Designation: E998 – 19

Standard Test Method for Structural Performance of Architectural Glass Products Under the Influence of Uniform Static Loads[1]

This standard is issued under the fixed designation E998; 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 a general test procedure for load tests of glass subjected to uniform static loads. It is applicable for test protocols involving specified loads, load durations, and loading rates.

1.2 This test method is applicable to architectural flat glass of various types; for example, annealed, heat-strengthened, fully tempered, laminated, insulating, and combinations thereof.

1.3 This test method describes a process of applying specific test loads to glass. The test may be conducted using a standard test frame specified herein or a test frame of the user's design.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety problems, 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.* For specific precautionary statements see Section 7.

1.6 *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]

C1036 Specification for Flat Glass

C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass

C1172 Specification for Laminated Architectural Flat Glass

C1376 Specification for Pyrolytic and Vacuum Deposition Coatings on Flat Glass

E631 Terminology of Building Constructions

E1237 Guide for Installing Bonded Resistance Strain Gages

E1561 Practice for Analysis of Strain Gage Rosette Data

3. Terminology

3.1 *Definitions*—For definitions of general terms related to building construction used in this test method refer to Terminology E631.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aspect ratio, n*—a ratio of long side to short side of the glass lite.

3.2.2 *dry glazed system, n*—a system with perimeter support designed to limit lateral (out-of-plane) displacements of the glass specimen edges while minimizing rotational and in-plane restraints of the glass specimen edges without adhesive material.

3.2.3 *glass specimen, n*—the glass to be tested, for example, a single lite, an insulating glass unit, laminated glass, and so forth (does not include test frame).

3.2.4 *negative load, n*—a load that results in the indoor side of a glass specimen being the high-pressure side.

3.2.5 *permanent set of test frame, n*—a load-induced permanent displacement from an original position of the test frame.

3.2.6 *positive load, n*—a load that results in the outdoor side of a glass specimen being the high-pressure side.

3.2.7 *specifying authority, n*—the professional or professionals responsible for determining and furnishing the information required to perform this test method as described in Section 10.

3.2.8 *test load, n*—magnitude of uniform load, load duration, and loading rate selected by the specifying authority.

4. Summary of Test Method

4.1 This test method consists of:

4.1.1 Glazing the test specimen into a test frame that is mounted on or against a test chamber.

[1] This test method is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.52 on Glass Use in Buildings.

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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.

4.1.2 Supplying or exhausting air from the chamber at a rate required to maintain a test-pressure difference across the test specimen.

4.1.3 Measuring and observing deflections, deformations, specimen strains, and the nature of failures, if applicable.

4.1.4 Recording the results in an orderly manner.

5. Significance and Use

5.1 This test method is a general procedure for testing architectural glass products under uniform static loads.

5.2 Loads on glass in windows, curtain walls, and doors may vary greatly in magnitude, direction, and duration. An understanding of wind loads on the building is required for selection of test loads and interpretation of results with respect to expected exposure at a particular site.

5.3 A thorough understanding of the variations of the strength of glass and the nature of loading is required to interpret results of this test method.

5.4 The proper use of this test method requires a knowledge of the principles of pressure, deflection, and strain measurement.

6. Apparatus

6.1 The description of apparatus is general in nature. Any equipment capable of performing the test procedure within the allowable tolerances shall be permitted.

6.2 *Major Components:*

6.2.1 *Test Frame*—The fixture in which glass specimens are mounted for testing. The test frame shall provide either standardized simple support conditions or other specified support conditions. Specifications of standardized support conditions are presented in Annex A1.

6.2.2 *Test Chamber*—A sealed enclosure with an opening in which or against which the test frame with the test specimen shall be installed. At least one static pressure tap shall be provided to measure the test chamber pressure and shall be so located that the reading is minimally affected by the velocity of the air supply to or from the test chamber or any other air movement. The air supply opening into the test chamber shall be arranged so that the air does not impinge directly on the glass specimen with any significant velocity. A means of access into the test chamber shall be permitted to facilitate adjustments and observations after the specimen has been installed.

6.2.3 *Air Pressure System*—A controllable blower, compressed air supply/vacuum system, or other suitable system capable of providing the required maximum air pressure differential (positive or negative load) across the test specimen with suitable control systems, such as manually operated valves, electronically operated valves, or computer controlled servo-valves.

6.2.4 *Air Pressure Measuring Apparatus*—Equipment to measure pressure differentials across the test specimen with an accuracy of ±2 % of its maximum rated capacity, or ±100 Pa (2 psf), whichever is less, and with a response time less than 50 ms. Acceptable apparatus includes manometers, mechanical pressure gages and electronic pressure transducers.

6.2.5 *Deflection Measuring System*—A means of measuring deflections within an accuracy of ±0.25 mm (0.01 in.).

6.2.5.1 The deflection indicator shall be mounted so that deflection of the test chamber or test frame is not included in the deflection gage reading. Provisions shall be made to ensure that readings can be made from a safe location.

6.2.6 *Temperature Measuring Apparatus*—Equipment to measure the ambient temperature within an accuracy of ±0.6 °C (1 °F).

6.2.7 *Barometric Pressure Measuring Apparatus*—Equipment to measure barometric pressure within an accuracy of ±100 Pa (2 psf).

7. Safety Precautions

7.1 This test method involves potentially hazardous situations resulting primarily from glass breakage. In cases of breakage or loss of support, the hazard to personnel is less with a vacuum system, as the specimen will tend to blow into rather than out of the test chamber. No personnel shall be permitted in such chambers during tests. Appropriate precautions shall be exercised during conduct of the test to protect personnel, especially in the case of breakage or loss of support.

8. Sampling and Glass Specimens

8.1 Surface condition, cutting, fabrication, and packaging of the glass specimens to be tested shall be representative of normal production of the particular glass type.

8.2 All glass specimens shall be visually inspected for edge or surface blemishes prior to testing in accordance with applicable standards (for example, Specifications C1036, C1048, C1172, and C1376). Depending on the purpose for testing the glass, specimens with edge or surface blemishes shall be appropriately documented or culled from the sample. All questionable glass specimens shall be reported to the specifying authority.

8.3 Glass specimens shall be handled carefully at all times because the strength of glass is influenced by its surface and edge conditions. If any further damage to a sample occurs as a result of handling during the test procedure, this damage should be visually reviewed and documented in accordance with 8.2.

9. Calibration

9.1 Air pressure measuring apparatus, deflection measuring systems, strain gages, temperature measuring apparatus, and barometric pressure measuring apparatus shall be routinely checked. If calibration is required, the manufacturer's recommendations or good engineering practice shall be followed.

10. Required Information

10.1 The specifying authority shall provide a test protocol consisting of the test load (positive or negative), number of samples to test for each glazing type, glass edge bite, and loading sequence.

10.2 The specifying authority shall state whether the glass specimens shall be dry glazed in a standard test frame or in a test frame designed to simulate a specific glazing system. If the

test frame is to simulate a specific glazing system, complete glazing details and support conditions shall be provided by the specifying authority.

10.3 The specifying authority shall provide locations for strain gage installation and deflection measuring devices, as well as a schedule of recording strain gage readings and deflections.

11. Procedure

11.1 Measure and record ambient temperature and barometric pressure.

11.2 Install strain gages to the glass specimen according to procedures in Annex A2. Refer to Appendix X1 for example strain gage locations.

11.3 Install glass specimens in the test frame in accordance with recommendations in Annex A1 for standard support conditions or as specified by the specifying authority.

11.4 Install deflection gages at locations specified by the specifying authority. Refer to Appendix X1 for example deflection gage locations.

11.5 Record reference strain and deflection readings at no-load conditions.

11.6 Load specimen to low level pressure, 20 % of test load for 1 min. Release load. Allow 3 to 5 min gage and restoration time.

11.7 If air leakage around the test specimen is excessive, tape or alternate soft, flexible material shall be permitted to be used to cover any cracks and joints through which the leakage is occurring. Such material shall not be used when there is a probability that it may significantly restrict differential movement between the glass and test frame.

11.8 Proceed with test and record strain gage readings and deflections according to the specified test protocol. Continuous load, strain, and deflection versus time records shall be kept for the duration of the test.

11.9 If the specimen breaks during testing, check for permanent set of the test frame and chamber and gasket damage before testing another specimen. Remove glass fragments from test assembly prior to testing another specimen.

12. Report

12.1 The report shall include the following information:

12.1.1 Date of the test, the date of the report, the ambient temperature, and the barometric pressure.

12.1.2 Identification of the glass specimens (manufacturer, source of supply, dimensions, both nominal and measured, manufacturer's designation, materials, and other pertinent information).

12.1.3 Detailed drawings of the glass specimen, test frame, test chamber, a complete description of all instrumentation, and a statement that the test was conducted using a standard test frame or a test frame specified by the specifying authority.

12.1.4 A detailed description of the specified test protocol.

12.1.5 Records of measured chamber pressures, deflections, and strain gage readings according to the test protocol, with each specimen being properly identified.

12.1.6 A summary of test observations, including unexpected behavior or failures of test specimens and time of occurrence.

12.1.7 Identification or description of any applicable specification. Documentation of each glass specimen inspection results (including culled specimens) in accordance with applicable specifications.

12.1.8 A statement that the tests were conducted in accordance with the specified test method, or a full description of any deviations.

13. Precision and Bias

13.1 No statement is made about either the precision or the bias of this test method since the variables impacting these values will vary depending on the specified test protocol.

14. Keywords

14.1 annealed glass; curtain walls; deflection; float glass; fully tempered glass; heat-strengthened glass; insulating glass; laminated glass; monolithic glass; strain gages; uniform static loads; windows

ANNEXES

(Mandatory Information)

A1. STANDARD GLASS TEST FRAME FOR SIMPLY-SUPPORTED DRY GLAZED EDGE CONDITIONS

A1.1 Introduction

A1.1.1 The standard test frame shall be designed to support a glass specimen and expose it to the test load. The test frame shall consist of two primary systems: a structural support system and a dry glazed edge support system. The structural support system shall be designed to resist applied loads with limited deflections and provide an interface between the test chamber and the glazing system. The dry glazed edge support system shall be designed to limit lateral displacements of the glass specimen edges while minimizing rotational and in-plane

restraints of the glass specimen edges. This annex presents pertinent details relating to the design and construction of a standard test frame.

A1.2 Structural Support System

A1.2.1 The structural support system shall consist of perimeter structural members arranged as shown in Fig. A1.1. The inside dimensions of the support system shall be maintained to provide the required glass bite tolerance in A1.3.2.

A1.2.2 The structural members shall be selected from available structural channels with flange widths ≥44 mm (1¾ in.). The structural members are to be designed to withstand the test load without permanent deformations. In addition, the structural members shall be designed to meet the following deflection criteria:

A1.2.2.1 The maximum out-of-plane deflection (referenced to glass specimen) of the structural members shall not exceed *L*/750 where *L* is the length of the respective supported side of the glass specimen,

A1.2.2.2 The maximum rotation of the structural members shall not exceed 1°, and

A1.2.2.3 The maximum in-plane deflection (referenced to the glass specimen) of the structural members shall not exceed *L*/2000, where *L* is the length of the shorter side of the glass specimen.

A1.2.3 The corner connections of the support system shall be designed to minimize racking or twisting during testing.

A1.2.4 In addition to the above criteria, the following fabrication tolerances shall be met:

A1.2.4.1 The maximum out-of-plane offset at the corners shall not exceed 0.4 mm (1⁄64 in.) (see Fig. A1.1),

A1.2.4.2 The maximum planar variation of the outside edges of the structural members shall not exceed 1.6 mm (1⁄16 in.),

A1.2.4.3 The maximum difference in the measured diagonals of the interior rectangular opening shall not exceed 3 mm (⅛ in.), and

A1.2.4.4 The depth of the structural members shall be sufficient to allow unimpaired out-of-plane displacements of the glass specimens during the test.

A1.2.5 Holes shall be provided, as required, in the flanges of the structural members for fasteners.

A1.3 Glazing System

A1.3.1 The dry glazed edge support system, which attaches to the structural support system, shall consist of the following major components (see examples in Figs. A1.2-A1.4):

A1.3.1.1 Inside and outside glazing stops,

A1.3.1.2 Aluminum spacers,

A1.3.1.3 Inside and outside neoprene gaskets,

A1.3.1.4 Structural fasteners, and

A1.3.1.5 Neoprene setting blocks.

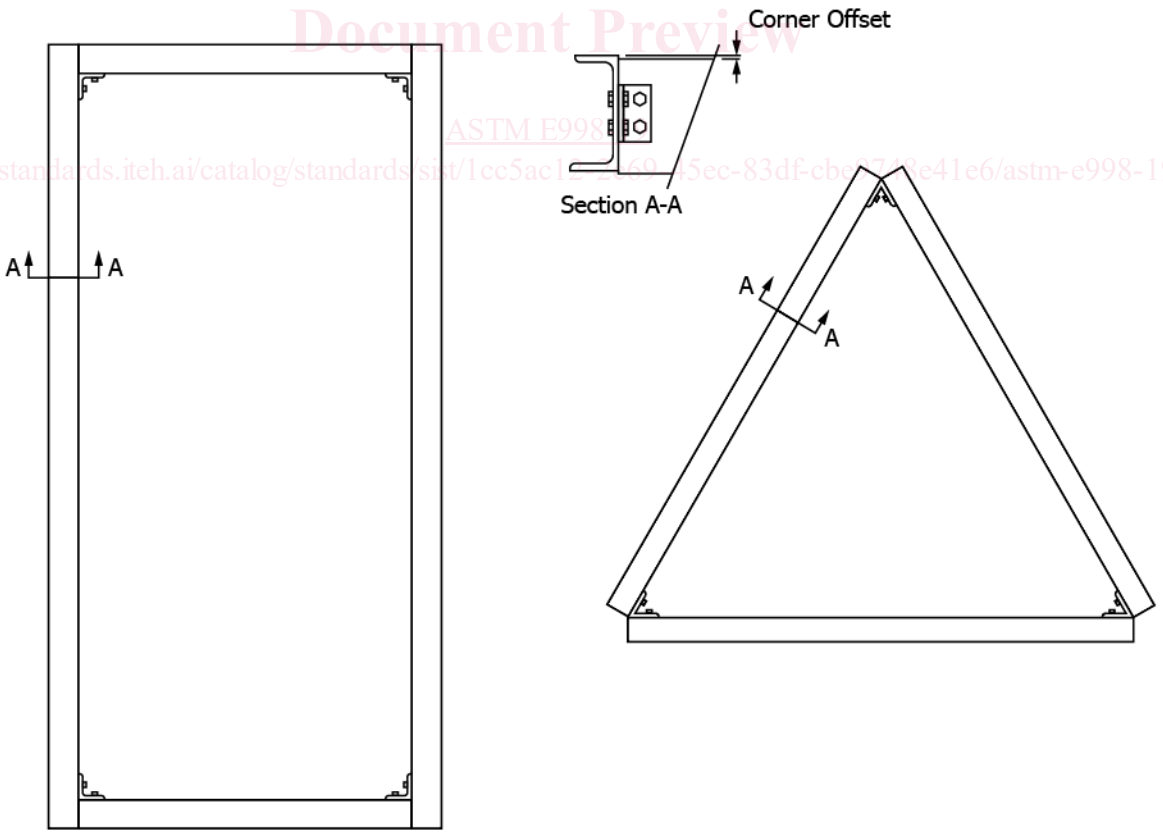

FIG. A1.1 Structural Support System