

American National Standard Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

1 INTRODUCTION (See Commentary: 1)

The following standard is a reference for those who design, specify or install edge materials used with low slope roofing systems. Although it does address corrosion, this Standard focuses primarily on design for wind resistance. It is intended for use with the specifications and requirements of the manufacturers of the specific roofing materials and the edge systems used in the roofing assembly, excluding gutters. The membrane manufacturer shall be consulted for specific recommendations for making the roof watertight at the edge.

This design standard addresses copings and horizontal roof edges, and the following factors shall be considered in designing a roof edge.

- Structural integrity of the substrate that anchors the edge
- Wind resistance of the edge detail
- Materials specifications

2 GENERAL DESIGN CONSIDERATIONS AND DEFINITIONS (See Commentary: 2)

All materials for roof edge construction shall have sufficient strength to withstand the design wind load. The following factors apply when designing a roof edge system: Wind speed, building height, corner and perimeter regions, edge condition, Exposure Factor, topography, galvanic compatibility and Importance Factor.

2.1 WIND SPEED (See Commentary: 2.1)

Basic wind speed values used in the design calculations are 3-second gust speeds in miles per hour (m/s) measured at 33 ft (10 m) above ground for Exposure Factor C associated with an annual probability of 0.02 (50 year return).

These values are taken from the ANSI/ASCE 7-95¹ document (See attachment I) or the authority having jurisdiction. Section 6.5.5 of ASCE 7-95¹ shall be used to adjust design wind speed for the intensifying effects of valleys and other unique topographic features such as hills or escarpments. (See Commentary: 2.1) The authority having jurisdiction shall be contacted for verification of wind data.

2.2 BUILDING HEIGHT

The building height shall be measured from ground level to the mean height of the roof section under design.

2.3 ROOF EDGE REGIONS

Wind forces near the corner regions are of greater intensity than in the perimeter regions between corners. These regions are defined as follows:

2.3.1 CORNER REGION

For buildings with mean roof height up to 60 feet (18 m), the corner region is a distance from the building corner that is 10% of the minimum building width or 40% of the building height at the eaves, whichever is smaller, but not less than 4% of the minimum building width and not less than 3 feet (0.9 m). For buildings with mean roof height greater than 60 feet (18 m), the corner region is a distance from the building corner that is 10% of the minimum building width but not less than 3 feet (0.9 m).



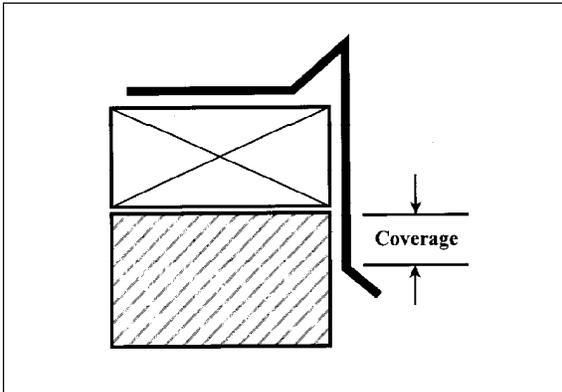


Figure 1: Edge Flashing Coverage

2.3.2 PERIMETER

The perimeter is the section of roof edge between corner regions as defined in Section 2.3.1 (above).

2.4 EDGE CONDITION (See Commentary: 2.4)

The edge condition includes the roof edge device (edge flashing or coping) and the nailer or other substrate to which the edge device is attached.

Coverage is the location of the lowest vertical point of the roof edge device or any extension of it, exclusive of any drip bend or other protrusion. The coverage shall extend a minimum of 1 inch (25 mm) below the bottom of the nailer. The roof membrane shall not extend below the coverage.

2.5 EXPOSURE (See Commentary: 2.5)

The building shall be classified into one of the following Exposures based on surrounding terrain:

2.5.1. EXPOSURE A.

Large city centers with at least 50% of the buildings having a height in excess of 70 feet (21.3 m). Use of this exposure category shall be limited to those areas for which terrain representative of Exposure A prevails in the upwind direction for a distance of at least one-half mile (0.8 km) or 10 times the height of the building or other structure, whichever is greater. Possible channeling effects or increased velocity pressures due to the building or structure being located in the wake of adjacent buildings shall be taken into account.

2.5.2. EXPOSURE B.

Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. Use of this exposure category shall be limited to those areas for which terrain representative of Exposure B prevails in the upwind direction for a distance of at least 1,500 feet (460 m) or 10 times the height of the building or structure, whichever is greater.

2.5.3. EXPOSURE C. (See Commentary: 2.5.3)

Open terrain with scattered obstructions having heights generally less than 30 feet (9.1 m). This category includes flat open country and grasslands.

2.5.4. EXPOSURE D.

Flat, unobstructed areas exposed to wind flowing over open water for a distance of at least 1 mile (1.61 km). This exposure shall apply only to those buildings and other structures exposed to the wind coming from over the water. Exposure D extends inland from the shoreline a distance of 1,500 feet (460 m) or 10 times the height of the building or structure, whichever is greater.

2.6 IMPORTANCE FACTOR (See Commentary: 2.6)

Buildings fitting one of the following criteria shall have an "Importance Factor" included in the wind design calculations. Table 1 (page 3) explains these building classifications. Refer to Section 5.1 and Table 3 for use of Importance Factor.

TABLE 1
IMPORTANCE FACTOR
CLASSIFICATION OF BUILDINGS AND OTHER STRUCTURES
FOR WIND, SNOW, AND EARTHQUAKE LOADS

Nature of Occupancy	Category
Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: <ul style="list-style-type: none"> • Agricultural facilities • Certain temporary facilities • Minor storage facilities 	I
All buildings and other structures except those listed in Categories I, III, IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to: <ul style="list-style-type: none"> • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with elementary school, secondary school, or day-care facilities with capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients but not having surgery or emergency treatment facilities • Jails and detention facilities • Power generating stations and other public utility facilities not included in Category IV • Buildings and other structures containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released 	III
Buildings and other structures designated as essential facilities including, but not limited to: <ul style="list-style-type: none"> • Hospitals and other healthcare facilities having surgery or emergency treatment facilities • Fire, rescue and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Communications centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Buildings and other structures having critical national defense functions 	IV

From ASCE 7/95¹

3 SYSTEM REQUIREMENTS (See Commentary: 3)

3.1 NAILER SECURED SYSTEMS

The basic attachment of the nailer shall be sufficient to carry the design wind uplift load and the load specified in Section 4.1. At outside building corners regions^a, nailer securement shall be designed to carry a load two times the

basic nailer attachment design load. Wood nailers shall be minimum thickness 1.5 inch (38 mm). For devices used to secure the roofing (e.g., gravel stops), the nailer shall extend at least 1/2 inch (13 mm) beyond the back edge of the horizontal flange of the roof edge device. The following fastener safety factors shall be applied to design loading.

^a See section 2.3 for definitions of corner regions.

Section 3.2

Table 2	
Substrate	Wind Load Safety Factor
Wood ²	4.5
Masonry ³	3.0
Steel ⁴	1.9

4 DESIGN OPTIONS (See Commentary: 4)

The following minimum securement criteria apply for edging systems. When building codes require higher wind resistance, the designer shall calculate and design for the required loads according to local building codes.

4.1 MEMBRANE ATTACHMENT (See Commentary: 4.1)

Except for Built-Up or fully adhered modified bitumen roofing, the design of the perimeter attachment, when terminating the roofing system, shall provide a minimum holding power of 100 pounds/foot (1.46 kN/m) holding power. This force shall be measured in a direction of 45 degrees back onto the roof as tested according to SPRI Test Method RE-1 (attached). Specifically for mechanically attached membrane roofing systems, the perimeter attachment loadings shall be calculated based on the force required to hold the roof system's perimeter sheet in place for the design wind speed. The fastener spacing shall be adjusted and the edge detail shall have sufficient strength to meet and resist these loads.

4.2 WIND RESISTANCE OF EDGE FLASHING (Gravelstop) (See Commentary: 4.2 & 4.3)

The vertical face of edge flashing shall be tested according to SPRI Test RE-2 (attached). Test results shall meet or exceed design wind pressures as calculated according to RE-2.

4.3 WIND RESISTANCE OF COPING (See Commentary: 4.2 & 4.3)

Copings shall be tested according to SPRI Test Method RE-3 (attached). Test results shall meet or exceed horizontal and vertical design wind pressures as calculated according to RE-3.

4.4 FASTENER SPACING

Fastener densities providing satisfactory results in SPRI Tests RE-2 and RE-3 shall be increased

by a factor of two at corner regions (as defined in Section 2.3.2) to allow for increased velocity pressure in these regions.

5 DESIGN PROVISIONS (See Commentary: 5)

5.1 WIND DESIGN (See Commentary: 5.1)

The roof edge design pressure (P) shall be calculated using the formula

$$P = GC_p \times q_z \times I \times k_{zt}$$

in which:

- P** = Design Pressure,
- GC_p** = Gust Factor times Pressure Coefficient, hereafter referred to simply as Pressure Coefficient,
- q_z** = Velocity Pressure at building height, z
- k_{zt}** = Topographic Factor (=1.0 for flat terrain, see ASCE 7-95, p. 20 for other terrain) and
- I** = Importance Factor Multiplier.

The basic wind speed shall be determined from Attachment I or the authority having jurisdiction. Velocity Pressure, "qz" shall be obtained from Table 4 corresponding to the appropriate Exposure (see Section 2.5) and the basic wind speed. Where the design speed, adjusted for topographic effects, exceeds 150 miles per hour (237 km/h) or when building height exceeds 150 feet (45 m), velocity pressure shall be calculated according to Equation 6-1 from ASCE 7-95.

The importance factor, "I", shall be obtained using Table 3:

TABLE 3 IMPORTANCE FACTOR	
Building Category (See Table 1, Section 2.6 of this Design Standard)	Importance Factor I
I	0.87
II	1.00
III	1.15
IV	1.15

ASCE 7-95¹ p. 17.

TABLE 4
Velocity Pressure (qz)

Exposure A

Building Height	Maximum Wind Speed							
	85 mph	90 mph	100 mph	110 mph	120 mph	130 mph	140 mph	150 mph
0-60 ft	Use Exposure "C"							
>60 - 80 ft	12	13	16	19	23	27	31	36
>80 - 100 ft	13	14	17	21	25	29	34	39
>100 - 125 ft	14	15	19	23	27	32	37	43
>125 - 150 ft	15	17	20	25	29	35	40	46

Exposure B

Building Height	Maximum Wind Speed							
	85 mph	90 mph	100 mph	110 mph	120 mph	130 mph	140 mph	150 mph
0-60 ft	Use 85% of Loads for Exposure "C"							
>60 - 80 ft	17	19	24	29	34	40	47	53
>80 - 100 ft	18	20	25	31	36	43	50	57
>100 - 125 ft	19	22	27	33	39	46	53	61
>125 - 150 ft	21	23	28	34	41	48	56	64

Exposure C

Building Height	Maximum Wind Speed							
	85 mph	90 mph	100 mph	110 mph	120 mph	130 mph	140 mph	150 mph
0 - 20 ft	17	19	23	28	33	39	45	52
>20 - 40 ft	19	22	27	32	38	45	52	60
>40 - 60 ft	21	24	29	35	42	49	57	65
>60 - 80 ft	22	25	31	37	45	52	61	70
>80 - 100 ft	23	26	32	39	47	55	64	73
>100 - 125 ft	25	28	34	41	49	57	67	76
>125 - 150 ft	25	29	35	43	51	60	69	79

Exposure D

Building Height	Maximum Wind Speed							
	85 mph	90 mph	100 mph	110 mph	120 mph	130 mph	140 mph	150 mph
0-60 ft	Use Exposure "C"							
>60 - 80 ft	25	29	35	43	51	60	69	79
>80 - 100 ft	27	30	37	44	53	62	72	83
>100 - 125 ft	28	31	38	46	55	64	75	86
>125 - 150 ft	28	32	39	48	57	67	77	89

Section 3.2

Table 5 Pressure Coefficient-Gust Factor Product, GC_p		
	Buildings 60 feet high or less	Buildings over 60 feet high
Horizontal GC _p (acting outward from the building face)	-1.4	-1.8
Vertical GC _p (acting upward at the building edge)	-1.8	-2.3

The Pressure Coefficient, "GC_p" shall be obtained from Table 5: (See Commentary 5.1)

In Table 5, the negative sign (-) means that the pressure is away from the building, tending to pull materials up or off.

Roof edge designs shall pass tests RE-1, RE-2 and RE-3 as appropriate for the application: Edge devices designed to act as membrane terminations shall pass SPRI Test RE-1. Edge flashings and other edge devices for which the exposed vertical component area exceeds the exposed horizontal component area (edge flashings, etc.) shall pass SPRI Test RE-2.

Copings and other devices for which the exposed horizontal area exceeds the exposed vertical area shall pass SPRI Test RE-3. To allow for higher wind loads at corners, double the fastening in the corner region instead of testing corner assemblies when the straight length assembly passes RE-3.

Exposed areas in the above requirements shall be those elements upon which the wind forces act directly.

5.2 METAL THICKNESS (See Commentary: 5.2)
Minimum gauges for exposed faces⁵ shall be determined from Table 6:

5.3 GALVANIC COMPATIBILITY AND RESISTANCE (See Commentary: 5.3)

Metal edge devices (face, clip and fastener) shall be of the same kind of metal, or shall be galvanically compatible metal pairs. Compatible metal pairs shall be selected from the following list:

- Aluminum-Galvanized Steel
- Aluminum-Stainless Steel
- Copper-Stainless Steel

or other pairs that can be shown to provide satisfactory galvanic compatibility.

Copper shall not be used in combination with steel, zinc or aluminum.

Fasteners shall be galvanically compatible with the other roof edge system components.

5.4 APPLIANCES

Appliance attachments, such as lightning rods, signs or antennae that penetrate the water seal, induce a galvanic reaction or otherwise compromise the effectiveness of the roof edge system, shall be eliminated or isolated to prevent problems.

TABLE 6 Minimum Metal Thicknesses for Flatness			
Exposed Face	Galvanized Steel	Cold Rolled Copper	Formed Aluminum
Up to 4" (to 100 mm)	26 ga (0.022" 0.6 mm)	16 oz (0.022" 0.6 mm)	0.040" 0.8 mm
>4" - 8" (>100 - 200 mm)	24 ga (0.028" 0.7 mm)	16 oz (0.022" 0.6 mm)	0.050" 1.3 mm
>8" - 10" (>200 - 250 mm)	22 ga (0.034" 0.9 mm)	20 oz (0.027" 0.7 mm)	0.063" 1.6 mm
>10" - 16" (>250 - 400 mm)	20 ga (0.040" 1.0 mm)	—	0.080" 2.8 mm

ATTACHMENT I
BASIC WIND SPEED MAP OF THE USA

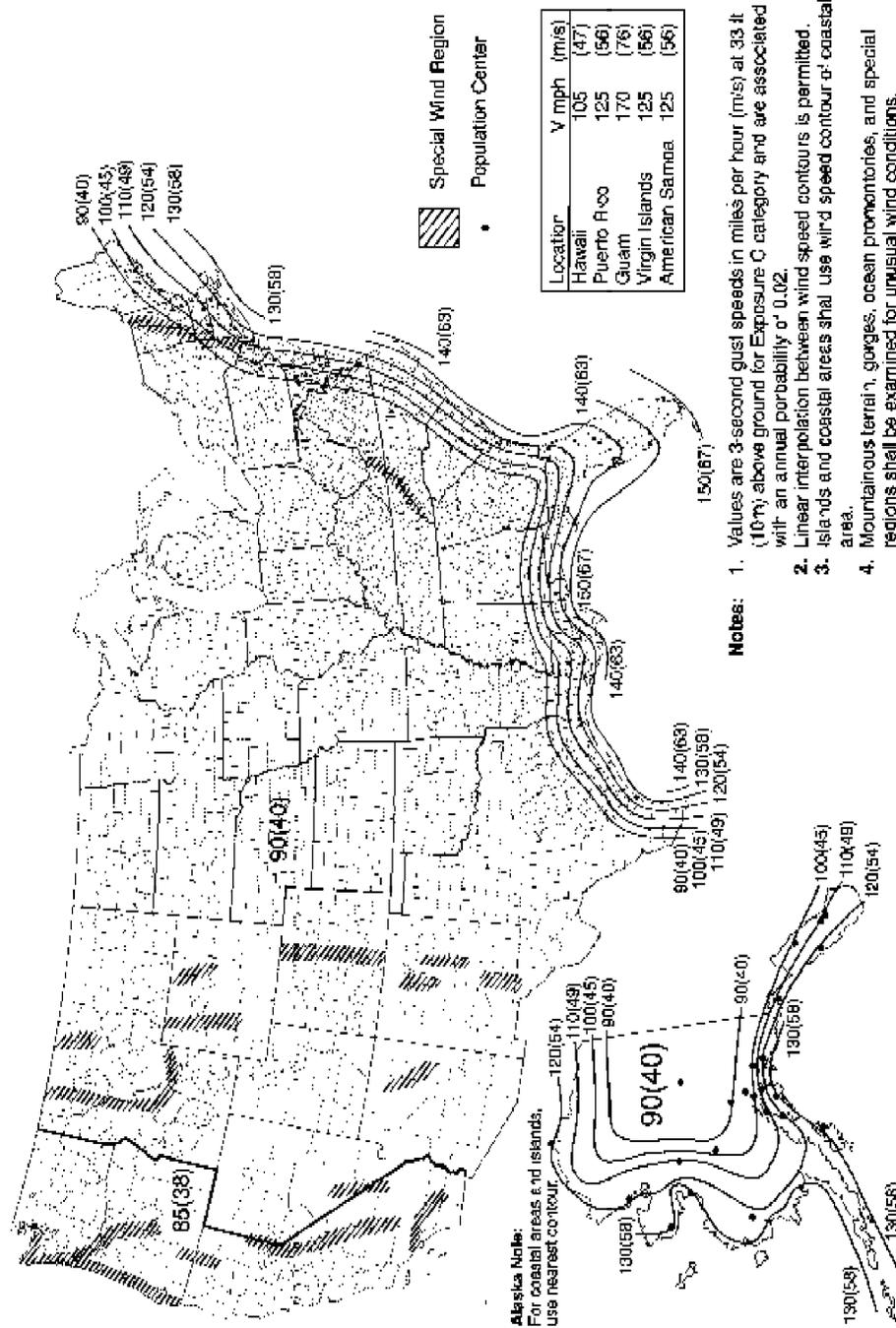


Figure 2: Basic Wind Speed from ANSI/ASCE 7-95, pp 18 - 19¹
reprinted from ASCE 7-95 Minimum Design Loads with permission of ASCE (2/96)

**SPRI Test Method RE-1
Test for Roof Edge Termination of
BALLASTED OR MECHANICALLY ATTACHED
ROOFING MEMBRANE SYSTEMS**

(See Commentary: SPRI Test Method RE-1)

The termination shall withstand a minimum force of 100 lbs/ft (134 kg/m) according to Section 4.1 of the Standard when tested using the following method.

A minimum 12 inch (300 mm) wide mock-up of the termination system shall be constructed and mounted on the base of a tensile testing device so the membrane is pulled at a 45° angle to the roof deck to simulate a billowing membrane (see Figure 3). For devices in which fasteners are part of the membrane securement, at least two such fasteners shall be included in a balanced sample.

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 Figure 3). The tester is loaded until failure occurs. Failure is defined as any event that allows the membrane to come free of the edge termination or the termination to come free of its mount. The roof edge termination strength is deemed satisfactory if the test force at failure on a 12 inch (300 mm) wide sample meets or exceeds 100 pounds per foot (150 kg/m).

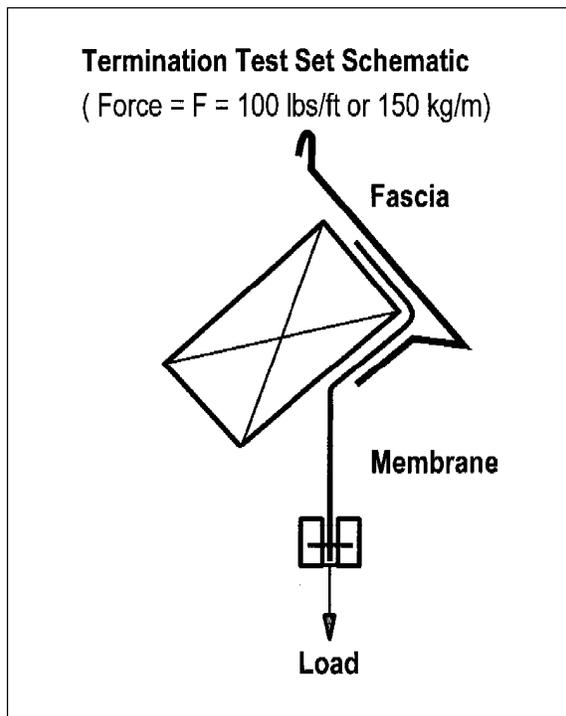


Figure 3: Termination Test Schematic

**SPRI Test Method RE-2
Pull-Off Test for Edge flashings**

(See Commentary: SPRI Test Method RE-2)

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 4. The test apparatus shall be constructed so that the performance of individual components is unaffected by edge or end constraints on the test sample.

2. Safety Precautions

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

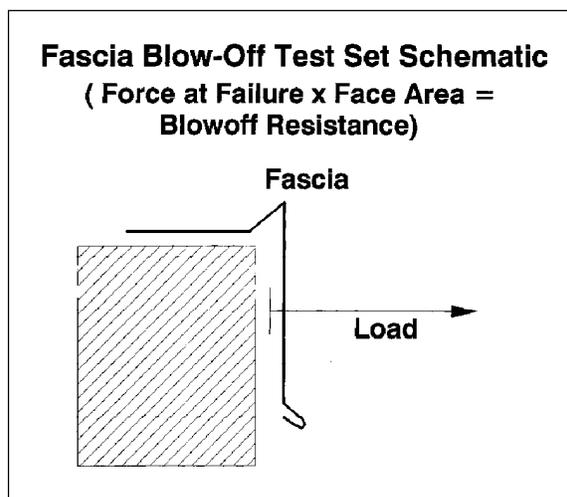


Figure 4: Fascia Test Schematic

3. Test Specimens

All parts of the test specimen shall be full size in width and all other dimensions, using the same materials, details and methods of construction and anchoring devices (such as clips or cleats) as used on the actual building. Sample length shall be the average length designed for field use on the project with a minimum of 8 feet (2.4 m). When the longest length designed for the project is less than 8 feet (2.4 m) the longest design length shall be used. When the anchoring means at the ends of the edge flashing are normally used to restrain other additional lengths of edge flashing, then the anchoring means shall be modified so that only that percentage that might restrain rotational movement in the test specimen is used.

4. Procedure

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 at the drip edges will not occur in the normal orientation.

4.2 Stabilization

A dial gauge shall be attached to the centerline of each loaded surface to detect movement. Stabilization of the test shall be when the gauge ceases to show movement.

4.3 Loading

Loading shall be applied uniformly on centers no greater than 12" (300 mm) to the vertical face of the edge flashing. 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 loading shall be reduced to zero until the specimen stabilizes, or for five minutes, whichever happens first. After a recovery period of not more than five minutes at zero load, initiate the next higher incremental load. Loading to the face of the edge flashing shall be applied in increments not to exceed 25 lb/sq. ft. (120 kg/m²) until approximately 60 lb/sq. ft. (300 kg/m²) is obtained. Thereafter, increments of load shall not exceed 10 lb/sq. ft. (5 kg/m²). Loading speed shall be such that each incremental load up to and including 60 lb/sq. ft. (300 kg/m²) shall be achieved in 60 seconds or less. Above 60 lb/sq. ft. (300 kg/m²), 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 increments of load application shall be chosen so that a sufficient number of observations are made to determine the exact load at failure. The last sustained 60-second load without failure is the maximum load recorded as the design value.

Section 3.2

4.4 Failure:

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

4.5 Test Results

The total force at the conditions described in 4.3 above shall be recorded. This force shall be converted to pressure by dividing the force by the area of the face: Force is measured in Pounds

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

Force, Length is the test sample length in feet, Height is in Feet (inches/12), Pressure is in Pounds per Square Foot. If test results exceed the design outward wind pressure, the edge flashing has acceptable wind blow-off resistance.

SPRI Test Method RE-3 Pull-Off Test for Copings

(See Commentary: SPRI Test Method RE-3)

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 5 and 6. The test apparatus shall be constructed so that the performance of individual components is unaffected by edge or end constraints on the test sample.

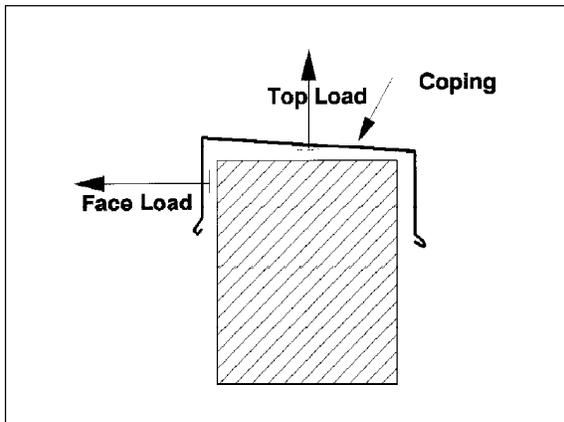


Figure 5: Coping Bi-Directional Test Schematic: Top and Face Leg.

2. Safety Precautions

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

3. Test Specimens

All parts of the test specimen shall be full size in width and all other dimensions, using the same materials, details and methods of construction and anchoring devices (such as clips or cleats) as used on the actual building. Sample length shall be the average length designed for field use on the project with a minimum of 8 feet (2.4 m). When the longest length designed for the project is less than 8 feet (2.4 m) the longest design length shall be used. When the anchoring means at the ends of the edge flashing are normally used to restrain other additional lengths of edge flashing, then the anchoring means shall be modified so that only that percentage that might restrain rotational movement in the test specimen is used.

4. Procedure

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.

4.2 Stabilization

A dial gauge shall be attached to the centerline of each loaded surface to detect movement. Stabilization of the test shall be when the gauge ceases to show movement.

4.3 Loading

Face and top loadings shall be applied simultaneously in the ratio of (Face Height x Horizontal C_p) to (Top Width x Vertical C_p) in which the Face Height is the height of the face (front or back leg) being tested. Loading shall be applied uniformly on centers no greater than 12" (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. 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 loading shall be reduced to zero until the specimen stabilizes, or for five minutes, whichever happens first. After a recovery period of not more than five minutes at zero load, initiate the next higher incremental load. Loading to the top of the coping shall be applied in

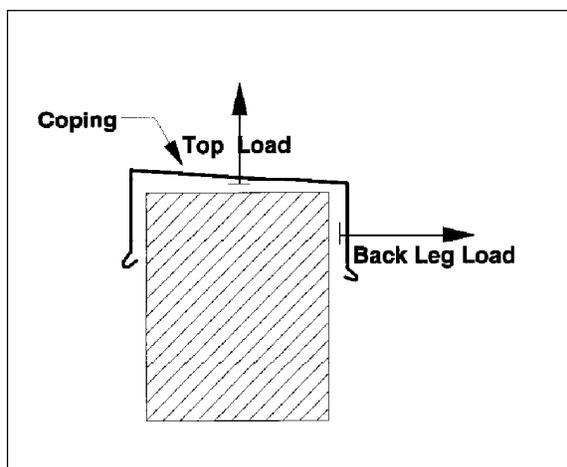


Figure 6: Coping Bi-Directional Test Schematic: Top and Back Leg.

increments not to exceed 25 lb/sq. ft. (120 kg/m²) until approximately 150 lb/sq. ft. (730 kg/m²) is obtained. Thereafter, increments of load shall not exceed 10 lb/sq. ft. (5 kg/m²). Loading speed shall be such that each incremental load up to and including 150 lb/sq. ft. (730 kg/m²) shall be achieved in 60 seconds or less. Above 150 lb/sq. ft. (730 kg/m²), 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 increments of load application shall be chosen so that a sufficient number of observations are made to determine the exact load at failure. The last sustained 60-second load without failure is the maximum load recorded as the design value.

Both face and back legs shall be tested in this manner. Separate test samples shall be used for testing the face and back legs: One sample to test the face while loading the top (See Figure 5), and the other to test the back leg while loading the top (See Figure 6).

4.4 Failure

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

4.5 Test Results

The total of upward and outward forces at the conditions described in 4.3 above shall be recorded. Each total force shall be converted to pressure by dividing the force by the area of the surface upon which it acts:

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

$$\text{Upward Pressure} = \frac{\text{Upward Force}}{\text{Coping Width} \times \text{Coping Length}}$$

Pressure is measured in pounds per square foot,

- Force is measured in Pounds Force,
- Length is the test sample length in feet,
- Height is in Feet (inches/12).
- "Face" refers to back leg or front leg of the coping specimen.

If the test results meet or exceed the design upward and outward wind pressures on both front and back leg tests, the coping has acceptable wind blow-off resistance.

**COMMENTARY to
WIND DESIGN STANDARD for EDGE SYSTEMS USED with
LOW SLOPE ROOFING**

This Commentary consists of explanatory and supplementary material designed to help designers, roofing contractors and local building authorities 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.

1 INTRODUCTION

This Design Standard was developed for use with Built-Up (BUR), Single-Ply and Modified Bitumen roofing systems. While the Standard is intended as a reference for designers and roofing contractors, the design responsibility rests with the “designer of record.”

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, edge flashing boards, etc.

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

Perimeter systems considered for this Standard are differentiated into two general types:

COPINGS/CAPS: These are designs that cover the tops of parapet walls, usually with the roofing membrane terminated under them.

EDGE FLASHINGS: These are products or designs that 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 by the edge by means of a mechanical gripping of the roofing between metal flanges or by a bond between the roofing and edging.

Termination devices against vertical walls in-board of the roof edge are not considered by this Guideline.

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.

Two general classes of materials cover nearly all perimeter systems. They are:

EXTRUSIONS: Shapes or designs made by forcing heated metal or polymeric material through pre-cut custom dies. These designs are usually of a heavier gauge than formed products, but many extrusions must have their finish applied after manufacturing.

FORMED METAL: Sheets of metal, usually steel, aluminum or copper, bent on press brakes or roll-forming equipment to match a desired design or configuration. Available in many thicknesses and frequently with a variety of finishes.

MAINTENANCE

The design engineer should consider maintenance of the roof edge. See the [ARMA/NRCA/SPRI Repair Manual for Low-Slope Roof Membrane Systems⁶](#).

SUMMARY

This document addresses factors that should be considered in the specification and design of roof edge systems for low slope roofing systems. Good design practice requires consideration of nailer, roof edge and membrane securement, and also selection of materials and finishes to minimize corrosion, and metal gauges to assure strength and flatness.

COMMENTARY

2 GENERAL DESIGN CONSIDERATIONS AND DEFINITIONS

Determination of the appropriate wind force category shall be based on wind speed, Exposure, building height, topography and the edge detail location on the building. Location of the edge detail on the building is also important, since blow-off forces increase near the corners.

2.1 WIND SPEED

Special wind regions (mountains or valleys): Refer to Section 6.5.5 of the ANSI/ASCE 7-95¹ Commentary.

The intensifying effects of topography (hills or escarpments) are to be accounted for. Speedup over hills and escarpments is accounted for in ASCE 7-95 by means of a topographic factor, k_{zt} that depends on the height of the building, the height and slope of the hill or escarpment, the distance of the crest upwind of the building, and whether the terrain is a hill or an escarpment.

2.3 CORNER REGION

The angle at which the walls meet to constitute a corner is undefined here and in ASCE 7-95. It has been suggested that an airflow separation effect begins to take effect when walls meet at 150°. Therefore, since most walls meet at angles more acute than this, the meeting angle is not a practical consideration for this Standard⁷.

2.4 EDGE CONDITION

The roof edge 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^b. Where multiple courses of nailers are used, these nailer courses should also be sealed to each other. Butt-joints should also be sealed.

2.5 EXPOSURE

The terrain surrounding a building will influence the exposure of that building to the wind.

2.5.3 EXPOSURE C

Consistent with ASCE 7-95, the Standard uses Exposure "C" for all buildings with heights 60 ft. (18 m) or less. For building heights of 60 feet or less in Exposure "B," use 15% lower load than for Exposure "C."

2.6 IMPORTANCE FACTOR

The **Importance Factor**, *I*, accounts for the degree of hazard to human life and damage to property. The Importance Factor, *I*, is used to modify the wind speed and, in effect, assign different levels of risk based upon intended use of the structure. Category I Exposure gives a 25 year mean recurrence value while Categories III and IV give 100 year mean recurrence values. Other recurrence values can be found in the Commentary of ASCE 7-95¹.

3 SYSTEM REQUIREMENTS

Resistance to blow-off depends not only upon the attachment of the roof edge device to the edge of the building, but also upon the integrity of the nailer or other substrate to which the edge device is attached. It is important to consider the load path from the nailer to the foundation of the building to assure proper wind load protection.

Table 7

Substrate	Safety Factor	
	Static Load	Wind Load
Wood ⁸	6.0	4.5
Masonry ⁹	4.0	3.0
Steel ¹⁰	2.5	1.9

Common fastener safety factors follow. Note that when designing for wind, static load safety factors may be reduced by 25%.

WOOD MEMBERS

Nailers should be pressure treated wood¹¹ secured by corrosion resistant¹² anchor bolts countersunk into the wood nailer and attached to the nailer with nuts and washers. Anchor bolts should be of sufficient size and spacing to re-

^bAn appropriate sealant is a single or multi-component elastomeric material used to weatherproof construction joints.

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sist the design load and a minimum 200 lbf/ft (300 kg/m) vertical load. For wood nailers wider than 6" (152 mm), bolts should be staggered to avoid splitting the wood. Each wood nailer member should have at least two fasteners. A fastener should be located approximately 4" (100 mm) and minimum 3" (75 mm) from each end of the wood. Additional wood members, such as edge flashings, cant strips and stacked nailers should be fastened with corrosion resistant fasteners having sufficient pullout resistance. Fasteners should be staggered, spaced at a maximum 12 inches (305 mm) on centers, and should penetrate the wood sufficiently to achieve design pullout resistance. Spacing should be on maximum 6 inches (152 mm) centers in corner regions^c.

MASONRY

When imbedded in masonry, anchor bolts as defined above should be bent 90° at the base or have heads designed to prevent rotation and slipping out. When hollow block masonry is used at the roof line, cores and voids in the top row of blocks should be filled with concrete having a minimum density of 140 lbs/cu ft (10,900 g/m³). When imbedded in light aggregate block, bolts should be embedded minimum 12 inches (300 mm) into concrete fill. When heavy aggregate blocks are used, bolts should be embedded minimum 8 inches (200 mm).

LIGHT WEIGHT CONCRETE AND GYPSUM DECKS

Nailers should not be fastened to light weight concrete or gypsum decks. Instead, anchor nailers directly to wall structural members using fasteners whose size and locations meet the Standard under 3.1 above.

STEEL DECK

The steel deck should be designed to withstand the design forces specified under 3.1. Nailer attachment should be strong enough to resist 200 lbf/ft (300 kg/m) vertical load.

NAILERLESS SYSTEMS

When the roof edge is attached directly to masonry or steel without the use of a nailer, its attachment configuration should be tested to resist wind loading, using tests specified in Section 4 of this Standard.

REROOFING

For nailer security when reroofing, the contractor should check to be sure the nailer or other substrate is in good condition and well secured to the building. Questionable members should be removed and replaced according to the above guidelines. Note that it is much more difficult to be sure that the load path (connection of roof members ultimately to the building foundation) is secure for an existing building than it is for new construction. The roofing contractor should notify the designer if unexpected conditions or deteriorated substrate materials are discovered during the reroofing process.

4 DESIGN OPTIONS

Holding power of the edge detail is divided into two considerations. The first is the resistance of the edge to outward and upward forces that tend to blow or peel the edge system off the substrate. The second is the ability of the edge to resist the pull of the roofing inwardly.

Edge details may be selected from manufacturers who certify certain minimum performance to meet design requirements, based upon testing. Other designs may be used, provided they are tested and certified by an independent testing laboratory to meet the wind and pullout resistance design standards suggested in this document.

4.1 MEMBRANE ATTACHMENT

The edge flashing may be the only restraint preventing a roof blow-off. In ballasted systems, ballast may be scoured away from the edge. Mechanically attached membranes may be attached only by the edge flashing at the building edge. The 100 lb/ft (1.46 kN/m) may not be sufficient if there is a large amount of scour, exposing a wide span of roofing.

Consideration should be given to sealing the edge against air infiltration. Air infiltration may affect the loads on the roofing and the perimeter edge detail¹³ by adding a positive pressure under the roofing, thus compounding the effect of negative pressure above the roofing.

^cSee section 2.3 of the standard for the definition of corner regions.

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4.2 & 4.3 WIND RESISTANCE OF EDGE FLASHINGS & COPINGS

Although all edge devices are to be tested according to the tests outlined in the Standard and its attachments, the following guidelines may be used to establish designs for testing. The guidelines may be modified to achieve desired test results.

Edge flashings, copings and the like should be secured with continuous cleats of 24 ga steel, 0.050 (2 mm) aluminum or metal of equivalent strength at the bottom of the face edge. Cleats should be secured with annular threaded or screw-shank nails long enough to penetrate the wood nailer at least 1-1/4" (3 cm). Nail heads should be at least 3/16" (5 mm) in diameter. Alternatively, cleats may be secured with minimum No. 8 (4 mm) screws long enough to penetrate the nailer 3/4" (20 mm) or penetrate metal 3/8" (10 mm). Where velocity pressures are less than 45 lbs/ft² (220 kg/m²), cleat fasteners should be placed no farther than 24" (600 mm) apart. Where velocity pressures are greater than 45 lbs/ft² (220 kg/m²) they should be spaced 16" (400 mm) or closer. Fastener frequency should be doubled in corner regions.

Nail heads should be larger than the narrowest dimension of the slotted holes. Where velocity pressures exceed 45 psf (220 kg/m²), add a screw through the back section of the edge flashing near the center of each section and at the center of the joint cover. Edge flashing sections should be spaced to allow for expansion around this screw.

Metal coping should be secured by a cleat at the wall exterior. Where velocity pressures exceed 45 psf (220 kg/m²), the coping should be secured on the inside with No. 10 (5 mm) galvanized screw fasteners through neoprene washers on 30" (760 mm) or narrower centers. At higher velocity pressures, the centers should be 20" (500 mm) or narrower. Screws should be long enough to penetrate the wood nailer at least 1" (25 mm). The effects of thermal expansion should be considered. Screw holes in the coping should be pre-punched or drilled oversize to allow for thermal expansion if aluminum thicker than .063" (1.6 mm) is used.

To ensure adequate holding, edge designs should also include a drip edge that securely engages the cleat. Inadequate securement may

lead to a release of the edge, resulting in the ultimate failure of the roof edge device.

Fastener spacing is doubled in corner regions to account for the increased wind forces in these regions.

5 DESIGN PROVISIONS

5.1 WIND RESISTANCE

TABLE 4 values have been calculated using Equation 6-1 from Section 6.5.1 of ASCE 7-95¹, for $I=1.0$ and $K_{zt}=1.0$:

$$q_z = 0.00256 \times K_z \times K_{zt} \times V^2 \times I$$

in which:

q_z = Velocity Pressure (the Velocity Pressures shown in Table 4 of this Standard is actually " q_z/I " as defined in ASCE 7-95 and therefore are to be multiplied by " I " to obtain q_z),

K_z = Velocity Pressure Exposure Coefficient from Equation C-3 in the Commentary Section of ASCE 7-95 (Also shown as Table 6-3 in ASCE 7-95),

K_{zt} = Topographical factor for buildings built on hills or escarpments (from Equation 6-2 of ASCE 7-95),

V = Basic Wind Speed, mph, from Attachment I of this Standard and

I = Importance factor defined in Table 3.

Velocity Pressure " q_z " is the pressure imparted by the energy of the wind. In practice, aerodynamics will cause actual wind pressures to differ from theoretical values at certain locations on the building. A building with a flat, level (or slightly sloped) roof will experience greater forces at the corners and eaves than on interior roof surfaces because of eddy effects at the eaves. These effects are accounted for by using the products of Pressure Coefficient and Gust Factor, GC_p obtained from Table 5 (Section 5.1) which is taken from ASCE 7-95¹, Figures 6-5 and 6-8, assuming an "effective wind area" of 10 square feet or less. The vertical component was taken from the values for Surface 2 on those Figures. ASCE-7-95 does not address the horizontal component of GC_p at the roof edge. Therefore, the horizontal value of GC_p was taken from the values for Surface 5, which is the vertical corner region. That surface

Section 3.2

was selected because it presents nearly the same geometry to the wind as would the roof edge.

ASCE 7-95 suggests different pressure coefficients in corner regions. Instead of using ASCE 7-95 pressure coefficients for corner regions in this Standard, the design method was simplified by requiring doubled fastening in these regions.

5.2 METAL THICKNESS

Increased metal thickness improves the flatness reduces the “oil-can” effect of the roof edge metal. The required minimums do not address other important design factors such as fastening pattern and frequency, continuous or intermittent cleating, stiffening ribs or brakes in the edges. Metal thickness may need to be increased for higher wind areas unless Tests RE-2 or RE-3 have been performed.

5.3 GALVANIC COMPATIBILITY AND RESISTANCE

Corrosion and strength should be considered in the choice of materials. This Standard focuses primarily on metal edge systems. When plastic materials are used, corrosion is not usually a factor (although environmental deterioration must be considered), however, strength of the materials must be considered.

Corrosive potential can be roughly predicted by knowing the placement of the two metals in the Galvanic Series. The farther apart the metals are in the Galvanic Series, the greater is this potential for corrosion. Metals adjacent to each other in the Series have little potential for corrosion. In the following list (Galvanic Series), the metals high on the list are potentially corroded while those low on this list are protected. Frequently, the corrosion rate of “sacrificed” metals will be low, even if there is a potential for corrosion. Thus there will generally be little corrosion between metals that are close to each other on the list, however, when they are in contact, the lower of a pair will be protected by the higher even if no perceptible corrosion is taking place.

For this reason, steel, being lower on the list than zinc will be protected by the zinc, which is “sacrificed” to save the steel. Fortunately, though there is a potential for corrosion between zinc and steel, under most conditions, the rate of corrosion is minuscule so that the zinc lasts many years while electrolytically protecting the steel.

Similarly, pairs of metals such as aluminum and zinc or aluminum and stainless steel will show no perceptible corrosion between them, because of their proximity to each other on the list. On the other hand, pairing copper with zinc or aluminum or even steel must be avoided because copper is far from them on the Galvanic Series and the potential for corrosion is great.

In extremely corrosive environments such as salt water environments, chemical plants or paper mills, corrosion resistant materials such as stainless steel shall be used.

**Table 8
Galvanic Series¹⁴**

Anodic or Least Noble (Corroded End)
Magnesium Zinc Aluminum Cadmium Steel Stainless Steel Lead Tin Copper Titanium Silver Gold
Cathodic or Most Noble (Protected End)

TEST METHOD RE-1

The method with which the edge of the roofing membrane is terminated (edge flashing, nailer, or other) is the last anchor point to hold the membrane in place should the membrane happen to separate from the roof deck during a high wind. When this happens, the roof system will put a load on the termination. Therefore, the termination must withstand a minimum force of 100 lbs/ft (134 kg/m) when tested using the method. This value has been adopted from the ANSI RP-4 Standard.

This is a new procedure. The precision and bias of the test measure has not been determined.

TEST METHODS RE-2 and RE-3

4.2 Stabilization

Stabilization is necessary during loading to insure 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.

4.3 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 coping or edge flashing system profiles or members of the anchor systems. Loads are applied to simulate the static wind loading of the members. Test RE-2, for edge flashings, requires loads on only the vertical face since the uplift wind loading on an edge flashing member is considered to be negligible. Since corners are difficult to test with these methods, corner areas are best handled by designing a device to pass RE-2 or RE-3 as appropriate and doubling the number of fasteners in corner regions.

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 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 relatively long times followed by brief recovery periods. This incremental method is more stringent than continuous loading because of the requirement of holding a load for 60 seconds.

The Standard requires 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 noncontinuous cleating can exhibit different performance under testing than in the field if the cleats do not act upon the products as they would in the field. For example, if a product requiring two cleats in a 144 inch (5669 mm) length were tested as a 36" (914 mm) sample with one cleat, the cleat would act over a larger percent of the product than would be experienced in the field, rendering the results difficult to translate to the field.

These are new procedures. The precision and bias of these test measures have not been determined.

4.4 Failure

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

- Full nail pull-out at some point
- Collapse of a cleat, fascia or cover
- Disengagement of a face or coping at the drip-edge

5.2 Metal Thickness

Table 6 was developed from NRCA and Factory Mutual recommendations. The table has been constructed to simplify its use over the Factory Mutual table and to extend the range of fascia widths beyond that given by NRCA.

EXAMPLE

Consider a 95 foot (30 m) high suburban conference-type hotel building in Suburban Atlanta. Attachment I is a map showing basic wind speeds for most of the United States.

Basic Wind Speed from the Map is 90 mph.

The "Exposure" for such a building according to the definitions given on Page 3 of the Design Standard is Exposure "C." Consulting Table 4 for Exposure "C," at 90 mph, the velocity pressure, q_z , for a 95 foot structure at 90 mph is 26 pounds per square foot (psf).

Velocity Pressure = 26 psf

The Importance Factor (see Table 1 and Table 3) would be that of a Category II building (occupancy by more than 300 people in one room). The importance factor I , is 1.15 for this building.

Importance Factor Multiplier (I) = 1.15

Velocity Pressure is multiplied by the Importance Factor Multiplier to obtain an Adjusted Velocity Pressure:

$$\text{Adjusted Velocity Pressure} = 26 \times 1.15 = 30 \text{ psf}$$

Using a Pressure Coefficient (GC_p) from Table 5 of -2.3 for the vertical direction and -1.8 horizontally, the following design force is calculated:

$$\text{Vertical Design Pressure: } -2.3 \times 30 \text{ lb/sq. ft.} = -69 \text{ lb/sq. ft}$$

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Horizontal Design Pressure:
-1.8 X 30 lb/sq. ft. = -54 lb/sq. ft

In this case, a coping must be tested to withstand 54 psf (lb/sq. ft.) outward force and 69 psf uplift force.

If the coping had 4" legs and a cap width of 18 inches, the cap would be required to withstand an upward force of:

1.5 sq. ft./ft x 69 lb/sq. ft. = 104 lb/ft
and outward forces of:
.33 sq. ft./ft x 54 lb/sq. ft. = 18 lb/ft
on each face.

The coping is to be tested according to SPRI Test RE-3 run on straight lengths. Doubling fasteners in the corner region will be sufficient instead of testing corner assemblies if the straight length assembly passes RE-3. Note that in testing the edge device, upward forces and outward forces on a face are to be applied simultaneously and both face leg and back leg tests are to be run.

If the perimeter were an edge flashing instead of a coping, it would need to withstand an outward design force of 54 psf.

If the edge flashing had a 6" (0.5 sq. ft./ft) face, the design resistance would need to be

0.5 sq. ft./ft x 54 lb/sq. ft. = 27 lb/ft.

The edge flashing is to be tested according to SPRI Test RE-2 run on straight lengths. Doubling fasteners in the corner region will be sufficient instead of testing corner assemblies if the straight length assembly passes RE-2. Furthermore, the edge flashing must be tested according to SPRI Test RE-1 to restrain a 45° pull of 100 pounds per foot if it is the termination of Single-Ply or Modified Bitumen Membrane.

A roof edge may be designed and tested to meet the above criteria, or one may be selected that has been previously certified to meet the minimum design requirements of this Standard.

REFERENCES

1. *Minimum Design Loads for Buildings and Other Structures*, ASCE 7-95, American Society of Civil Engineers, New York, 1996.
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4. *Cold formed Steel Manual*, AISI, 1986.
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7. James R. McDonald, Texas Tech University, Private communication with John Hickman, August, 1997.
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14. Perry ed. *Chemical Engineers Handbook*, McGraw-Hill, New York, 1963. Table 23-1.

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