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

This standard is issued under the fixed designation F2927; 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 identifies the standard procedures that shall be followed when utilizing either a shock tube or a controlled open-air explosion to evaluate the blast capacity of a door system. This test method is designed for all types of swinging doors, including single and double doors construction. This method is used to test complete door assemblies. A door assembly includes the door panel(s), latching hardware, hinges, post mullion (if applicable), frame and frame connection to a rigid reaction structure. The door panel(s) may also contain one or more integral vision lites (glazing systems). The glazing system may include, but not be limited to those fabricated from monolithic glass, laminated glass, plastic, glass-clad plastics, glass/plastic glazing materials, and filmed-backed glass. The results gathered from this method can be used for door installations in non-rigid wall openings. The test method may be adapted to horizontal sliding and vertical-lift doors.

1.2 The scaled range or standoff of the charge shall be 1 m (3 ft, 3 in.) or greater from the specimen in order to reduce or eliminate any punching effect the blast may have on the specimen. A charge-in-contact blast test is not covered by this method.

1.3 This test method and the resulting data are valid for the door size tested and smaller doors of identical construction. Acceptance criteria are divided into five Door Response Damage Categories (Categories I, II, III, IV and V). Refer to section 7.1 and Table 1 for a description of each category.

1.4 A door assembly may also contain ancillary hardware such as pulls, closers, kickplates, coordinators, gaskets, etc. Although these hardware components may not influence blast resistance performance, the specifier may wish to verify that these items do not dislodge from the door or frame during a test and become a flying debris hazard.

1.5 For doors equipped with a vision lite, the door shall be evaluated using the Door Response Damage Categories introduced in section 1.3 and defined in Table 1 and the glazing and glazing system of the vision lite shall also be evaluated using a *No Break, No Hazard, Minimal Hazard, Very Low Hazard, Low Hazard and High Hazard* rating system. Refer to section 7.5 and Table 2 for glazing hazard definitions.

1.6 This method is intended to test the blast capacity of a door assembly from a shock wave. It does not attempt to address all testing required of door assemblies. These tests may include, but are not limited to, charge-in-contact blast resistance, forced entry resistance, bullet resistance, fire resistance, sound attenuation, and gas or water leakage. These types of tests are not covered by this test method.

1.7 This test method does not verify the blast performance of the wall that a tested door will be placed in.

1.8 The values stated in SI units (International System of Units) are to be regarded as the standard. The values given in parentheses are provided for information only.

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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E699 Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components

F1642 Test Method for Glazing and Glazing Systems Subject to Airblast Loadings

2.2 *Other Standards:*[3]

ISO/IEC International Standard 17025 General Requirements for the Competence of Testing and Calibration Laboratories

3. Terminology

3.1 *Definitions:*

[1] This test method is under the jurisdiction of ASTM Committee F12 on Security Systems and Equipment and is the direct responsibility of Subcommittee F12.10 on Systems Products and Services.

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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, http://www.ansi.org.

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TABLE 1 Door Response Damage Categories and Descriptions

Damage Rating	Description of Door / Frame Response	Damage Level Category
Undamaged	The door specimen is substantially unchanged after the airblast loading and is fully operable. Any permanent deformation shall be within 3 mm (⅛ in.) of the pretest condition. The door must be checked that it is operable by unlatching and swinging the door open and then closed and latched. The door can be secured. The external portion of the frame, frame anchorage, latches, and hinges shall not show any visible damage. If strain gauges were used, the recorded stresses in the door material are within the specifier's acceptable limits.	I
Damaged but Openable	The door panel, the frame, and/or the hardware has acceptable permanent deformation or damage; however, the door remains openable. The door must be checked that it is openable by unlatching and swinging the door open far enough to allow ingress / egress. Acceptable permanent deformation or damage and degree of opening to permit ingress / egress is determined by the specifier based on the end use of the door.	II
Non-catastrophic Failure	The door may get lodged into the frame from the blast force or the door may swing open in rebound. The door may be inoperable and may hinder ingress / egress. Acceptable permanent deformation or damage is determined by the specifier based on the end use of the door. The door and hardware components are not permitted to detach from the frame and be thrown into the test structure witness area. The frame and frame anchorage must remain and integral system and attached to the test structure wall.	III
Limited Hazard Failure	The door leaf becomes separated frame or the frame anchorage fails and the entire door leaf and frame assembly become separated from the test structure wall and are thrown into the test structure witness area. The dislodged door leaf or assembly must remain within the 3 m (120 in.) finish floor as shown in Fig. 1. There shall be no evidence of any dislodged hardware component striking the witness panel mounted on the back wall of the test structure. Note: A door assembly equal to or exceeding 3 m (120 in.) in height cannot obtain a "Limited Hazard Failure – Category IV Rating" due to the size limitation of the test structure witness area.	IV
High Hazard Failure	The door leaf becomes separated frame or the frame anchorage fails and the entire door leaf and frame assembly become separated from the test structure wall and are thrown into the test structure witness area and strikes the witness panel above the "High Hazard Threshold" shown in Fig. 1. There shall be no evidence of any dislodged hardware component striking the witness panel above the High Hazard Threshold.	V

TABLE 2 Glazing Hazard Levels and Descriptions

Hazard Rating	Description of Door's Glazing Response	Hazard Level
No Break	The glazing is observed not to fracture and there is no visible damage to the glazing system.	H1
No Hazard	The glazing is observed to fracture but is fully retained in the door's vision lite frame and the rear surface (the side opposite the airblast loaded side of the specimen) is unbroken.	H1
Minimal Hazard	The glazing is observed to fracture and the total length of tears in the glazing plus the total length of pullout from the edge of the vision lite frame is less than 20 % of the glazing sight perimeter. Also, there are three or less perforations caused by glazing slivers and no fragment indents anywhere in a vertical witness panel located 3 m (120 in.) from the interior face of the specimen and there are fragments with a sum total united dimension of 25 cm (10 in.) or less on the floor between 0 m to 1 m (0 in. to 40 in.) from the interior face of the specimen. Glazing dust and slivers are not accounted for in the rating. Fragments are defined as any particle with a united dimension of 2.5 cm (1 in.) or greater. The united dimension of a glass particle is deter- mined by adding its width, length, and thickness. Glazing dust and slivers are all smaller particles.	H2
Very Low Hazard	The glazing is observed to fracture within 1 m (40 in.) of the original location. Also, there are three or less perforations caused by glazing slivers and no fragment indents anywhere in a vertical witness panel located 3 m (120 in.) from the interior face of the specimen and there are fragments with a sum total united dimension of 25 cm (10 in.) or less on the floor between 1 m (40 in.) and 3 m (120 in.) from the interior face of the specimen. Glazing dust and slivers are not accounted for in the rating.	H3
Low Hazard	The glazing is observed to fracture, but the glazing fragments generally fall between 1 m (40 in.) of the interior face of the specimen and 50 cm (20 in.) or less above the floor of a vertical witness panel located 3 m (120 in.) from the interior face of the specimen. Also, there are ten or fewer perforations in the area of a vertical witness panel located 3 m (120 in.) from the interior face of the specimen and higher than 50 cm (20 in.) above the floor and none of the perforations penetrate through the full thickness of the foil backed insulation board layer of the witness panel.	H4
High Hazard	Glazing is observed to fracture and there are more than ten perforations in the area of a vertical witness panel located 3 m (120 in.) from the interior face of the specimen and higher than 50 cm (20 in.) above the floor or there are one or more perforations in the same witness panel area with fragment penetration through the first layer and into the second layer of the witness panel.	N/A

3.1.1 *actual door size*—for swing doors, the exact width and height of the door panel itself.

3.1.2 *ambient temperature*—refers to the temperature of the air that surrounds the test specimen.

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

3.1.4 *blast-resistant door*—a door assembly that is designed and manufactured to resist a specified series of impulse pressures of designated magnitude in kilopascals (kPa) (or pounds-force) and duration in milliseconds (msec). Blast may result from an accidental or planned explosion or pressure release. The door assembly may be made from any materials that the door vendor/manufacturer or specifier desires.

3.1.5 *door clearance*—refers to the space between the top of the door and header rabbet, the door and jamb rabbets, and the bottom of the door and the finished floor.

3.1.6 *effective positive phase duration*—duration, in milliseconds (msec), of an idealized triangular-shaped positive air blast, having an instantaneous rise-time to the measured peak positive pressure and a linear decay to ambient conditions. The impulse of the idealized pressure/time history equals the measured positive phase impulse of the air blast pressure/time history.

3.1.7 *door opening size:*

3.1.7.1 *height*—the distance measured vertically between the frame head rabbet and the bottom of the frame. Equal to the Actual Door Height + Undercut + Top Clearance.

3.1.7.2 *width*—the distance measured horizontally between the jamb rabbets. Equal to the Actual Door Width (or widths for pairs) + Door Edge Clearance.

3.1.8 *glazing*—transparent materials used for windows within the door's vision lite.

3.1.9 *glazing system*—the assembly comprised of the glazing, its framing system, and anchoring devices of the vision lite that mount to the door panel.

3.1.10 *header*—the main horizontal member that forms the top of the door frame.

3.1.11 *jamb*—the main vertical members forming the sides of the door frame.

3.1.12 *latchbolt*—a bolt or bolts, typically spring-activated and beveled, in the edge of the door to keep the door closed.

3.1.13 *peak positive pressure*—the maximum measured positive phase air blast pressure in kilopascals (kPa) (or pounds-force per square foot (psf) or pounds-force per square inch (psi)).

3.1.14 *permanent deformation*—the permanent displacement from an original position remaining after an applied load has been removed, measured in millimeters (mm) (or inches (in.)).

3.1.15 *positive phase duration*—the duration, in milliseconds (msec), of a classic air blast pressure/time history, having a nearly instantaneous rise-time to the peak positive pressure and an exponential decay to ambient conditions. A negative phase of the air blast pressure will follow the positive phase. However, it does not need to be included in this test method unless required by the specifier.

3.1.16 *positive phase impulse*—the integral of the measured positive phase air blast pressure/time history, expressed in kilopascals-millisecond (kPa-msec) (or pounds-force per square foot-millisecond (psf-msec) or pounds-force per square inch-millisecond (psi-msec)).

3.1.17 *post mullion*—a slender vertical member that subdivides a door opening.

3.1.18 *rabbet*—the recess or offset in the frame to receive the door.

3.1.19 *rebound*—stress reversal in the material of the door.

3.1.20 *seating pressure*—an applied pressure that causes the door to seat against the frame, expressed in kilopascals (kPa) (or pounds-force per square foot (psf) or pounds-force per square inch (psi)).

3.1.21 *shock tube*—an apparatus that produces a shock load used for testing building components.

3.1.22 *specifier*—individual or party requiring that a door assembly meets specific blast resistance criteria.

3.1.23 *strike plate*—a metal plate affixed to the door jamb with a hole or holes for the latchbolt(s) of the door. When the door is closed, the latchbot(s) extend into the hole(s) and holds the door closed.

3.1.24 *test agency*—the party performing the testing and documenting the test results.

3.1.25 *test director*—the individual identified by the test agency as being responsible to complete the specified tests as required and to document the results in accordance with this test method. The test director must sign all of the test reports.

3.1.26 *test frame*—the rigid steel fixture supporting the test specimen at the end of a shock tube or in an open-air arena. The fixture allows for the installation of the door assembly onto the shock tube or at a particular standoff distance from an explosion in an open-air arena. The door assembly will be installed to the test frame in a manner similar to the way it would be installed into a steel subframe.

3.1.27 *test load*—the specified pressure differential (positive or negative) for which the specimen is to be rated, expressed in kilopascals (kPa) (or pounds-force per square foot (psf) or pounds-force per square inch (psi)).

3.1.28 *test specimen*—a complete door assembly provided for the test. It includes a door panel(s), a frame, hardware, and anchors to attach the frame to the test frame. A test specimen may be shipped to the test site as a pre-hung unit or it can be assembled at the site.

3.1.29 *test sponsor*—party requesting and sponsoring the test program. The test sponsor may be the end user of the door assembly or the door assembly manufacturer. The end user may desire proof of performance on a particular project and the door manufacturer may desire general proof of performance of a door assembly that will be used for numerous projects.

3.1.30 *ultimate load*—the pressure at which failure of the specimen occurs, expressed in kilopascals (kPa) (or pounds-force per square foot (psf) or pounds-force per square inch (psi)).

3.1.31 *undercut*—clearance between the finished floor or threshold and the bottom of the door.

3.1.32 *unseating pressure*—an applied pressure that tends to "unseat" the door from the frame, expressed in kilopascals (kPa) (pounds-force per square foot (psf) or pounds-force per square inch (psi)). The unseating pressure is resisted by the restraining hardware only.

3.1.33 *vendor / manufacturer*—company or individual that offers door products to clients for purchase.

3.1.34 *vision lite*—the glazed area of the glazing system in the door.

4. Summary of Test Method

4.1 This test method describes the required procedures, apparatus, test specimens, reporting requirements, and any other requirements necessary to verify that a door assembly meets a defined damage category after being subjected to a known air blast pressure over a given period of time. The door shall be evaluated using the five (5) Door Response Damage Categories defined in section 1.3 and Table 1. For doors equipped with a vision lite, the glazing and glazing system of the door lite will also be evaluated using the six (6) hazard rating system defined in section 1.5 and Table 2.

5. Significance and Use

5.1 This test method provides standardized procedures that must be followed to establish that a particular door assembly meets a defined damage category. Test results can be used to specify a door assembly for a particular pressure/time loading and damage level.

5.2 Establish a door design and, if applicable its glazing system, subjected to this test method does not imply that door systems of similar design will resist the applied test load. The probability that a single door assembly will resist the specified air blast pressure for which it is certified increases with the number of test specimens used to certify the door design. See Annex A1 for additional statistical considerations.

6. Apparatus

6.1 *Test Facility*—Test facilities shall be accredited for this method to the requirements of ISO/IEC 17025 or qualified according to Practice E699. The test facility shall consist of either a shock tube or an open-air arena from which the airblast loading is generated. Open-air arenas should be sited on a clear and level terrain 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 facility shall also consist of a test frame and witness area as described below. The test director shall ensure that potential environmental impact issues are determined and resolved prior to testing.

6.2 *Airblast Load*—Either a shock tube or a high explosive charge shall be used to generate the desired peak pressure and the positive phase impulse on the test specimen. If an explosive charge is used, the charge shape and location shall be determined by the test director to accommodate the desired peak positive pressure and positive phase impulse. See Annex A1 for information to be used in calculating pressures, impulses, and durations, and for accounting for different types of explosives. Note that the procedures in Annex A1 account for loading from a hemispherical charge imparting load on a large facade and do not address the issues of clearing or other explosive shapes.

6.3 *Blast Mat*—Used only in an open-air arena test. If there is a possibility of crater ejecta interfering with the test, the 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.

6.4 *Shock Tube*—A general shock tube consists of two major sections: a driven section and an expansion section. The shock tube may be driven by compressed gas or explosively driven with fuel-air mixtures or explosives. A shock wave is created by the sudden release of the compressed gas or explosive that, when suddenly released or ignited, creates a shock wave that travels into the expansion section. As the shock wave travels through the expansion section, it enlarges. The test specimen or target is generally located at the end of the expansion section, opposite the driven section. The peak pressure and impulse applied to the target is controlled by the initial conditions of the driven section. Specific features of shock tubes can vary greatly depending on the type and specific design and configuration of the shock tube used.

6.5 *Test Frame*—A test frame suitable for supporting a door specimen shall be used. The test frame shall represent the rough opening in a wall for the installation of the door assembly. Unless otherwise specified, the dimensions of the rough opening shall be from 10 mm (3⁄8 in.) to 25 mm (1 in.) greater than the actual door frame. The frame shall be capable of resisting the air blast elastically and the maximum deflection, including connection displacement of any individual component shall be limited to L/360. Once installed, the door face shall be recessed no more than 150 mm (6 in.) from the loaded surface of the test frame. The door frame shall be centered in the test frame ± 3 mm (1⁄8 in.) and, unless otherwise specified shall be anchored and shimmed in accordance with the supplier's recommendations for the intended application.

6.6 *Enclosure and Witness Area*—The area immediately behind the door specimen shall be enclosed to prevent the air blast pressure from wrapping behind the test specimen and reducing the applied test load. The enclosed area shall be of sufficient size to replicate the degree of swing that the door required by the specifier. Thus, the swing arc of the door shall range from 90° minimum to 180° maximum without interference. In some circumstances, it may be beneficial to have the enclosure designed to replicate a room of a building. Within the enclosure is the Witness Area. The witness area shall have the following attributes. The floor of the witness area shall be at or below the bottom of the opening where the door is being mounted. The vision lite glazing and glazing system shall be rated based on throw distance relative to its position in the door panel. The ceiling of the enclosure shall be a minimum of 100 mm (4 in.) from the top of the test frame opening used to receive the door and door frame assembly. The back wall of the witness area shall be 3.0 ± 0.15 m (120 ± 6 in.) from the interior face of the door.

6.7 *Pressure Transducers*—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 airblast pressure history.

6.8 *Strain Gauge*—Strain gauges may be used and positioned at the discretion of the test specifier and test director. The stain gauge sensors shall measure the electrical resistance variation from the applied force.

6.9 *Data Acquisition System (DAS)*—The DAS shall consist of an analog or digital recording system with a sufficient number of data 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. Pressure transducers and strain gauges would be considered to be part of the DAS.

6.10 *Photographic Equipment*—Each test shall be documented with still photography. Video or high speed photography of the testing is also recommended.

NOTE 1—Unless using a visual aid such placing masking tape across the door panel and frame, video or high speed photography may be the only way to confirm if a door rebounds open and then closes.

6.11 *Force Gauge*—A force gauge shall be used to measure the force required to operate the door's hardware and to swing the door open and closed before and after each test. The force gauge shall have the capacity to measure twice the listed operable force of an undamaged door and have an accuracy rating of 0.5 kg (1 lb) or less. The force gauge shall have memory storage for the maximum force.

6.12 *Temperature Measuring Device (TMD)*—A TMD shall be used to measure for ambient temperature and also, if applicable, measure the glazing surface temperature.

6.13 *Witness Panel*—A witness panel is used to detect flying debris from the glazing or glazing systems or hardware components. The witness panel shall be mounted parallel to and at a distance no greater than 3.0 ± 0.15 m (120 ± 6 in.) from the most interior face of the door panel. The witness panel shall cover the entire back wall of the witness area and shall consist of two layers of material. The witness panel shall consist of a rear layer of 25-mm (1-in.) extruded polystyrene foam with a density of 28.0 kg/m^3 (1.8 lb/ft^3) to 32.0 kg/m^3 (2.0 lb/ft^3) and a front layer consisting of 12.5 mm (0.5 in.) rigid foam plastic thermal insulation board composed of polyisocyanurate foam bonded to a durable white-matte non-glare aluminum facer and a reflective reinforced aluminum facer. The reflective surface shall be placed toward the door system. The insulation board shall have a density of 32.0 kg/m^3 (2.0 lb/ft^3). The reflective reinforced facer shall be 0.08 mm (0.003 in.) thick and shall be reinforced through lamination to kraft paper. To accommodate high-speed photography, a hole no greater than 30.5 by 30.5 cm (12 by 12 in.) may be made in the upper or lower one-ninth portions of the witness panel.

7. Acceptance Criteria Door Response Damage Categories and Door Glazing Hazard Ratings

7.1 Door Response Damage Categories shall be according to the following rating criteria definitions. The Damage Category that the door assembly receives is based upon the severity of the deformation and hardware component damage resulting from the airblast test. Refer to Table 1 for Door Damage Categories and Descriptions.

7.2 The frame anchorage shall not fail in shear, tension, or pullout for Categories I, II, or III. Limited deformation in the anchors is permitted for Categories II and III.

7.3 In applying the test results by this method, consideration must be given that the performance of the door assembly, the wall and/or its components, or both, may be a function of fabrication, installation, or adjustment, and that the test specimen may or may not truly represent the actual structure. In service, the performance will depend on the rigidity of the supporting construction and on the resistance of the components to deterioration by various causes.

7.4 Should any door assembly have a door panel or overall frame height of 3 m (approximately 10 feet) or greater become dislodged, a Category V shall be applied. This is due to the size limitation of the test structure witness area.

7.5 For door specimens equipped with a vision lite, the hazard rating of the glazing or glazing system shall be according to the Gazing Hazard Levels and Descriptions provided in Table 2 and further demonstrated in Fig. 1. The hazard rating that glazing or glazing systems receive is based upon the severity of fragments generated during an airblast test. The fragment severity is determined based upon the number, size and location of fragments observed during post-test data gathering. Fragments to be considered in rating the glazing or glazing system include those generated by the glazing, and any other parts of the glazing system not considered to be part of the test facility. Refer to section 6.1 for a definition of the test facility.

8. Hazards

8.1 Storage, handling, and detonation of high explosive material or the operation of a shock tube should be conducted in accordance with applicable state and federal statutes by experienced professionals qualified by a U.S. government agency to handle explosives.

9. Sampling, Test Specimens, and Test Units

9.1 Each test specimen shall be supplied as a complete door assembly. This includes a door panel(s), frame, hardware, and anchors to attach the frame to the test frame and structure wall.

9.2 For testing to meet Damage Category I, a minimum of one test specimen shall be supplied for each pressure and

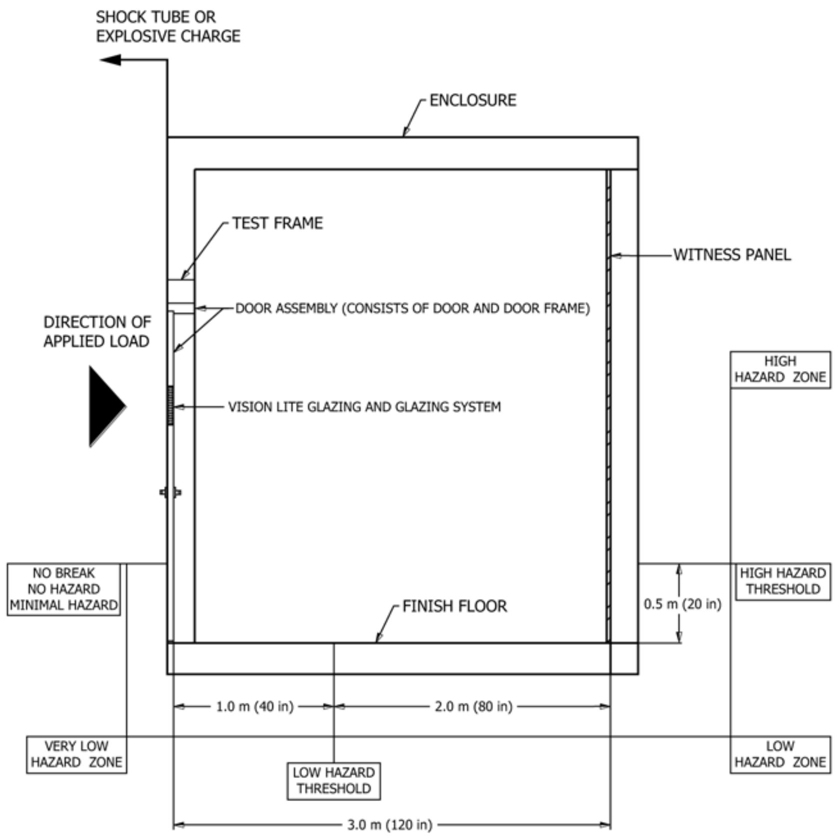

FIG. 1 Cross-Section Through Witness Area

impulse combination. For less predictable scenarios, a minimum of three test specimens shall be supplied for each pressure and impulse combination

9.3 The test director shall ensure that the test specimens are handled and stored according to the manufacturer's instructions.

10. Preparation of Test Specimens

10.1 *Door Construction*—The door shall adhere to the requirements for a blast resistant door, as defined in section 3.1.4. This test method is general and does not limit the door vendor/manufacturer to specific material(s), door construction(s) or fabrication process(es). Ultimately, the door's design is based upon the test load established by the specifier or vendor/manufacturer and proven through testing and/or structural analysis.

10.2 The size of the specimen shall be equal to or larger than the door assembly application being investigated.

10.3 Materials used for to internally stiffen the door panel such as; pre-manufactured cores, injected foams, individual stiffeners, etc. shall be designed by the specifier or the door vendor/manufacturer. If applicable, the voids between the stiffeners may be filled with insulation.

10.4 Since the structural strength and behavior of certain glazing materials under uniform loading of constant magnitude have been shown to be affected adversely by large variations in temperature beyond the recorded ambient, it is possible that large temperature variations might also affect adversely the behavior of such materials under blast loading and their ability to resist blast. It is permissible to shade the glazing material from direct heat prior to the test.

10.5 A typical door assembly shall be considered as a 3-sided, simply supported, one edge free loading condition for a seating load case. Typically, the bottom edge of the door is free (no structural threshold). If the door assembly does have a structural threshold, the door shall be considered as a 4-sided, simply supported loading condition for a seating load case. The door is supported by the restraining hardware (i.e., latchbolt(s) and hinges) during an unseating load case.

10.6 The door shall be attached to the frame with the same quantity and size of hinge fasteners the specifier or vendor/manufacturer intends to use in the actual door installation. The door frame shall be attached to the test fixture using the same quantity, size, and spacing of fasteners, anchors or welds that the specifier or vendor/manufacturer intends to use in the actual door installation.

10.7 The test director shall assign a test number to each test specimen and permanently mark each test specimen accordingly.

10.8 Each test specimen shall be measured and inspected, using nondestructive methods, in sufficient detail to ensure compliance with the vendor's/manufacturer's specifications. If possible, comparisons to detailed shop drawings shall be implemented, with the shop drawings referenced by the test report.

11. Preparation of Apparatus

11.1 *Instrumentation:*

11.1.1 For arena tests, three pressure transducers shall be installed on the test frame or on a transducer panel of the same size as the test frame and located and oriented in the same manner as the test frame. The pressure transducers shall be flush with the surface of the test frame or transducer panel, facing the detonation point. For test frames capable of supporting multiple specimens, the transducers shall be located on the horizontal centerline of the test specimens at a distance from the edge of the test specimens not to exceed one half the shortest dimension of the specimen. For test frames capable of holding only a single specimen, two transducers shall be located on the horizontal centerline of the specimen and one at the top of the vertical centerline of the specimen. The distance from the edge of the test specimen shall not exceed one half the shortest dimension of the specimen. For shock tube tests, all pressure transducers shall be mounted on the front surface of the test frame or bulkhead. A minimum of two pressure transducers shall be used and shall have one located on the horizontal centerline and one located on the vertical centerline of the test specimen. It must be verified that any mounted pressure transducer is indeed measuring the applied load on the test specimen.

11.1.2 For arena tests, at least one free-field pressure transducer shall be used in each test. The free-field pressure transducer shall be located at least 7.6 m (25 ft) from any frame at the same distance from the high explosive charge as is the frame.

11.1.3 The pressure transducers shall then be connected to the DAS and tested to verify proper operation.

11.1.4 Strain gauges shall be attached to predetermined points, if used.

11.2 *Test Frames:*

11.2.1 The test specimens shall be installed in the test frame. The face of the test frame with the test specimens installed shall be approximately a plane surface. No openings shall exist in this surface through which airblast pressure can infiltrate behind the test specimens. The area immediately behind the test specimens shall be enclosed to prevent airblast pressure from wrapping behind the test specimens.

11.2.2 The test frame shall be placed so that the test specimens are oriented perpendicular to a line from the detonation or air release point to the center of the test frame.

11.3 *Photography:*

11.3.1 Prior to the test, a photographic record that adequately portrays the door system, the test frame, and the test configuration shall be made. This photographic record shall consist of still photographs and may include motion pictures or video.

11.3.2 If a photographic record of the response of the door system during the test is desired, high speed motion picture cameras or high speed video cameras, or both, shall be set up.

11.4 *Witness Panels:*

11.4.1 Witness panels shall be put in place to record impact from door panel or frame, hardware components that dislodge from the door system, and pieces from the glazing and glazing system.

12. Procedure

12.1 The specified air blast loading shall be applied to the test specimen in a manner as selected by the operator or agency. The effects of blast load clearing, backside loading of the specimen, and other load reducing mechanisms shall be accounted for in the test. A calculated blast load is not acceptable as a reported test load. Only recorded loads may be used in the test reports. The peak pressure and positive phase impulse shall be equal to or greater than specified loading parameters, but typically not greater than 10 % of either desired value. Test pressures that exceed the specified loading parameters should not invalidate a successful test. Testing a product at a particular blast load qualifies the product against a lesser blast load.

12.2 Prior to testing, measurements shall be made from no less than nine (9) locations on the door panel to fixed points on the test frame. These measurements shall be compared with post-test measurements at the same locations. These measurements shall be used to calculate any permanent deformation in the door or door frame. Measurements shall be made to the nearest 2 mm (1⁄16 in.). For each measurement, the use of a straight edge spanning across the door is recommended. Measurements shall taken to the door panel adjacent to each frame jamb stop (2 measurements) and one (1) measurement at the midpoint of the door. This series of measurements shall be performed at three (3) height locations on the door. The recommended locations are measured from the finished floor at ¼ the door height, at the midspan of the door height, and at ¾ the door height. The specifier may also select additional measuring points.

12.3 Ambient temperature shall be measured no more than 30 minutes and, if applicable, the temperature of the glazing shall measured no more than 15 minutes prior to the test director clearing the area near the explosive charges or start of charging the shock tube. Remote temperature sensors may be used to record ambient and surface temperatures just prior to testing, if desired.

12.4 Measurement of the operational forces before and after the testing shall be made and recorded for comparison. Force measurements shall include the torque required for latch retraction, the force required to set the door into motion from a 90 degree open position, the force required to maintain door motion, and the force required to set the door into motion from a closed position. The measurements shall be made with force measuring devices with peak value storage and a minimum accuracy of 0.5 kg (1 lb).

13. Report

13.1 Upon completion of the testing, the test director shall assign a test number and record the test measurement and observations obtained from all test specimens. The test report shall include the following information:

13.1.1 Manufacturer's name and address.

13.1.2 Date of the test.

13.1.3 The number of specimens tested.

13.1.4 Thickness, width, and height of the door(s).

13.1.5 Width and height of the door frame.

13.1.6 Thickness of the door skin(s) or facesheet(s).

13.1.7 Description of the internal construction used to stiffen the door panel.

13.1.8 Description of the glazing system, including pertinent dimensions, location on the door panel, construction, glazing materials, fastening materials, and installed location of the specimen relative to the witness panel.

13.1.9 Dimensions of the door frame jamb, including rabbet depth and stop height, and anchorage to test frame description and anchor locations.

13.1.10 Clearances between the door and frame and the door's undercut.

13.1.11 Number and size of hinges.

13.1.12 Number and type of latchbolt points.

13.1.13 Depth of sill stop, if necessary.

13.1.14 Nine (9) dimensions of the door panel after door testing per section 12.2.

13.1.15 Operational forces. Record pretest and, if applicable, post test.

13.1.16 Ambient temperature, and if applicable the surface temperature of the glazing.

13.1.17 Peak positive pressure measured in graphical form from each reflected airblast pressure transducer on the frames supporting the test specimen.

13.1.18 Positive phase duration measured in graphical form from each reflected airblast pressure transducer on the frames supporting the test specimen.

13.1.19 Positive phase impulse in graphical form.

13.1.20 The recorded airblast history from each pressure transducer in graphical form.

13.1.21 Condition of the test specimen immediately following the test. If determination is possible, the test report shall include a description of the failure mechanism (e.g., latch failure in rebound due to deflection of the frame jamb, latchbolt shear, tear out of the strike plate, failure of frame anchors in shear, tension, or pullout, failure of frame connections, door panel push-through the frame opening, etc.).

13.1.22 Damage to the witness panel as determined by detailed examination and post-test photographs.

13.1.23 Photographic records and, if applicable, motion picture records.

13.1.24 The test director shall classify the door with a Door Response Damage Category and, if applicable, a Glazing System Hazard Rating for the vision lite.

13.2 The test director shall sign the report. The original copy of the test report shall be furnished to the sponsor of the test. The test director shall keep a copy of the report on file.

14. Precision and Bias

14.1 *Precision and Bias*—No statement is made concerning either the precision or bias of this test method, since the result merely states whether the door assembly and, if applicable, an integral vision lite can resist a given air blast loading and meet the requirements of a specified damage category response or hazard rating.

15. Keywords

15.1 airblast rating; blast capacity; blast door assembly; door response damage categories; effective positive; glazing; glazing hazard levels; glazing system; phase duration; peak positive pressure; positive phase impulse; reflected airblast pressure damage; vision lite

ANNEX

(Mandatory Information)

A1. DETERMINATION OF STANDOFF DISTANCE FOR A SELECTED REFLECTED AIRBLAST PRESSURE, WEIGHT, AND TYPE OF EXPLOSIVE FOR AN ARENA TEST

A1.1 Project a horizontal line across Fig. A1.1 from the values on vertical axes that correspond to the desired peak positive pressure, *P*, in kPa.

A1.2 From the intersection of the horizontal line with the curve labeled *P*, project a vertical line to the horizontal axes.

A1.3 The values on the horizontal axes denote the required scaled range, *Z*, in m/(kg TNT)$^{1/3}$ [ft/lb$_m$TNT$^{1/3}$].

A1.4 From the intersection point of the vertical line with the curve labeled *i*' (SI units), project a horizontal line to the left vertical axis and read the value of the scaled positive phase impulse, *i*', in kPa-ms (kg TNT)$^{1/3}$. [From the intersection point of the vertical line with the curve labeled *i*' (US units), project a line to the right vertical axis and read the value of the scaled positive phase impulse in psi-ms (lb$_m$ TNT$^{1/3}$).]

A1.5 Use Eq A1.1 to determine the positive phase impulse, *i*, in kPa-ms (psi-ms) for the charge mass, *M*, of TNT in kg (lb$_m$):

$$i = (i')M^{\left(\frac{1}{3}\right)} \quad (A1.1)$$

A1.6 Use Eq A1.2 to determine the standoff distance, *R*, in m (ft):

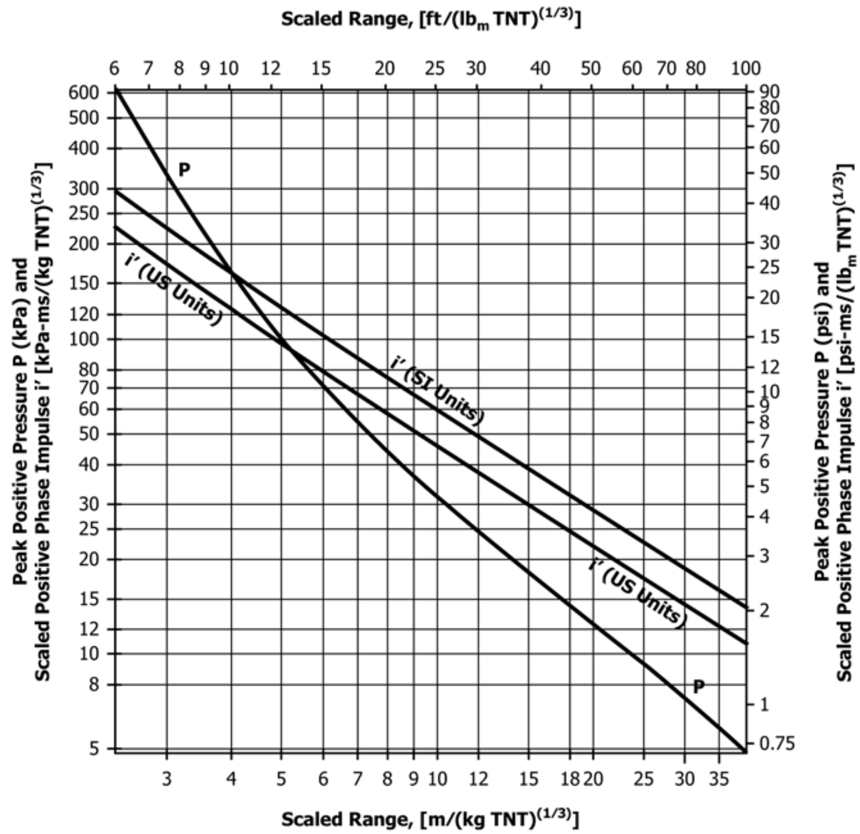

FIG. A1.1 Reflected Airblast Parameters (Hemispherical Surface Detonation)

$$R = ZM^{\left(\frac{1}{3}\right)} \tag{A1.2}$$

A1.7 When using a high explosive other than TNT, Eq A1.3 gives the required mass of explosive, M', in kg (lbm):

$$M' = \frac{M}{k} \tag{A1.3}$$

where:

K = equivalence factor found in Table A1.1. (Tabulated as k_p and k_i, equivalence factors for pressure and impulse respectively. Either equivalence factor can be used, or the test director can average them at the test director's discretion.)

A1.8 The equivalent weight of an explosive based on blast pressure or impulse varies at different pressure levels. Generally an average value for equivalency provides adequate results.

A1.9 At elevations greater than 900 m (3000 ft) above sea level, adjust airblast pressure calculations to account for altitude.

A1.10 Sample Calculation—The desired peak positive airblast pressure is 69 kPa (10 psi). The test site is limited to a maximum charge size of 12 kg (26 lb) TNT. Determine the standoff distance required and the expected positive phase impulse. Fig. A1.2 illustrates the process.

TABLE A1.1 Equivalence Factors for High Explosives[A]

Explosive	k_p	k_i	Pressure Range, psi
ANFO (94/6 Am Ni/ Fuel Oil)	0.82		0–690 (0–100)
Composition A-3	1.09	1.07	35–345 (5–50)
Composition B	1.11	0.98	35–340 (5–50)
Composition C-4	1.37	1.19	69–700 (10–100)
Cyclotol 70/30 (RDX/TNT)	1.14	1.09	35–340 (5–50)
HBX-1	1.17	1.16	35–140 (5–20)
HBX-3	1.14	0.97	35–170 (5–25)
H6	1.38	1.1	35–700 (5–100)
Minol II 70/30 (HMX/TNT)	1.2	1.11	20–140 (3–20)
Octol 75/25 (HMX/TNT)	1.06		
PETN	1.27		35–700 (5–100)
Pentolite	1.42	1.00	35–700 (5–100)
	1.38	1.14	35–4200 (5–600)
TNETB	1.36	1.1	35–700 (5–100)
TNT	1	1	standard for pressure ranges shown
Tritonal	1.07	0.96	35–700 (5–100)

[A] Any explosive certified by the Department of Transportation (including explosive number and classification) may be used in this test method. For highly repeatable pressure histories, the following explosives are recommended: Composition C-4, Composition B, Cyclotol 70/30 (RDX/TNT), and TNT.

A1.10.1 *Step 1*—Project a horizontal line across the chart in Fig. A1.2 corresponding to 69 kPa (10 psi) along the vertical axes.

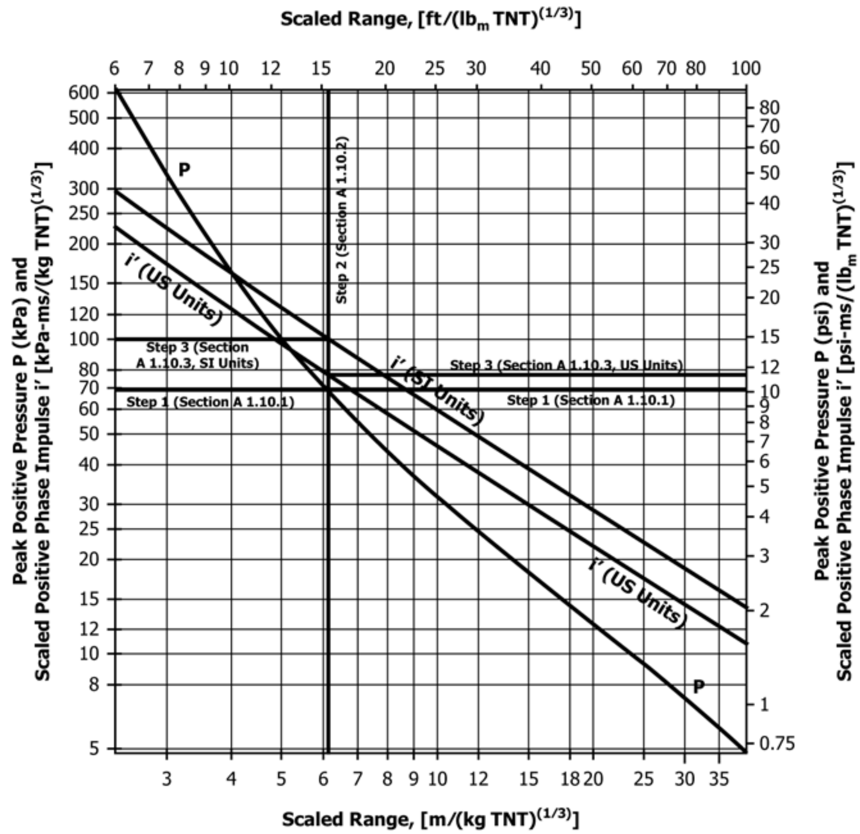

FIG. A1.2 Example Use of Reflected Airblast Parameters (Hemispherical Surface Detonation) Chart

A1.10.2 *Step 2*—Project a vertical line from the intersection of the horizontal line in Step 1 with the curve labeled *P* to the horizontal axes. Read the scaled range, *Z*, from the horizontal axes:

$$Z = 6.12 \frac{m}{(kg \quad TNT)^{\left(\frac{1}{3}\right)}} \left[15.4 \frac{ft}{(lb_m \quad TNT)^{\left(\frac{1}{3}\right)}} \right] \quad (A1.4)$$

A1.10.3 For SI units, project a horizontal line to the left vertical axis from the intersection point between the vertical line and the curve labeled *i*' (SI units). From the left vertical axis read the following scaled impulse:

$$i' = 100 \frac{kPa - ms}{(kg \quad TNT)^{\left(\frac{1}{3}\right)}} \quad (A1.5)$$

For US units, project a horizontal line to the right vertical axis from the intersection point between the vertical line and the line labeled *i*' (US units). From the right vertical axis, read the following scaled impulse:

$$i' = 11.2 \frac{psi - ms}{(lb_m)^{\left(\frac{1}{3}\right)}} \quad (A1.6)$$

A1.10.4 Calculate the required standoff distance as follows:

$$R = \left(6.12 \frac{m}{(kg \quad TNT)^{\left(\frac{1}{3}\right)}} \right) \times (12 \quad kg \quad TNT)^{\left(\frac{1}{3}\right)}$$
$$= 14.0\, m \left[\left(15.4 \frac{ft}{(lb_m \quad TNT)^{\left(\frac{1}{3}\right)}} \right) \times (26\, lb_m \quad TNT)^{\left(\frac{1}{3}\right)} \right]$$
$$= 45.5\, ft \quad (A1.7)$$

A1.10.5 Calculate the expected positive phase impulse as follows:

$$i = \left(100 \frac{kPa - ms}{(kg \quad TNT)^{\left(\frac{1}{3}\right)}} \right) \times (12 \quad kg \quad TNT)^{\left(\frac{1}{3}\right)} = 230\, kPa$$
$$- ms \left[\left(11.2 \frac{psi - ms}{(lb_m \quad TNT)^{\left(\frac{1}{3}\right)}} \right) \times (26\, lb_m \quad TNT)^{\left(\frac{1}{3}\right)} \right]$$
$$= 33.2\, psi - ms \quad (A1.8)$$

A1.10.6 To use Composition C-4 in place of TNT, find the required charge mass by computing the average *k* value as follows:

$$(1.37 + 1.19)/2 = 1.28 \quad (A1.9)$$

A1.10.7 The required mass of Composition C-4 is as follows:

$$M' = \frac{12\, kg}{1.28} = 9.37\, kg\ (20.7 \quad lb_m) \quad (A1.10)$$

APPENDIX

(Nonmandatory Information)

X1. STATISTICAL CONSIDERATIONS

X1.1 The use of this test method does not provide absolute assurance that a door system will resist a specific blast. For the following, assume that three specimens are tested and all pass. Based on the assumption that failure of a specimen is a binomial random variable, the following statements can be made:

X1.1.1 With 95 % confidence, the probability that one specimen will survive a blast similar to that used to test it is 36.8 %.

X1.1.2 With 90 % confidence, the probability that one specimen will survive a blast similar to that used to test it is 46.4 %.

X1.1.3 With 50 % confidence, the probability that one specimen will survive a blast similar to that used to test it is 79.4 %.

X1.2 As more specimens than three are tested, the probability of survival increases at a given confidence level.

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