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~~An American National Standard~~ Designation: E 330 – 02

Standard Test Method for Structural Performance of Exterior Windows, ~~Curtain Walls,~~Doors, Skylights and ~~Doors~~Curtain Walls by Uniform Static Air Pressure Difference[1]

This standard is issued under the fixed designation E 330; 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.

This standard has been approved for use by agencies of the Department of Defense.

~~ε1 Note—Editorial changes were made to this standard in August 1998.~~

1. Scope

1.1 This test method describes the determination of the structural performance of exterior windows, ~~curtain walls,~~doors, skylights, and ~~doors~~curtain walls under uniform static air pressure differences, using a test chamber. This test method is applicable to curtain wall assemblies including, but not limited to, metal, glass, masonry, and stone components.

1.2 This test method is intended only for evaluating the structural performance associated with the specified test specimen and not the structural performance of adjacent construction.

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

1.4 This test method describes the apparatus and the procedure to be used for applying uniformly distributed test loads to a specimen.

1.4.1 Procedure A (see ~~section~~ 11.2) shall be used when a load-deflection curve is not required.

1.4.2 Procedure B (see ~~section~~ 11.3) shall be used when a load-deflection curve is required.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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 Section 7.

1.7 The text of this standard references notes and footnotes which provide explanatory materials. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the standard.

2. Referenced Documents [2]

2.1 *ASTM Standards:*

E 631 Terminology of Building Constructions[3]

E 997 Test Method for Structural Performance of Glass in Exterior Windows, Curtain Walls, and Doors Under the Influence of Uniform Static Loads by Destructive Methods[3]

E 998 Test Method for Structural Performance of Glass in Windows, Curtain Walls, and Doors Under the Influence of Uniform Static Loads by Nondestructive Method[3]

~~E1233Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Cyclic Static Air Pressure Differential~~[3]

E 1233 Test Method for Structural Performance of Exterior Windows, Curtain Walls, and Doors by Cyclic Air Pressure Differential[3]

E 1300 Practice for Determining Load Resistance of Glass in Buildings[3]

E 1886 Test Method for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Missile(s)

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[1] This test method is under the jurisdiction of ASTM Committee ~~E-6~~ E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 ~~on Component Performance of Windows, Curtain Walls, and Doors.~~

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~~[2] Additional information on curtain wall assemblies can be obtained from the American Architectural Manufacturers' Association, 1540 East Dundee, Palantine, IL 60067.~~

[2] Additional information on curtain wall assemblies can be obtained from the American Architectural Manufacturers' Association, 1827 Walden Office Square, Suite 550, Schaumburg, IL 60173.

[3] *Annual Book of ASTM Standards*, Vol 04.11.

and Exposed to Cyclic Pressure Differentials[4]

E 1996 Specification for Performance of Exterior Windows, Curtain Walls, Doors, and Storm Shutters Impacted by Windborne Debris in Hurricanes[4]

2.2 *ASCE Standard:*

ASCE 7~~(formerly ANSI A58.1) Minimum Design Loads for Buildings and Other Structures~~ Minimum Design Loads for Buildings and Other Structures[5]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology E 631, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *design wind load*—the uniform static air pressure differences, inward and outward, for which the specimen would be designed under service load conditions using conventional wind engineering specifications and concepts, expressed in pascals (or pounds-force per square foot). This pressure is determined by either analytical or wind-tunnel procedures (such as are specified in ASCE 7).

3.2.2 *permanent deformation*, *n*—the displacement or change in dimension of the specimen after the applied load has been removed and the specimen has relaxed for the specified period of time.

~~3.2.2~~

3.2.3 *proof load*—a test load multiplied by a factor of safety.

3.2.4 *stick system*, *n*—a curtain wall assembly composed of individually framed continuous members, vertical mullions, and horizontal rails that are installed in a sequential, piece-by-piece process. The completed system is assembled entirely in the field.

~~3.2.3~~

3.2.5 *structural distress*—a change in condition of the specimen indicative of deterioration or incipient failure, such as cracking, local yielding, fastener loosening, or loss of adhesive bond.

~~3.2.4~~

3.2.6 *test load*—the specified difference in static air pressure (positive or negative) for which the specimen is to be tested, expressed in pascals (or pounds-force per square foot).

~~3.2.5~~

3.2.7 *test specimen*, *n*—the entire assembled unit submitted for test (as described in Section 8).

~~3.2.6~~

3.2.8 *unit/panel system*, *n*—a curtain wall assembly composed of pre-assembled groups of individual framing members. The completed system is designed to be modular, transportable, and installed as a finished assembly.

4. Summary of Test Method

4.1 This test method consists of sealing the test specimen into or against one face of a test chamber, supplying air to or exhausting air from the chamber according to a specific test loading program, at the rate required to maintain the test pressure difference across the specimen, and observing, measuring, and recording the deflection, deformations, and nature of any distress or failures of the specimen.

5. Significance and Use

5.1 This test method is a standard procedure for determining structural performance under uniform static air pressure difference. This typically is intended to represent the effects of a wind load on exterior building surface elements. ~~This standard is not intended to account for the effect of windborne debris.~~ The actual loading on building surfaces is quite complex, varying with wind direction, time, height above ground, building shape, terrain, surrounding structures, and other factors. The resistance of many windows, curtain walls, and door assemblies to wind loading is also complex and depends on the complete history of load, magnitude, duration, and repetition. These factors are discussed in ASCE 7and in the literature (**~~1,2,3~~1-8**).

~~5.2Design wind velocities are selected for particular geographic locations and probabilities of occurrence based on data from wind velocity maps such as are prepared by the National Weather Service. The approach in collecting data for these maps is to measure the fastest average wind during finite time periods within each hour. The finite time duration used is given by the equation $t = 5800/V$ (3600/V), where t is the time span in seconds and V is the wind velocity in kilometres (miles) per hour. Wind velocity maps therefore show isotachs of the fastest average wind velocities during time spans which become shorter as the wind velocity increases. For example, a 144.8 km/h (90 mph) wind is actually the highest sustained average wind for a 40-s time span and a 289.6 km/h (180 mph) wind is actually the highest sustained average wind for a 20-s time span. Measurements obtained in this way are known as the fastest kilometre (fastest mile) of wind because the procedure is actually to measure the time required for a 1.609~~

~~[4] Available from the American Society of Civil Engineers, 345 E. 45th Street, New York, NY 10017-2398.~~

[4] *Annual Book of ASTM Standards*, Vol 04.12.

~~[5] The boldface numbers in parentheses refer to the list of references appended to this test method.~~

[5] Available from The American Society of Civil Engineers (ASCE), 1801 Alexander Bell Dr., Reston, VA 20191.

km (1 mile) long sample of air to pass a fixed point. ASCE 7 provides additional information on this subject. The wind velocity maps of ASCE 7 are based on a 2% per year probability of being exceeded. Map velocities are increased or decreased, where appropriate, through an importance factor, *I*, to reflect a design criterion accepting lesser or greater risk than the ordinary annual risk of 0.02. Importance factors are also applied to hurricane-prone regions within 160.9 km (100 miles) of a coastline.

5.3The person specifying the test must translate anticipated wind velocities and durations into uniform static air pressure differences and durations. Complexities of wind pressures, as related to building design, wind intensity versus duration, frequency of occurrence, and other factors must be considered. Superimposed on sustained winds are gusting winds which, for short periods of time from a fraction of a second to a few seconds, are capable of moving at considerably higher velocities than the sustained winds. Wind tunnel studies, computer simulations, and model analyses are helpful in determining the appropriate wind pressures on buildings by showing how a particular building acts under wind velocities established by others.

5.3.1If a 144.8 km/h (90 mph) wind storm is considered, the average velocity during at least one 40-s time period is 144.8 km/h. Studies reveal that there are also 2-s average velocities of 193.1 km/h (120 mph), 10-s average velocities of 170.6 km/h (106 mph), and 1-h average velocities of 86.9 km/h (54 mph) in the same storm. Reference **(4)** gives information on these studies. For a 144.8 km/h fastest kilometre (fastest mile) wind, it is apparent that there are other velocities that may be considered for the purpose of testing exterior window, wall, and door products. If the 144.8 km/h fastest kilometre wind has been selected as appropriate for a particular location, the time duration at 144.8 km/h would be 40 s. This period of time is considered as the time duration for a test at a load equivalent to the design pressure for the 144.8 km/h wind. Following the line of reasoning in the example above that the test load and time duration of tests are related, if a 10-s time duration is used, the test should be conducted at a load equivalent to the design pressure for a 107.6 km/h wind which is 39% greater than for a 144.8 km/h wind. If structural performance under both sustained and gust loads is to be checked, testing should be conducted at both the sustained and gust load static pressure differences and for the time duration appropriate to each.

5.4The duration of the applied test load are capable of imposing serious effects on materials used in the test specimen. Most materials have strength or deflection characteristics that are time dependent. For this reason, test for the time duration to which an assembly will be exposed to a sustained or gust load, or both, as discussed in 5.3. Generally, U.S. practice in the past has been to require a minimum test period of 10 s for specific loads equal to 1.5 times the design pressure, unless requirements have been otherwise specified. Thus a safety factor was incorporated in the testing. With higher test loads and longer time durations, the designer must also consider what safety factors are essential, particularly with regard to gust wind loads. Gust wind loads are of relatively short duration, so that care shall be exercised not to specify unnecessarily long duration loads for purposes of testing the adequacy of the structure to withstand wind gusts. [6]

5.2 Design wind velocities are selected for particular geographic locations and probabilities of occurrence based on data from wind velocity maps such as are provided in ASCE 7. These wind velocities are translated into uniform static air pressure differences and durations acting inward and outward. Complexities of wind pressures, as related to building design, wind intensity versus duration, frequency of occurrence, and other factors must be considered. Superimposed on sustained winds are gusting winds which, for short periods of time from a fraction of a second to a few seconds, are capable of moving at considerably higher velocities than the sustained winds. The analytical procedures in ASCE 7, wind tunnel studies, computer simulations, and model analyses are helpful in determining the appropriate design wind loads on exterior surface elements of buildings. Generally, wind load durations obtained from ASCE 7 are 2 to 10 s and are dependent upon the specific time reference employed in determining the pressure coefficients.

5.3 Some materials have strength or deflection characteristics that are time dependent. Therefore, the duration of the applied test load may have a significant impact on the performance of materials used in the test specimen. The most common examples of materials with time-dependent response characteristics that are used are glass, plastics, and composites that employ plastics. For this reason, the strength of an assembly is tested for the actual time duration to which it would be exposed to a sustained or a gust load, or both, as discussed above. Generally, U.S. practice for wind load testing has been to require a minimum test period of 10 s for test loads equal to the design wind load and proof loads equal to 1.5 times the design wind load. Thus a safety factor is incorporated in the testing. With test loads for wind higher than those determined by ASCE 7 or of longer time duration than 10 s, the designer must consider what safety factors are appropriate. For test loads that represent design loads other than wind, such as snow load, consideration shall be given to establish an appropriate test period for both design and proof load testing.

5.4 This standard is not intended to account for the effect of windborne debris or cyclic loads. Consideration of cyclic air pressure differentials is addressed in Test Method E 1233. Consideration of windborne debris in combination with cyclic air pressure differential representing extreme wind events is addressed in Test Method E 1886 and Specification E 1996.

5.5 This test method is not intended for use in evaluating the structural adequacy of glass for a particular application. When the structural performance of glass is to be evaluated, the procedure described in Test Method E 997 or E 998 shall be used.

5.6Further information on the subjects covered above is available in the literature **(4,5,6,7,8)** .

NOTE 1—In applying the results of tests by this test method, it should be borne in mind note that the performance of a wall or its components, or both, may be a function of fabrication, installation, and adjustment, and that the adjustment. The specimen may or may not truly represent every aspect of the actual structure. In service, the performance will also depend on the rigidity of supporting construction, temperature, and on the resistance of components

[6] The boldface numbers in parentheses refer to the list of references appended to this test method.

to deterioration by various other causes, including vibration, thermal expansion and contraction, ~~and so forth.~~ etc.

6. Apparatus

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

6.2 *Major Components* (see Fig. 1):

6.2.1 *Test Chamber*, or a box with an opening, a removable mounting panel, or one open side in which or against which the specimen is installed. Provide a static pressure tap to measure the pressure difference across the test specimen. Locate the tap so that the reading is unaffected by the velocity of air supplied to or from the chamber or by any other air movements. The air supply opening into the chamber shall be arranged so that the air does not impinge directly on the test specimen with any significant velocity. A means shall be provided to facilitate test specimen adjustments and observations. The test chamber or the specimen mounting frame, or both, must not deflect under the test load in such a manner that the performance of the specimen will be affected.

6.2.2 *Air System*, a controllable blower, a compressed-air supply, an exhaust system, or reversible controllable blower designed to provide the required maximum air-pressure difference across the specimen. The system shall provide an essentially constant air-pressure difference for the required test period.

NOTE 2—It is convenient to use a reversible blower or a separate pressure and exhaust system to provide the required air-pressure difference so that the test specimen can be tested for the effect of wind blowing against the wall (positive pressure) or for the effect of suction on the lee side of the building (negative pressure) without removing, reversing, and reinstalling the test specimen. If an adequate air supply is available, a completely airtight seal need not be provided around the perimeter of the test specimen and the mounting panel, although it is preferable. However, substantial air leakage will require an air supply of much greater capacity to maintain the required pressure differences.

6.2.3 *Pressure-Measuring Apparatus* , to measure the test pressure difference within a tolerance of ±2 % or ±2.5 Pa (±0.01 in. of water column), whichever is greater.

6.2.4 *Deflection-Measuring System* , to measure deflections within a tolerance of ±0.25 mm (±0.01 in.).

6.2.4.1 For Procedure A, any locations at which deflections are to be measured shall be stated by the specifier.

6.2.4.2 For Procedure B, maximum and end deflections of at least one of each type of principal member not directly and continuously supported by surrounding construction shall be measured. Additional locations for deflection measurements, if required, shall be stated by the specifier.

6.2.4.3 When deflections are to be measured, the deflection gages shall be installed so that the deflections of the components can be measured without being influenced by possible movements of, or movements within, the specimen or member supports.

6.2.4.4 For ~~tests to determine the ultimate performance of a specimen. Permanent~~proof load tests, permanent deformation can be determined by the use of a straightedge-type gage applied to the members after preloading and again after the test load has been removed.

7. Hazards

7.1 Take proper precautions to protect the observers in the event of any failure. Considerable energy and hazard are involved at the pressures used in this test method. ~~WARNING:~~ (**Warning—**At the pressure used in this test method, considerable hazards are involved. Do not permit personnel in negative pressure chambers during tests.)

8. Test Specimens

8.1 Curtain wall test specimens shall be of sufficient size and configuration to determine the performance of all typical parts of the system and to provide full loading on each typical vertical and horizontal framing member, including building corner details

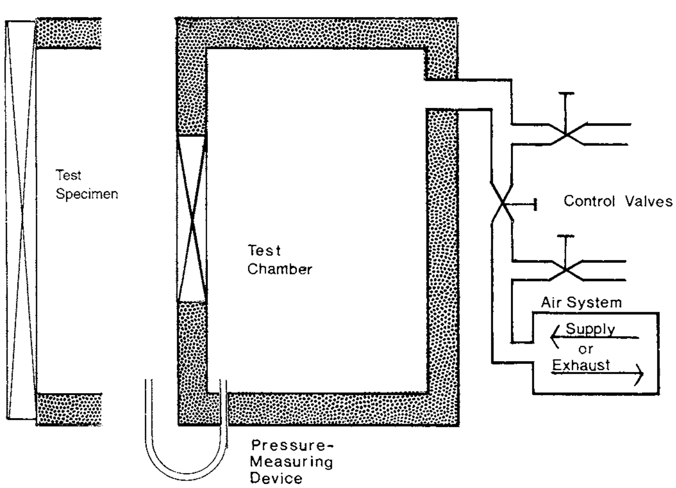

FIG. 1 General Arrangement of Testing Apparatus