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## Standard Test Method for Metal Doors Used in Blast Resistant Applications (Equivalent Static Load Method)<sup>1</sup>

This standard is issued under the fixed designation F2247; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 This test method covers the structural performance of metal doors and frames and their restraining hardware (such as latches and hinges) used as a blast resistant barrier. This method involves applying an equivalent static pressure based on the characteristics of the specified blast pressure and structural properties of the door panel design.

1.2 The static tests are valid for the unit size tested or for smaller units of analogous construction. Extrapolation of test results for units larger than the test specimen are not permitted.

1.3 This standard test method is not applicable to tests where the forces are created by explosive charges, forced air from a shock tube apparatus, or any other method used to generate a dynamic load.

1.4 The proper use of this method requires knowledge of the principles of pressure, deflection, and when applicable, strain gauge measurement.

1.5 Using this method, specimens may be tested to determine ultimate static capacity or tested to specific static test loads.

1.5.1 *Procedure A* shall be used when a load-deflection curve is not required and a single load is applied.

1.5.2 *Procedure B* shall be used when a load-deflection curve is required and a single or multiple loads are applied.

1.6 The values stated in SI units are to be regarded as the standard. The values provided in parenthesis are for information only.

1.7 *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*:<sup>2</sup>

E330 Test Method for Structural Performance of Exterior Windows, Doors, Skylights and Curtain Walls by Uniform Static Air Pressure Difference

2.2 *Other Standard*:

~~TM5-1300 Structures to Resist Effects of Accidental Explosions, Volume V, Structural Steel Design, Special Publication No. ARLCD-SP-840001~~ UFC 3-340-02 Unified Facilities Criteria (UFC), Structures to Resist the Effects of Accidental Explosions<sup>3</sup>

### 3. Terminology

3.1 *Definitions*:

3.1.1 *metal door*—a term used in reference to doors which are built from steel sheets, internally stiffened with cold-formed shapes or structural steel shapes. Materials can be carbon or stainless steel. The materials may be joined together by any fabrication technique (that is, welding, bolting, structural adhesive, etc.). The material voids may be filled with insulation.

3.1.2 *permanent deformation*—the permanent displacement from an original position that remains after an applied load has been removed. Measured in millimetres (mm) (inches (in.)).

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

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> Available from U.S. Army Armament Research Development and Engineering Center, Dover, NJ.

<sup>3</sup> Available from National Institute of Building Sciences, 1090 Vermont Avenue, NW, Suite 700, Washington, DC 20005, <http://www.wbdg.org/index.php>.

3.1.4 *seating pressure*—an applied pressure that causes the door panel to seat against the frame that is expressed in pascals (Pa) (pounds-force per square foot (psf) or pounds-force per square inch (psi)).

3.1.5 *specifier*—individual or party requesting that a metal door assembly meet specific blast resistance criteria.

3.1.6 *specimen*—the entire assembly unit submitted for test as described in Section 6.

3.1.7 *steady state pressure*—a test pressure held for a minimum of 3 min.

3.1.8 *test director*—the individual identified as being responsible to complete the specified tests as required and to document the results.

3.1.9 *test load*—the specified static pressure differential (positive or negative) for which the specimen is to be tested, expressed in pascals (Pa) (pounds-force per square foot (psf) or pounds-force per square inch (psi)).

3.1.10 *ultimate load*—the pressure (positive or negative) at which failure of the specimen occurs expressed in Pa (psf or psi).

3.1.11 *unseating pressure*—an applied pressure that tends the door panel to unseat from the frame so that the door reactions must be resisted by the restraining hardware, that is expressed in pascals (Pa) (pounds-force per square foot (psf) or pounds-force per square inch (psi)).

#### 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 the chamber at a ratio required to maintain the test pressure difference across the specimen, and observing, measuring, and recording the deflection, deformations, stresses (if recorded), and nature of any failures of principal or critical members or the entire specimen.

#### 5. Significance and Use

5.1 Blast resistant doors are designed to protect against the problems and dangers created by a planned or accidental explosion or pressure leak. This test method will provide reasonable assurance to the specifier of the reliability of a door's structure, the restraining hardware, the frame, and the frame anchors when used in a blast resistant application.

#### 6. Specimen Preparation

6.1 *Construction*—The door panel shall meet the general definition of a metal door as outlined in 3.1.1. The test method is general and does not limit the door manufacturer to a specific door panel construction or fabrication process. Ultimately, the design of the door panel is based upon the target pressure rating established by the specifier or door manufacturer.

6.1.1 The size of the specimen (door panel and frame) shall be representative or larger than the application under investigation.

6.1.2 Configuration and spacing of the door panel's internal stiffeners will be as designed by the specifier or the door manufacturer. Space between stiffeners may be filled with insulation.

6.1.3 The typical door panel shall be considered as a three side supported, one edge free loading condition for a seating load case. Generally, the bottom edge of the door panel is free (no structural threshold). If the door assembly does have a structural threshold, the door panel may be considered as a four side supported condition for a seating load case. The door panel is supported by the restraining hardware during the unseating load case. The door panel will be attached to the frame with the same quantity and size of hinge fasteners that the specifier or the door manufacturer intends to use in the actual door installation. The door frame will be attached to the test fixture using the same quantity, size, and spacing of fasteners or anchors that the specifier or door manufacturer intends to use in the actual door installation.

#### 7. Apparatus

7.1 Equipment capable of performing the test procedure described in this standard within the allowable tolerances is acceptable. Figures 1 through 4 are examples of apparatus layout.

##### 7.2 Major Components:

7.2.1 *Test Chamber*—A chamber or box with an opening and a removable mounting panel, into which the specimen is installed. At least one pressure tap shall be provided to measure the chamber pressure and shall be so located that the reading is unaffected by the velocity of the fluid supply to or from the chamber or any other fluid movement. A means of access is permitted to be provided to facilitate adjustments and observations after the specimen is installed. The test chamber must not deflect under the test load in such a manner that the performance of the specimen will be affected.

7.2.2 *Air System*—A controllable blower or a compressed air supply, designed to provide the required air-pressure difference across the specimen. The system shall provide a constant air pressure difference for the duration of the test.

7.2.3 *Combined Air/Water System*—A combined air and water (fluid) system (See Fig. 1).

7.2.4 *Pressure-Measuring Apparatus*—A device to measure the test pressure difference with accuracy of  $\pm 2\%$  of the reading over the full range of test pressures.

7.2.5 *Deflection-Measuring System*—A means of measuring deflections with an accuracy of  $\pm 0.25$  mm ( $\pm 0.01$  in.).

7.2.5.1 *For Procedure A* (see 10.2), any locations at which deflections are to be measured shall be stated by the Specifier or the Test Director. See Figs. 2 and 3 for suggested locations.

7.2.5.2 *For Procedure B* (see 10.3), any locations at which deflections are to be measured shall be stated by the Specifier or the Test Director. See Figs. 2 and 3 for suggested locations.

7.2.5.3 Deflection measurements shall be independent of movements of, or movements within, the specimen or member supports.

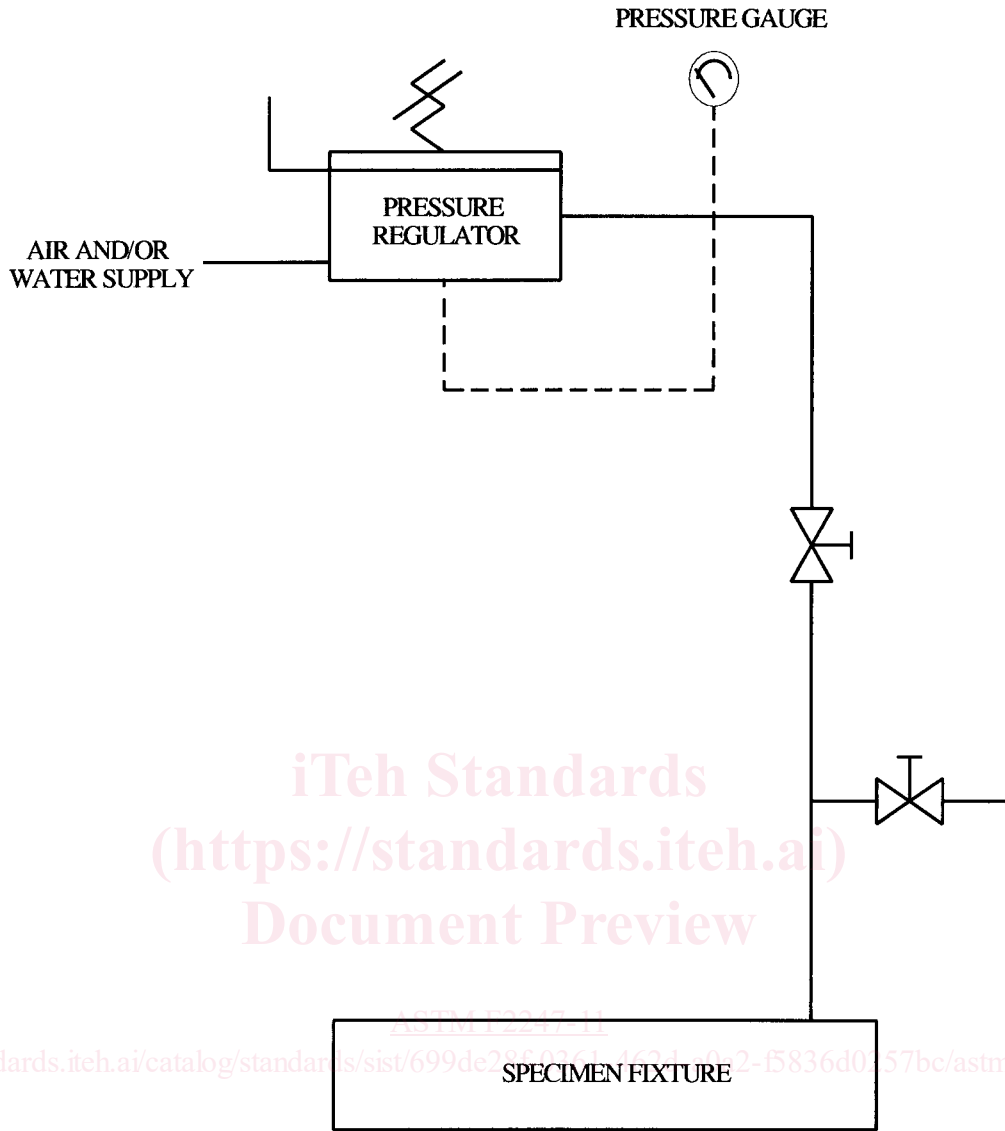


FIG. 1 Schematic of Test Arrangement

7.2.6 If desired, strain gauges to measure strain shall be mounted on the side of the door panel in tension. Strain gauges are attached to the tension side of the door panel. They are to be mounted in accordance with the strain gauge manufacturer's instructions.

7.2.6.1 The location of the gauges are to be determined by the specifier or the door manufacturer and they shall be placed where the greatest changes in strain are anticipated, typically at the points of greatest flexure. See Figs. 2 and 3 for suggested locations.

**8. Hazards**

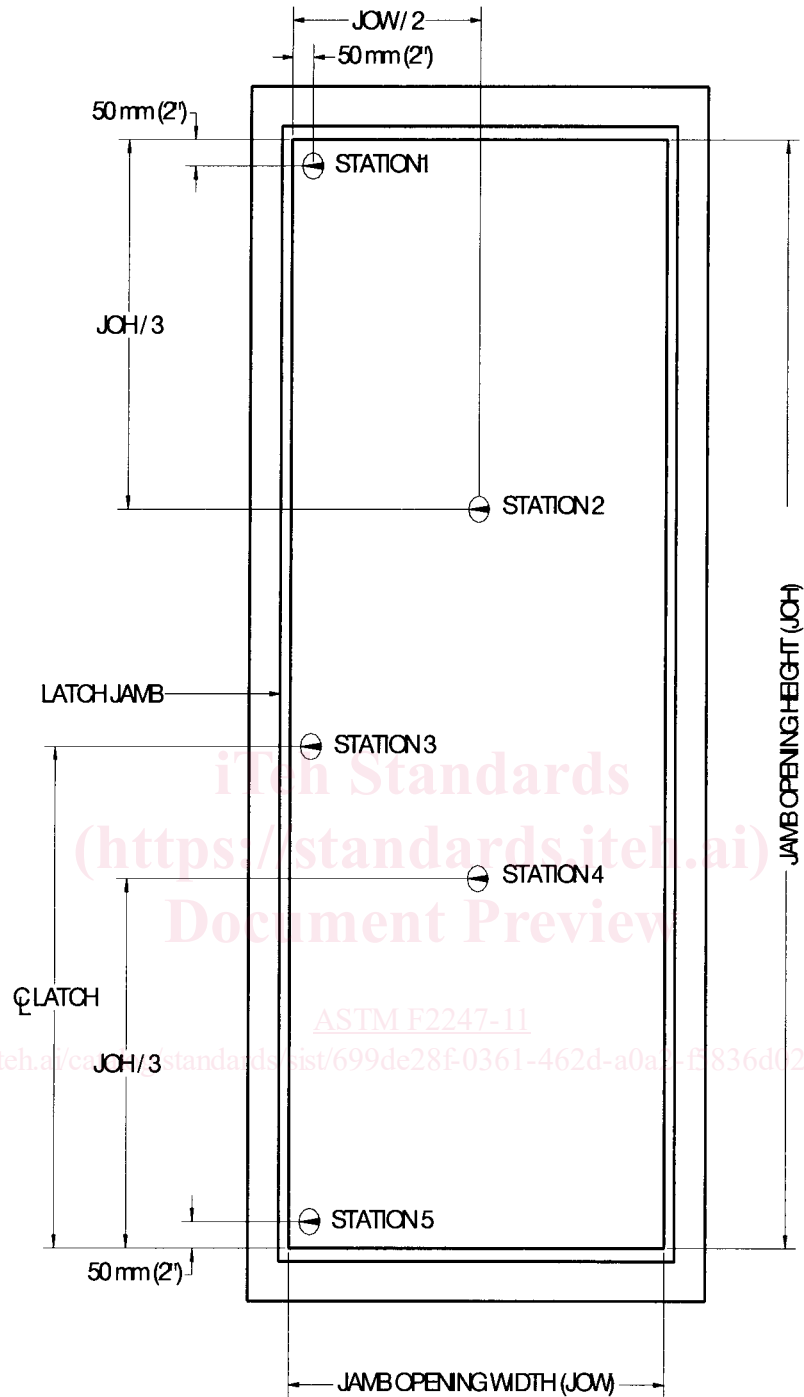
8.1 Proper care must be taken for the possibility of a failure. The system used in this test method contains considerable stored energy and constitutes a hazard. The testing apparatus shall be equipped with a method to restrain the specimen in the event of failure. The restraint method shall not interfere with the test nor the results of the test.

**9. Calibration**

9.1 *Pressure Gage*, deflection-measuring devices, and strain gauges shall be calibrated prior to testing to make certain the devices are within specifications and requirements (see 7.2.4 and 7.2.5). Calibration of test equipment shall be in accordance with the manufacturer's recommendations and to a national recognized standard.

**10. Required Information**

- 10.1 The following information shall be supplied by the specifier:
- 10.2 *Procedure A—Single Loading with no Deflection Curve:*



⊙ DEFLECTION DIAL / STRAIN GAUGE INDICATOR LOCATION

FIG. 2 Test Fixture Elevation—Unseating Load Case

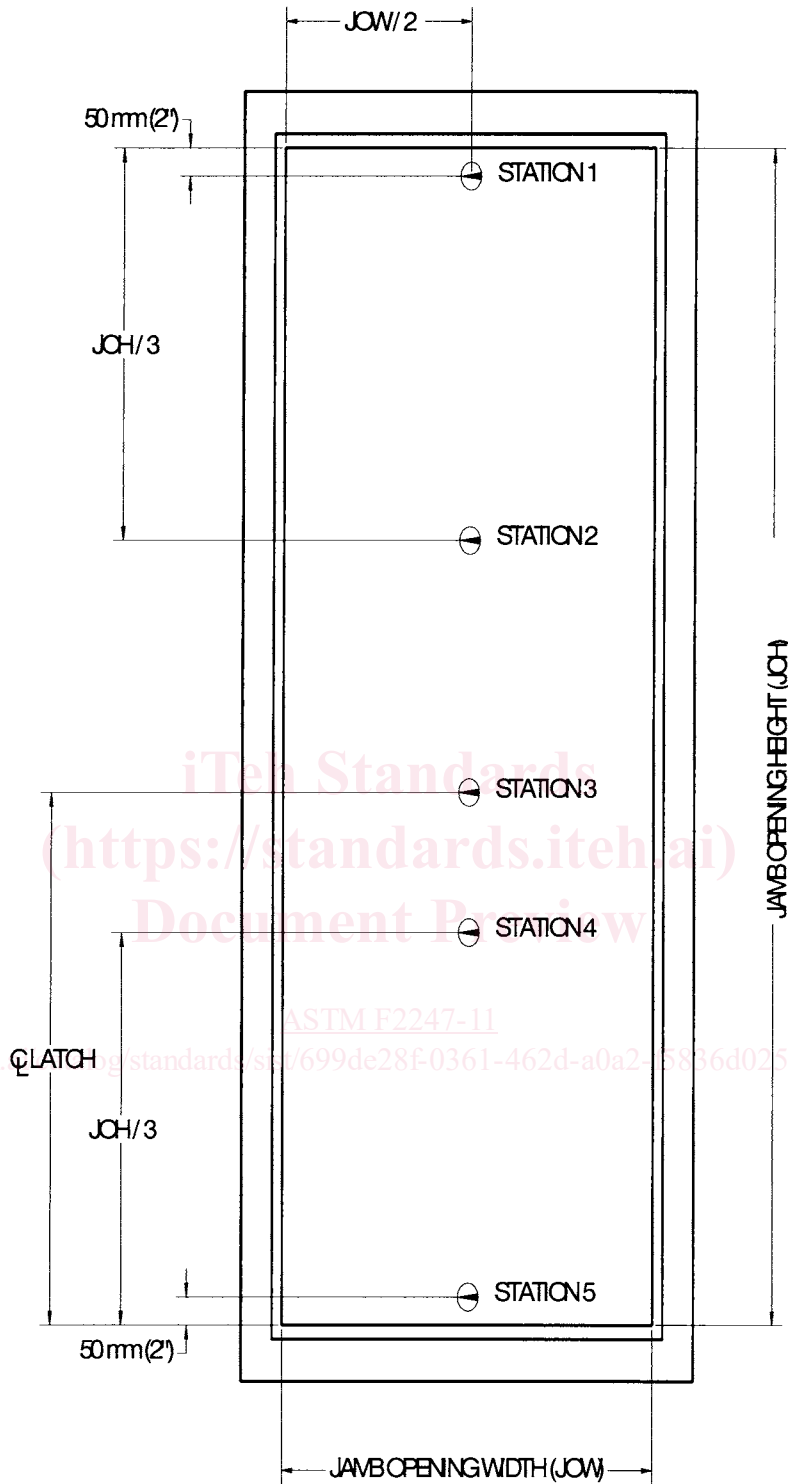
10.2.1 Performance criteria and the number and gage location.

10.2.2 The blast duration defined as the time interval between time of arrival of the blast wave at a given location and the time for the magnitude of the pressure to return to ambient pressure. See Annex A1 for example of converting a dynamic pressure into an equivalent static load.

10.2.3 The permitted damage level category in accordance with Section 11.

10.2.4 The number and location of deflection and, if applicable, strain gages.

10.3 Procedure B—Single or Multiple Loading with Deflection Curve:



⊖ DEFLECTION DIAL / STRAIN GAUGE INDICATOR LOCATION

FIG. 3 Test Fixture Elevation—Seating Load Case

10.3.1 Same as 10.2.1-10.2.4, additionally:

10.3.2 The number of load cycles at which deflection and stress-strain measurements are required.

10.3.3 The number and location of required deflection and strain gages (if desired).

## 11. Acceptance Criteria

11.1 Acceptance of the door is based on the end use of the door. The door is classified into one of four damage level categories. The criterion and acceptance for each category is:

11.1.1 *Category I*—The specimen is unchanged (no permanent deformation) after the loading incident and the door is fully operable. The specimen remains intact and responds elastically.

11.1.1.1 *Acceptance:*

(1) After the specimen has been unloaded, verify that the deflection gages have returned to zero reading with a tolerance of +2 mm ( $\frac{3}{64}$  in.).

(2) Verify that the door is operable by unlatching the door and swinging the panel.

(3) If strain gages are used, check that the recorded stresses are within acceptable limits of door material.

(4) Verify that the door can be latched.

(5) Verify that the external portions of the latch and hinges have not suffered any permanent set.

11.1.2 *Category II*—The door is operable but measurable; permanent deformation to the door panel exceeding the tolerance listed in 11.1.1.1 has been experienced. The specimen remains as an integral system.

11.1.2.1 *Acceptance:*

(1) After the specimen has been unloaded, verify that the measurable deformation is acceptable to the end use of the door.

(2) Verify that the specimen remains an integral system.

(3) If strain gages are used, check that the recorded stresses are within acceptable limits of door material.

(4) Verify that the door is operable by unlatching the door and swinging the panel.

11.1.3 *Category III*—Non-catastrophic failure. No structural failure occurs to the specimen that prevents the specimen from providing a barrier to blast wave propagation. However, the specimen is permanently deformed and the door panel is inoperable.

11.1.3.1 *Acceptance:*

(1) After the specimen has been unloaded, verify that the measurable deformation is acceptable to the end use of the door.

(2) Verify that the specimen remains an integral system.

11.1.4 *Category IV*—The door panel is severely deformed. For a seating load test, the deformation of the door panel must be limited to a level that does not cause the door panel to be forced through the door frame opening. For an unseating load test, the latching mechanism is permitted to fail, allowing the door to swing open; however, the door panel shall remain supported by the hinges and it is evident that the door panel will not become a flying debris hazard.

11.1.4.1 *Acceptance:*

(1) After the specimen has been unloaded, verify that the measurable deformation is acceptable to the end use of the door.

(2) Verify that the specimen remains an integral system and there has been no flying debris hazards.

11.2 The frame anchorage connections shall not fail in shear or tension. Limited permanent deformation in the anchors is permitted for Categories II, III, and IV.

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

## 12. Procedure

12.1 The door shall be installed in the test fixture as shown in Figs. 4 and 5 for an unseating load case and as shown in Figs. 6 and 7 for a seating load case. The test fixture shall be positioned vertically with the specimen hung in the operational mode.

12.2 The entire specimen is to be covered with a flexible, tear-resistant membrane. For example, a 3 mm ( $\frac{1}{8}$  in.) thick sheet of solid neoprene or polyethylene. Refer to Figs. 4-7. The membrane shall allow uninhibited load transfer to the specimen. The membrane shall not prevent movement or failure of the specimen. The membrane is to be applied loosely with extra folds of material at each corner and at all offsets and recesses. When the load is applied, there shall be no fillet caused by tightness of membrane. Sponge rubber pads are permitted to be placed over any protrusions that may puncture the membrane. Tape shall not be used when it can restrict differential movement between adjoining members.

12.3 *Procedure A*—Use Procedure A when a load-deflection curve is not required:

12.3.1 Check the specimen for proper adjustments and clearances in the closed position and close all latches,

12.3.2 Install any required deflection and if applicable, strain measuring devices at their suggested locations (see Figs. 2 and 3),

12.3.3 Apply half the full test load and maintain this load at a steady state until the pertinent test data are recorded (not less than 3 min),

12.3.4 Apply the full test load and maintain this load at a steady state until the pertinent test data are recorded (not less than 3 min),

12.3.5 Reduce the pressure difference to zero, and after a recovery period of not less than 3 min, take readings to determine any permanent deformation,

12.3.6 Determine the damage category of the door according to Section 11 criteria,