ANSI/SPRI/FM 4435/ES-1

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

Approved September 29, 2011

Table of Contents

1. **Introduction** 2

2. **Background Information** 5

3. **General Design Factors** 5

4. **Wind Design of Edge Systems** 8

5. **Edge System Resistance** 10

6 **Performance of Light Gauge Metal** 10

7. **Appliances** 11

8. **Packaging and Identification** 11

9. **Installation Instructions** 11

10. **References** 11

Appendix A—Tables 12

Appendix B—Edge System Testing 22

Appendix C—Basic Wind Speed Map 28

Commentary 30

Approved American National Standard
ANSI

SPRI
Single Ply Roofing Industry

FM Approvals
Member of the FM Global Group

Copyright by SPRI 2010

411 Waverley Oaks Road
Suite 331
Waltham, MA 02452

www.spri.org.

All Rights Reserved

Disclaimer

This standard is 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.

1. Introduction

1.1 Scope

This Standard provides the basic requirements for wind load resistance testing and design for roof edge securement, edge systems and nailers. It also provides minimum material thicknesses that lead to satisfactory flatness, and designs to minimize corrosion. This Standard is intended for use by those that design, specify, and manufacturer roofing materials and edge systems used in the roofing industry. The membrane manufacturer shall be consulted for specific recommendations for making the roof watertight at the edge.

This Standard applies to low slope membrane roof systems, with low slope defined here as roofs having a slope ≤ 9.5 degrees (2:12). The design and installation information found in this document addresses copings and horizontal roof edges, as well as the following factors which shall be considered in designing a roof edge:

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

This version of the Standard has been revised based upon the design document titled *ASCE 7-05—Minimum Design Loads for Buildings and Other Structures*[1] to provide a calculation method for the determination of the wind uplift pressures on components and cladding for any building. The complete ASCE 7-05 document has not been duplicated here; however key information does appear as necessary. The intent of this Standard is to organize information within the ASCE 7-05 document which directly pertains to the design of roof edges, and to condense design information when possible. Gutter designs are not included in this design standard.

The External Pressure Coefficients, GCp, in this document have changed from the ANSI/SPRI ES-1 2003 Standard. This has produced a small change in the ratio of horizontal loading to vertical loading in the RE-3 Test for any roof height. Any products tested in accordance with previous versions of the ANSI/SPRI ES-1 Standard will not need to be retested per RE-3 solely as a result of the change in the ratio of horizontal to vertical loads.

1.2 Definitions

ANSI
American National Standards Institute

ASCE
American Society of Civil Engineers

Aluminum
a non-rusting, malleable metal sometimes used for metal flashings.

Ballast
an anchoring material, such as aggregate 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.

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

Clips
a non-continuous metal component or angle piece used to secure two or more metal components together.

Cold rolled
the process of forming steel, aluminum, and copper into sheets, panels, or shapes on a series of rollers at room temperature.

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

Copper
a natural weathering metal used in metal roofing or flashings.

Design loads
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 and help protect underlying building components.

Escarpment
a steep slope in front of a fortification which separates two relatively level areas of differing elevations.

Extrusion
a process in which heated or unheated materials is forced through a shaping orifice (a die) in one continuously formed shape, as in film, sheet, rod or tubing.

Fascia
the vertical or steeply sloped roof or 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 edge components.

Fastener pull-out
a type of failure mode in which a fastener pulls away from a substrate (e.g.: nailer) under load.

Fastener pull-through
a type of failure mode in which a fastener head pulls through a substrate (e.g.: nailer) under load.

Field of roof pressure
the wind pressure (generally upwards) imparted on a central area of the roof.

Flatness
a three-dimensional geometric tolerance that controls how much a feature can deviate from a flat plane.

Galvanic action
an electrochemical action that generates electrical current between two metals of dissimilar electrode potential.

Galvanic series
a list of metals and alloys arranged according to their relative electrolytic potentials in a given environment.

Galvanize
to coat steel or iron with zinc.

Gravel stop
a flanged device, frequently metallic, designed to prevent loose aggregate from washing off the roof and to provide a continuous finish edge 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).

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 and hammered into thin sheets.

NRCA
National Roofing Contractors Association

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

Press brake
a machine used in cold-forming sheet metal or strips of metal into desired profiles.

Ridge
highest point on the roof, represented by a horizontal line where two roof areas intersect, running the length of the area.

Roof deck
the flat or sloped surface not including its supporting members or vertical supports.

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 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 edge system
a component or system of components at the perimeter of the roof that typically is integrated into the roof system for the purpose of flashing and securing the roof membrane.

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

SMACNA
Sheet Metal and Air Conditioning Contractors' National Association, Incorporated.

Static load
any load that does not change in magnitude or position with time.

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.

Thermal expansion
the increase in the dimension or volume of a body due to temperature variations.

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

Wind uplift
wind that is deflected at roof edges, roof peaks or obstructions can cause a drop in air pressure immediately above the roof surface. The resultant force is transmitted to the roof surface and is called wind uplift.

Zinc
A bluish-white, lustrous metallic element which is used to form a wide variety of alloys including brass, bronze, in galvanizing iron and other metals, for roofing and gutters and other various components.

2. Background Information

2.1 Wind Related Roofing Damage

No area of the country is exempt from wind related roofing damage. A study of 145 FM Global losses involving built-up roof (BUR) systems showed 85 losses (59 percent) occurred because the roof perimeter failed[2]. 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"[3]. RICOWI notes that their "studies reinforced the need for secure roof edges, and codes that require secure roof edging need to be enforced"[4].

3. General Design Factors

3.1 Roof Slope

Roof Slope is accounted for in the pressure coefficient factors used in this document. Only roof slopes ≤ 9.5° (2:12) are addressed by this document.

3.2 Roof Edge Conditions

Roof edges composed of low slope roofs terminating into a parapet wall or a lower vertical element of the building are addressed in this document.

3.3 Wind Speed

Basic wind speed values used in the design calculations are 3 second gust speeds in miles per hour (0.45 m/s) measured at 33 ft. (10 m) above ground for Exposure Factor C associated with an annual probability of 0.02. These values are to be taken from the ASCE 7-05 document (See Appendix C) or the authority having jurisdiction. The authority having jurisdiction shall be contacted for verification of wind data for special wind regions mentioned in applicable local building codes. Consult ASCE 7-05 for further information concerning special wind regions. **Limitation:** Wind conditions above basic wind speeds (e.g. tornadoes) were not considered in developing the basic wind speed distributions.

3.4 Building Height

The building height shall be measured from the ground to the eave of the roof section. Specific topographic features, such as hills, shall be considered when calculating building height. See Commentary.

3.5 Roof Edge Regions

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

3.5.1 Corner Region

For buildings with mean roof height of 60 ft. (18 m) or less: 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 ft. (0.9 m). See also ASCE 7-05.

For buildings with mean roof height greater than 60 ft. (18 m): The corner region is a distance from the building corner that is 20% of the minimum building width but not less than 6 ft. (0.9 m). See also Commentary and ASCE 7-05.

3.5.2 Perimeter Region

The perimeter is the section of roof edge between building corner regions as defined in Section 3.5.1 (above). The edge condition includes the roof edge device (edging or coping) and the nailer or other substrate to which the edge device is attached. See Commentary for further information.

3.5.3 Face Height and Coverage

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

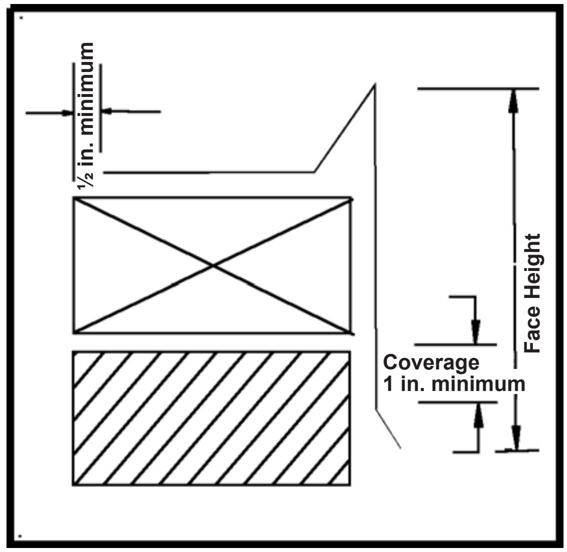


Figure 1: Face Height and Coverage

3.6 Exposure

The building shall be classified into Exposure Categories based on surrounding terrain. Table 1 explains these exposure categories.

Table 1
Exposure Categories

Wind Exposure Categories	
B	Surface Roughness B: Urban and Suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger. This applies where the ground surface roughness condition prevails in the upwind direction for a distance of at least 2600 ft. (792 m) or 20 times the height of the building, whichever is greater. **Exception:** For buildings whose mean roof height is less than or equal to 30 ft. (9.1 m), the upwind distance may be reduced to 1500 ft. (457 m)
C	Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 30 ft. (9.1 m). This category includes flat open country, grasslands, and all water surfaces in hurricane prone regions. Exposure C shall apply for all cases where exposures B or D do not apply.
D	Surface Roughness D: Flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice. This shall apply where the ground surface roughness, as defined by surface roughness D, prevails in the upwind direction for a distance at least 5000 ft. (1524 m) or 20 times the building height, whichever is greater. Exposure D shall extend into downwind areas of Surface Roughness B or C for a distance of 600ft (200 m) or 20 times the height of the building, whichever is greater.

See Commentary for more information related to surface roughness condition B, C, and D

ANSI/SPRI/FM 4435/ES-1
Wind Design Standard for Edge Systems Used with Low Slope Roofing Systems

Approved September 29, 2011

3.7 Importance Factor

Buildings shall have an "Importance Factor" included in the wind design calculations. Table A1 (See Appendix A) defines these building classifications. Refer to Section 4.2.1 for use of Importance Factor. See also Commentary and ASCE 7-05 for details and exceptions.

3.8 Membrane Termination

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

3.8.1 Dependently Terminated Systems

Ballasted Systems, ribbon 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 outside edge of the nailer are considered dependently terminated by the edge system. For these systems the RE-1 Test is applicable in addition to the RE-2 Test.

3.8.2 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 outside edge of the nailer are considered independently terminated. For these systems the RE-2 Test or RE-3 Test is applicable.

3.9 Nailer System Requirements

3.9.1 Nailer Secured Systems

Wood blocking or nailers used to attach roof edge system components shall be designed and installed to resist the design outward and upward loads determined for the roof edge system per Section 4.2.1. Commentary Section 3.9 shall be used as a nailer design guide.

Wood nailers shall have minimum thickness of 1.5 in. (38 mm). For edge systems used to secure the roofing (e.g., gravel stops), the substrate (e.g. nailer) shall extend at least ½ in. (13 mm) beyond the back edge of the horizontal flange of the roof edge device (See Figure 1).

3.9.1.1 Nailer Attachment to Masonry

All anchor bolts shall be designed to resist the design wind load and shall be firmly attached to the masonry structure to provide a continuous load path. See Commentary 3.9.1.1 for specific information concerning anchor bolts.

3.9.1.2 Nailer Attachment to Lightweight Concrete and Gypsum

Anchors and anchor substrates shall be designed to resist the design wind load. Alternatively, all roof perimeter nailers shall be attached directly to building structural members to provide a continuous load path.

3.9.2 Nailer Attached to Steel Deck

All roof perimeter nailers attached to steel decks shall be designed to resist the design wind loads. The steel decks shall be attached to the structure to provide a continuous load path.

3.9.3 Nailerless Systems

The direct attachment of edge systems to masonry or steel shall be designed to resist the design wind loads.

3.9.4 Re-roofing

Edge nailers shall be in good condition with no rotted wood or splits. Fasteners shall be adequate to resist the design wind load and not be corroded or missing.

3.10 Other Design Requirements

3.10.1 Local building codes

A local or state building code may have additional wind load provisions which contain additional wind design requirements beyond those found in ASCE 7-05.

3.10.2 Main Wind Force Resisting System

The project engineer of record shall provide the edge system manufacturer with additional design requirements of the edge system as a result of special or non-typical design considerations of the building's main wind force resisting system.

4. Wind Design of Edge Systems

4.1 General Information

The wind design of edge systems is comprised of two parts, the determination of the edge system wind loads (Section 4.2), and the determination of the edge system resistance (Section 5). All materials for roof edge construction shall have sufficient strength (resistance) to withstand the design wind load.

4.2 Wind Load Determination

The following factors apply when determining the wind load of a roof edge system: wind speed, building height, exposure factor, topography, importance factor, corner and perimeter regions, and edge condition. See Commentary and Section 3 for further information.

This document includes an edge system design factor (safety factor) of 2.0.

4.2.1 General Wind Load Design Equation

The roof edge design pressure, P, shall be calculated using the equation shown below:

$$\mathbf{P = 2.0 \times q_{fz} \times GC_p \times I} \qquad \textbf{Equation (1)}$$

where:

P = Roof Edge Design Pressure, psf (kPa)

2.0 = Design Factor

$\mathbf{q_{fz}}$ = Field of roof pressure at height z in feet

$\mathbf{GC_p}$ = External Pressure Coefficient from Table 2

I = Importance Factor from Table A1

To determine the Roof Edge Design Pressure (**P**) determine:

- Building Height (z) from project plans and specifications
- The Wind Speed (V) from Appendix C or the authority having jurisdiction
- The applicable Exposure Category (B, C, or D) by referring to Section 3.6 and project plans or specifications
- Field of Roof Pressure (q_{fz}) in Tables A2–A4.
- The roof edge design Pressure (P) from the equation above by multiplying q_{fz} by I and GC_p. Choose the GC_p value from Table 2 for either a horizontal force or vertical force, and for either a perimeter region or corner region. The horizontal or vertical force pressure, P, can then be compared to edge system resistance (See Section 5).

Notes:

1. Where significant topological features (hills, ridges or escarpments) are present, Topologic Factor, $\mathbf{K_{zt}}$ shall be calculated according to ASCE 7-05 and applied to the Roof Edge Design Pressure, P as calculated in this Standard. See Commentary for more information regarding $\mathbf{K_{zt}}$.
2. See Table 2 and Commentary for open and partially enclosed buildings.

3. A value of I =1.0 (Occupancy Category II) has been used to calculate entries in Tables A2–A4. See Table A1 of this document for other occupancy categories.

4.2.2 GC_p Values

Equation (1) requires the determination of the External Pressure Coefficient, GC_p. Table 2 contains values of GC_p which are applicable to a roof edge system design. See also Table 2 Notes and Commentary for further information.

Table 2
External Pressure Coefficient[1] (GC_p)
Enclosed Building[2]

Type of Loading	Edge Location	Roof Height 60 ft. (18.3 m) or less $z \leq 60$ ft. (18.3 m)	Roof Height over 60 ft. (18.3 m) $z > 60$ ft. (18.3 m)
Horizontal (acting outward from the building edge)	Perimeter	-0.97[3]	-0.68
	Corner	-1.21[3]	-1.25
Vertical (acting upward at the building edge)	Perimeter	-1.68	-1.57
	Corner	-2.53	-2.14

Table Notes:
1. Values of GC_p shown above differ from ASCE 7-05 values due to the incorporation of the internal pressure coefficient, GC_{pi}, and the application of GC_p to the field of roof pressure. See Commentary 4.2
2. See Commentary 4.2 for GC_p values for partially enclosed buildings.
3. Per ASCE 7-05 values shown have taken into account a 10% reduction for roof slopes ≤ 10 degrees. See ASCE 7-05 Figure 6-11A, Note 5, for more information.
4. The negative signs (-) in the External Pressure Coefficients represent vector directionality of the force acting away from the building, tending to pull materials upward or outward (horizontal) from the building.

4.3 Edge Pressure Wind Load Tables

Values of the field of roof pressure, q_{fz}, have been found for various wind speeds and building heights. Tables A2–A4 (Appendix A) contain these values for Exposure Conditions A, B, and C respectively. Refer to Section 3.6 for exposure categories.

Horizontal and vertical edge pressure values are given in Tables A5 (roof height, h, ≤ 60 ft.) and A6 (h > 60 ft.) for various field of roof pressures.

Membrane tension loads are given in Tables A7 (roof height, h, ≤ 60 ft.), and A8 (h > 60 ft.). See RE-1 Test (Appendix B) and Commentary for further information.

4.4 Nailer Securement Load Tables

The load values shown in Tables A9 (roof height, h, ≤ 60 ft.) and A10 (h > 60 ft.) are based on the load imparted to a fastener for a given fastener spacing. See Commentary for more information.

5. Edge System Resistance

Roof edge designs shall be tested in accordance with RE-1, RE-2 or RE-3 as appropriate for the application. See Appendix B—Edge System Testing.

5.1 Dependently Terminated Systems

Edge devices designed to act as membrane termination shall be tested according Test RE-1 and RE-2.

5.2 Edge Flashing, Gravel Stops

For edge systems where the exposed horizontal component is 4 in. (100 mm) or less, the exposed vertical component (face) area shall be tested via the RE-2 Test. For exposed horizontal components greater than 4 in., RE-3 Test is applicable. See RE-2 Test for more information.

5.3 Copings

Coping and other edge devices for which the exposed horizontal component exceeds 4 in. (100 mm) shall pass Test RE-3.

5.4 FM Classifications

Refer to Commentary Section 5.4 for edge system classifications based on their resistance to wind loads.

5.5 Perimeter and Corner Regions

Edge systems installed within perimeter regions shall have sufficient strength to meet perimeter design loads. Similarly, edge systems installed within corner regions shall have sufficient strength to meet corner design loads.

6 Performance of Light Gauge Metal

6.1 Thermal Expansion

Edge Systems shall be designed to allow for free thermal movement due to any differing rates of expansion/contraction between system components and between the system and the substrate to which it is attached. See Commentary.

6.2 Metal Thickness

Minimum gauges for flatness of exposed faces shall be determined from Table 3.

Table 3
Recommended Minimum Metal Thickness for Flatness

Exposed Face	Galvanized Steel	Cold Rolled Copper	Formed Aluminum	Stainless Steel
Up to 4 in. (to 100 mm)	24 ga (0.028 in. 0.7 mm)	16 oz. (0.022 in. 0.6 mm)	0.032 in. (0.82 mm)	26 ga (0.016 in. 0.4 mm)
> 4 in.–8 in. (> 100–200 mm)	24 ga (0.028 in. 0.7 mm)	16 oz. (0.022 in. 0.6 mm)	0.040 in. (1.0 mm)	24 ga (0.016 in. 0.4 mm)
> 8 in.–10 in. (> 200–250 mm)	22 ga (0.034 in. 0.9 mm)	20 oz. (0.027 in. 0.7 mm)	0.050 in. (1.3 mm)	24 ga (0.023 in. 0.6 mm
> 10 in.–16 in. (> 250–400 mm)	20 ga (0.040 in. 1.0 mm)	20 oz. w/stiffening ribs	0.063 in. (1.6 mm)	22 ga (0.029 in. 0.7 mm)

6.3 Galvanic Corrosion

Metal edge devices (face, clip and fastener) shall be comprised of the same kind of metal, or shall be galvanically compatible metal pairs. See Commentary for more information related to galvanic corrosion of dissimilar materials.

Fasteners shall be galvanically compatible with the other roof edge system components[5]. When used with aluminum, steel fasteners shall have a dielectric resistive coating. Copper shall not be used in combination with mill finish steel, zinc or aluminum. Only copper, stainless steel, or copper-alloy fasteners shall be used with the copper components.

6.4 Non-typical building Environments

Metal to be used for highly acidic, caustic or other non-typical environments shall be designed and/or specified by the owner's representative or building's engineer of record.

7. Appliances

Appliance attachments, such as air terminals (lightning rods), signs or antennae that penetrate the water seal, induce a galvanic reaction, or induce a wind load may compromise the effectiveness of the roof edge system. Appliances shall not be attached to the roof edge system, or shall be isolated to prevent the transfer of wind, thermal, or other forces which may compromise the performance of the edge system. Any attached appliances shall also be isolated to prevent galvanic reaction.

8. Packaging and Identification

Edge system components or packaging shall contain written documentation which identifies the components which have 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.

9. Installation Instructions

Installation instructions shall be provided for all edge metal systems in compliance with the ES-1 design document, and shall include fastener and cleat requirements.

10. References

1. *Minimum Design Loads for Buildings and Other Structures*, ASCE 7-05, American Society of Civil Engineers (ASCE), New York, 2005.
2. Factory Mutual Approved Product News Vol. 21, No. 2, 2005.
3. Roofing Industry Committee on Weather Issues (RICOWI), *Hurricane Katrina Wind Investigation Report*, 2007, pp. xiv
4. Roofing Industry Committee on Weather Issues (RICOWI), *Hurricanes Charley and Ivan Wind Investigation Report, 2006*, pp.xiv
5. *Procedure for Evaluation of Corrosion Resistance of Steel Fasteners*, Single Ply Roofing Industry (SPRI) Publication, Needham MA, 1988.

Appendix A—Tables

Table A1–Importance Factors

Nature of Occupancy	Category	Importance Factor: Non-Hurricane Prone Regions & Alaska V=85–100 mph	Importance Factor: Hurricane Prone Regions V> 100 mph
Buildings and other structures that represent a low hazard to human life in the event of failure including, but not limited to: ▶ Agricultural facilities ▶ Certain temporary facilities ▶ Minor storage facilities	I	0.87	0.77
All buildings and other structures except those listed in Categories I, III, and IV	II	1.00	1.00
Buildings and other structures that represent a substantial hazard to human life in the event of failure including, but not limited to: ▶ Buildings and other structures where more than 300 people congregate in one area ▶ Buildings and other structures with day care facilities with capacity greater than 150 ▶ Buildings and other structures with elementary school or secondary school 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 not included in Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of hazardous materials to be dangerous to the public if released.	III	1.15	1.15
Buildings and other structures designated as essential facilities including, but not limited to: ▶ Hospitals and other health care facilities having surgery or emergency treatment facilities ▶ Fire, rescue, ambulance, and police stations and emergency vehicle garages ▶ Designated earthquake, hurricane, or other emergency shelters ▶ Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response ▶ Power generating stations and other public utility facilities required in an emergency ▶ Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Category IV structures during an emergency ▶ Aviation control towers, air traffic control centers, and emergency aircraft hangars ▶ Water storage facilities and pump structures required to maintain water pressure for fire suppression ▶ Buildings and other structures having critical national defense functions ▶ Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing extremely hazardous materials where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction.	IV	1.15	1.15

From Table 1-1 and 6-1 of ASCE 7-05

Table A2
Field of Roof Pressure q_{fz} psf (kPa)—Exposure B
Enclosed Building[1]

Building Height ft. (m)	Exposure B, Occupancy Category II (I=1.0) Wind Speed, 3 Second Gust, mph (m/sec)									
	85 (38.1)	90 (40.3)	100 (44.8)	110 (49.3)	120 (53.8)	130 (58.2)	140 (62.7)	150 (67.2)	160 (71.7)	170 (76.2)
0 ≤ 15 (0–4.6)	**-15.3** -(0.73)	**-17.1** -(0.82)	**-21.1** -(1.01)	**-25.6** -(1.23)	**-30.4** -(1.46)	**-35.7** -(1.71)	**-41.4** -(1.98)	**-47.6** -(2.28)	**-54.1** -(2.59)	**-61.1** -(2.93)
> 15 ≤ 20 (4.6–6.1)	**-15.3** -(0.73)	**-17.1** -(0.82)	**-21.1** -(1.01)	**-25.6** -(1.23)	**-30.4** -(1.46)	**-35.7** -(1.71)	**-41.4** -(1.98)	**-47.6** -(2.28)	**-54.1** -(2.59)	**-61.1** -(2.93)
> 20 ≤ 25 (6.1–7.6)	**-15.3** -(0.73)	**-17.1** -(0.82)	**-21.1** -(1.01)	**-25.6** -(1.23)	**-30.4** -(1.46)	**-35.7** -(1.71)	**-41.4** -(1.98)	**-47.6** -(2.28)	**-54.1** -(2.59)	**-61.1** -(2.93)
> 25 ≤ 30 (7.6–9.1)	**-15.3** -(0.73)	**-17.1** -(0.82)	**-21.1** -(1.01)	**-25.6** -(1.23)	**-30.4** -(1.46)	**-35.7** -(1.71)	**-41.4** -(1.98)	**-47.6** -(2.28)	**-54.1** -(2.59)	**-61.1** -(2.93)
> 30 ≤ 40 (9.1–12.2)	**-16.6** -(0.79)	**-18.6** -(0.89)	**-23.0** -(1.10)	**-27.8** -(1.33)	**-33.1** -(1.58)	**-38.8** -(1.86)	**-45.0** -(2.15)	**-51.7** -(2.47)	**-58.8** -(2.81)	**-66.3** -(3.18)
> 40 ≤ 50 (12.2–15.2)	**-17.7** -(0.85)	**-19.8** -(0.95)	**-24.5** -(1.17)	**-29.6** -(1.42)	**-35.2** -(1.69)	**-41.4** -(1.98)	**-48.0** -(2.30)	**-55.1** -(2.64)	**-62.6** -(3.00)	**-70.7** -(3.39)
> 50 ≤ 60 (15.2–18.3)	**-18.6** -(0.89)	**-20.8** -(1.00)	**-25.7** -(1.23)	**-31.1** -(1.49)	**-37.0** -(1.77)	**-43.4** -(2.08)	**-50.3** -(2.41)	**-57.8** -(2.77)	**-65.7** -(3.15)	**-74.2** -(3.55)
> 60 ≤ 70 (18.3–21.3)	**-26.0** -(1.25)	**-29.2** -(1.40)	**-36.0** -(1.72)	**-43.6** -(2.09)	**-51.8** -(2.48)	**-60.8** -(2.91)	**-70.6** -(3.38)	**-81.0** -(3.88)	**-92.2** -(4.41)	**-104** -(4.98)
> 70 ≤ 80 (21.3–24.4)	**-27.2** -(1.30)	**-30.5** -(1.46)	**-37.6** -(1.80)	**-45.5** -(2.18)	**-54.2** -(2.59)	**-63.6** -(3.04)	**-73.7** -(3.53)	**-84.6** -(4.05)	**-96.3** -(4.61)	**-109** -(5.21)
> 80 ≤ 90 (24.4–27.4)	**-28.1** -(1.34)	**-31.5** -(1.51)	**-38.8** -(1.86)	**-47.0** -(2.25)	**-55.9** -(2.68)	**-65.6** -(3.14)	**-76.1** -(3.64)	**-87.4** -(4.18)	**-99.4** -(4.76)	**-112** -(5.37)
> 90 ≤ 100 (27.4–30.5)	**-28.9** -(1.39)	**-32.4** -(1.55)	**-40.0** -(1.92)	**-48.5** -(2.32)	**-57.7** -(2.76)	**-67.7** -(3.24)	**-78.5** -(3.76)	**-90.1** -(4.31)	**-103** -(4.91)	**-116** -(5.54)
> 100 ≤ 110 (30.5–33.5)	**-29.8** -(1.43)	**-33.4** -(1.60)	**-41.3** -(1.98)	**-49.9** -(2.39)	**-59.4** -(2.84)	**-69.7** -(3.34)	**-80.9** -(3.87)	**-92.8** -(4.44)	**-106** -(5.06)	**-119** -(5.71)
> 110 ≤ 120 (33.5–36.6)	**-30.4** -(1.46)	**-34.1** -(1.63)	**-42.1** -(2.01)	**-50.9** -(2.44)	**-60.6** -(2.90)	**-71.1** -(3.40)	**-82.4** -(3.95)	**-94.6** -(4.53)	**-108** -(5.16)	**-122** -(5.82)
> 120 ≤ 130 (36.6–39.6)	**-31.3** -(1.50)	**-35.1** -(1.68)	**-43.3** -(2.07)	**-52.4** -(2.51)	**-62.3** -(2.98)	**-73.1** -(3.50)	**-84.8** -(4.06)	**-97.4** -(4.66)	**-111** -(5.31)	**-125** -(5.99)
> 130 ≤ 140 (39.6–42.7)	**-31.9** -(1.53)	**-35.7** -(1.71)	**-44.1** -(2.11)	**-53.3** -(2.55)	**-63.5** -(3.04)	**-74.5** -(3.57)	**-86.4** -(4.14)	**-99.2** -(4.75)	**-113** -(5.40)	**-127** -(6.10)
> 140 ≤ 160 (42.7–48.8)	**-33.0** -(1.58)	**-37.0** -(1.77)	**-45.7** -(2.19)	**-55.3** -(2.65)	**-65.8** -(3.15)	**-77.2** -(3.70)	**-89.6** -(4.29)	**-103** -(4.92)	**-117** -(5.60)	**-132** -(6.32)
> 160 ≤ 180 (48.8–54.9)	**-34.2** -(1.64)	**-38.3** -(1.84)	**-47.3** -(2.27)	**-57.3** -(2.74)	**-68.1** -(3.26)	**-80.0** -(3.83)	**-92.8** -(4.44)	**-106** -(5.10)	**-121** -(5.80)	**-137** -(6.55)
> 180 ≤ 200 (54.9–61.0)	**-35.1** -(1.68)	**-39.3** -(1.88)	**-48.5** -(2.32)	**-58.7** -(2.81)	**-69.9** -(3.35)	**-82.0** -(3.93)	**-95.1** -(4.56)	**-109.2** -(5.23)	**-124.3** -(5.95)	**-140.3** -(6.72)
> 200 ≤ 250 (61.0–76.2)	**-37.4** -(1.79)	**-41.9** -(2.01)	**-51.8** -(2.48)	**-62.6** -(3.00)	**-74.6** -(3.57)	**-87.5** -(4.19)	**-101** -(4.86)	**-116** -(5.58)	**-133** -(6.35)	**-150** -(7.16)
> 250 ≤ 300 (76.2–91.4)	**-39.5** -(1.89)	**-44.2** -(2.12)	**-54.6** -(2.61)	**-66.1** -(3.16)	**-78.6** -(3.76)	**-92.3** -(4.42)	**-107** -(5.12)	**-123** -(5.88)	**-140** -(6.69)	**-158** -(7.56)
> 300 ≤ 350 (91.4–107)	**-41.2** -(1.97)	**-46.2** -(2.21)	**-57.0** -(2.73)	**-69.0** -(3.30)	**-82.1** -(3.93)	**-96.4** -(4.61)	**-112** -(5.35)	**-128** -(6.14)	**-146** -(6.99)	**-165** -(7.89)
> 350 ≤ 400 (107–122)	**-43.0** -(2.06)	**-48.2** -(2.31)	**-59.5** -(2.85)	**-71.9** -(3.44)	**-85.6** -(4.10)	**-100** -(4.81)	**-117** -(5.58)	**-134** -(6.41)	**-152** -(7.29)	**-172** -(8.23)
> 400 ≤ 450 (122–137)	**-44.4** -(2.13)	**-49.8** -(2.38)	**-61.5** -(2.94)	**-74.4** -(3.56)	**-88.5** -(4.24)	**-104** -(4.97)	**-121** -(5.77)	**-138** -(6.62)	**-157** -(7.54)	**-178** -(8.51)
> 450 ≤ 500 (137–152)	**-45.6** -(2.18)	**-51.1** -(2.45)	**-63.1** -(3.02)	**-76.3** -(3.66)	**-90.9** -(4.35)	**-107** -(5.11)	**-124** -(5.92)	**-142** -(6.80)	**-162** -(7.73)	**-182** -(8.73)

Table Notes:
1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. See Commentary for more information concerning the calculation of q_{fz}.

Table A3
Field of Roof Pressure q_{fz} psf (kPa)—Exposure C
Enclosed Building[1]

Building Height ft. (m)	Exposure C, Occupancy Category II (I=1.0) Wind Speed, 3 Second Gust, mph (m/sec)									
	85 (38.1)	90 (40.3)	100 (44.8)	110 (49.3)	120 (53.8)	130 (58.2)	140 (62.7)	150 (67.2)	160 (71.7)	170 (76.2)
0 ≤ 15 (0–4.6)	**-18.6** -(0.89)	**-20.8** -(1.00)	**-25.7** -(1.23)	**-31.1** -(1.49)	**-37.0** -(1.77)	**-43.4** -(2.08)	**-50.3** -(2.41)	**-57.8** -(2.77)	**-65.7** -(3.15)	**-74.2** -(3.55)
> 15 ≤ 20 (4.6–6.1)	**-19.6** -(0.94)	**-22.0** -(1.05)	**-27.2** -(1.30)	**-32.9** -(1.58)	**-39.1** -(1.87)	**-45.9** -(2.20)	**-53.3** -(2.55)	**-61.2** -(2.93)	**-69.6** -(3.33)	**-78.6** -(3.76)
> 20 ≤ 25 (6.1–7.6)	**-20.5** -(0.98)	**-23.0** -(1.10)	**-28.4** -(1.36)	**-34.4** -(1.65)	**-40.9** -(1.96)	**-48.0** -(2.30)	**-55.7** -(2.66)	**-63.9** -(3.06)	**-72.7** -(3.48)	**-82.1** -(3.93)
> 25 ≤ 30 (7.6–9.1)	**-21.4** -(1.02)	**-24.0** -(1.15)	**-29.6** -(1.42)	**-35.8** -(1.72)	**-42.6** -(2.04)	**-50.0** -(2.40)	**-58.0** -(2.78)	**-66.6** -(3.19)	**-75.8** -(3.63)	**-85.6** -(4.10)
> 30 ≤ 40 (9.1–12.2)	**-22.7** -(1.09)	**-25.4** -(1.22)	**-31.4** -(1.50)	**-38.0** -(1.82)	**-45.2** -(2.17)	**-53.1** -(2.54)	**-61.6** -(2.95)	**-70.7** -(3.38)	**-80.4** -(3.85)	**-90.8** -(4.35)
> 40 ≤ 50 (12.2–15.2)	**-23.8** -(1.14)	**-26.7** -(1.28)	**-32.9** -(1.58)	**-39.8** -(1.91)	**-47.4** -(2.27)	**-55.6** -(2.66)	**-64.5** -(3.09)	**-74.1** -(3.55)	**-84.3** -(4.04)	**-95.2** -(4.56)
> 50 ≤ 60 (15.2–18.3)	**-24.7** -(1.18)	**-27.6** -(1.32)	**-34.1** -(1.63)	**-41.3** -(1.98)	**-49.2** -(2.35)	**-57.7** -(2.76)	**-66.9** -(3.20)	**-76.8** -(3.68)	**-87.4** -(4.18)	**-98.7** -(4.72)
> 60 ≤ 70 (18.3–21.3)	-34.2 -(1.64)	**-38.3** -(1.84)	**-47.3** -(2.27)	**-57.3** -(2.74)	**-68.1** -(3.26)	**-80.0** -(3.83)	**-92.8** -(4.44)	**-106** -(5.10)	**-121** -(5.80)	**-137** -(6.55)
> 70 ≤ 80 (21.3–24.4)	**-35.4** -(1.69)	**-39.6** -(1.90)	**-48.9** -(2.34)	**-59.2** -(2.84)	**-70.5** -(3.37)	**-82.7** -(3.96)	**-95.9** -(4.59)	**-110** -(5.27)	**-125** -(6.00)	**-141** -(6.77)
> 80 ≤ 90 (24.4–27.4)	**-36.2** -(1.74)	**-40.6** -(1.95)	**-50.2** -(2.40)	**-60.7** -(2.91)	**-72.2** -(3.46)	**-84.8** -(4.06)	**-98.3** -(4.71)	**-113** -(5.40)	**-128** -(6.15)	**-145** -(6.94)
> 90 ≤ 100 (27.4–30.5)	**-36.8** -(1.76)	**-41.3** -(1.98)	**-51.0** -(2.44)	**-61.7** -(2.95)	**-73.4** -(3.51)	**-86.1** -(4.12)	**-99.9** -(4.78)	**-115** -(5.49)	**-130** -(6.25)	**-147** -(7.05)
> 100 ≤ 110 (30.5–33.5)	**-37.6** -(1.80)	**-42.1** -(2.02)	**-52.0** -(2.49)	**-62.9** -(3.01)	**-74.8** -(3.58)	**-87.8** -(4.21)	**-102** -(4.88)	**-117** -(5.60)	**-133** -(6.37)	**-150** -(7.19)
> 110 ≤ 120 (33.5–36.6)	**-38.3** -(1.83)	**-42.9** -(2.06)	**-53.0** -(2.54)	**-64.1** -(3.07)	**-76.3** -(3.65)	**-89.5** -(4.29)	**-104** -(4.97)	**-119** -(5.71)	**-136** -(6.49)	**-153** -(7.33)
> 120 ≤ 130 (36.6–39.6)	**-39.0** -(1.87)	**-43.7** -(2.09)	**-54.0** -(2.59)	**-65.3** -(3.13)	**-77.8** -(3.72)	**-91.3** -(4.37)	**-106** -(5.07)	**-121** -(5.82)	**-138** -(6.62)	**-156** -(7.47)
> 130 ≤ 140 (39.6–42.7)	**-39.7** -(1.90)	**-44.6** -(2.13)	**-55.0** -(2.63)	**-66.6** -(3.19)	**-79.2** -(3.79)	**-93.0** -(4.45)	**-108** -(5.16)	**-124** -(5.93)	**-141** -(6.74)	**-159** -(7.61)
> 140 ≤ 160 (42.7–48.8)	**-40.6** -(1.94)	**-45.5** -(2.18)	**-56.2** -(2.69)	**-68.0** -(3.26)	**-81.0** -(3.88)	**-95.0** -(4.55)	**-110** -(5.28)	**-127** -(6.06)	**-144** -(6.89)	**-162** -(7.78)
> 160 ≤ 180 (48.8–54.9)	**-41.8** -(2.00)	**-46.9** -(2.24)	**-57.8** -(2.77)	**-70.0** -(3.35)	**-83.3** -(3.99)	**-97.8** -(4.68)	**-113** -(5.43)	**-130** -(6.23)	**-148** -(7.09)	**-167** -(8.00)
> 180 ≤ 200 (54.9–61.0)	**-42.7** -(2.04)	**-47.8** -(2.29)	**-59.1** -(2.83)	**-71.5** -(3.42)	**-85.0** -(4.07)	**-99.8** -(4.78)	**-116** -(5.54)	**-133** -(6.36)	**-151** -(7.24)	**-171** -(8.17)
> 200 ≤ 250 (61.0–76.2)	**-44.7** -(2.14)	**-50.1** -(2.40)	**-61.9** -(2.96)	**-74.9** -(3.59)	**-89.1** -(4.27)	**-105** -(5.01)	**-121** -(5.81)	**-139** -(6.67)	**-158** -(7.59)	**-179** -(8.56)
> 250 ≤ 300 (76.2–91.4)	**-46.5** -(2.22)	**-52.1** -(2.49)	**-64.3** -(3.08)	**-77.8** -(3.73)	**-92.6** -(4.43)	**-109** -(5.20)	**-126** -(6.04)	**-145** -(6.93)	**-165** -(7.88)	**-186** -(8.90)
> 300 ≤ 350 (91.4–107)	**-47.9** -(2.29)	**-53.7** -(2.57)	**-66.3** -(3.18)	**-80.3** -(3.84)	**-95.5** -(4.57)	**-112** -(5.37)	**-130** -(6.23)	**-149** -(7.15)	**-170** -(8.13)	**-192** -(9.18)
> 350 ≤ 400 (107–122)	**-49.4** -(2.36)	**-55.4** -(2.65)	**-68.4** -(3.27)	**-82.7** -(3.96)	**-98.4** -(4.71)	**-116** -(5.53)	**-134** -(6.42)	**-154** -(7.36)	**-175** -(8.38)	**-198** -(9.46)
> 400 ≤ 450 (122–137)	**-50.6** -(2.42)	**-56.7** -(2.71)	**-70.0** -(3.35)	**-84.7** -(4.05)	**-101** -(4.82)	**-118** -(5.66)	**-137** -(6.57)	**-157** -(7.54)	**-179** -(8.58)	**-202** -(9.68)
> 450 ≤ 500 (137–152)	**-51.7** -(2.48)	**-58.0** -(2.78)	**-71.6** -(3.43)	**-86.6** -(4.15)	**-103** -(4.94)	**-121** -(5.79)	**-140** -(6.72)	**-161** -(7.71)	**-183** -(8.78)	**-207** -(9.91)

Table Notes:
1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. See Commentary for more information concerning the calculation of q_{fz}.

Table A4
Field of Roof Pressure q_{fz} psf (kPa)—Exposure D
Enclosed Building[1]

Building Height ft. (m)	Exposure D, Occupancy Category II (I=1.0) Wind Speed, 3 Second Gust, mph (m/sec)									
	85 (38.1)	90 (40.3)	100 (44.8)	110 (49.3)	120 (53.8)	130 (58.2)	140 (62.7)	150 (67.2)	160 (71.7)	170 (76.2)
0 ≤ 15 (0–4.6)	**-22.5** -(1.08)	**-25.2** -(1.21)	**-31.1** -(1.49)	**-37.6** -(1.80)	**-44.8** -(2.15)	**-52.6** -(2.52)	**-61.0** -(2.92)	**-70.0** -(3.35)	**-79.7** -(3.81)	**-89.9** -(4.31)
> 15 ≤ 20 (4.6–6.1)	**-23.6** -(1.13)	**-26.4** -(1.27)	**-32.6** -(1.56)	**-39.5** -(1.89)	**-47.0** -(2.25)	**-55.1** -(2.64)	**-63.9** -(3.06)	**-73.4** -(3.51)	**-83.5** -(4.00)	**-94.3** -(4.51)
> 20 ≤ 25 (6.1–7.6)	**-24.4** -(1.17)	**-27.4** -(1.31)	**-33.8** -(1.62)	**-40.9** -(1.96)	**-48.7** -(2.33)	**-57.2** -(2.74)	**-66.3** -(3.18)	**-76.1** -(3.64)	**-86.6** -(4.15)	**-97.8** -(4.68)
> 25 ≤ 30 (7.6–9.1)	**-25.3** -(1.21)	**-28.4** -(1.36)	**-35.0** -(1.68)	**-42.4** -(2.03)	**-50.5** -(2.42)	**-59.2** -(2.84)	**-68.7** -(3.29)	**-78.8** -(3.78)	**-89.7** -(4.30)	**-101.3** -(4.85)
> 30 ≤ 40 (9.1–12.2)	**-26.6** -(1.27)	**-29.9** -(1.43)	**-36.9** -(1.76)	**-44.6** -(2.14)	**-53.1** -(2.54)	**-62.3** -(2.98)	**-72.2** -(3.46)	**-82.9** -(3.97)	**-94.3** -(4.52)	**-106.5** -(5.10)
> 40 ≤ 50 (12.2–15.2)	**-27.7** -(1.33)	**-31.1** -(1.49)	**-38.4** -(1.84)	**-46.4** -(2.22)	**-55.2** -(2.65)	**-64.8** -(3.10)	**-75.2** -(3.60)	**-86.3** -(4.13)	**-98.2** -(4.70)	**-111** -(5.31)
> 50 ≤ 60 (15.2–18.3)	**-28.6** -(1.37)	**-32.1** -(1.53)	**-39.6** -(1.89)	**-47.9** -(2.29)	**-57.0** -(2.73)	**-66.9** -(3.20)	**-77.6** -(3.71)	**-89.0** -(4.26)	**-101** -(4.85)	**-114** -(5.48)
> 60 ≤ 70 (18.3–21.3)	**-39.2** -(1.88)	**-43.9** -(2.10)	**-54.2** -(2.60)	**-65.6** -(3.14)	**-78.0** -(3.74)	**-91.6** -(4.39)	**-106** -(5.09)	**-122** -(5.84)	**-139** -(6.64)	**-157** -(7.50)
> 70 ≤ 80 (21.3–24.4)	**-40.3** -(1.93)	**-45.2** -(2.16)	**-55.8** -(2.67)	**-67.5** -(3.23)	**-80.4** -(3.85)	**-94.3** -(4.52)	**-109** -(5.24)	**-126** -(6.01)	**-143** -(6.84)	**-161** -(7.72)
> 80 ≤ 90 (24.4–27.4)	**-40.9** -(1.96)	**-45.9** -(2.20)	**-56.6** -(2.71)	**-68.5** -(3.28)	**-81.5** -(3.90)	**-95.7** -(4.58)	**-111** -(5.31)	**-127** -(6.10)	**-145** -(6.94)	**-164** -(7.84)
> 90 ≤ 100 (27.4–30.5)	**-41.8** -(2.00)	**-46.9** -(2.24)	**-57.8** -(2.77)	**-70.0** -(3.35)	**-83.3** -(3.99)	**-97.8** -(4.68)	**-113** -(5.43)	**-130** -(6.23)	**-148** -(7.09)	**-167** -(8.00)
> 100 ≤ 110 (30.5–33.5)	**-42.5** -(2.04)	**-47.7** -(2.28)	**-58.9** -(2.82)	**-71.2** -(3.41)	**-84.7** -(4.06)	**-99.5** -(4.76)	**-115** -(5.52)	**-132** -(6.34)	**-151** -(7.21)	**-170** -(8.14)
> 110 ≤ 120 (33.5–36.6)	**-43.3** -(2.07)	**-48.5** -(2.32)	**-59.9** -(2.87)	**-72.4** -(3.47)	**-86.2** -(4.13)	**-101** -(4.84)	**-117** -(5.62)	**-135** -(6.45)	**-153** -(7.34)	**-173** -(8.28)
> 120 ≤ 130 (36.6–39.6)	**-43.8** -(2.10)	**-49.1** -(2.35)	**-60.7** -(2.91)	**-73.4** -(3.52)	**-87.4** -(4.18)	**-103** -(4.91)	**-119** -(5.69)	**-137** -(6.54)	**-155** -(7.44)	**-175** -(8.40)
> 130 ≤ 140 (39.6–42.7)	**-44.4** -(2.13)	**-49.8** -(2.38)	**-61.5** -(2.94)	**-74.4** -(3.56)	**-88.5** -(4.24)	**-104** -(4.97)	**-121** -(5.77)	**-138** -(6.62)	**-157** -(7.54)	**-178** -(8.51)
> 140 ≤ 160 (42.7–48.8)	**-45.3** -(2.17)	**-50.8** -(2.43)	**-62.7** -(3.00)	**-75.9** -(3.63)	**-90.3** -(4.32)	**-106** -(5.07)	**-123** -(5.88)	**-141** -(6.75)	**-160** -(7.68)	**-181** -(8.68)
> 160 ≤ 180 (48.8–54.9)	**-46.2** -(2.21)	**-51.8** -(2.48)	**-63.9** -(3.06)	**-77.3** -(3.70)	**-92.0** -(4.41)	**-108** -(5.17)	**-125** -(6.00)	**-144** -(6.88)	**-164** -(7.83)	**-185** -(8.84)
> 180 ≤ 200 (54.9–61.0)	**-47.1** -(2.25)	**-52.7** -(2.53)	**-65.1** -(3.12)	**-78.8** -(3.77)	**-93.8** -(4.49)	**-110** -(5.27)	**-128** -(6.11)	**-147** -(7.02)	**-167** -(7.98)	**-188** -(9.01)
> 200 ≤ 250 (61.0–76.2)	**-49.1** -(2.35)	**-55.0** -(2.64)	**-68.0** -(3.25)	**-82.2** -(3.94)	**-97.9** -(4.69)	**-115** -(5.50)	**-133** -(6.38)	**-153** -(7.32)	**-174** -(8.33)	**-196** -(9.40)
> 250 ≤ 300 (76.2–91.4)	**-50.6** -(2.42)	**-56.7** -(2.71)	**-70.0** -(3.35)	**-84.7** -(4.05)	**-101** -(4.82)	**-118** -(5.66)	**-137** -(6.57)	**-157** -(7.54)	**-179** -(8.58)	**-202** -(9.68)
> 300 ≤ 350 (91.4–107)	**-52.0** -(2.49)	**-58.3** -(2.79)	**-72.0** -(3.45)	**-87.1** -(4.17)	**-104** -(4.96)	**-122** -(5.83)	**-141** -(6.76)	**-162** -(7.76)	**-184** -(8.83)	**-208** -(9.96)
> 350 ≤ 400 (107–122)	**-53.2** -(2.55)	**-59.6** -(2.86)	**-73.6** -(3.52)	**-89.1** -(4.27)	**-106** -(5.08)	**-124** -(5.96)	**-144** -(6.91)	**-166** -(7.93)	**-188** -(9.02)	**-213** -(10.19)
> 400 ≤ 450 (122–137)	**-54.4** -(2.60)	**-60.9** -(2.92)	**-75.2** -(3.60)	**-91.0** -(4.36)	**-108** -(5.19)	**-127** -(6.09)	**-147** -(7.06)	**-169** -(8.11)	**-193** -(9.22)	**-217** -(10.41)
> 450 ≤ 500 (137–152)	**-55.2** -(2.64)	**-61.9** -(2.96)	**-76.4** -(3.66)	**-92.5** -(4.43)	**-110** -(5.27)	**-129** -(6.19)	**-150** -(7.17)	**-172** -(8.24)	**-196** -(9.37)	**-221** -(10.58)

Table Notes:
1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. See Commentary for more information concerning the calculation of q_{fz}.

Table A5
Horizontal and Vertical Edge Pressures
Enclosed Building[1]
Occupancy Category II (Importance Factor, I=1.0)
h ≤ 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	2.42 × X	3.36 × X	5.06 × X

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. Design factors such as exposure, wind speed, and building height are used to determine the appropriate field of roof pressure. See Tables A2–A4 and Commentary Section 4.2 for more information.
3. Horizontal and vertical load values are calculated directly from a field of roof pressure given in column 1 and from Equation (1) which contains a safety factor.

Table A6
Horizontal and Vertical Edge Pressures
Enclosed Building[1]
Occupancy Category II (Importance Factor, I=1.0)
h > 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)	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	4.28 × X

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. Design factors such as exposure, wind speed, and building height are used to determine the appropriate field of roof pressure. See Tables A2–A4 and Commentary Section 4.2 for more information.
3. Horizontal and vertical load values are calculated directly from a field of roof pressure given in column 1 and from Equation (1) which contains a safety factor.

Table A7
RE-1 Classifications—Dependently Terminated Systems
Enclosed Building[1]
Occupancy Category II (Importance Factor, I=1.0)
for $h \le 60$ ft.

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.				
		$1 < r \le 2$ ($0.3 < r \le 0.6$)	$2 < r \le 3$ ($0.6 < r \le 0.9$)	$3 < r \le 4$ ($0.9 < r \le 1.2$)	$4 < r \le 5$ ($1.2 < r \le 0.5$)	Note[2] $5 < r \le 6$ ($1.5 < r \le 1.8$)
$q_{fz} \le 30.0$ ($q_{fz} \le 1.44$)	101 (4.83)	239 (356)	358 (533)	477 (710)	596 (887)	716 (1066)
$30.0 < q_{fz} \le 37.5$ ($1.44 < q_{fz} \le 1.8$)	126 (6.03)	298 (443)	447 (664)	596 (887)	745 (1109)	894 (1330)
$37.5 < q_{fz} \le 45.0$ ($1.8 < q_{fz} \le 2.15$)	151 (7.24)	358 (533)	537 (799)	716 (1066)	894 (1330)	1073 (1597)
$45.0 < q_{fz} \le 52.5$ ($2.15 < q_{fz} \le 2.51$)	176 (8.45)	417 (621)	626 (932)	835 (1243)	1042 (1552)	1251 (1863)
$52.5 < q_{fz} \le 60.0$ ($2.51 < q_{fz} \le 2.87$)	202 (9.65)	477 (710)	716 (1066)	954 (1419)	1193 (1775)	1431 (2130)
$60.0 < q_{fz} \le 67.5$ ($2.87 < q_{fz} \le 3.23$)	227 (10.9)	537 (799)	804 (1198)	1073 (1597)	1342 (1997)	1610 (2395)
$67.5 < q_{fz} \le 75.0$ ($3.23 < q_{fz} \le 3.59$)	252 (12.1)	596 (887)	894 (1330)	1193 (1775)	1490 (2218)	1789 (2661)
$75.0 < q_{fz} \le 82.5$ ($3.59 < q_{fz} \le 3.95$)	277 (13.3)	656 (976)	984 (1464)	1312 (1951)	1640 (2440)	1968 (2928)
$82.5 < q_{fz} \le 90.0$ ($3.95 < q_{fz} \le 4.31$)	302 (14.5)	716 (1066)	1073 (1597)	1431 (2130)	1789 (2661)	2146 (3194)
$90.0 < q_{fz} \le 97.5$ ($4.31 < q_{fz} \le 4.67$)	328 (15.7)	775 (1152)	1163 (1731)	1550 (2307)	1937 (2884)	2326 (3460)
$97.5 < q_{fz} \le 105.0$ ($4.67 < q_{fz} \le 5.03$)	353 (16.9)	835 (1243)	1251 (1863)	1669 (2484)	2087 (3106)	2504 (3725)
$105 < q_{fz} \le 112.5$ ($5.03 < q_{fz} \le 5.39$)	378 (18.1)	894 (1330)	1342 (1997)	1789 (2661)	2236 (3328)	2683 (3992)
$112.5 < q_{fz} \le 120$ ($5.39 < q_{fz} \le 5.75$)	403 (19.3)	954 (1419)	1431 (2130)	1907 (2839)	2384 (3548)	2861 (4258)
$120 < q_{fz} \le 127.5$ ($5.75 < q_{fz} \le 6.11$)	428 (20.5)	1013 (1509)	1521 (2263)	2027 (3016)	2534 (3770)	3040 (4525)

Table Notes:
1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. This column to be used for ballasted systems. See Appendix A—RE-1 Test information.
3. See Commentary—Test Method RE-1 for the calculations used to determine entries in Tables A7.

Table A8
RE-1 Classifications—Dependently Terminated Systems
Enclosed Building[1]
Occupancy Category II (Importance Factor, I=1.0)
for *h* > *60* ft.

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.				
		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)	418 (622)	559 (830)	698 (1037)	836 (1245)
37.5 < q_{fz} ≤ 45.0 (1.8 < q_{fz} ≤ 2.15)	141 (6.77)	336 (498)	502 (747)	670 (997)	836 (1245)	1004 (1494)
45.0 < q_{fz} ≤ 52.5 (2.15 < q_{fz} ≤ 2.51)	165 (7.89)	390 (581)	586 (873)	782 (1163)	975 (1452)	1171 (1742)
52.5 < q_{fz} ≤ 60.0 (2.51 < q_{fz} ≤ 2.87)	188 (9.02)	446 (664)	670 (997)	893 (1329)	1116 (1661)	1339 (1993)
60.0 < q_{fz} ≤ 67.5 (2.87 < q_{fz} ≤ 3.23)	212 (10.2)	502 (747)	752 (1121)	1004 (1494)	1255 (1869)	1506 (2242)
67.5 < q_{fz} ≤ 75.0 (3.23 < q_{fz} ≤ 3.59)	236 (11.3)	559 (830)	836 (1245)	1116 (1661)	1395 (2075)	1674 (2491)
75.0 < q_{fz} ≤ 82.5 (3.59 < q_{fz} ≤ 3.95)	259 (12.4)	613 (914)	920 (1370)	1229 (1827)	1535 (2283)	1842 (2740)
82.5 < q_{fz} ≤ 90.0 (3.95 < q_{fz} ≤ 4.31)	283 (13.5)	670 (997)	1004 (1494)	1339 (1993)	1674 (2491)	2008 (2989)
90.0 < q_{fz} ≤ 97.5 (4.31 < q_{fz} ≤ 4.67)	306 (14.7)	725 (1078)	1088 (1620)	1451 (2159)	1813 (2698)	2176 (3238)
97.5 < q_{fz} ≤ 105.0 (4.67 < q_{fz} ≤ 5.03)	330 (15.8)	782 (1163)	1171 (1742)	1562 (2325)	1953 (2907)	2343 (3487)
105 < q_{fz} ≤ 112.5 (5.03 < q_{fz} ≤ 5.39)	353 (16.9)	836 (1245)	1255 (1869)	1674 (2491)	2093 (3114)	2511 (3735)
112.5 < q_{fz} ≤ 120 (5.39 < q_{fz} ≤ 5.75)	377 (18.0)	893 (1329)	1339 (1993)	1785 (2656)	2231 (3320)	2678 (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)

Table Notes:
1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. This column to be used for ballasted systems. See Appendix A—RE-1 Test information.
3. See Commentary—Test Method RE-1 for the calculations used to determine entries in Tables A8.

Table A9
Nailer Attachment—Fastener Loads
Enclosed Building
Occupancy Category II (Importance Factor, I=1.0)
for *h* ≤ *60* ft.

Field of Roof Pressure psf (kPa)	Fastener Spacing ft. (m)	Perimeter Fastener Load[5] lb/ ft. (kg/m)
30 (1.4)	2 (0.61)	101 (150)
30 (1.4)	3 (0.91)	151 (225)
30 (1.4)	4 (1.22)	202 (300)
30 (1.4)	5 (1.52)	252 (375)
30 (1.4)	6 (1.83)	302 (450)
37.5 (1.8)	2 (0.61)	126 (187)
37.5 (1.8)	3 (0.91)	189 (281)
37.5 (1.8)	4 (1.22)	252 (375)
37.5 (1.8)	5 (1.52)	315 (469)
37.5 (1.8)	6 (1.83)	378 (562)
45 (2.2)	2 (0.61)	151 (225)
45 (2.2)	3 (0.91)	227 (337)
45 (2.2)	4 (1.22)	302 (450)
45 (2.2)	5 (1.52)	378 (562)
45 (2.2)	6 (1.83)	454 (675)
52.5 (2.2)	2 (0.61)	176 (262)
52.5 (2.2)	3 (0.91)	265 (394)
52.5 (2.2)	4 (1.22)	353 (525)
52.5 (2.2)	5 (1.52)	441 (656)
52.5 (2.2)	6 (1.83)	529 (787)

Table Notes:

1. Loads are given in units of lb/ft. due to the variation in edge system widths. A fastener attached to a nailer securing a 12 in. wide coping cap shall have a fastener load of 101 lbs. for a 2 ft. fastener spacing for a field of roof pressure of 30 psf. The same fastener shall have a load of 51 lbs. for a 6 in. (1/2 ft.) wide coping cap (101 lb/ft. × 0.5 ft.=51 lbs.). Additional loads (field of roof fasteners, attachments) are excluded.
2. Values given above can be used as a design aid in lieu of nailer design calculations or nailer testing. See Section 3.9 for more information.
3. Perimeter Fastener Load values are based on Equation (1) with no safety factor.
4. Fasteners shall have a working load rating equal to the values shown in the table, with appropriate safety factors for the medium (masonry, steel, wood) to which the nailer is attached.
5. Loads are given for the perimeter region only. Multiply *Perimeter Fastener Load* values by 1.51 (2.53/1.68 from Table 2) in order to determine fastener loads within a corner region.
6. The nailer should be designed by the engineer of record to withstand bending, shear, or other stresses imparted by the wind loads and fastener resistance loads, as well as fastener pull through.

Table A10
Nailer Attachment—Fastener Loads
Enclosed Building
Occupancy Category II (Importance Factor, I=1.0)
for *h* > *60* ft.

Field of Roof Pressure psf (kPa)	Fastener Spacing ft. (m)	Perimeter Fastener Load[5] lb/ ft. (kg/m)
30 (1.4)	2 (0.61)	94 (140)
30 (1.4)	3 (0.91)	141 (210)
30 (1.4)	4 (1.22)	188 (280)
30 (1.4)	5 (1.52)	236 (350)
30 (1.4)	6 (1.83)	283 (421)
37.5 (1.8)	2 (0.61)	118 (175)
37.5 (1.8)	3 (0.91)	177 (263)
37.5 (1.8)	4 (1.22)	236 (350)
37.5 (1.8)	5 (1.52)	294 (438)
37.5 (1.8)	6 (1.83)	353 (526)
45 (2.2)	2 (0.61)	141 (210)
45 (2.2)	3 (0.91)	212 (315)
45 (2.2)	4 (1.22)	283 (421)
45 (2.2)	5 (1.52)	353 (526)
45 (2.2)	6 (1.83)	424 (631)
52.5 (2.2)	2 (0.61)	165 (245)
52.5 (2.2)	3 (0.91)	247 (368)
52.5 (2.2)	4 (1.22)	330 (491)
52.5 (2.2)	5 (1.52)	412 (613)
52.5 (2.2)	6 (1.83)	495 (736)

Table Notes:

1. Loads are given in units of lb/ft. due to the variation in edge system widths. A fastener attached to a nailer securing a 12 in. wide coping cap shall have a fastener load of 94 lbs. for a 2 ft. fastener spacing for a field of roof pressure of 30 psf. The same fastener shall have a load of 47 lbs. for a 6 in. (1/2 ft.) wide coping cap (101 lb/ft. × 0.5 ft.=47 lbs.). Additional loads (field of roof fasteners, attachments) are excluded.
2. Values given above can be used as a design aid in lieu of nailer design calculations or nailer testing. See Section 3.9 for more information.
3. Perimeter Fastener Load values are based on Equation (1) with no safety factor.
4. Fasteners shall have a working load rating equal to the values shown in the table, with appropriate safety factors for the medium (masonry, steel, wood) to which the nailer is attached.
5. Loads are given for the perimeter region only. *Multiply Perimeter Fastener Load* values by 1.36 (2.14/1.57 from Table 2) in order to determine fastener loads within a corner region.
6. The nailer should be designed by the engineer of record to withstand bending, shear, or other stresses imparted by the wind loads and fastener resistance loads, as well as fastener pull through.

Appendix B—Edge System Testing

RE-1 Test

Test Method for Dependently Terminated Roof Membrane Systems

Note: This test is only needed for mechanically attached or ballasted systems which do NOT contain a “peel stop” within 12 in. of the roof edge.

RE1.1 Determination of applied load

For mechanically attached roof membrane systems the load is determined based upon the distance (r) between the roof side of the edge system and the first row of fasteners parallel to the edge. The design membrane tension (S) shall be calculated using the formula below.

Note:

With r = Row Spacing = horizontal distance to first row of fasteners from edge of system:

1. Test is waived if r ≤ 12 in. (305 mm)
2. For ballasted systems r is assumed to be 6 ft. (1.8 m).
3. Fully adhered systems are assumed to apply no stress on the edge system under consideration and thus exempt from RE-1 testing.

For Mechanically Attached Systems (See RE-1 Test Commentary):

$$\text{Design membrane tension (S)} = SF \times 2.37 \times q_{fz} \times GC_p \times \frac{r}{2} \qquad \text{Equation (RE1-1)}$$

where

SF = Safety Factor

q_{fz} = Field of roof pressure (See Section 4.0)

GC_p = External pressure coefficient (See Section 4.0 and 4.2.2), choose either perimeter region or corner

r = Row spacing = horizontal distance to first row of fasteners from edge of system

When a SF = 2 is used, the equation becomes:

$$\text{Design membrane tension (S)} = 2.37 \times q_{fz} \times GC_p \times r \qquad \text{Equation (RE1-2)}$$

RE1.2 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 unaffected by edge or end constraints on the test sample. Load shall be applied and measured with calibrated load cells, each accurate to within +/-3% of 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.

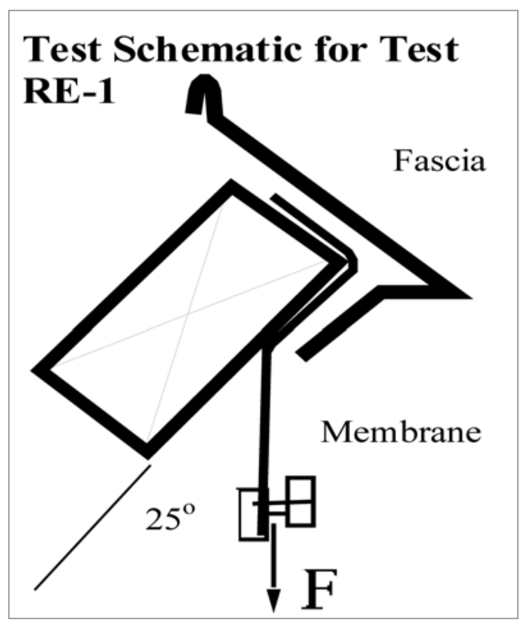


Figure RE1.1

Re1.3 Safety Precautions

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

RE1.4 Test Method

To test the 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 edge

shall be such that the edge sample contains three (3) attachment fasteners at the design fastener spacing, or is 3 ft. 0 in.
(915 mm) in length, whichever is greater. The device shall be constructed and mounted on the base of a tensile testing device so the membrane is pulled at a 25º angle to the roof deck to simulate a billowing membrane (See Figure RE1.2). For devices in which fasteners are part of the membrane securement, at least two such fasteners shall be included in a balanced sample. However, no more fasteners shall be installed than would be typically installed in field conditions. Note that:

Applied Load = F × L
where:

L = the length of the flashing sample, use 1 ft. to determine the load per linear ft.

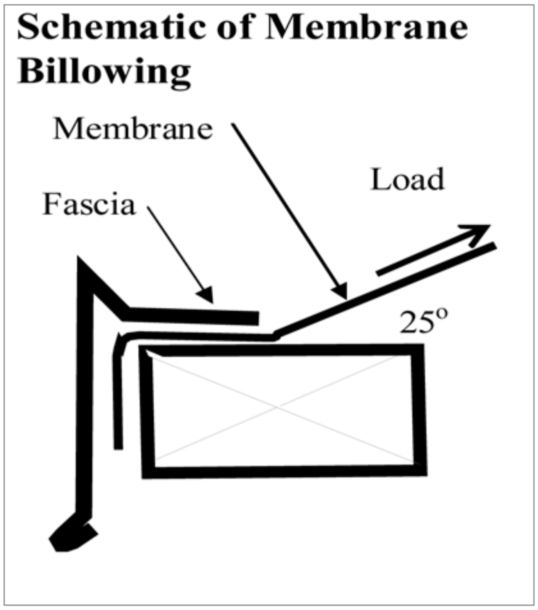


Figure RE1.2

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 2 in./min (50 mm/min) 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 minimum12 in. (300 mm) wide sample meets or exceeds the force, S.

RE1.5 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.

RE-2 Test

Test Method for Dependently or Independently Terminated Edge Systems

(Exposed horizontal component 4 in. (100 mm) 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 unaffected by edge or end constraints on the test sample. Load shall be applied and measured with calibrated load cells, each accurate to within +/-3% of 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. For exposed horizontal components greater than 4 in. (See Figure RE2.1) Test RE-3 is applicable.

Fascia Blow-Off Test Set Schematic

(Force at Failure x Face Area = Blowoff Resistnace)

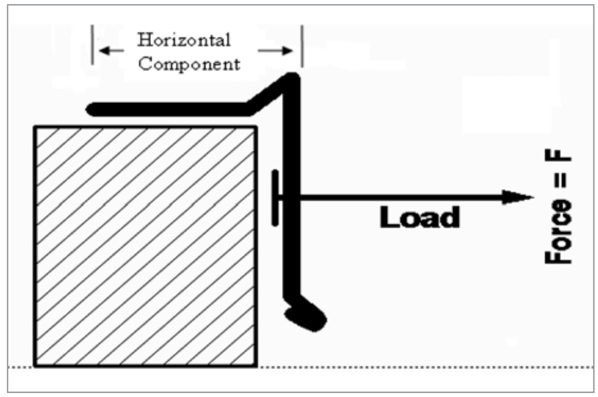


Figure RE2.1

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 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 a minimum of 8 ft. (2.4 m). 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.

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 mm) to the centerline of the vertical face of the 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 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/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. (7.2kPa), 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 sustained 60-second load 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 or deformation that would result in loss of weather protection of the edge.

RE2.4.4 Test Results

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

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

- 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).

RE-3 Test for Copings

(Exposed horizontal component exceeds 4 inches)

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 unaffected by edge or end constraints on the test sample. Load shall be applied and measured with calibrated load cells, each accurate to within +/-3% of 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.

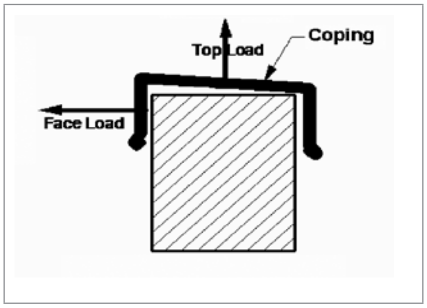


Figure RE3.1
RE3 Test—Face Leg Pull

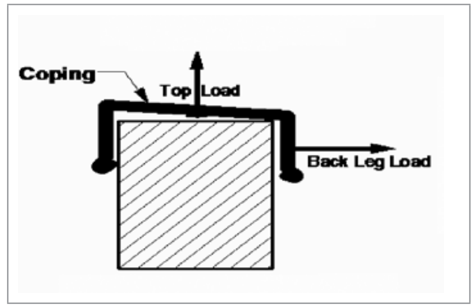


Figure RE3.2
RE3 Test—Back Leg Pull

R3.2 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 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 a minimum of 8 ft. (2.4 m). 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. A minimum of 1 face/top test and 1 top/back test shall be performed.

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.

RE3.4.2 Loading

Face and top loadings shall be applied simultaneously in the horizontal and vertical directions. Face and top loadings shall be applied in the approximate ratio of (Face Height x Horizontal GC_p) to (Top Width x Vertical GC_p) using the perimeter GC_p values from Table 2. 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 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. Coping systems tested under the ANSI/SPRI ES-1 2003 Standard do not require re-testing due to changes in the load ratio. See RE-3 Commentary for more information.

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 top of the 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/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. (7.2 kPa), incremental loading shall be achieved in ≤ 120 seconds.

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

Both face and back legs shall be tested in this manner. Separate test samples shall be used for testing the face and back legs. 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 any component of the roof edge system.

RE3.4.4 Test Results:

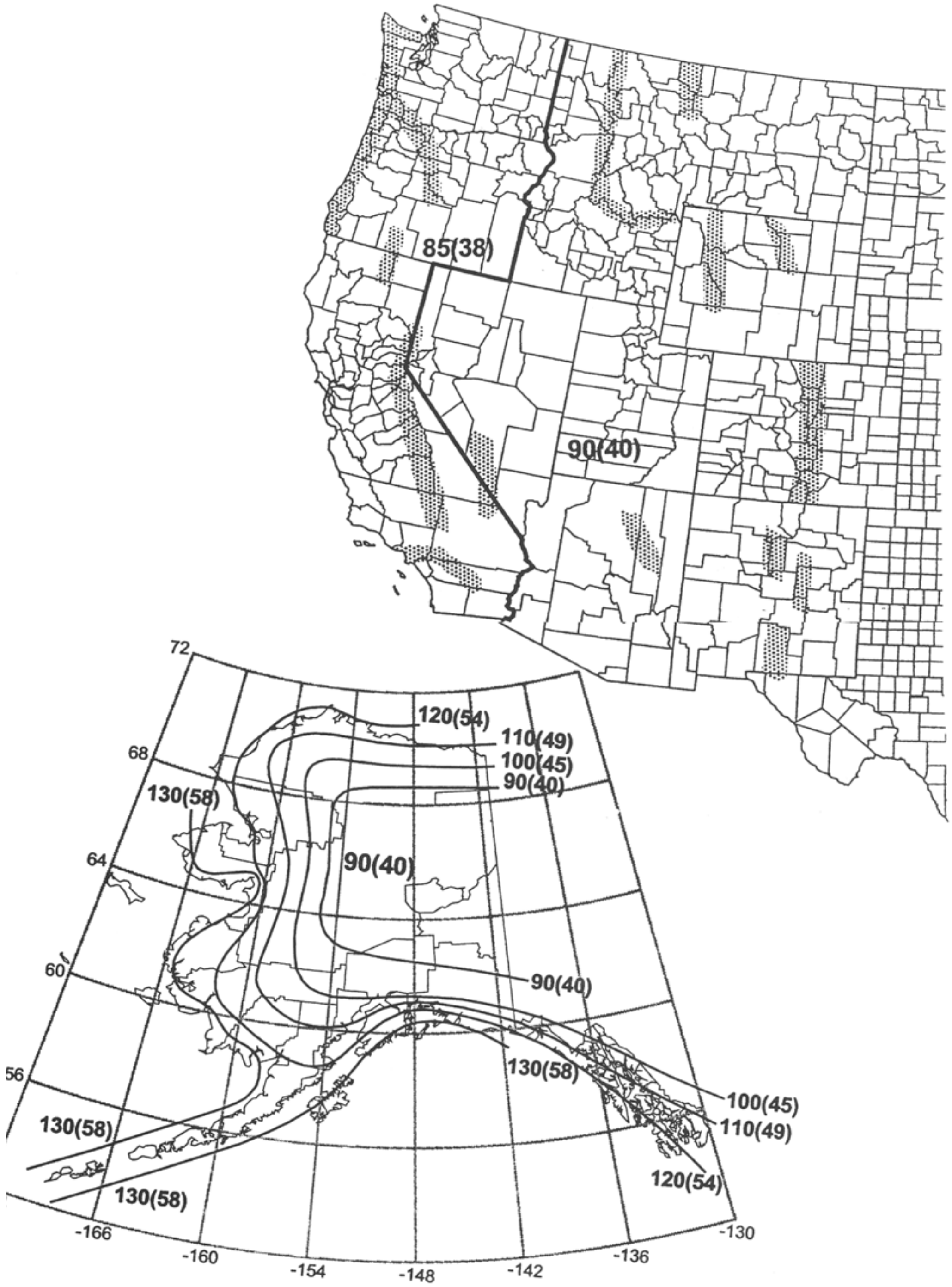
The data for the conditions described in 3.4.3 above shall be recorded. If this data is units of force (in pounds), the data shall be converted to pressure by dividing the force by the area of the face:

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

- 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).

Appendix C—Basic Wind Speed Map

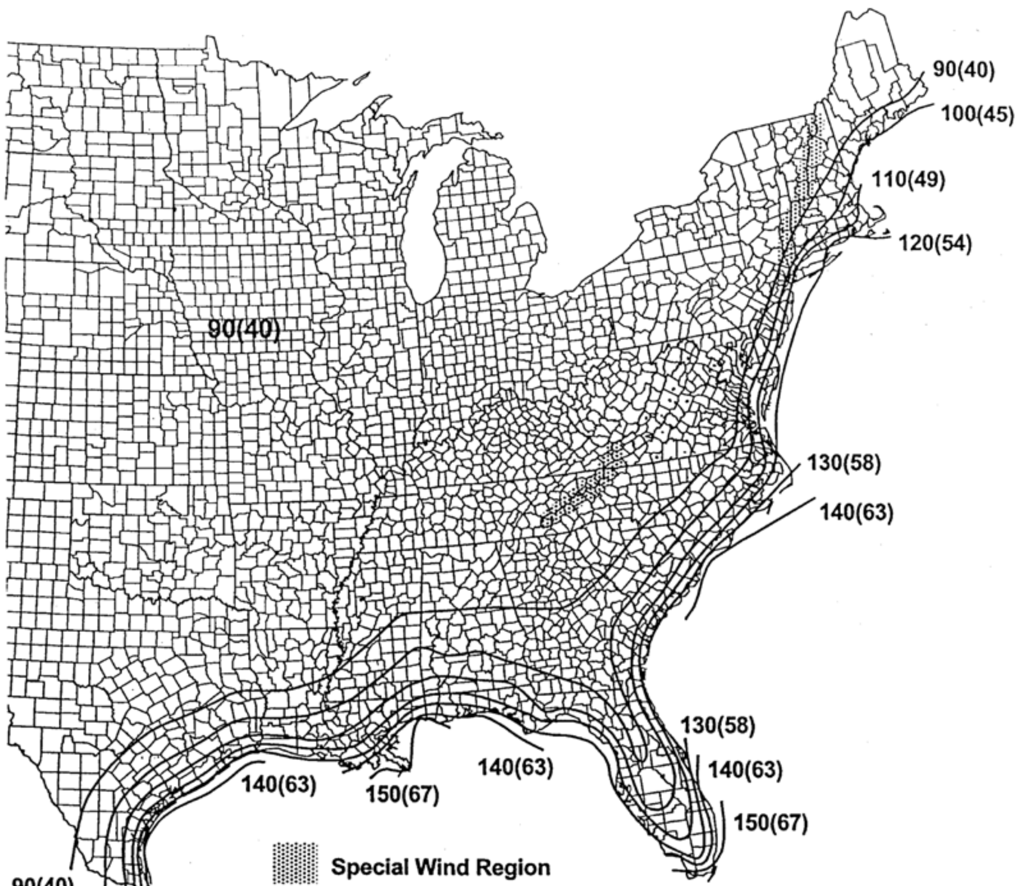
(From ASCE 7-05, Figure 1609)



Basic Wind Speed (3 second gust) in mph (m/s)

Appendix C—Basic Wind Speed Map, cont.

(From ASCE 7-05, Figure 1609)



Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

Notes:

1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

Commentary

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.

C1.1 Scope

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."

The low slope value defined in this Standard comes from an industry accepted value of ≤ 9.5 degrees (2:12), The ASCE 7-05 document, used as a model for the development of this Standard, provides tables for GC_p for slopes less than or greater than 7 degrees (1.5:12) based on previous wind tunnel testing.

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 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 device assembly itself must not come loose in a design wind. A loose edge assembly not only endangers surrounding property or persons, but it also exposes the roofing to blow-off, starting at the edge. Good design practice requires consideration of nailer, roof edge and membrane securement, and selection of materials and finishes to minimize corrosion, and metal gauges to assure strength and flatness.

It is recommended that the roof edge designer be familiar with the ASCE 7-05 document and its commentary.

C2.0 Background Information

The 1980s saw a dramatic increase in the popularity of single-ply roof systems. With this increase, metal edge termination systems began receiving additional attention. Throughout the 1980s into the early 1990s a variety of organizations developed 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 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 that fabricate and install roof edges.

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.

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

C3.3 Wind Speed

Special wind regions (mountains or valleys): Refer to Section 6.5.4.1 of ANSI/ASCE 7-05.

Special Wind Regions

The basic wind speed shall be increased where records or experience indicate that the wind speeds are higher than those reflected in Appendix C. Mountainous terrain, gorges and special topographic regions shall be examined for unusual wind conditions. The authority having jurisdiction, if necessary, shall adjust the values given in Appendix C to account for higher local wind speeds.

Topographic Factor

Refer to Section 6.5.7 of ASCE 7-05 if the height of the hill or escarpment is greater than 15 ft. in exposure C or D and 60 ft. for exposure B. The intensifying effects of topography (hills or escarpments) are to be accounted for. Speedup over hills and escarpments is accounted for in ASCE 7-05 by means of a topographic factor, Kzt 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. See Commentary 4.2.

Corner Region

The angle at which the walls meet to constitute a corner is undefined here and in ASCE 7-05. It has been suggested that an airflow separation effect begins to take effect when walls meet at 150°. Since most walls meet at angles more acute than this, the meeting angle is not a practical consideration for this Standard. Because it is difficult to test corner systems, the increased wind forces on the component have been accounted for by recommending doubled fastening at the building corner regions rather than testing corner components directly as such.

C3.6 Exposure

The terrain surrounding a building will influence the exposure of that building to the wind. See ASCE 7-05 Section 6.5.6.2 for surface roughness information. Exposure A, once used for large cities, has been omitted from the ASCE 7-05 document. Special wind conditions could apply. Therefore the engineer of record shall be contacted to determine wind design loads.

C3.7 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. The tables are incomplete in this document; ASCE 7-05 provides additional information, and exceptions. 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 7-05.

C3.8 Membrane Termination Systems

The roof edging 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 edge. In ballasted systems, ballast may be scoured away from the edge. Ballasted roofs should be designed to meet ANSI/SPRI RP-4 to prevent excessive scour.

Consideration should be given to sealing the edge against air infiltration. Air infiltration may affect the loads on the roofing and the perimeter edge detail 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 they shall follow the rules for all mechanically attached systems.

C3.8.1 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. (305 mm) from the outside edge of the nailer are considered dependently terminated by the edge system. For these systems Tables A7 and A8, and Test RE-1 are applicable. Dependently Terminated systems 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.

Systems whose membrane tension, found from the RE-1 Test, meets or exceeds the membrane tension in a row are classified at 60–75 etc, which means they can be used as the perimeter securement for the classified systems with appropriate edge spacing. As an example a 50 ft. tall building in wind exposure B in a 110 mph wind zone would have a field of roof pressure of 29.6 psf (from Table A2). A system that has a vertical force resistance, found from an RE-1 Test, of 600 pounds/ft. could be used with a perimeter row fastener spacing of up to 5 ft. for a Class 60 rating (from Table A7), up to 4 ft. spacing for a Class 75 rating, up to 3 ft. spacing for a class 90 rating, and up to 2 ft. spacing for a Class 105 rating.

Normally the roofing membrane is restrained at the edge by means of a mechanical gripping of the roofing between metal members or by a bond between the roofing and edging.

An edge flashing 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 vertical walls inboard of the roof edge are not considered by this Standard.

C3.8.2 Independently terminated

Systems in which the roof cover is fully adhered to the substrate or a mechanically attached roof cover is secured the substrate at a distance less than or equal to 12 in. (305 mm) from the outside edge of the nailer are considered independently terminated. For these systems Tables A5 and A6 and Test RE-2 or RE-3 are applicable.

Copings/Caps
are Independently terminated systems: These are systems that cover the tops of parapet walls, usually with the roofing membrane terminated under them. Tables A5 and A6 provide classification for these systems.

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.

C3.9 Nailer 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. The design professional or authority having jurisdiction should determine if the load path is complete and the appropriate safety factor is applied.

C3.9.1 Nailer Secured Systems Wood Members

Nailers should be preservative treated wood (borate treatment is recommended) secured to structural components of the building by corrosion resistant[1,2] means sufficient to resist a vertical load of 200 lbs./ft. (300 kg/m) or the design load, whichever is greater. For wood nailers wider than 6 in. (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 in. (100 mm) but not less than 3 in. (75 mm) from each end of the wood.

Additional wood members, such as cant strips and stacked nailers should be fastened with corrosion resistant fasteners having sufficient pullout resistance prior to edge system failure. These fasteners should be staggered, spaced at a maximum 12 in. (300 mm) on centers, and should penetrate the wood sufficiently to achieve design pullout resistance. Spacing should be on maximum 6 in. (152 mm) centers in corner regions of the building. When re-roofing, the existing nailer should be exposed and inspected. If it has deteriorated, it should be replaced.

The following references are provided to assist in the design of the wood nailer system.

- The American Forrest & Paper Association's (AF&PA's) "National Design Standard for Wood Construction (NDS)"
- The American Institute of Timber Construction's (AITC), "Design Manual"
- IBC Chapter 23
- FM 1-49 regarding wood blocking and nailers, Sec. 2.2-Construction and Location.
- Third party fastener test data.

C3.9.1.1 Masonry

When embedded in masonry, anchor bolts as defined above should be bent 90 degrees at the base or have heads designed to prevent rotation and slipping out. When hollow block masonry is used at the roofline, 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/m^3). When embedded in lightweight aggregate hollow block, bolts should be embedded minimum 12 in. (300 mm) into concrete fill. When heavy aggregate blocks are used, bolts should be embedded minimum 8 in. (200 mm).

C3.9.1.2 Light Weight Concrete and Gypsum Decks

Anchor all roof perimeter nailers using fasteners whose size and locations meet provisions in Section 3.9.1.1 of this Standard. It is recommended that the fasteners be attached directly to the structure if industry approved calculations verifying the anchor attachment strength, anchor substrate strength, and substrate attachment strength are not available.

C3.9.2 Nailer Attached to Steel Deck

The steel deck should be designed to withstand the design forces specified under Section 3.9 of the Standard. Nailer attachment should provide a minimum resistance of 200-lb/ft. (300 kg/m) vertical load.

C3.9.3 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 3.9 of this Standard.

C3.9.4 Re-roofing

For nailer security when re-roofing, the contractor should check to ensure that 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 re-roofing process. ANSI/ SPRI/ FX-1 should be used to verify the resistance of fasteners to pull out.

C4.2 Wind Load Determination

The Roof Edge Design Pressure, P, has been calculated based on a conservative form of the Components and Cladding "Velocity Pressure", q_z, found in Equations 6-15, 6-22, and 6-23 of ASCE 7-05. For purposes of calculating the Field of Roof Pressure, defined in this document as q_{fz}, the velocity pressure, q_z, from ASCE 7-05 has been used :

q = Velocity Pressure at height z (Equation 6-15 of ASCE 7-05) = $0.00256(K_z)(K_{zt})K_d(V^2)(I)$ in which:

K_z = Velocity Pressure Exposure Coefficient (Table 6-3 in ASCE 7-05). Values of K_z vary from a minimum 0.70 (0–30 ft.) upwards to 1.56 (500 ft.) for Exposure B, depending on the roof edge height. Values shown in Tables A2–A4 take into account the values of K_z for the given building height.

K_{zt} = Topographic Factor for buildings built near hills or escarpments, found from Equation 6-3 of ASCE 7-05 (Also shown as Figure 6-4 in ASCE 7-05). A value of K_{zt} = 1 is used in this ES-1 document. The design forces for edge metal systems upon buildings near "abrupt changes in general topography" should consider a more accurate K_{zt} value based on ASCE 7-05, Section 6.5.7. This K_{zt} value can then be multiplied directly to $GC_p \times q_{fz} \times I$ to determine the value of P for the building located significantly close to, or upon, a hill, ridge, or escarpment.

K_d = Wind Directionality Factor (ASCE 7-05 Section 6.5.4.4). Per Section 6.5.4.4 of ASCE 7-05, K_d =1.0 since load combinations are not used in this document.

V = Basic Wind Speed, in mph, from Appendix C of this Standard.

I = Importance Factor for Wind Load defined in Table A1 (See also ASCE 7-05 Table 6-1). A value of unity (I=1.0, denoting a Category II building) is used in the q_{fz} tables. A field of roof pressure, q_{fz}, can be easily found for Occupancy Category I, III, and IV by multiplying the entry in Tables A2–A4 by 0.87, 1.15, or 1.15, respectively. Alternatively for determining the Roof Edge Design Pressure, the Importance Factor, I, can be changed to 0.87 or 1.15 in Equation (1) and used directly with the q_{fz} values shown in Tables A2–A4. See ASCE 7-05 Table 6-1 for more information concerning occupancy categories.

q_{fz} = Field of Roof Pressure as defined in the ES-1 design document. The value of q_{fz} is found from Equations 6-22 (h ≤ 60 ft.) and 6-23 (h > 60 ft.) of ASCE 7-05 by using the GC_p value for the field of roof found from Region 1 of Figure 6-11B (h ≤ 60 ft.) and Figure 6-17 (h > 60 ft.). Per ASCE 7-05 the GC_{pi} term is also used. Thus from ASCE 7-05:

p = q_h (GC-GC_{pi}) = components and cladding design wind pressure (in this case the field of roof pressure) per Equation 6-22 of ASCE 7-05.

where

q_h = velocity pressure evaluated at mean roof height h (See Equation 6-22 and Figure 6-11A for more information)

GC_{pi} = Internal Pressure coefficient for Enclosed Buildings, GC_{pi} = +/-0.18, use +0.18 for worst case pressure (See ASCE 7-05 Figure 6-5 for more information)

GC_p = External Pressure Coefficient. Choose $GC_{p,\ perimeter}$, $GC_{p,\ corner}$, or $GC_{p,\ roof}$ as seen in ASCE 7-05 Figures 6-11A, 6-11B, 6-17

$GC_{p,\ roof}$ = -1.0 (h ≤ 60 ft.) for the field of roof (from ASCE 7-05 Figure 6-11B)
= -1.4 (h > 60 ft.) for the field of roof (from ASCE 7-05 Figure 6-17)

Thus to find q_{fz} for h ≤ 60 ft., set p = q_{fz} = field of roof pressure, and use the GC_p term for the roof:

Thus q_{fz} = q_h [-1.0 – (0.18)]

= q_h [-1.18] for h ≤ 60 ft.

For h > 60 ft. a value of -1.4 is used (instead of -1.0) per ASCE 7-05 Figure 6-17.

Tables A2–A4 were created using this procedure, where a velocity pressure, q_h, was calculated per Equation (6-15) of ASCE7-05 and multiplied by either -1.18 (h ≤ 60 ft.) or -1.58 (h > 60 ft.).

P = Roof Edge Design Pressure = 2.0 × (GC_p) × (q_{fz}) × I, where

2.0 = Design Factor (Safety Factor) for perimeter edge metal system designs.

GC_p = External Pressure Coefficient (See Table 2). Horizontal GC_p values (used for comparison to RE-2 and RE-3 Test values) and vertical GC_p values (used for comparison to RE-3 Test values) are presented for building heights less than or equal to 60 ft., or greater than 60 ft.

ASCE 7-05 does not address the horizontal component of GC_p at the actual roof edge. Therefore, the horizontal value of GC_p shown in Table 2 of this ES-1 document was taken from the value of Zone 4 of Figure 6-11A for height ≤ 60 ft. 1). Values for the horizontal GC_p term, h ≤ 60 ft. have been reduced per ASCE 7-05 Figure 6-11A, Note: For walls 60 ft. high, the horizontal GC_p can be reduced by 10% for low slope roofs (< 10%).

Vertical GC_p values are considered for vertical forces on edge metal systems such as coping (or fascia systems with a horizontal exposure which exceeds 4 in. in length). Values for the vertical GC_p term where chosen based on Region 2 of Figure 6-11B and 6-17 of ASCE 7-05.

To produce a representative horizontal and vertical design force for various edge metal systems, an effective wind area of 10 ft^2 was chosen for all GC_p terms (See Figure 6-11 and 6-17 of ASCE 7-05).

Note:
Values given in Tables A2–A4 were found from

$q_{fz} = q_h \times (GC_{p,\ roof}-GC_{pi})$
where per ASCE 7-05:

GC_{pi} = +/-0.18 for an enclosed building. choose +0.18

$GC_{p,\ roof}$ = -1.0 for h ≤ 60 ft.
= -1.4 for h > 60 ft.

In this document the GC_p term is multiplied by the field of roof pressure and not the velocity pressure. As such the values of GC_p shown in Table 2 were found by ensuring that the roof edge design pressure, P, has the same value as compared to ASCE 7-05 before a safety factor is applied:

Let Edge Pressure SPRI/FM 4435/ES-1 document = Edge pressure ASCE 7-05 calculation (See ASCE 7-05 equations 6-15, 6-22, and 6-23 for calculation of the edge pressure via ASCE 7-05)

Thus $q_{fz}GC_{pTable\ 2} = q_h(GC_p\text{-}GC_{pi})$

where q_h = velocity pressure evaluated at mean roof height

Knowing q_{fz} = field of roof pressure

$= q_h \times (GC_{p,\ roof}\text{-}GC_{pi})$

per ASCE 7-05 eqn 6-22

Thus

$$q_h(GC_{p,\ roof}\text{-}GC_{pi})Gc_{Table\ 2} = q_h(GC_p\text{-}GC_{pi})$$

Solve for $GC_{pTable\ 2}$

$$GC_{pTable\ 2} = \frac{GC_p\text{-}GC_{pi}}{GC_{p,\ roof}\text{-}GC_{pi}} \quad \text{(Equation C4.4-1)}$$

Where the values of GC_p and GC_{pi} in the ratio above are taken directly from ASCE 7-05.

GC_p Calculation Example: For H ≤ 60 ft. vertical perimeter pressure, determine $GC_{p\ Table\ 2}$ value:

Table 2 $GC_{pTable\ 2}$ value $= \frac{-1.8 - (0.18)}{-1.0 - (0.18)}$ = 1.678, round off to 1.68, and use negative sign.

Thus $GC_{pTable\ 2}$ value = -1.68 (See Table 2). The negative sign is used since it is an outward pressure (consistent with ASCE 7-05).

In the ratio above:

-1.8 = Perimeter roof GC_p value from ASCE 7-05 Figure 6-11B (h ≤ 60 ft.)

-1.0 = Field of Roof GC_p ($GC_{p,\ roof}$) from ASCE 7-05 Figure 6-11B (h ≤ 60 ft.)

0.18 = Internal Pressure Coefficient from ASCE 7-05 Figure 6-5 for an enclosed building. A positive value is used as it creates the worst case loading (positive internal pressure).

All values shown in Table 2 are found similarly: the corner region, horizontal pressure, and roof height factors are determined from the appropriate ASCE 7-05 Figure. Upon choosing the correct $GC_{pTable\ 2}$ apply the Safety Factor and Importance Factor, I, as needed to Equation (1) of the SPRI/FM 4435/ES-1 document.

Roof Pressure Calculation Examples: ES-1 design calculation as compared to ASCE 7-05 procedure:

Example 1: Choose h = 40 ft., Exposure B, 90 mph wind, perimeter area, enclosed building, Occupancy Category II (I=1.0). Find the design vertical perimeter pressure:

ASCE 7-05 Calculation Method

Step 1. q_z (Equation 6-15 of ASCE 7-05) = $0.00256(K_z)(K_{zt})K_d(V^2)(I)$ = 15.8 psf

Step 2. The GC_{pi} term per Figure 6-5 of ASCE 7-05 = +/-0.18, use 0.18

Step 3. The GC_p term per Figure 6-11B of ASCE 7-05 = -1.8

Step 4. Thus the design vertical roof edge design pressure, P, per ASCE 7-05 equation 6-22 = 15.8 × [-1.8 - (0.18)] = -31.3 psf

SPRI/FM 4435/ES-1 Method (Via Table 2 and Table A2)

Step 1. Choose q_{fz} from Table A2 for h = 40 ft. : q_{fz} = 18.6 psf

Step 2. The vertical, perimeter GC_p term from Table 2 = -1.68

Step 3. The vertical roof edge design pressure from Eqn (1): P = SF × 18.6 × -1.68 = -31.3 × SF psf, where SF = safety factor.

Example 2: Choose h = 100 ft., Exposure C, 140 mph wind, corner region, enclosed building, Occupancy Category II (I=1.0). Find the design vertical corner pressure:

ASCE 7-05 Calculation Method

Step 1. qz (Equation 6-15 of ASCE 7-05) = $0.00256(K_z)(K_{zt})K_d(V^2)(I)$ = 63.22 psf

Step 2. The GC_{pi} term per Figure 6-5 of ASCE 7-05 = +/-0.18, use 0.18

Step 3. The GC_p term per Figure 6-17 of ASCE 7-05 = -3.2

Step 4. Thus the design vertical roof edge design pressure, P, per ASCE 7-05 equation 6-22 = 63.22 × [-3.2 - (0.18)] = -214 psf

SPRI/FM 4435/ES-1 Method (Via Table 2 and Table A3)

Step 1. Choose q_{fz} from Table A3 for h = 100 ft. : q_{fz} = 99.9 psf

Step 2. The vertical, corner GC_p term from Table 2 = -2.14

Step 3. The vertical roof edge design pressure from Eqn (1): P = SF × 99.9 × -2.14 = -214 × SF psf, where SF = safety factor.

To be consistent with ASCE 7-05 and the 2003 ANSI/SPRI ES-1 document the negative sign will not appear in the field of roof pressure tables (Tables A2–A4).

Partially Enclosed Buildings

Equation (1) can be used to determine the roof edge design pressures, P, for partially enclosed buildings by following the steps below. Consult Section 6.2, 6.5.12.4 and Figure 6-5 of ASCE 7-05 for definition and references of open and partially enclosed buildings:

Steps for Determining Edge Pressure, Partially Enclosed Buildings

Step 1. Multiply appropriate value in Tables A2–A4 by 1.31 × for h ≤ 60 ft. or 1.23 × for h > 60 ft.

Step 2. Use GC_p value from Table C-A2 below

Step 3. Apply Equation (1)

*The values 1.31 and 1.23 were found by the ratio of $\dfrac{(GC_{p,\ roof} - GC_{pi\ \text{partially enclosed}})}{(GC_{p,\ roof} - GC_{pi\ \text{enclosed}})}$

$$= \frac{(-1 - 0.55)}{(-1 - 0.18)} = 1.3 \text{ for } h \le 60 \text{ ft.}$$

$$= \frac{(-1.4 - 0.55)}{(-1.4 - 0.18)} = 1.23 \text{ for } h \le 60 \text{ ft.}$$

See Equation C4.4-1, ASCE 7-05 Figure 6-11B and Figure 6-17 for more information.

Table C-A2
External Pressure Coefficient[1] (GC_p)
Partially Enclosed Building

Type of Loading	Edge Location	Roof Height 60 ft. (18.3 m) or less z ≤ 60 ft. (18.3 m)	Roof Height over 60 ft. (18.3 m) z > 60 ft. (18.3 m)
Horizontal (acting outward from the building edge)	Perimeter	-0.95[2]	-0.74
	Corner	-1.13[2]	-1.21
Vertical (acting upward at the building edge)	Perimeter	-1.52	-1.46
	Corner	-2.16	-1.92

Table Notes:

1. Values of GC_p shown above differ from ASCE 7-05 values due to the incorporation of the internal pressure coefficient, GC_{pi}, and the application of GC_p to the field of roof pressure. See Commentary 4.2
2. Per ASCE 7-05 values shown have taken into account a 10% reduction for roof slopes ≤ 10 degrees. See ASCE 7-05 Figure 6-11A, Note 5, for more information.
3. The negative signs (-) in the External Pressure Coefficients represent vector directionality of the force acting away from the building, tending to pull materials upward or outward (horizontal) from the building.
4. Values in the table above were found by applying Equation C4.4-1 with GC_{pi} = 0.55. See ASCE 7-05 Figure 6-5, Figure 6-11A, 6-11B, and Figure 6-17 for more information.

Open Buildings

Consult ASCE 7-05 to determine roof edge pressures for open buildings.

C4.3 Edge Pressure Wind Load Tables, Wind Exposure

Wind Exposure Conditions B, C, and D (See ASCE 7-05 Section 6.5.6 for more information) is accounted for by presenting three individual tables (A2–A4). It is noted here that values in Tables A2–A4 are the field of roof design pressures to be used when calculating the load on the edge systems. 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. The vertical component was taken from the values for the perimeter area (surface area 2) on Figures 6-11B and 6-17 of ASCE 7-05 using an effective wind area of 10 ft^2.

C4.4 Nailer Securement Load Tables

For mechanically attached or ballasted systems which do NOT contain a “peel stop” within 12 in. of the roof edge, Tables A9 and A10 shall be used. Values in Tables A9 and A10 were found by placing the field of roof pressure into Equation (1) using the vertical GC_p value for the perimeter region. However, Tables A9 and A10 do not address the horizontal loads given in Tables A5 and A6; therefore, additional engineering may be required to verify that the nailer attachment resists the total applied force for these specific systems.

C5.0 Edge System Resistance

Once the design loads have been determined, edge systems may be selected from manufacturers who certify certain minimum performance to meet design requirements, based upon testing. Any edge system may be used provided that it is tested and certified by an independent testing laboratory to meet the wind and pullout resistance design standards found in this document.

The vertical face of an edge flashing (gravelstop) shall be tested according to Test RE-2 and provide a strength that meets or exceeds the horizontal pressure found in Tables A5 (roof height, h, ≤ 60 ft.), and A6 (h > 60 ft.). The test shall be applicable to systems with exposed horizontal components less than 4 in. (100 mm) as detailed in the RE-2 Test Method; otherwise Test RE-3 is applicable.

The vertical and horizontal faces of copings (and like edge systems) shall be tested according to Test RE-3 and provide a strength that meets or exceeds the horizontal and vertical pressures found in Tables A5 (roof height, h, ≤ 60 ft.), and A6 (h > 60 ft.).

The edging, when used for securing dependently terminated roofing systems, shall be tested according to Test RE-1 and provide a strength that meets or exceeds the membrane tension found in Tables A7 (roof height, h, ≤ 60 ft.), and A8 (h > 60 ft.).

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

C5.4 FM Classifications

Classifications based on their resistance to wind loads are provided in Tables C-A5, C-A7 as a reference.

Table C-A5
Horizontal and Vertical Edge Pressures
Enclosed Building[1], Occupancy Category II (I=1.0)

Field of Roof Pressure q_{fz} Psf (KPa)	Class	Horizontal Load Psf (KPa)		Vertical Load Psf (KPa)	
		Perimeter P_{hp}	Corner P_{hc}	Perimeter P_{vp}	Corner P_{vc}
30 (1.44)	60	58 (2.8)	73 (3.5)	101 (4.8)	152 (7.3)
37.5 (1.80)	75	73 (3.5)	91 (4.3)	126 (6.0)	190 (9.1)
45 (2.15)	90	87 (4.2)	109 (5.2)	151 (7.2)	228 (10.9)
52.5 (2.51)	105	102 (4.9)	127 (6.1)	176 (8.4)	266 (12.7)
60 (2.87)	120	116 (5.6)	145 (7.0)	202 (9.7)	304 (14.5)
67.5 (3.23)	135	131 (6.3)	163 (7.8)	227 (10.9)	342 (16.4)
75 (3.59)	150	146 (7.0)	182 (8.7)	252 (12.1)	380 (18.2)
82.5 (3.95)	165	160 (7.7)	200 (9.6)	277 (13.3)	417 (20.0)
90 (4.31)	180	175 (8.4)	218 (10.4)	302 (14.5)	455 (21.8)
97.5 (4.67)	195	189 (9.1)	236 (11.3)	328 (15.7)	493 (23.6)
X	2 × X	1.94 × X	2.42 × X	3.36 × X	5.06 × X

Table Notes:

1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. Design factors such as exposure, wind speed, and building height are used to determine the appropriate field of roof pressure. See Tables A2–A4 and Commentary Section 4.2 for more information.
3. Horizontal and vertical load values are calculated directly from a field of roof pressure given in column 1 and from Equation (1) which contains a safety factor.
4. The "Class" column is given as a reference to designers requiring FM classification.

Table C-A7
RE-1 Classifications—Dependently Terminated Systems
Enclosed Building[1], Occupancy Category II (I=1.0)

Field of Roof Pressure q_{fz} psf (kPa)	Class	Vertical Perimeter Pressure P^{vp} psf (kPa)	Membrane Tension lb/ft. (kg/m) Distance to first Row of Fasteners ft.				
			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)	60	101 (4.83)	239 (356)	358 (533)	477 (710)	596 (887)	716 (1066)
30.0 < q_{fz} ≤ 37.5 (1.44 < q_{fz} ≤ 1.8)	75	126 (6.03)	298 (443)	447 (664)	596 (887)	745 (1109)	894 (1330)
37.5 < q_{fz} ≤ 45.0 (1.8 < q_{fz} ≤ 2.15)	90	151 (7.24)	358 (533)	537 (799)	716 (1066)	894 (1330)	1073 (1597)
45.0 < q_{fz} ≤ 52.5 (2.15 < q_{fz} ≤ 2.51)	105	176 (8.45)	417 (621)	626 (932)	835 (1243)	1042 (1552)	1251 (1863)
52.5 < q_{fz} ≤ 60.0 (2.51 < q_{fz} ≤ 2.87)	120	202 (9.65)	477 (710)	716 (1066)	954 (1419)	1193 (1775)	1431 (2130)
60.0 < q_{fz} ≤ 67.5 (2.87 < q_{fz} ≤ 3.23)	135	227 (10.9)	537 (799)	804 (1198)	1073 (1597)	1342 (1997)	1610 (2395)
67.5 < q_{fz} ≤ 75.0 (3.23 < q_{fz} ≤ 3.59)	150	252 (12.1)	596 (887)	894 (1330)	1193 (1775)	1490 (2218)	1789 (2661)
75.0 < q_{fz} ≤ 82.5 (3.59 < q_{fz} ≤ 3.95)	165	277 (13.3)	656 (976)	984 (1464)	1312 (1951)	1640 (2440)	1968 (2928)
82.5 < q_{fz} ≤ 90.0 (3.95 < q_{fz} ≤ 4.31)	180	302 (14.5)	716 (1066)	1073 (1597)	1431 (2130)	1789 (2661)	2146 (3194)
90.0 < q_{fz} ≤ 97.5 (4.31 < q_{fz} ≤ 4.67)	195	328 (15.7)	775 (1152)	1163 (1731)	1550 (2307)	1937 (2884)	2326 (3460)
97.5 < q_{fz} ≤ 105.0 (4.67 < q_{fz} ≤ 5.03)	210	353 (16.9)	835 (1243)	1251 (1863)	1669 (2484)	2087 (3106)	2504 (3725)
105 < q_{fz} ≤ 112.5 (5.03 < q_{fz} ≤ 5.39)	225	378 (18.1)	894 (1330)	1342 (1997)	1789 (2661)	2236 (3328)	2683 (3992)
112.5 < q_{fz} ≤ 120 (5.39 < q_{fz} ≤ 5.75)	240	403 (19.3)	954 (1419)	1431 (2130)	1907 (2839)	2384 (3548)	2861 (4258)
120 < q_{fz} ≤ 127.5 (5.75 < q_{fz} ≤ 6.11)	255	428 (20.5)	1013 (1509)	1521 (2263)	2027 (3016)	2534 (3770)	3040 (4525)

Table Notes:
1. See Commentary 4.2 for open buildings or partially enclosed buildings.
2. This column to be used for ballasted systems. See Appendix A—RE-1 Test information.
3. See Commentary—Test Method RE-1 for the calculations used to determine entries in Tables A7.

C6.0 Performance of Light Gauge Metal

The performance and appearance of metal roofing systems are significantly affected by several material properties.

C6.1 Thermal Expansion/Contraction

The effects of thermal expansion should be considered. Edge system elements which are not allowed to expand/contract freely can cause internal stresses and unwanted deflections (including face bowing) that may compromise both the appearance and performance of the roof edge system. Sections of the roof edge system should be designed to allow for the expected expansion/contraction of each section. Fastener holes for attaching materials with differing coefficients of expansion should have slotted or oversized holes to allow for differing amounts of thermal expansion deflection.

C6.2 Metal Thickness

Increased metal thickness improves the flatness and reduces the "oil-can" effect of the roof edge metal. Table 3 was developed from NRCA, Factory Mutual, and SMACNA recommendations[3]. 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. The required minimums do not address other important design factors such as fastening pattern and frequency, continuous or intermittent cleating, stiffening ribs or breaks in the edges. Tests RE-2 and RE-3 may determine that metal thickness need to be increased for higher wind loads.

C6.3 Galvanic Corrosion/Compatibility and Resistance

Corrosion and strength should be considered in the choice of materials. Regarding corrosion, this Standard focuses primarily on metal edge systems. Corrosive potential can be roughly predicted by knowing the placement of the two metals in the galvanic series[4,5]. 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 Figure C1, the metals low on the list are potentially corroded while those high on this list are protected. Basically 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 and zinc or aluminum or steel must be avoided because copper is far from them in the galvanic series and the potential for corrosion is great.

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 higher of a pair will be protected by the lower even if no perceptible corrosion is taking place. For this reason, steel, being higher 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 protecting the steel.

Galvanic Series[6]
More Protected
Platinum
Gold
Graphite
Silver
316 Stainless steel (passive)
304 Stainless steel (passive)
Monel
Inconel (passive)
Nickel (passive)
70-30 cupro-nickel
Silicon bronze
Copper
Red brass
Admiralty bronze
Admiralty brass
Yellow brass
Hastelloy C (active)
Inconel (active)
Nickel (active)
Naval bronze
Muntz metal
Tin
Lead
316 Stainless steel (active)
304 Stainless steel (active)
400 Series stainless steels
50-50 lead-tin solder
13% Cr stainless steel (active)
Ni–resist
Cast iron
Wrought iron
Mild steel
Cadmium
Alclad
Aluminum
Aluminum 2024
Aluminum 3003
Aluminum 6053
Galvanized steel
Zinc
Magnesium alloys
Magnesium
More Corroded

Figure C1 Galvanic Corrosion Series Chart

The edge metal's immediate environment or "medium" greatly affects the rate of galvanic corrosion[4,5]; materials in a salt water spray environment will corrode faster than areas far from a salt water lagoon or ocean. In extremely corrosive environments such as salt-water environments, chemical plants or paper mills, corrosion resistant materials such as stainless steel shall be used. When plastic materials are used, corrosion is not usually a factor (although environmental deterioration must be considered). However, as with metals the strength of the materials must be considered.

C8.0 Packaging and Identification

Follow-up programs are required for systems that are classified by FM, UL and other organizations.

C9.0 Installation

Installation shall be performed in the same manner as the tested edge system. This requires that the fastener spacing is no greater than the test spacing, and the fasteners' performance values are equal to or greater than the tested fasteners values.

Test Method RE-1 Commentary

The roof membrane termination (edge system, nailer, or other) is a key anchor point holding the membrane in place. During high-speed wind loading, the roof system can create extreme loads on the edge device assembly.

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 angle[7,8]. Figure RE1.4 shows a closer look at the membrane forces.

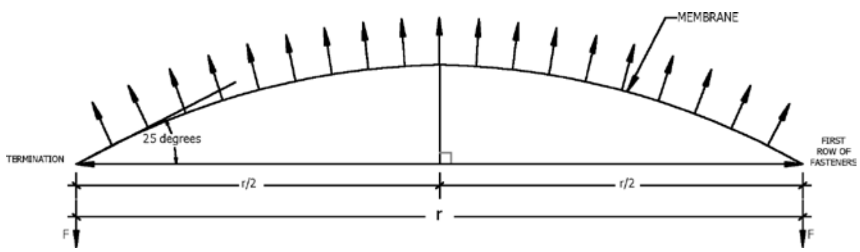


Figure RE1.3—Mechanically Attached Roof Forces

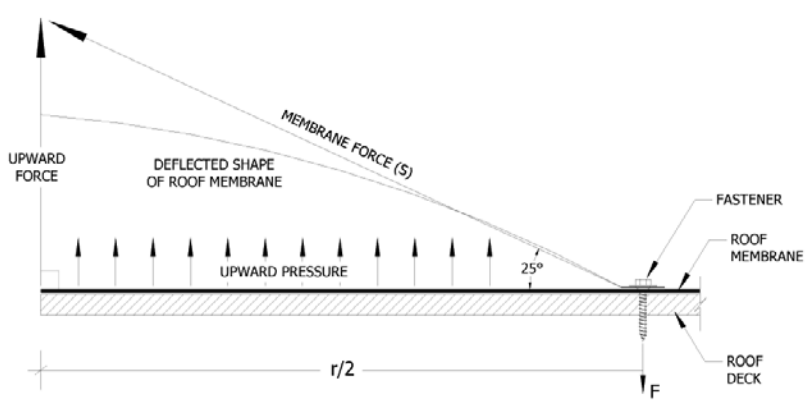


Figure RE1.4—System of Forces, ½ of Membrane width between Fasteners

If an upward pressure (lb/ft^2) is applied to the membrane, then the upward force = upward pressure × 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:

$$\sin 25^\circ = \frac{\text{UpwardForce}}{S}$$

$$\sin 25^\circ = \frac{\text{Upwardpessure} \times \frac{r}{2}}{S}$$

Thus,

$$S = \frac{\text{Upwardpessure} \times \frac{r}{2}}{\sin 25^\circ}$$

If the edge region of the roof is considered, then the upward pressure (See Figure RE1.4) equals either the vertical perimeter pressure, P_{vp}, or the vertical corner pressure, P_{vc}. Considering the perimeter region, the perimeter pressure can be found from Section 4.2 of this document:

P_{vp} = Perimeter Pressure = SF × q_{fz} × GC_p from Equation (1) for I=1.0

The design membrane tension, at the perimeter region, can be found from:

$$\text{Design membrane tension (S)} = SF \times q_{fz} \times GC_p \times \frac{\frac{r}{2}}{\sin 25^\circ}$$

Where GC_p = External pressure coefficient (See Section 4.2), choose either perimeter region or corner.

The equation can be simplified noting:

sin (25°) = 0.42262

1/sin (25°) = 2.37, thus:

$$\text{Design membrane tension (S)} = SF \times 2.37 \times q_{fz} \times GC_p \times \frac{r}{2} \quad \text{Equation (RE1-1)}$$

If SF=2 is used, the equation becomes:

$$\text{Design membrane tension (S)} = 2.37 \times q_{fz} \times GC_p \times r \quad \text{Equation (RE1-2)}$$

<u>Example of Determining a Design Membrane Tension Force</u>:

Given a 2 ft. perimeter sheet, Class 135 (actual field pressure = 67.5 psf),
building height= 50 feet (See Table A5):

$$S = \text{Design membrane tension} = SF \times 2.37 \times q_{fz} \times GC_p \times \frac{r}{2}$$

Using SF=2, the equation becomes:

$$S = 2.37 \times -1.68 \times 67.5 \text{ psf} \times 2 \text{ ft.} = -536 \text{ lb}$$

Values in Table A7 and A8 are found from the equations described above.

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 systems are assumed to apply no stress on the 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. Recent hurricane investigations have shown that both can occur.

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 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 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 non-continuous 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 in. (5.669 m) length were tested as a 36 in. (0.914 m) 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.

No special testing is required of fabricated miters. However, the 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 edge systems to establish lab-to-lab variability of individual test results.

The External Pressure Coefficients, GC_p, in this document (Table 2) have changed from the ANSI/SPRI ES-1 2003 Standard (Table 3) as discussed in Commentary Section 4.2. This has produced a small change, up to a maximum 11%, in the ratio of horizontal loading to vertical loading in the RE-3 Test for any roof height. Since the new ratio is within 11% of the ratios prescribed in the ANSI/SPRI ES-1 2003 Standard any products previously tested in accordance with the ANSI/SPRI ES-1 2003 Standard will not need to be retested.

Failure

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

- Full fastener pull-out
- Collapse of a cleat, fascia or cover
- Disengagement of a face or coping at the drip-edge
- Failure of the nailer

1. *Standard C15-03 Wood for Commercial-Residential Construction*, Preservative Treatment, American Wood-Preservers Association, Granbury, TX, 1996.
2. Procedure for Evaluation of Corrosion Resistance of Steel Fasteners, SPRI, Needham MA, 1988.
3. NRCA Roofing and Waterproofing Manual, National Roofing Contractors Association, Rosemont, IL, 1996, and Loss Prevention Data Sheet 1-49, Factory Mutual Research Corporation, Norwood, MA. 1985 and Architectural Sheet Metal Manual SMACNA, Chantilly, VA 1993.
4. Corrosionsource.com ©2000 http://www.corrosionsource.com/handbook/galv_series.htm
5. http://www.corrosion-doctors.org/Definitions/galvanic-series.htm
6. *Handbook of Materials Selection for Engineering Applications*, G. T. Murray, CRC Press.
7. 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.
8. 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.