Designation: F2248 – 12

Standard Practice for Specifying an Equivalent 3-Second Duration Design Loading for Blast Resistant Glazing Fabricated with Laminated Glass[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. This standard practice provides a means for designers to determine equivalent 3-second duration design loadings with which they can size blast resistant glazing comprised of laminated glass or insulating glass fabricated with laminated glass, or both. Blast resistant glazing systems of this genre can reduce the number and size of glass fragments in an explosion as well as reducing greatly or eliminating blast pressure that enters buildings when an explosion occurs.

1. Scope

1.1 This practice sets forth a method to specify an equivalent 3-second design loading suitable to use with Practice E1300 to select the thickness and type of blast resistant glazing fabricated with laminated glass to glaze a fenestration. Glass plies used to construct laminated glass are recommended to be either annealed or heat strengthened glass.

1.2 This practice applies to blast resistant glazing fabricated using laminated glass only, including single laminated glass and insulating glass fabricated with laminated glass. As a minimum, insulating glass shall use laminated glass for the inboard (protected side) lite.

1.3 This practice assumes that blast resistant glazing shall be adhered to its supporting frame using structural silicone sealant or adhesive glazing tape. The width of the structural silicone sealant bead shall be at least equal to the larger of 10-mm (⅜-in.) or the thickness designation of the glass to which it adheres but not larger than two times the thickness designation of the glass to which it adheres. The minimum thickness of the structural silicone bead shall be 5-mm (3⁄16-in.). The width of glazing tape shall be at least equal to two times but not more than four times the thickness designation of the glass to which it adheres. The width of silicone or glazing tape is referred to as bite and is shown and discussed in Guide C1564.

1.4 This practice assumes that the structural silicone bead or glazing tape is applied to both sides of single lite laminated glass but need only be applied to the inboard side (protected side) of insulating glass.

1.5 This practice assumes the framing members shall restrict deflections of edges of blast resistant glazing they support to $L/60$ under 2.0× the load resistance of the blast resistant glazing for inward loading, where L denotes the length of the supported edge.

1.6 This practice assumes the framing system supporting the blast resistant glazing shall attach mechanically to the structural framing system. The system shall be designed to ensure that the glazing fails prior to the framing system that supports the glazing and its attachment to the structural framing system. The fasteners that attach the framing system that supports the glazing to the structural framing system shall be designed to resist a uniform load acting on the blast resistant glazing that has a magnitude of at least:

1.6.1 Two (2.0) times the magnitude of the load resistance of the blast resistant glazing if the maximum air blast pressure is greater than one half the magnitude of the load resistance of the blast resistant glazing, or

1.6.2 One (1.0) times the magnitude of the load resistance of the blast resistant glazing if the maximum air blast pressure is less than one half the magnitude of the load resistance of the blast resistant glazing.

[1] This practice 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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1.7 Blast resistant glazing designed using this practice recommends the use of annealed or heat strengthened glass plies for the laminated glass. Blast testing has shown that use of fully tempered glass plies, when fractured during a blast event, have poorer post blast performance than annealled or heat strengthened glass plies. Laminated glass fabricated with fully tempered glass plies has a tendency to leave the supporting glazing system frame after fracture whereas laminated glass fabricated with annealed or heat strengthened glass plies will remain in the frame and absorb remaining load through tensile membrane behavior. Use of the annealed or heat strengthened glass plies will also reduce the amount of load transferred into the structure.

1.8 The equivalent 3-second design load as determined herein shall not apply to the design of monolithic glazing, plastic glazing, or security film applied to existing glazing configurations in an attempt to achieve blast resistance.

1.9 The values stated in SI units are to be regarded as the standard. Values given in parentheses are for information only. For conversion of quantities in various systems of measurements to SI units refer to ANSI IEEE/SI 10.

1.10 *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]

C1036 Specification for Flat Glass

C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass

C1172 Specification for Laminated Architectural Flat Glass

C1422 Specification for Chemically Strengthened Flat Glass

C1564 Guide for Use of Silicone Sealants for Protective Glazing Systems

E631 Terminology of Building Constructions

E1300 Practice for Determining Load Resistance of Glass in Buildings

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

2.2 *ANSI Standard:*[3]

IEEE/SI 10 Use of the International System of Units (SI): (The Modernized Metric System)[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *blast resistant glazing, n*—glazing that provides protection against air blast pressure generated by explosions.

3.1.2 *design load, n*—magnitude in kPa (psf) of 3-second duration uniformly distributed lateral pressure.

3.1.3 *equivalent TNT charge mass, n*—mass of TNT placed on the ground in a hemisphere that represents the design explosive threat.

NOTE 1—If a different high explosive material comprises the design threat, tables exist to convert its mass to an equivalent TNT mass. Refer to Test Method F1642, for example.

3.1.4 *glass breakage, n*—the fracture of any lite or ply in monolithic, laminated, or insulating glass.

3.1.5 *glass types:*

3.1.5.1 *annealed (AN) glass, n*—a flat, monolithic, glass lite of uniform thickness where the residual surface stresses are nearly zero as defined in Specification C1036.

3.1.5.2 *chemically strengthened glass, n*—glass that has been strengthened by ion-exchange to produce a compressive stress at the treated surface as defined in Specification C1422.

3.1.5.3 *fully tempered (FT) glass, n*—a flat, monolithic, glass plate of uniform thickness made from annealed glass subjected to a special heat treatment process whereby the residual surface compression is not less than 69 MPa (10 000 psi) or the edge compression not less than 67 MPa (9700 psi) as defined in Specification C1048.

3.1.5.4 *heat strengthened (HS) glass, n*—a flat, monolithic, glass lite of uniform thickness that has been subjected to a special process where the residual surface compression is not less than 24 MPa (3500 psi) or greater than 52 MPa (7500 psi) as defined in Specification C1048.

3.1.5.5 *insulating glass (IG), n*—consists of any combination of two glass lites that enclose a sealed space filled with air or other gas.

3.1.5.6 *laminated glass, n*—a flat lite of uniform thickness consisting of two monolithic glass plies bonded together with an interlayer material as defined in Specification C1172.

3.1.5.7 *Discussion*—Many different interlayer materials are used in laminated glass. The information in this practice applies only to laminated glass fabricated with polyvinyl butyral (PVB) interlayers.

3.1.6 *glazing, n*—transparent, translucent, or opaque laminated glass used for windows, doors, or other panels.

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

3.1.8 *lateral, adj*—perpendicular to the glass surface.

3.1.9 *load, n*—a uniformly distributed lateral pressure.

3.1.10 *load resistance, n*—the 3-second duration uniform lateral load that a glass construction can sustain associated with a probability of breakage of 8 L per 1000 as determined from Practice E1300.

3.1.11 *maximum air blast pressure, n*—the peak reflected positive pressure that the blast resistant glazing will experience.

3.1.12 *probability of breakage (P_b) , n*—the fraction of glass lites or plies that would break at the first occurrence of a specified design load, typically expressed in lites per 1000.

[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.

3.1.13 *standoff distance, n*—the distance from the glazing surface to the centroid of a hemispherical high explosive charge.

4. Summary of Practice

4.1 This practice facilitates the determination of a 3-second duration design load associated with a specified weight of a hemispherical TNT charge located at a specified standoff distance from a building fenestration.

4.2 The design load shall be used in conjunction with Practice E1300 to select the thickness(es) and glass type(s) for blast resistant glazing comprised of a single lite of laminated glass or insulating glass fabricated with laminated glass.

5. Significance and Use

5.1 This practice provides a design load suitable for sizing blast resistant glazing comprised of laminated glass or insulating glass fabricated with laminated glass.

5.2 Blast resistant glazing comprised of laminated glass or insulating glass fabricated with laminated glass shall be sized to resist the 3-second duration equivalent design loading from this standard practice using the procedures described in Practice E1300.

5.3 Blast resistant glazing comprised of laminated glass or insulating glass fabricated with laminated glass sized using the 3-second design loading determined from this practice will fracture safely in the event of a blast, thus reducing the potential for personal injury, structural and non-structural building damage, and cleanup costs should an explosion occur.

5.4 In the event a blast loading never occurs to blast resistant glazing comprised of laminated glass or insulating glass fabricated with laminated glass sized using the 3-second duration loading determined herein, the blast resistant glazing will have a probability of breakage less than or equal to 8 lites per 1000 at the first occurrence of a loading equal to the 3-second duration design loading determined herein.

5.5 Blast resistant glazing designed to resist the 3-second equivalent load as determined herein, properly supported, will perform to minimal hazard as defined in Test Method F1642.

6. Determination of Equivalent 3-Second Duration Design Loading

6.1 The chart in Fig. 1 relates the mass of an equivalent hemispherical TNT charge (sloping lines), its standoff distance from a fenestration (horizontal axes), and a 3-second duration design load (vertical axes) suitable for selecting the thickness(es) and glass type(s) of single laminated glass or insulating glass fabricated with laminated glass.

6.2 In Fig. 1 project a vertical line from the point along the horizontal axes that represent standoff distance between the high explosive charge and the fenestration to be glazed with blast resistant glazing.

6.3 From the intersection of the vertical line with the sloping line representing equivalent TNT mass, project a horizontal line. For equivalent TNT masses not represented by sloping lines, the user shall interpolate between the lines.

6.4 Read the 3-second duration design load from the vertical axes, interpolating as necessary.

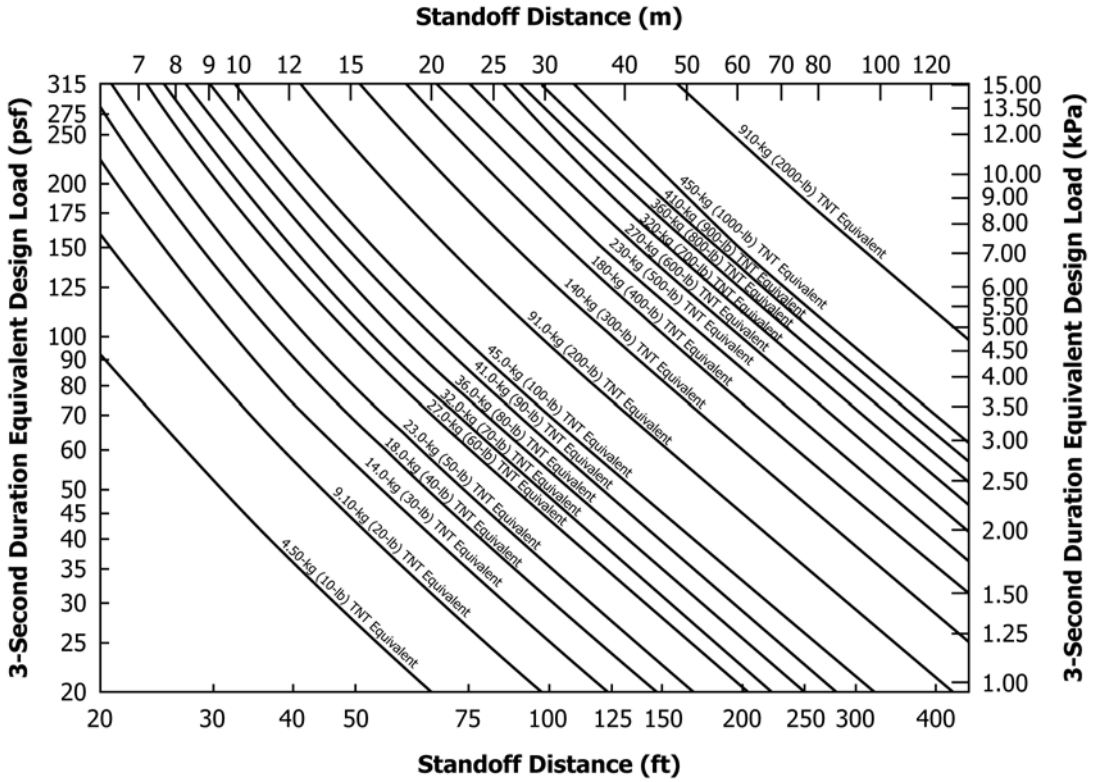

FIG. 1 Graphical Relationship Between Standoff Distance, TNT Charge Mass, and 3-Second Equivalent Design Load

7. Report

7.1 Report the following:
7.1.1 Date of calculation,
7.1.2 Mass of hemispherical TNT charge size,
7.1.3 Standoff distance of charge from fenestration, and
7.1.4 Magnitude of the 3-second duration equivalent design loading.

8. Precision and Bias

8.1 *Precision and Bias*—No statement is made concerning either the precision or bias of this practice since the result merely states whether a glazing or glazing system can resist an airblast loading.

9. Keywords

9.1 air blast pressure; blast resistant glazing; explosion; insulating glass; laminated glass; specified design load