Designation: E 1300 – 00

An American National Standard

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

This standard is issued under the fixed designation E 1300; 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 practice covers a procedure to determine the load resistance of specified glass types, including combinations of glass types used in a sealed insulating glass unit, exposed to a uniform lateral load of short or long duration, for a specified probability of breakage.

1.2 This practice is applicable to common architectural designs only for which the specified design loads are less than or equal to 10 kPa (210 psf).

1.3 This practice can only be applied to monolithic, laminated, or insulating glass of rectangular shape with continuous lateral support of all four edges. This practice assumes that the edges of the glass are simply supported and free to slip in plane.

1.4 This practice is applicable to annealed, heat strengthened, fully tempered, laminated, and insulating glass units as defined in 3.2.4. This practice is not applicable to any form of wired, patterned, etched, sandblasted, or types of glass with surface treatments that reduce the glass strength.

1.5 This practice only addresses 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 Two procedures are presented which allow the approximate center of glass lateral deflection to be calculated (see Appendix X1 and Appendix X2). A procedure is also presented to calculate the probability of breakage of any annealed lite or ply (see Appendix X3), for short or long duration loads.

1.7 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only. For conversion of quantities in various systems of measurements to SI units refer to Practice E 380.

1.8 Appendix X4 lists the key variables used in calculating the mandatory type factors in Tables 1-4 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:*

C 1036 Specification for Flat Glass[2]

C 1048 Specification for Heat-Treated Flat Glass-Kind HS, Kind FT Coated and Uncoated Glass[2]

E 380 Practice for Use of the International System of Units (SI) (the Modernized Metric System)[3]

E 631 Terminology of Building Constructions[4]

2.2 *ASCE Standard:*

ASCE 7-95 Minimum Design Loads for Buildings and Other Structures[5]

3. Terminology

3.1 *Definitions:*

3.1.1 Refer to Terminology E 631 for additional terms used in this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aspect ratio (AR)*, *n*—the ratio of the long dimension of the glass to the short dimension of the glass. AR is always equal to or greater than 1.0.

3.2.2 *flexibility ratio (b/t)*, *n*—the ratio of the short dimension of the laminated glass lite to the laminated glass thickness designation given in Table 5 of this specification.

3.2.3 *glass breakage*, *n*—the fracture of any lite or ply in monolithic, laminated, or insulating glass due to stress from an applied uniform lateral load.

3.2.4 *Glass Thickness*:

3.2.4.1 *designated thickness for laminated glass (LG), n*—the designated thickness for LG shall be as specified in Table 5.

3.2.4.2 *designated thickness for monolithic glass, n*—the designated or nominal thickness commonly used in specifying a particular glass product, based on the minimum thicknesses presented in Table 6 and Specification C 1036.

[1] This practice is under the jurisdiction of ASTM Committee E-6 on Performance of Buildings and is the direct responsibility of Subcommittee E06.51 on Component Performance of Windows, Curtain Walls, and Doors.

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[2] *Annual Book of ASTM Standards*, Vol 15.02.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] *Annual Book of ASTM Standards*, Vol 04.11.

[5] Available from American Society of Civil Engineers, 345 E. 47th St., New York, NY 10017.

TABLE 1 Glass Type (GT) Factors for a Single Lite of Monolithic or Laminated Glass for Short Duration Load

Short Duration Load			
	Monolithic	Laminated	
		AR ≤ 2.0 and *b*/*t* > 150	AR > 2.0 or *b*/*t* ≤ 150
AN	1.0	0.90	0.75
HS	2.0	1.8	1.5
FT	4.0	3.6	3.0

TABLE 2 Glass Type (GT) Factors for a Single Lite of Monolithic or Laminated Glass for Long Duration Load

Long Duration Load			
	Monolithic	Laminated	
		AR ≤ 2.5	AR > 2.5
AN	0.6	0.45	0.30
HS	1.6	1.2	0.80
FT	3.6	2.7	1.8

3.2.4.3 *minimum thickness of monolithic glass, n*—the minimum allowable thickness associated with a nominal or designated glass thickness as given in Table 6 and Specification C 1036.

3.2.4.4 *monolithic glass thickness, n*—the thickness of monolithic glass determined through measurement.

3.2.5 *Glass Types*:

3.2.5.1 *annealed (AN) glass, n*—a flat, monolithic, glass plate of uniform thickness; it is formed by a process whereby the magnitudes of the residual stresses are nearly zero.

3.2.5.2 *fully tempered (FT) glass, n*—a flat, monolithic, glass plate of uniform thickness.

(*a*) *Discussion*—Fully tempered glass has been 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 C 1048.

3.2.5.3 *heat strengthened (HS) glass, n*—a flat, monolithic, glass plate of uniform thickness.

(*a*) *Discussion*—Heat strengthened glass has been subjected to a special heat treatment process whereby the residual surface compression is not less than 24 MPa (3500 psi) or greater than 69 MPa (10 000 psi), or the edge compression is not less than 38 MPa (5500 psi) as defined in Specification C 1048.

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

3.2.5.5 *laminated glass (LG), n*—a flat-plate of uniform thickness that is fabricated by bonding two monolithic glass plates or plies of equal thickness, as defined herein, together with a polyvinyl butyral (PVB) interlayer.

3.2.6 *glass type (GT) factor*, *n*—a multiplying factor for annealed, heat strengthened, fully tempered or laminated glass, used with the non-factored load charts.

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

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

3.2.8.1 *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.

3.2.8.2 *load resistance (LR), or resistance load, n*—the uniform lateral load that a single glass lite of a specified type or sealed IG unit of a specified type, can carry for a given probability of breakage.

(*a*) *Discussion*—Multiplying the non-factored load from figures in Annex A1, by the relevant GT and LS factors gives the load resistance for 8 in 1000 breakage probability.

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

3.2.8.4 *non-factored load (NFL), n*—sixty second duration uniform load associated with a probability of breakage of 8 lites per thousand for monolithic annealed glass as determined from the figures in Annex A1.

3.2.8.5 *short duration load, n*—any load lasting 60 s or less.

3.2.9 *load share (LS) factor*, *n*—a multiplying factor derived from the load sharing between the two lites, of equal or different thicknesses and types (including the layered behavior of laminated glass under long duration loads), in a sealed IG unit.

3.2.9.1 *Discussion*—The LS factor is used along with the glass type factor (GT) and the value (NFL) from the non-factored load charts to give the load resistance of the IG unit, based on the resistance to breakage of one specific lite only.

3.2.10 *probability of breakage* (P_b), *n*—the theoretical fraction of glass lites or plies that would break at the first occurrence of the resistance load, typically expressed in lites per thousand.

3.2.11 *specifying authority*, *n*—the designer responsible for interpreting local, state, and federal building codes and responsible for considering appropriate site specific factors on behalf of an architect, engineer or owner, in order to determine the appropriate values to be used to calculate the specified design load and for furnishing all other information required to perform this practice.

4. Summary of Practice

4.1 The specifying authority shall provide the specified design load (shall be not more than 10 kPa, or 210 psf), the rectangular glass dimensions, the type of glass required, and a statement, or details, showing that the framing system is stiff enough to meet the requirements of this practice (see 5.2.4).

4.2 The procedure specified in this practice is used to determine the uniform lateral load resistance of a glazing assembly. If the load resistance is less than the specified load, then other glass types and thicknesses can be evaluated to find a suitable assembly whose load resistance exceeds the specified load.

4.3 Two procedures that can be used to determine the approximate center of glass lateral deflection for a specified load are presented in Appendix X1 and Appendix X2.

4.4 An optional procedure for determining the probability of breakage at a given load is presented in Appendix X3.

5. Significance and Use

5.1 This practice can be used to determine the load resistance of specified glass types, including combinations of glass types used in sealed insulating glass units, exposed to uniform lateral loads, of short or long duration.

5.2 Use of this practice assumes:

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

TABLE 3 Glass Type (GT) Factors for Insulating Glass (IG), Short Duration Load

Short Duration Load																	
Lite No. 1[A]		Lite No. 2[B]															
						Laminated Glass											
Monolithic Glass		Monolithic Glass				AR ≤ 2.0 and *b/t* > 150						AR > 2.0 or *b/t* ≤ 150					
	AN		HS		FT		AN/AN		HS/HS		FT/FT		AN/AN		HS/HS		FT/FT	
	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2
AN	0.90	0.90	1.0	1.9	1.0	3.8	0.95	0.86	1.0	1.7	1.0	3.4	0.95	0.71	1.0	1.4	1.0	2.9
HS			1.8	1.8	1.9	3.8	1.9	0.86	1.9	1.7	1.9	3.4	1.9	0.71	1.9	1.4	1.9	2.9
FT					3.6	3.6	3.8	0.86	3.8	1.7	3.8	3.4	3.8	0.71	3.8	1.4	3.8	2.9

[A] Lite No. 1 Monolithic.
[B] Lite No. 2 Monolithic or Laminated.

TABLE 4 Glass Type (GT) Factors for IG, Long Duration Load

Long Duration Load												
Lite No. 1[A]		Lite No. 2[B]										
Monolithic Glass		Monolithic Glass				Laminated Glass						
	AN		HS		FT		AN/AN		HS/HS		FT/FT	
	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2	GT1	GT2
AN	0.54	0.54	0.6	1.5	0.6	3.4	0.57	0.57	0.60	1.5	0.60	3.4
HS			1.5	1.5	1.5	3.4	1.5	0.57	1.5	1.5	1.5	3.4
FT					3.4	3.4	3.4	0.57	3.4	1.5	3.4	3.4

[A] Lite No. 1 Monolithic.
[B] Lite No. 2 Monolithic or Laminated.

TABLE 5 Thickness Designations for Laminated Glass

Laminated Glass Industry Designation, mm (in.)	Laminated Glass Construction Nominal Thicknesses (mm) Glass/PVB[A] Glass	Laminated Glass Thickness Designation for Use in Practice E 1300, mm (in.)
5 (3⁄16)	2.5/0.38/2.5	5 (3⁄16)
5 (3⁄16)	2.5/0.76/2.5	
6 (1⁄4)	2.7/0.76/2.7	6 (1⁄4)
6 (1⁄4)	3/0.76/3	
6 (1⁄4)	3/1.52/3	
8 (5⁄16)	4/0.76/4	8 (5⁄16)
10 (3⁄8)	5/0.76/5	10 (3⁄8)
11 (7⁄16)	5/1.52/5	
12 (1⁄2)	6/0.76/6	12 (1⁄2)
13 (9⁄16)	6/1.52/6	
16 (5⁄8)	8/0.76/8	16 (5⁄8)
19 (3⁄4)	10/0.76/10	19 (3⁄4)

[A] 0.38 mm = 0.015 in., 0.76 mm = 0.030 in., 1.52 mm = 0.060 in.

TABLE 6 Minimum Glass Thicknesses

Nominal Thickness or Designation, mm	Nominal Thickness or Designation, in.	Minimum Thickness, mm	Minimum Thickness, in.
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

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, that is, glass that may be significantly weaker than freshly manufactured glass due to minor abrasions on exposed surfaces,

5.2.4 The framing system in which the glass is to be installed is sufficiently stiff to limit the lateral deflections of the edges of the glass to less than 1⁄175 of their lengths. The specified design load should be used for this calculation, and

5.2.5 The center of glass deflection will not be detrimental to the overall performance of the glazing system.

5.3 Many other factors need to 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, seismic effects, heat flow, edge bite, noise abatement, potential post-breakage consequences, etc. In addition, considerations set forth in federal, state, and local building codes along with criteria presented in safety glazing standards and site specific concerns may control the ultimate glass type and thickness selection.

6. Procedure

6.1 Select a glass type, thickness, and construction for load-resistance evaluation.

6.2 *For Monolithic Single Glazing*:

6.2.1 Determine the non-factored load (NFL) from the appropriate chart (Figs. 1-12) for the glass thickness and size.

6.2.2 Determine the glass type (GT) factor for the appropriate glass type and load duration (short or long) from Table 1 or Table 2.

6.2.3 Multiply NFL by GT to get the load resistance (LR) of the lite.

6.3 *For Single-glazed Laminated Glass Constructed of Two Glass Plies of Equal Thickness and Glass Type Bonded Together with a PVB Interlayer*:

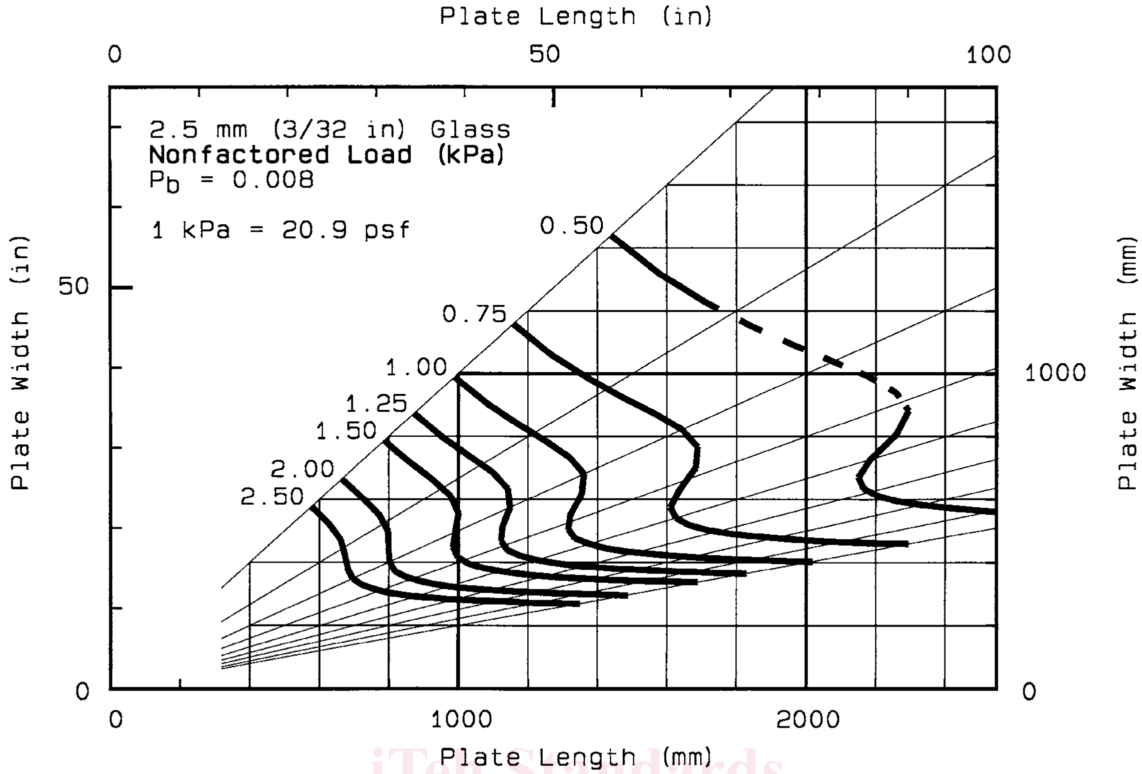

FIG. 1 Glass Thickness Selection Chart for 2.5 mm (3⁄32 in.) Glass

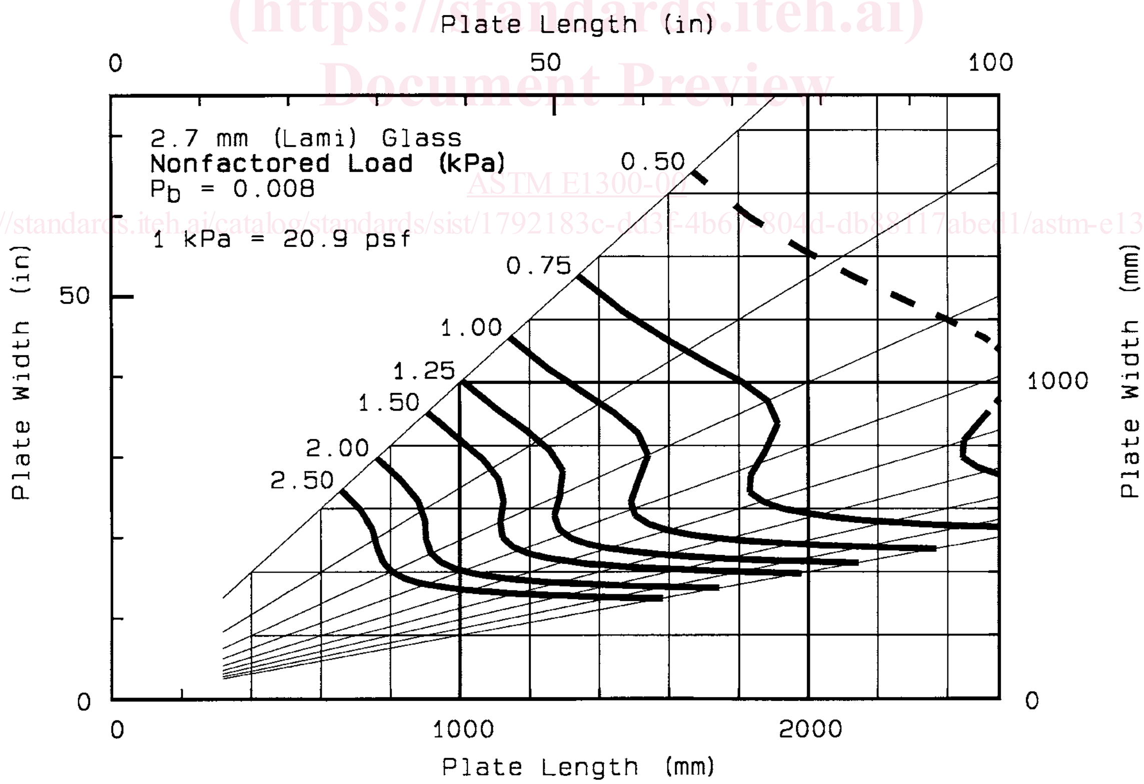

FIG. 2 Glass Thickness Selection Chart for 2.7 mm Glass

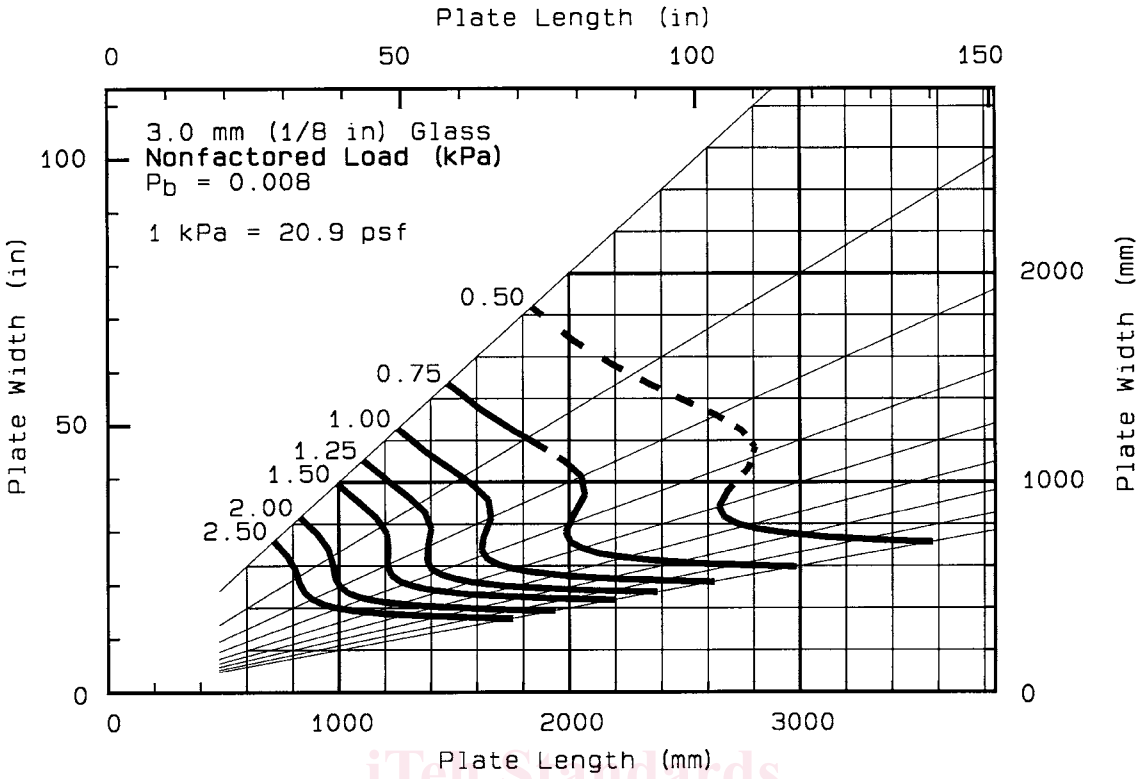

FIG. 3 Glass Thickness Selection Chart for 3.0 mm (⅛ in.) Glass

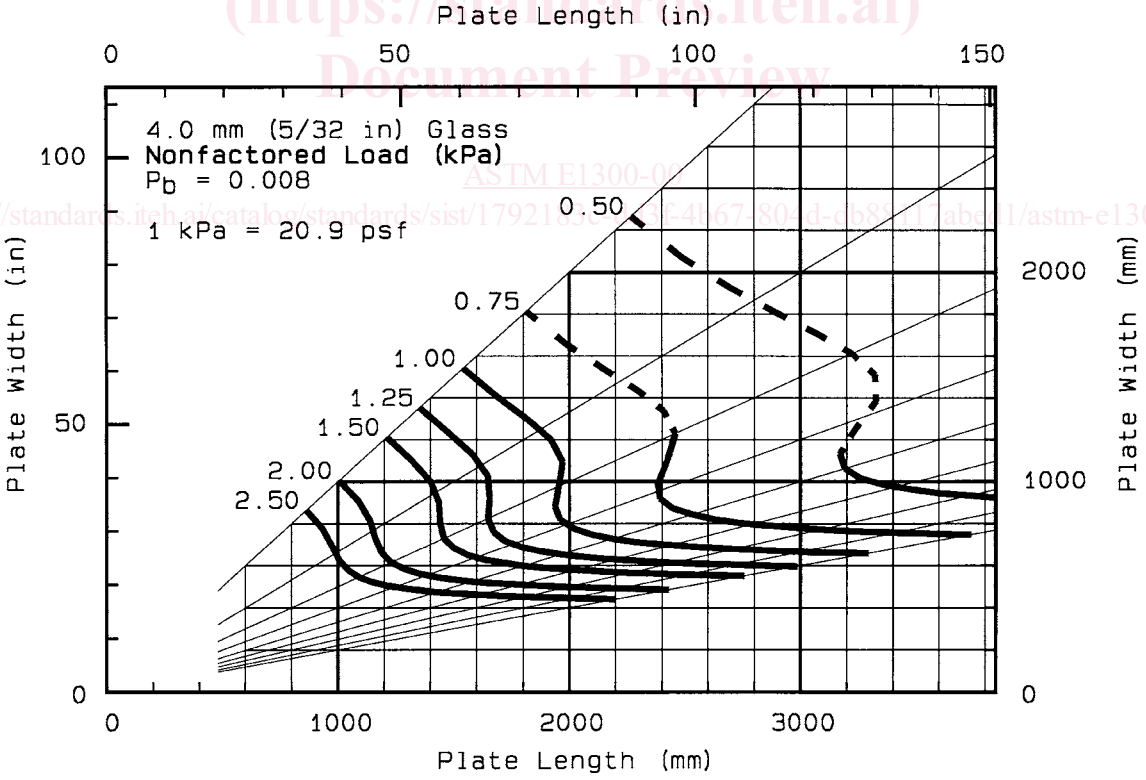

FIG. 4 Glass Thickness Selection Chart for 4.0 mm (5⁄32 in.) Glass

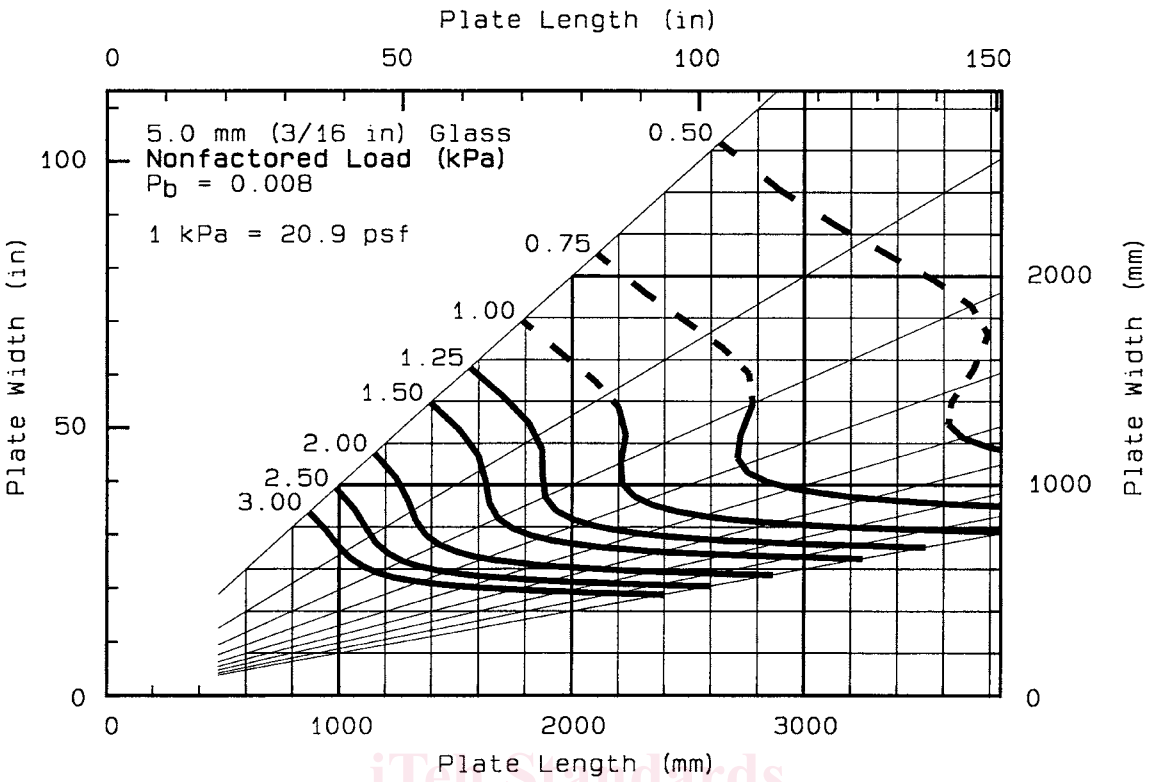

FIG. 5 Glass Thickness Selection Chart for 5.0 mm (3⁄16 in.) Glass

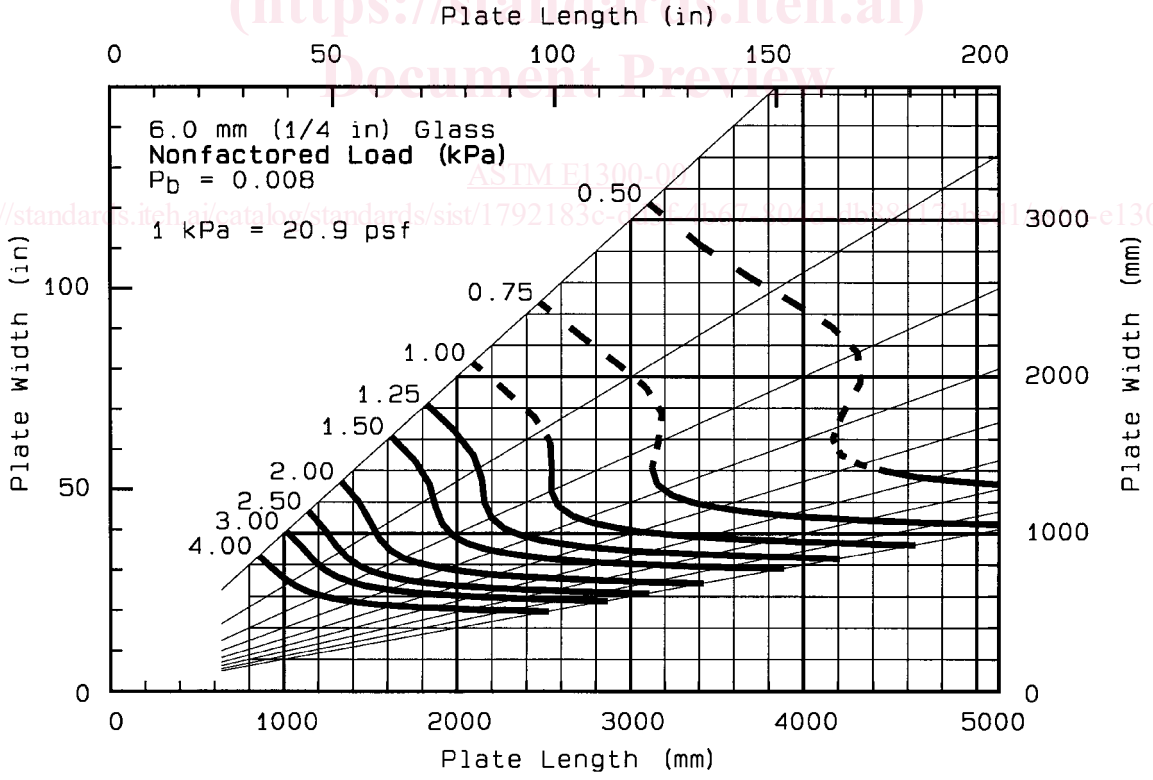

FIG. 6 Glass Thickness Selection Chart for 6.0 mm (¼ in.) Glass

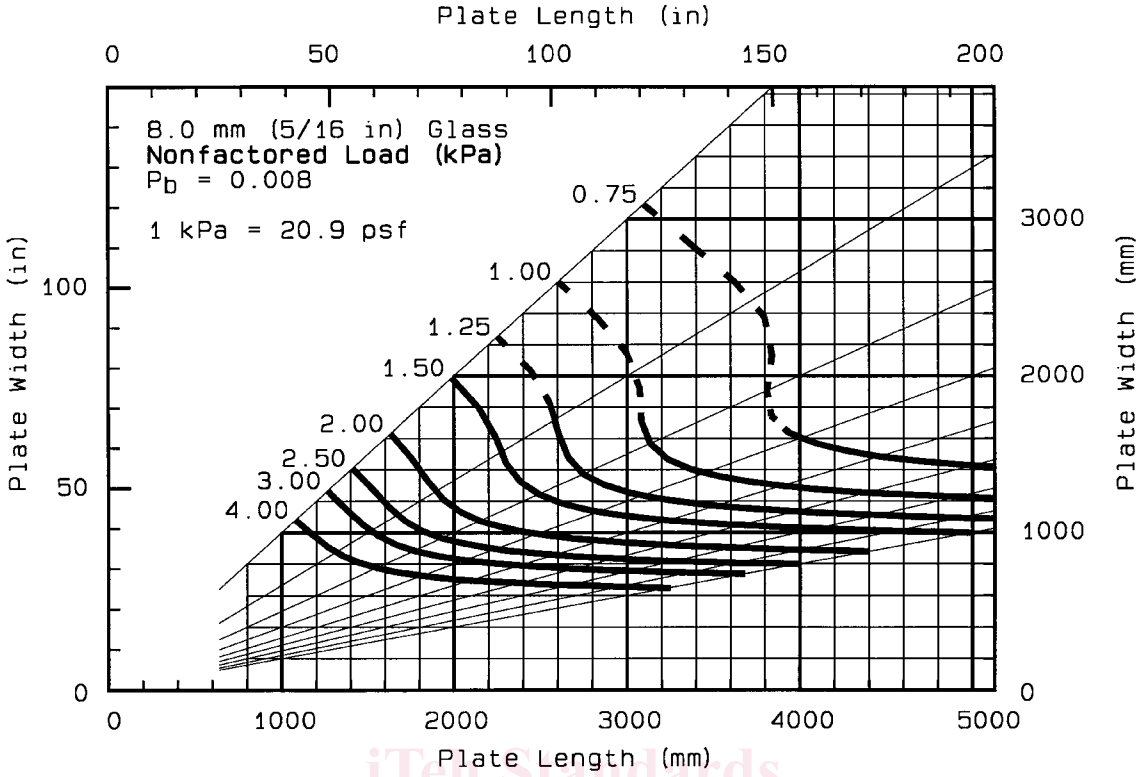

FIG. 7 Glass Thickness Selection Chart for 8.0 mm (5⁄16 in.) Glass

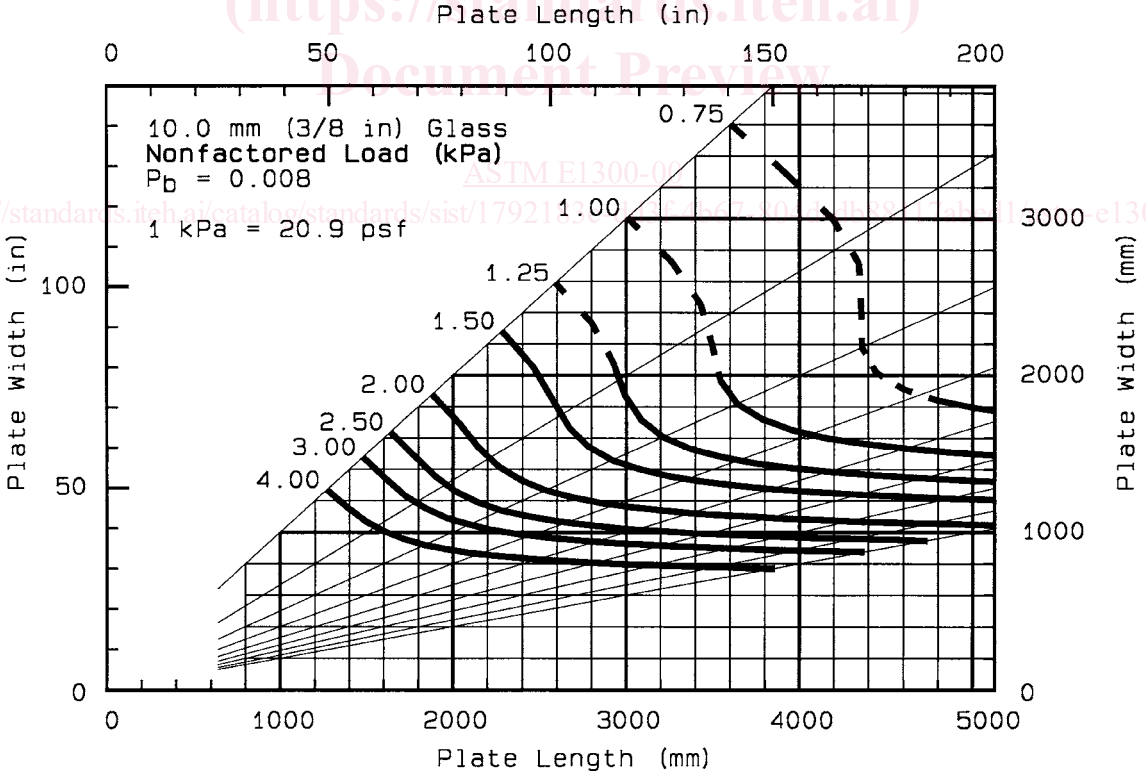

FIG. 8 Glass Thickness Selection Chart for 10.0 mm (3⁄8 in.) Glass

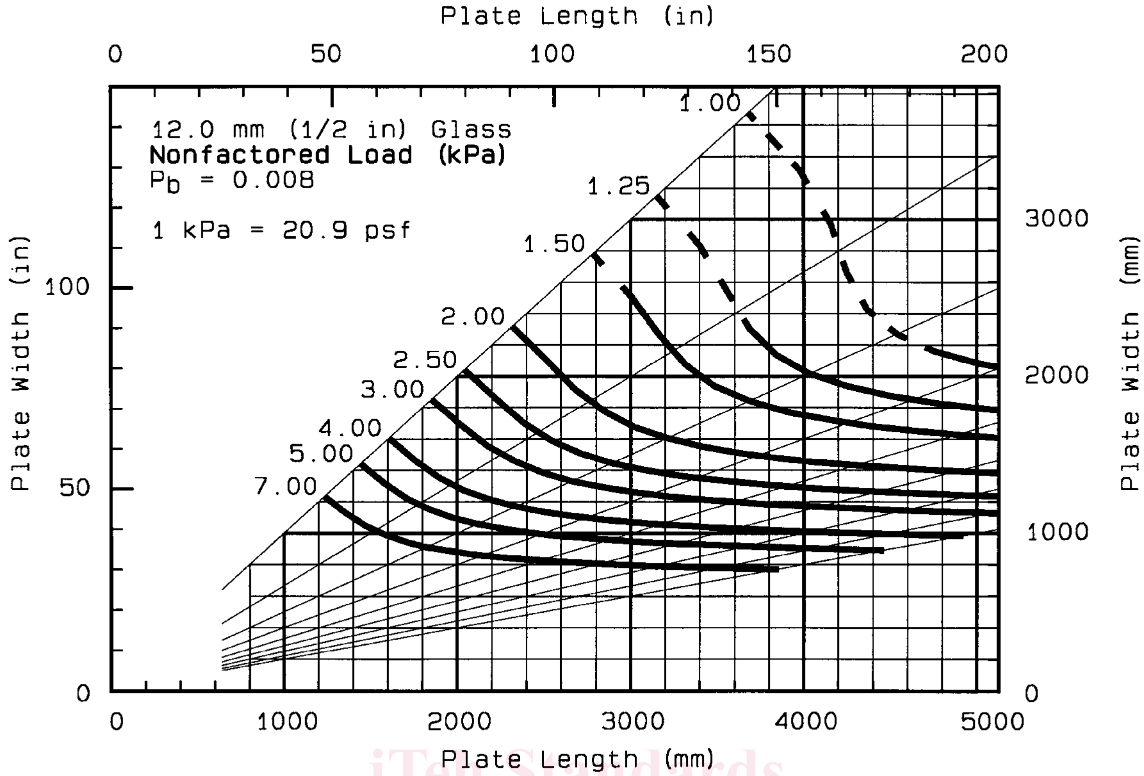

FIG. 9 Glass Thickness Selection Chart for 12.0 mm (½ in.) Glass

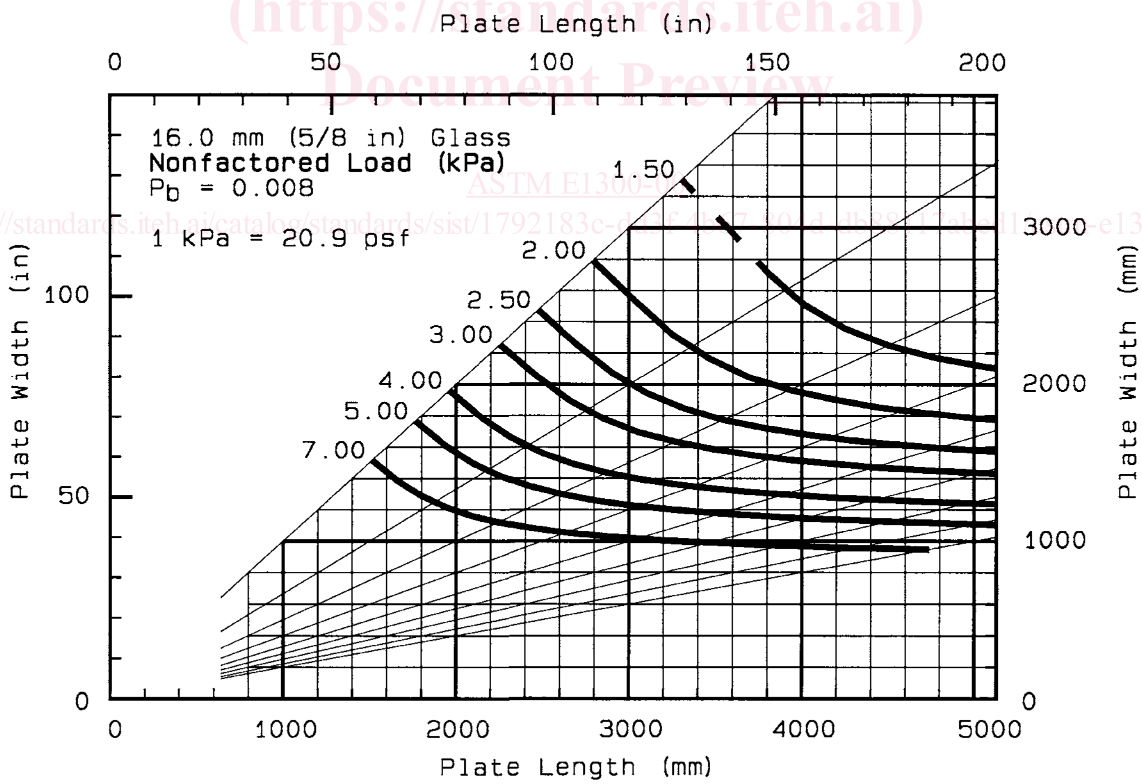

FIG. 10 Glass Thickness Selection Chart for 16.0 mm (⅝ in.) Glass

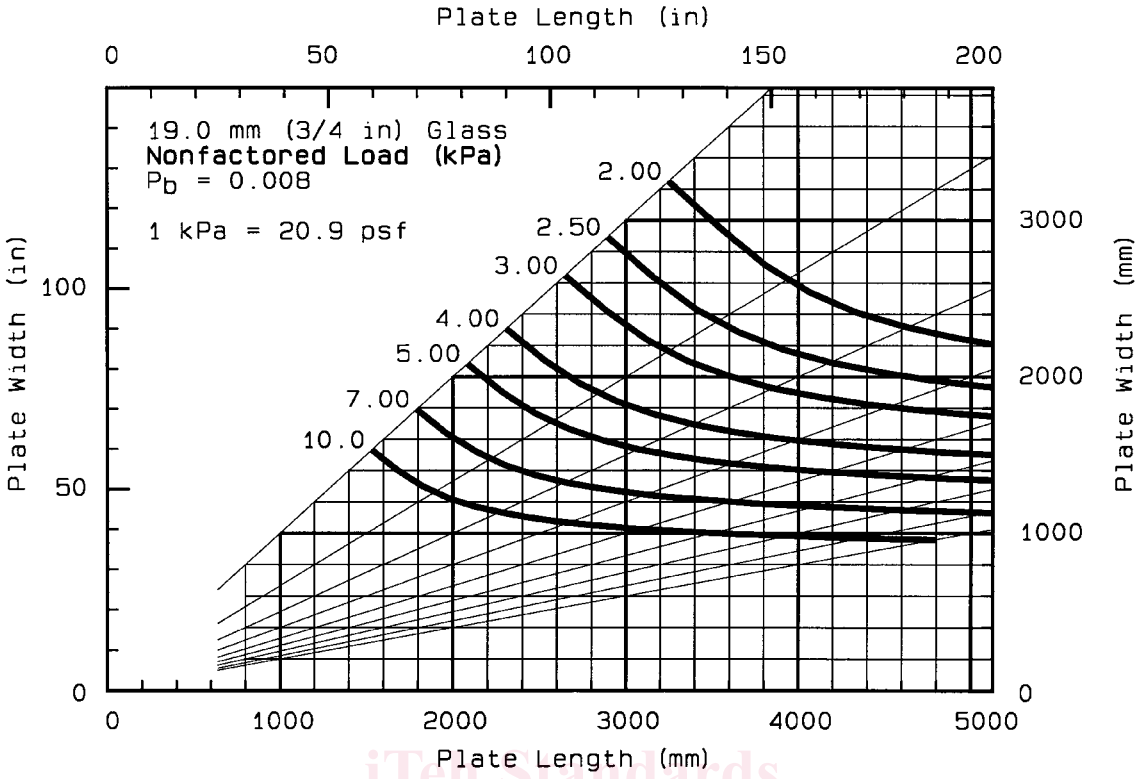

FIG. 11 Glass Thickness Selection Chart for 19.0 mm (¾ in.) Glass

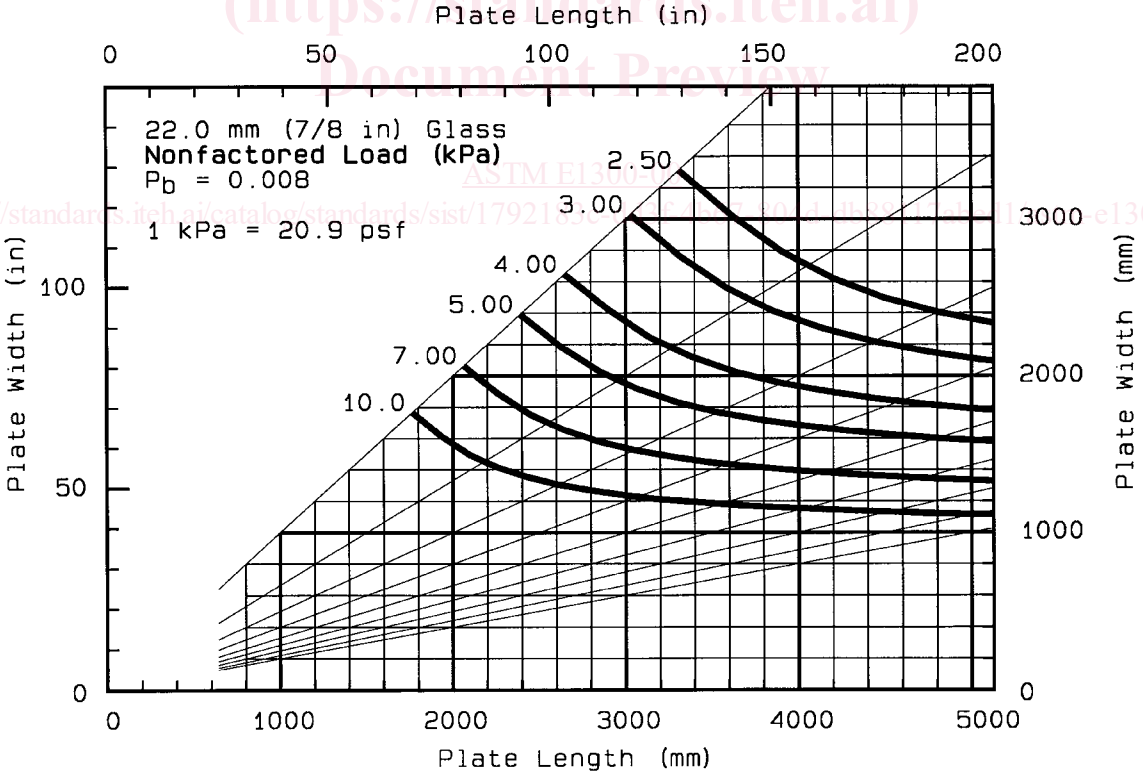

FIG. 12 Glass Thickness Selection Chart for 22.0 mm (⅞ in.) Glass

6.3.1 Determine the non-factored load (NFL) from the appropriate chart (Figs. 1-12) for glass thickness equal to the laminated glass thickness designation from Table 5.

6.3.2 Calculate the aspect ratio (AR) of the lite by dividing the long side length (*a*) by the short side length (*b*): AR = *a*/*b*.

6.3.3 For short duration loads only, calculate the flexibility ratio (*b*/*t*) by dividing the short side length (*b*) by the laminated glass thickness designation (*t*), from Table 5.

6.3.4 Determine the glass type (GT) factor for the appropriate glass type, load duration (short or long), aspect ratio (AR), and flexibility ratio (*b*/*t*) from Table 1 or Table 2.

NOTE 1—The laminated GT factors are interim values pending the results of ongoing evaluations. The factors for short duration loads, for AR ≤ 2.0 and *b*/*t* > 150, are representative of room temperature data. Higher temperatures may result in lower factors for short duration loads.

6.3.5 Multiply NFL by GT to get the load resistance (LR) of the laminated lite.

6.4 *For Insulating Glass (IG) with Monolithic Glass Lites of Equal (Symmetric) or Different (Asymmetric) Glass Type and Thickness*:

6.4.1 Determine the non-factored loads (NFL1 and NFL2 for lites Nos. 1 and 2) from the appropriate charts, Figs. 1-12. (See Annex A2 for examples.)

NOTE 2—Lite Nos. 1 or 2 can represent either the outward or inward facing lite of the IG unit.

6.4.2 For each lite, determine the glass type factor (GT1 and GT2 for lites Nos. 1 and 2) from Table 3 or Table 4, for the relevant glass type and load duration.

6.4.3 For each lite, determine the load share factors (LS1 and LS2 for lites Nos. 1 and 2) from Table 7, for the relevant lite thickness.

6.4.4 Multiply NFL by GT and by LS for each lite to determine the load resistances (LR1 and LR2) of the insulating glass unit based on the load resistance of lite Nos. 1 and 2.

6.4.5 The load resistance of the IG unit is the lowest of the two calculated LR values.

6.5 *For Insulating Glass (IG) with One Monolithic Lite and One Laminated Lite Under Short Duration Load*:

6.5.1 The monolithic lite is designated lite No. 1, and the laminated lite is designated lite No. 2.

6.5.2 Determine the non-factored load (NFL) for each lite from the appropriate chart, Figs. 1-12. For the laminated lite use the laminated glass thickness designation from Table 5.

6.5.3 Determine AR and *b*/*t* as in 6.3.2 and 6.3.3.

6.5.4 For each lite, determine the glass type factor (GT1 and GT2 for lites Nos. 1 and 2) from Table 3 for the relevant glass type, AR, and flexibility ratio.

6.5.5 For each lite, determine the load share factors (LS1 and LS2 for lites Nos. 1 and 2), from Table 7, for the relevant lite thickness.

6.5.6 Multiply NFL by GT and by LS for each lite to determine the load resistances (LR1 and LR2), of the insulating glass unit, based on the load resistances of lite No. 1 and lite No. 2.

6.5.7 The load resistance of the IG unit is the lowest of the two calculated LR values.

6.6 *For Insulating Glass (IG) with One Monolithic Lite and One Laminated Lite, Under Long Duration Load*:

6.6.1 The monolithic lite is designated lite No. 1, and the laminated lite is designated lite No. 2.

6.6.2 The load resistance of each lite must first be calculated for that load acting for a short duration as in 6.5, and then for the same load acting for a long duration as given in 6.6.3-6.6.6.

NOTE 3—There are some combinations of IG with laminated glass where its monolithic-like behavior under a short duration load gives the IG a lesser load resistance than under the layered behavior of long duration loads.

6.6.3 Determine the values for the non-factored loads (NFL1 and NFL2 for lites Nos. 1 and 2) from Figs. 1-12 (see Annex A2 for examples). The NFL for the laminated lite for this long duration load case is taken from the NFL chart for the thickness of one ply of the laminate, not the designated laminated thickness.

6.6.4 For each lite, determine the glass type factor (GT1 and GT2 for lites Nos. 1 and 2) from Table 4 for the relevant glass type.

TABLE 7 Load Share (LS) Factors for Insulating Glass (IGi) Units

NOTE 1—Lite No. 1 Monolithic glass, Lite No. 2 Monolithic glass, short or long duration load, or Lite No. 1 Monolithic glass, Lite No. 2 Laminated glass, short duration load only.

Lite No. 1		Lite No. 2																					
Monolithic Glass		Monolithic Glass, Short or Long Duration Load or Laminated Glass, Short Duration Load Only																					
Nominal Thickness		2.5 3/32		2.7 lami		3 1/8		4 5/32		5 3/16		6 1/4		8 5/16		10 3/8		12 1/2		16 5/8		19 3/4	
mm	in.	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2	LS1	LS2
2.5	3/32	2.00	2.00	2.73	1.58	3.48	1.40	6.39	1.19	10.5	1.11	18.1	1.06	41.5	1.02	73.8	1.01	169.	1.01	344.	1.00	606.	1.00
2.7	lami	1.58	2.73	2.00	2.00	2.43	1.70	4.12	1.32	6.50	1.18	10.9	1.10	24.5	1.04	43.2	1.02	98.2	1.01	199.	1.01	351.	1.00
3	1/8	1.40	3.48	1.70	2.43	2.00	2.00	3.18	1.46	4.83	1.26	7.91	1.14	17.4	1.06	30.4	1.03	68.8	1.01	140.	1.01	245.	1.00
4	5/32	1.19	6.39	1.32	4.12	1.46	3.18	2.00	2.00	2.76	1.57	4.18	1.31	8.53	1.13	14.5	1.07	32.2	1.03	64.7	1.02	113.	1.01
5	3/16	1.11	10.5	1.18	6.50	1.26	4.83	1.57	2.76	2.00	2.00	2.80	1.56	5.27	1.23	8.67	1.13	18.7	1.06	37.1	1.03	64.7	1.02
6	1/4	1.06	18.1	1.10	10.9	1.14	7.91	1.31	4.18	1.56	2.80	2.00	2.00	3.37	1.42	5.26	1.23	10.8	1.10	21.1	1.05	36.4	1.03
8	5/16	1.02	41.5	1.04	24.5	1.06	17.4	1.13	8.53	1.23	5.27	1.42	3.37	2.00	2.00	2.80	1.56	5.14	1.24	9.46	1.12	15.9	1.07
10	3/8	1.01	73.8	1.02	43.2	1.03	30.4	1.07	14.5	1.13	8.67	1.23	5.26	1.56	2.80	2.00	2.00	3.31	1.43	5.71	1.21	9.31	1.12
12	1/2	1.01	169.	1.01	98.2	1.01	68.8	1.03	32.2	1.06	18.7	1.10	10.8	1.24	5.14	1.43	3.31	2.00	2.00	3.04	1.49	4.60	1.28
16	5/8	1.00	344.	1.01	199.	1.01	140.	1.02	64.7	1.03	37.1	1.05	21.1	1.12	9.46	1.21	5.71	1.49	3.04	2.00	2.00	2.76	1.57
19	3/4	1.00	606.	1.00	351.	1.00	245.	1.01	113.	1.02	64.7	1.03	36.4	1.07	15.9	1.12	9.31	1.28	4.60	1.57	2.76	2.00	2.00