the perimeter roof edge

FIRST LINE OF DEFENSE IN A WIND EVENT

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A tradesman installs a roof edge system. The roof edge represents only about 1% of the total cost of most low-slope projects, but improper edges can account for more than half of all roof failures.

LEARNING OBJECTIVES

After reading this article, you should be able to:

+ NAME the three organizations that were involved in developing standards for the perimeter roof edge prior to the adoption of the ANSI/SPRI ES-1 standard by the International Building Code.
+ LIST the three test procedures that are performed as part of the ANSI/SPRI ES-1 requirement.
+ DELINEATE the five key elements of the roof that affect the performance of the roof edge treatment, as considered in the ANSI/SPRI ES-1 calculation.
+ CALCULATE the adjusted velocity pressures for the coping top, coping face, and coping back of a perimeter roof edge under the ANSI/SPRI ES-1 standard.

BY DREW BALLENSKY

What is a perimeter roof edge? The term can mean different things to different design and construction professionals.

The technical definition of a perimeter roof edge is a termination and transition between the roof and other building components. Because it is normally the part of a roof that is the most visible, some consider it an aesthetic feature of the building's exterior. In reality, it is a roof system's first line of defense in a wind event; aside from the roof membrane itself, it is the most critical component of the roofing system.

When you consider how small the cost of the roof edge system is compared to the overall cost of the building itself (typically about 1%), it is interesting that the perimeter roof edge is one of the first components of the roof system targeted for value engineering. It is unfortunate, however, when you consider that it is estimated that 60% of litigation claims related to a building originate from the roof area and that 60% of roof warranty claims are attributed to metal edge failures. By extension, out of all the litigation, 36% of litigations are attributed to metal edge failures.

Based on these statistics, therefore, the perimeter roof edge is second only to the membrane itself in importance to overall integrity of the roofing assembly. It is a component that warrants more scrutiny when designing a roof system.

INDUSTRY BACKGROUND: SETTING THE STANDARDS

For many years standards developed by three organizations—SMACNA, NRCA, and Factory Mutual—have been used to design perimeter roof edges.

SMACNA. Founded in 1943, the Sheet Metal & Air Conditioning Contractors National Association (www.smacna.org) specializes in architectural and industrial sheet metal; HVAC systems; kitchen equipment; specialty stainless steel work; siding, and decking.

SMACNA provides recommendations for fabricating and installing roof-termination assemblies as well as other sheet metal applications. SMACNA assemblies are not tested for resistance to wind uplift, and they concentrate on basic sheet metal design, assuming that the roof edge designer is familiar with basic flashing and waterproofing.

The SMACNA manual helps provide the minimum design standard under normal conditions. It is important to understand that SMACNA provides guidance on topics such as metal gauges, cleat gauges, and fastener placement. Although cited in specifications today, SMACNA is a prescriptive standard and not a performance standard because there are no performance numbers to match job requirements.

NRCA. The National Roofing Contractors Association, or NRCA (www.nrca.net), supplies details for edge metal terminations, but only select details that have been ANSI/SPRI ES-1 tested. They are available through an NRCA sublisting program with member contractors.

Factory Mutual. The last and most commonly used resource for building standards is Factory Mutual, known as FM Global (www.fmglobal.com). Formed from a conglomeration of insurance companies, FM Global developed its own test standards for materials used on the properties it insures to limit its own exposure to loss. Even though FM Global testing was meant for FM Global–insured buildings, it became the default performance standard for the construction industry because no other standard was available at the time.

More recently, a new standard has come on to the roofing scene: ANSI/SPRI ES-1.

ANSI/SPRI ES-1 (www.spri.org) is a reference for those who design, specify, or install edge materials used with low-slope roofing systems, addressing copings and horizontal roof edges. The factors considered when designing a roof edge are:

- Structural integrity of the substrate that anchors the edge (e.g., nailers)
- Wind resistance of the edge detail
- Materials specifications

WHY THE NEED FOR A NEW STANDARD?

The importance of a proper perimeter roof edge system in reducing losses cannot be underestimated. According to a September 2003 article in *Building Design+Construction*, "A leaky roof is usually expensive to repair and often leads to lawsuits. A building skin accounts for 80% of construction-related litigation, according to officials, with roof accounting for an inordinately large part of these lawsuits."

For example, it is estimated that 75% of all losses from 1992's Hurricane Andrew were related to roof failure, according to Factory Mutual, which conducted a study of 145 FM Global losses involving BUR (built-up roofing) systems. This study, cited in *Approved Product News* (Vol. 21, No. 2, 2005), showed that 59% of losses occurred because the roof perimeter failed.

The Roofing Industry Committee on Weather Issues (www.ricowi.org) is a nonprofit organization that promotes education and research on wind and hail issues. Established in 1990, RICOWI publishes very detailed and comprehensive reports on recent hurricanes, providing great examples of design practices that leave the roofs vulnerable to wind damage compared to proper design practices that can withstand harsh wind conditions.

RICOWI's findings reinforce the fact that the edge and the corners are a roof's most vulnerable areas and that current practices don't take this into account, leaving the roof open to wind damage. They conclude that proper design and installation are key to guarding against such damage:

- "Many examples of damage appeared to originate at failed edge details" (2007, p. xiv).
- "These studies reinforced the need for secure roof edges, and codes that require secure roof edging need to be enforced" (2006, p. xiv).
- "Design/construct roof coverings in accordance with available high-wind design guidelines and roof materials manufacturers' instructions" (2006, p. 178).

With Hurricanes Ivan and Charley in 2006, RICOWI found that nearly 95% of roof failures were caused by poor workmanship and substituted materials. Also, cleat gauges were often less than that recommended by FM Global and the ANSI/SPRI ES-1 Standard.

While hurricanes frequently get the most press coverage, it is important to remember that it doesn't take a hurricane for roof damage to occur. Other weather events, such as wind, tropical storms, tornados, hail and lightning, can all have damaging effects on roofs. Dangerous conditions can be caused by straight-line winds such as downbursts, which can exceed 100 mph and lead to damage that is equivalent to a strong tornado.

HOW ANSI/SPRI ES-1 WAS DEVELOPED

Prior to 1980 there were no perimeter roof edge standards that manufacturers could hold themselves to. In that year, FM Global created a system of standards and approvals to apply to its own insured properties, and this became the industry standard by default.

It wasn't until 1998 that the Single Ply Roofing Industry, or SPRI (www.spri.org), developed a series of three tests for judging the quality and durability of fascia and coping. These tests, RE-1, RE-2, and RE-3, are used today in the ES-1 standard.

Founded in 1981, SPRI is the recognized technical and statistical authority on single ply roofing, developing many industry standards such as:

- ANSI/SPRI WD-1 2008 Wind Design Standard Practice for Roofing Assemblies
- ANSI/SPRI FX-1 2006 Standard Field Test Procedure for Determining the Withdrawal Resistance of Roofing Fasteners
- ANSI/SPRI IA-1 2005 Standard Field Test Procedure for Determining the Mechanical Uplift Resistance of Insulation Adhesives over Various Substrates


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Calculating the correct design pressure for the roof edge should be done according to ANSI/SPRI ES-1, based on five key factors: 1) the building's height; 2) wind speed, using the ASCE 2-07 wind speed map; 3) building location characteristics; 4) building occupancy characteristics; and 5) any special terrain characteristics.

SPRI continues to be an excellent resource for building owners, architects, engineers, specifiers, contractors, and maintenance personnel, providing objective information about commercial roofing components and systems. The SPRI website provides many valuable resource documents, ranging from technical guidelines for design and applications to general information about roof maintenance and emergency repairs.

The process involved in bringing the ANSI/SPRI ES-1 Standard from idea to code began with SPRI's development of a rigorous procedure for testing roof edge products and determining the ideal wind design pressure needed for a particular building. Once the standard was written, SPRI built consensus by canvassing the roofing industry, collecting and incorporating stakeholders' feedback into a revised standard.

Once revised, the ES-1 Standard was submitted to ANSI, the American National Standards Institute (www.ansi.org), a nonprofit organization that does third-party endorsements of performance-testing processes and procedures, which reviewed and approved the standard. The ES-1 Standard can be downloaded for free at www.spri.org/publications.

The International Code Council, or ICC (www.iccsafe.org), recognized the value of this standard, and in 2002 the IBC wrote the ES-1 guidelines into its 2003 code. Many states have adopted the 2003 IBC, and the list is continually growing.

The ICC code, 2003 IBC, 1504.5, reads as follows: "Edge securement for low-slope roofs. Low-slope membrane roof systems metal edge securement, except gutters, installed in accordance with Section 1507, shall be designed in accordance with ANSI/SPRI ES-1, except the basic wind speed shall be determined from Figure 1609." (Note: The Figure 1609 wind speed map varies from the wind speed map in ANSI/SPRI ES-1 1998 in the hurricane coastal regions, as the map in Figure 1609 was updated in 2003.)

Two main considerations were involved with the creation of the ANSI/ SPRI ES-1 Standard:

- The ability of the edge treatment to resist the pull of the roof material inwardly
- The resistance of the edge to outward and upward forces which tend to blow or peel edge systems off

The ANSI/SPRI ES-1 Standard is designed to be the most complete and concise method for evaluating roof edges. Therefore, several other issues that impact the performance of a roof edge system—metal thickness, galvanic compatibility, appliances, and building substrates—were considered.

Using the correct gauge material for a particular project is critical to avoiding oil canning or the waviness that can occur in the fascia cover. Use heavier gauges for fascia systems covering large face heights or coping systems covering wider parapet walls.

Galvanic compatibility is another issue addressed by the ANSI/ SPRI ES-1 Standard. Corrosive potential can be roughly predicted by the placement of the two metals in the Galvanic Series. The farther apart the two metals are, the greater the potential for corrosion. Metals adjacent to each other have little potential for corrosion.

For this reason, zinc (used in galvanized steel) and aluminum can be used in conjunction with each other. Many manufacturers use a galvanized cleat with an aluminum cap piece for increased strength.

Resistance to blow off depends on what substrate the roof edge is attached to. For example, wood, masonry, and steel carry different safety factors that need to be accounted for. Depending on the roof edge system and the substrate, different types of fasteners will be recommended. An important factor to consider is the use of corrosion-resistant fasteners into nailers that are now required to be made of treated wood. In some cases, fasteners may not be needed at all, as some manufacturers have systems that incorporate adhesives.

ES-1'S THREE TEST METHODS

ANSI/SPRI ES-1 utilizes three test methods: RE-1, RE-2, and RE-3.

RE-1 is intended for fascia systems. A mockup of the system that is at least 12 inches long must be used. The RE-1 is a static test with a 100-pound load hung every foot. The membrane is pulled at a 45-degree angle to the roof deck, to simulate the forces applied to a billowing membrane. RE-1 is a pass/fail test; the termination must withstand a minimum force of 100 lb/sf to pass.

RE-2 is also a fascia test. It is used to determine the maximum load at failure. Failure is considered the loss of securement of any component of the roof edge system or deformation that would result in the loss of weather protection at the edge.

To run the RE-2 test, a full-size mockup is created and attached according to the manufacturer's installation instructions. A load is applied to the face of the fascia incrementally and held for at least 60 seconds. The load is then removed, and then increased in increments of 25 lb/sf until 150 lb/sf is reached. Then increments of 10 lb/sf are used.

RE-3 is a bi-directional test for coping systems, with simultaneous loads applied to the face and top of the system. The back leg and top and the front leg and top are tested individually on separate samples. The legs are tested individually to determine the product's weakest point, with the lowest test results being used. The loads are applied incrementally in the same manner as the RE-2. The edge is tested until failure occurs, which is the loss of securement of any component of the roof edge system or deformation that would result in the loss of weather protection at the edge.

ANSI/SPRI ES-1 Table 3.
EXTERNAL PRESSURE COEFFICIENT (GC_p)

	Roof height 60 feet or less ($z \leq 60$ feet)	Roof height over 60 feet ($z > 60$ feet)
Horizontal GC_p (acting outward from the building face)	-1.1	-0.9
Vertical GC_p (acting upward from the building edge)	-1.8	-2.3

Note: The negative signs (-) in the external pressure coefficients represent vector directionality of the force acting away from the building, tening to pull materials upward or outward from the building.

SOURCE: ANSI/SPRI "WIND DESIGN STANDARD FOR EDGE SYSTEMS USED WITH LOW SLOPE ROOFING SYSTEMS" (HTTP://WWW.SPRI.ORG/PDF/ES-1_2003.PDF)

ANSI/SPRI ES-1 Table 4. VELOCITY PRESSURE, q_z (psf)
EXPOSURE B

Height	Wind speed, mph (3-second gust)							
z (feet)	85	90	100	110	120	130	140	150
0-60	16	18	22	26	31	37	43	49
>60-70	17	19	23	28	33	39	45	51
>70-80	17	19	24	29	34	40	47	53
>80-90	18	20	25	30	35	41	48	55
>90-100	18	20	25	31	36	43	50	57
>100-120	19	22	27	32	38	45	52	60
>120-140	20	23	28	34	40	47	55	63

SOURCE: ADAPTED FROM ANSI/SPRI "WIND DESIGN STANDARD FOR EDGE SYSTEMS USED WITH LOW SLOPE ROOFING SYSTEMS" (HTTP://WWW.SPRI.ORG/PDF/ES-1_2003.PDF)

DESIGNING FOR ANSI/SPRI ES-1 WWW.SPRI.ORG/PUBLICATIONS

Once the edge manufacturer has tested its products, the architect or specifier needs to determine the design pressure required by the specific project, using the following formula:

GC_p x q_z x I x kzt, where
GC_p = external pressure coefficient (gust factor product)
q_z = velocity pressure
I = importance factor
kzt = topographical factor

In other words, the gust factor product is multiplied by the velocity pressure times the importance factor times the topographical factor.

There are five key elements of the roof that affect the performance of the roof edge treatment and that are considered in the ANSI/SPRI ES-1 calculation. They are:

1. Building height
2. Wind speed
3. Building location
4. Building occupancy factor
5. Special terrain characteristics

The easiest way to understand how ES-1 calculation works is to walk through a simple example—in this case, a 95-foot-tall office building in suburban Milwaukee, Wis., where coping will be used on the roof edge.

Note: The height required for the calculation is the height at which the roof edge will be installed. If the building has multiple roof levels, separate calculations may be needed for each level.

STEP 1. LOCATE AND CLASSIFY THE BUILDING.

Building height. The building is 95 feet in height.

Wind speed. To determine the correct wind speed in the project area, use the ASCE 2-07 wind speed map from ANSI/ASCE 7-02 document "Minimum Design Loads for Buildings and Other Structures." Note that "Special Wind Regions," such as mountainous areas, are marked in gray. Our building is just outside of Milwaukee, which has a 90 mph wind speed.

ASCE exposure. The next step is to look at the building location characteristics, or exposure categories:

- Exposure A is now classified as Exposure B, urban and suburban areas with single-family dwellings.
- Exposure C consists of mostly open areas, with scattered obstructions.
- Exposure D is made up of flat, unobstructed areas or open water for one mile or greater, usually along coastlines or in desert areas. Note: Hurricane coastal areas should be classified as Exposure C due to high waves creating scattered obstructions.

ANSI/SPRI ES-1 Design Pressure Worksheet

Building parameters: 95-foot office building located in suburban Milwaukee, Wis. Coping will be used on the roof edge.

Step 1. Locate and classify the building

A. Building height 95 feet

B. Wind speed (from Wind Map ASCE 2-07) 90 mph

C. ASCE exposure B

D. Occupancy category III = Importance factor 1.15

Step 2. Determine pressure confidences (from ES-1 Table 3)

A. Coping top (vertical—acting upward at building edge) 2.3

B. Coping face (horizontal—acting outward from building face) 0.9

C. Coping back (horizontal—acting outward from building face) 0.9

Step 3. Calculate adjusted velocity and design pressures

A. Velocity pressure (using ES-1 Table 4* with Steps 1A and 1B)

20 psf x Step 1D 1.15 = 23 psf

B. Coping top: Adjusted velocity pressure (Step 3A)

23 psf x Step 2A 2.3 = 52.9 psf

C. Coping face: Adjusted velocity pressure (Step 3A)

23 psf x Step 2B 0.9 = 20.7 psf

B. Coping back: Adjusted velocity pressure (Step 3A)

23 psf x Step 2C 0.9 = 20.7 psf

* Velocity pressure must be determined from the table that corresponds with the building's exposure.

Note: All tables and calculations are derived from the ANSI/SPRI "Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems" (http://www.spri.org/pdf/ES-1_2003.pdf). Design pressure calculations can also be done through Metal-Era's free online calculator (www.metalera.com).

Our building is an Exposure B because it is in a suburban area.

Building category importance factor. This factor recognizes that certain buildings should be built with greater attention, depending on their level of hazard to human life.

- CATEGORY I buildings, the lowest level of importance, present little hazard to human life, such as in agricultural, temporary, or storage facilities.
- CATEGORY II covers all buildings and other structures except those limited in Categories I, III, and IV.
- CATEGORY III buildings pose a hazard to human life should they fail. This category includes facilities where more than 300 people congregate; schools with capacities over 250; healthcare facilities with a capacity of 50 or more beds that don't provide surgery or emergency treatment; and jail and detention facilities.
- CATEGORY IV buildings not only have a high hazard to human life should they fail, but are also critical to community welfare in an emergency. These include healthcare facilities offering surgery or emergency treatment; fire, rescue, and police stations; emergency vehicle garages; communication centers; and other facilities required for emergency response.

The ES-1 document gives the Building Category Importance Factor as follows: Category I, 0.87; Category II, 1.00; Categories III and IV, 1.15.

Because the office building in our example is 95 feet tall, we must assume it will have more than 300 occupants, making it a Category III with an importance factor of 1.15.

STEP 2: DETERMINE THE BUILDING'S PRESSURE CONFIDENCES.

To calculate the forces acting on the building's roof edge, consult Table 3, External Pressure Coefficient (GC_p), of the ES-1 document. Because there are simultaneous horizontal and vertical pressures on a coping cap, both the horizontal external pressure coefficient and the vertical external pressure coefficient must be determined. Obviously, taller buildings will experience higher pressures than those of medium or lesser height.

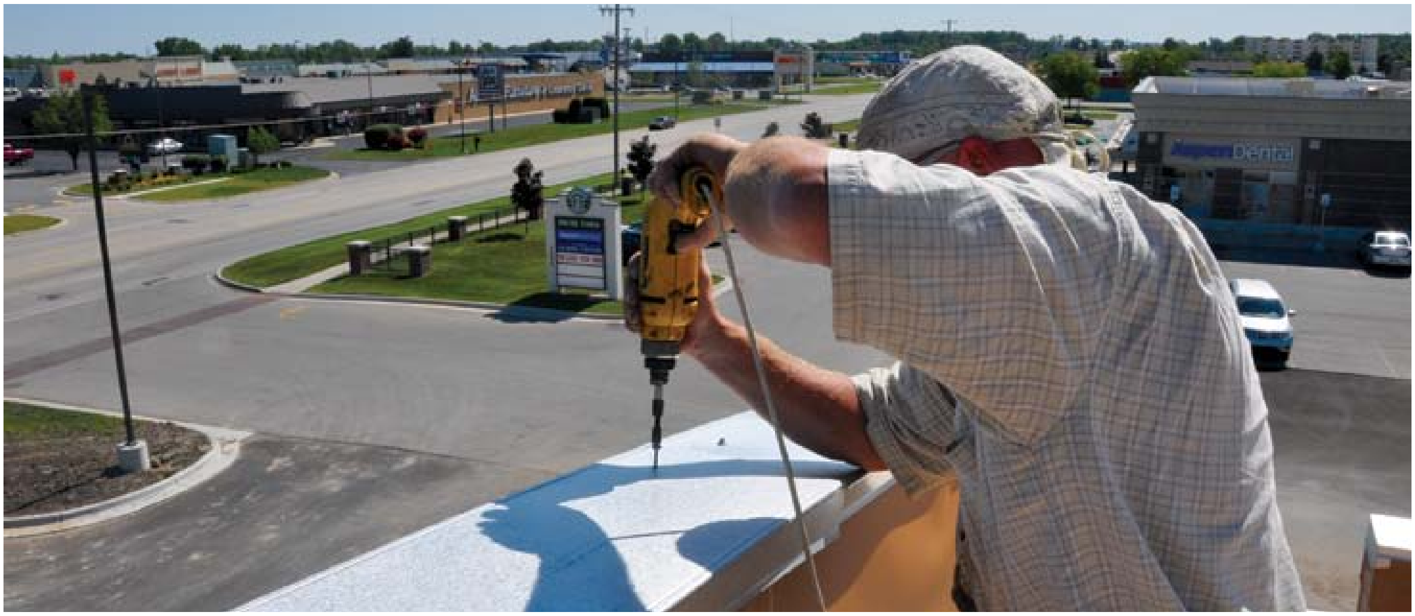
In our example the building is 95 feet, so the vertical pressure coefficient would be 2.3 and the horizontal pressure coefficient would be 0.9.

STEP 3. CALCULATE THE ADJUSTED VELOCITY AND DESIGN PRESSURES.

From Table 4, Velocity Pressure, q_z (psf), of the ES-1 document, we found that the velocity pressure was 20.

Now it's time for some basic arithmetic. Multiply the velocity pressure (20) times the importance factor (from Step 1d) of 1.15 to solve for Step 3a. The answer: 23 psf.

Use this figure (23 psf) to calculate the design pressure for the coping top (Step 3b), the coping face (Step 3c), and the coping back (Step 3d) by multiplying it times the appropriate pressure coefficient from ES-1 Table 3, External Pressure Coefficient (be sure to



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Designers, contractors, and other specifiers must be aware of the code requirements and design, testing, and installation of edge metal terminations.

use the table that corresponds with the correct building exposure—in this case, Exposure B):

Coping Top Adjusted Velocity Pressure
23 psf x 2.3 = 52.9 psf

Coping Face Adjusted Velocity Pressure
23 psf x 0.9 = 20.7 psf

Coping Back Adjusted Velocity Pressure
23 psf x 0.9 = 20.7 psf

To summarize, a 95-foot-tall office building in suburban Milwaukee should have a coping system that meets or exceeds 53 psf on the coping top and 21 psf on the coping face and coping back. These numbers should be included in the specification and required of the roof edge manufacturer.

Finally, it should be noted that certain obstructions or special terrain characteristics, such as hills or escarpments, may influence the wind patterns on your building. These require more detailed calculation that is beyond the scope of this course; however, the ES-1 Standard does provide guidance in this area. Remember, too, that the ends of a valley can intensify wind speeds; no special calculations are available at this time.

WHERE TO SOURCE tested roof edge systems

Where can you find tested roof edges? There are several sources:

- Numerous manufacturers of pre-engineered roof edge systems who have invested in testing their products.
- Roofing contractors who have had their products directly tested.
- Contractors who have gone through the National Roofing Contractors Association's sublisting process. Be aware, however, that not all NRCA members have gone through this process. Moreover, the NRCA sublisting simply means that the contractor is able to offer only the selected details in the particular gauges and sizes that have been tested as part of this program.

No matter which source you use, it is important to verify that your supplier is able to offer an ANSI/SPRI ES-1–tested edge that meets the gauge and size requirements as well as the design pressure for your project.

STEP 4. CONTACT A ROOF EDGE MANUFACTURER WHO CAN MANUFACTURE AN EDGE TO MEET THESE REQUIREMENTS.

Over half of roof failures are related to improper edge metal. The perimeter roof edge is the first line of defense in a wind event and if the edge is lost, the membrane is likely to follow shortly.

The roof edge may represent only a small part of a building's overall cost, but it carries a potentially significant risk of liability. Therefore, designers, engineers, and specifiers need to be cognizant of the code requirements and design, testing, and installation of edge metal terminations.+

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> EDITOR'S NOTE

This completes the reading for this course!
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