Designation: E2353 – 14

StandardTest Methods for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades[1]

This standard is issued under the fixed designation E2353; 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 These test methods cover procedures to be followed in testing the performance of glazing in permanent railing systems, guards and balustrades including components such as rails and swing gates or other forms of required guardrail opening protection installed in and for assembly, commercial, educational, industrial, institutional, stadiums, recreational, and residential buildings and other structures such as towers or elevated platforms.

1.2 These test methods are applicable to such railing, guard, and balustrade systems having glass or other glazing materials as the major structural component or the infill panel including swing gates and other forms of guardrail protection.

1.3 These test methods can be used to determine whether permanent rails, guards and balustrades including components, having glass or other glazing material comply with requirements of performance specifications, codes, norms, and standards.

1.4 Specifically, these test methods cover procedures for determining the static strength, impact performance, and post-breakage characteristics of railing systems, guards, and balustrades, including a component with glass or other glazing material installed in one, two, three and four-side support systems fastened to concrete, masonry, wood, metal, and related products.

1.5 No consideration is given in these test methods to any possible deterioration of the railing, guard, or balustrade system or their connections and fasteners as resulting from adverse environmental or in-service conditions. The performance of special tests covering this aspect may be desirable.

1.6 These test methods are limited to the application of loads and impact resistance described herein. Whenever uniformly distributed loads are to be resisted by a railing system, guard, or balustrade in accordance with governing specifications, codes, norms, and standards, the effects of such loads on the member stresses shall be determined by calculation and the corresponding concentrated and linear loads shall be tested. Should computations make it possible to provide the needed information, testing can be employed for verification.

1.7 These test methods address the capability of glass or other glazing material rails, guards, and balustrades in one, two, three and four-sided support systems to continue in their function as a barrier by remaining in the designed framing system after impact or glass breakage. These test methods do not address structural limitation of glass rails, guards, and balustrades or vehicular guards except when in the area of a pedestrian walkway.

1.8 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.9 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E329 Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection

E631 Terminology of Building Constructions

E699 Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components

E935 Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings

E1481 Terminology of Railing Systems and Rails for Buildings

E2025 Test Method for Evaluating Fenestration Components

[1] These test methods are under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.56 on Performance of Railing Systems and Glass for Floors and Stairs.

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[2] 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.

and Assemblies for Resistance to Impact Energies (Withdrawn 2015)[3]
E2358 Specification for the Performance of Glass in Permanent Glass Railing Systems, Guards, and Balustrades
2.2 *Other Standards:*
16 CFR Part 1201 CPSC Safety Standard for Architectural Glazing Materials[4]
ANSI Z97.1 Standard Glazing Materials Used in Buildings[5]

3. Terminology

3.1 *Definitions*—General terms used in this test method are defined in Terminologies E631 and E1481. Terms common to this test method and referenced test methods are defined in the respective document unless defined herein.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *failure, n*—the loss of load carrying capacity or the inability to meet the required load carrying capacity specified in the applicable performance standard, depending on the purpose of the test.

3.2.2 *glazing retention, v*—the property of maintaining the glass or other glazing material, post breakage, in a system, such that the glass or other glazing material must be held in the framing system with no opening sufficient to pass a 3 in. (75 mm) solid steel sphere through the original plane of the glazing system ±15 degrees slope using a horizontally applied force of 4.0 lb (18 N).

3.2.3 *glazing shard containment, n*—the property of maintaining the broken glass or glazing material in essentially one piece with no more than the equivalent weight of 10 in.^{2} (6452 mm^2) of the original specimen detaching from the specimen.

3.2.4 *guardrail opening protection, n*—swing gates or other form of barrier to prevent unintended egress or fall through guardrail openings.

3.2.5 *interlayer, n*—a layer of material acting as an adhesive between lites of glazing, which adds additional performance attributes to the finished product; for example: impact resistance, solar control, and acoustical insulation.

3.2.6 *lite, n*—a term for a single pane (or piece) of glass or other glazing material.

3.2.7 *specifying authority, n*—the design professional responsible for interpreting applicable regulations of authorities having jurisdiction and considering appropriate site specific factors to determine the appropriate values used to calculate the specified design load and furnishing other information required for performance of specified materials.

3.2.8 *stile, n*—one of the upright structural members of a frame or a framework of bars.

4. Significance and Use

4.1 These test methods are intended to provide information from which applicable design and performance data can be derived for the performance of glass and other glazing materials in rails, guards, and balustrade systems as infill panels that are fastened to concrete, masonry, wood, metal, and related products, and to the performance of glazing as a structural element of the rail, guard, or balustrade system.

4.2 Specification E329 and Practice E699 are standards that assist the user of these test methods to apply appropriate procedures and methods to ensure a quality result is provided.

4.3 These test methods determine whether railing systems comply with requirements of the applicable performance specifications.

4.4 These test methods are intended for use in the buying and selling of railing systems and components according to performance specifications, for use in product development research, for use in quality assurance and manufacturing process control, for use in developing performance standards, and for use in field and laboratory compliance determination.

5. Types

5.1 For purposes of these test methods, glass rail, guard, and balustrade assemblies are classified as types and are described in 5.1.1 through 5.1.5 and as shown in Figs. 1-10.

5.1.1 *Type I*—A glass rail, guard, or balustrade assembly with a single full view glazing material that is fully captured on all sides (that is, four side support).

5.1.2 *Type II*—A glass rail, guard, or balustrade assembly with a single full view or multiple units of glazing material that are captured on two sides (that is, two side support).

5.1.3 *Type III*—A glass rail, guard, or balustrade assembly with a single full view glazing material that is held in place by a point fixed glazing system, corner brackets, edge clamping or other non-continuous brace along a portion of the glazing.

5.1.4 *Type IV*—A glass rail, guard, or balustrade assembly with a single full view glazing material that is fully captured on three sides (that is, three side support).

5.1.5 *Type V*—A glass rail, guard, or balustrade assembly with a single full view glazing material that is fully captured on only one side (that is, single side support). A decorative or protective top rail (Fig. 8), or a handrail may or may not be attached to the glass (Fig. 9), but does not offer structural support to the system.

5.1.6 *Type VI*—A glass rail, guard, or balustrade assembly with a single full view glazing material that is point supported only (Fig. 10). A decorative or protective top rail may or may not be attached to the glass, but does not offer structural support to the system.

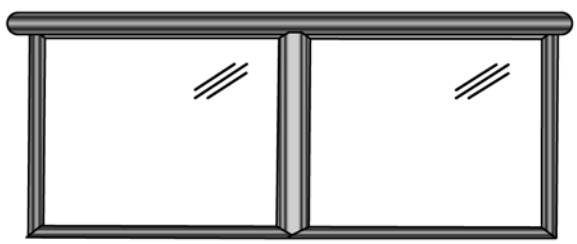

FIG. 1 Type I: Four-Side Support—Glazing as Infill

[3] The last approved version of this historical standard is referenced on www.astm.org.
[4] Available from U.S. Consumer Product Safety Commission (CPSC), 4330 East West Hwy., Bethesda, MD 20814, http://www.cpsc.gov.
[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

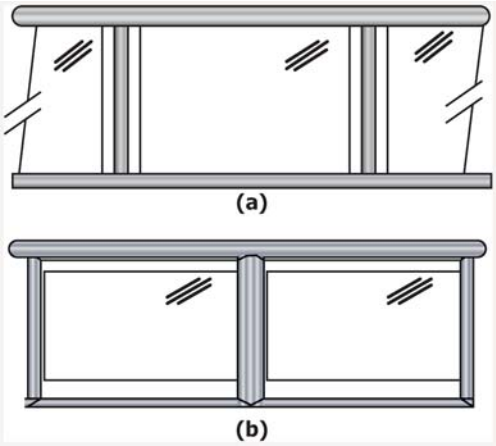

FIG. 2 Type II: Two-Side Support—Single Lite Glazing as Infill

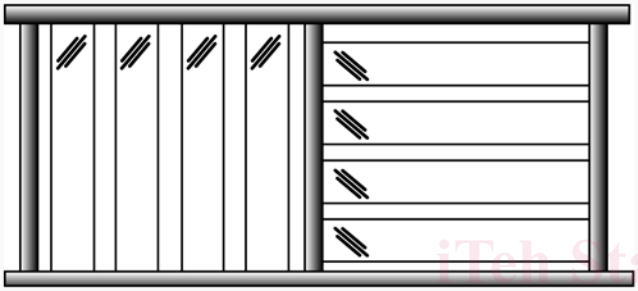

FIG. 3 Type II: Two-Side Support—Multiple Lite Glazing as Infill

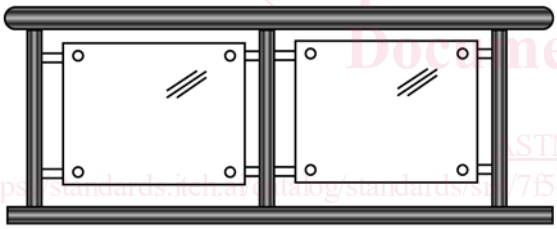

FIG. 4 Type III: Point Fixed Glazing System—Glazing as Infill

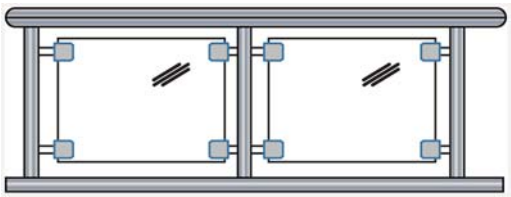

FIG. 5 Type III: Edge Clamping Glazing System—Glazing as Infill

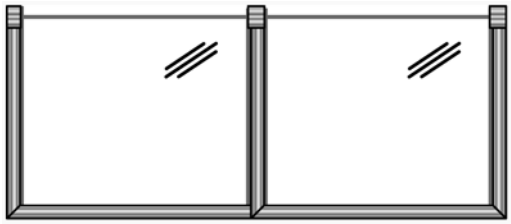

FIG. 6 Type IV: Three-Side Support—Glazing as Structural Member

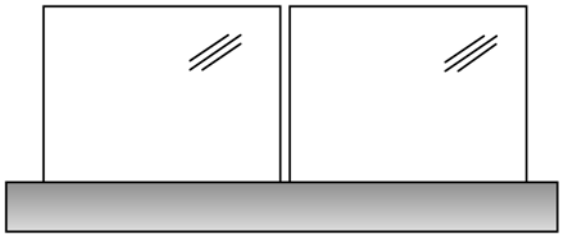

FIG. 7 Type V: One-Side Support—Glazing as Structural Member

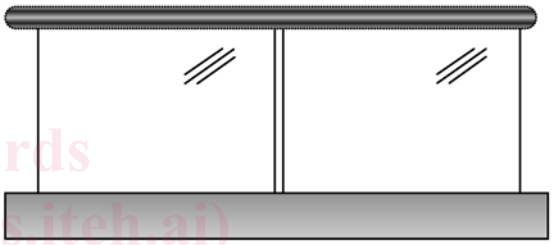

FIG. 8 Type V: One-Side Support with Protective Top Rail—Glazing as Structural Member

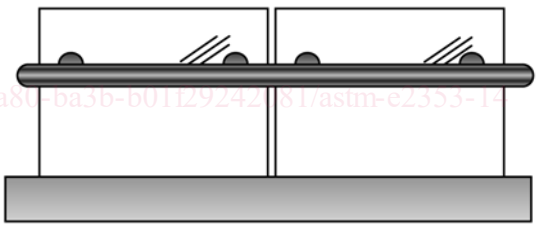

FIG. 9 Type V: One-Side Support with Surface Attached / Bolted Handrail—Glazing as Structural Member

6. Summary of Test Method

6.1 The procedure consists of preparing a specimen in accordance with the manufacturers or designers specifications. The supporting and embedding materials shall be in accordance with intended use. The system or infill material is tested by applying loads and impacting the glazed portion of the assembly in the prescribed sequence, as outlined in Table 1. Asymmetrical systems shall be tested from both sides.

6.2 Acceptance criteria for performance levels provided by the specifying authority. Adoption of performance criteria shall be a matter for authorities having specific jurisdiction.

7. Apparatus

7.1 *Instrumentation,* load and time-measuring devices with an accuracy of ±2 % of the full scale shall be incorporated in the test setups. The scale ranges used shall assure that the performance levels are within an accuracy of ±5 %.

7.2 *Load Attachments,* brackets, fasteners, or other devices used in performing these tests shall be designed and attached so as to minimize their influence on the test results.

7.3 *Shot Bag, Traction and Release System:*

7.3.1 The test apparatus shall be capable of supporting a 100 lb (45.4 kg) shot bag and allowing unimpeded swinging of the shot bag from a drop height of 48 in. (1220 mm). The impactor system consists of the impactor, traction, release, and suspension devices as described in CPSC 16 CFR Part 1201.

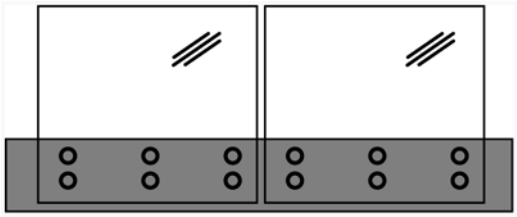

FIG. 10 Type VI: Point Supported Only—Glazing as Structural Member

TABLE 1 Test Summary

Type	Test 1: Frame[A]	Test 2: Glazing Infill Impact 1[B]	Test 3: Glazing Infill Impact 2[C]
	E935 Section	Shot Bag (Soft Body) Pendulum	Steel (Hard Body) Pendulum
I through V	10.1, 10.5, and 10.6	13.3 Center	13.4
V and VI	10.1, 10.5, and 10.6	13.3 Top Edge	13.4

[A] Tests performed as outlined in Test Methods E935.
[B] Tests performed as described in ANSI Z97.1 and 13.3 of this test method.
[C] Tests performed as described in Test Method E2025 and 13.4 of this test method.

7.3.2 The impactor shall consist of the leather bag described in Fig. 11, a commercial punching bag[6] with its bladder left in place, or any other leather bag of nominally identical shape and size. The bag shall be filled with lead shot of 2.4 ± 0.1 mm diameter (nominal USA No. 71/2 or European No. 7 lead shot) and taped. After filling with lead shot, the top shall be either pulled over the metal sleeve and tied with a cord; or twisted around the threaded eyebolt shaft and tied below the metal sleeve, or both. To reduce bag damage during testing, the exterior of the leather bag surface shall be completely covered with glass filament reinforced pressure sensitive polyester adhesive tape,[7] 0.5 to 0.6 in. (12 to 15 mm) in width and 0.006 in. (0.15 mm) thick. Tape the entire bag, using three (3) rolls or 180 yd (165 m) total length, and taping in a diagonal-overlapping manner. Tape the neck of the bag separately, with additional glass filament reinforced tape of the same kind. The total mass of the impactor assembly shall be 100 lb ± 4 oz (45.4 ± 0.1 kg), excluding traction system attachments.

7.3.3 A traction system shall be used which enables the impactor to be brought into its launch position. The launch position depends on the drop height selected. The traction cable shall be connected to the impactor traction system by a release mechanism, with provisions for rotating the impactor.

[6] Such as 9 in. (230 mm) diameter by 14 in. (360 mm) high Everlast 4207 (raw, full grain 3-oz (85-g) cowhide) or Everlast 4212 (split 3-oz (85-g) cowhide) available from Everlast Sports, Bronx, New York, USA. These are tradenames. This information is given for the convenience of users and does not constitute an endorsement of any product named. Equivalent products may be used if they can be shown to lead to the same results. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[7] Such as 3M No. 898 (a tradename), or equal. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

7.4 *Pendulum Impactor:*

7.4.1 Apparatus specified in Section 6 of Test Method E2025 with the specifications noted in sections 6.4.2 and 6.4.3.

7.4.2 *Impactor:*

7.4.2.1 The impactor shall be a pendulum system made of steel and capable of delivering horizontal impacts of up to 74 ft-lbf (100 J). The striking end of the impactor shall have a removable steel hemispherical nose approximately 1.25 in. (30 mm) diameter.

7.4.3 *Impact Nose:*

7.4.3.1 The impact nose shall be 2.5 ± 0.2 in. (63 ± 5 mm) in diameter and the radial tolerance shall be within ⅛ in. (3.2 mm). The nose shall be made of steel. No chips, irregularities, or surface blemishes that may affect the outcome of the impact shall be present on the impact nose.

8. Hazards

8.1 Glass breakage may occur during the application of loads or forces required by the test methods. Take adequate precautions to protect personnel from broken glass.

8.2 Glazing anchorage, glass, and other test specimen components may suddenly fail when loads and forces are applied during these test methods, causing the assembly to rapidly move. Take adequate precautions to protect personnel from rapidly moving weights and test specimen components.

9. Test Selection, Sampling, Test Specimens, and Installation

9.1 *Test Selection:*

9.1.1 Load test methods described in Section 12 for the uniform load test and the concentrated load test are selected based on the performance specification, testing agency and regulatory body involved. Glazing impact shall be conducted on all systems in accordance with Section 13. Selection of necessary tests are based on the performance level required as outlined in Specification E2358 Section 6 or the specifying authority.

9.2 *Sequence of Test Methods:*

9.2.1 Specimens tested for two or more of the loading conditions are subjected first to the in-fill load test, followed by the uniform load test, and then the concentrated load test and shot bag glazing impact test, sphere penetration evaluation, steel nose pendulum impact, and sphere penetration evaluation, in that order, unless directed otherwise by the performance specification.

9.3 *Sampling:*

9.3.1 A minimum of three representative replicate specimens of each type of system shall be tested.

9.3.2 Sequential testing of the same specimen shall be permissible provided no breakage of any component occurs during the previously performed tests.

9.4 *Test Specimens:*

9.4.1 The specimen installation, including the post spacing, shall be the same as the actual field installation. The specimen shall have a minimum of three posts or have a minimum linear length of 10 ft (3 m). Each unique attachment scenario shall be tested.