



February 11, 2025

To: Whom it may concern,
From: Building Drops, Inc.
On behalf of: Glass Warehouse/Future Glass
1319 Rocky Point Drive, Suite 200
Oceanside, CA 92056
Report: PER 9534
Subject: DOR-BPRD Glass Spigot Clamping System

Scope:

The purpose of this report is to evaluate the performance of the DOR-BPRD Spigot Clamping System manufactured by Glass Warehouse. The conditions in this report meet all the applicable requirements of the current International Building Code. Glass thicknesses and properties were extracted from ASTM E1300. Steel members and connections were designed according to AISC Design Guides. ICC Acceptance Criteria AC439 and ASTM E2358 were used for determining applicable design criteria for railing systems. A summary of standards can be found on the following pages.

Only rectangular glass is covered within this report, different glass shapes do not apply to this analysis. Gaskets may be modified according to different glass thicknesses as long as thickness is specified in this analysis.

For fall protection requirements, this product has been analyzed in accordance with section 1607.9.1 and meets the requirements of the 50 plf linear load and 200 lb concentrated load specified in ASCE 7 section 4.5.1.

The glass spigot system uses 2205 stainless steel clamps to point support the glass lights specified herein. The glass spigot system has been designed for the following loading conditions:

- 200 lb concentrated load at the top of glass or at the top rail
- 50 lbs linear load applied at the top of glass or at the top rail
- Allowable wind load as shown on the tables within this report

This report provides glass thicknesses the spigots have been designed to support. Other glass thicknesses may be used but are outside of the scope of this report.

Instructions for Use

1. Select desired glass composition from tables 5, 7, 8, 9, 10, 11, or 12.
2. Determine max. glass size based on wind load requirements.
3. Using table 13, verify that the allowable installation load at desired size is greater than the allowable wind load of the desired glass size.

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DOR-BPRD Glass Spigot Clamping System



Note: (4) installation anchors per spigot.

Standards/Referenced Publications

| | | |
|----------------------|--------------------|--|
| ASTM E1300 | IBC 1607.8.1 | ICC AC439 |
| ASTM E2358 | AISC Design Guides | ASTM C1048-97b |
| CPSC 16 CFR 1201 | ANSI Z97.1 | AAMA CW-12-84, Structural Properties for glass |
| AISC Design Guide 27 | IBC 2407.1.1 | NDS 2018 |
| ASTM E6.2.1.1 | SEI/ASCE 8-02 | |

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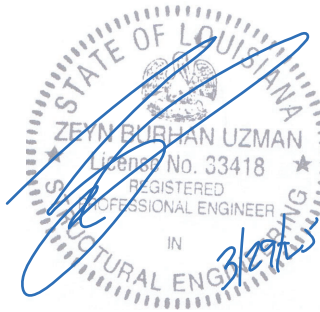
Limits of Use:

1. This product has been evaluated and is in compliance with the 2015, 2018, and 2021 editions of the International Building Code.
2. Product installation shall be as listed herein. Site conditions that deviate from those specified shall require further engineering analysis by a licensed engineer or registered architect.
3. When used in areas requiring wind borne debris protection this product complies with chapter 16 of the 2015, 2018, and 2021 editions of the International Building Code and does require an impact resistant covering in areas requiring impact resistance.

Conclusion:

In my professional opinion, the DOR-BPRD Spigot Clamping System manufactured by Glass Warehouse is adequate for use under the limitations provided within this report.

I trust that this will satisfy your needs, however, feel free to call if you have any questions.



Certification of Independence: Please note that I do not have nor will I acquire a financial interest in any company manufacturing or distributing the product(s) for which this report is being issued. Also, I do not have nor will I acquire a financial interest in any other entity involved in the approval process of the listed product(s).

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Wind Loads on Fences or Guards

The wind load table below has been calculated in accordance with ASCE 7 section 29.4, Design Wind Loads on Solid Freestanding Wall and Solid Signs. This section is applicable for free standing building guard rails, wind walls, and balcony railings that return to building walls. The values listed in the table below are generic values for heights up to 15 ft and may not reflect the values needed for a specific jobsite. If site specific wind loads are required, a licensed engineer shall prepare site specific wind loads for use with this product.

| Wind Loads (PSF) | | | | | | |
|------------------|---|---------------------------------|---------------------------------|---|---------------------------------|---------------------------------|
| Wind Speed (mph) | W _{ASD} for C _f = 1.3 | | | W _{ASD} for C _f = 2.6 | | |
| | Exp. B K _z = 0.7 | Exp. C K _z = 0.85 | Exp. D K _z = 1.03 | Exp. B K _z = 0.7 | Exp. C K _z = 0.85 | Exp. D K _z = 1.03 |
| 100 | 9.50 | 11.53 | 13.98 | 19.00 | 23.07 | 27.95 |
| 110 | 11.49 | 13.95 | 16.91 | 22.98 | 27.91 | 33.82 |
| 120 | 13.68 | 16.61 | 20.12 | 27.35 | 33.21 | 40.25 |
| 130 | 16.05 | 19.49 | 23.62 | 32.10 | 38.98 | 47.24 |
| 140 | 18.62 | 22.60 | 27.39 | 37.23 | 45.21 | 54.78 |
| 150 | 21.37 | 25.95 | 31.44 | 42.74 | 51.90 | 62.89 |
| 160 | 24.31 | 29.52 | 35.78 | 48.63 | 59.05 | 71.55 |
| 170 | 27.45 | 33.33 | 40.39 | 54.90 | 66.66 | 80.78 |
| 180 | 30.77 | 37.37 | 45.28 | 61.54 | 74.73 | 90.56 |



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Table 2: Moment Amplification Factor for Uniform Wind Loading

| Glass Height (in.) | Glass Width (in.) | | | | |
|--------------------|-------------------|------|------|------|------|
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 1.98 | 2.53 | 3.15 | 3.55 | 3.75 |
| 42 | 2.01 | 2.60 | 3.20 | 3.61 | 3.81 |
| 48 | 2.07 | 2.67 | 3.27 | 3.68 | 3.89 |
| 60 | 2.12 | 2.72 | 3.32 | 3.32 | 3.95 |

Table 3: Deflection Amplification Factor for Live Loading

| Glass Height (in.) | Glass Width (in.) | | | | |
|--------------------|-------------------|------|------|------|------|
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 1.00 | 1.14 | 1.29 | 1.39 | 1.45 |
| 42 | 1.00 | 1.12 | 1.25 | 1.35 | 1.40 |
| 48 | 1.00 | 1.11 | 1.23 | 1.31 | 1.36 |
| 60 | 1.00 | 1.09 | 1.19 | 1.26 | 1.29 |

Table 4: Deflection Amplification Factor for Uniform Wind Loading

| Glass Height (in.) | Glass Width (in.) | | | | |
|--------------------|-------------------|------|------|------|------|
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 0.99 | 1.15 | 1.32 | 1.46 | 1.53 |
| 42 | 0.99 | 1.13 | 1.29 | 1.40 | 1.46 |
| 48 | 1.00 | 1.12 | 1.27 | 1.37 | 1.42 |
| 60 | 1.00 | 1.10 | 1.22 | 1.31 | 1.35 |

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Table 5: 1/2" Monolithic Tempered Glass Allowable Wind Load

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 39.64 | 31.00 | 24.96 | 22.13 | 20.93 |
| 42 | 28.70 | 22.18 | 18.01 | 15.98 | 15.13 |
| 48 | 21.36 | 16.56 | 13.51 | 12.00 | 11.36 |
| 60 | 13.36 | 10.41 | 8.51 | 8.51 | 7.15 |

Table 6: Deflection from 50 plf Load on 1/2" Monolithic Tempered Glass

| Deflection from 50plf Load (in.) | | | | | |
|----------------------------------|-------------------|------|------|------|------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 0.73 | 0.82 | 0.93 | 1.01 | 1.05 |
| 42 | 1.15 | 1.29 | 1.44 | 1.55 | 1.61 |
| 48 | 1.72 | 1.90 | 2.11 | 2.25 | 2.33 |
| 60 | 3.36 | 3.65 | 3.98 | 4.22 | 4.34 |

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Allowable Wind Load Tables for Laminated Glass

Table 7: 7/16" O.A. Laminated Glass: 3/16" Tempered Glass – 0.060" PVB – 3/16" Tempered Glass

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|------|------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 17.33 | 13.55 | 10.91 | 9.67 | 9.15 |
| 42 | 13.50 | 10.44 | 8.48 | 7.52 | 7.12 |
| 48 | 10.73 | 8.32 | 6.79 | 6.03 | 5.71 |
| 60 | 7.46 | 5.81 | 4.75 | 4.75 | 3.99 |

Table 8: 7/16" O.A. Laminated Glass: 3/16" Tempered Glass – 0.060" PVB Stiff – 3/16" Tempered Glass

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 23.30 | 18.22 | 14.67 | 13.01 | 12.31 |
| 42 | 17.92 | 13.85 | 11.25 | 9.98 | 9.45 |
| 48 | 13.96 | 10.82 | 8.83 | 7.84 | 7.43 |
| 60 | 9.29 | 7.24 | 5.91 | 5.91 | 4.97 |

Table 9: 7/16" O.A. Laminated Glass: 3/16" Tempered Glass – 0.060" SentryGlas – 3/16" Tempered Glass

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 29.74 | 23.25 | 18.72 | 16.60 | 15.70 |
| 42 | 21.88 | 16.91 | 13.73 | 12.18 | 11.53 |
| 48 | 16.46 | 12.76 | 10.41 | 9.25 | 8.75 |
| 60 | 10.43 | 8.13 | 6.64 | 6.64 | 5.58 |

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Table 10: 9/16" O.A. Laminated Glass: 1/4" Tempered Glass – 0.090" PVB – 1/4" Tempered Glass

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 23.83 | 18.63 | 15.00 | 13.30 | 12.58 |
| 42 | 18.45 | 14.26 | 11.58 | 10.27 | 9.72 |
| 48 | 14.60 | 11.32 | 9.23 | 8.20 | 7.76 |
| 60 | 10.12 | 7.89 | 6.44 | 6.44 | 5.42 |

Table 11: 9/16" O.A. Laminated Glass: 1/4" Tempered Glass – 0.090" PVB Stiff – 1/4" Tempered Glass

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 31.65 | 24.75 | 19.93 | 17.67 | 16.72 |
| 42 | 24.41 | 18.87 | 15.32 | 13.60 | 12.87 |
| 48 | 19.08 | 14.79 | 12.07 | 10.72 | 10.15 |
| 60 | 12.78 | 9.96 | 8.14 | 8.14 | 6.84 |

Table 12: 9/16" O.A. Laminated Glass: 1/4" Tempered Glass – 0.090" SentryGlas – 1/4" Tempered Glass

| Allowable Wind Load (PSF) | | | | | |
|---------------------------|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 41.35 | 32.33 | 26.03 | 23.08 | 21.84 |
| 42 | 30.51 | 23.58 | 19.15 | 16.99 | 16.08 |
| 48 | 22.99 | 17.83 | 14.55 | 12.92 | 12.23 |
| 60 | 14.61 | 11.38 | 9.30 | 9.30 | 7.82 |

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DOR-BPRD Spigot Installation

Anchor Schedule

| Anchor Schedule | | | | |
|---------------------------|-------------------------|---|--------------------------|--------------------------|
| Substrate | Anchor Type | Min. Embedment (in.) | Min. Edge Distance (in.) | Allowable Moment (in-lb) |
| Wood SG = 0.55 min. | 5/16" ASTM F593 Bolt | 3.00 | 1.00 | 4313.76 |
| Concrete 3000 PSI min. | 1/4" Dewalt Screw-Bolt+ | 2.50 | 2.50 | 4058.78 |
| Steel 16 Ga. Min. | 5/16" ASTM F593 Bolt | Min. 3 threads penetration past steel structure | 0.50 | 11215.38 |

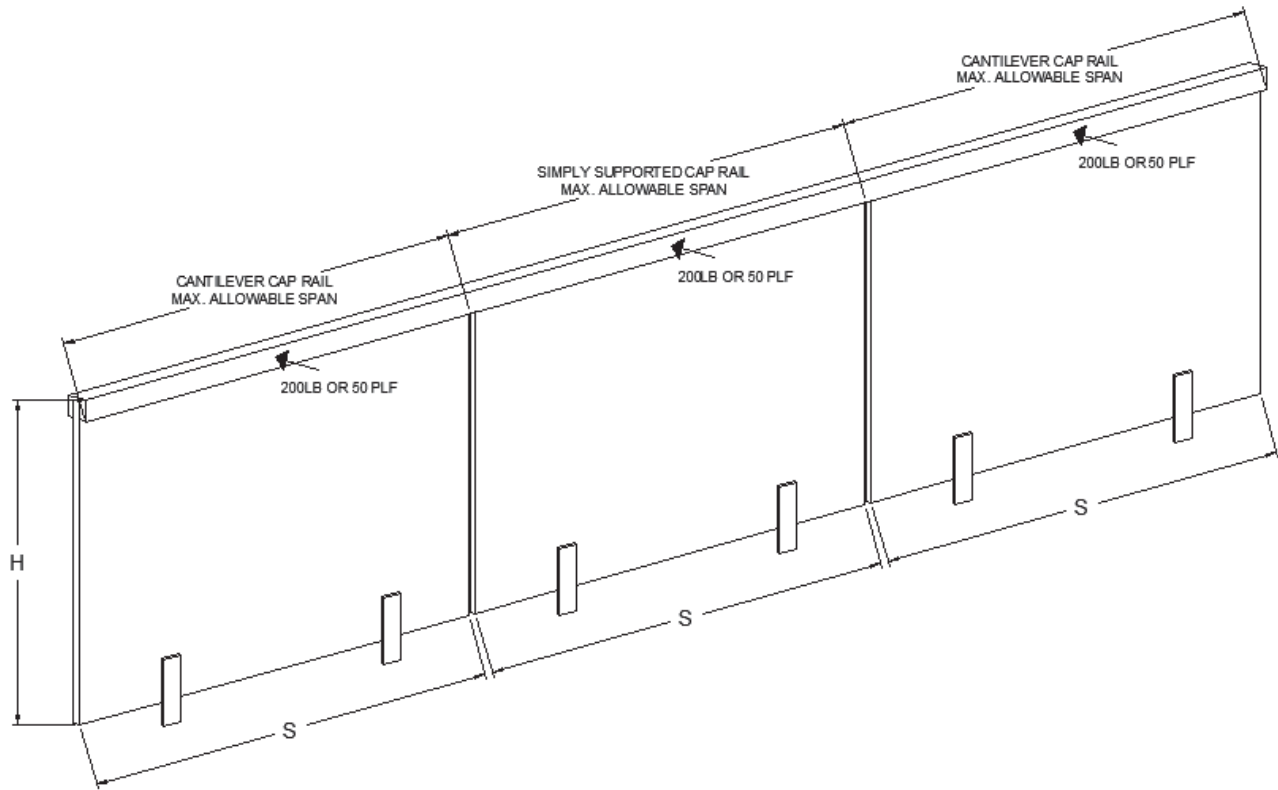
Table 13: Installation Design Pressure Table

| Spigot Base Installation Allowable Wind Load (PSF) | | | | | |
|--|-------------------|-------|-------|-------|-------|
| Glass Height (in.) | Glass Width (in.) | | | | |
| | 36 | 48 | 60 | 68 | 72 |
| 36 | 102.14 | 76.60 | 61.28 | 54.07 | 51.07 |
| 42 | 73.80 | 55.35 | 44.28 | 39.07 | 36.90 |
| 48 | 55.80 | 41.85 | 33.48 | 29.54 | 27.90 |
| 60 | 35.10 | 26.32 | 21.06 | 18.58 | 17.55 |

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Cap Rail Allowable Span Calculations

Guard applications require a top rail or handrail. The rail shall have adequate strength to support the live load of 200 lb concentrated or 50 plf distributed load assuming the failure of one glass light at the location of the loading. No US building codes or adopted standards define the limit state of the guard cap rail for this condition. IBC 2407.1.2 states “shall be otherwise supported to remain in place should one baluster fail.” There is no additional explanation in the IBC as to how this is to be determined. ICC Acceptance Criteria 439 was adopted to provide a methodology for determining if a glass balustrade guard meets the requirements of IBC 2407. ICC AC 439 requires the rail to be capable of supporting a 334# load (SF = 1.67 for 200# load) with no more than 12” deflection, yielding or other damage is permitted since the loss of a glass light will necessitate guard repairs. For light failure only the horizontal load case applies for laminated glass.



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COR-AHS Cap Rail Allowable Span



Area = 0.8134 in²
 Perim. = 13.9414 in
 Ixx = 0.1621 in⁴
 Iyy = 0.2794 in⁴
 rxx = 0.4464 in
 ryy = 0.5861 in
 Cxx = 0.7874 in
 Cyy = 0.5723 in
 Sxx = 0.2832 in³
 Syy = 0.3548 in³
 t = 0.1181 in
 w = 0.70865 in
 Material = Aluminum
 Fy = 37 ksi
 Fu = 42 ksi

$$F_{cr} = \frac{\pi^2 k \eta E_o}{12(1-\mu^2)(w/t)^2}$$

η (Plasticity Reduction Factor) = 0.62 (Table A6a)
 K (plate buckling coef.) = 3.50 (Section 2)
 E_o = 10100 ksi
 μ (Poisson's Ratio) = 0.33 (Elastic Range)

$$\eta = \sqrt{\frac{E_t}{E_o}}$$

F_{cr} = 562.17 ksi

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$$M_n = 1.25S_eF_y$$

$$M_n \text{ Vertical Load} = 13.1000 \text{ k-in}$$

$$M_n \text{ Horizontal Load} = 16.4113 \text{ k-in}$$

$$M_{nult} = S_eF_{cr}$$

$$M_{ULT} \text{ Vertical Load} = 159.2321 \text{ k-in}$$

$$M_{ULT} \text{ Horizontal Load} = 199.4814 \text{ k-in}$$

Simply Supported Rail

$$M_w = wL^2/10$$

$$L_{\text{uniform Vert.}} = 177.31 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 198.46 \text{ in}$$

$$M_c = PL/5$$

$$L_{\text{concentrated vert.}} = 327.50 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 410.28 \text{ in}$$

Allowable Rail Span = 177 in = 14.75 ft

Cantilever Supported Rail

$$M_{wc} = wL^2/2$$

$$L_{\text{uniform Vert.}} = 79.30 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 88.75 \text{ in}$$

$$M_{cc} = PL$$

$$L_{\text{concentrated vert.}} = 65.50 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 82.06 \text{ in}$$

Allowable Rail Span = 65 in = 5.42 ft

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R7 DRA-AHR42 Cap Rail Allowable Span



Area = 0.7087 in²
 Perim. = 11.598 in
 Ixx = 0.1141 in⁴
 Iyy = 0.2143 in⁴
 rxx = 0.4012 in
 ryy = 0.5499 in
 Cxx = 0.8277 in
 Cyy = 0.8015 in
 Sxx = 0.1424 in³
 Syy = 0.2589 in³
 t = 0.1181 in
 w = 0.72305 in
 Material = Aluminum
 Fy = 37 ksi
 Fu = 42 ksi

$$F_{cr} = \frac{\pi^2 k \eta E_o}{12(1-\mu^2)(w/t)^2}$$

η (Plasticity Reduction Factor) = 0.62 (Table A6a)
 K (plate buckling coef.) = 4 (Section 2)
 E_o = 10100 ksi
 μ (Poisson's Ratio) = 0.33 (Elastic Range)

$$\eta = \sqrt{\frac{E_t}{E_o}}$$

F_{cr} = 616.78 ksi

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$$M_n = 1.25S_eF_y$$

M_n Vertical Load = 6.5841 k-in
 M_n Horizontal Load = 11.9746 k-in

$$M_{nult} = S_eF_{cr}$$

M_{ULT} Vertical Load = 87.8032 k-in
 M_{ULT} Horizontal Load = 159.6899 k-in

Simply Supported Rail

$$M_w = wL^2/10$$

$L_{uniform\ Vert.}$ = 125.70 in
 $L_{uniform\ Horiz.}$ = 169.53 in

$$M_c = PL/5$$

$L_{concentrated\ vert.}$ = 164.60 in
 $L_{concentrated\ horiz.}$ = 299.36 in

Allowable Rail Span = 125 in = 10.41667 ft

Cantilever Supported Rail

$$M_{wc} = wL^2/2$$

$L_{uniform\ Vert.}$ = 56.22 in
 $L_{uniform\ Horiz.}$ = 75.81 in

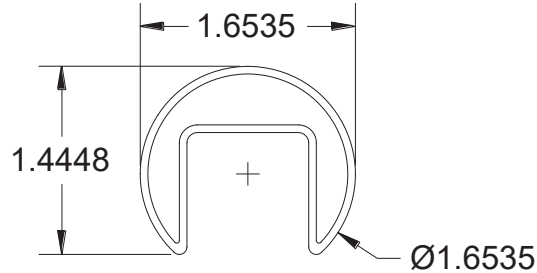
$$M_{cc} = PL$$

$L_{concentrated\ vert.}$ = 32.92 in
 $L_{concentrated\ horiz.}$ = 59.87 in

Allowable Rail Span = 32 in = 2.66667 ft

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R24 AGE-SHR42 Cap Rail Allowable Span



Area = 0.3905 in²
 Perim. = 13.2204 in
 Ixx = 0.0668 in⁴
 Iyy = 0.1178 in⁴
 rxx = 0.4135 in
 ryy = 0.5492 in
 Cxx = 0.8268 in
 Cyy = 0.7533 in
 Sxx = 0.0887 in³
 Syy = 0.1425 in³
 t = 0.059055 in
 w = 0.7224 in
 Material = 2205 Stainless Steel
 Fy = 65 ksi
 Fu = 90 ksi

$$F_{cr} = \frac{\pi^2 k \eta E_o}{12(1-\mu^2)(w/t)^2}$$

η (Plasticity Reduction Factor) = 0.62 (Table A6a)
 K (plate buckling coef.) = 4 (Section 2)
 E_o = 29000 ksi
 μ (Poisson's Ratio) = 0.3 (Elastic Range)

$$\eta = \sqrt{\frac{E_t}{E_o}}$$

F_{cr} = 434.40 ksi

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$$M_n = 1.25 S_e F_y$$

$$M_n \text{ Vertical Load} = 7.2050 \text{ k-in}$$

$$M_n \text{ Horizontal Load} = 11.5763 \text{ k-in}$$

$$M_{mult} = S_e F_{cr}$$

$$M_{ULT} \text{ Vertical Load} = 38.5208 \text{ k-in}$$

$$M_{ULT} \text{ Horizontal Load} = 61.8915 \text{ k-in}$$

Simply Supported Rail

$$M_w = wL^2/10$$

$$L_{\text{uniform Vert.}} = 131.50 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 166.68 \text{ in}$$

$$M_c = PL/5$$

$$L_{\text{concentrated vert.}} = 180.12 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 289.41 \text{ in}$$

$$\text{Allowable Rail Span} = 131 \text{ in} = 10.92 \text{ ft}$$

Cantilever Supported Rail

$$M_{wc} = wL^2/2$$

$$L_{\text{uniform Vert.}} = 58.81 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 74.54 \text{ in}$$

$$M_{cc} = PL$$

$$L_{\text{concentrated vert.}} = 36.02 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 57.88 \text{ in}$$

$$\text{Allowable Rail Span} = 36 \text{ in} = 3.00 \text{ ft}$$

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HG25S XS Cap Rail Allowable Span



Area = 0.2071 in²
 Perim. = 8.7687 in
 I_{xx} = 0.0143 in⁴
 I_{yy} = 0.0261 in⁴
 r_{xx} = 0.2629 in
 r_{yy} = 0.3548 in
 C_{xx} = 0.4921 in
 C_{yy} = 0.4685 in
 S_{xx} = 0.0305 in³
 S_{yy} = 0.0530 in³
 t = 0.0472 in
 w = 0.4134 in

Material = 2205 Stainless Steel

F_y = 65 ksi
 F_u = 90 ksi

$$F_{cr} = \frac{\pi^2 k \eta E_o}{12(1-\mu^2)(w/t)^2}$$

η (Plasticity Reduction Factor) = 0.62 (Table A6a)

K (plate buckling coef.) = 4 (Section 2)

E_o = 29000 ksi

μ (Poisson's Ratio) = 0.3 (Elastic Range)

$$\eta = \sqrt{\frac{E_t}{E_o}}$$

F_{cr} = 847.36 ksi

| | | | |
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$$M_n = 1.25S_eF_y$$

$$M_n \text{ Vertical Load} = 2.4800 \text{ k-in}$$

$$M_n \text{ Horizontal Load} = 4.3093 \text{ k-in}$$

$$M_{nult} = S_eF_{cr}$$

$$M_{ULT} \text{ Vertical Load} = 25.8640 \text{ k-in}$$

$$M_{ULT} \text{ Horizontal Load} = 44.9425 \text{ k-in}$$

Simply Supported Rail

$$M_w = wL^2/10$$

$$L_{\text{uniform Vert.}} = 77.15 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 101.70 \text{ in}$$

$$M_c = PL/5$$

$$L_{\text{concentrated vert.}} = 62.00 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 107.73 \text{ in}$$

Allowable Rail Span = 61 in = 5.08 ft

Cantilever Supported Rail

$$M_{wc} = wL^2/2$$

$$L_{\text{uniform Vert.}} = 34.50 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 45.48 \text{ in}$$

$$M_{cc} = PL$$

$$L_{\text{concentrated vert.}} = 12.40 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 21.55 \text{ in}$$

Allowable Rail Span = 12 in = 1.00 ft

| | | | |
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R15 MAT-SHS Cap Rail Allowable Span



Area = 0.4022 in²
 Perim. = 13.621 in
 Ixx = 0.0588 in⁴
 Iyy = 0.1302 in⁴
 rxx = 0.3824 in
 ryy = 0.569 in
 Cxx = 0.7874 in
 Cyy = 0.7041 in
 Sxx = 0.0835 in³
 Syy = 0.1654 in³
 t = 0.0591 in
 w = 0.59055 in

Material = 2205 Stainless Steel

Fy = 65 ksi
 Fu = 90 ksi

$$F_{cr} = \frac{\pi^2 k \eta E_o}{12(1-\mu^2)(w/t)^2}$$

η (Plasticity Reduction Factor) = 0.62 (Table A6a)
 K (plate buckling coef.) = 4 (Section 2)
 E_o = 29000 ksi
 μ (Poisson's Ratio) = 0.3 (Elastic Range)

$$\eta = \sqrt{\frac{E_t}{E_o}}$$

F_{cr} = 651.01 ksi

| | | | |
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$$M_n = 1.25 S_e F_y$$

$$M_n \text{ Vertical Load} = 6.7853 \text{ k-in}$$

$$M_n \text{ Horizontal Load} = 13.4350 \text{ k-in}$$

$$M_{nult} = S_e F_{cr}$$

$$M_{ULT} \text{ Vertical Load} = 54.3665 \text{ k-in}$$

$$M_{ULT} \text{ Horizontal Load} = 107.6475 \text{ k-in}$$

Simply Supported Rail

$$M_w = wL^2/10$$

$$L_{\text{uniform Vert.}} = 127.61 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 179.57 \text{ in}$$

$$M_c = PL/5$$

$$L_{\text{concentrated vert.}} = 169.63 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 335.88 \text{ in}$$

Allowable Rail Span = 127 in = 10.58 ft

Cantilever Supported Rail

$$M_{wc} = wL^2/2$$

$$L_{\text{uniform Vert.}} = 57.07 \text{ in}$$

$$L_{\text{uniform Horiz.}} = 80.30 \text{ in}$$

$$M_{cc} = PL$$

$$L_{\text{concentrated vert.}} = 33.93 \text{ in}$$

$$L_{\text{concentrated horiz.}} = 67.18 \text{ in}$$

Allowable Rail Span = 33 in = 2.75 ft

| | | | |
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APPENDIX

| | | | |
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Determination of moment and amplification factors

Glass Panel Width: 36 in Uniform Load: 50 plf

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 1800 | 2100 | 2400 | 3000 |
| Calculated Stress (psi) | 4090.90 | 4772.72 | 5454.54 | 6818.17 |
| Stress by FEA (psi) | 8729 | 10250 | 11920 | 15110 |
| β | 2.1338 | 2.1476 | 2.1853 | 2.2161 |
| Calculated Defl. (in.) | 0.7246 | 1.1506 | 1.7175 | 3.3545 |
| Defl. by FEA (in.) | 0.726 | 1.153 | 1.720 | 3.358 |
| λ | 1.00196 | 1.00208 | 1.00144 | 1.00103 |

Glass Panel Width: 36 in Wind Load: 10 PSF

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 540 | 735 | 960 | 1500 |
| Calculated Stress (psi) | 1227.27 | 1670.45 | 2181.81 | 3409.08 |
| Stress by FEA (psi) | 2431 | 3358 | 4512 | 7213 |
| β | 1.9808 | 2.0102 | 2.0680 | 2.1158 |
| Calculated Defl. (in.) | 0.1630 | 0.3020 | 0.5153 | 1.2580 |
| Defl. by FEA (in.) | 0.162 | 0.300 | 0.513 | 1.255 |
| λ | 0.9937 | 0.9933 | 0.9956 | 0.9977 |

| | | | |
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Glass Panel Width: 48 in Uniform Load: 50 plf

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 1800 | 2100 | 2400 | 3000 |
| Calculated Stress (psi) | 4090.90 | 4772.72 | 5454.54 | 6818.17 |
| Stress by FEA (psi) | 11080 | 13150 | 15300 | 19280 |
| β | 2.7084 | 2.7552 | 2.8050 | 2.8277 |
| Calculated Defl. (in.) | 0.7246 | 1.1506 | 1.7175 | 3.3545 |
| Defl. by FEA (in.) | 0.823 | 1.288 | 1.901 | 3.646 |
| λ | 1.1358 | 1.1194 | 1.1068 | 1.0869 |

Glass Panel Width: 48 in Wind Load: 10 PSF

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 540 | 735 | 960 | 1500 |
| Calculated Stress (psi) | 1227.27 | 1670.45 | 2181.81 | 3409.08 |
| Stress by FEA (psi) | 3109 | 4344 | 5820 | 9257 |
| β | 2.5333 | 2.6005 | 2.6675 | 2.7154 |
| Calculated Defl. (in.) | 0.1630 | 0.3020 | 0.5153 | 1.2580 |
| Defl. by FEA (in.) | 0.187 | 0.342 | 0.578 | 1.388 |
| λ | 1.1470 | 1.1323 | 1.1218 | 1.1034 |

| | | | |
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Glass Panel Width: 60 in Uniform Load: 50 plf

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 1800 | 2100 | 2400 | 3000 |
| Calculated Stress (psi) | 4090.90 | 4772.72 | 5454.54 | 6818.17 |
| Stress by FEA (psi) | 13700 | 16140 | 18690 | 23550 |
| β | 3.3489 | 3.3817 | 3.4265 | 3.4540 |
| Calculated Defl. (in.) | 0.7246 | 1.1506 | 1.7175 | 3.3545 |
| Defl. by FEA (in.) | 0.932 | 1.442 | 2.106 | 3.978 |
| λ | 1.2863 | 1.2532 | 1.2262 | 1.1859 |

Glass Panel Width: 60 in Wind Load: 10 PSF

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 540 | 735 | 960 | 1500 |
| Calculated Stress (psi) | 1227.27 | 1670.45 | 2181.81 | 3409.08 |
| Stress by FEA (psi) | 3861 | 5350 | 7132 | 11330 |
| β | 3.1460 | 3.2027 | 3.2688 | 3.3235 |
| Calculated Defl. (in.) | 0.1630 | 0.3020 | 0.5153 | 1.2580 |
| Defl. by FEA (in.) | 0.215 | 0.390 | 0.652 | 1.539 |
| λ | 1.3188 | 1.2912 | 1.2654 | 1.2234 |

| | | | |
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Glass Panel Width: 68 in Uniform Load: 50 plf

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 1800 | 2100 | 2400 | 3000 |
| Calculated Stress (psi) | 4090.90 | 4772.72 | 5454.54 | 6818.17 |
| Stress by FEA (psi) | 15430 | 18150 | 21020 | 26470 |
| β | 3.7718 | 3.8029 | 3.8537 | 3.8823 |
| Calculated Defl. (in.) | 0.7246 | 1.1506 | 1.7175 | 3.3545 |
| Defl. by FEA (in.) | 1.01 | 1.552 | 2.254 | 4.219 |
| λ | 1.3939 | 1.3488 | 1.3124 | 1.2577 |

Glass Panel Width: 68 in Wind Load: 10 PSF

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 540 | 735 | 960 | 1500 |
| Calculated Stress (psi) | 1227.27 | 1670.45 | 2181.81 | 3409.08 |
| Stress by FEA (psi) | 4355 | 6029 | 8031 | 11330 |
| β | 3.5485 | 3.6092 | 3.6809 | 3.3235 |
| Calculated Defl. (in.) | 0.1630 | 0.3020 | 0.5153 | 1.2580 |
| Defl. by FEA (in.) | 0.238 | 0.423 | 0.704 | 1.648 |
| λ | 1.4598 | 1.4005 | 1.3663 | 1.3101 |

| | | | |
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Glass Panel Width: 72 in Uniform Load: 50 pif

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 1800 | 2100 | 2400 | 3000 |
| Calculated Stress (psi) | 4090.90 | 4772.72 | 5454.54 | 6818.17 |
| Stress by FEA (psi) | 16300 | 19170 | 22190 | 27940 |
| β | 3.9845 | 4.0166 | 4.0682 | 4.0979 |
| Calculated Defl. (in.) | 0.7246 | 1.1506 | 1.7175 | 3.3545 |
| Defl. by FEA (in.) | 1.05 | 1.609 | 2.331 | 4.344 |
| λ | 1.4491 | 1.3984 | 1.3572 | 1.2950 |

Glass Panel Width: 72 in Wind Load: 10 PSF

| Height | 36 | 42 | 48 | 60 |
|-------------------------|---------|---------|---------|---------|
| Mave (lb-in) | 540 | 735 | 960 | 1500 |
| Calculated Stress (psi) | 1227.27 | 1670.45 | 2181.81 | 3409.08 |
| Stress by FEA (psi) | 4603 | 6370 | 8483 | 13470 |
| β | 3.7506 | 3.8133 | 3.8880 | 3.9512 |
| Calculated Defl. (in.) | 0.1630 | 0.3020 | 0.5153 | 1.2580 |
| Defl. by FEA (in.) | 0.25 | 0.441 | 0.730 | 1.704 |
| λ | 1.5335 | 1.4601 | 1.4168 | 1.3546 |

| | | | |
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Determination of Effective Thickness of Laminated Glass

3/16 + 0.06 PVB + 3/16 = 7/16 Laminated Glass

Glass Ply 1 Nominal Thickness: 3/16 in
 Glass Ply 2 Nominal Thickness: 3/16 in
 Interlayer Type: PVB
 Interlayer Complex Shear Modulus: 70 psi

Laminate Nominal Thickness: 7/16 in
 Glass Temper: Fully Tempered:

Glass Ply 1 min. Thickness (h1): 0.18 in
 Glass Ply 2 min. Thickness (h2): 0.18 in
 Interlayer Thickness (hv): 0.060 in

Laminate Minimum Thickness (hs): 0.240 in
 Ply 1 weighted Thickness (hs1): 0.120 in
 Ply 2 weighted Thickness (hs2): 0.120 in

Glass Inertia (Is): 0.0052 in³

| Height Dimension (in) | Shear Transfer Coefficient (Γ) | Effective Thickness for Deflection (h _{ef} ;w) | Effective thickness for Bending (h ₁ ;e _f ;σ) | Effective thickness for Bending (h ₂ ;e _f ;σ) |
|-----------------------|--------------------------------|---|---|---|
| 24 | 0.070 | 0.252 | 0.285 | 0.285 |
| 30 | 0.105 | 0.263 | 0.298 | 0.298 |
| 36 | 0.144 | 0.274 | 0.310 | 0.310 |
| 42 | 0.186 | 0.285 | 0.322 | 0.322 |
| 48 | 0.230 | 0.296 | 0.332 | 0.332 |
| 54 | 0.275 | 0.306 | 0.342 | 0.342 |
| 60 | 0.319 | 0.316 | 0.350 | 0.350 |
| 66 | 0.361 | 0.324 | 0.358 | 0.358 |
| 72 | 0.402 | 0.332 | 0.364 | 0.364 |

| | | | |
|--|-------------------------|--|--|
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3/16 + 0.06 PVB ES + 3/16 = 7/16 Laminated Glass

Glass Ply 1 Nominal Thickness: 3/16 in
 Glass Ply 2 Nominal Thickness: 3/16 in
 Interlayer Type: PVB ES
 Interlayer Complex Shear Modulus: 246.56 psi

Laminate Nominal Thickness: 7/16 in
 Glass Temper: Fully Tempered:

Glass Ply 1 min. Thickness (h1): 0.18 in
 Glass Ply 2 min. Thickness (h2): 0.18 in
 Interlayer Thickness (hv): 0.060 in
 Laminate Minimum Thickness (hs): 0.240 in
 Ply 1 weighted Thickness (hs1): 0.120 in
 Ply 2 weighted Thickness (hs2): 0.120 in

Glass Inertia (Is): 0.0052 in³

| Height Dimension (in) | Shear Transfer Coefficient (Γ) | Effective Thickness for Deflection (hef;w) | Effective thickness for Bending (h1;ef,σ) | Effective thickness for Bending (h2;ef,σ) |
|-----------------------|--------------------------------|--|---|---|
| 24 | 0.208 | 0.291 | 0.327 | 0.327 |
| 30 | 0.292 | 0.310 | 0.345 | 0.345 |
| 36 | 0.372 | 0.327 | 0.360 | 0.360 |
| 42 | 0.447 | 0.340 | 0.371 | 0.371 |
| 48 | 0.513 | 0.352 | 0.379 | 0.379 |
| 54 | 0.571 | 0.361 | 0.386 | 0.386 |
| 60 | 0.622 | 0.369 | 0.391 | 0.391 |
| 66 | 0.666 | 0.376 | 0.395 | 0.395 |
| 72 | 0.703 | 0.381 | 0.399 | 0.399 |

| | | | |
|--|-------------------------|--|--|
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3/16 + 0.06 SGP + 3/16 = 7/16 Laminated Glass

Glass Ply 1 Nominal Thickness: 3/16 in
 Glass Ply 2 Nominal Thickness: 3/16 in
 Interlayer Type: SGP
 Interlayer Complex Shear Modulus: 1638.9 psi

Laminate Nominal Thickness: 7/16 in
 Glass Temper: Fully Tempered:

Glass Ply 1 min. Thickness (h1): 0.18 in
 Glass Ply 2 min. Thickness (h2): 0.18 in
 Interlayer Thickness (hv): 0.060 in

Laminate Minimum Thickness (hs): 0.240 in
 Ply 1 weighted Thickness (hs1): 0.120 in
 Ply 2 weighted Thickness (hs2): 0.120 in

Glass Inertia (Is): 0.0052 in⁴

| Height Dimension (in) | Shear Transfer Coefficient (Γ) | Effective Thickness for Deflection (hef;w) | Effective thickness for Bending (h1;ef;σ) | Effective thickness for Bending (h2;ef;σ) |
|-----------------------|--------------------------------|--|---|---|
| 24 | 0.636 | 0.372 | 0.393 | 0.393 |
| 30 | 0.732 | 0.385 | 0.401 | 0.401 |
| 36 | 0.798 | 0.394 | 0.406 | 0.406 |
| 42 | 0.843 | 0.400 | 0.410 | 0.410 |
| 48 | 0.875 | 0.404 | 0.412 | 0.412 |
| 54 | 0.899 | 0.407 | 0.413 | 0.413 |
| 60 | 0.916 | 0.410 | 0.414 | 0.414 |
| 66 | 0.930 | 0.411 | 0.415 | 0.415 |
| 72 | 0.940 | 0.412 | 0.416 | 0.416 |

| | | | |
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1/4 + 0.06 PVB + 1/4 = 9/16 Laminated Glass

Glass Ply 1 Nominal Thickness: 1/4 in
 Glass Ply 2 Nominal Thickness: 1/4 in
 Interlayer Type: PVB
 Interlayer Complex Shear Modulus: 70 psi

Laminate Nominal Thickness: 9/16 in
 Glass Temper: Fully Tempered:

Glass Ply 1 min. Thickness (h1): 0.219 in
 Glass Ply 2 min. Thickness (h2): 0.219 in
 Interlayer Thickness (hv): 0.060 in

Laminate Minimum Thickness (hs): 0.279 in
 Ply 1 weighted Thickness (hs1): 0.140 in
 Ply 2 weighted Thickness (hs2): 0.140 in

Glass Inertia (Is): 0.0085 in³

| Height Dimension (in) | Shear Transfer Coefficient (Γ) | Effective Thickness for Deflection (hef;w) | Effective thickness for Bending (h1;ef;σ) | Effective thickness for Bending (h2;ef;σ) |
|-----------------------|--------------------------------|--|---|---|
| 24 | 0.058 | 0.300 | 0.338 | 0.338 |
| 30 | 0.088 | 0.311 | 0.351 | 0.351 |
| 36 | 0.121 | 0.322 | 0.364 | 0.364 |
| 42 | 0.158 | 0.334 | 0.376 | 0.376 |
| 48 | 0.197 | 0.345 | 0.388 | 0.388 |
| 54 | 0.237 | 0.356 | 0.399 | 0.399 |
| 60 | 0.278 | 0.367 | 0.408 | 0.408 |
| 66 | 0.317 | 0.377 | 0.417 | 0.417 |
| 72 | 0.356 | 0.386 | 0.425 | 0.425 |

| | | | |
|--|-------------------------|--|-----------------------|
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1/4 + 0.06 PVB ES + 1/4 = 9/16 Laminated Glass

Glass Ply 1 Nominal Thickness: 1/4 in
 Glass Ply 2 Nominal Thickness: 1/4 in
 Interlayer Type: PVB ES
 Interlayer Complex Shear Modulus: 246.56 psi

Laminate Nominal Thickness: 9/16 in
 Glass Temper: Fully Tempered:

Glass Ply 1 min. Thickness (h1): 0.219 in
 Glass Ply 2 min. Thickness (h2): 0.219 in
 Interlayer Thickness (hv): 0.060 in

Laminate Minimum Thickness (hs): 0.279 in
 Ply 1 weighted Thickness (hs1): 0.140 in
 Ply 2 weighted Thickness (hs2): 0.140 in

Glass Inertia (Is): 0.0085 in³

| Height Dimension (in) | Shear Transfer Coefficient (Γ) | Effective Thickness for Deflection (hef;w) | Effective thickness for Bending (h1;ef,σ) | Effective thickness for Bending (h2;ef,σ) |
|-----------------------|--------------------------------|--|---|---|
| 24 | 0.178 | 0.340 | 0.382 | 0.382 |
| 30 | 0.253 | 0.361 | 0.402 | 0.402 |
| 36 | 0.328 | 0.379 | 0.419 | 0.419 |
| 42 | 0.399 | 0.395 | 0.433 | 0.433 |
| 48 | 0.464 | 0.409 | 0.443 | 0.443 |
| 54 | 0.523 | 0.421 | 0.452 | 0.452 |
| 60 | 0.575 | 0.431 | 0.459 | 0.459 |
| 66 | 0.621 | 0.439 | 0.464 | 0.464 |
| 72 | 0.661 | 0.446 | 0.469 | 0.469 |

| | | | |
|--|-------------------------|--|-----------------------|
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1/4 + 0.06 SGP + 1/4 = 9/16 Laminated Glass

Glass Ply 1 Nominal Thickness: 1/4 in
 Glass Ply 2 Nominal Thickness: 1/4 in
 Interlayer Type: SGP
 Interlayer Complex Shear Modulus: 1638.9 psi

Laminate Nominal Thickness: 9/16 in
 Glass Temper: Fully Tempered:

Glass Ply 1 min. Thickness (h1): 0.219 in
 Glass Ply 2 min. Thickness (h2): 0.219 in
 Interlayer Thickness (hv): 0.060 in
 Laminate Minimum Thickness (hs): 0.279 in
 Ply 1 weighted Thickness (hs1): 0.140 in
 Ply 2 weighted Thickness (hs2): 0.140 in

Glass Inertia (Is): 0.0085 in³

| Height Dimension (in) | Shear Transfer Coefficient (Γ) | Effective Thickness for Deflection (hef;w) | Effective thickness for Bending (h1;ef;σ) | Effective thickness for Bending (h2;ef;σ) |
|-----------------------|--------------------------------|--|---|---|
| 24 | 0.590 | 0.433 | 0.461 | 0.461 |
| 30 | 0.692 | 0.451 | 0.472 | 0.472 |
| 36 | 0.764 | 0.463 | 0.479 | 0.479 |
| 42 | 0.815 | 0.471 | 0.484 | 0.484 |
| 48 | 0.852 | 0.476 | 0.487 | 0.487 |
| 54 | 0.879 | 0.481 | 0.489 | 0.489 |
| 60 | 0.900 | 0.484 | 0.490 | 0.490 |
| 66 | 0.916 | 0.486 | 0.492 | 0.492 |
| 72 | 0.928 | 0.488 | 0.493 | 0.493 |

| | | | |
|--|-------------------------|--|-----------------------|
| Project Description: Glass Warehouse/Future Glass DOR-BPRD Spigot Engineering Analysis | Date: February 11, 2025 | Customer: Glass Warehouse/Future Glass | |
| | | Project #: EEV-24-0853 | |
| | Engineer: SH | PER: 9534 | Page #: Page 33 of 33 |