Standard Practice for
Determining Load Resistance of Glass in Buildings[1]

1. Scope

1.1 This practice describes procedures to determine the load resistance (LR) of specified glass types, including combinations of glass types used in a sealed insulating glass (IG) unit, exposed to a uniform lateral load of short or long duration, for a specified probability of breakage.

1.2 This practice applies to vertical and sloped glazing in buildings for which the specified design loads consist of wind load, snow load and self-weight with a total combined magnitude less than or equal to 15 kPa (315 psf). This practice shall not apply to other applications including, but not limited to, balustrades, glass floor panels, aquariums, structural glass members, and glass shelves.

1.3 This practice applies only to monolithic and laminated glass constructions of rectangular shape with continuous lateral support along one, two, three, or four edges. This practice assumes that (*1*) the supported glass edges for two, three, and four-sided support conditions are simply supported and free to slip in plane; (*2*) glass supported on two sides acts as a simply supported beam; and (*3*) glass supported on one side acts as a cantilever. For insulating glass units, this practice only applies to insulating glass units with four-sided edge support.

1.4 This practice does not apply to any form of wired, patterned, sandblasted, drilled, notched, or grooved glass. This practice does not apply to glass with surface or edge treatments that reduce the glass strength.

1.5 This practice addresses only the determination of the resistance of glass to uniform lateral loads. The final thickness and type of glass selected also depends upon a variety of other factors (see 5.3).

1.6 Charts in this practice provide a means to determine approximate maximum lateral glass deflection. Appendix X1 provides additional procedures to determine maximum lateral deflection for glass simply supported on four sides.

1.7 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.8 Appendix X2 lists the key variables used in calculating the mandatory type factors in Tables 1-3 and comments on their conservative values.

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]

C1036 Specification for Flat Glass

C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass

C1172 Specification for Laminated Architectural Flat Glass

D4065 Practice for Plastics: Dynamic Mechanical Properties: Determination and Report of Procedures

E631 Terminology of Building Constructions

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology E631 for additional terms used in this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *acid etched glass, n*—glass surface that has been treated primarily with hydrofluoric acid and potentially in combination with other agents. Acid etched glass strength shall be considered as equivalent to float glass in this practice provided the glass thickness conforms to Specification C1036.

3.2.2 *aspect ratio (AR), n*—for glass simply supported on four sides, the ratio of the long dimension of the glass to the short dimension of the glass is always equal to or greater than 1.0. For glass simply supported on three sides, the ratio of the

TABLE 1 Glass Type Factors (GTF) for a Single Lite of Monolithic or Laminated Glass (LG)

| Glass Type | GTF | |
	Short Duration Load (3 s)	Long Duration Load (30 days)
AN	1.0	0.43
HS	2.0	1.3
FT	4.0	3.0

TABLE 2 Glass Type Factors (GTF) for Double Glazed Insulating Glass (IG), Short Duration Load

| Lite No. 1 Monolithic Glass or Laminated Glass Type | Lite No. 2 Monolithic Glass or Laminated Glass Type | | | | | |
| | AN | | HS | | FT | |
	GTF1	GTF2	GTF1	GTF2	GTF1	GTF2
AN	0.9	0.9	1.0	1.9	1.0	3.8
HS	1.9	1.0	1.8	1.8	1.9	3.8
FT	3.8	1.0	3.8	1.9	3.6	3.6

TABLE 3 Glass Type Factors (GTF) for Double Glazed Insulating Glass (IG), Long Duration Load (30 day)

| Lite No. 1 Monolithic Glass or Laminated Glass Type | Lite No. 2 Monolithic Glass or Laminated Glass Type | | | | | |
| | AN | | HS | | FT | |
	GTF1	GTF2	GTF1	GTF2	GTF1	GTF2
AN	0.39	0.39	0.43	1.25	0.43	2.85
HS	1.25	0.43	1.17	1.17	1.25	2.85
FT	2.85	0.43	2.85	1.25	2.71	2.71

TABLE 4 Nominal and Minimum Glass Thicknesses

Nominal Thickness or Designation, mm (in.)	Minimum Thickness, mm (in.)
2.0 (picture)	1.80 (0.071)
2.5 (³⁄₃₂)	2.16 (0.085)
2.7 (lami)	2.59 (0.102)
3.0 (¹⁄₈)	2.92 (0.115)
4.0 (⁵⁄₃₂)	3.78 (0.149)
5.0 (³⁄₁₆)	4.57 (0.180)
6.0 (¹⁄₄)	5.56 (0.219)
8.0 (⁵⁄₁₆)	7.42 (0.292)
10.0 (³⁄₈)	9.02 (0.355)
12.0 (¹⁄₂)	11.91 (0.469)
16.0 (⁵⁄₈)	15.09 (0.595)
19.0 (³⁄₄)	18.26 (0.719)
22.0 (⁷⁄₈)	21.44 (0.844)
25.0 (1)	24.61 (0.969)

length of one of the supported edges perpendicular to the free edge, to the length of the free edge, is equal to or greater than 0.5.

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

3.2.4 *Glass Thickness:*

3.2.4.1 *thickness designation for laminated glass (LG), n*—a term used to specify a LG construction based on the combined thicknesses of component plies.

(1) Add the minimum thicknesses of the individual glass plies and the nominal interlayer thickness. If the sum of all interlayer thicknesses is greater than 1.52 mm (0.060 in.) use 1.52 mm (0.060 in.) in the calculation.

(2) Select the nominal thickness or designation in Table 4 having the closest minimum thickness that is equal to or less than the value obtained in 3.2.4.1 *(1)*.

(3) Exceptions—The construction of two 6-mm (¼-in.) glass plies plus 0.38-mm (0.015-in) or 0.76-mm (0.030-in.) interlayer shall be defined as 12 mm (½ in.). The construction of two 2.5-mm (³⁄₃₂-in.) glass plies plus 1.52-mm (0.060-in.) interlayer shall be defined as 5 mm (³⁄₁₆ in.). The construction of two 4-mm (⁵⁄₃₂-in.) glass plies plus any thickness interlayer shall be defined as 8 mm (⁵⁄₁₆ in.).

3.2.4.2 *thickness designation for monolithic glass, n*—a term that defines a designated thickness for monolithic glass as specified in Table 4 and Specification C1036.

3.2.5 *Glass Types:*

3.2.5.1 *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.

3.2.5.2 *fully tempered (FT) glass, n*—a flat, monolithic, glass lite of uniform thickness that has been subjected to a special heat treatment process where 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.

3.2.5.3 *heat strengthened (HS) glass, n*—a flat, monolithic, glass lite of uniform thickness that has been subjected to a special heat treatment 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.

3.2.5.4 *insulating glass (IG) unit, n*—any combination of two or three glass lites that enclose one or two sealed spaces respectively, filled with air or other gas.

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

(1) Discussion—Many different interlayer materials are used in LG. The information in this practice applies only to polyvinyl butyral (PVB) interlayer or those interlayers that demonstrate equivalency according to Appendix X8.

3.2.6 *glass type factor (GTF), n*—a multiplying factor for adjusting the LR of different glass types, that is, AN, HS, or FT in monolithic glass, LG, or IG constructions.

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

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

3.2.8.1 *glass weight load, n*—the dead load component of the glass weight.

3.2.8.2 *load resistance (LR), n*—the uniform lateral load that a glass construction can sustain based upon a given probability of breakage and load duration.

(1) Discussion—Multiplying the non-factored load (NFL) from figures in Annex A1 by the relevant GTF and load share (LS) factors gives the LR associated with a breakage probability less than or equal to 8 lites per 1000.

3.2.8.3 *long duration load, n*—any load lasting approximately 30 days.

(1) Discussion—For loads having durations other than 3 s or 30 days, refer to Table X4.1.

3.2.8.4 *non-factored load (NFL)*—three second duration uniform load associated with a probability of breakage less than or equal to 8 lites per 1000 for monolithic AN glass as determined from the figures in Annex A1.

3.2.8.5 *short duration load, n*—any load lasting 3 s or less.

3.2.8.6 *specified design load, n*—the magnitude in kPa (psf), type (for example, wind or snow) and duration of the load given by the specifying authority.

3.2.9 *load share factor (LSF), n*—the portion of applied load going to a particular lite in consideration in a sealed IG unit, whether the lite be monolithic glass or LG (including the layered behavior of LG under long duration loads).

3.2.9.1 *Discussion*—The LSF is used along with the GTF and the NFL value from the NFL charts to give the LR of the IG unit, based on the resistance to breakage of one specific lite only.

3.2.10 *patterned glass, n*—rolled flat glass having a pattern on one or both surfaces.

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

3.2.12 *sandblasted glass, n*—flat glass with a surface that has been sprayed by sand or other media at high velocities to produce a translucent effect.

3.2.13 *specifying authority, n*—the design professional responsible for interpreting applicable regulations of authorities having jurisdiction and considering appropriate site specific factors to determine the appropriate values used to calculate the specified design load, and furnishing other information required to perform this practice.

3.2.14 *wired glass, n*—flat glass with a layer of wire strands or mesh completely embedded in the glass.

4. Summary of Practice

4.1 The specifying authority shall provide the design load, the rectangular glass dimensions, the type of glass required, and a statement, or details, showing that the glass edge support system meets the stiffness requirement in 5.2.4.

4.2 The procedure specified in this practice shall be used to determine the uniform lateral LR of glass in buildings. If the LR is less than the specified load, then other glass types and thicknesses may be evaluated to find a suitable assembly having LR equal to or exceeding the specified design load.

4.3 The charts presented in this practice shall be used to determine the approximate maximum lateral glass deflection. Appendix X1 presents additional procedures to determine the approximate maximum lateral deflection for a specified load on glass simply supported on four sides.

5. Significance and Use

5.1 This practice is used to determine the LR of specified glass types and constructions exposed to uniform lateral loads.

5.2 Use of this practice assumes:

5.2.1 The glass is free of edge damage and is properly glazed,

5.2.2 The glass has not been subjected to abuse,

5.2.3 The surface condition of the glass is typical of glass that has been in service for several years, and is weaker than freshly manufactured glass due to minor abrasions on exposed surfaces,

5.2.4 The glass edge support system is sufficiently stiff to limit the lateral deflections of the supported glass edges to no more than $1/175$ of their lengths. The specified design load shall be used for this calculation.

5.2.5 The deflection of glass or support system, or both, shall not result in loss of glass edge support.

NOTE 1—Glass deflections are to be reviewed. This practice does not address aesthetic issues caused by glass deflection.

NOTE 2—This practice does not consider the effects of deflection on insulating glass unit seal performance.

5.3 Many other factors shall be considered in glass type and thickness selection. These factors include but are not limited to: thermal stresses, spontaneous breakage of tempered glass, the effects of windborne debris, excessive deflections, behavior of glass fragments after breakage, blast, seismic effects, building movement, heat flow, edge bite, noise abatement, and potential post-breakage consequences. In addition, considerations set forth in building codes along with criteria presented in safety-glazing standards and site-specific concerns may control the ultimate glass type and thickness selection.

5.4 For situations not specifically addressed in this standard, the design professional shall use engineering analysis and judgment to determine the LR of glass in buildings.

6. Procedure

6.1 Select the procedure to determine the load resistance.

6.2 *Basic Procedure:*

6.2.1 *For Monolithic Single Glazing Simply Supported Continuously Along Four Sides:*

6.2.1.1 Determine the NFL from the appropriate chart in Annex A1 (the upper charts of Figs. A1.1-A1.14) for the glass thickness and size.

6.2.1.2 Determine the GTF for the appropriate glass type and load duration (short and long) from Table 1.

6.2.1.3 Multiply NFL by GTF to get the LR of the lite.

6.2.1.4 Determine the appropriate maximum lateral (center of glass) deflection from the approximate chart in Annex A1 (the lower charts of Figs. A1.1-A1.14) for the designation glass thickness, size, and design load. If the maximum lateral deflection falls outside the charges in Annex A1, then use the procedures outlined in Appendix X1.

6.2.2 *For Monolithic Single Glazing Simply Supported Continuously Along Three Sides:*

6.2.2.1 Determine the NFL from the appropriate chart in Annex A1 (the upper charts of Figs. A1.15-A1.26) for the designated glass thickness and size.

6.2.2.2 Determine the GTF for the appropriate glass type and load duration (short or long) from Table 1.

6.2.2.3 Multiply NFL by GTF to get the LR of the lite.