Designation: E 2025 – 99

Standard Test Method for Evaluating Fenestration Components and Assemblies for Resistance to Impact Energies[1]

This standard is issued under the fixed designation E 2025; 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 test method is intended to evaluate the resistance of fenestration components, fenestration assemblies, and impact protection systems to specified impact energies.

1.2 Window, glazed door, and skylight assemblies covered by this test method also include individual components, such as the glazing in-fill.

1.3 *This standard does no 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 631 Terminology of Building Constructions[2]

E 1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors and Storm Shutters Impacted by Missile(s) and Exposed to Cyclic Pressure Differentials[2]

F 476 Test Methods for Security of Swinging Door Assemblies[3]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *assembly support fixture*, *n*—the assembly or structure that supports the test specimen.

3.1.2 *component (fenestration)*, *n*—an individual product that combines with other components to make up a complete fenestration assembly.

3.1.3 *fenestration assembly*, *n*—a glazed aperture in a building composed of a group of parts or components that may include glass or plastic panels or lites, opaque panels, framing, mullions, muntins and dividers, screens and shading devices, for example, windows or glazed doors, or both.

3.1.4 *glazed panel*, *n*—glazing installed in a framing system.

3.1.5 *impact energy*, *n*—impact energy is expressed as vertical drop height of the pendulum, times its weight, for a particular impact event.

3.1.6 *impact energy (cumulative)*, *n*—the sum of impact energies from each of the respective impact events for the entire applied impact sequence, derived from intentionally impacting the test specimen more than once; the total impact energy either applied to meet a test protocol or observed during an impact sequence and associated with a particular level of damage.

3.1.7 *impact protection system*, *n*—moveable (or permanent) construction that may be applied, attached or locked over a fenestration assembly to protect the assembly from impact, for example, shutters.

3.1.8 *impact ram*, *n*—the device that (when released) delivers the impact energy to the test specimen. The impact ram includes the impact nose.

3.1.9 *instrumented impact testing*, *n*—additional apparatus attached to the impact ram to provide for the load versus deformation responses of fenestration components and assemblies under various impact conditions.

3.1.10 *plastic glazing sheet material*, *n*—an organic plastic sheet specifically developed for glazing.

3.1.11 *required impact energy*, *n*—the potential energy level specified for a single impact event to be applied in the test as required by the specifying authority.

3.1.12 *required impact sequence*, *n*—the number of impact events and the required impact energy for each event to be applied to a specimen in the test and the order in which the events are to be applied as required by the specifying authority.

3.1.13 *required cumulative energy*, *n*—the sum of the impact energy times the number of each such impact events for the entire required impact sequence to be applied to a specimen in the test as required by the specifying authority.

3.1.14 *test specimen*, *n*—the fenestration assembly, impact protection system or glazing in-fill, which is subject to the impact energies delivered by the impact ram.

---

[1] This test method is under the jurisdiction of ASTM Committee E-06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on

Current edition approved July 10, 1999. Published October 1999.

[2] *Annual Book of ASTM Standards*, Vol 04.11.

[3] *Annual Book of ASTM Standards*, Vol 15.07.

4. Summary of Test Method

4.1 This test method consists of installing a fenestration component, fenestration assembly, or impact protection system in a wall assembly and impacting the test specimen.

4.2 The impact is applied by an impact ram supported by a pendulum system and released from a specified height.

5. Significance and Use

5.1 This test method is intended for determining the ability of a fenestration component, fenestration assembly, or impact protection system to resist specified impact energies.

5.2 The test apparatus, referenced herein, is capable of applying a variety of impacts to a specimen as the impactor head may be fabricated into a variety of shapes and from materials having different degrees of hardness. The user is able to simulate a specific type of impact and the impact energy with this apparatus.

5.3 There is a need to correlate the damage to fenestration assemblies from the impacts in question with the impacts delivered by the test apparatus in order for the test results to be properly interpreted. Due to the nature of the test apparatus, care must be taken when interpreting the results of a specific test to actual performance in the field. The impact energies involved in a pendulum impact cannot be directly transferred to impact energies applied by other devices, for example, projectiles; therefore, the performance of a specimen to the impacts applied by this test method are not directly transferable to performance in actual use. The application of impact energies to a specimen, as applied in this test method, however, does provide valuable information regarding the ability of the specimen to resist damage when impacted.

NOTE 1—Use Test Method E 1886 for determining the performance of fenestration components subjected to impacts from windborne debris in a windstorm environment.

5.4 When using this test method to compare the performance of products the same impact nose, impact device mass and impact speed must be applied to each product tested.

6. Apparatus

6.1 *Impact Device*—A variable mass moving carriage (impact ram), supported by a suspension system of four cables, shall be used to supply the specified level of impact energy.

6.1.1 The impact device shall be a pendulum system with an impact ram capable of delivering the specified horizontal impact energy.

6.1.2 The mass of the (movable) suspension system shall not exceed 5 % of the mass of the impact ram, including impact ram nose, and shall not be included as part of the specified impact mass.

6.1.3 Care shall be taken to prevent impact ram wobble and to assure that the impact ram is level and perpendicular to the specimen at impact. No slack in the supporting cables is allowed when retracting the impact ram to the specified drop height. The length of the cables in the suspension system defines the allowable drop height for that system. To prevent impact ram wobble, it is necessary to use two pairs of cables of sufficient separation that, hanging unrestrained, are parallel to each other when viewed perpendicular to the long axis of the impact ram.

6.1.4 Use a quick release mechanism that is capable of holding the impact ram and releasing it in uniform manner without imparting any forward motion or acceleration. Provide a means to assure that the impact ram does not unintentionally strike the specimen after the initial impact, that is, rebound and strike the specimen again.

6.1.5 The nose of the impact ram shall be of any material, shape, size, or surface as specified and within the weight limits for the impact device. Standardize the impact nose specified and referenced for particular tests. Impact nose substitutions shall meet the criteria of hardness, shape, and composition specified for the impact nose by the test protocol. Adjust the impact ram length for the specified impact nose to comply with impact device system weight limits.

NOTE 2—Variations in impact nose specifications or composition may affect test results.

6.1.5.1 Unless otherwise specified, the impact nose shall be 2.5 ± 0.2 in. (63 mm ± 5 mm) in diameter and the radial tolerance shall be within 0.125 in. (3.2 mm). The nose shall be made from cast epoxy-polyamide resin with a measured Shore A durometer hardness of 80 (± 5). No chips or surface blemishes shall be present on the impact nose.

6.2 An assembly support fixture shall supply the rigidity normally provided to an assembly in a building by the ceiling, floor, and walls. The support fixture for the specimen shall consist of a vertical wall section constructed from nominal steel or 2 × 4-in. wood studs, 16 in. (406 mm) on center, with a rough opening of sufficient size to support the test specimen. Install the specimen into the rough opening in accordance with the manufacturer specifications with clearances between the specimen and rough opening no greater than 0.75 in. (18 mm) on all sides of the specimen. Cover both sides of the vertical wall section with ½ in. (12.7 mm) exterior grade plywood. The assembly shall conform to the wall assembly described in Test Methods F 476. The limiting deflection of the wall shall be L/175 (based on the anticipated loads).

6.3 *Standard Test Frame*—To test glazed panels, design the standard test frame to support a rectangular specimen in a vertical plane and expose it to impact energies. Construct the frame of 2-in. (50-mm) steel angles, at least ¼-in. (6.4-mm) thick, welded at all four corners to form a rigid assembly. Support the assembly is with a support fixture similar to that described in 6.2. Line that part of the test frame that comes in contact with the glazed panel with hardwood stripping. The wood stripping in turn is to be covered with ⅜× ¾in. (9.5 × 19 mm) neoprene stripping, which shall have a Shore A durometer hardness of 30 to 50 and a compressive strength of 4–10 lb/lineal in. (0.7–1.7 kN/m). The neoprene stripping shall be in full contact with all four edges of the specimen.

7. Test Specimen

7.1 Tests are conducted on fenestration assemblies, impact protection systems, and glazed panels.

7.2 For fenestration assemblies, all parts of the test specimen, including glazing and structural framing shall be full-size,

using the same materials, glass type, details, and method of construction and fastening as proposed for actual use. The specimen shall consist of the entire assembled unit and shall consist of one or more sash 36 ± 2 in. (900 ± 50 mm) by 30 ± 2 in. (750 ± 50 mm) for each operation type, that is vertical or horizontal sliding, projected, fixed.

7.3 For impact protective systems, conduct a test on a specimen that can be attached to the specimen described in 7.1 or to the framing in accordance with manufacturer's recommendations.

7.4 For glazed panels, conduct a test on a specimen that can be the glazing in-fill for the specimen described in 7.1.

8. Test Specimen Mounting

8.1 Fenestration assemblies shall be installed in a surround panel in strict accordance with manufacturers installation instructions. The surround panel shall be configured to typical residential wall construction (nominal 2 × 4 in. stud support). The surround panel shall be installed in the assembly support fixture (see 6.2).

8.2 Unless otherwise specified, mount the impact protective systems to installed fenestration systems in accordance with manufacturer's installation instructions. Use attachment methods and hardware in this test the same as that used in the field.

NOTE 3—Some impact protective systems are integral to specific fenestration systems and therefore shall be tested with that system. Some impact protective systems are stand-alone applications, and therefore, are mounted in accordance with 8.1.

8.3 Mount glazed panel specimen in the standard test frame (described in 6.3) and install in the assembly support fixture. Install glass specimen with an edge bite of ½ ± 1⁄16in. (12.7 ± 1.6 mm). Install non-glass specimen, for example, plastic glazing sheet material, with an edge bite of 2 ± ¼ in. (50 ± 6 mm) to prevent disengagement when impacted, or in accordance with the manufacturer's specifications.

8.4 *Test Specimen Conditioning*—Condition the test specimen for at least 24 h at the temperature and humidity levels specified (see Section 9).

9. Information Required

9.1 The specifying authority shall supply the following information:

9.1.1 The required impact energy (expressed in foot-pounds or joules), including the drop height and impact ram mass.

9.1.2 The allowable tolerance for the drop height and impactor mass.

9.1.3 The required impact sequence for the specimen.

9.1.4 The required cumulative impact energy to be applied, if any.

9.1.5 The impact nose to be used for impacting the specimen (if other than specified in 6.1.5.1).

9.1.6 Any other areas on the specimen to be impacted (other than the center).

9.1.7 The post-impact test procedures, if any, for each specimen.

9.1.8 The temperature and humidity conditions at which the tests will be conducted.

10. Report

10.1 Report the following information:

10.1.1 The date of the test, date of the report, the ambient temperature and relative humidity at the time of the test. It is helpful to have a video record of the test.

10.1.2 A complete description of the test specimen prior to impact, including parts and components and a detailed drawing of the test specimen.

10.1.3 The impact energy (in accordance with 9.4) in terms of foot-pounds (joules), including the drop height and impactor mass.

10.1.4 The cumulative impact energy in foot-pounds (joules), if applicable.

10.1.5 A description of the condition of the test specimen after completion of the test including details of gasket displacement, damage to the glass, damage to the sash or framing system, including any twisting or distortion of the corner and a measurement of the amount of deflection and permanent distortion in the framing system, damage to the impact protective device, and damage to the assembly support structure.

10.1.6 A description of the impact nose.

11. Procedure

11.1 *Impact Test:*

11.1.1 Mount the test specimen in the assembly support fixture. Set up the impact device so that the impact ram has its axis horizontal and perpendicular to the face of the test specimen.

11.1.2 For operating fenestration assemblies, set up the impact device so that the nose of the impact ram, when hanging unrestrained, is within 0.25 in. (6 mm) of the front surface of the specimen at a point defined by the intersection of the vertical and horizontal center line of the outermost sash of the test specimen. Close and lock the specimen. For fixed (nonoperating) fenestration assemblies, impact protective systems and glazed panels, set up the impact device so that the nose of the impact ram, when hanging unrestrained, is within 0.25 in. (10 mm) of the front (outdoor) surface of the specimen at a point defined by the intersection of the vertical and horizontal center line of the test specimen.

11.1.3 Pull back the impact ram to the drop height necessary to produce the required or specified impact energy and release it. Following the impact, inspect the test specimen and complete the test report (see Section 10).

NOTE 4—This test procedure provides impacts at the center of the specimen. If other areas of the specimen are to be impacted that information should be specified in Section 9.

12. Precision and Bias

12.1 Due to the lack of sufficient test data, the precision and bias of this test method cannot be determined at this time.

13. Keywords

13.1 fenestration; glazed opening; impact; impact energy; impact protective systems; impact ram; pendulum

APPENDIX

(Nonmandatory Information)

X1. TEST METHOD FOR EVALUATING FENESTRATION COMPONENTS AND ASSEMBLIES FOR RESISTANCE TO IMPACT ENERGIES

X1.1 Instrumented Impact Testing of Fenestration Components and Assemblies

X1.1.1 *Scope*—This test method describes the four-wire pendulum impact testing of fenestration components and assemblies using an instrumented dynamic force measuring apparatus. This test method simulates impact conditions by attaching various shaped striking tups (to simulate various missile shapes) and recording impact energies.

X1.1.1.1 The specimen is loaded dynamically using a suitable method to achieve and maintain the required impact velocity.

X1.1.1.2 This test method covers the determination of peak force, fracture initiation energy, fracture propagation energy, energy returned to pendulum (rebound case), impact velocity, and impact energy.

X1.1.2 *Terminology*:

X1.1.2.1 *fracture initiation energy, n*—the energy absorbed by the test specimen up to the time of the beginning of the fracture event.

X1.1.2.2 *fracture propagation energy, n*—the energy absorbed by the test specimen between fracture initiation point and completion of deformation, or fracture event, or both.

X1.1.2.3 *impact energy, n*—a calculated value based on pendulum mass and impact velocity. Used to verify conformance with classes of airborne debris.

X1.1.2.4 *impact velocity, n*—the measured velocity of the pendulum immediately prior to impact with specimen.

X1.1.2.5 *peak force, n*—the maximum force measured by the force transducer during the entire impact event.

X1.1.2.6 *returned energy, n*—the amount of energy returned to the pendulum system as a result of a rebound event.

X1.1.2.7 *total energy, n*—the energy absorbed by the test specimen at the conclusion of the test event.

X1.1.3 *Significance and Use*:

X1.1.3.1 This test method is designed to provide the load versus deformation response of fenestration components and assemblies under various impact conditions.

X1.1.3.2 The dynamic response of a test specimen plays an integral role in causing the type of fracture seen in that specimen. A fixed velocity pass/fail type of test will not determine whether or not a certain specimen design/material exhibits a sensitivity to impact velocity rate changes.

X1.1.3.3 This test method may be used to establish classes of impact conditions for ranking component/assembly designs and materials.

X1.1.4 *Summary of Test Method*:

X1.1.4.1 This test method involves impacting a test specimen, mounted to simulate actual usage configurations, under a number of impact conditions by attaching various striking tups to a moving variable mass. The impact location shall be varied until the point of poorest response is determined.

X1.1.4.2 Manufacture specimens as they would for actual installation and end use. Specimen dimensions should conform to standard component sizes.