading, and high (but not the highest) reading for each roof section surveyed. Core size shall not be less than a nominal two (2) inches (50 mm) in diameter and shall include all material down to the deck. If the deck material is capable of moisture absorption, a portion of it shall be included (structural concrete cores are not required). See Commentary C6.1.1.

6.1.2 Each element (membrane, each insulation layer, if they are not multiple layers of the same material within the extracted cores) shall be immediately sealed in separate moisture tight containers and labeled to identify the date, location (building, roof section, and x-y coordinate), person taking the core, and any other information required by the Survey Director.

6.1.3 The core cuts to provide samples for testing shall be extracted directly after the equipment readings have been completed for the roof section to assure the core cuts are taken from the correct x-y coordinate point relational to the equipment reading obtained.

6.1.4 Core samples shall be analyzed for moisture content by weight. Separate different elements of the roof assembly, such as insulation layers and construction material layers (without damaging materials), and perform gravimetric analysis (see 6.2) separately for each layer of each core sample (i.e., membrane, insulation, base sheet, vapor retarder, moisture sensitive deck, etc.).

6.1.5 Sampling and the repair of core cuts made shall be accomplished in accordance with the manufacturer's recommendations and/or NRCA Repair Manual for Low-slope Membrane Roofingl.

6.2 **Gravimetric Analysis**

6.2.1. The different elements of the roof assembly (see 6.1.4.) shall be separated at the time of sampling and analyzed separately. Each element (deck, vapor retarder, insulation, and membrane) shall be weighed immediately after removing from the sealed container. The sample container and material extracted from the roof shall be chamber dried for a minimum of 24 hours at 220° F/104.4° C and re-weighed. The chamber drying procedure shall continue until no weight loss is observed (within limits of balance equipment). Moisture content by weight is determined by the following formula:

[(Wet weight - Dry weight)/Dry Weight] x 100 [Eq. 1]

See Commentary C.6.2.1.

6.2.2. A determination of moisture content by dry weight shall be made for each analyzed material. For bituminous built up roof membrane materials moisture content shall be determined by ASTM D95, *Standard Test Method for Water in Petroleum Products and Bituminous Material By Distillation*.

7.0 Analysis of Collected Data

7.1 The interpretation of the nuclear equipment readings and the correlation of core sample test data shall be accomplished by the Survey Director. See Commentary C7.1

7.2 Once the actual moisture content levels have been determined for the low, mid, and high readings, a straight line graph shall be drawn relating count rates to actual moisture levels. The measurement counts must be converted to a defined unit of measurement, such as percent moisture (See Table 2).

7.3 **Histogram**
The volume of data collected is normally voluminous. A histogram shall be prepared to compile the data into a compact form. A histogram simply groups data points by defining intervals and combining all data points that fall within that interval.

Return to Schedule

7.3.1 The interval size shall be carefully considered; it shall be large enough to ease the computational task, but small enough to easily distinguish the normal distribution produced by the dry sections of a dry roof (See Table 3).

7.3.2 The normal distribution curve shall be calculated for the main part of the data, with the three-sigma limits corresponding roughly to the acceptable moisture limits for "dry" insulation of the materials being considered (See Table 4).

7.4. **Graphic Plot**

Once the wet areas can be defined from the count rate data, a graph of the roof plan shall be drawn to summarize the survey. The moisture map shall be prepared depicting a minimum of three (3) levels of moisture content (See Table 2) per material tested. The graphic plot (moisture map) shall be prepared by computer program, hand contouring, or colored graphics within a spreadsheet program. If possible, the graphic plot of suspected wet areas shall be overlaid onto scaled drawings of each surveyed section roof and compared to architectural and structural drawing available to determine potential impact of latent building and structural features on the collected field data. See Commentary C7.4.

7.5 **Statistical Analysis of Data**

7.5.1 Statistically, the histogram produced by using a nuclear gauge on a dry roof section will form a bell-shaped curve. This curve is called the "normal distribution." Two conditions shall be met to produce a statistically meaningful curve:

7.5.1.1 The roof section must be of similar composition throughout.

7.5.1.2 A minimum of 100 data points shall be taken within the roof section to allow the normal distribution to appear.

7.5.2 The "width" of the normal distribution is determined by the standard deviation of the main data. The importance of the standard deviation is that once the mean (average) and the standard deviation are known, the "end points" of the normal distribution, and therefore the count rate range for dry areas of the roof, can be defined.

7.5.3 The normal distribution curve shall be overlaid on the measurement data histogram. To verify the end points for the overlay process, the mean and standard deviation must be calculated for the main data (excluding extreme outlying data points). The mean is simply the sum of the midpoint of the histogram interval multiplied by the frequency of occurrence and divided by the total number of points. The equation is:

$$\textbf{Mean} = (X_i \times F_i) / N \qquad \text{[Eq. 2]}$$

Return to Schedule

7.5.4 The equation for standard deviation for grouped data is:

$$\frac{\left\{ [(Xi)^2 \times Fi] - \frac{[Xi \times Fi]^2}{N} \right\}^{1/2}}{(N-1)^{1/2}}$$

[Eq. 3]

Where **Xi** = the midpoint of histogram interval
Fi = Frequency of occurrence
N = Total number of points

Note: These equations are easily implemented with a programmable calculator, computer, or spreadsheet

8.0 Precision & Bias

8.1 Precision, 99.7% of the measurement counts for the dry areas of the roof will fall between the plus or minus three (3) standard deviation limits.

8.2 Bias, since there is no accepted reference material suitable for determining bias for this test method, bias has not been determined.

9.0 Reporting

1.1. The Nuclear Roof Moisture Survey Report shall include, at a minimum, the following information:

9.1.1 Description of methodology.

9.1.2 Identification of existing roof construction and the make and model of the nuclear equipment used.

9.1.3 A record of all nuclear readings including the ten (10) test readings taken on the roof prior to the start of the survey confirming proper function of the equipment.

9.1.4 Analysis of data, including moisture content charts correlating to the moisture map.

9.1.5 A scaled drawing depicting at least three (3) distinct moisture levels and including major roof top structures and penetrations.

9.1.6 A histogram summarizing all data collected.

9.1.7 Record of laboratory gravimetric analysis of extracted core cuts.

9.1.8 A record of all core cuts including precise location.

Return to Schedule

9.1.9 A statement of basis for unacceptable moisture content levels established for each material present.

Table 1
Moisture Levels Computed From Gravimetric Analysis of Core Samples (Example)

Moisture Levels Based on Core Cuts		
Core #1 =	1.4% Membrane	2.4% Insulation
Core #2 =	2.2% Membrane	223.0% Insulation
Core #3 =	3.1% Membrane	443.7% Insulation

Table 2
Moisture Contour Levels (Example Only)

Moisture Level	Moisture in Plies	Moisture in Insulation	Sq. Ft. of Area
1 (Low)	1.4%	2.4%	1,540
2	1.8%	112% (Interpolated)	14,730*
3	2.2%	223%	619*
4	2.6%	333% (Interpolated)	357*
5 (High)	3.1%	444%	111*

** Water Saturated Areas Requiring Removal*

Table 3
Moisture Content of Roofing Materials (see commentary)

Type Material	Equilibrium Moisture Content at 90% RH 75° F	Maximum Moisture Content Obtained by Immersion
Organic Felt Membrane	1.0%	20%
Fiberboard	12.0%	430%
Perlite Board	4.0%	580%
Glass Fiber	2.0%	610%
Urethane	6.0%	520%
Expanded Polystyrene	3.0%	540%
Lightweight Concrete	6.0%	110%
Dry Asphaltic Fills	0.1%	60%
Cellular Glass	0.01%	30%
Extruded Polystyrene	0.5%	10% to 15%

Source: Anderson, Richard G., "Dry Range and Wet Range Moisture Content of Roofing Materials as Found in Existing Roofs." *Proceedings of the 1985 International Symposium on Roofing Technology: A Decade of Change and Future Trends in Roofing,* National Roofing Contractors Association, Chicago, 1985

Table 4
Equilibrium Moisture Content and Moisture Content at 80% TRR (see commentary)
(TRR = thermal resistance ratio)

Insulation	Equilibrium M.C. (% of dry weight)		Moisture Content (% of dry weight)
	at 45% RH	at 90% RH	at 80% TRR
Cellular Glass	0.1	0.2	23
Expanded Polystyrene [16 kg/m3 (1 .0 pcf)]	1.9	2.0	383
Extruded Polystyrene	0.5	0.8	185
Fibrous Glass	0.6	1.1	42
Isocyanurate	1.4	3.0	262
Perlite	1.7	5.0	17
Phenolic	6.4	23.4	25
Urethane	2.0	6.0	262

Source: Griffin, C.W., and Fricklas, R.L., *Manual of Low-Slope Roof Systems,* Fourth Edition. The McGraw-Hill Companies, Inc., New York, 2006, Table. 5.2, pg.81.

Return to Schedule

Table 5
Moisture Content at 80% TRR (see commentary)
(TRR = thermal resistance ratio)

Type Material	**(% of dry weight)**	**(% of volume)**
Cork	39	9.9
Fibrous Glass	15	4.4
Perlite	17	2.7
Fibrous Glass	42	6.2
Cellular Glass	23	3.1
Gypsum	8	7.0
Lightweight Concrete: 369 kg/m^3 (23 pcf)	10	3.7
Lightweight Concrete: 594 kg/m^3 (37 pcf)	9	5.3
Expanded Polystyrene: [16 kg/m^3 (1 .0 pcf)]	383	6.1
Expanded Polystyrene: [32 kg/m^3 (2.0 pcf)]	248	7.2
Expanded Polystyrene: [48 kg/m^3 (3.0 pcf)]	82	4.3
Extruded Polystyrene	185	5.9
Urethane/Isocyanurate	262	8.8
Foamed-in-place urethane	130	6.5
Phenolic	25	1.0

Source: Griffin, C.W., and Fricklas, R.L.*, Manual of Low-Slope Roof Systems, Fourth Edition, The McGraw-Hill Companies, Inc., New York, 2006, Table. 5.2, pg.81*

Commentary to NT-1

This Commentary is not a part of this standard. It consists of explanatory and supplementary material designed to assist users in complying with the requirements of the preceding standard. It is intended to create an understanding of the requirements through brief explanations of the reasoning employed in arriving at these requirements or to provide other clarifications. It therefore, has not been processed in accordance with ANSI Essential Requirements, and may contain material that has not been subjected to public review or a consensus process. Thus it does not contain requirements necessary for conformance with the standard.

The sections of this Commentary are numbered to correspond to the sections of the NT-1 standard to which they refer. Since it is not necessary to have supplementary material for every section in the standard, there are gaps in the numbering of the Commentary.

C.2.3 Per the Nuclear Regulatory Commission (NRC) the film badge may contain two or three films of differing sensitivities, and it may also contain a filter that shields part of the film from certain types of radiation.

C.5.1.1 Rooftop access should not be permitted without adequate roof and roof deck condition data. Prior to or as part of the nondestructive nuclear evaluation, a physical roof survey is required to visually determine areas that are not safe for access by persons required to perform the survey. The survey should include, at a minimum, a physical interior deck and exterior roof survey. Use a checklist to ensure that all equipment, supplies, and documentation required for the survey are operational, packed, and transported to the job site.

C.5.2.2.1 Exact US to SI conversions are not required or included since consistency in the increments between x-y coordinates throughout the roof section is most important, and maintaining an even number of units of measure improves accuracy during layout in the field. If the roof section grid or x-y coordinates layout is based upon feet or meters, use feet or meters throughout.

C. 5.2.2.6 Additional readings may be taken in areas producing elevated readings and at other locations as determined by the Survey Director to optimize the survey results.

C.6.1.1 The Survey Director may decide to extract more cores on each roof section as dictated by job conditions and the readings obtained.

a) Caution should be taken to not extract cores at extreme low and high end readings unless there are a number of other readings at similar levels (preferably in the immediate vicinity). The low and high reading locations sampled for testing should represent at least ten percent of equipment readings obtained.

b) If the “high” core sample exhibits free water, it may be advisable to extract another core sample of more moderate moisture content, as determined by a review of the equipment readings obtained.

C.6.2.1 Oven drying of extracted roof materials at temperatures exceeding those tolerated by the materials will affect results:

a) High temperatures may damage or otherwise modify the chemical composition of styrene-based foam insulations, gypsum-based products, lightweight concretes, and sample containers. It is recommended that a lower temperature (e.g., 110° F/43° C) be utilized for such materials.

b) Moisture contents of organic felt-based BUR membranes cannot be accurately determined by oven drying, since the low end volatiles are typically cooked off with the moisture. These membranes require the use of distillation methods, such as ASTM D 95.

C.7.1 A licensed architect, Professional Engineer (PE) or Registered Roof Consultant (RRC) who meets the requirements of a survey director and is experienced with both roofing and the nuclear survey equipment is preferred but not required provided the survey director meets the requirements otherwise stated.

C.7.4 It is often sufficient to utilize three or four color ranges to indicate the degree of moisture saturation. Red may be "failed," Orange may be "high," Yellow may be "low," and White (or blank) could be "dry." However, some definition of these terms should be provided in relation to the extrapolated moisture levels estimated within each roof. The intervals chosen may be modified depending on the assembly under evaluation and the type of insulation within the roof system.

C.9.1.9 An evaluation of the acceptability of moisture contents within installed roofing materials is a highly subjective matter, and should be conducted on the basis of experience, practicality, and judgment. Certain guidelines may be derived from data available pertaining to the thermal resistance ratio (TRR) of insulation materials. The thermal resistance ratio is equal to the wet thermal resistivity divided by the dry thermal resistivity. Some experts have established a TRR of 80% or higher as acceptable from the perspective of thermal performance. For some materials, while the thermal resistance is still considered acceptable, the suitability of the product with highly elevated moisture content above equilibrium may not be suitable as a substrate for roofing material applications as determined by a roof expert or roof material manufacturer.

C. Tables 3, 4, and 5

Tables 3, 4, and 5 provide published values for materials available and commonly used in roofing assemblies at the time of the study to develop the data presented in the tables. Other materials may be encountered that are not listed. For those materials not listed the manufacturer of the material may be the only source for similar data and test result information. Exercise caution to assure all products are judged on the same basis since 80% TRR data may not be available for all products that may be encountered.

NT-1 Precanvass Survey List

Return to Schedule

Voter Name	Company	Answer
Andy Baker	Baker Roofing	
Tom Irvine	Benchmark	
Andrew Reynolds	Benchmark	
Russell Raymond	BESGRP	
Christopher Mader	Blue Ridge Fiber Board	
David Hawn	Dedicated Roof & Hydro-Solutions	
Jennifer O'Neal	Firestone	
Michael Giangiacomo	Flex Membrane International	Other Producer
Phillip Smith	FM Approvals / FM Global	General Interest
Warren French	French Engineering	
Emily Lorenz	IIBEC	
Joe Fitzpatrick	Infrared PSI	
Peter Brooks	IR Analyzers	
Juliana Salas	Miami Dade	
Andre Desjarlais	Oak Ridge National Laboratory	
Stephen Childs	OMG Roofing Products	
Scott Seaman	Seaman Nuclear	
Randall Ober	SPRI	Other Producer
Robyn Myers	Troxler labs	

Return to Schedule

SPRI
Technical Committee
Crowne Plaza at the Crossings
Warwick, RI
July 12, 2022
3:00 p.m.

AGENDA

I.	Call to Order	O'Neal
II.	Roll Call & Reading of SPRI Antitrust Statement	
III.	Minutes: Vote on approval of the minutes of the May 2022 meeting (attached)	
IV.	Task Force Reports	
	a.) Code Development	A. Hickman
	b.) Codes & Standards	R. Ober
	c.) Code Compliance Interface	L. Cadena
	d.) D6878 TPO Considerations for Revision	W. Sanborn
	e.) Definition of Low Slope	S. Wadding
	f.) DORA® Listing Service	M. Darsch
	g.) ES-1 Revision	Patel
	h.) Lightning Protection	B. Van Dam
	i.) Membrane / Plate Attachment	Childs/Shyti
	j.) NT-1 Revision	D. Hawn
	k.) Rooftop Attachments	D. Blasini
	l.) RP-14 Revision	C. Mader
	m.) VF-1 Revision	R. Ober
	n.) VOC Regulatory Monitoring	J. Bates
	o.) Website/Digital Content & Communication	R. Montoya
	p.) Education Committee	B. Chamberlain
	q.) SPPI Committee	B. Van Dam
V.	New Business	
VI.	Adjournment	

Return to Schedule

SPRI
Technical Committee
Crowne Plaza at the Crossings
Warwick, RI
May 10, 2022

Minutes

Call to Order
Technical Committee Chair Jenny O'Neal called the meeting to order at #:## a.m. ET .The SPRI Antitrust Statement was read.*

Roll Call
Those present were:
Jenny O'Neal, Firestone Building Products Co, LLC
Justin Bates, HB Fuller
Daniel Blasini, Anchor Products
Adam Burzynski, Carlisle Construction Materials
Luis Cadena, Nemo etc
Brian Chamberlain, Carlisle Construction Materials
Stan Choiniere, StanC Consulting
Brian Davis, GAF
Nick Eschhofen, TruFfast
Carl Flieler, Element Materials Technology
Michael Giangiacomo, Flex Membrane Intl
Al Janni, Duro-last
Evan Kennard, Duro-last
Sean Koren, Firestone Building Products Co, LLC
Mikael Kuronen, GP Gypsum
Saverio Marzella, Rockwool
Christopher Meyer, Fibertite
Rick Montoya, Acme Cone
Steve Moskowitz, Atlas Roofing Corporation
Jim Pieczynski, BRF Inc
Ralph Raulie, Seaman Corp
Robert Reel, HB Fuller
Andrew Reynolds, Benchmark, Inc.
Mike Schwent, GAF
Dwayne Sloan, UL
Jodi Thomas, TruFast
Ryan Van Wert, Seaman Corporation
Steven Wadding, Polyglass USA Inc
Karen Yetter, Intertek
Eric Younkin, Metal era

Staff present:
Linda King, Managing Director
Randy Ober, Technical Director
Carl Silverman, Legal Counsel

Task Force Reports
Code Development chair Amanda Hickman reported the following:
- ICC codes 2024 editions currently under development;
    - IBC chapter 15 proposals included in this year's update:
      SPRI's lightning protection proposal was recommended for disapproval due to LP opposition;
    - SPRI will be submitting a public comment by the June 20th deadline;
    - Public comment hearing will take place in Louisville, KY in mid September; and
    - A full list of proposals and the committees actions will be made available.

*SPRI Antitrust Statement: SPRI complies with antitrust laws and requires participants in its programs to comply with antitrust laws. Discussions which could affect competitive pricing decisions or other competitive factors are forbidden. There may be no discussions of pricing policies or future prices, production capacity, profit margins or other factors that may tend to influence prices. In discussing technical issues, care should be taken to avoid discussing potential or planned competitive activities. Members and participants should be familiar with the SPRI Antitrust Policy and act in conformity with it.

- IECC and ASHRAE activity - thermal bridging language - SPRI is maintaining exception for blocking/nailer so membrane can be wrapped over parapet and tied into membrane.
- Florida currently undergoing code update. Considering proposals from ICC 2021 edition and other submitted modifications.

Codes and Standards chair Randy Ober reported the following:

- Events Attended:
  - ICC EduCode – Las Vegas NV;
  - RICOWI Spring Meeting – Orlando FL;
  - IIBEC Spring Meeting – Orlando FL;
  - CRRC Board Meeting – Las Vegas NV; and
  - NRCA Roofing Day – Washington DC.
- Standards:
  - ANSI/SPRI RP-4 revision passed and a 2022 date has been assigned;
  - ANSI/SPRI RP-14 renewal ballot 1 has been reviewed and comments sent to the objector; and
  - ANSI/SPRI GT-1 renewal ballot 1 has been reviewed and comments sent to the objector.
- ASTM:
  - E1918 Alternative Test Method is currently being balloted through SubCommittee D08.18;
  - D6878 TPO fleeceback addition – is addressing negatives received; and
  - SPRI Reinforced & Non-Reinforced EPDs are in the final stage of completion.
- Paper:
  - CIB W83 International Council for Research and Innovation in Building and Construction - TPO Roof Membrane Systems: A World Historical Perspective and Summary of Best Practice paper has been completed and published. Free download is available at: https://cibworld.org/commissions/w083-roofing-materials-and-systems; and
  - ASTM Rubber and Rubber-Like Products for Low Slope Roofing Applications – Final draft accepted and will be incorporated in next ASTM publication.
- Studies:
  - Insurance Institute for Business & Home Safety; and
  - Ballasted wind tunnel study.

Code Compliance Interface (No TF Meeting) -

D6878 TPO Considerations for Revisions (No TF Meeting) -

Definitions for Low Sloped Roofing Task Force chair Steve Wadding reported:

- TF objective was discussed; and
- <u>On motion duly made, the Technical Committee accepted the Task Force recommendation that SPRI and the Task Force should not have its own low slope definition due to the anticipated Code acceptance of a definition acceptable to SPRI, and that SPRI will consider preparing and Technical Bulletin/Position Statement on its website in due course</u>**.**

DORA Listing Service chair Mike Darsch reported that:

- Michelle Jones presented Marketing analytics;

- The Task Force agreed that the EduCode trade show attendance rate was not high enough to warrant attending in the near future;
- Mike Darsch is going to develop and send a survey to the Task Force to determine if the goals for the DORA program are accurate; and
- On motion duly made, the Technical Committee agreed to recommend to the Board that SPRI open up transparency with DORA users by requesting demographic information (i.e. type of user: Contractor, Building Owner, Architect, Building Official, etc.).

DORA Rule for Adding Fire and Impact chair Jenny O'Neal

- The Impact Update was moved to a virtual update due to time constraints;
- The voting process were shared with the Task Force noting that the vote results from January 2022 Task Force meeting was shared with the Board of Directors who will likely respond;
- The commentary of the definitions and Section 1505 was opened for discussion with the Task Force. The Task Force agreed that the DORA program meets the definition of the IBC;
- It was noted that the manufacturer owns the data from the testing program outcome and can place it as necessary; and
- UL maintained that the building code states that a listing agency is required to provide its own quality auditing program.

ES-1 Revision chair Martin Moesgaard reported that:

- The document is undergoing a prelimary review; and
- Changes are being incorporated into the document prior to the first ballot.

GT-1 Revision chair Bob LeClare reported that:

- The Task Force objective was to reaffirm the GT-1 standard from 2016;
- Mark Graham, NRCA, submitted one negative vote with 17 comments within it. SPRI responded to all comments and worked with NRCA to resolve its negative vote;
- NRCA, retracted its vote and entered a positive vote; and
- The standard will be resubmitted to ANSI for approval.

Lightening Protection chair Brad Van Dam reported that:

- The Task Force discussed the current status of LPI proposal disapproval at code hearing in Rochester;
- Expressed gratitude for support of NRCA, UL, ARMA, and Chadwick Collins at the hearing;
- Reviewed proposed alternative language with committee and took feedback;
- Established the goal to submit language for consensus discussion with Amanda Hickman and stakeholder group including LPI for public comments; and
- Amanda Hickman, with the support of Task Force members, will schedule follow up meeting to discuss with stakeholders before public comment.

NT-1 Revision chair David Hawn reported that:

- This is a reaffirmation of the standard as the equipment and process has not changed;
- RCI is still listed and he is reaching out to IIBEC to verify the change to its new name; and
- At that time, the NT-1 will be balloted.

Rooftop Attachments co-chair Jodi Thomas reported that:

- The white paper, written by Curt Lipscom, was reviewed and the previously submitted comments were discussed; and
- The new ASCE 22 requirements concerning tornadoes will be added to the scope of the paper and perhaps some calculations could be run.

RP-14 Revision – No update

RP-4 Revision chair Randy Ober reported that:
All the negatives were resolved and the document has been reapproved as an ANSI Standard.

VOC Regulatory Monitoring chair Justin Bates reported:

- <u>On motion duly made, the Technical Committee approved the Task Force request that the VOC Task Force can use Zoom meetings and electronic votes within the Task Force and to approve communications to SCAQMD related to a PCBTF risk assessment response and proposed VOC subcategories and limits;</u>
- Linda King will create an online form to track responses and comments from voting members;
- Voting will follow SPRI bylaws and communications will be reviewed by SPRI legal counsel;
- This will allow the TF to communicate on behalf of SPRI before the July meeting and stay engaged with SCAQMD ahead of its November report to its governing board.

Website/Digital Content & Communication chair Rick Montoya reported that:

- An audit was performed on the SPRI website and the results were shared with the Task Force;
- Six key areas were noted and will be addressed; and
- The process improvement was envisioned for all social media platforms to interact with each other.

Education Committee chair Brian Chamberlain reported that:

- The EduCode presentation had low attendance;
- The Task Force would like to develop Roofing 101 for onboarding into the industry;
- The Task Force will review the older previously prepared SPRI presentations: and
- Preparation has begun for the wind design presentation in October 2022.

New Business

Onboarding to SPRI:
Zebonie Sukle suggested that a clear onboarding program is needed for SPRI. President Brad Van Dam shared that the SPPI's goal was to improve the process of the Task Force conduct and that it will be reviewed by the BOD tomorrow and this would support the onboarding efforts.

The Membrane Plate Standard Development Task Force:
<u>On motion duly made, The Committee accepted the request that a recommendation be made to the Board to formally approve the creation of the Membrane Plate Standard Development Task Force that held a preliminary meeting (May 10, 2022)</u>. The Task Force will move forward with the development of an objective statement and milestones.

Return to Schedule

Safety of 5G Towers:
David Hawn shared that there is a health safety concern in the industry with 5G towers and roofs. It was agreed that this would be a good Tuesday evening speaker topic, however, it may be difficult to identify a knowledgeable speaker. Mr. Hawn will research this further. It was requested that if any SPRI Member Company has information regarding this topic or knowledge of the problem, that an email be sent to Mr. Hawn (drhawn@drhroofsolutions.com).

Direction of the DORA program:
It was requested that historic information regarding the original request for proposal to potential program administrators be researched to determine the original intent for the program. In particular, towhom was the request for proposals sent? Was Fire part of the original scope of work?

This information may provide guidance on the the path forward for the DORA program. On motion duly made, it was agreed that the original request for proposal and timeline will be gathered for discussion at the SPRI July meeting.

Adjournment
There being no further business, the meeting adjourned at 4:00 p.m.

Submitted: Jennifer O’Neal, Chair

These minutes have been reviewed by SPRI Legal Counsel.