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Standard Test Method for Glazing and Glazing Systems Subject to Airblast Loadings[1]

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INTRODUCTION

Historical records show that fragments from glazing that has failed as the result of intentional or accidental explosions present a serious threat of personal injury. Glazing failure also allows blast pressure to enter the interior of buildings thus resulting in additional threat of personal injury and facility damage. These risks increase in direct proportion to the amount of glazing used on the building facade. This test method addresses only glazing and glazing systems. It assumes that the designer has verified that other structural elements have been adequately designed to resist the anticipated airblast pressures.

1. Scope

1.1 This test method sets forth procedures for the evaluation of the resistance of glazing or glazing systems against airblast loadings.

1.2 This test method allows for glazings to be tested with or without framing systems.

1.3 This test method is designed to test all glazings and glazing systems, including those fabricated from glass, plastic, glass-clad plastics, laminated glass, glass/plastic glazing materials, and film-backed glass.

1.4 The values stated in inch-pound units are to be regarded as the standard.

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 determine the applicability of regulatory limitations prior to use.* See Section 8 for specific hazards statements.

2. Referenced Documents

2.1 *ASTM Standards:*

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[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *ambient temperature*—75 ± 20°F.

3.1.2 *blast mat*—a steel or concrete pad upon which high explosive may be detonated to reduce the incidence of ejecta.

3.1.3 *effective positive phase duration (T)*—the duration of an idealized triangular positive phase reflected airblast pressure time history, having an instantaneous rise to the measured *P*, with a linear decay to ambient, such that the impulse of the idealized pressure time history equals *i* of the measured positive phase of the reflected airblast time history.

3.1.3.1 *Discussion*—The idealized triangular airblast wave is considered to provide a reliable standard measure of the positive phase airblast intensity.

3.1.4 *glazing*—transparent materials used for windows, doors, or other panels.

3.1.5 *glazing system*—the assembly comprised of the glazing, its framing system, and anchorage devices.

3.1.6 *peak positive pressure (P)*—the maximum measured positive phase reflected airblast pressure, pounds per square inch.

3.1.7 *positive phase impulse (i)*—the integral of the measured positive phase reflected airblast pressure time history, pounds per square inch–metres per second (more correctly called the *specific positive phase impulse*).

3.1.8 *reflected airblast pressure*—the pressure increase that a surface, oriented other than parallel to the line from the detonation point to the surface, experiences due to the detonation of a high explosive charge.

3.1.8.1 *Discussion*—The reflected airblast pressure time history, as measured at a point on the surface, consists of two separate phases. The positive phase is characterized by a nearly instantaneous rise to a maximum pressure followed by an exponential decay to ambient pressure. In the negative phase, which follows immediately the positive phase, the pressure

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[2] *Annual Book of ASTM Standards*, Vol 04.07.

decreases below ambient for a period of time before returning to ambient.

3.1.9 *simply supported glazings*—glazings supported in accordance with Test Method E 997 with the edges of the glass extending a minimum of ⅛ in. beyond the neoprene supports.

3.1.10 *test director*—the individual identified by the independent testing laboratory as being responsible to complete the specified tests as required and to document the results, in accordance with this test method.

4. Summary of Test Method

4.1 This test method prescribes the required apparatus, procedures, specimens, and other requirements necessary to determine the airblast resistance capacity of a glazing or glazing system.

5. Significance and Use

5.1 This test method provides a structured procedure to establish the airblast resistance capacity of glazings and glazing systems. Knowing the airblast resistance capacity reduces the risk of personal injury and facility damage.

5.2 The airblast resistance capacity for a glazing or glazing material does not imply that a single specimen will resist the specific airblast for which it is rated with a probability of 1.0. The probability that a single glazing or glazing construction specimen will resist the specific airblast for which it is rated increases proportionally with the number of test specimens that successfully resist the given level of airblast.

6. Number of Specimens

6.1 *Number of Specimens*—A minimum of three test specimens representative of a glazing or glazing system shall be tested at a given level of airblast, defined in terms of *P* and *i*.

6.2 *Failure*—A specimen shall not be deemed to have successfully resisted an airblast if (*1*) any openings are created during the test through which airblast pressure can pass through the specimen, or (*2*) spall from the specimen penetrates the witness panel behind the specimen. In the case of testing of glazing and not a glazing system, the specimen shall be prevented from pulling away from the supporting frame. Simply supported glazing pulling away from the frame does not constitute failure of the glazing but is considered a nontest. The glazing must be retested.

7. Apparatus

7.1 *Test Facility*—The test facility shall consist of either a shock tube or an open-air arena. Open-air arenas should be sited on clear and level terrain. The test facility shall be situated, and be of sufficient size, to accommodate the detonation of the required amount of explosives to provide the desired peak positive pressure and positive phase impulse. The test director shall ensure that potential environmental impact issues are determined and resolved prior to testing. The test director shall ensure that testing is conducted at ambient temperature in accordance with Section 3.1.1.

7.2 *High Explosive (HE) Charge*—A high explosive charge shall be used to generate the desired peak pressure and the positive phase impulse on the test specimen. The charge shall be hemispherical and detonated at ground level. Other charge configurations can be used. The effects of using other charge configurations must be accounted for and documented.

7.3 *Blast Mat*—If there is a possibility of crater ejecta interfering with the test, the high explosive charge shall be placed on a blast mat. The decision to use a blast mat shall be at the discretion of the test director.

7.4 *Test Frame*—A test frame suitable for supporting glazings or glazing systems. Glazing tested without a specific framing system shall be supported in a simple support subframe that is attached to the test frame. If a glazing system is tested, the glazing system shall be mounted to the test frame in a manner that closely models the manner in which it will be mounted in the field. The test frame shall be capable of resisting the airblast with deflections that do not exceed *L*/360 along lines of support for the simple support subframe or the glazing system. The area immediately behind the test specimens shall be enclosed to prevent airblast pressure from wrapping behind the test specimens.

7.5 *Simple Support Subframe*—A subframe, attachable to the test frame, to support glazing in accordance with Test Method E 997.

7.6 *Instrumentation*:

7.6.1 *Pressure Transducers*—A minimum of three reflected and one free field airblast pressure transducers shall be used in each test frame. The airblast pressure transducer shall be capable of defining the anticipated airblast pressure history within the linear range of the transducer. The transducers shall have a rise/response time and resolution sufficient to capture the complete event. Limited low frequency response transducers shall have a discharge time constant equal to approximately 30 to 50 times the initial positive phase duration of the anticipated reflected airblast pressure history.

7.6.2 *Data Acquisition System (DAS)*—The DAS shall consist of either an analog or digital recording system with a sufficient number of channels to accommodate the pressure transducers and any other electronic measuring devices. The DAS must operate at a sufficiently high frequency to record reliably the peak positive pressure. The DAS shall also incorporate filters to preclude alias frequency effects from the data.

7.6.3 *Photographic Equipment*—Photographic equipment shall be available to document the test.

7.6.4 *Temperature Measuring Device (TMD)*—A TMD shall be used to accurately measure glazing surface temperatures.

7.6.5 *Witness Panels*—Witness panels shall be mounted parallel to and at a distance no greater than 12 in. in back of the glazing or glazing system test specimens. The witness panels shall cover the full area of the test specimens. The witness panels shall consist of sheets of maximum 0.001 in. thick, Alloy 1100 Temper 0 aluminum stretched within the perimeter of a suitable frame to provide a taut surface or mounted on styrofoam panels. To accommodate the shaft of a linear variable displacement transducer (LVDT), a hole no greater than 2 by 2 in. may be made in the witness panel.

8. Hazards

8.1 Storage, handling, and detonation of high explosive material should be conducted in accordance with applicable