Designation: E935 – 13$^{\varepsilon 1}$

Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings[1]

This standard is issued under the fixed designation E935; 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.

ε[1] NOTE—Section 1.2 was editorially revised in October 2013.

1. Scope

1.1 These test methods cover procedures to be followed in testing the performance of permanent metal railing systems (guard, stair, and ramp-rail systems), including components such as rails (hand, wall, grab, and transfer rails) and swing gates or other forms of required guardrail opening protection, installed in and for agricultural, assembly, commercial, educational, industrial, institutional, recreational, and residential buildings and other structures, such as towers or elevated platforms.

1.2 These test methods are applicable to such railing systems and rails having major structural components made of metal, with their secondary components, including swing gates or other forms of guardrail opening protection, made of metal or other materials such as wood, plastic, and glass.

1.3 These test methods can be used to determine whether permanent metal railing systems and rails,[2] including components, comply with requirements of the applicable performance specifications, such as building codes, or performance standards such as those described in Specification E985, ANSI/ASSE A1264.1, and OSHA 1910.23.

1.4 Specifically, these test methods cover procedures for determining the static strength of metal railing systems, rails and components as structural elements when installed and fastened to concrete, masonry, wood, and metal, as well as related products.

1.5 No consideration is given in these test methods to any possible deterioration of metal railing systems, rails, and connections, resulting from adverse environmental conditions. The performance of special tests covering this aspect may be desirable.

1.6 These test methods are limited to the application of the loads described herein.

1.7 Should computations make it possible to provide the needed information, testing can be employed for verification.

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.* For specific hazard statements, see 11.2.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E4 Practices for Force Verification of Testing Machines

E575 Practice for Reporting Data from Structural Tests of Building Constructions, Elements, Connections, and Assemblies

E631 Terminology of Building Constructions

E985 Specification for Permanent Metal Railing Systems and Rails for Buildings

E1481 Terminology of Railing Systems and Rails for Buildings

2.2 *Other Standards:*

ANSI/ASSE A1264.1 Safety Requirements for Workplace Walking/Working Surfaces and Their Access[4]

OSHA 1910.23 Guarding floor and wall openings and holes[5]

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

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[2] "Field Testing Device for Railing Systems and Rails," *Journal of Testing and Evaluation*, Vol. 16, No. 6, ID JTE11274J, Online, Available: http://www.astm.org, 01 November 1988.

[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 Society of Safety Engineers (ASSE), 1800 E. Oakton St., Des Plaines, IL 60018, http://www.asse.org.

[5] Available from Occupational Safety and Health Administration (OSHA), 200 Constitution Ave., Washington, DC 20210, http://www.osha.gov/law-regs.html.

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, see Terminology E631 and Terminology E1481.

3.2 *Definitions of Terms Specific to This Standard:*

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

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 metal railing systems and rails installed and fastened to structural elements of concrete, masonry, wood, and metal as well as related products.

4.2 These test methods may be used to determine whether railing systems comply with requirements of the applicable performance specifications.

4.3 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. Typical floor-mounted railings are shown in Fig. 1.

5. Apparatus

5.1 *Testing Machine*—Any testing machine or loading device, capable of imposing forces accurate to within ±1 % when calibrated in accordance with Practices E4, is suitable and may be used provided the requirements of specified rate of loading are met. The testing device shall be of sufficient capacity to prevent yielding of its various components and shall insure that the applied load remains essentially parallel to the relevant axis of the assembly during testing.

5.2 *Test System*—Attach the loading device to the assembly by means of pins or a swivel connector to prevent the direct transfer of any flexural forces through the connection. Load contact points against the test specimen shall be a maximum width of 2 in. (51 mm), unless otherwise specified by the applicable performance specification or required for the purpose of the test and applied such that the centerline of the load contact point is located at the position indicated by the test method.

5.3 *Deflection Measurements*—Unless otherwise specified by the applicable performance specification, dial gages, having a smallest division of not more than 0.01 in. (0.25 mm), or any suitable measurement devices or calibrated sensors of at least comparable accuracy and sensitivity shall be used to measure the horizontal displacements of the top of the railing system or rail relative to its original location at each loading point prior to load application. These devices shall have sufficient measurement capability to indicate the displacement throughout the test range.

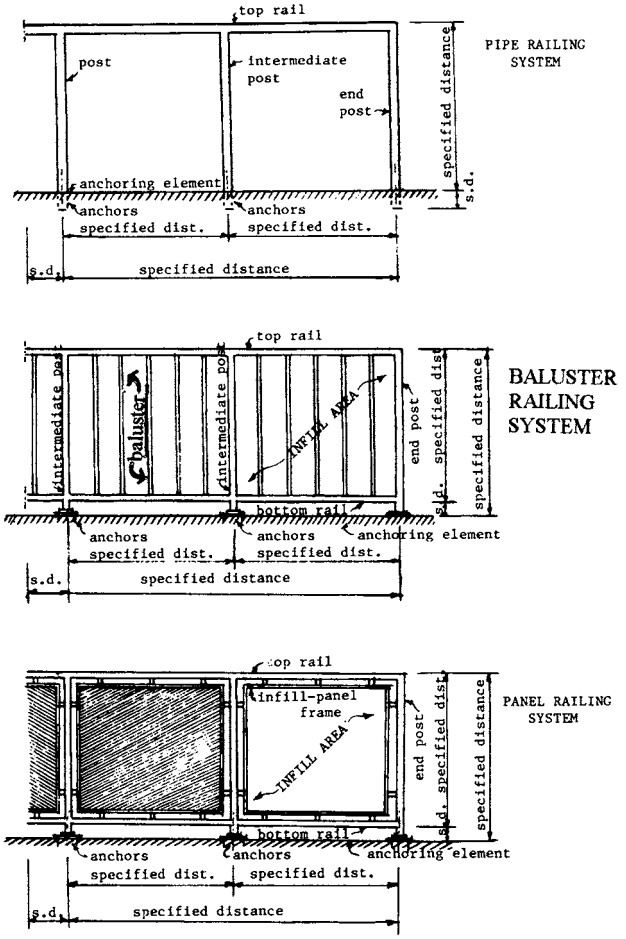

FIG. 1 Front Views of Sections of Three Typical Railing Systems

6. Test Selection

6.1 The only tests that need to be performed are those that are necessary to provide information required by the requesting party, testing agency, and regulatory body involved or those that are specified by, or otherwise required to provide information related to, applicable performance specifications.

7. Installation

7.1 Install the railing system, rail or component being tested in accordance with the manufacturer's or designer's specifications.

8. Sampling

8.1 A sampling plan appropriate for the purposes of the test shall be used.

8.1.1 If a sampling plan is specified by the applicable performance specification, that plan shall be used for compliance testing.

9. Test Specimens

9.1 *Specimen Definition*—The guard and handrail test specimen shall be defined as two vertical posts at maximum center-to-center spacing, and all components, and all connections used in the guard and handrail system, including the vertical post bases.

9.1.1 A guardrail opening protection specimen such as a swing gate shall be defined as a single example of the guardrail opening protection, at maximum span if adjustable, all connections used in attachment to the guardrail system, the two vertical posts that define the opening, and sufficient installation of the guardrail system to permit installation of the guardrail opening protection according to the manufacturer's instructions with adequate structural support by the guardrail system. If the purpose of the test is to determine compliance or performance as installed in a specific field example, the span of the gate should be as in the field installation.

9.2 *Specimen Assembly*—Test specimens may be assembled using the actual post base anchors to be installed to a representative substrate of the completed installation, or test specimens may be assembled using post base anchors consistent with the size and location of anchors to be installed in the completed installation, connected to a rigid support, installed according to the manufacturer's recommendations and as specified by the applicable performance standard or as required for the purposes of the test. If adhesive anchors are used, cure adhesive according to the manufacturer's recommendations to ensure reliable strength during testing. The test results shall state the minimum required edge distance to ensure adequate performance.

9.3 *Specimen Description*—Examples of typical floor-mounted test specimens are shown in Fig. 1 in diagrammatic form. The specimen installation, including the post spacing, shall be the same as the actual or anticipated field installation. A guardrail specimen shall have a minimum of three posts if this is in line with the actual field installation simulated.

10. Procedure

10.1 *Selection of Test Methods*—The user may select one or more of the test methods described in 10.4, 10.5, and 10.6, as determined by the performance specification or the purposes of the test.

10.2 *Sequence of Test Methods*—Specimens tested for two or more of the loading conditions shall be subjected first to the in-fill load test, followed by the uniform load test, and last, the concentrated load test, in that order unless specified otherwise by the performance specification.

10.3 *Replacement of Failed Components*—If the test is conducted for research, design or product development purposes, if a component(s) or connection(s) fails in any of the tests, testing may continue after the failed component or connection is removed and replaced. The failure must be recorded. If testing is conducted for purposes of determining compliance with a performance standard or to determine performance of the complete railing system or any element of the railing system, the failed component or connection may not be replaced. The test series continues as defined in 10.1.

10.4 *In-Fill Load Test*—The test specimen shall be capable of satisfactorily resisting the required test load applied over a 1 ft^2 (0.0929-m^2) square area normal to the in-fill. The test load shall be applied at the intersection of the horizontal and vertical center lines of the in-fill, unless specified otherwise by the performance specification or the purposes of the test. If it is determined that another location will yield lesser results, that position should be used instead of the indicated intersection point of the center lines. Record deflection of the in-fill at the point of maximum deflection of the in-fill.

10.5 *Uniform Load Test*—Subject the top rail or other rail of the test specimen to the required maximum uniform test load applied vertically and horizontally, as required by the performance specification. Required vertical and horizontal test loads shall be applied separately and sequentially, unless otherwise required by the performance specification or to meet the purpose of the test. Record the deflection at mid-span during each test.

10.5.1 *Quarter Point Rule*—For purposes of this test, quarter-point loading shall be deemed to be equivalent to uniform loading by calculating the equivalent bending moment generated in a uniform load scenario using the following equation (see Fig. 2):

$$P = \frac{wL}{2} \tag{1}$$

where:

P = Force (lb) applied at each quarter point,
w = Uniform load (lb/ft),
L = Span (ft) between the two posts.

10.6 *Concentrated Load Test*—The top rail or other subject rail of the test specimen shall be subjected to the concentrated test load applied vertically and horizontally, as required by the performance specification. Apply required vertical and horizontal test separately and sequentially, unless otherwise required by the performance specification or to meet the purpose of the test. The required concentrated test load shall be applied at the following three critical locations: rail midspan between posts, top rail adjacent to a post (maximum 3 in. from post), top of a single post. Test loads are to be applied and deflection recorded sequentially, one location at a time. The load applied on the rail adjacent to the post can be applied to the opposite post from which the top-of-post test was performed on. In the case of swing gates, if the structure of the gate requires locating the test load more than 3 in. from a post due to hinge or latch construction, the load should be located as close to the 3-in. maximum distance from the post as is possible. Record the deflection at the point of application of the load.

11. Load Application

11.1 *Rate of Loading*—The rate of loading shall be such that the maximum specified load is achieved in no less than 10 s and no more than 5 min.

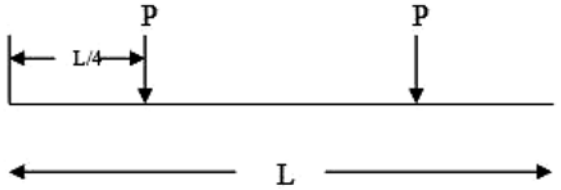

FIG. 2 Calculating the Equivalent Bending Moment Generated in a Uniform Load Scenario (see Eq 1)

11.2 *Load Duration*—Maintain the maximum specified load for 1 min before releasing. (**Warning—**Possible injury to personnel and damage to the test equipment and instrumentation prior to, during, and after load application by any unexpected release of potential strain energy accumulated during testing can occur and must be given consideration.) (**Warning—**If tests are conducted in a structure and not in a testing laboratory, exercise caution against unwanted damage to the building, its components, and its finish.)

12. Calculation

12.1 *Load-Deflection Data*—As required by the performance specification or other purpose of the test, determine the actual, adjusted, and average load deflection data for each loading point of each of the test series, including residual deflection, if required.

12.1.1 Calculate the actual deflection (Δ) at a given load for an individual test in the following manner:

$$\Delta = A_n - A_1 \quad (2)$$

where:

A_n = the instrument reading at a given load, and
A_1 = the initial instrument reading.

12.1.2 If required, obtain the adjusted deflection by plotting the actual deflection versus the applied load and extrapolating a smooth curve through the data points back to zero load. The adjusted deflection at maximum load or any other test load is observed from the plot relative to the zero load.

12.1.3 Obtain the average adjusted deflection at maximum load or any other test load for each of the test series as the arithmetic mean of the appropriate individual deflection determinations at a given load in a given series.

12.2 *Required Test-Load and Maximum-Load Data*—If required and unless specified otherwise in the applicable performance standard, determine the average required test load and maximum load for given assembly as the arithmetic mean of the appropriate test and maximum loads for each of the test series depending on the test requirements.

13. Failure Analysis

13.1 *Deflection and Load at Failure*—Determine the required test load and maximum test load and the corresponding deflection for each assembly or component tested, depending on the test requirements.

13.2 *Failure Modes*—Determine and describe the type of failure as follows:

13.2.1 Failure of the total railing system or rail.

13.2.2 Failure of elements or components of the railing system or rail.

13.2.3 Failure of the connections of the elements or components of the railing system or rail.

13.2.4 Failure of the anchorage.

14. Report

14.1 Report the applicable information as listed in Practice E575 and specifically the following information:

14.1.1 Relevant physical-strength properties of the railing-system or rail materials used for the test specimens.

14.1.2 Description of the procedure used for the assembly and installation of the railing system or rail.

14.1.3 Description of the anchorage system.

14.1.4 Age, in days, at time of test of the railing or rail anchorage system, if this information is of any significance.

14.1.5 Age, in hours or days, since assembly and installation of the railing system or rail, if this information is of any significance.

14.1.6 Species, oven-dry specific gravity, and moisture content at time of test, in percent of the oven-dry weight and volume, of any wood members or components of the anchorage system.

14.1.7 Actual rate of loading between increments.

14.2 *Reporting of Failure*—Report the deflection at failure and failure modes as described in Section 13, and specifically the following information:

14.2.1 The applicable performance standard, if any.

14.2.2 A description of any deformation or breakage that causes a specimen to fail to meet the requirements of the applicable performance standard.

14.2.3 A description of all factors and affected components that contributed to failure.

14.2.4 A description of any condition that renders any component of the guardrail system, including any guardrail opening protection, unable to function as intended.

15. Precision and Bias

15.1 No statement is made on the precision or on the bias of these test methods since no data are available at this time that are based on the use of the test methods described.

16. Keywords

16.1 building components; gates; opening protection; railing systems (metal); rails (metal); test methods; thrust resistance