



Designation: ~~E2353 – 16~~ E2353 – 21

Standard Test Methods for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades¹

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.

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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 supported by rails, guards, or balustrades, or both, 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 glazing breakage. These test methods do not address structural limitation of glazed or glass rails, guards, and balustrades or vehicular guards except when in the area of a pedestrian walkway.

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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1.8 ~~The values are stated in SI units and are to be regarded as standard. Values~~—The values given in parentheses are for information only after SI units are provided for information only and are not considered standard. Certain values contained in reference documents cited and quoted herein may be stated in inch-pound units and must be converted by the user.

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

1.10 *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:²

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

E631 Terminology of Building Constructions

E699 Specification for Agencies Involved in Testing, Quality Assurance, and Evaluating of Manufactured 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 and Assemblies for Resistance to Impact Energies (Withdrawn 2015)³~~

E2358 Specification for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades

2.2 Other Standards:

16 CFR Part 1201 CPSC Safety Standard for Architectural Glazing Materials³

ANSI Z97.1 Standard Glazing Materials Used in Buildings⁴

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 76 mm (3 in.) solid steel sphere through the original plane of the glazing system within a ± 15 degree slope using a horizontally applied force of 18 N (4.0 lb).

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 6452 mm² (10 in.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 plies of a lite of laminated 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.

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.

³ Available from U.S. Consumer Product Safety Commission (CPSC), 4330 East West Hwy., Bethesda, MD 20814, <http://www.cpsc.gov>.

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

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, rail, guard, and balustrade assemblies that incorporate glazing are classified as types and are described in 5.1.1 through 5.1.5.1.6 and as shown in Figs. 1-6. Each supported edge is indicated by a dashed line (---).

5.1.1 *Type I*—A glazed 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 glazed 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 glazed 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 glazed 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 glazed 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. 5b), or a handrail may or may not be attached to the glass (Fig. 5c), 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. 6). A decorative or protective top rail may or may not be attached to the glass, but does not offer structural support to the system.

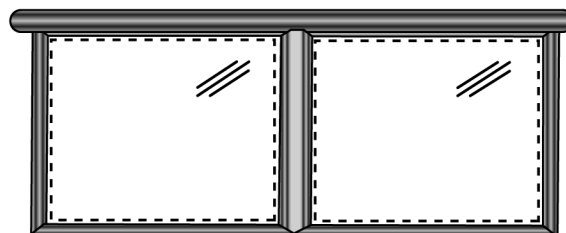


FIG. 1 Type I: Four-Side Support—Glazing as Infill

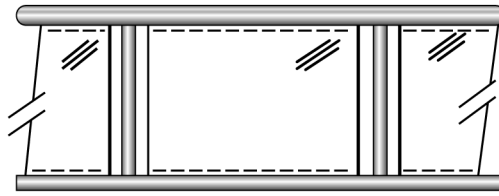


FIG. 2 a Type II: Two-Side Support—Single Lite Glazing as Infill

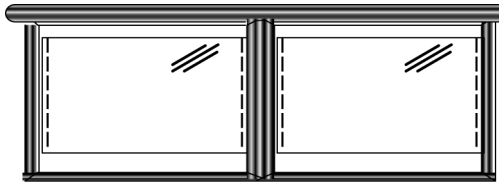


FIG. 2 b Type II: Two-Side Support—Single Lite Glazing as Infill (continued)

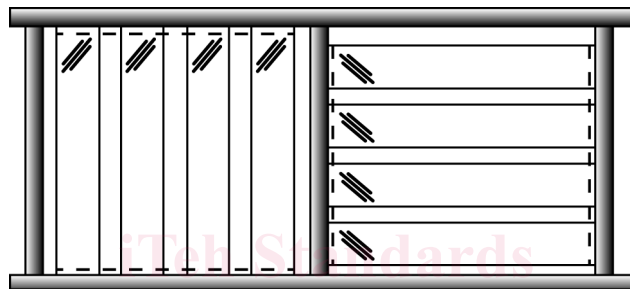


FIG. 2 c Type II: Two-Side Support—Multiple Lite Glazing as Infill (continued)

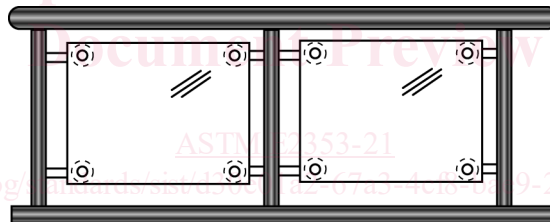


FIG. 3 a Type III: Point Fixed Glazing System—Glazing as Infill

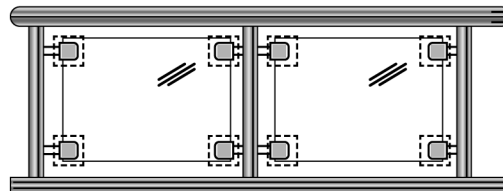


FIG. 3 b Type III: Edge Clamping Glazing System—Glazing as Infill (continued)

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 are to be provided by the specifying authority. Adoption of performance criteria shall be a matter for authorities having specific jurisdiction.

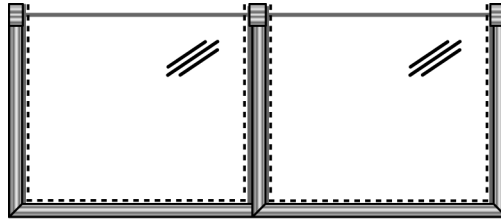


FIG. 4 Type IV: Three-Side Support—Glazing as Structural Member

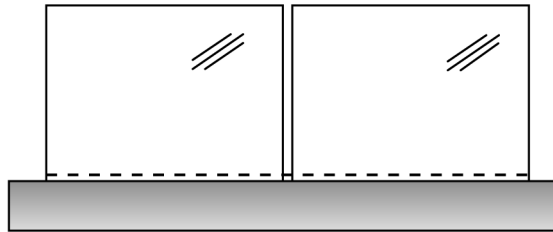


FIG. 5 a Type V: One-Side Support—Glazing as Structural Member

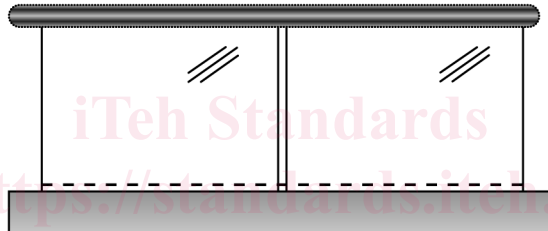


FIG. 5 b Type V: One-Side Support with Protective Top Rail—Glazing as Structural Member (continued)

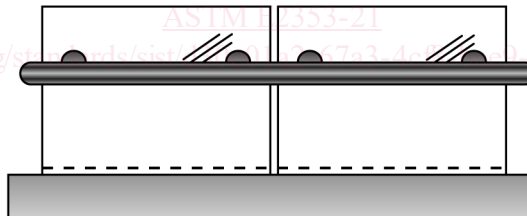


FIG. 5 c Type V: One-Side Support with Surface Attached / Bolted Handrail—Glazing as Structural Member (continued)

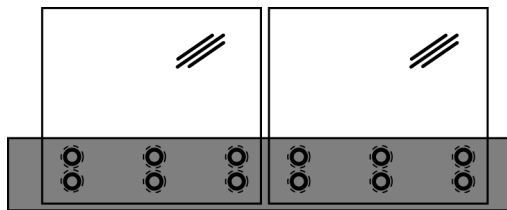


FIG. 6 Type VI: Point Supported Only—Glazing as Structural Member

7. Apparatus

7.1 *Instrumentation*, load and time-measuring devices with an accuracy of $\pm 2\%$ 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 $\pm 5\%$.

7.2 *Assembly Support Fixture*, an assembly support fixture shall supply the rigidity normally provided to an assembly in a building

TABLE 1 Test Summary

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

TABLE 1 Test Summary

Type	Test 1: Frame ^A	Test 2: Glazing Infill Impact 1 ^B	Test 3: Glazing Infill Impact 2 ^C
I through IV	<u>Section 12</u> <u>12.2.4,</u> <u>12.2.5, and</u> <u>12.2.6</u>	Shot Bag (Soft Body) Pendulum 13.3 Center	Steel (Hard Body) Pendulum 13.4
V and VI	<u>12.2.4,</u> <u>12.2.5, and</u> <u>12.2.6</u>	13.3 Top Edge	13.4

^A Tests performed as outlined in Test Methods Section 12E935.

^B Tests performed as described in ANSI Z97.1 and 13.3 of this test method.

^C Tests performed as using impactor described in Test Method E2025 and 13.47.4 of this test method.

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 by 4 wood studs, 406 mm (16 in.) on center, with a rough opening of sufficient size to support the test specimen in accordance with the manufacturer specifications. The limiting deflection of the wall shall be L/175 (based on the anticipated loads).

7.3 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.

7.4 Shot Bag, Traction and Release System:

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

7.4.2 The impactor shall consist of the leather bag described in Fig. 7, a commercial punching bag⁵ 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 $2.42.4 \text{ mm} \pm 0.1 \text{ mm}$ 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,⁶ $\pm 12 \text{ mm}$ to 15 mm (0.5 (0.5 in. to 0.6 in.) in width and 0.15 mm (0.006 in.) thick. Tape the entire bag, using three (3) rolls or 165 m (180 yd) 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 $45.445.4 \text{ kg} \pm 0.1 \text{ kg}$ (100 lb $\pm 4 \text{ oz}$), excluding traction system attachments.

7.4.3 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.

⁵ Such as 230 mm (9 in.) diameter by 360 mm (14 in.) high Everlast 4207 (raw, full grain ~~85 g (3 oz)~~ 85 g (3 oz) cowhide) or Everlast 4212 (split ~~85 g (3 oz)~~ 85 g (3 oz) 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.

⁶ 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.

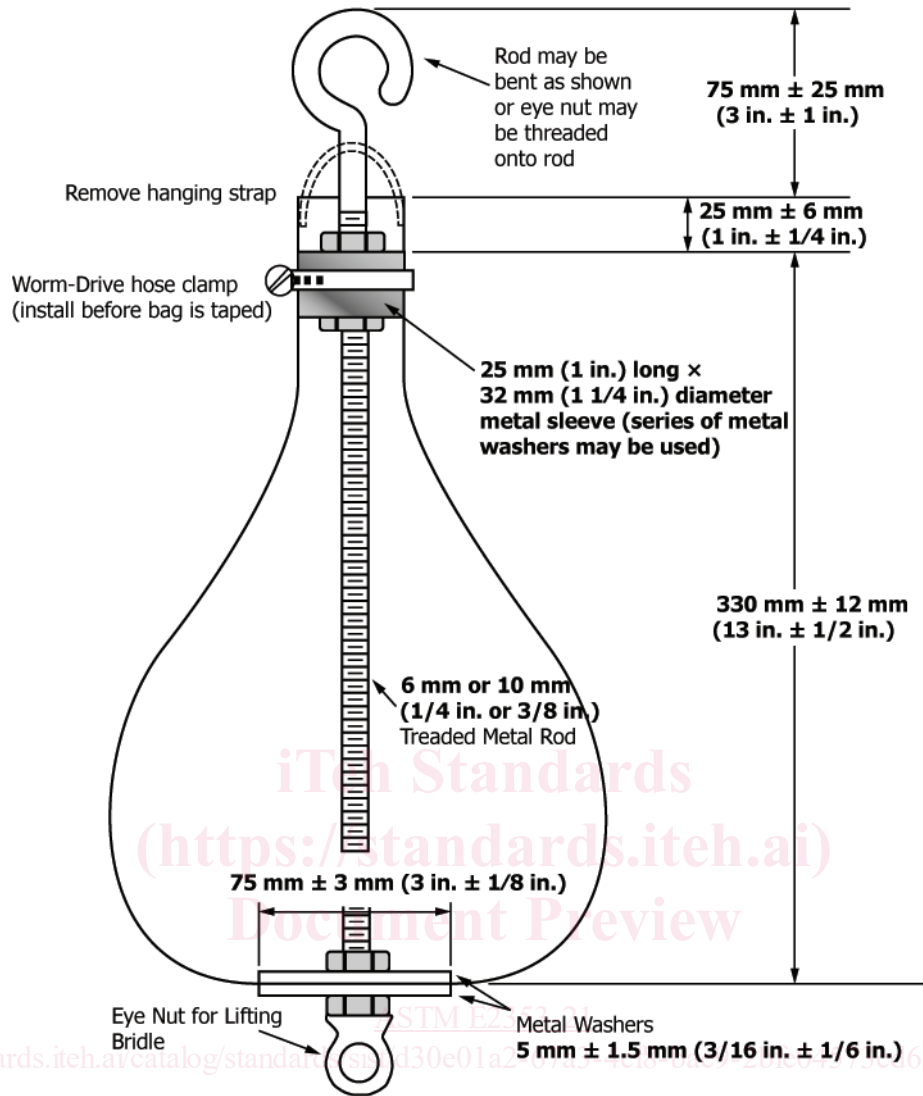


FIG. 7 Shot Bag Impactor

7.5 Pendulum Impactor:

7.5.1 Apparatus having 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 with the specifications noted in 7.6 and 7.7.

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

7.5.3 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.

7.5.4 Care shall be taken to prevent impact ram wobble and to ensure 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.

7.5.5 Use a quick release mechanism that is capable of holding the impact ram and releasing it in uniform manner without