Designing Glass to Resist Wind and Snow Loads

One of the design requirements of glass used in buildings is to resist the loads created by wind and snow. ASTM E1300-02: *Standard Practice for Determining Load Resistance of Glass in Buildings* provides numerical and graphical procedures to help design professionals and other specifying authorities determine the appropriate glass thickness and type to meet specified wind and snow loads.

The E1300 standard has been developed by a broad group of industry representatives and has evolved and expanded to its present form over a period of more than 10 years.

E1300 does not address glass design issues related to thermal stress, for which we invite our customers to use Vitro's (formerly PPG Industries) Thermal Stress Update publication and related software tool.

The purpose of this document is to familiarize Vitro's customers with this standard, including its scope and limitations. Examples are shown and directions on obtaining a copy of the standard are given. Also, directions are given on how to obtain a software package, based on ASTM E1300-02,that can be used to produce compatible recommendations. Examples from the software package are also shown.

Scope of E1300-02

E1300-02 includes procedures that address:

- Monolithic, laminated, and insulating glass constructions.
  - ✓ Insulating glass units can have lites of same or different types and thickness.
  - ✓ Insulating glass units can have one monolithic lite and one laminated lite, or can be comprised of two laminated lites.
- 1, 2, 3, and 4 sides supported conditions.
- Short or long duration uniform lateral loads.
- Calculated center-of-glass deflection.
- Specified probabilities of glass breakage.

Glass Products NOT Covered

- Wired glass.
- Patterned glass.
- Etched, sandblasted, drilled, notched or grooved glass.

Assumptions

The procedures defined by ASTM E1300-02 include the following assumptions.

- Glass is properly glazed and free of edge damage.
- Glass has not been subjected to abuse.
- Surface condition of the glass is typical of in-service glass.
- Glass edge support limits the lateral deflections of the supported glass edges to less than 1/175 of their lengths.
- Center of glass deflection will not result in loss of edge support.

Vitro encourages its customers to purchase a copy of the ASTM E 1300-02 standard. Copies may be purchased on line at www.astm.org .

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Using E1300-02

► KEY CONCEPTS

- ***Glass Type Factor* –** multiplying factor for adjusting the load resistance of different glass types.
- ***Specified Design Load*** – magnitude (in kPa or lb/sq. ft.), type of load (wind or snow), and duration of the load given by the specifying authority.
- ***Nonfactored Load*** – 3-second uniform load associated with a probability of glass breakage of ≤ 8 lites per 1,000.
- ***Load Share Factor*** – multiplying factor derived from the load sharing between the two lites of equal or different types and thickness.
- ***Load Resistance*** – the uniform lateral load that a glass construction can sustain based upon a probability of breakage and load duration.

► DESIGN PROCEDURE

1. Start with glass dimensions and specified design loading.
   - ✓ Design load must be in psf or kPa. Wind velocity can be converted to psf as follows:

     $Psf = 0.00256V^2$
2. Formulate a trial design (glass thickness and type).
3. Use E 1300 to determine the load resistance (***LR)*** and center of glass deflection.
4. If ***LR*** is greater than the specified design loading, then trial design is OK and you are done.
5. If ***LR*** is less than the specified design loading, then modify the trial glazing configuration and return to step 3.

Note: *For insulating glass units, compute the load resistance for each lite. The load resistance of the unit is the minimum of the two.*

Insulating Glass Unit Design Example

- Determine the glass thickness and glass types for an insulating glass unit with rectangular dimensions of 60 in. x 96 in. that is simply supported on all four edges.
- The 3-second duration design loading is 125 psf.

1. *Trial Design*
   - ✓ Outboard Lite (#1): Nominal ¼ in. heat strengthened monolithic glass.
   - ✓ Inboard Lite (#2): Nominal 3/8 in. heat strengthened laminated glass.
2. *Determine the load resistance based on Lite #1.*
   - ✓ Use the nonfactored load chart for ¼ in. glass (See Fig. 1 on page 3).
   - ✓ Thus, the nonfactored load for lite #1 (NFL1) is 28.8 psf.
   - ✓ ***Note:*** *You must interpolate between curves*

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FIGURE 1 (*Ref. Fig. A1.6 in ASTM Standard*)

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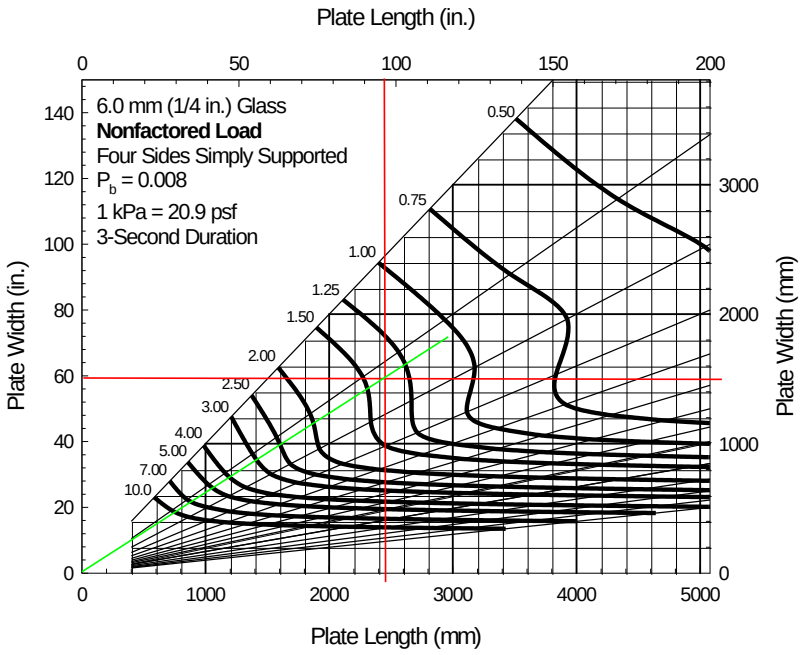

3. *Determine the Glass Type Factor for Lite #1 (GTF1) from Table 2 (reproduced below).* Thus, ***GTF1 = 1.8***

TABLE 2 Glass Type Factors (GTF) for Insulating Glass Short Duration Load

Extracted, with permission, from E 1300-02 Standard Practice for Determining Load Resistance of Glass in Buildings, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA

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	GTF2	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	3.88	1.9	3.6	3.6

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4. *Determine the Load Share Factor for Lite #1 (LSF1) from Table 5 on page 6.*

   Thus, ***LSF1 = 5.26***

5. *Calculate the Load Resistance (based on Lite #1):*

   LR1 = NFL1 x GTF1 x LSF1
   = 28.8 x 1.8 x 5.26
   = 273 psf

This meets the requirements, but you must check lite #2.

6. *Determine the load resistance based on lite #2.*
   - ✓ Use the nonfactored load chart for 3/8 in. laminated glass (See Fig. 2 on page 6).
   - ✓ Thus, the nonfactored load for lite #2 (NFL2) is 49.2 psf.
7. *Determine the Glass Type Factor for Lite #2 (GTF2) from Table 2 (p. 3)*

   Thus, ***GTF2 = 1.8***
8. *Determine the Load Share Factor for Lite #2 (LSF2) from Table 5 (p. 6)*

   Thus, ***LSF2 = 1.23***
9. *Calculate the Load Resistance (based on Lite #2):*

   LR2 = NFL2 x GTF2 x LSF2
   = 49.2 x 1.8 x 1.23
   = 109 psf

This does not meet the requirements and therefore this trial design is not adequate. It is necessary to modify the glass thickness and/or types and perform another iteration of the process.

10. *Modified Trial Design*
    - ✓ Outboard Lite (#1): Nominal 3/8 in. heat strengthened monolithic glass.
    - ✓ Inboard Lite (#2): Nominal 5/16 in. heat strengthened laminated glass.

12. *Determine the load resistance based on Lite #1.*
    - ✓ Use the nonfactored load chart for 3/8 in. glass (See Fig. 3 on page 7).
    - ✓ Thus, the nonfactored load for lite #1 (NFL1) is 47.0 psf.

13. *Determine the Glass Type Factor for lite #1 (GTF1) from Table 2 (p. 3).*
    - ✓ Thus, ***GTF1 = 1.8***

14. *Determine the Load Share Factor for lite #1 (LSF1) from Table 5 (p. 4).*
    - ✓ Thus, ***LSF1 = 1.56***

15. *Calculate the Load Resistance (based on lite #1):*
    - ✓ *LR1 = NFL1 x GTF1 x LSF1*
      = 47.0 x 1.8 x 1.56
      = 132 psf

This meets the requirements, but you must check lite #2.

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16. *Determine the load resistance based on lite #2.*
    - ✓ Use the nonfactored load chart for 5/16 in. laminated glass (See Figure 4 on page 7).
    - ✓ Thus, the nonfactored load for lite #2 (NFL2) is 40.8 psf.

17. *Determine the Glass Type Factor for lite #2 (GTF2 from Table 2 (p. 3)*
    - ✓ Thus, ***GTF2 = 1.8***

18. *Determine the Load Share Factor for lite #2 (LSF2) from Table 5 (p. 6)*
    - ✓ Thus, ***LSF2 = 2.80***

19. *Calculate the Load Resistance (based on lite #2):*
    - ✓ LR2 = NFL2 x GTF2 x LSF2

      = 40.8 x 1.8 x 2.80

      = 205 psf

This meets the requirements. Since the load resistance of both Lite 1 and Lite 2 meet the requirement, this trial design is adequate.

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TABLE 5 Load Share (LS) Factors for Insulating Glass Units
Note: This reproduction represents only a portion of Table 5 as shown in ASTM E 1300-02
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Lite No.1	Lite No. 2					
Monolithic Glass	Monolithic glass, Short or Long Duration Load or Laminated Glass, Short Duration Load Only					
Nominal Thickness (in.)	1/4		5/16		3/8	
	LS1	LS2	LS1	LS2	LS1	LS2
1/4	2.00	2.00	3.37	1.42	5.26	1.23
5/16	1.42	3.37	2.00	2.00	2.80	1.56
3/8	1.23	5.26	1.56	2.80	2.00	2.00

FIGURE 2 (*Ref. Fig. A1.30 from ASTM Standard*)
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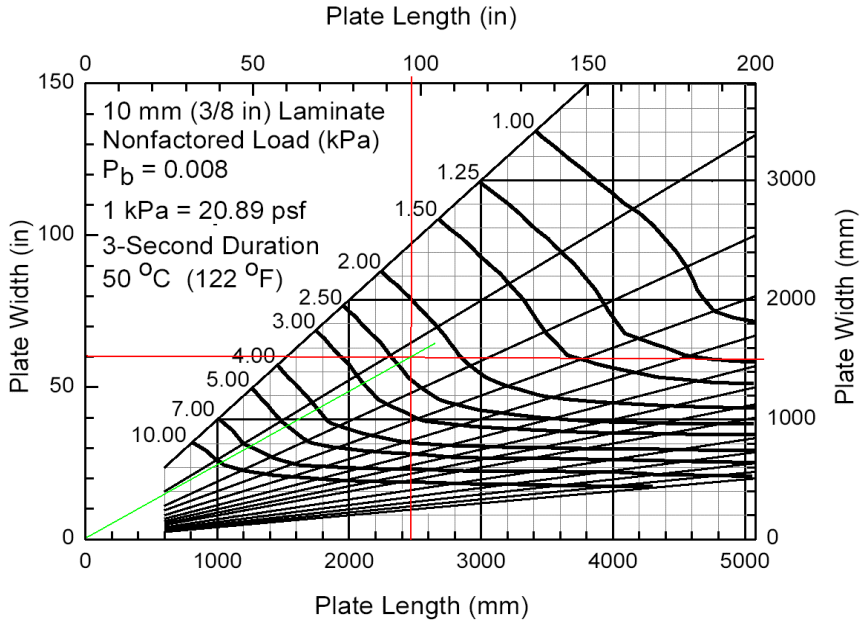

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FIGURE 3 (*Ref. Fig. A1.8 from ASTM Standard*)

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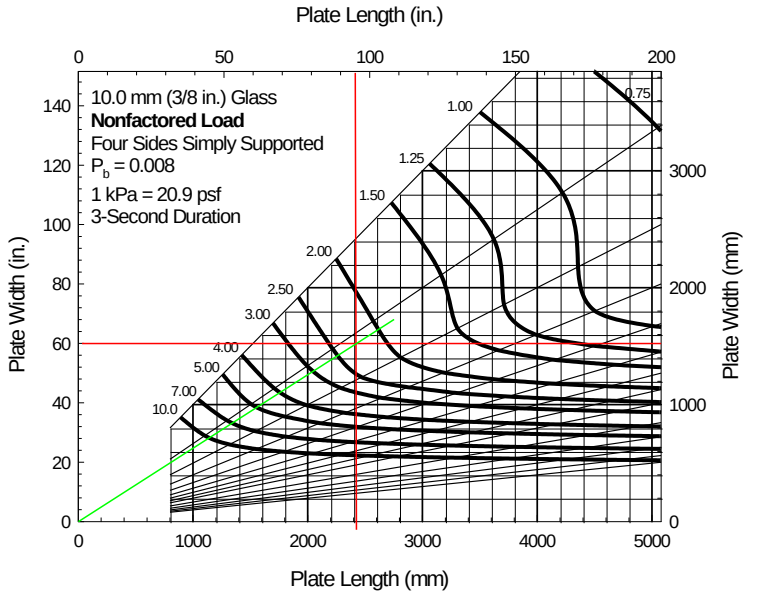

FIGURE 4 (*Ref. Fig. A1.29 from ASTM Standard*)

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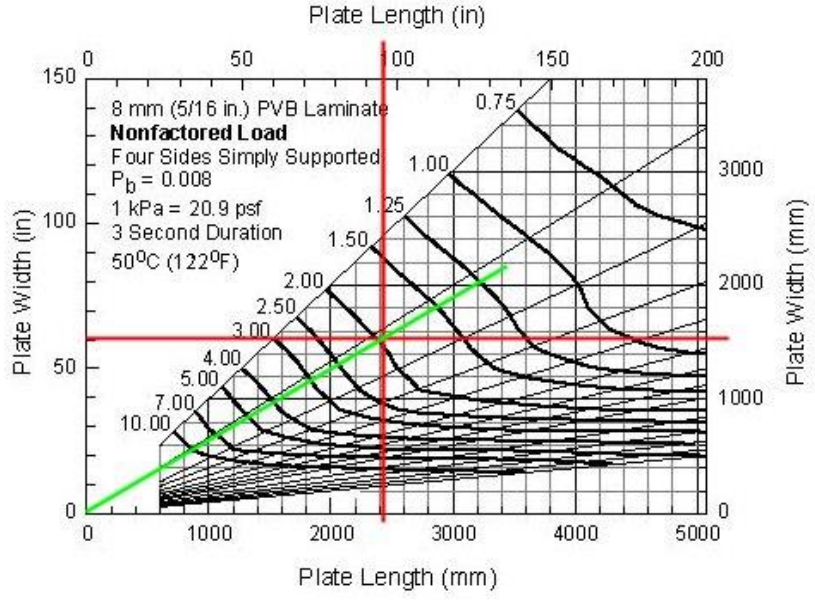

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Center-of Glass Deflection

ASTM E 1300-02 includes procedures for calculating the center-of-glass deflection. An example of this calculation, using the above design example, the procedure is as follows.

1. *Calculate the center-of-glass deflection for lite #1 under the specified design load.*
   - ✓ Load carried by lite #1 (P1):

     P1 = Specified Load /LSF1

     = 125 psf/1.56 = 80.1 psf
   - ✓ Aspect Ratio (AR) =

     long dimension /short dimension

     = 96 in./60 in. = 1.6
   - ✓ Load * Area^2 =

     = 80.1 psf * (40 sq. ft.)^2

     = 128,160 pounds-ft^2

     = 128 kip-ft^2
   - ✓ Using Figure 5 on page 9:
     - ► Project a vertical line (shown in red) from 128 kip-ft^2 along the horizontal axis.
     - ► Project a horizontal line (shown in green) from the intersection of the vertical line with the curved line for Aspect Ratio = 1.6 (determined by interpolation between curved lines for AR =1 and AR =2).

1. The approximate center-of-glass deflection is then determined by the intersection of the horizontal (green) line with the vertical axes as 0.89 in.

2. *Calculate the center-of-glass deflection for lite #2 under the specified design load.*
   - ✓ Load carried by lite #2 (P2):

     P1 = Specified Load /LSF2

     = 125 psf/2.80 = 44.7 psf
   - ✓ Aspect Ratio (AR) =

     long dimension /short dimension

     = 96 in./60 in. = 1.6
   - ✓ Load * Area^2 =

     = 44.7 psf * (40 sq. ft.)^2

     = 71,520 pounds-ft^2

     = 71.5 kip-ft^2
   - ✓ Using Figure 6 on page 9:
     - ► Project a vertical line (shown in red) from 71.5 kip-ft^2 along the horizontal axis.
     - ► Project a horizontal line (shown in green) from the intersection of the vertical line with the curved line for Aspect Ratio = 1.6 (determined by interpolation between curved lines for AR =1 and AR =2).

3. The approximate center-of-glass deflection is then determined by the intersection of the horizontal (green) line with the vertical axes as 0.83 in.

4. The approximate center deflection of the insulating glass unit is the larger of the calculated center-of-glass deflections for lite 1 and lite 2. Thus the approximate center-of-glass deflection would be 0.89 in

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FIGURE 5 (*Ref. Fig. A1.8 from ASTM Standard*)

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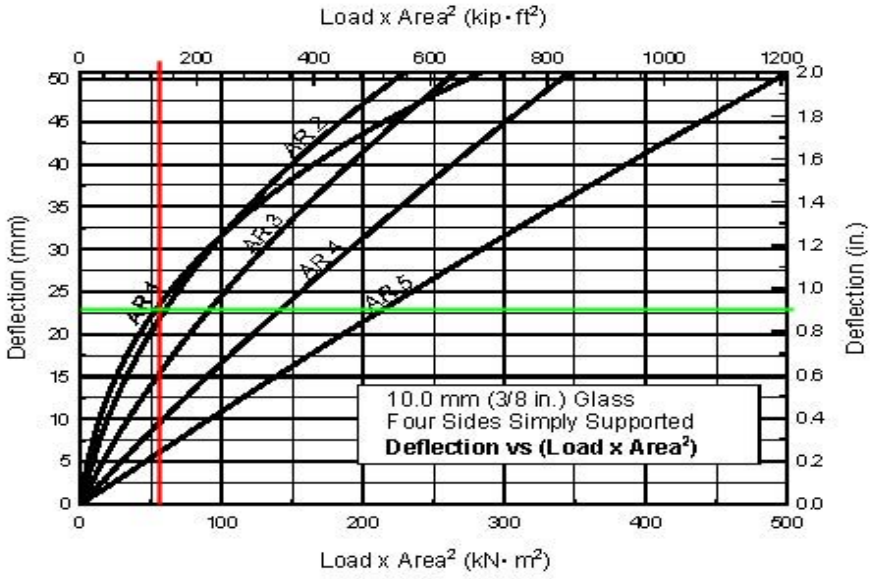

FIGURE 6 (*Ref. Fig. A1.29 from ASTM Standard*)

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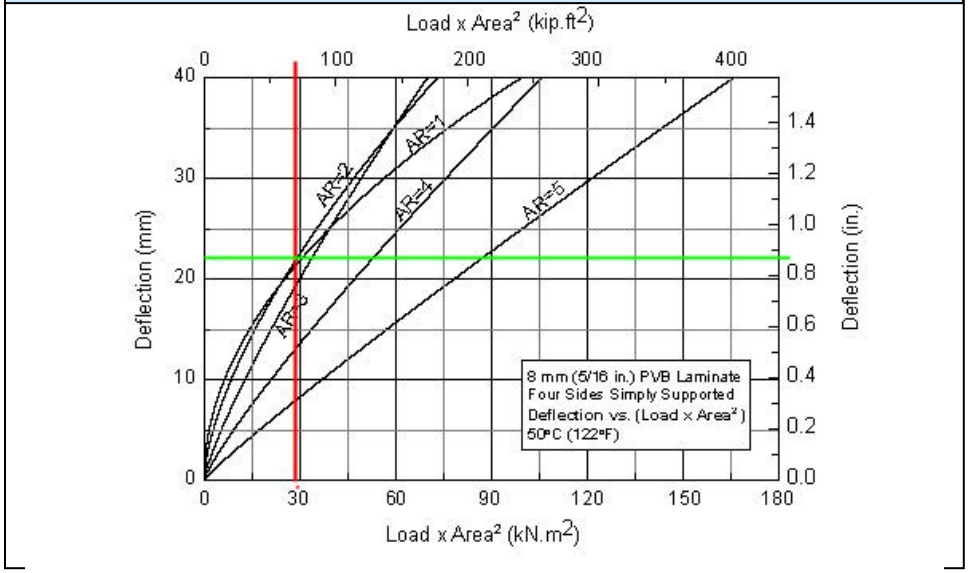

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Computer Based Version

Computer software, created by the Standards Design Group, is available that generates results that are consistent with ASTM E 1300-02. The software is easy to use and reasonably priced. Using the software is obviously much quicker and greatly reduces the chance for error that can result from the tedious manual procedure.

Vitro encourages its customers to investigate this software through the Standards Design Group Website, www.standardsdesign.com

Examples of input and output screens, based on the previous manual example are given here for reference.

Window Glass Design Software
Modified Trial Design Input Screen – SI Units
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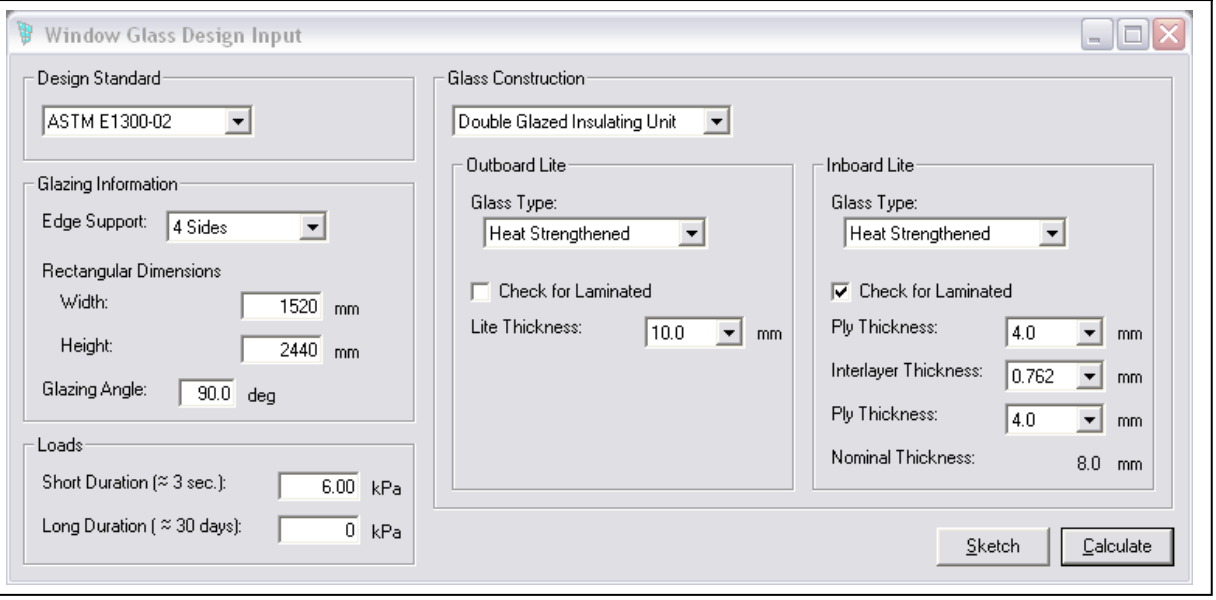

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Window Glass Design Software
Modified Trial Design – Results Screen (SI Units)
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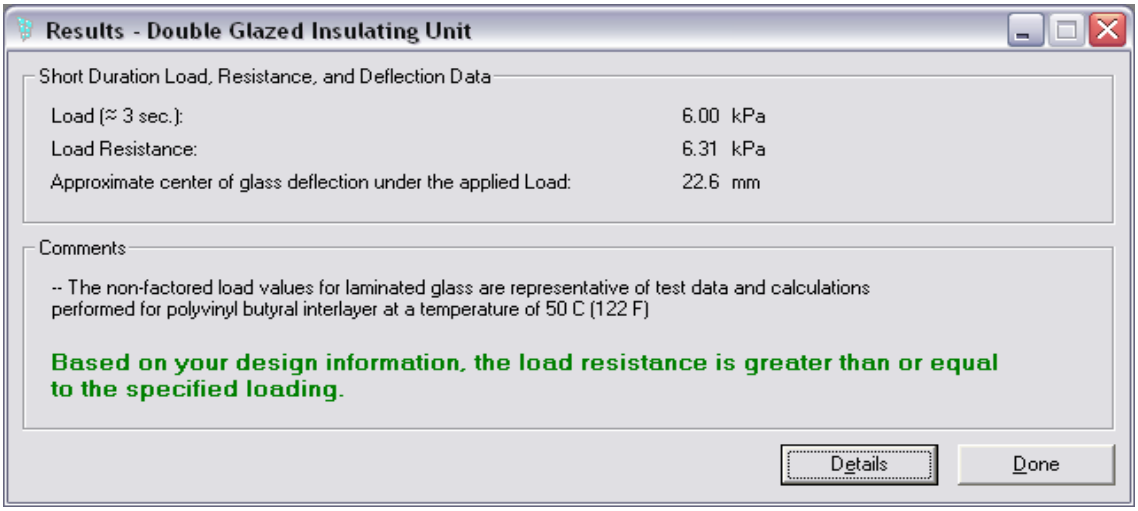

Window Design Group Software
Modified Trial Design – Details Screen (SI Units)
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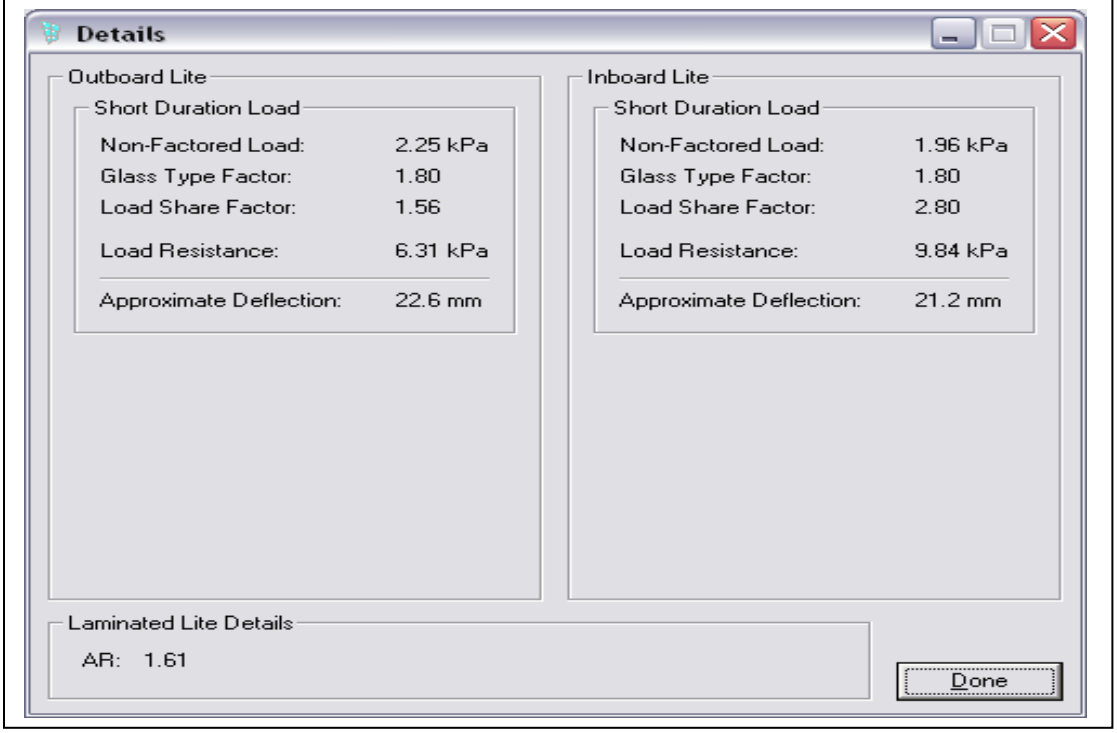

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HISTORY TABLE		
ITEM	DATE	DESCRIPTION
Original Publication	4/2/2003	TD-134
Revision 1	2016-10-04	Updated to Vitro logo and format