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Product Evaluation Report

of

Hardware and Glass Group LLC
BR68/BR80 Railing System with Laminated Glass

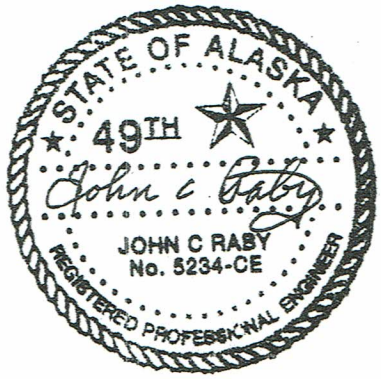
Report No. 6605

2003, 2012, 2015 and 2018 Edition of the International Building Code (IBC)

Product: ***BR68/BR80 Railing System with Laminated Glass***
Material: ***Aluminum 6063-T6***

Prepared for:
Hardware and Glass Group LLC
8 The Green Suite #7407
Dover, DE 19901

Prepared by:
John C Raby P.E. - Engineer of Record



EXP 12/31/2021
4/6/2020

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John C. Raby
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Date:
04/06/2020
Report No: 6605

Manufacturer: **Hardware and Glass Group LLC**

Product Name: **BR68/BR80 Railing System with Laminated Glass**

Scope: This is a Product Evaluation Report issued by John C Raby P.E. for **Hardware and Glass Group LLC**.

John C Raby P.E. does not have nor will acquire financial interest in the company manufacturing or distributing the product or in any other entity involved in the approval process of the product named herein.

This product has been evaluated for use in locations adhering to the 2003, 2012, 2015 and 2018 Edition of the International Building Code (IBC).

See Installation Instructions **"BR68-T3680"**, signed and sealed by John C Raby P.E. for specific use parameters.

Limits of Use:

1. This product has been evaluated and is in compliance with the 2003, 2012, 2015 and 2018 Edition of the International Building Code.
2. Product anchors shall be as listed and spaced as shown on details. Anchor embedment into concrete substrate (Min. F'c = 3000 psi).
3. When used in areas requiring wind borne debris protection this product complies with Chapter 16 of the 2003, 2012, 2015 and 2018 Edition of the International Building Code and does not require an impact resistant covering in areas requiring Impact Resistance.
4. Site conditions that deviate from the details of drawing **"BR68-T3680"**, require further engineering analysis by a licensed engineer or registered architect.
5. See Installation Instructions **"BR68-T3680"**, for size and design pressure limitations.

Performance Standards: The product described herein has been tested per:

- TAS 202-94 (ASTM E330)
- Concentrated and Distributed Load per the 2003, 2012, 2015 and 2018 International Building Code, chapter 16.
- TAS 201-94
- ASTM E1996
- ASTM E1886
- ANSI Z97.1

Referenced Data:

1. Product Testing performed by **Blackwater Testing Inc.**
   (FBC Organization # TST10394)
   Report #: BT-HWG-19-001 Report Date: 12/06/2019
   Signed and sealed by Constantin Bortes, PE #77915

Installation:

Refer to Installation Instructions (**"BR68-T3680"**) for more details of the installation details.

Design Pressure:

Refer to Installation Instructions (**"BR68-T3680"**) for design pressures dependent on reinforcements, hardware type, configuration, and size of units.

APPENDIX

Wind Load Tables

Anchor Layout Calculations

WIND LOAD ANALYSIS

To not exceed the maximum stress and deflection of the glass from the analysis, the glass has been analyzed under the following cases for sizes different than tested, but within the square footage of the testing.

- **Live Load:**
  - **50 lb/ft distributed load:** The distributed load has been considered for the stress and deflection limitations for the glass.
    - Stress: The allowable glass stress is 6000 psi (24000 psi with a safety factor of 4).

$$H_{D.L.O.} = \frac{12 * \theta * [1/6 * ta^2]}{50\ lb/ft}$$

    - Deflection: 1" max.

$$Deflection = \frac{50\ lb * {H_{D.L.O.}}^3}{3 * 10.4 * 10^6\ psi * b * ta^3}$$

$$H_{D.L.O.} = \sqrt[3]{\frac{3 * 10.4 * 10^6\ psi * b * ta^3 * Deflection}{50\ lb}}$$

$H_{D.L.O.}$= Unsupported glass height, in.
$b =$ Glass pane width, in.
$Deflection =$ 1 in.
$\theta =$ Allowable Glass Stress, psi.
$ta =$ Effective Glass Thickness, in.

  - **Concentrated Load:** The concentrated load has been considered for the stress and deflection limitations using the following values:
    - Stress: The allowable glass stress is 6000 psi (24000 psi with a safety factor of 4).

$$H_{D.L.O.} = \frac{12 * \theta * \left[\frac{1}{6} * b * ta^2\right]}{200\ lb}$$

    - Deflection: 1" max.

$$Deflection = \frac{200\ lb * {H_{D.L.O.}}^3 * [1 + b/(H_{D.L.O.}/2)]^{1/2}}{3 * 10.4 * 10^6\ psi * b * ta^3}$$

$H_{D.L.O.}$= Unsupported glass height, in.
$b =$ Glass pane width, in.
$Deflection =$ 1 in.
$\theta =$ Allowable Glass Stress, psi.
$ta =$ Effective Glass Thickness, in.

*The concentrated load maximum D.L.O. Height was obtained using iterations.

- **Wind Load:**
  - **Design Pressure:** The design pressure proposed for different glass dimensions (less or equal to tested area) is based on the equivalent pressure require to produce the same moment at the base of unsupported glass (top of base shoe), without exceeding the design pressure during testing.

$$M_0 = M_x$$

$$M_0 = \frac{DP_x * {H_{D.L.O.}}^2}{2 * 144}$$

$$DP_x = \frac{2 * 144 * M_0}{{H_{D.L.O.}}^2}$$

$M_0 =$ Moment from testing, lb-in/in.
$H_{D.L.O.}$= Unsupported glass height, in.
$DP_x =$ Design Pressure for a specific glass D.L.O. Height, psf.

Test Report Data

Glass:		
Glass pane width:	48.03	in
Unsupported Glass Pane Height	40.00	in
Design Pressure	50.00	psf
Glass Thickness	0.38	in
Interlayer Thickness	0.09	in
Glass Section Modulus	0.02	in^3/in
Area of Glass Tested:	13.34	ft²
Tested Moment at base of unsupported glass:	277.78	lb-in/in
Glass Stress	24000	psi
Safety Factor	4	
Allowable Glass Stress	6000	psi
Max. Deflection	1	in

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Concentrated Load Height Iterations

Glass Width		12
Height	Deflection	Target Deflection
50	0.84	1.00
54.47	1.06	
53.01	0.98	
53.47	1.01	
53.32	1.00	
53.37	1.00	
53.35	1.00	
53.36	1.00	
53.36	1.00	
53.36	1.00	
53.36	1.00	
53.36	1.00	
53.36	1.00	
53.36	1.00	
53.36	1.00	

Glass Width		24
Height	Deflection	Target Deflection
50.00	0.33	1.00
86.87	1.39	
73.73	0.90	
77.50	1.03	
76.35	0.99	
76.69	1.00	
76.59	1.00	
76.62	1.00	
76.61	1.00	
76.61	1.00	
76.61	1.00	
76.61	1.00	
76.61	1.00	
76.61	1.00	
76.61	1.00	

Glass Width		36
Height	Deflection	Target Deflection
50.00	0.21	1
109.92	1.57	
87.66	0.87	
93.74	1.04	
91.92	0.99	
92.45	1.00	
92.29	1.00	
92.34	1.00	
92.32	1.00	
92.33	1.00	
92.33	1.00	
92.33	1.00	
92.33	1.00	
92.33	1.00	
92.33	1.00	

Glass Width		48
Height	Deflection	Target Deflection
100	0.92	1.00
104.03	1.02	
102.85	0.99	
103.19	1.00	
103.09	1.00	
103.12	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	
103.11	1.00	

Glass Width		60
Height	Deflection	Target Deflection
100.00	0.76	1.00
114.39	1.08	
110.13	0.98	
111.32	1.01	
110.98	1.00	
111.08	1.00	
111.05	1.00	
111.06	1.00	
111.06	1.00	
111.06	1.00	
111.06	1.00	
111.06	1.00	
111.06	1.00	
111.06	1.00	
111.06	1.00	

Glass Width		72
Height	Deflection	Target Deflection
110.00	0.85	1.00
119.41	1.05	
116.70	0.99	
117.45	1.00	
117.24	1.00	
117.30	1.00	
117.28	1.00	
117.29	1.00	
117.29	1.00	
117.29	1.00	
117.29	1.00	
117.29	1.00	
117.29	1.00	
117.29	1.00	
117.29	1.00	

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Results

GLASS PANE WIDTH (IN)	EFFECTIVE GLASS		MOMENT AT TOP OF BASE SHOE (LB-IN/IN)	ALLOWABLE DESIGN PRESSURE (PSF)				200 LB LIVE LOAD		50 LB/FT LIVE LOAD	
	DEFLECTION (IN)	STRESS (IN)		MAX. D.L.O. HEIGHT (IN)				MAX. UNSSUPORTED GLASS HEIGHT (IN)		MAX. UNSSUPORTED GLASS HEIGHT (IN)	
				36	39.81	42	48	STRESS	DEFLECTION	STRESS	DEFLECTION
12	0.5384	0.6023	366.9	66.7	66.7	59.9	45.9	21.8	53.4	87.1	46.0
24	0.6399	0.6901	366.9	66.7	66.7	59.9	45.9	57.1	76.6	114.3	54.7
36	0.6938	0.7272	366.9	66.7	66.7	59.9	45.9	95.2	92.3	126.9	59.3
48	0.7216	0.744	366.9	66.7	66.7	-	-	132.8	103.1	132.8	61.7

Note: The design pressure values are based on a 1.5 factor of safety.

Anchor Calculations

Moment at Base from testing:

Railing Height:	44.00	in
Tested Moment at base railings (Wind Load):	448.38	lb-in/in
Tested Moment at base railings (Live Load, 50 lb/ft):	183.33	lb-in/in
Tested Moment at base railings (Live Load, 200 lb):	433.34	lb-in/in (52" height, 24" glass pane width)

Maximum moment at base = 448.38 lb-in/in

Anchor reactions:

- Shear = 66.7 psf /144 * 44 in = 20.38 lb/in
- Tension = $\frac{66.7\ psf/144*(44\ in)^2}{2*2.835\ in/2} = 316.32\ lb/in$

Using 7-7/8" Max. O.C. anchors, the reactions are the following:

- Shear = 20.38 lb/in * 7-7/8 in = 160.5 lb
- Tension = 316.32 lb/in * 7-7/8 in = 2491.1 lb

Option 1. Using the ½" Screw-Bolt+, DeWalt anchor, 4.25" min. embedment, 4" Min. Edge Distance and 7-7/8" Max. O.C. spacing for the installation of the system, the combined forces analysis is the following:

$$Combined\ Reactions = \left[\frac{160.5\ lb}{(1242\ lb)}\right]^{5/3} + \left[\frac{2491.1\ lb}{(2679\ lb)}\right]^{5/3} = 0.92 < 1$$

The allowable values may be found in the following pages.

Option 2. Using the ½" LTD ITW Red Head, 4.5" min. embedment, 4" Min. Edge Distance and 7-7/8" Max. O.C. spacing for the installation of the system, the combined forces analysis is the following:

$$Combined\ Reactions = \left[\frac{160.5\ lb}{(1449\ lb)}\right]^{5/3} + \left[\frac{2491.1\ lb}{(2543\ lb)}\right]^{5/3} = 0.991 < 1$$

The allowable values may be found in the following pages.

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Product Evaluation Report

Manufacture: Hardware and Glass Group LLC

Product: BR68/BR80 Railing System

Tension Design Value

Concrete Anchor Calculations			Masonry Anchor Calculations		
Fastener type:	1/2" Screw-Bolt+, DeWalt		Fastener type:	-	
Reference:	Manufacture Published Data		Reference:	-	
Substrate:	3000 PSI Concrete or Greater		Substrate:	-	
Minimum embedment:	4.25	in	Minimum embedment:	-	in
Minimum Spacing:	6.00	in	Minimum Spacing:	-	in
Spacing Reduction:	0.82		Spacing Reduction:	-	
Minimum edge distance:	4.00	in	Minimum edge distance:	-	in
Edge Distance Reduction:	0.78				
Allowable Design Value:	**W'=** 2322	lbs / anchor	**Allowable Design Value:**	**W'=** -	lbs / anchor

Shear Design Value

Concrete Anchor Calculations			Masonry Anchor Calculations		
Fastener type:	1/2" Screw-Bolt+, DeWalt		Fastener type:	-	
Reference:	Manufacture Published Data		Reference:	-	
Substrate:	4000 PSI Concrete or Greater		Substrate:	-	
Minimum embedment:	4.25	in	Minimum embedment:	-	in
Minimum Spacing:	6.00	in	Minimum Spacing:	-	in
Spacing Reduction:	0.67		Spacing Reduction:	-	
Minimum edge distance:	4.00	in	Minimum edge distance:	-	in
Edge Distance Reduction:	0.69				
Allowable Design Value:	**Z'=** 1190	lbs / anchor	**Allowable Design Value:**	**Z'=** -	lbs / anchor

Fastener type:	1/2" Screw-Bolt+, DeWalt					
Nominal Diameter:	D =	0.500	in	Factor of Safety:	Ω=	2.00	
Cantilever distance:		0.00	in	Bending Yield strength:	F_y =	92.50	ksi
Moment arm:		0.00	in	Ultimate strength:	F_u =	115.00	ksi
Allowable bending stress:	F_b =	43.13	ksi	Allowable shear stress:	Fv =	25.88	ksi
Actual bending stress:	f_b =	0.00	ksi	Actual shear stress:	f_v =	25.88	ksi
Combined bending plus shear:	**(fb/Fb)+(fv/Fv) =**	**1.0**	**≤ 1.0**	Elastic Modulus:	*S* =	0.0123	in^3
Maximum design value in cantilever:	5081	lbs / anchor		Area:	*A* =	0.19634954	in^2
Minimum anchor capacity:	1190	lbs / anchor					

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Product Evaluation Report

Manufacture: Hardware and Glass Group LLC

Product: BR68/BR80 Railing System

Manufacture Published Data

SCREW-BOLT+™

High Performance Screw Anchor

Allowable Load Capacities for Screw-Bolt+ in Normal-Weight Concrete[1,2,3,4,5]

Nominal Anchor Diameter in.	Minimum Nominal Embedment Depth in. (mm)	Minimum Concrete Compressive Strength							
		f'c = 2,500 psi (17.3 MPa)		f'c = 3,000 psi (20.7 MPa)		f'c = 4,000 psi (27.6 MPa)		f'c = 6,0 (41.4	
		Tension lbs (kN)	Shear lbs (kN)	Tension lbs (kN)	Shear lbs (kN)	Tension lbs (kN)	Shear lbs (kN)	Tension lbs (kN)	
1/4	1 (25)	330 (1.5)	415 (1.8)	350 (1.6)	440 (2.0)	385 (1.7)	480 (2.1)	430 (1.9)	
	1-5/8 (41)	710 (3.2)	415 (1.8)	750 (3.3)	440 (2.0)	815 (3.6)	480 (2.1)	815 (3.6)	
	2-1/2 (64)	915 (4.1)	505 (2.2)	965 (4.3)	535 (2.4)	1,050 (4.7)	585 (2.6)	1,070 (4.8)	
3/8	1-1/2 (38)	660 (2.9)	890 (4.0)	720 (3.2)	975 (4.3)	835 (3.7)	1,125 (5.0)	1,020 (4.5)	
	2 (51)	920 (4.1)	1,080 (4.8)	1,005 (4.5)	1,185 (5.3)	1,160 (5.2)	1,365 (6.1)	1,180 (5.2)	
	3-1/4 (83)	1,855 (8.3)	1,580 (7.0)	2,035 (9.1)	1,735 (7.7)	2,265 (10.1)	2,000 (8.9)	2,265 (10.1)	
	4-1/2 (114)	2,725 (12.1)	1,580 (7.0)	2,985 (13.3)	1,735 (7.7)	3,450 (15.3)	2,000 (8.9)	3,770 (16.8)	
1/2	1-3/4 (44)	710 (3.2)	1,495 (6.7)	780 (3.5)	1,640 (7.3)	900 (4.0)	1,895 (8.4)	1,100 (4.9)	
	2-1/2 (64)	1,670 (7.4)	2,010 (8.9)	1,830 (8.1)	2,200 (9.8)	2,115 (9.4)	2,540 (11.3)	2,115 (9.4)	
	4-1/4 (108)	3,315 (14.7)	2,350 (10.5)	3,630 (16.1)	2,575 (11.5)	4,120 (18.3)	2,970 (13.2)	4,120 (18.3)	
	5-1/2 (140)	3,935 (17.5)	2,350 (10.5)	4,310 (19.2)	2,575 (11.5)	4,975 (22.1)	2,970 (13.2)	5,330 (23.7)	
	2-1/2 (64)	1,435 (6.4)	2,655 (11.8)	1,570 (7.0)	2,910 (12.9)	1,815 (8.1)	3,355 (14.9)	2,220 (9.9)	

Edge Distance Reduction Factors - Tension (F_{NC})

Diameter (in)		1/4			3/8				1/2			
Nominal Embedment h_{nom} (in)		1	1-5/8	2-1/2	1-1/2	2	3-1/4	4-1/2	1-3/4	2-1/2	4-1/4	5-1/2
Min. Edge Distance c_{min} (in)		1-1/2	1-1/2	1-1/2	1-1/2	1-1/2	1-1/2	1-1/2	1-3/4	1-3/4	1-3/4	1-3/4
Edge Distance (inches)	1-1/2	1.00	0.77	0.64	0.85	0.74	0.59	0.55	-	-	-	-
	1-3/4	1.00	0.83	0.67	0.93	0.79	0.62	0.57	0.87	0.71	0.58	0.54
	2	1.00	0.88	0.71	1.00	0.84	0.65	0.59	0.94	0.76	0.60	0.56
	2-1/4	1.00	0.94	0.75	1.00	0.89	0.68	0.61	1.00	0.80	0.63	0.57
	2-1/2	1.00	1.00	0.78	1.00	0.95	0.71	0.63	1.00	0.84	0.65	0.59
	2-3/4	1.00	1.00	0.82	1.00	1.00	0.74	0.65	1.00	0.88	0.67	0.61
	3	1.00	1.00	0.86	1.00	1.00	0.77	0.67	1.00	0.92	0.69	0.62
	3-1/2	1.00	1.00	0.93	1.00	1.00	0.83	0.71	1.00	1.00	0.74	0.65
	4	1.00	1.00	1.00	1.00	1.00	0.88	0.75	1.00	1.00	0.78	0.69
	4-1/2	1.00	1.00	1.00	1.00	1.00	0.94	0.79	1.00	1.00	0.82	0.72
	5	1.00	1.00	1.00	1.00	1.00	1.00	0.84	1.00	1.00	0.87	0.75
	5-1/2	1.00	1.00	1.00	1.00	1.00	1.00	0.88	1.00	1.00	0.91	0.79
	6	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00	1.00	0.96	0.82
	6-1/2	1.00	1.00	1.00	1.00	1.00	1.00	0.96	1.00	1.00	1.00	0.85
	7	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.88

Spacing Reduction Factors - Tension (F_{NS})

Diameter (in)		1/4			3/8				1/2			
Nominal Embedment h_{nom} (in)		1	1-5/8	2-1/2	1-1/2	2	3-1/4	4-1/2	1-3/4	2-1/2	4-1/4	5-1/2
Minimum Spacing s_{min} (in)		1-1/2	1-1/2	1-1/2	2	2	2	2	2-3/4	2-3/4	2-3/4	2-3/4
Spacing Distance (inches)	1-1/2	0.89	0.73	0.66	-	-	-	-	-	-	-	-
	1-3/4	0.94	0.77	0.68	-	-	-	-	-	-	-	-
	2	1.00	0.80	0.70	0.88	0.77	0.67	0.63	-	-	-	-
	2-1/4	1.00	0.83	0.72	0.93	0.80	0.69	0.64	-	-	-	-
	2-1/2	1.00	0.86	0.74	0.97	0.83	0.70	0.65	-	-	-	-
	2-3/4	1.00	0.89	0.76	1.00	0.86	0.72	0.66	0.92	0.78	0.67	0.64
	3	1.00	0.92	0.78	1.00	0.89	0.74	0.67	0.95	0.80	0.68	0.65
	3-1/2	1.00	0.99	0.82	1.00	0.94	0.77	0.70	1.00	0.85	0.71	0.67
	4	1.00	1.00	0.86	1.00	1.00	0.80	0.72	1.00	0.89	0.73	0.68
	4-1/2	1.00	1.00	0.90	1.00	1.00	0.83	0.74	1.00	0.93	0.75	0.70
	5	1.00	1.00	0.94	1.00	1.00	0.86	0.76	1.00	0.98	0.78	0.72
	5-1/2	1.00	1.00	0.97	1.00	1.00	0.89	0.78	1.00	1.00	0.80	0.74
	6	1.00	1.00	1.00	1.00	1.00	0.93	0.81	1.00	1.00	0.82	0.75
	6-1/2	1.00	1.00	1.00	1.00	1.00	0.96	0.83	1.00	1.00	0.85	0.77
	7	1.00	1.00	1.00	1.00	1.00	0.99	0.85	1.00	1.00	0.87	0.79
	7-1/2	1.00	1.00	1.00	1.00	1.00	1.00	0.87	1.00	1.00	0.90	0.81
	8	1.00	1.00	1.00	1.00	1.00	1.00	0.90	1.00	1.00	0.92	0.83
	8-1/2	1.00	1.00	1.00	1.00	1.00	1.00	0.92	1.00	1.00	0.94	0.84

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Product Evaluation Report

Manufacture: Hardware and Glass Group LLC

Product: BR68/BR80 Railing System

Edge Distance Reduction Factors - Shear (F_{VC})

Diameter (in)		1/4			3/8				1/2			
Nominal Embedment h_{nom} (in)		1	1-5/8	2-1/2	1-1/2	2	3-1/4	4-1/2	1-3/4	2-1/2	4-1/4	5-1/2
Min. Edge Distance c_{min} (in)		1-1/2	1-1/2	1-1/2	1-1/2	1-1/2	1-1/2	1-1/2	1-3/4	1-3/4	1-3/4	1-3/4
Edge Distance (inches)	1-1/2	0.58	0.63	0.59	0.40	0.37	0.31	0.32	-	-	-	-
	1-3/4	0.68	0.73	0.69	0.46	0.43	0.36	0.38	0.35	0.31	0.30	0.31
	2	0.78	0.84	0.78	0.53	0.49	0.41	0.43	0.41	0.35	0.35	0.36
	2-1/4	0.87	0.94	0.88	0.59	0.55	0.46	0.48	0.46	0.40	0.39	0.40
	2-1/2	0.97	1.00	0.98	0.66	0.61	0.51	0.54	0.51	0.44	0.43	0.45
	2-3/4	1.00	1.00	1.00	0.73	0.67	0.56	0.59	0.56	0.49	0.48	0.49
	3	1.00	1.00	1.00	0.79	0.73	0.61	0.64	0.61	0.53	0.52	0.54
	3-1/2	1.00	1.00	1.00	0.92	0.85	0.72	0.75	0.71	0.62	0.61	0.63
	4	1.00	1.00	1.00	1.00	0.97	0.82	0.86	0.81	0.71	0.69	0.72
	4-1/2	1.00	1.00	1.00	1.00	1.00	0.92	0.97	0.91	0.80	0.78	0.81
	5	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.89	0.87	0.90
	5-1/2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.95	0.99
	6	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Spacing Reduction Factors - Shear (F_{VS})

Diameter (in)		1/4			3/8				1/2			
Nominal Embedment h_{nom} (in)		1	1-5/8	2-1/2	1-1/2	2	3-1/4	4-1/2	1-3/4	2-1/2	4-1/4	5-1/2
Minimum Spacing s_{min} (in)		1-1/2	1-1/2	1-1/2	2	2	2	2	2-3/4	2-3/4	2-3/4	2-3/4
Spacing Distance (inches)	1-1/2	0.60	0.60	0.60	-	-	-	-	-	-	-	-
	1-3/4	0.61	0.62	0.61	-	-	-	-	-	-	-	-
	2	0.63	0.64	0.63	0.59	0.58	0.57	0.57	-	-	-	-
	2-1/4	0.65	0.66	0.65	0.60	0.59	0.58	0.58	-	-	-	-
	2-1/2	0.66	0.67	0.66	0.61	0.60	0.59	0.59	-	-	-	-
	2-3/4	0.68	0.69	0.68	0.62	0.61	0.59	0.60	0.59	0.58	0.58	0.58
	3	0.69	0.71	0.70	0.63	0.62	0.60	0.61	0.60	0.59	0.59	0.59
	3-1/2	0.73	0.74	0.73	0.65	0.64	0.62	0.63	0.62	0.60	0.60	0.60
	4	0.76	0.78	0.76	0.68	0.66	0.64	0.64	0.64	0.62	0.62	0.62
	4-1/2	0.79	0.81	0.79	0.70	0.68	0.65	0.66	0.65	0.63	0.63	0.63
	5	0.82	0.85	0.83	0.72	0.70	0.67	0.68	0.67	0.65	0.64	0.65
	5-1/2	0.86	0.88	0.86	0.74	0.72	0.69	0.70	0.69	0.66	0.66	0.66
	6	0.89	0.92	0.89	0.76	0.74	0.70	0.71	0.70	0.68	0.67	0.68
	6-1/2	0.92	0.95	0.92	0.79	0.76	0.72	0.73	0.72	0.69	0.69	0.69
	7	0.95	0.99	0.96	0.81	0.78	0.74	0.75	0.74	0.71	0.70	0.71
	7-1/2	0.99	1.00	0.99	0.83	0.80	0.76	0.77	0.75	0.72	0.72	0.72
	8	1.00	1.00	1.00	0.85	0.82	0.77	0.79	0.77	0.74	0.73	0.74
	9	1.00	1.00	1.00	0.90	0.87	0.81	0.82	0.80	0.77	0.76	0.77
	10	1.00	1.00	1.00	0.94	0.91	0.84	0.86	0.84	0.80	0.79	0.80
	11	1.00	1.00	1.00	0.98	0.95	0.87	0.89	0.87	0.82	0.82	0.83

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Product Evaluation Report

Manufacture: Hardware and Glass Group LLC

Product: BR68/BR80 Railing System

Tension Design Value

Concrete Anchor Calculations			Masonry Anchor Calculations		
Fastener type:	1/2" LDT ITW Red Head		Fastener type:	-	
Reference:	Manufacture Published Data		Reference:	-	
Substrate:	3000 PSI Concrete or Greater		Substrate:	-	
Minimum embedment:	4.50	in	Minimum embedment:	-	in
Minimum Spacing:	7.88	in	Minimum Spacing:	-	in
Spacing Reduction:	0.98		Spacing Reduction:	-	
Safety Factor:	4.00		Safety Factor:	-	
Minimum edge distance:	4.00	in	Minimum edge distance:	-	in
Edge Distance Reduction:	1.00				
Allowable Design Value:	**W'=** 2543	lbs / anchor	**Allowable Design Value:**	**W'=** -	lbs / anchor

Shear Design Value

Concrete Anchor Calculations			Masonry Anchor Calculations		
Fastener type:	1/2" LDT ITW Red Head		Fastener type:	-	
Reference:	Manufacture Published Data		Reference:	-	
Substrate:	3000 PSI Concrete or Greater		Substrate:	-	
Minimum embedment:	4.50	in	Minimum embedment:	-	in
Minimum Spacing:	7.88	in	Minimum Spacing:	-	in
Spacing Reduction:	0.98		Spacing Reduction:	-	
Safety Factor:	4.00		Safety Factor:	-	
Minimum edge distance:	4.00	in	Minimum edge distance:	-	in
Edge Distance Reduction:	0.73				
Allowable Design Value:	**Z'=** 1449	lbs / anchor	**Allowable Design Value:**	**Z'=** -	lbs / anchor

Fastener type:	1/2" LDT ITW Red Head					
Nominal Diameter:	D =	0.500	in	Factor of Safety:	Ω=	2.00	
Cantilever distance:		0.00	in	Bending Yield strength:	F_y =	100.00	ksi
Moment arm:		0.00	in	Ultimate strength:	F_u =	125.00	ksi
Allowable bending stress:	F_b =	46.88	ksi	Allowable shear stress:	Fv =	28.13	ksi
Actual bending stress:	f_b =	0.00	ksi	Actual shear stress:	f_v =	28.13	ksi
Combined bending plus shear:	**(fb/Fb)+(fv/Fv) =**	**1.0**	**≤ 1.0**	Elastic Modulus:	*S* =	0.0123	in^3
Maximum design value in cantilever:		5522	lbs / anchor	Area:	*A* =	0.19634954	in^2

Minimum anchor capacity: 1449 lbs / anchor

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Product Evaluation Report

Manufacture: Hardware and Glass Group LLC

Product: BR68/BR80 Railing System

Manufacture Published Data

PERFORMANCE TABLE

LDT Anchors — *Allowable Tension and Shear Values* (Lbs/kN) in Concrete Carbon and Stainless Steel*

ANCHOR DIA. In. (mm)	EMBEDMENT DEPTH In. (mm)	f'c = 2000 PSI (13.8 MPa) TENSION Lbs. (kN)	f'c = 2000 PSI (13.8 MPa) SHEAR Lbs. (kN)	f'c = 3000 PSI (20.7 MPa) TENSION Lbs. (kN)	f'c = 3000 PSI (20.7 MPa) SHEAR Lbs. (kN)	f'c = 4000 PSI (27.6 MPa) TENSION Lbs. (kN)	f'c = 4000 PSI (27.6 MPa) SHEAR Lbs. (kN)
3/8 (9.5)	1-1/2 (38.1)	334 (1.5)	527 (2.3)	413 (1.8)	691 (3.1)	492 (2.1)	854 (3.8)
	2 (50.8)	373 (1.7)	759 (3.4)	506 (2.2)	807 (3.6)	638 (2.8)	855 (3.8)
	2-1/2 (63.5)	933 (4.2)	828 (3.7)	937 (4.2)	841 (3.7)	940 (4.2)	856 (3.8)
	3-1/2 (88.9)	1,349 (6.0)	828 (3.7)	1,656 (7.4)	842 (3.7)	1,963 (8.7)	857 (3.8)
1/2 (12.7)	2 (50.8)	895 (4.0)	1,411 (6.3)	977 (4.3)	1,628 (7.2)	1,059 (4.7)	1,845 (8.2)
	3-1/2 (88.9)	1,813 (8.0)	1,609 (7.2)	2,011 (8.9)	1,822 (8.1)	2,209 (9.8)	2,035 (9.0)
	4-1/2 (114.3)	2,544 (11.3)	1,846 (8.2)	2,583 (11.5)	1,992 (8.9)	2,622 (11.7)	2,138 (9.5)
5/8 (15.9)	2-3/4 (69.9)	1,319 (5.9)	2,164 (9.7)	1,640 (7.3)	2,766 (12.3)	1,961 (8.7)	3,369 (15.0)
	3-1/2 (88.9)	1,993 (8.9)	2,556 (11.4)	2,462 (10.9)	3,036 (13.5)	2,931 (13.0)	3,515 (15.6)
	4-1/2 (114.3)	2,892 (12.9)	3,079 (13.7)	3,358 (14.9)	3,395 (15.1)	4,223 (18.8)	3,710 (16.5)
3/4 (19.1)	3-1/4 (82.6)	1,719 (7.6)	1,785 (7.9)	2,439 (10.8)	2,682 (11.9)	3,159 (14.0)	3,579 (15.9)
	4-1/2 (114.3)	2,576 (11.5)	3,280 (14.6)	3,606 (16.0)	4,217 (18.7)	4,635 (20.6)	5,153 (22.9)
	5-1/2 (139.7)	3,262 (14.5)	4,477 (19.9)	4,539 (20.2)	5,445 (24.2)	5,817 (25.9)	6,413 (28.5)

* Allowable values are based upon a 4 to 1 safety factor. (Ultimate/4)

PERFORMANCE TABLE

LDT Anchors — *Recommended Edge & Spacing Requirements for Tension Loads* Carbon and Stainless Steel*

ANCHOR DIA. In. (mm)	EMBEDMENT DEPTH In. (mm)	EDGE DISTANCE REQUIRED TO OBTAIN MAX. WORKING LOAD In. (mm)	AT MIN. EDGE DISTANCE 1-3/4 Inches (44mm)	SPACING DISTANCE REQUIRED TO OBTAIN MAX. WORKING LOAD In. (mm)	LOAD FACTOR APPLIED AT MIN. SPACING DISTANCE 3 Inches (76mm)
3/8 (9.5)	1-1/2 (38.1)	2 (50.8)	70%	6 (152.4)	44%
	2 (50.8)	2 (50.8)	70%	6 (152.4)	44%
	2-1/2 (63.5)	3 (76.2)	70%	6 (152.4)	44%
	3-1/2 (88.9)	4 (101.6)	70%	6 (152.4)	44%
1/2 (12.7)	2 (50.8)	2-1/4 (57.2)	65%	8 (203.2)	27%
	3-1/2 (88.9)	3 (76.2)	65%	8 (203.2)	27%
	4-1/2 (114.3)	4 (101.6)	65%	8 (203.2)	27%

PERFORMANCE TABLE

LDT Anchors — *Recommended Edge & Spacing Requirements for Shear Loads* Carbon and Stainless Steel*

ANCHOR DIA. In. (mm)	EMBEDMENT DEPTH In. (mm)	EDGE DISTANCE REQUIRED TO OBTAIN MAX. WORKING LOAD In. (mm)	AT MIN. EDGE DISTANCE 1-3/4 Inches (44mm)	SPACING DISTANCE REQUIRED TO OBTAIN MAX. WORKING LOAD In. (mm)	LOAD FACTOR APPLIED AT MIN. SPACING DISTANCE 3 Inches (76mm)
3/8 (9.5)	1-1/2 (38.1)	3 (76.2)	25%	6 (152.4)	57%
	2 (50.8)	4 (101.6)	25%	6 (152.4)	57%
	2-1/2 (63.5)	5 (127.0)	25%	6 (152.4)	57%
	3-1/2 (88.9)	5 (127.0)	25%	6 (152.4)	57%
1/2 (12.7)	2 (50.8)	5 (127.0)	25%	8 (203.2)	60%
	3-1/2 (88.9)	5 (127.0)	25%	8 (203.2)	60%
	4-1/2 (114.3)	5-1/2 (139.7)	25%	8 (203.2)	60%