

27 March 2013

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**SUBJ: CRL SRS STANDOFF RAILING SYSTEM
GLASS BALUSTRADE GUARDS**

The SRS Standoff Railing System is an engineered guardrail system that utilizes point supported glass balustrades. When constructed in accordance with the attached details and installation guidelines the guardrail will safely support the following loading conditions:

- 200 pound point load on top rail, vertical or horizontal
- 50 plf load on top rail, vertical or horizontal or
- 25 psf uniform load on glass panel horizontal or
- 50 lb conc load on 1 sf

Wind load 25 psf or higher loads in accordance with the wind load tables herein.

For single family residential construction only the 200# concentrated top rail load, 50# concentrated load and wind load are applicable.

The SRS is to be used with tempered glass only, laminated or monolithic. Laminated glass shall be made with DuPont SentryGlas+ interlayer.

Glass light stresses may be evaluated using either the simplified methods shown herein or by finite element analysis models for the specific proposed installation.

For these conditions the railing meets applicable requirements of the 2006, 2009 and 2012 International Building Code and state codes adopted from the IBC codes, SEI/ASCE 8-02 and all requirements of ASTM E 2358-04.

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Typical Installation:

For **single family residential**:

1/2" tempered glass

2 pairs of standoffs:

Interior installation, 5' maximum width and 44" maximum height above standoffs.

Exterior installation 4' maximum width and 44" maximum height above standoffs, 15.3 psf.

3 pairs of standoffs:

Interior installation, 7' maximum width and 44" maximum height above standoffs.

Exterior installation 5' maximum width and 44" maximum height above standoffs, 15.9 psf.

For commercial and other applications:

3/4" tempered glass

2 pairs of standoffs:

5'-6" maximum width and 44" maximum height above standoffs, 30.8 psf.

3 pairs of standoffs:

7' maximum width and 44" maximum height above standoffs, 28 psf.

For other light sizes and wind loads refer to the equations and figures herein.

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Signature Page

Signed 03/28/2013

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GLASS BALUSTRADE GUARD RAIL GLASS STRENGTH

All glass is fully tempered glass conforming to the specifications of ANSI Z97.1, ASTM C 1048-97b and CPSC 16 CFR 1201. For the 1/2" glass the typical Modulus of Rupture, F_r is 24,000 psi. The applicable safety factor against glass rupture is 4.0 in accordance with IBC 2407.1.1

Allowable glass bending stress: $24,000/4 = 6,000$ psi. – Tension stress calculated.

Bending strength of glass for the given thickness:

$$S = \frac{12'' * (t)^2}{6} = 2 * (t)^2 \text{ in}^3/\text{ft}$$

Use the minimum glass thickness for stress calculations:

Figure 1

For 1/2" glass, $t_{\min} = 0.469''$; Weight = 6.5 psf

$$S = 2 * (0.469)^2 = 0.44 \text{ in}^3/\text{ft}$$

$$M_{\text{alive}} = 6,000 \text{ psi} * 0.44 \text{ in}^3/\text{ft} = 2,640''\#/\text{ft} = 220'\#$$

For 5/8" glass, $t_{\min} = 0.595''$; Weight = 9.8 psf

$$S = 2 * (0.595)^2 = 0.708 \text{ in}^3/\text{ft}$$

$$M_{\text{alive}} = 6,000 \text{ psi} * 0.708 \text{ in}^3/\text{ft} = 4,248''\#/\text{ft} = 354'\#$$

For 3/4" glass, $t_{\min} = 0.719''$; Weight = 9.8 psf

$$S = 2 * (0.719)^2 = 1.034 \text{ in}^3/\text{ft}$$

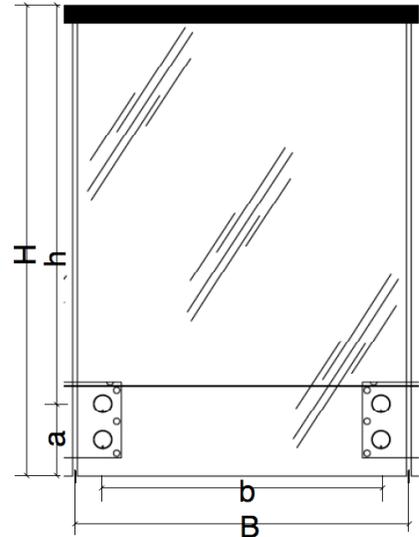
$$M_{\text{alive}} = 6,000 \text{ psi} * 1.034 \text{ in}^3/\text{ft} = 6,204''\#/\text{ft} = 517'\#$$

The allowable moments are based on the minimum glass thickness allowed for the nominal thickness. The section properties and allowable moments may be calculated based on the actual glass thickness supplied.

Laminated glass shall be evaluated based on the effective thickness determined in accordance with ASTM E1300 or the DuPont online laminated glass calculator.

For wind loading the allowable glass stress may be increased in accordance with ASTM E1300. It is recommended that a maximum allowable stress of 9,600 psi be used for wind loads. For wind loads the allowable moment may be taken as:

$$M_{\text{wind}} = M_{\text{alive}} * 9,600/6000 = 1.6 M_{\text{alive}}$$



For cantilevered elements basic beam theory for cantilevered beams is used.

$$M_u = \chi W * h^2 / 2 \text{ for uniform load } u \text{ or}$$

$$M_p = \chi P * h / B \text{ for concentrated load } P \text{ or}$$

$$M_U = \chi U * h \text{ for uniform top rail load } U \text{ or}$$

$$M_w = \chi W * h^2 * 0.55 \text{ for uniform wind load } W$$

Where χ is the moment amplification factor accounting for the increased maximum moment caused by the point supports. Where:

$$x = f(\alpha) \text{ where the function is derived from FEA models and}$$

$$\alpha = B/h$$

MOMENT AMPLIFICATION FACTORS:

The moment amplification factors were derived from a series of FEA models. The equations are applicable for the geometric configurations shown. In lieu of using the amplification factors shown herein the glass light stresses may be evaluated using either the simplified methods shown herein or by finite element analysis models for the specific proposed installation.

GLASS PANELS LOADS:

From IBC 1607.7

On hand rail or top of glass – 200lb concentrated or 50 plf
Any direction

Or On panel – 25 psf horizontal load

Or Wind load horizontal to glass either direction.

For vertical glass dead loads will not cause glass bending stress and glass bearing stresses are small and may be ignored.

ALLOWABLE WIND LOAD

Allowable wind load pressure may be calculated from:

$$W = 1.6 * M_{\text{alive}} / (\chi * 0.55 * h^2) = 2.9 * M_{\text{alive}} / (\chi * h^2)$$

WIND LOADING

For wind load surface area is full area of guard:

Calculated in accordance with SEI/ASCE 7 Section 6.5.13 Design Wind Loads on Open Buildings and Other Structures. This section is applicable for free standing building guardrails, wind walls and balcony railings that return to building walls. Section 6.5.12.4.4 Parapets may be applicable when the rail is along a roof perimeter. **Actual wind loads must be determined by a qualified individual for a specific installation.**

$$p = q_p(GC_p) = q_zGC_f \text{ (SEI/ASCE 7-05 eq. 6-26)}$$

For guardrails the coefficients have the following values:

$G = 0.925$ from section 6.5.8.2 for a very flexible structure.

$C_f = 2.5 * 0.8 * 0.6 = 1.2$ Figure 6-20 with reduction for solid and end returns, will vary.

$Q_z = K_zK_{zt}K_dV^2I$ Where:

$$I = 1.0$$

K_z from Table 6-3 at the height z of the railing centroid and exposure.

$K_d = 0.85$ from Table 6-4.

K_{zt} From Figure 6-4 for the site topography, typically 1.0.

$V =$ Wind speed (mph) 3 second gust, Figure 6-1 or per local authority.

Exp B				Exp C				Exp D			
Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp
120	1	0.85	1.11	120	1	0.85	1.11	120	1	0.85	1.11
Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)
30	0.7	21.9	24.3	15	0.85	26.6	29.6	15	1.03	32.3	35.8
40	0.76	23.8	26.4	20	0.9	28.2	31.3	20	1.08	33.8	37.6
Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp
130	1	0.85	1.11	130	1	0.85	1.11	130	1	0.85	1.11
Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)
30	0.7	25.7	28.6	15	0.85	31.3	34.7	15	1.03	37.9	42.0
40	0.76	27.9	31.0	20	0.9	33.1	36.7	20	1.08	39.7	44.1
Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp
140	1	0.85	1.11	140	1	0.85	1.11	140	1	0.85	1.11
Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)
30	0.7	29.9	33.1	15	0.85	36.3	40.2	15	1.03	43.9	48.8
40	0.76	32.4	36.0	20	0.9	38.4	42.6	20	1.08	46.1	51.1
Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp	Wind Sp	Kzt	Kd	GCp
150	1	0.85	1.11	150	1	0.85	1.11	150	1	0.85	1.11
Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)	Height	Kz	qz	p (psf)
30	0.7	34.3	38.0	15	0.85	41.6	46.2	15	1.03	50.4	56.0
40	0.76	37.2	41.3	20	0.9	44.1	48.9	20	1.08	52.9	58.7

For free standing guards and wind walls that do not return to a building wind loads shall be determined in accordance with SEI/ASCE 7-05 section 6.15.14 and figure 6-20.

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**CALCULATE PEAK GLASS MOMENT
DETERMINATION OF χ**

For two pairs of standoffs:

Applicability – Light Geometry

Standoffs in pairs are located 4” apart.

a: $6'' \leq a \leq 2h$

b: $12'' \leq b \leq 60''$

c: $3'' \leq c \leq h$

d: $2'' \leq d \leq 10''$

h: limited by glass stress

B: $b+2d$

$\alpha = B/h: 0.1 < \alpha \leq 2.0$

Example:

Glass light width $B = 48''$ and $h = 48''$

$\alpha = B/h = 48/48 = 1.0$

$\chi = 1.85$ Determine value of χ from graph, figure 2

Load = 50 plf or 200# or 25 psf:

$M_u = \chi u * h^2 / 2 = 1.90 * 25 \text{psf} * 4'^2 / 2 = 380' \text{#/ft}$

$M_p = \chi P * h / B = 1.90 * 200\# * 4' / 4' = 380' \text{#/ft}$

$M_U = \chi U * h = 1.90 * 50 \text{plf} * 4' = 380' \text{#/ft}$

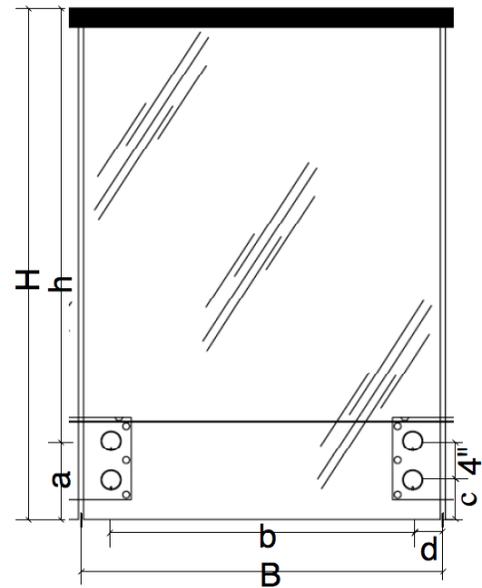


Figure 1

Two Standoff Pairs

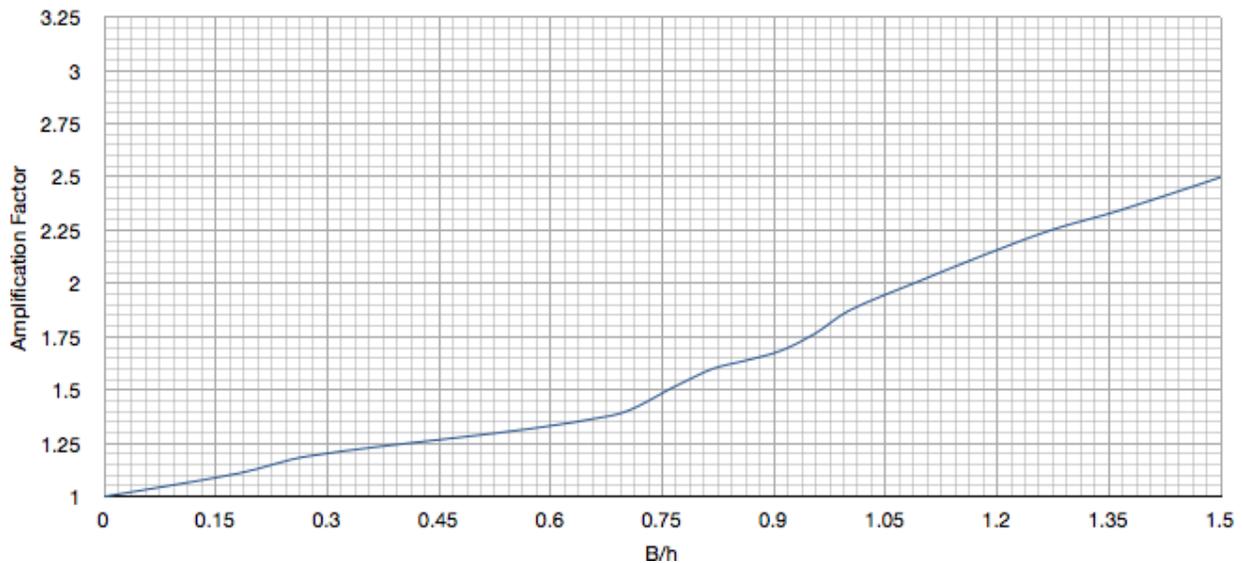


Figure 2

For 200# concentrated load on 1 sf of glass (at top corner for worst case) the moment is distributed across the panel width at the standoffs so that moment is essentially the same as for a top rail applied load. C = lesser of B or h

$M_p = \chi P * (h - 6'') / C = 1.90 * 200\# * (4' - 0.5') / 4' = 332.5' \text{#/ft}$

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For three pairs of standoffs:

Applicability – Light Geometry

Center standoff is always located at centerline

Standoffs in pairs are located 4” apart.

- a: $6'' \leq a \leq 2h$
- b: $12'' \leq b \leq 84''$
- c: $3'' \leq c \leq h$
- d: $2'' \leq d \leq 10''$
- h: limited by glass stress
- B: $b+2d$
- $\alpha = B/h: 0.1 < \alpha \leq 2.0$

Example:

Glass light width $B = 48''$ and $h = 48''$

$$\alpha = B/h = 48/48 = 1.0$$

$\chi = 1.84$ Determine value of χ from graph

Load = 50 plf or 200# or 25 psf:

$$M_u = \chi u * h^2 / 2 = 1.84 * 25 \text{psf} * 4'^2 / 2 = 368' \# / \text{ft}$$

$$M_p = \chi P * h / B = 1.84 * 200 \# * 4' / 4' = 368' \# / \text{ft}$$

$$M_U = \chi U * h = 1.84 * 50 \text{plf} * 4' = 368' \# / \text{ft}$$

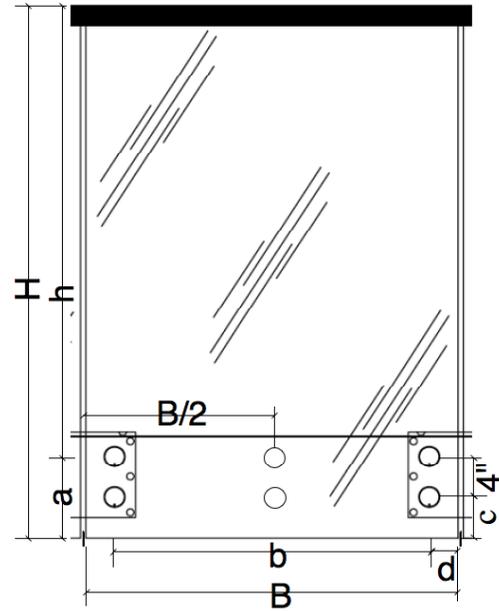


Figure 3

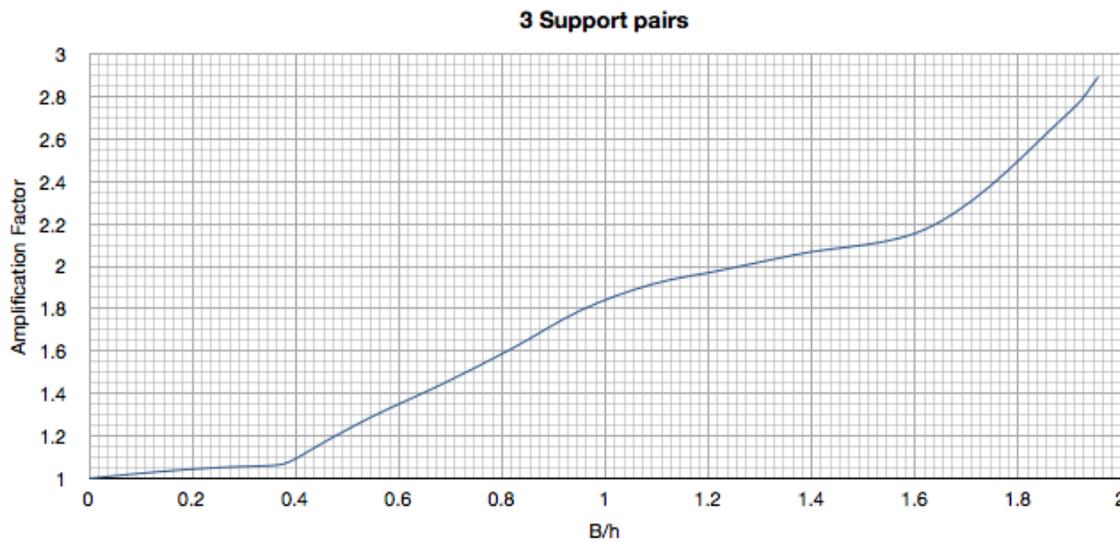


Figure 4

For 200# concentrated load on 1 sf of glass (at top corner for worst case) the moment is distributed across the panel width at the standoffs so that moment is essentially the same as for a top rail applied load. C = lesser of B or h

$$M_p = \chi P * (h - 6'') / C = 1.84 * 200 \# * (4' - 0.5') / 4' = 322' \# / \text{ft}$$

For typical 42” guard height, $h = 44$ ”: Figure 5
 $h = 44$ ”

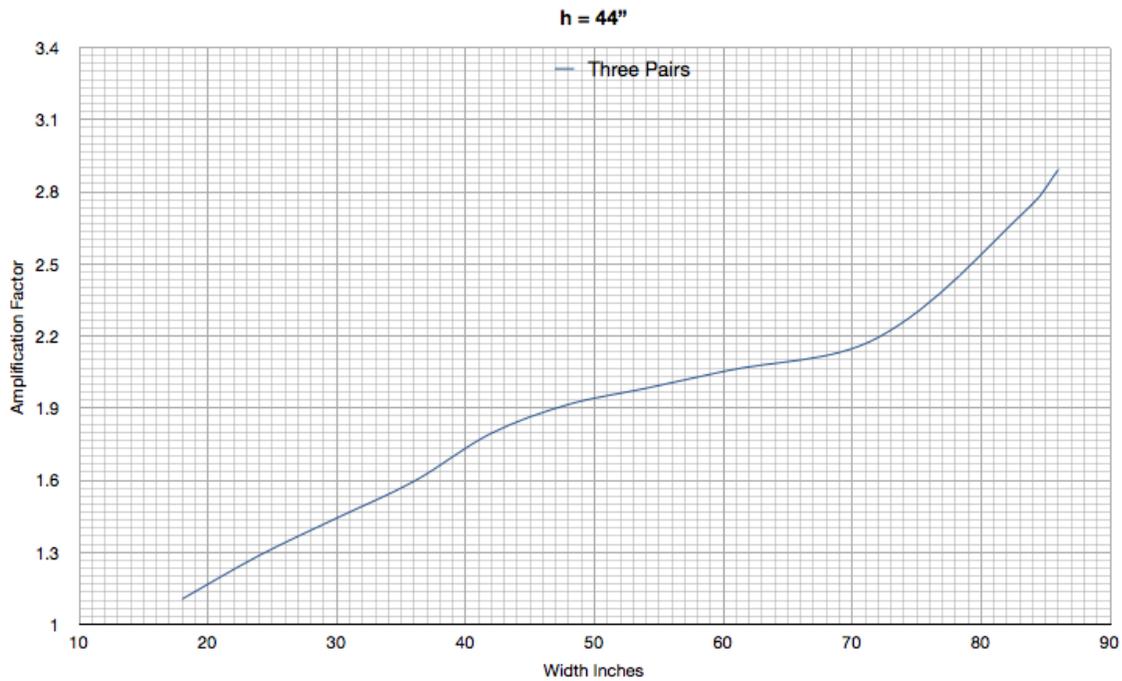
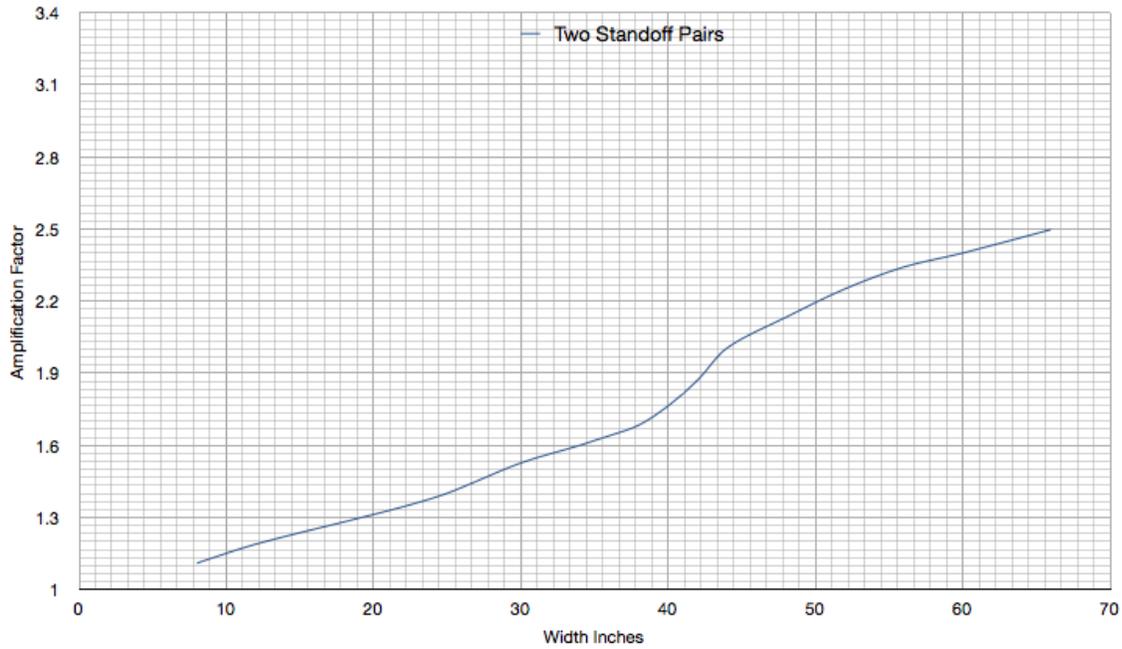


Figure 6

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1/2" Glass Applications

Acceptable light sizes for 1/2" glass:

For 1/2" glass, $t_{\min} = 0.469''$

$$S = 2*(0.469)^2 = 0.44 \text{ in}^3/\text{ft}$$

$$M_{\text{alive}} = 6,000\text{psi} * 0.44 \text{ in}^3/\text{ft} = 2,640''\#/ft = 220'\#$$

For single family residential applications apply 200# concentrated top rail load – 50 plf load is not applicable.

With top rail distributing concentrated load to two lights minimum – 100# each light

For Two Support Pairs:

Try minimum light size of 32", height 44"; $\alpha = 32/44 = 0.727$

$$\chi_2 = 1.57 \text{ for 2 pairs}$$

$$M = 1.57 * 100\# * 44'' = 6,908''\# \leq 2.667' * 2,640''\#/ft = 7,041''\#$$

For interior residential applications infill load = 5 psf for differential pressure:

$$M = 1.57 * 5\text{psf} * 3.667^2/2 = 52.78''\#/ft \text{ for 32" light width}$$

$$\text{Maximum uniform load} = 220/52.78 * 5 = 20.8 \text{ psf}$$

Check maximum light width of 66" x 44" high

$$\chi_2 = 2.5 \text{ for 2 pairs}$$

$$M = 2.5 * 5\text{psf} * 3.667^2/2 = 84.04''\#/ft \text{ for 32" light width}$$

$$\text{Maximum wind load} = W = 2.9 * M_{\text{alive}} / (\chi^2 * h^2) = 2.9 * 220 / (2.5 * 3.667^2) = 19 \text{ psf}$$

okay for 85 mph 3 sec gust exposure B below 30'

Check wind load for a standard light width, B = 48" and h = 44"

$$\alpha = 48/44 = 1.091$$

$$\chi_2 = 2.133 \text{ for 2 pairs}$$

$$M = 2.133 * W\text{psf} * 3.667^2 * 0.55 \leq 1.6 * 220'\# \text{ solving for } W$$

$$W = 220'\# * 1.6 / (2.133 * 0.55 * 3.667^2) = 22.3 \text{ psf}$$

General Equation for 1/2" glass and 2 support pairs:

$$\text{Allowable wind load} = 640'\# / (\chi_2^2 * h^2)$$

For Non-single family residential applications guard must be designed for 50 plf top rail load:

For $\chi_2 = 2.4$, $a = 1.364$ determine the maximum height:

$$h = 220 / (2.4 * 50) = 1.833' \text{ (1'-10")}$$

$$B = 1.833' * 1.364 = 2.5' \text{ (30")}$$

Typically 1/2" Glass is not to be used in Non-single family residential applications.

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For Three Support Pairs:

Try minimum light size of 30", height 44"; $\alpha = 30/44 = 0.682$

$\chi_3 = 1.442$ for 3 pairs

$M = 1.442 * 100 \# * 44" = 6,345" \# \leq 2.5' * 2,640" \# / ft = 6,600" \#$

For interior residential applications infill load = 5 psf for differential pressure:

$M = 1.442 * 5 \text{psf} * 3.667^2 / 2 = 48.48' \# / ft$ for 30" light width

Maximum uniform load = $220 / 48.48 * 5 = 22.7$ psf

Check maximum light width of 84"

$\chi_3 = 2.749$ for 3 pairs

$M = 2.749 * 5 \text{psf} * 3.667^2 / 2 = 92.41' \# / ft$ for 84" light width

Maximum wind load = $W = 2.9 * 220 / (2.749 * 3.667^2) = 17.3$ psf

okay for 85 mph 3 sec gust exposure B below 30'

Check wind load for a standard light width, B = 60" and h = 44"

$\alpha = 60/44 = 1.364$

$\chi_3 = 2.052$ for 2 pairs

$M = 2.052 * W \text{psf} * 3.667^2 * 0.55 \leq 1.6 * 220' \#$ solving for W

$W = 1.6 * 220' \# / (2.052 * 0.55 * 3.667^2) = 23.2$ psf

General Equation for 1/2" glass and 3 support pairs:

Allowable wind load = $640' \# / (\chi_3 * h^2)$

For Non-single family residential applications guard must be designed for 50 plf top rail load:

For $\chi_3 = 2.052$, $a = 1.364$ determine the maximum height:

$h = 220 / (2.052 * 50) = 2.14'$ (2' - 1-3/4")

$B = 2.14' * 1.364 = 2.92'$ (35")

For $\chi_3 = 1.442$, $a = 0.682$ determine the maximum height:

$h = 220 / (1.442 * 50) = 3.051'$ (3' - 0-5/8")

$B = 3.051 * 0.682 = 2.081'$ (2' - 1")

Typically 1/2" Glass is not to be used in Non-single family residential applications.

3/4" Glass Applications

Acceptable light sizes for 3/4" glass:

For 3/4" glass, $t_{\min} = 0.719''$

$$S = 2*(0.719)^2 = 1.034 \text{ in}^3/\text{ft}$$

$$M_{\text{alive}} = 6,000\text{psi} * 1.034 \text{ in}^3/\text{ft} = 6,204''\#/ft = 517'\#/ft$$

For general applications apply 200# concentrated top rail load or 50 plf load.

For rails longer than 4' the 50 plf load will control therefore all checks will be based on 50 plf top rail load

For Two Support Pairs:

Try minimum light size of 16", height 44"; $\alpha = 16/44 = 0.364$

$$\chi_2 = 1.285 \text{ for 2 pairs}$$

$$M = 1.285 * 50\# * 44'' = 2,827''\# \leq 6,204''\#/ft$$

Maximum Width $B = 66''$, height 44"; $\alpha = 66/44 = 1.50$

$$\chi_2 = 2.5 \text{ for 2 pairs}$$

$$M = 2.5 * 50\# * 44'' = 5,500''\# \leq 6,204''\#/ft$$

For commercial applications infill load = 25 psf:

For width $B = 66''$

$$M = 2.5 * 25\text{psf} * 3.667^2/2 = 420.2'\#/ft \leq 517'\#/ft$$

$$W = 517'\# * 1.6 / (0.55 * 2.5 * 3.667^2) = 44.7 \text{ psf}$$

Check wind load for a standard light width, $B = 48''$ and $h = 44''$

$$\alpha = 48/44 = 1.091$$

$$\chi_2 = 2.133 \text{ for 2 pairs}$$

$$M = 2.133 * W\text{psf} * 3.667^2/2 \leq 517'\# \text{ solving for } W$$

$$W = 517'\# * 1.6 / (0.55 * 2.133 * 3.667^2) = 52.4 \text{ psf}$$

General Equation for 3/4" glass and 2 support pairs:

$$\text{Allowable wind load} = 1,504'\# / (\chi_2 * h^2)$$

For heights greater than 44" above the top standoff ($h > 44''$) the glass moment is evaluated similarly:

Example $h = 48''$ and $B = 60''$

$$\alpha = 60/48 = 1.25$$

$$\chi_2 = 2.32 \text{ for 2 pairs}$$

$$W = 1,504'\# / (2.32 * 4^2) = 40.5 \text{ psf}$$

Three Support Pairs

Acceptable light sizes for 3/4" glass:

Try minimum light size of 18", height 44"; $\alpha = 18/44 = 0.409$

$\chi_3 = 1.105$ for 3 pairs

$M = 1.105 * 50 \# * 44'' = 2,431'' \# \leq 6,204'' \# / ft$

Maximum Width $B = 84''$, height 44"; $\alpha = 84/44 = 1.909$

$\chi_3 = 2.749$ for 3 pairs

$M = 2.749 * 50 \# * 44'' = 6,048'' \# \leq 6,204'' \# / ft$

For commercial applications infill load = 25 psf:

For width $B = 84''$

$M = 2.749 * 25 \text{ psf} * 3.667^2 / 2 = 462.07' \# / ft \leq 517' \# / ft$

$W = 517' \# * 1.6 / (0.55 * 2.749 * 3.667^2) = 40.7 \text{ psf}$

Check wind load for a standard light width, $B = 48''$ and $h = 44''$

$\alpha = 48/44 = 1.091$

$\chi_3 = 1.915$ for 3 pairs

$M = 1.915 * W \text{ psf} * 3.667^2 / 2 \leq 517' \#$ solving for W

$W = 517' \# * 1.6 / (1.915 * 0.55 * 3.667^2) = 58.4 \text{ psf}$

General Equation for 3/4" glass and 3 support pairs:

Allowable wind load = $1,504' \# / (\chi_3 * h^2)$

For heights greater than 44" above the top standoff ($h > 44''$) the glass moment is evaluated similarly:

Example $h = 48''$ and $B = 72''$

$\alpha = 72/48 = 1.5$

$\chi_3 = 2.12$ for 3 pairs

$W = 1,504' \# / (2.12 * 4^2) = 44.3 \text{ psf}$

EXAMPLE:

To determine the allowable wind load for a glass light:

$t = 3/4''$, $h = 48 \text{ } 3/8''$ and $B = 66''$

$a = 66/48.375 = 1.364$

From figure 2, $\chi_2 = 2.4$ or from figure 4 $\chi_3 = 2.07$

$W_2 = 1,504' \# / (2.4 * 4.032^2) = 38.5 \text{ psf}$

$W_3 = 1,504' \# / (2.07 * 4.032^2) = 44.7 \text{ psf}$

Procedure for checking light sizes where $h > 44''$

General equation for determining allowable light size – 3/4" glass:

For 50 plf load:

$$\chi_{\max} = 517' \# / (50 * h)$$

Use appropriate figure to determine α from the calculated χ

$$B_{\max} = \alpha h$$

For example for $h = 60''$

$$\chi = 517' \# / (50 * 5') = 2.068$$

$\alpha = 1.4$ from figure for 3 support pairs

$$B_{\max} = 1.4 * 60'' = 84''$$

Check size for wind:

$$\chi_3 = 1,504' \# / (W * h^2) =$$

For $h = 60''$ and $W = 25$ psf

$$\chi_3 = 1,504' \# / (25 * 5^2) = 2.406$$

$\alpha = 0.85$ from figure for 3 support pairs

$$B_{\max} = 0.85 * 60'' = 51''$$

In this example maximum light width is 51" based on live load of 25 psf.

To determine the allowable maximum glass height, h for a given width, B

3/4" Glass and Two Support Pairs

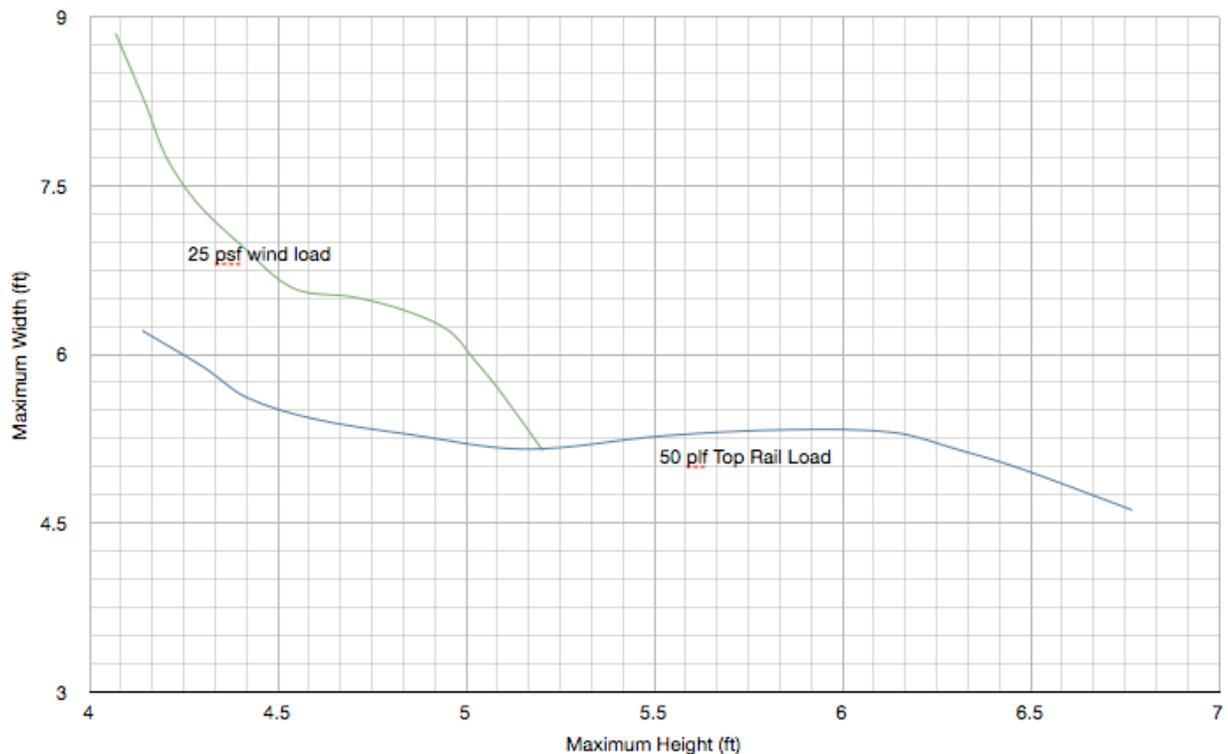


Figure 7

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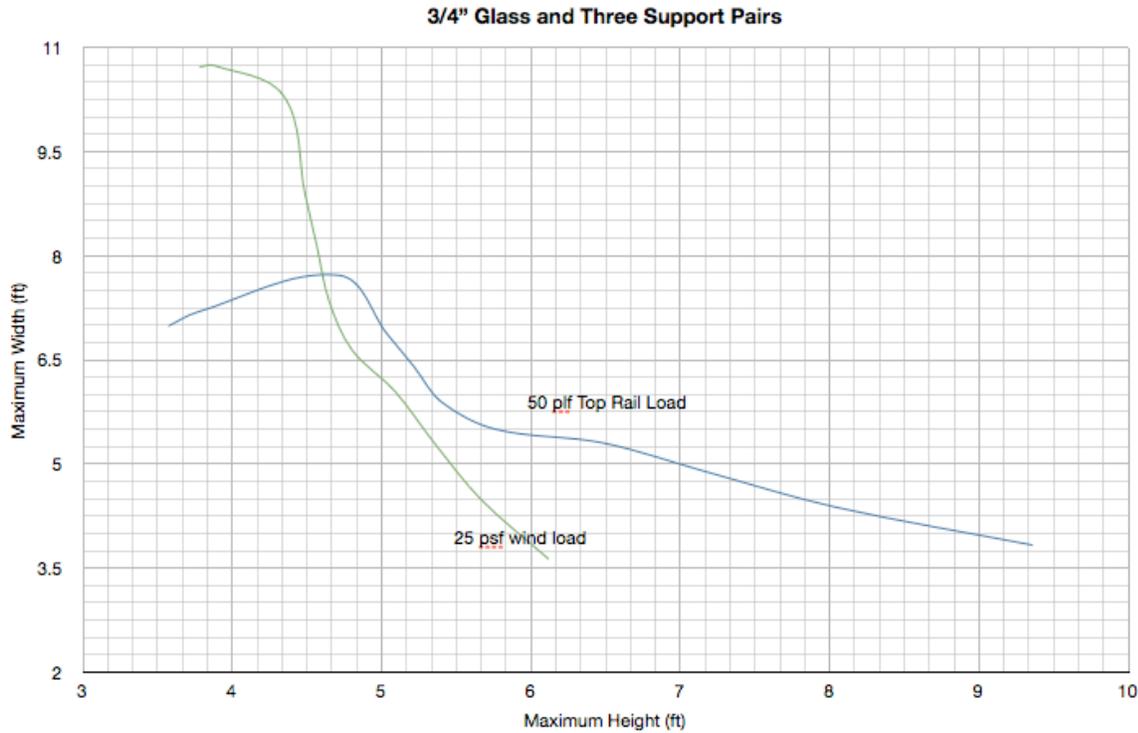


Figure 8

Acceptable combinations of height and width will plot below the applicable line.

For example for a glass light with dimensions:

$h = 60'' (5')$

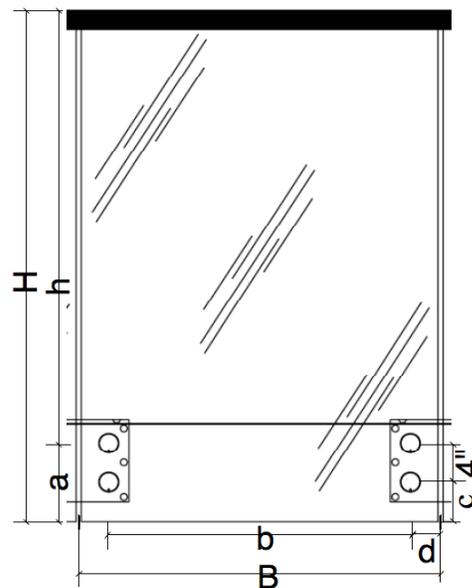
$B = 51'' (4'-3'')$

wind load = 25 psf and 50 plf top rail load is applicable.

From figures 9 and 10 it is determined that 1/2" glass can't be used.

From figure 7 the light size plots below the 50 plf line but above the 25 psf line therefore 2 standoff pairs isn't acceptable.

From figure 8 the light plots just below the 25 psf line therefore the light is size is acceptable for 3/4" glass with three standoff pairs.



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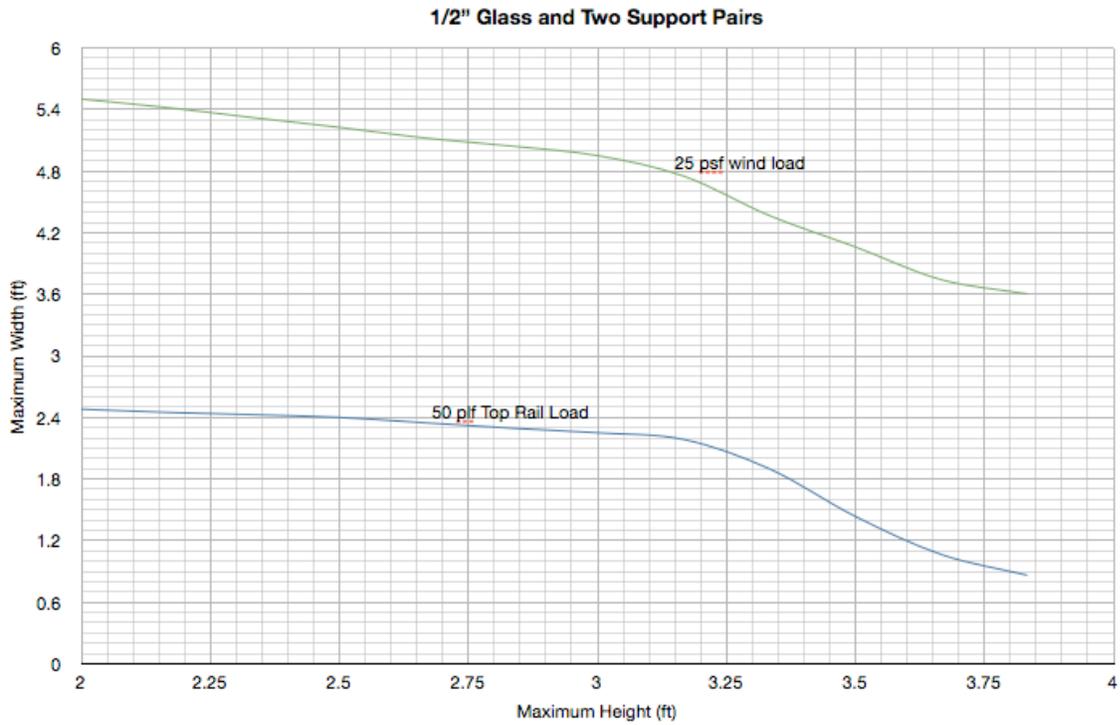


Figure 9

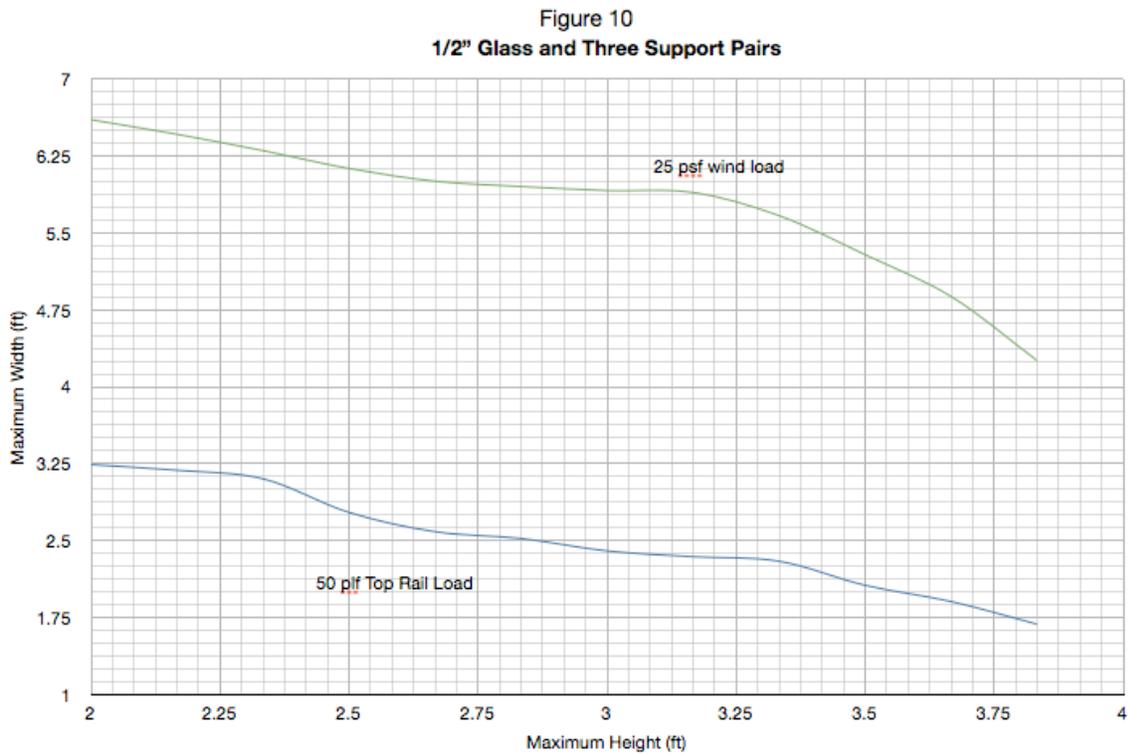


Figure 10

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GLASS STANDOFFS

To determine reactions on the standoffs:
 Reactions are calculated using summation of forces and summation of moments:

$$V = D+L$$

where D = glass dead load plus cap rail or other attachments to the glass.

L = greater of 200# or 50plf* B

Vertical load share per standoff:

$$V_s = D/2 \text{ standoffs}$$

Assumes vertical load is supported on any 2 standoffs to allow for construction tolerances, glass expansion and contraction and other factors that may cause uneven vertical loading on the standoffs

Moment on standoffs from vertical force:

$$M_v = V_s * k$$

where k = distance from centerline of glass to face of support attachment, typically 2" for RSOB2134 standard fitting.

For horizontal loading, moment about upper standoffs:

$$M_L = 50plf * B * h \text{ or } 200\# * h$$

$$M_w = w * B * h^2 * 0.55$$

$$W = w * B * h$$

$$M_T = \text{greater of } (M_L \text{ or } M_w) + M_v$$

Glass standoffs resist loading by forming a couple (tension and compression reactions)

Two pairs of standoffs per panel

Calculate R_1 by $\sum M$ about R_u

$$\sum M = M_T + (a-c) * R_1 = 0$$

$$R_1 = M_T / (a-c)$$

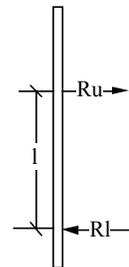
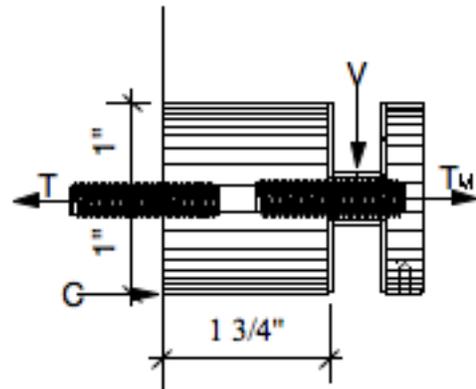
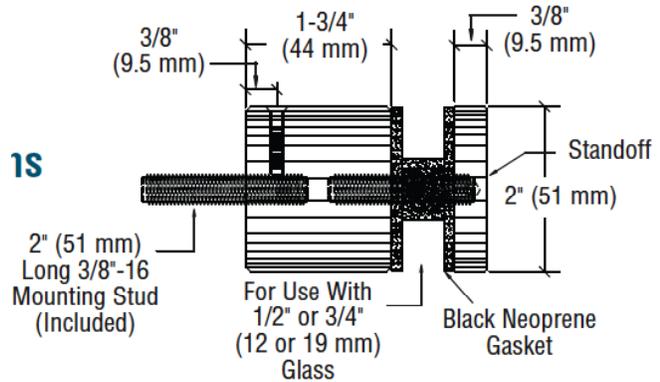
Typically a-c = 4"

Load share to individual standoff:

$$R_{s1} = R_1 / n \text{ where } n = \text{number of standoff pairs, 2 or 3.}$$

$R_u = R_1 + F$ where F = either wind force or live load depending on which produced the greatest moment.

$$R_{su} = R_u / n$$



Standoff anchors – 3/8” stainless steel threaded rod to standoff and 3/8” rod to steel support.

Tensile area of 3/8” threaded rod (UNC) = 0.0775 in²

Rod strength = (0.6*75ksi) * 0.0775 in² = 3,487#

Check thread strength into standoff – minimum thread embed = 3/8”

Internal thread stripping area = 0.828 in² for 3/8 – 16 threads

Allowable load on threads = 0.58*A_{sn}*t*F_{tu}/3 = 0.58*0.828*(3/8)*45ksi/3 = 2,700#

Allowable shear strength = 0.3*75 ksi*0.0775 in² = 1,744#

Standoff welded to plate – 1/8” fillet weld: (welded option)

$$T_a = 0.9*1/8''*\pi*2''*40 \text{ ksi}/1.6 = 17.7 \text{ k}$$

$$V_a = 0.3*17.7 \text{ k} = 5.3 \text{ k}$$

For welded standoff case the button attachment strength limits the loading.

Determine tension and shear on mounting stud:

From Σ forces:

Vertical loads will increase tension force in mounting stud:

$$T = T_M + V*2''/1''$$

Check Interaction of shear and tension.

Check combined tension and shear on anchors:

$$\frac{H\#}{2,700\#} + \frac{V\#}{1,744} = 0.44 < 1.2 \text{ Ok}$$

Example for a glass light, 3/4” x 52” tall x 84” long with 25 psf wind loading:

$$D = 9.8*(7'*4.333')/2 = 149\# < 1,744\#$$

Tension component of reaction

$$W = 25\text{psf}*3.667'*7'/2 = 321\# \text{ to standoff}$$

$$M = (25\text{psf}*3.667'^2*7'/2)*0.55 = 647.1'\#$$

$$R_l = (647.1*12)/(4'') = 1,941\#$$

$$R_u = 1,941+321 = 2,262\#$$

$$T = 2,262+149*2''/1'' = 2,560 < 2,700$$

Combined tension and shear:

$$\frac{2,560\#}{2,700\#} + \frac{149\#}{1,744} = 1.03 < 1.2 \text{ Ok}$$

STANDOFF STRENGTH IS ADEQUATE FOR ALL ACCEPTABLE LIGHT SIZES.

CUSTOM STANDOFF SIZE:

The standoff design allows easy customization by changing the length of the standoff body so as to increase or decrease the standoff distance.

The moment and tension on the standoff is calculated the same as for the standard standoff:

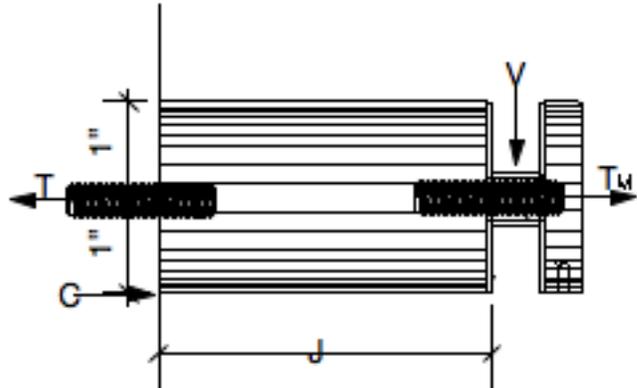
$$T = T_m + V * (J + t / 2) / 1''$$

where:

T_m and V are as previously calculated based on light size and loading;

J = standoff body length

t = glass thickness



based on the calculated T and V the standoff is checked from:

$$\frac{T\#}{2,700\#} + \frac{V\#}{1,744} < 1.2 \text{ Ok}$$

and $T \leq 2,700\#$

For most cases $V \leq 0.2 * 1,744\# = 348.8\#$ so the combined check may be skipped.

Example:

Determine the maximum allowable standoff length for the glass light checked on previous page:
Example for a glass light, 3/4" x 52" tall x 84" long with 25 psf wind loading:

$$D = 9.8 * (7' * 4.333') / 2 = 149\# < 1,744\#$$

Tension component of reaction

$$W = 25\text{psf} * 3.667' * 7' / 2 = 321\# \text{ to standoff}$$

$$M = (25\text{psf} * 3.667'^2 * 7' / 2) * 0.55 = 647.1'\#$$

$$R_l = (647.1 * 12) / (4'') = 1,941\#$$

$$R_u = 1,941 + 321 = 2,262\# < 2,700$$

$$T = 2,262 + 149 * (J + 0.75 / 2) / 1'' \leq 2,700\#$$

$$J = (2,700 - 2,262) * 1'' / (149\# - 0.375'') = 2.56''$$

For standoff bodies less than 2.56" the light sizes and wind loads are the same as for the standard standoff. For standoffs longer than 2.56" the light size and wind load must be checked.

RSOB20 STANDOFF FITTING

Bracket strength

Bending in plate:

Bracket bending strength:

$$Z = 4'' * (0.375)² / 4 = 0.1406 \text{ in}³$$

$$\phi M_n = 0.85 * 30 \text{ ksi} * 0.1406 \text{ in}³ = 3,585''\#$$

$$M_s = \phi M_n / 1.6 = 3,585 / 1.6 = 2,241''\#$$

Allowable moment on glass standoff:

$$M = 2 * 2,241''\# = 4,482''\#$$

Or allowable tension

$$T = 2,241 * 4.93 / 3.5'' = 3,157\#$$

Bracket bending will not limit standoff loads below the values based on the stud strength.

Bracket reactions on anchors:

Anchors form couple to resist moment on the guards.

Determine anchor tension from ΣM about the bottom of the bracket:

$$\Sigma M_b = w * B * H² / 2 + V * 2.25'' - n * 2T(7.5'' + 4² / 7.5)$$

solving for T:

$$T = (12'' / \text{ft} * w * B * H² + 2.25V) / (38.5''n)$$

If V is dead load only:

$$V = 9.8 \text{ psf} * B * H / 2$$

substitute and simplify

$$T = [12 * w * B * H² + 11.025B * H] / (38.5''n)$$

where n = number of brackets

For typical maximum light size and load:

3/4'' x 52'' tall x 84'' long with 25 psf wind loading

$$T = [12 * 25 * 7 * 4.333² + 11.025 * 7 * 4.333] / (38.5'')$$

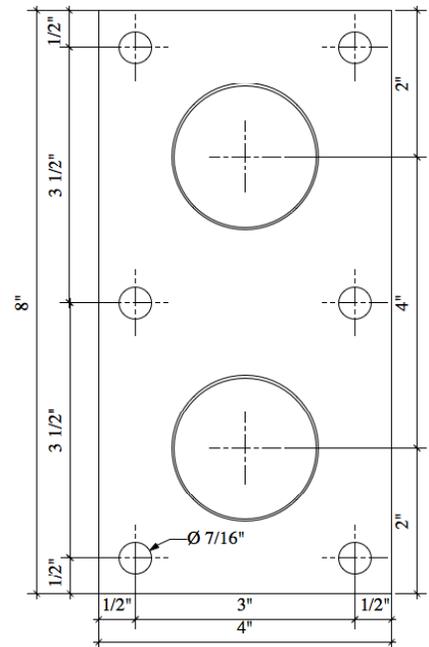
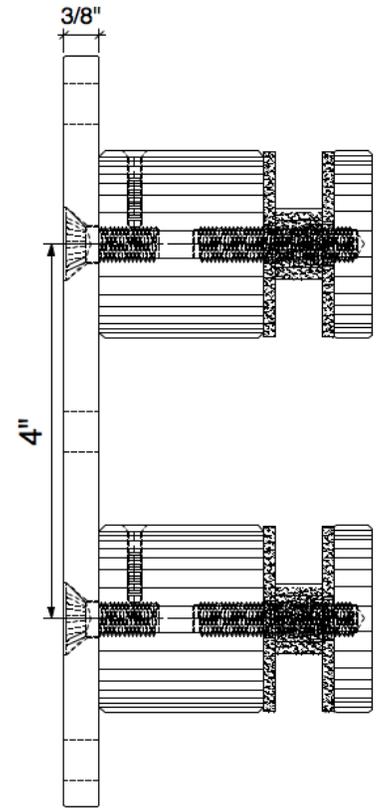
$$T = 344\# / \text{fastener}$$

Typical fastener:

1/2'' x 3'' lag screw to wood or

3/8'' x 3'' expansion bolt to concrete or

3/8'' bolt to steel.



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Cap Rail/ Grab Rail

For guard installations – Fall protection required, a cap rail or grab rail is required.

Cap rails and grab rails are the same as used in the GRS – Glass Rail System, refer to the GRS engineering report for the cap rails and grab rails.

All cap rails intended for use with the GRS may be used with the SRS for the appropriate glass thickness.

All grab rail brackets used with the GRS may be used with the SRS. The grab rail brackets' installation and strength is the same as for the GRS.

Other Glass Thicknesses and Laminated Glass

The Standoffs may be used with glass thicknesses other than 1/2” and 3/4”. The standoffs may also be used with laminated glass. When used with other glass thicknesses or laminated glass the glass bending moment shall be evaluated using the amplification factors and procedures in this report.