Designation: E2358 – 04 (Reapproved 2010)

Standard Specification for the Performance of Glass in Permanent Glass Railing Systems, Guards, and Balustrades[1]

This standard is issued under the fixed designation E2358; 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 glass in permanent railing systems, guards and balustrades installed in agricultural, assembly, commercial, educational, industrial, institutional, recreational, and residential buildings.

1.2 This specification is intended to be applied to permanent glass railing systems for buildings and to such railing systems, rails, guards and balustrades having major structural components made of glass, or the secondary components such as infill or balusters made of glass.

1.3 This specification considers that the overall outlook is based on the health and safety of all potential users of buildings. The criteria incorporated in this specification provide for normal and anticipated building uses, but not for abuses for which the building and its components are not designed.

1.4 This specification establishes basic minimum requirements and criteria that lead to satisfactory products under normal use conditions and does not give consideration to design criteria for specific field conditions, the establishment of which is the prerogative and responsibility of the designer, specification writer, and regulatory agencies.

1.5 *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 to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E2025 Test Method for Evaluating Fenestration Components and Assemblies for Resistance to Impact Energies

F1233 Test Method for Security Glazing Materials And Systems

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

E1481 Terminology of Railing Systems and Rails for Buildings

E2353 Test Methods for Performance of Glazing in Permanent Railing Systems, Guards, and Balustrades

2.2 *Other Standards:*

ANSI Z97.1 Glazing Materials Used in Buildings, Safety Performance Specifications and Methods of Test[3]

CPSC 16 CFR Part 1201 Architectural Glazing Materials, Federal Register[4]

3. Terminology

3.1 *Definitions:*General terms used in this standard test method are defined in Terminologies E631 and E1481. Terms common to this standard 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 Load*—A load, which, if placed upon a structure or test piece, is just great enough to break it.

3.2.2 *Glazing Retention*—the property of maintaining the glass or glazing material, post breakage, in a system, such that the glass must be held in the framing system with no opening sufficient to pass a 76 mm (3 in.) solid steel sphere through the system using a horizontally applied force of 18 N (4.0 lbs).

3.2.3 *Guard System*—A protective railing system along the outer edges of locations of an accessible roof, parapet, balcony, landing, platform or ramp, designed to minimize the probability of an accidental fall from the walking surface.

3.2.4 *Interlayer*—a layer of material acting as an adhesive between lites of glazing, which adds additional performance

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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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from U.S. Consumer Product Safety Commission (CPSC), 4330 East-West Hwy., Bethesda, MD 20814.

attributes to the finished product, for example: impact resistance, solar control, and acoustical insulation.

3.2.5 *Lite*—a term for a single pane (or piece) of glass or other glazing material.

3.2.6 *Stile*—one of the upright structural members of a frame or a framework of bars

4. Design Requirements

4.1 *Railing Height*

4.1.1 Guardrail Systems:

4.1.1.1 The fabricated height of a guardrail system, measured from its top surface to the finished floor level, shall be at least 1070 mm (42 in.). When variation in the evenness of the finished floor will result in any individual height measurement of the installed guardrail system to be less than 1040 mm (41 in.), the fabricated height of the entire guardrail system shall be increased accordingly.

4.1.1.2 Within an individual dwelling unit, the required railing height shall be permitted to be reduced as allowed by the governing jurisdiction.

(1) Where the vertical distance between adjacent finished floor levels is less than 1830 mm (72 in.), the height of the guardrail system shall be at least 810 mm (32 in.) (Fig. 1). When variation in the evenness of the finished floor results in any individual height measurement of the installed guardrail system less than 790 mm (31 in.), the fabricated height of the entire guardrail system shall be increased accordingly.

(2) Where the vertical distance between adjacent finished floor levels is a minimum of 1830 mm (72 in.), the height shall be a minimum of 860 mm (34 in.) (Fig. 2). When variations in the evenness of the finished floor results in individual height measurements of the installed guardrail system less than 840 mm (33 in.), the fabricated height of the guardrail system shall be increased accordingly.

4.1.1.3 In public assembly, elementary school, and multiple-family buildings where the vertical distance between stair and adjacent floor levels is more than 6100 mm (20 ft), the required height of the top of the railing above the finished floor including any variation shall be at least 1220 mm (48 in.).

4.1.1.4 For balconies in public-assembly buildings, the required railing height in front of the first row of fixed seats shall be reduced to 660 mm (26 in.) provided adequate safety is established by the design and approved by the authority having jurisdiction; however, it shall be a minimum of 910 mm (36 in.) at aisle ends and a minimum of 1070 mm (42 in.) where aisle steps are perpendicular to the railing system.

4.1.2 Handrails and Stair-rail Systems

4.1.2.1 In corridors, ramp, walkways, and enclosed stairways having a slope of at least 1 in 20, the height of the handrail of the stair-rail system, measured from its top surface to the finished floor level or tread-nose line, shall be not less than 860 mm (34 in.) nor more than 970 mm (38 in.). When a stair-rail system is higher than 970 mm (38 in.), a separate handrail shall be installed at a height of not less than 860 mm (34 in.) nor more than 970 mm (38 in.).

4.1.2.2 Where required and in childcare and educational facilities serving children under the age of 12 years, a second separate handrail shall be permitted to be installed at a mounting height of 610 mm to 710 mm (24 in. to 28 in.). The vertical clearance between the handrails shall be at least 230 mm (9 in.).

4.1.3 *Transfer Rails Systems*—where transfer rail systems are to be installed, such as in toilets and bathrooms, the required height, measured from its top surface to the finished floor level, shall not be less than 760 mm (30 in.) nor more than 860 mm (34 in.).

4.2 *Railing System Penetration*

4.2.1 Various members of the railing system, such as balusters, screens, wire mesh, or scrolls, shall be arranged in such a way that a sphere, 76 mm (3 in.) in diameter cannot be passed through any opening in the system.

4.2.2 Toe boards shall be provided in areas where tools and other objects could be dislodged and fall on occupants below. The top of the toe board shall not be less than 102 mm (4 in.)

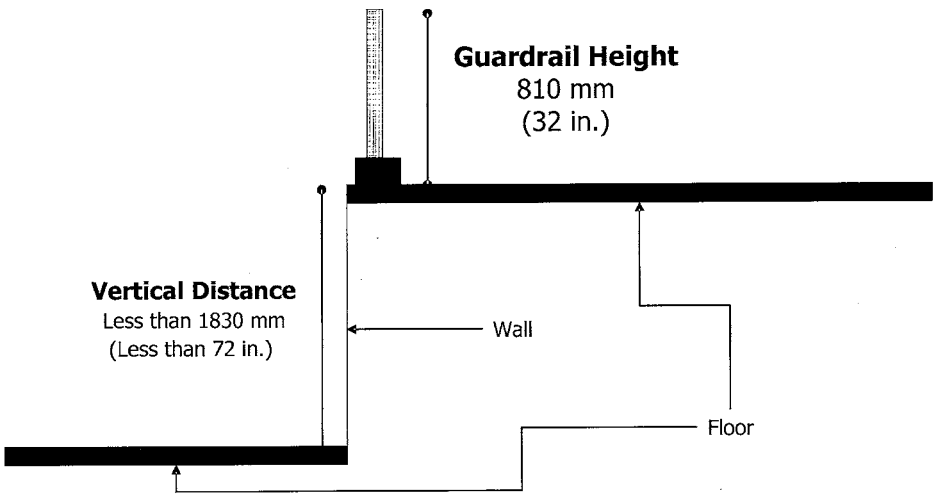

FIG. 1 Guardrail height for adjacent floors with wall heights up to but not including 1830 mm (72 in).

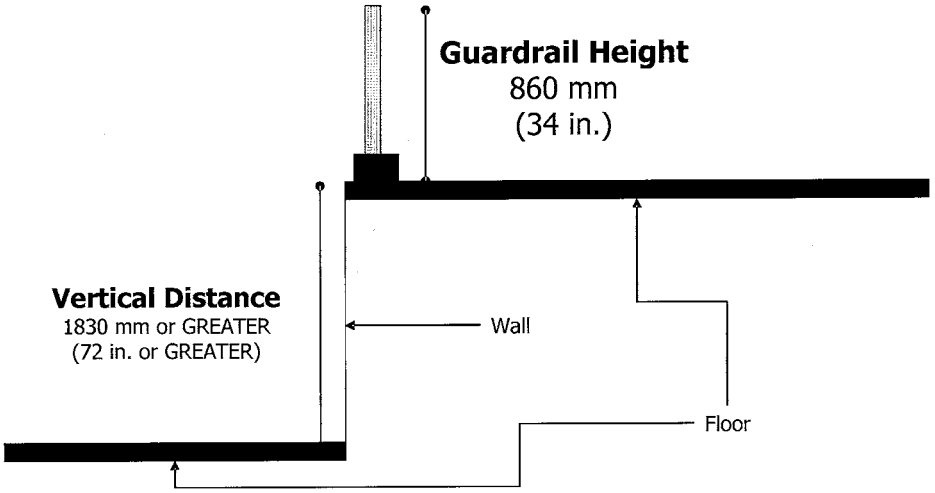

FIG. 2 Guardrail height for adjacent floors with wall heights equal to or greater than 1830 mm (72 in.)

and the bottom not more than 12 mm (½ in.) above the average finished level at the line of the vertical supports of the railing system.

4.3 *Handrail Design:*

4.3.1 Handrails shall be designed to permit continuous sliding of hands. The hardware chosen for attaching handrails to balusters or walls shall be such that projecting lugs, devices, or other construction elements shall have no sharp edges or dangerous protrusions.

4.3.2 Handrail ends shall be returned to supporting walls or otherwise arranged to avoid projecting rail ends. Wall handrails at stairs and ramps and other handrails that are not continuous shall be extended horizontally for a distance of at least 305 mm (12 in.) beyond the intersection of the finish line (plane of tread nose lines) of the stair or ramp and the landings, unless interference limits such an extension.

4.3.3 The clearance between the handrail and the mounting surface or any protrusions from this surface shall be 38 mm (1 ½ in.). The handrail shall project no more than 89 mm (3 ½ in.) into the required egress width. The vertical clearance in a recess shall be in accordance with the provision in 4.4.5.

4.3.4 The hand-grip portion of the handrail shall not be less than 32 mm (1¼ in.) or more than 51 mm (2 in.) in outside diameter.

4.4 *Transfer Rail Design:*

4.4.1 Transfer rails shall be designed to permit continuous sliding of the arm and hand supporting the body weight during transfer. The hardware chosen for attaching the transfer rails shall be such that projecting lugs, devices, or other construction elements shall not interrupt the continuous sliding of the arm or hand or catches loose clothing. The transfer rails, including their fasteners, shall not have sharp edges or dangerous protrusions. The transfer rail top surface shall not be abrasive.

4.4.2 Transfer rails shall be returned to supporting walls or otherwise arranged to avoid projecting rail ends that could catch clothing or objects during normal activity around the rail ends.

4.4.3 The clearance between the face of the transfer rail and that of the mounting surface or any protrusions from this surface shall be at least 38mm (1-½ in.).

4.4.4 The hand-grip portion of the transfer rail shall have a perimeter of not less than 102 mm (4 in.) nor more than 165 mm (6-½ in.), and a maximum to minimum cross-sectional dimension ratio of not more than two.

4.4.5 Transfer rails shall not be located in a wall recess unless this recess is not more than 76 mm (3 in.) deep and extends at least 460 mm (18 in.) above the top of the transfer rail, with the extension parallel with the wall surface or sloping from the depth of the recess to the wall surface above the recess in such a way that grasping of the transfer rail and transfer of the body weight is not impeded.

4.5 *Special Consideration Concerning Performance of Structural System*—In the event of lateral loading resulting from wind and seismic forces, the designer of the railing

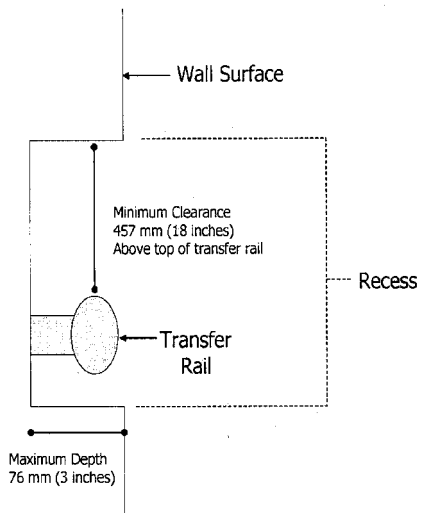

FIG. 3 Recessed Transfer Rail

system shall evaluate the influence of the railing system on the building's structural system.

4.6 *Permissible Dimensional Tolerances, except as indicated otherwise:*

4.6.1 Fabrication tolerances of components shall be within ± 1.5 mm (0.0625 in.).

4.6.2 Alignment tolerances of installed products shall be within ± 6 mm (¼ in.) within a length of 6100 mm (20 ft).

5. Classification

5.1 Classifications of systems passing the performance requirements are outlined in section 5 of this standard. Basic classification shall indicate type of system (Type I through V see Figs. 4–8c) and level of performance (1, 2, 3 or 4), with level one relating to Basic, level two relating to Safety, and level three and four relating to Enhanced.

6. Performance Requirements

6.1 The Performance Requirements are outlined in Table 1 and section 6.2 below:

6.2 *Deflection Requirements*

6.2.1 The maximum allowable deflection at the required test load, measured at the top of the rail system at the critical point of load application and from the position of the rail after release of the preload, shall not be more than described in 6.2.1.1 – 6.2.1.4 of this standard.

6.2.1.1 When the load is applied at the line of vertical support, the horizontal deflection shall not exceed the rail height *(h)* divided by 12 or *h*/12, with *h* being the distance between the surface of the uppermost post anchorage and the top of the top rail.

6.2.1.2 When the horizontal load is applied at the mid-span of the rail, the horizontal deflection shall not exceed the sum of the rail height *(h)* divided by 24 plus the rail length *(l)* between the vertical supports divided by 96, or *h*/24+ *l*/96.

6.2.1.3 When the vertical load is applied at the mid-span of the rail, the vertical deflection shall not exceed the length *(l)* divided by 96 or *l*/96.

6.2.1.4 Residual deflection at the released test load, which is at 50% of the preload, shall not exceed 20% of the deflection permitted in 6.2.1.1 – 6.2.1.3 or 12 mm (½ in.), whichever is less.

7. Pass/Fail Criteria

7.1 *Structural (Frame) Performance*

7.1.1 Complete glazing retention must occur and the glass must be unbroken at the completion of each test.

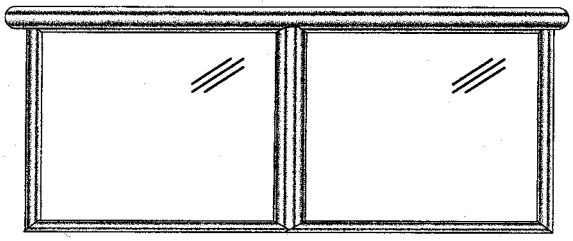

FIG. 4 Type I: Four-side support - Infill

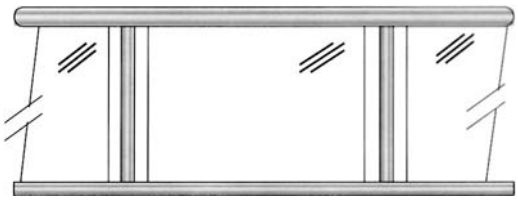

FIG. 5 a Type II: Two-side support – Single Lite Infill

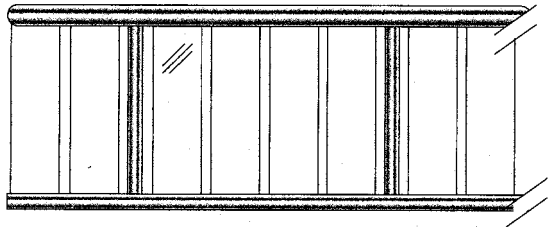

FIG. 5 b Type II: Two-side support – Multiple Lite Infill *(continued)*

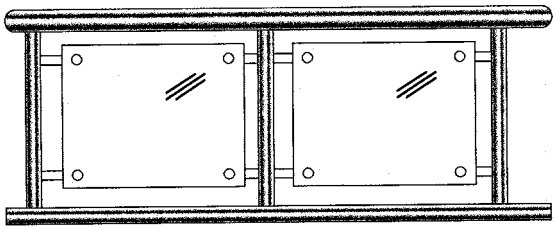

FIG. 6 Type III: Point Fixed Glazing System - Infill

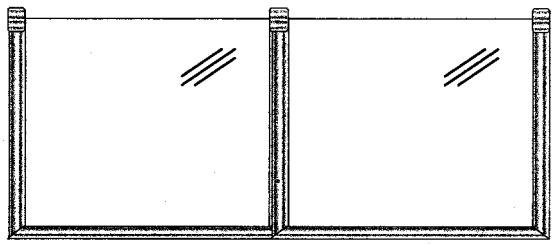

FIG. 7 Type IV: Three-side support - Structural

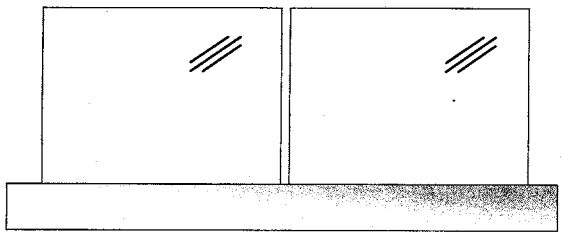

FIG. 8 a Type V: One-side support - Structural

7.2 *Shot Bag Impact Performance*

7.2.1 The glass shall be retained in the framing system such that a 76 mm (3 in.) solid steel sphere shall not pass through any part of the system using a horizontally applied force of 18 N (4.0 lb).

7.3 *Pendulum Impact Performance*

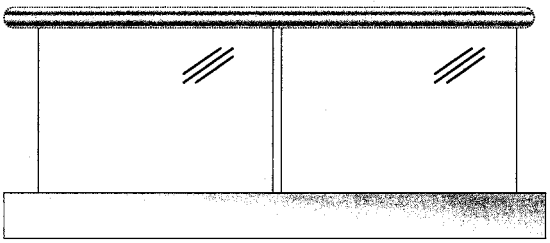

FIG. 8 b Type V: One-side support with protective top rail - Structural *(continued)*

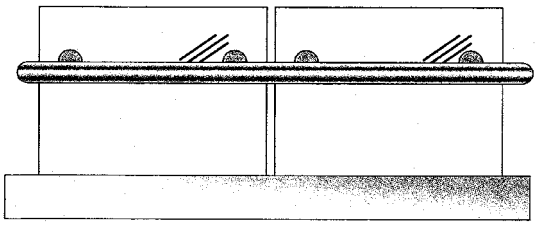

FIG. 8 c Type V: One-side support with surface attached/bolted handrail - Structural *(continued)*

7.3.1 The glass shall be retained in the framing system such that a 76 mm (3 in.) solid steel sphere will not pass through any part of the system using a horizontally applied force of 18 N (4.0 lb).

8. Permissible Variations and Substitutions

8.1 Thinner glazing shall qualify thicker glazing provided at least one of the following criteria is met:

8.1.1 Tempered Glass shall be capable of meeting the fragmentation particle size test as outlined in CPSC 16 CFR Part 1201.

8.1.2 Laminated glass shall have the same glass type (e.g. heat treatment) and minimum thickness of interlayer material as that which was originally qualified.

8.2 Laminated glass shall be permitted to be substituted for tempered glass provided the structural loads (frame loads) are met and the nominal thickness is achieved with a minimum of 0.76 mm (0.030 inch) interlayer.

8.3 Color and pattern of the same nominal thickness or greater shall be substituted for clear glazing provided the visual enhancement causes no decrease in the structural performance of the material as compared to that which was originally qualified (sandblasting or grooving shall not be permitted unless specifically tested according to the requirements of this specification).

8.4 Larger systems shall qualify smaller systems provided there is no change to the attachment, anchoring or any other property that would decrease the structural performance of the system.

9. Workmanship, Finish, and Appearance

9.1 Any exposed edge of frame material or glazing shall be finished (such as, sanded, polished and so forth) to reduce the likelihood of accidental laceration during intended use in the systems unbroken form.

TEST METHODS

10. Scope

10.1 The scope of the test methods is contained in Test Methods E2353.

11. Significance and Use

11.1 The significance and use of the test methods is contained in Test Methods E2353..

12. Hazards

12.1 The hazards of the test method are contained in Test Methods E2353..

13. Procedure

13.1 The procedure of test methods is contained in Test Methods E2353..

14. Precision and Bias

14.1 The precision and bias of the test methods is outlined in Test Methods E2353.

15. Product Marking

15.1 The system shall be permanently marked with the performance indicator level (Table 1) on the glazing or the rating shall be contained in a certificate of compliance along with a detailed drawing of the system and description of the glazing material.

16. Keywords

16.1 balcony; Balustrades; fall-out; Flat glass; Glass; glazing; Guards; impact; laminated glass; Rails; retention; safety; safety glazing; tempered glass

TABLE 1 Performance Requirements

System Type	Performance Level (Indicator)	Structural Performance[A]	Safety Impact Performance[B]	Enhanced Impact Performance[C]
I -V	Level 1 (Type-L1)	Concentrated load: 890 N (200 lbf) Uniform Load: 290 N/m (20 lbf/ft) Infill Horizontal Load: 220 N (50lbf)[D]	Pass 203 J 150 ft ·lb	Not Required
I - V	Level 2 (Type-L2)	Concentrated load: 890 N (200 lbf) Uniform Load: 730 N/m (50 lbf/ft) Infill Horizontal Load: 220 N (50lbf)[D]	Pass 542 J 400 ft ·lb	Not Required
I – V	Level 3 (Type-L3)	Concentrated load: 1330 N (300 lbf) Uniform Load: 730 N/m (50 lbf/ft) Infill Horizontal Load: 220 N (50lbf)[D]	Pass 542 J 400 ft ·lb	Pass
I - V	Level 4 (Type-L4)	Concentrated load: 1620 N (365 lbf) Uniform Load: 880 N/m (60 lbf/ft) Infill Horizontal Load: 220 N (50lbf)[D]	Pass 542 J 400 ft ·lb	Pass

[A]Tests performed as outlined in ASTM E935
[B]Tests performed as described in ANSI Z97.1 and section 13.3 of Test Methof E2353.
[C]Tests performed as described in ASTM E2025 and section 13.4 of Test Method E2353.
[D]Horizontal load applied to glazing infill (Test Method C of Test Method E935) shall be distributed evenly over a 7740 mm^2 (12 in^2) area located at the most critical point of the glazing.

APPENDIX

(Nonmandatory Information)

X1. Performance Levels

The products evaluated by this specification are potentially subjected to a wide variety of forces and impacts that could cause breakage and lead to the potential fall-out if the glazing vacates the frame. This specification outlines a test methodology that takes into account the various impacts from a sharp blow of a knee to a blunt object impact to a full body impact. Although not every form of impact and force can be accounted for in a test method, this specification provides a means of establishing a level of retention that may help glazing in rails, guards and balustrades perform their intended function of protection and fall-out prevention.