



Designation: E1996 – 23

Standard Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Windborne Debris in Hurricanes¹

This standard is issued under the fixed designation E1996; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers exterior windows, glazed curtain walls, doors, and impact protective systems used in buildings located in geographic regions that are prone to hurricanes.

1.1.1 *Exception*—Exterior garage doors and rolling doors are governed by ANSI/DASMA 115 and are beyond the scope of this specification.

1.2 This specification provides the information required to conduct Test Method E1886.

1.3 Qualification under this specification provides a basis for judgment of the ability of applicable elements of the building envelope to remain unbreached during a hurricane; thereby minimizing the damaging effects of hurricanes on the building interior and reducing the magnitude of internal pressurization. While this standard was developed for hurricanes, it may be used for other types of similar windstorms capable of generating windborne debris.

1.4 This specification provides a uniform set of guidelines based upon currently available information and research.² As new information and research becomes available it will be considered.

1.5 All values are stated in SI units and are to be regarded as standard. Values given in parentheses are for information only. Where certain values contained in reference documents cited and quoted herein are stated in inch-pound units, they must be converted by the user.

1.6 The following precautionary statement pertains only to the test method portion, Section 5, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and*

environmental practices and determine the applicability of regulatory limitations prior to use.

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:³

C719 Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)

C1135 Test Method for Determining Tensile Adhesion Properties of Structural Sealants

D3575 Test Methods for Flexible Cellular Materials Made from Olefin Polymers

E631 Terminology of Building Constructions

E1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Impact Protective Systems Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials

2.2 ANSI/DASMA Standard:⁴

ANSI/DASMA 115 Standard Method for Testing Sectional Garage Doors and Rolling Doors: Determination of Structural Performance Under Missile Impact and Cyclic Wind Pressure

2.3 ASCE/SEI Standard:⁵

ASCE/SEI 7 American Society of Civil Engineers Minimum Design Loads for Buildings and Other Structures

¹ This specification is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on Performance of Windows, Doors, Skylights and Curtain Walls.

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² See the Significance and Use Section of Test Method E1886.

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

⁴ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

⁵ Available from American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191, <http://www.asce.org>.

2.4 *Other Standard:*⁶
International Residential Code

3. Terminology

3.1 Definitions:

3.1.1 General terms used in this specification are defined in Terminology **E631**.

3.1.2 Terms common to this specification and Test Method **E1886** are defined in Test Method **E1886**, unless defined herein.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *assembly elevation, n*—vertical dimension above adjacent mean ground level at which fenestration or impact protective system assembly is to be installed, measured to the lowest point of the assembly.

3.2.2 *basic wind speed, n*—three-second gust speeds as defined in the latest edition of ASCE/SEI 7.

3.2.3 *combination mullion, n*—a horizontal or vertical member formed by joining two or more individual fenestration units together without a mullion stiffener.

3.2.4 *impact protective system, n*—construction applied, attached, or locked over an exterior glazed opening system to protect that system from windborne debris during high wind events.

3.2.4.1 *Discussion*—Impact protective systems include types that are fixed, operable, or removable.

3.2.5 *infill, n*—glazing in a fenestration assembly or curtain wall.

3.2.6 *integral mullion, n*—a horizontal or vertical member which is bounded at both ends by crossing frame members.

3.2.7 *maximum deflection, n*—greatest deformation of an element or component under the application of an applied force.

3.2.8 *maximum dynamic deflection, n*—greatest deformation of an element or component during the missile impact.

3.2.9 *meeting rail or check rail, n*—one of the two horizontal members of a sliding sash that come together when in the closed position.

3.2.10 *meeting stile, n*—one of the two vertical members of a sliding sash that come together when in the closed position.

3.2.11 *porous impact protective system, n*—an assembly whose aggregate open area exceeds ten percent of its projected surface area.

3.2.12 *valley, n*—a pivoting axis of an impact protective system designed to rotate adjacent slats or panels outward.

4. Test Specimens

4.1 Number of Test Specimens:

4.1.1 Fenestration Assemblies:

4.1.1.1 Three test specimens shall be submitted for the large missile test.

4.1.1.2 Three test specimens shall be submitted for the small missile test.

4.1.1.3 One additional test specimen may be submitted for each of the tests should no more than one of the original three specimens fail any portion of the testing.

4.1.2 Impact Protective Systems:

4.1.2.1 A minimum of three test specimens shall be submitted for the large missile test for the largest span to be qualified.

4.1.2.2 A minimum of three test specimens shall be submitted for the small missile test.

4.1.2.3 One additional test specimen may be submitted for each of the tests should no more than one of the original specimens fail any portion of the testing.

4.1.2.4 For porous impact protective systems, the large and small missile tests shall be allowed to be performed on the same specimens, or on separate specimens. If the large and small missile tests are performed on the same specimens, the small missile impacts shall be performed first, followed by the large missile impacts.

4.2 Test specimens shall be prepared as specified in Test Method **E1886**.

4.3 The size of the test specimen shall be determined by the specifying authority. All components of each test specimen shall be full size.

4.4 Where it is impractical to test the entire fenestration assembly such as curtain wall and heavy commercial assemblies, test the largest size of each type of panel as required by the specifying authority to qualify the entire assembly.

4.5 Fenestration assemblies and impact protective systems intended to be mulled together shall be tested separately or tested by combining three specimens into one mounting frame separated only by the mullions.

5. Test Methods

5.1 Test specimens shall be tested according to Test Method **E1886**.

5.2 Determine the missile based upon building classification, wind speed, and assembly elevation according to Section 6.

5.3 Location of Impact:

5.3.1 *Large Missile Test*—Impact each impact protective system specimen and each fenestration assembly infill type once as shown in **Fig. 1**.

5.3.1.1 Impact one specimen with the center of the missile within a 65 mm (2½ in.) radius circle and with the center of the circle located at the center of each type of infill.

5.3.1.2 Impact a different specimen with the center of the missile within a 65 mm (2½ in.) radius circle and with the center of the circle located 150 mm (6 in.) from supporting members at a corner.

5.3.1.3 Impact the remaining specimen with the center of the missile within a 65 mm (2½ in.) radius circle and with the center of the circle located 150 mm (6 in.) from supporting members at a diagonally opposite corner.

5.3.2 Special Considerations:

⁶ Available from International Code Council (ICC), 500 New Jersey Ave., NW, 6th Floor, Washington, DC 20001, <http://www.iccsafe.org>.

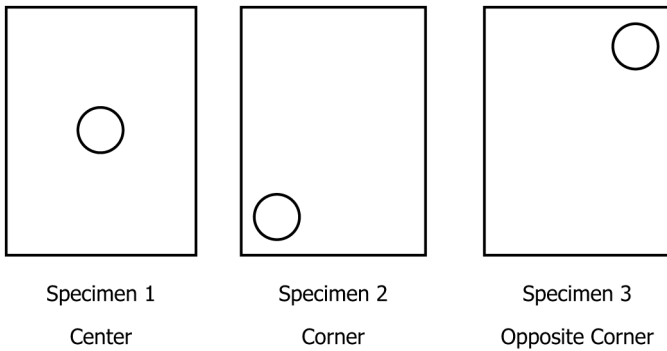


FIG. 1 Impact Locations for Large Missile Test (Each Type of Infill)

5.3.3.4 The center impact location shall be entirely within a 250 mm (10 in.) radius circle having its center located at the horizontal and vertical centerline of the infill.

NOTE 1—Impact locations for small missile test may overlap depending on the size of the specimen.

5.4 Air Pressure Cycling:

5.4.1 Air Pressure Differential:

5.4.1.1 The air pressure portion of the test shall use the test loading program in Table 1. Select P_{pos} and P_{neg} for the maximum inward (positive) and maximum outward (negative) air pressure differential for which qualification is sought.

5.4.1.2 The air pressure differential to be used for porous impact protective systems shall be F (the design wind force for other structures as specified in ASCE/SEI 7) divided by the horizontally projected area of the entire assembly.

5.4.2 Porous impact protective systems whose aggregate open area exceeds 50 % of their projected surface area that pass the small missile test and that are not subject to the large missile test need not be tested for the air pressure portion of the test described in this section.

5.5 For impact protective system specimens that are tested independently of the fenestration assemblies they are intended to protect, measure, and record both the maximum dynamic deflection and the residual deflection following the impact test and measure and record the maximum positive deflection in combination with the residual deflection during the air pressure cycling test. Measure all deflections to the nearest 2 mm (0.1 in.).

5.3.2.1 For test specimens containing multiple panels, impact the exterior glazing surface innermost from the exterior plane of the fenestration assembly or impact protective system panel innermost from the exterior.

5.3.2.2 For test specimens containing fixed and operable panels of the same type of infill, impact the operable portion.

5.3.2.3 For operable test specimens, a corner impact location shall be nearest a locking device and the other corner impact location shall be at a corner diagonally opposite.

5.3.2.4 For test specimens with bracing at the specified impact location(s), the impact location(s) shall be relocated to the nearest area with no bracing.

5.3.2.5 The impacts on accordion impact protective systems shall be at the valleys located closest to the impact locations shown in Fig. 1.

5.3.3 Small Missile Test—Impact each impact protective system specimen and each fenestration assembly infill type three times with ten steel balls each as shown in Fig. 2.

5.3.3.1 Each impact location shall receive distributed impacts simultaneously from ten steel balls. The impact shall be described in the test report.

5.3.3.2 The corner impact locations shall be entirely within a 250 mm (10 in.) radius circle having its center located at 275 mm (11 in.) from the edges.

5.3.3.3 The edge impact locations shall be entirely within a 250 mm (10 in.) radius circle at the centerline between two corners having its center located at 275 mm (11 in.) from the edge.

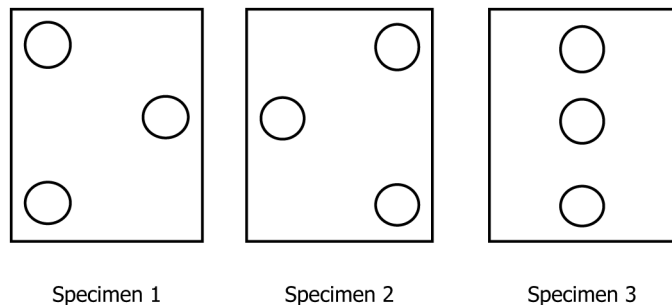


FIG. 2 Impact Locations for Small Missile Test (Each Type of Infill)

6. Missiles

6.1 The specifying authority shall select an applicable missile by defining a level of protection, a wind zone, and an assembly elevation above the ground.

6.2 The applicable missile from Table 2 shall be chosen using Table 3 or Table 4, unless otherwise specified.

6.2.1 Unless otherwise specified, select the appropriate level of building protection from 6.2.1.1 – 6.2.1.3 and enter Table 3 or Table 4 at the appropriate column.

6.2.1.1 Enhanced Protection (Essential Facilities)—Buildings and other structures designated as essential facilities, including, but not limited to, hospitals; other health care facilities having emergency treatment facilities; jails and detention facilities; fire, rescue and police stations, and emergency vehicle garages; designated emergency shelters; communications centers and other facilities required for emergency

TABLE 1 Cyclic Static Air Pressure Loading

Loading Sequence	Loading Direction	Air Pressure Cycles	Number of Air Pressure Cycles
1	Positive	0.2 to 0.5 P_{pos}	3500
2	Positive	0.0 to 0.6 P_{pos}	300
3	Positive	0.5 to 0.8 P_{pos}	600
4	Positive	0.3 to 1.0 P_{pos}	100
5	Negative	0.3 to 1.0 P_{neg}	50
6	Negative	0.5 to 0.8 P_{neg}	1050
7	Negative	0.0 to 0.6 P_{neg}	50
8	Negative	0.2 to 0.5 P_{neg}	3350