



ICC-ES Evaluation Report

ESR-3269

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DIVISION: 05 00 00—METALS
Section: 05 52 00—Metal Railings
Section: 05 73 13—Glazed Decorative Metal Railings

DIVISION: 08 00 00—OPENINGS
Section: 08 81 00—Glass Glazing
Section: 08 88 00—Special Function Glazing

DIVISION: 32 00 00—EXTERIOR IMPROVEMENTS
Section: 32 35 00—Screening Devices

REPORT HOLDER:

C.R. LAURENCE COMPANY, INC.

EVALUATION SUBJECT:

GRS™ GLASS BALUSTRADE GUARD SYSTEM FOR MONOLITHIC TEMPERED GLASS APPLICATIONS

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2018, 2015, 2012, 2009 and 2006 *International Building Code*® (IBC)
- 2018, 2015, 2012, 2009 and 2006 *International Residential Code*® (IRC)
- 2013 *Abu Dhabi International Building Code* (ADIBC)[†]

[†]The ADIBC is based on the 2009 IBC. 2009 IBC code sections referenced in this report are the same sections in the ADIBC.

Properties evaluated:

- Structural
- Durability

2.0 USES

The GRS Glass Rail System structural glass balustrades described in this report are intended for interior and exterior weather-exposed applications, and are suitable for use in most natural environments. The GRS system may be used for residential, commercial and industrial applications for guards along balconies, porches, mezzanines, stairs and similar locations except where vehicle impact resistance is required. The system is compatible with all construction types.

3.0 DESCRIPTION

3.1 General:

The GRS Glass Rail System utilizes an extruded aluminum base shoe, complying with 6063-T52, to anchor and support single fully tempered structural glass balustrades (1/2-inch [12.7 mm], 5/8-inch [15.9 mm], or 3/4-inch [19.1 mm], depending on use) which support the selected top rail and/or handrail [various profiles are made of stainless steel complying with 304 or 316 (in some cases, the top rails are required to have higher yield strengths than specified in 304 or 316 which are verified through mill certifications for the stainless steel sheets), brass complying with C26000, or aluminum complying with 6063-T6] to construct building guards. A complete GRS specification requires identification of the top rail (cap rail) profile and material; glass thickness with the maximum and minimum light widths; glazing system (either wet or a specific dry glazing method); base shoe; and anchorage to the supporting structure. When a handrail is used, the handrail profile, mounting bracket, and mounting bracket spacing must be specified. A complete installation requires either a top rail or a handrail. The base shoe may be installed with non-structural cladding of any compatible material bonded to it with adhesive. Figure 1 shows the typical guard elevation with the components. The complete GRS specifications must be noted on plans submitted to the code official for approval.

The profiles, section properties and strengths of the various base shoes are detailed in Section 4.2.3 of this report.

The profiles, section properties and strengths of the various top rails are detailed in Section 4.2.4.

The profiles, section properties and strengths of the various handrails are detailed in Section 4.2.7.

The glass must be Kind FT fully tempered glass conforming to the requirements of ANSI Z97.1-14, ASTM C1048 and CPSC 16 CFR 1201. The fully tempered glass must have an average Modulus of Rupture $F_r \geq 24,000$ psi. Glass type, condition, class, form, quality and finish as defined in ASTM C1036 must meet these standards and the modulus of rupture.

3.2 Durability:

The materials incorporated in the system described in this report are inherently corrosion-resistant. The material type specified must be appropriate for the environment of the

installation. Information verifying the durability must be submitted to the code official, when requested.

4.0 DESIGN AND INSTALLATION

4.1 General:

Installation of the GRS glass balustrade guards must comply with the manufacturer's published instructions, this report and IBC Sections 1015, 1607.8.1, and 2407 (2012 IBC Sections 1013, 1607.8.1, and 2407; 2009 and 2006 IBC Sections 1013, 1607.7.1, and 2407) or IRC Section R312, whichever is applicable. Handrails/grab rails must comply with IBC Sections 1011.11 and 1014 (2012 IBC Sections 1012 and 1009.15, 2009 IBC Sections 1012 and 1009.12, and 2006 IBC Sections 1012 and 1009.10) or IRC Sections R311.7.8 and R311.8.3 (2009 IRC Sections R311.7.7 and R311.8.3, and 2006 IRC Sections R311.5.6 and R311.6.3), whichever is applicable. The manufacturer's published installation instructions, called "GRS Glass Railing Dry Glaze Taper-Loc System for Tempered Glass Applications (AVD3919-2/11)," must be available at the jobsite at all times during installation. In the event of a conflict between this report and the manufacturer's instructions, this report governs.

4.2 Design:

4.2.1 Loading: The applicable project-specific loads must be identified. Minimum required loads are one of the following:

- 50 plf (0.73 kN/m) on the top rail in any direction
- 200 lbs (0.89 kN) on the top rail in any direction, and 50 lbs (0.22 kN) on one square foot at any location perpendicular to the glass balustrade
- The wind load on the full area of glass, in psf

Wind load must be determined by a qualified individual based on the project-specific conditions, taking into account the balustrade location on the structure. For installations in compliance with the IRC Section R312, the 50 plf (0.73 kN/m) top rail load is not applicable.

4.2.2 Glass:

4.2.2.1 General: Sandblasted glass must have a $\frac{3}{4}$ -inch nominal thickness, with the allowable loads based on a $\frac{1}{2}$ -inch (12.7 mm) thickness, as noted in the tables of this report.

Minimum spacing between glass panels is $\frac{1}{4}$ inch (6.4 mm) for $\frac{1}{2}$ -inch- and $\frac{5}{8}$ -inch-thick (12.7 and 15.9 mm) glass panels, and $\frac{1}{2}$ inch (12.7 mm) for $\frac{3}{4}$ -inch-thick (19.1 mm) glass panels.

Holes and notches must not be located within the first third of the balustrade height from the base shoe. Holes and notches must conform to ASTM C1048.

4.2.2.2 Live Loads: The allowable live load glass panel stress is equal to the modulus of rupture divided by a safety factor of 4 [$24,000/4 = 6,000$ psi (41.3 MPa)].

4.2.2.3 Wind Loads: Table 1 provides the allowable wind loads. This is based on an allowable wind load stress of 9600 psi.

4.2.3 Base Shoes:

The appropriate base shoe must be selected based on glass thickness, installation method and loading. Figure 2 shows the base shoe options. Tables 2a through 2g provide the allowable wind loads for the base shoes, glass thickness and anchorages. The base shoe must be installed in accordance with the manufacturer's published installation instructions and this report. The end anchor must be installed no less than $1\frac{1}{2}$ inches nor more than

12 inches from the end of the base shoes to the centerline of the anchor. A minimum of two anchors are required for any base shoe section.

4.2.3.1 Steel Substrate: The base shoe is attached to a structural steel member with a minimum thickness of $\frac{1}{4}$ inch (6.4 mm) using $\frac{1}{2}$ -13 by $\frac{3}{4}$ -inch long, ASTM F-837 Alloy Group 1 (condition AF with a minimum tensile strength of 67.5 ksi), stainless steel, socket head cap screws installed into tapped holes. When installation is in a through-bolt condition, the cap screw length must be increased to a length sufficient to permit proper installation with full engagement of the nut. When installation is to weld blocks, drainage blocks or solid shims more than 2 inches (51 mm) long by the full base shoe width at each anchor, no reduction in allowable wind loads is required.

4.2.3.1.1 Surface-mounted to Steel: The allowable wind loads must be as shown in Table 2a. Guard height (Hg) is measured from the bottom of base shoe to the top of the guard. An appropriate top rail or grab rail must be used.

4.2.3.1.2 Fascia-mounted to Steel: The allowable wind loads must be as shown in Table 2b (heights from top of base shoe to top of guard).

4.2.3.2 Concrete Substrate: The base shoe is attached to a concrete member with a minimum thickness of 5 inches and minimum compression strength of 3,000 psi (20.6 MPa), and in an uncracked condition. The attachment is made using either a $\frac{3}{8}$ -inch-diameter-by-4-inch screw-in Hilti HUS-EZ (KH-EZ) anchor in accordance with [ESR-3027](#), or a Hilti HSL-3 M8 x $3\frac{3}{4}$ -inch (95 mm) anchor in accordance with [ESR-1545](#). Minimum spacing between anchors is 6 inches (152 mm). For 12-inch-on-center (305 mm) anchor spacing, anchor locations may be moved to avoid reinforcement, provided the same number of anchors is provided and no two anchors are closer than 6 inches (152 mm) center-to-center.

4.2.3.2.1 Concrete Strength: The allowable wind load (W') for concrete strengths between 3000 psi (20.6 MPa) and 5,000 psi (34.4 MPa) may be adjusted by applying the adjustment factor in the following equation:

$$c_w = \sqrt{(f'_c/3000)}$$

$$W' = c_w * W$$

where W is allowable wind load from the tables

f'_c = specified concrete compressive strength, in psi

4.2.3.2.2 Sand-lightweight Concrete: When installation is into sand-lightweight concrete, the allowable wind loads from the tables in this report must be reduced by a factor of 0.6.

4.2.3.2.3 Adjusted Wind Load: For a 42-inch (1067 mm) guard height, the allowable wind load from the tables in this report must be greater than 26 psf (1.25 kN/m²) in order for the guard anchorage to be able to support the 50 plf (0.73 kN/m) live load. When typical anchor spacing is 12 inches (305 mm) on center, additional anchors may be added to the base shoe (for 10-foot (304 mm) base shoes or shorter lengths) as follows to provide a 26 psf (1.25 kN/m²) allowable wind load and a 50 plf (0.73 kN/m) top rail live load:

- 26.0 psf $\geq W' > 23.6$ psf, add one anchor
- 23.6 psf $\geq W' > 21.7$ psf, add two anchors
- psf $\geq W' > 20.0$ psf, add three anchors

For **SI**: 1 psf = 0.0479 kN/m²

Added anchors must be distributed to divide the base shoe into approximately equal segments.

4.2.3.2.4 Surface-mounted: When edge distance is equal to or greater than 3.75 inches (95 mm) (concrete edge parallel to the anchor and to the centerline of the anchor), the allowable wind loads must be as provided in Table 2c for the guard height (Hg) from bottom of the base shoe. For edge distances less than 3.75 inches (95 mm), required for the full anchor strength, the allowable wind load must be as provided in Table 2d. Linear interpolation between Tables 2c and 2d is permitted for edge distances from 1.75 inches to 3.75 inches.

4.2.3.2.4.1 When installation is to drainage blocks or solid shims, 2 inches long by the full base shoe width at each anchor, the allowable wind loads must be as provided in Table 2e.

4.2.3.2.5 Fascia-mounted: When fascia-mounted to a slab edge, beam, wall or similar item, the minimum concrete thickness must be 6 inches (152 mm). The top and bottom of the base shoe must not extend past the concrete edge. The allowable wind load must be as determined using Table 2f, where guard height is total height above the top of the base shoe. Applicable adjustment factors from Sections 4.2.3.2.1 and 4.2.3.2.2 must be applied. Minimum wind loads must be verified in accordance with Section 4.2.3.2.3

4.2.3.2.5.1 Fascia-mounted over Drainage Blocks: When installation is with aluminum drainage blocks 2 inches (51 mm) wide by 4 inches (102 mm) deep at each anchor, the allowable wind load must be reduced by multiplying by 0.95 as shown in the following equation:

$$W' = 0.95W$$

4.2.3.3 Wood Substrate: Wood must have a moisture content under 19 percent at the time of fabrication and be a species and grade with specific gravity $G \geq 0.49$. For exterior locations all base shoes and fasteners must be stainless steel (304 or 316). Fasteners must be tightened so that the base shoe is in tight contact with the supporting wood.

4.2.3.3.1 Surface-mounted: All base shoes are similar and interchangeable.

4.2.3.3.1.1 Wet service (Moisture content of wood may exceed 19% at any extended period of time):

Direct surface mounting of the base shoes to wood in wet service locations is prohibited. The base shoe must be attached to steel or aluminum brackets or continuous angles which are directly attached to the wood structure.

Refer to Figure 3 for the aluminum bracket. Refer to Figure 4 for the steel bracket. The allowable wind loads using the steel or aluminum brackets are:

36-inch guard height, $W = 46.7$ psf (2.24 kN/m²)

42-inch guard height, $W = 34.3$ psf (1.64 kN/m²)

The continuous angles must be L5x5x⁵/₁₆ inch and comply with ASTM A36 with a G90 galvanization or 6063 T5 aluminum.

The base shoe must be connected to the steel angle with ¹/₂ inch (12.7 mm) diameter by ³/₄ inch (19.1 mm) long ASTM F837 Alloy Group 1 (condition AF with a minimum tensile strength of 67.5 ksi) stainless steel socket head cap screws into tapped holes spaced 12 inches o.c. (305 mm).

The attachment of the continuous angle to the wood substrate must be with minimum No. 14x3-inch (76 mm) stainless steel wood screws spaced 3 inches on center along each leg.

Allowable wind load using the continuous angles is:

42-inch guard height, $W = 68.8$ psf (3.289 kN/m²)

4.2.3.3.1.2 Dry service (Moisture content of wood $\leq 19\%$ at all times):

Dry service conditions include interior and exterior locations where the wood is adequately protected so that the moisture content remains at or below 19% at all times.

Base shoes are surface mounted directly to wood with a specific gravity $G \geq 0.49$ and a compressive strength perpendicular to the grain ≥ 625 psi (4.1 MPa).

The base shoe must be anchored with ³/₈-inch (9.5 mm) diameter by 5-inch (127 mm) long lag screws.

The B5L base shoe must not be used for surface mounting to wood when guard height exceeds 24 inches (610 mm).

Lag screw length must be increased as needed to obtain a minimum of 3¹/₂" embedment into the solid wood when subfloor thickness exceeds ³/₄ inch.

4.2.3.3.1.2.1 One- and Two-family Dwellings and IRC Applications [(200 pounds (0.89 kN) Top Rail Live Load Only)]: When installed in private residences, the anchors must be installed at 12 inches (305 mm) on center or less. For a 36-inch (914 mm) guard height, the minimum number of anchors is four; and for a 42-inch (1067 mm) guard height, the minimum number of anchors is five.

4.2.3.3.1.2.2 Other Locations [(50 plf (0.73 kN/m) Top Rail Live Load)]: When installed in applications where the 50 plf (0.73 kN/m) live load is applicable in accordance with IBC Section 1607.8.1 (2009 and 2006 IBC Section 1607.7.1), the anchors must be installed at 6 inches (152 mm) on center or less. The minimum number of anchors in any guard segment is five.

4.2.3.3.2 Fascia-mounted: The base shoes must be attached with ¹/₂-inch-by-4-inch (12.7 mm by 102 mm) lag screws installed directly to the structural wood member. The top of the base shoe must be flush with or below the top of the beam corner radius and the beam must extend below the bottom of the base shoe. The allowable wind load must be as determined in accordance with Table 2G. Linear interpolation for other heights or anchor spacing is allowable.

4.2.4 Top Rails: A top rail is required for a code-compliant guard installation, except as noted in Figure 1. The term "cap rail" denotes the same thing as "top rail" and the two may be used interchangeably. The top rail is installed in accordance with the details provided in the manufacturer's installation details referenced in Section 4.1 of this report.

4.2.4.1 Support: The top rail must be installed so as to remain in place in the event of the failure of any one glass light. This requires the use of a minimum of three glass lights or a combination of other top rail supports and glass lights totaling three, minimum. Figure 5 illustrates the top rail support conditions. The top rail end condition (Figure 6) must be checked to verify that the rail will remain in place in the event of failure of the end glass light. End support must be designed when required for a code-compliant installation. The stabilizing end cap shown in Figure 14 is an acceptable method of end support.

4.2.4.2 Top Rail Profiles: The top rail profiles are shown in Figure 7. The maximum middle and end spans of the top rail profiles supported by glass only are given in Table 3.

4.2.4.3 Stainless Steel End Post: Where the end glass panel width exceeds the maximum end top rail span in Table 3, the top rail must be supported at the end by a post or the wall. A stainless steel post inserted in the base shoe and top rail may be used, as shown in Figure 6. The post minimum width for a maximum glass height of

42 inches (1067 mm) must be as shown in Table 4. Posts may either match glass thickness or fit tightly into the base shoe.

4.2.5 Taper-Loc® X Dry Glazed System:

4.2.5.1 Description: This is a dry glazing system where the glass is clamped inside the base shoe by the Taper-Loc® Shoe Setting Plate (an L-shaped piece on the back side) and the Taper-Loc® Shim Plates (front side), as illustrated in Figure 8. The glass is locked in place by the compressive forces created by the Taper-Loc® shim plates being compressed together by the installation tool. Use of the calibrated installation tool assures that the proper compressive forces are developed. The Taper-Loc® system is compatible with all base shoes except for the B5L, which is too shallow for the tapers.

4.2.5.2 Use: The appropriate Taper-Loc® set must be used for the specified base shoe and glass thickness, and installed in accordance with the manufacturer's printed instructions using the calibrated installation tool. Figure 8 shows the applicable dimensions. The spacing of the Taper-Loc® sets must be as noted in Figure 8.

4.2.6 Wet Glazing: Glass may be wet glazed into any of the base shoes using a pourable grout that is compatible with aluminum and glass (see Figure 9).

4.2.6.1 Installation: Minimum grout compressive strength must exceed 1,500 psi (10.3 Mpa) at 24 hours, and 4,000 psi (27.6 MPa) at 28 days. The grout must be mixed, placed and cured in accordance with the grout manufacturer's instructions. Wet glazing grout must be continuous in the base shoe, filling all voids, and extend to the roll-in rubber glazing channel in the base shoe.

4.2.7 Handrails:

4.2.7.1 Use: Handrails are required along ramps and stairs in accordance with IBC Sections 1011.11 and 1012.8 (2012 IBC Sections 1009.15 and 1010.9, 2009 IBC Sections 1009.12 and 1010.8, and 2006 IBC Sections 1009.10 and 1010.8) or IRC Sections R311.7.8 and R311.8.3 (2009 IRC Sections R311.7.7 and R311.8.3 and 2006 IRC Sections R311.5.6 and R311.6.3), as applicable. Also, the handrail must comply with the applicable code sections noted in Section 4.1 of this report.

4.2.7.2 Brackets: C.R. Laurence brackets covered by this report are HR2S, HR2D, HR3E, HR2F, HR15G, and HR2J (see Figure 11). The handrails listed in Section 4.2.7.3 may be used with any of the brackets or combination of brackets shown in this report such that the handrail clearance and projections are within the limits defined in the IBC Section 1014 (2012, 2009, and 2006 IBC Section 1012). The outer diameter of the handrail tubing attached to the HRE3 brackets shall not exceed 1.5 inches.

4.2.7.3 Handrail: The handrails may use any of the rails noted below:

- 1¹/₄-inch Schedule 40 pipe - steel, stainless steel or aluminum
- 1¹/₂-inch Schedule 40 pipe - steel, stainless steel or aluminum
- 1¹/₂-inch OD by 1¹/₈-inch tube - stainless steel or aluminum
- 1¹/₂-inch OD by 0.05-inch tube - stainless steel
- 2-inch OD by 0.05-inch tube - stainless steel

4.2.7.4 Installation: Handrails may be installed to glass balustrade guards using the through-glass mounting brackets shown in this report (see Figure 11). The brackets

must be installed in accordance with the manufacturer's instructions. The glass holes must comply with Section 4.2.2.2 of this report.

4.2.7.5 Support: The handrail must be installed so as to remain in place in the event of the failure of any one glass light. This requires the use of a minimum of three glass lights or a combination of other handrail supports and glass lights totaling three, minimum, similar to the top rail support illustrated in Figure 5. The handrail end condition must be checked to verify that the rail will remain in place in the event of failure of the end glass light. End support must be designed when required for a code-compliant-installation.

4.2.7.6 Spacing: The bracket spacing must be within the limits shown in Table 5, with dimensions as defined in Figure 10.

4.2.7.7 Attachment: The handrail, when supported by the glass balustrade, must be attached to one of the brackets noted in this report, in accordance with the detail shown in Figure 12, and to the glass as shown in Figure 13. Alternative attachment must be designed to safely support the loads as given in the IBC Section 1607.8.1 (2009 and 2006 IBC Section 1607.7.1), whichever is applicable. The stabilizing end cap shown in Figure 14 may be used to attach the handrail or top rail to a wall or perpendicular post face.

5.0 CONDITIONS OF USE

The C.R. Laurence Glass Rail System described in this report complies with, or is a suitable alternative to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1** The product is limited to installation where it is not subject to vehicle impacts.
- 5.2** Installation must comply with this report, the manufacturer's published installation instructions, and Sections of the IBC or Sections of the IRC, identified in Section 4.1 of this report, whichever is applicable. When the manufacturer's instructions conflict with this report, this report governs.
- 5.3** Under the 2018 and 2015 IBC the single fully tempered glass is limited to uses in handrails and guardrails where there is no walking surface beneath them or the walking surface is permanently protected from the risk of falling glass, as noted in the exception in Section 2407.1 of the IBC.
- 5.4** The supporting structure must be designed and constructed to support the loads imposed by the GRS guards in accordance with the applicable code. The anchorage to the frame must be as specified in this report or designed to provide the required strength for the specified balustrade height and imposed loads. Drawings and design details for the GRS system, using the information noted in this report, must be included on construction plans submitted to the code official for approval. The drawings and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.
- 5.5** When use is in exterior locations, the wind loads on the GRS guards must not exceed the values noted in this report. For glass heights other than those noted in this report, the allowable wind loads must not exceed the value calculated by the following equation:

$$W = \frac{(M_{qmax}/2.5)}{(0.55 \cdot H^2)}$$

where:

H = glass height above supports, in feet

$M_{gmax}/2.5 = 352$ ft-lb for 1/2-inch fully tempered glass

566.4 ft-lb for 5/8-inch fully tempered glass

827.2 ft-lb for 3/4-inch fully tempered glass

For SI: 1 ft – 1 lbf = 1.356 N-m

- 5.6 When installed where exposed to moisture, the base shoe anchors must be of a material intended for the use and identified by the manufacturer as acceptable for exterior applications. When installed in a corrosive environment, such as one where there is exposure to salt water or pool water, the anchors must be 316 stainless steel.
- 5.7 All metals in contact with aluminum must be either an alloy approved for direct aluminum contact, or isolated from the aluminum by an approved coating.
- 5.8 The GRS systems described in this report must not be used in Wind-Borne Debris Regions.
- 5.9 The GRS™ Glass Balustrade Guard System and the proper top rail or handrail must be installed in accordance with the manufacturer's instructions, this report, Sections 1014, 1015, and 2407 of the IBC (Sections 1012, 1013, and 2407 of the 2012, 2009 and 2006 IBC) or Sections R311.7.8 and R312 of the IRC, whichever is applicable.
- 5.10 All glass must be fully tempered, fabricated, and inspected in accordance with ASTM C1048, and the glass fabricator must provide certification of compliance with ASTM C1058 for fully tempered glass.

Glass must be procured directly from a qualified glass fabricator and is not produced or supplied by C.R. Laurence Co., Inc.

- 5.11 The CRL GRS™ and Taper-Loc® components, except for the glass, are supplied by C.R. Laurence Co., Inc., in Los Angeles, California.

6.0 EVIDENCE SUBMITTED

- 6.1 Data in accordance with the ICC-ES Acceptance Criteria for Glass Railing and Balustrade Systems (AC439) dated April 2019.
- 6.2 Manufacturer's published installation instructions.

7.0 IDENTIFICATION

- 7.1 The CRL GRS™ and Taper-Loc® guard system components described in this report are identified by a stamp on the packaging bearing the manufacturer's name (C.R. Laurence Co., Inc., sometimes abbreviated as CRL); product description and/or part number; and the ICC-ES evaluation report number (ESR-3269).
- 7.2 The report holder's contact information is the following:

C.R. LAURENCE COMPANY, INC.
ARCHITECTURAL RAILING DIVISION
2503 EAST VERNON AVENUE
LOS ANGELES, CALIFORNIA 90058
(800) 421-6144
www.crlaurence.com
www.crl-arch.com

TABLE 1—GLASS PANELS STRENGTH

GLASS PANEL THICKNESS (in.)	MINIMUM GLASS PANEL THICKNESS (in.)	MINIMUM GLASS PANEL WIDTH ² (in.)	GUARD HEIGHT (Hg) ¹ (in.)	GLASS HEIGHT ABOVE TOP OF BASE SHOE (in.)	ALLOWABLE WIND PRESSURE (psf)	LIVE LOAD ³ 50 PLF	
						MAXIMUM HEIGHT ABOVE TOP OF BASE SHOE (in.) BASED ON:	
						STRESS	1" DEFLECTION
1/2	0.469	2'-6"	36	32	71.1	52.75	40.08
		2'-10.5"	42	38	52.2		
5/8	0.595	1'-7"	36	32	114.4	84.0	50.84
		1'-10"	42	38	84.1		
3/4	0.719	1'-0"	36	32	167.1	124	64.44
		1'-3"	42	38	122.8		

For SI: 1 inch = 25.4 mm; 1 foot = 305 mm; 1 psf = 0.0479 kN/m².

¹The allowable wind loads may be adjusted for other panel heights by:

$$W' = \frac{W_{42} \cdot 42^2}{H_g^2}$$

where H_g = total guard height measured from bottom of base shoe to top of top rail in inches.
W₄₂ = Allowable load at 42-inch guard height.

²Minimum glass panel width is defined as the minimum width of glass required to support the 200 pound concentrated live load acting horizontally. The minimum glass light width is 6 inches when top rail is continuous across a total glass width of 1.5 times the minimum width or attached to additional supports at rail ends. Where the top rail is continuous, multiple adjacent glass lights may be added together to provide the total length.³Other loads listed in Section 4.2.1 must be considered.

TABLE 2A—SURFACE-MOUNTED SHOE

Surface mounted to steel with 1/2-inch cap screws @ 12 inches on center ¹ :			
Total guard height (Hg) from bottom of base shoe			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load ² 50 plf
			Max. Height
8B, B5G, B5S, B5T B5L B6S B7S	75.3 psf	55.3 psf	89 in.
	67.7 psf	49.8 psf	80 in.
	78.9 psf	58.0 psf	93 in.
	82.8 psf	60.9 psf	98 in.
Surface mounted to steel with 1/2-inch cap screws @ 6 inches on center:			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load ² 50 plf
			Max. Height
8B, B5G, B5S, B5T B5L B6S B7S	150.0 psf	110.2 psf	178 in.
	134.5 psf	98.8 psf	160 in.
	157.2 psf	115.5 psf	186 in.
	165.1 psf	121.3 psf	196 in.

For SI: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m².

¹Allowable wind load may be limited by glass strength. See Table 1 in this report.

²Other loads listed in Section 4.2.1 must be considered.

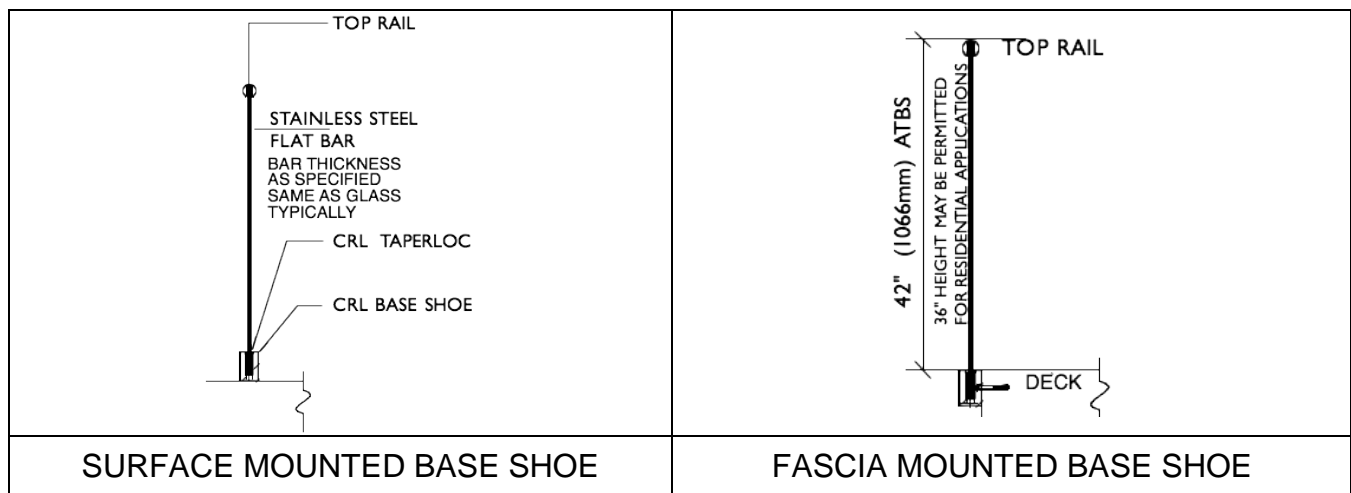


TABLE 2B—FASCIA-MOUNTED SHOE

Fascia mounted to steel with 1/2-inch cap screws @ 12 inches on center ¹ :			
Total Guard Height above top of base shoe			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load ² 50 plf
			Max. Height
8B, B5G, B5S B5L B6S B7S	68.7 psf	51.2 psf	87 in.
	47.5 psf	35.3 psf	58 in.
	68.7 psf	51.2 psf	87 in.
	68.7 psf	51.2 psf	87 in.
Fascia mounted to steel with 1/2-inch cap screws @ 6 inches on center:			
1/2-inch cap screw to steel Base Shoe	36-inch Height Allowable wind load	42-inch Height Allowable wind load	Live Load ² 50 plf
			Max. Height
8B, B5G, B5S B5L B6S B7S	138.2 psf	103.0 psf	178 in.
	95.6 psf	71.2 psf	121 in.
	138.2 psf	103.0 psf	178 in.
	138.2 psf	103.0 psf	178 in.

For SI: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m².

¹Allowable wind load may be limited by glass strength. See Table 1 in this report.

²Other loads listed in Section 4.2.1 must be considered.

TABLE 2C—ANCHORAGE TO CONCRETE

For anchorage to concrete Surface Mounted: ³ / ₈ -inch diameter x 4-inch Hilti HUS-EZ (KH-EZ) in accordance with ESR-3027 or Hilti HSL-3 M8 x 3 ³ / ₄ -inch anchor in accordance with ESR-1545 . f _c = 3,000 psi ^B (20.6 MPa) ² embed depth = 2.5-inches (63.7 mm) effective depth			
Concrete anchors ≥ 3.75 inches edge distance^{1,2,3,4} Anchor spacing to concrete 12-inches O.C.			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load ⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B	42.7 psf	31.4 psf	61 in.
B5L	39.0 psf	28.6 psf	51 in.
B6S	45.6 psf	33.5 psf	61 in.
B7S	47.9 psf	35.2 psf	61 in.
Anchor spacing to concrete 6-inches O.C.			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load ⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B	68.6 psf	50.4 psf	97 in.
B5L	61.5 psf	45.2 psf	63 in.
B6S	73.2 psf	53.8 psf	97 in.
B7S	75.7 psf	55.6 psf	97 in.

For **SI**: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m². See footnotes at the end of Table 2d.

TABLE 2D—ANCHORAGE TO CONCRETE

Surface Mounted Base Shoes: Concrete anchors 2.35-inches edge distance^{1,2,3,4}			
Anchor spacing to concrete 12-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load ⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B	35.5 psf	26.1 psf	42 in.
B5L (3.047-inches min edge dist)	35.4 psf	26.0 psf ^a	42 in.
B6S	37.2 psf	27.3 psf	44 in.
B7S	39.1 psf	28.7 psf	46 in.
^a Does not meet 50 plf live load on top rail required by Section 1607.8.1 of the IBC. See Section 4.2.1 of this report.			
Concrete anchors 1.75-inches edge distance Anchor spacing to concrete 6-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load ⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B	50.8 psf	37.3 psf	60 in.
B5L	45.6 psf	33.5 psf	54 in.
B6S	53.3 psf	53.3 psf	63 in.
B7S	56.0 psf	41.1 psf	66 in.
B7S 2.35-inches edge distance	61.9 psf	45.5 psf	73 in.

For **SI**: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m².

¹Linear interpolation between guard heights, anchor spacing and edge distances is permitted.

²Adjustment for concrete strength other than f_c = 3,000 psi, see section 4.2.3.2.1 of this report.

³Adjustment for sand light-weight concrete: W' = 0.6*W

⁴Allowable wind load maybe limited by glass strength. See Table 1 in this report.

⁵Other loads listed in Section 4.2.1 must be considered.

TABLE 2E—SURFACE MOUNTED WITH DRAIN BLOCKS ON CONCRETE^{1,2,3,4}

Concrete anchors ≥ 3.75-inches edge distance			
Anchor spacing to concrete 12-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load 50plf
			Max. Height
B5G, B5S, B5T, 8B B5L	41.2 psf 37.0 psf	30.2 psf 27.2 psf	48 in. 44 in.
B6S	44.0 psf	32.3 psf	52 in.
B7S	50.5 psf	37.1 psf	54 in.
Concrete anchors ≥ 3.75-inches edge distance			
Anchor spacing to concrete 6-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L	66.9 psf 60.2 psf	49.2 psf 44.2 psf	79 in. 71 in.
B6S	71.2 psf	52.3 psf	84 in.
B7S	74.6 psf	54.8 psf	88 in.
Concrete anchors ≥ 2.35-inches edge distance			
Anchor spacing to concrete 12-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L (3.047-inches min edge dist)	34.0 psf 30.6 psf	25.0 psf 26.9 psf	40 in. 36 in.
B6S	36.2 psf	26.6 psf	42 in.
B7S	41.6 psf	30.5 psf	44 in.
Concrete anchors ≥ 2.35-inches edge distance			
Anchor spacing to concrete 6-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L	55.0 psf 49.5 psf	40.4 psf 36.4 psf	65 in. 58 in.
B6S	58.4 psf	42.9 psf	69 in.
B7S	61.2 psf	45.0 psf	72 in.

For **SI**: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m².

¹Linear interpolation between guard heights, anchor spacing and edge distances is permitted.

²Adjustment for concrete strength other than f_c = 3,000 psi. See Section 4.2.3.2.1

³Adjustment for sand light-weight concrete:

$$W' = 0.6 * W$$

⁴Allowable wind load may be limited by glass strength. See Table 1 in this report.

TABLE 2F—FASCIA MOUNTED WITH DRAIN BLOCKS (CONCRETE SUBSTRATE)

Concrete anchors ≥ 3.75-inches edge distance			
Anchor spacing to concrete 12-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load 50plf
			Max. Height
B5G, B5S, B5T, 8B B5L	<u>49.7 psf</u> <u>42.0 psf</u>	<u>37.0 psf</u> <u>31.2 psf</u>	<u>65 in.</u> <u>54 in.</u>
B6S	<u>49.7 psf</u>	<u>37.0 psf</u>	<u>65 in.</u>
B7S	<u>49.7 psf</u>	<u>37.0 psf</u>	<u>65 in.</u>
Concrete anchors ≥ 3.75-inches edge distance			

Anchor spacing to concrete 6-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L	77.1 psf 51.0 psf	57.5 psf 37.9 psf	101 in. 66 in.
B6S	77.1 psf	57.5 psf	101 in.
B7S	77.1 psf	57.5 psf	101 in.

For SI: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m².

TABLE 2G—FASCIA MOUNTED OVER DRAIN BLOCKS (WOOD SUBSTRATE)

To Wood With ½-inch Lag Screws With 2.37-inch Minimum Embedment to Wood G > 0.49			
Screw spacing 12-inches on-center for dry Locations M_c < 19%			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load 50plf
			Max. Height
B5G, B5S, B5T, 8B B5L	48.7 psf 41.4 psf	36.3 psf 30.8 psf	60 in. 50 in.
B6S	48.7 psf	36.3 psf	60 in.
B7S	48.7 psf	36.3 psf	60 in.
Screw spacing 6-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L	92.6 psf 77.8 psf	69.0 psf 57.9 psf	118 in. 97 in.
B6S	92.6 psf	69.0 psf	118 in.
B7S	92.6 psf	69.0 psf	118 in.
Screw spacing 12-inches on-center for wet locations M_c > 19%			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L (3.047-inches min edge dist)	34.5 psf 29.4 psf	25.7 psf 21.9 psf	41 in. 34 in.
B6S	34.5 psf	25.7 psf	41 in.
B7S	34.5 psf	25.7 psf	41 in.
Screw spacing 6-inches on-center			
Total Guard Height (Hg) Base Shoe	36-inches Allowable wind load	42-inches Allowable wind load	Live Load⁵ 50 plf
			Max. Height
B5G, B5S, B5T, 8B B5L	66.9 psf 56.8 psf	49.9 psf 42.2 psf	84 in. 70 in.
B6S	66.9 psf	49.9 psf	84 in.
B7S	66.9 psf	49.9 psf	84 in.

For SI: 1 inch = 25.4 mm; 1 psf = 0.0479 kN/m².

The allowable wind loads may be adjusted for other light heights by equation 3:

$$W' = \frac{W_{42} \cdot 42^2}{H_G^2} \quad \text{Eq. 3}$$

Where H_G = glass height measured from top of base shoe to top of top rail in inches.

TABLE 3—MAXIMUM TOP RAIL SPAN LENGTHS^{1, 4, 5}
(Based on the top rail spanning over a minimum of three glass panels)

Top Rail Profile	Material	Maximum Middle Span ^{2,3} (inches)	Maximum End Span ³ (inches)
GR15	Stainless	55	17
GR15	Brass	43	9
GRS/GRSC15	Stainless	73	15
GR16	Stainless	72	21
GR19	Aluminum	84	21
GR20	Stainless	96	33
GR20	Brass	96	20
GRS/GRSC20	Stainless	96	30
GR25	Stainless	96	58
GR25	Brass	96	32
GR25	Aluminum	96	40
GRS25	Stainless	96	30
GR30	Stainless	96	72
GR30	Brass	96	50
GR30	Aluminum	96	63
GR35	Stainless	96	72
GR35	Brass	96	56
GR35	Aluminum	96	85
GR40	Stainless	96	72
GR40	Brass	96	42
GR207	Stainless	96	34
GR257	Stainless	96	56
GR257	Brass	96	29
GR307	Stainless	98	69
GR307	Brass	96	37
GR307M	Aluminum	96	64
GROV4	Aluminum	96	60
WCR20	Wood	40	11
WCR25	Wood	83	21
WCR30	Wood	96	36
GRLC10	Stainless	83	24
GRL10	Stainless	81	24

For **SI**: 1 inch = 25.4 mm.

1. Based on the capacity of the top rail considering the worst case between a 50 plf uniform load and a 200 lb. concentrated load.
2. The maximum middle glass panel widths must not be greater than the maximum middle top rail span.
3. The maximum end glass panel must not be greater than the maximum end top rail span.
4. The glass panel widths must not be less than the minimum glass panel width noted in Table 1.
5. When the top rail is attached to a wall or post, the maximum top rail end span may be increased to the same for the maximum middle span tabulated.

TABLE 4—PLATE POST SIZES

Plate Thickness (inches)	Minimum Width (inches)	Base shoes
$\frac{1}{2}$	9	B5 series
$\frac{5}{8}$	5.75	B6 series
$\frac{3}{4}$	4	B7 series
1	2.25	B5 series
1.125	1.81	B6 series
1.25	1.437	B7 series

For SI: 1 inch = 25.4 mm.

1. The plate post must be manufactured from stainless steel complying with 304 or 316 stainless steel with a minimum yield strength (Fy) of 30 ksi and a minimum tensile strength (Fu) of 70 ksi.
2. The maximum end span of the top rail next to the post must not be greater than that in Table 3.
3. Based on the capacity of the plate post considering the worst case between a 50 plf uniform load and a 200 lb. concentrated load.

TABLE 5—BRACKET SPACING¹

Handrail	Material ²	L2 in	Le in
1 ¹ / ₄ -inch Sched 40	St or SS	96	24
1 ¹ / ₄ -inch Sched 40	6063-T6 Al	84	21
1 ¹ / ₂ -inch Sched 40	St or SS	115	34
1 ¹ / ₂ -inch Sched 40	6063-T6 Al	96	29
1 ¹ / ₂ -inch x 1 ¹ / ₈ -inch Tube	SS	102	27
1 ¹ / ₂ -inch x 1 ¹ / ₈ -inch Tube	6063-T6 Al	62	15
1 ¹ / ₂ -inch x 0.05-inch Tube	SS	50	12
2-inch x 0.05-inch Tube	SS	92	22

For SI: 1 inch = 25.4 mm.

¹See Figure 10 for additional details.

²St = A53 Steel, SS = 304 or 316 Stainless Steel

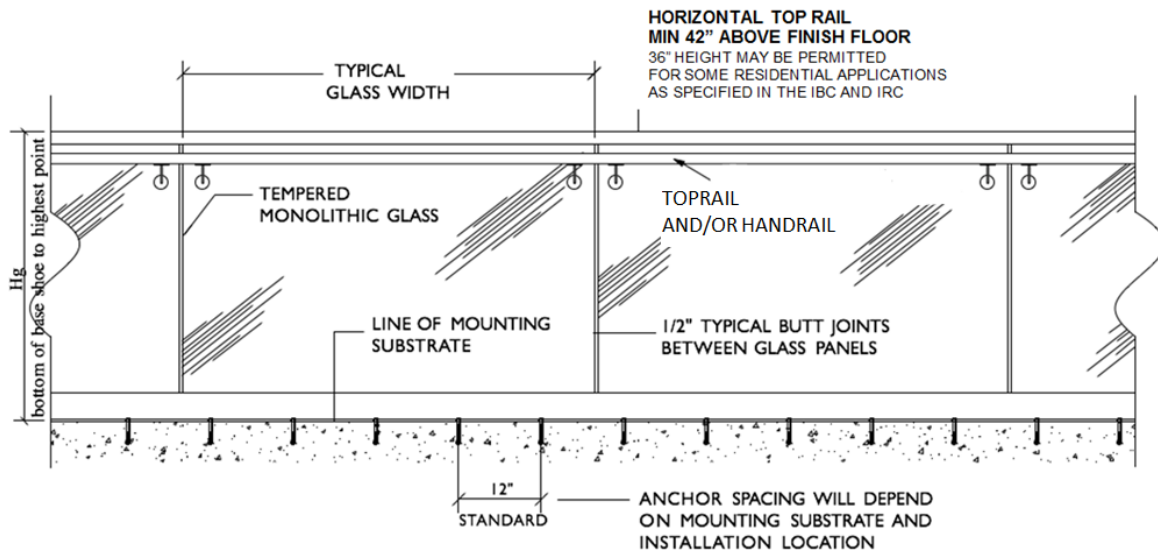
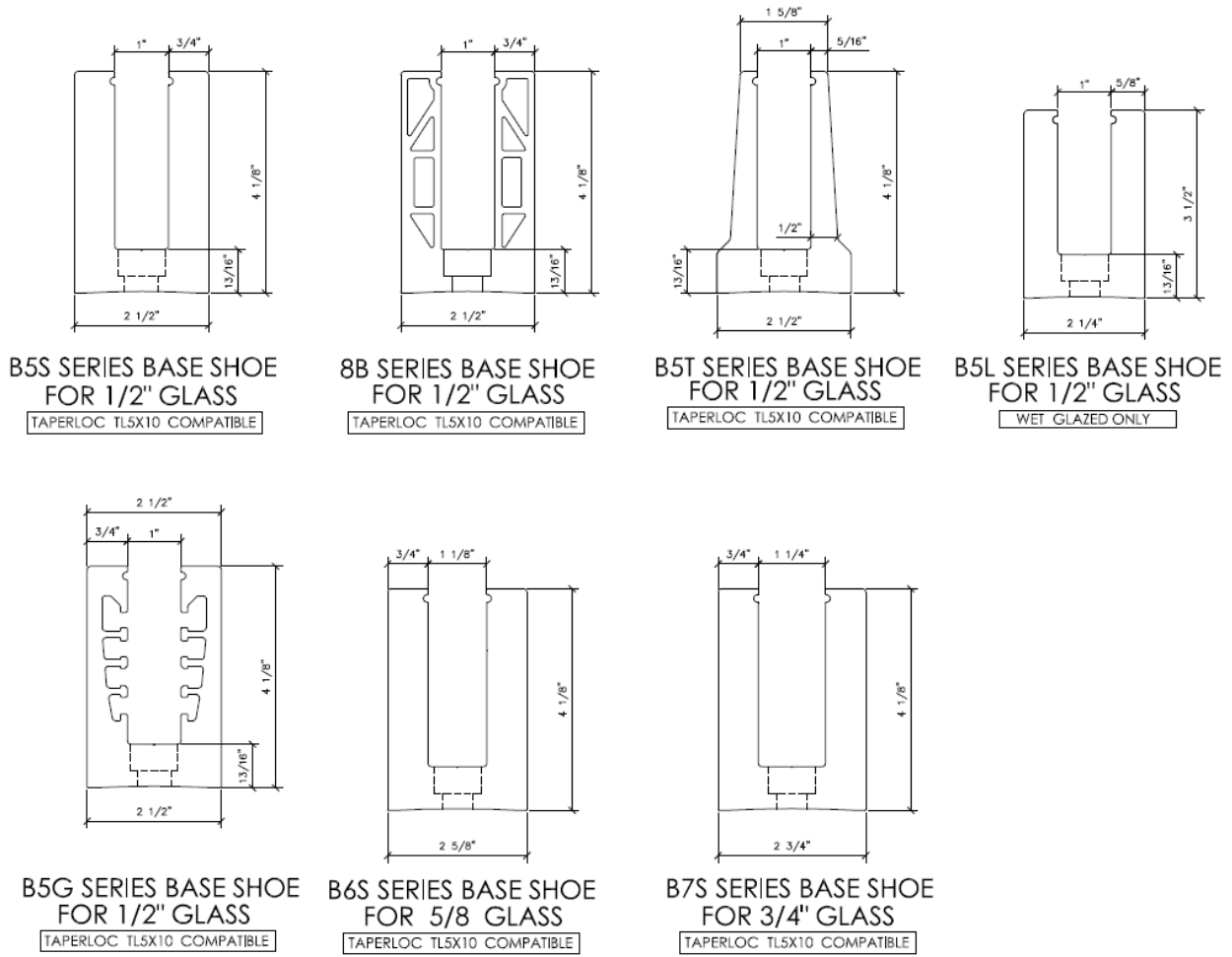


FIGURE 1—TYPICAL GLASS RAILING ELEVATION

Note: A top rail or handrail must be installed.
 When a handrail is required to be installed per the applicable code,
 then the top rail is optional.



For SI: 1 inch = 25.4 mm.

FIGURE 2—BASE SHOES

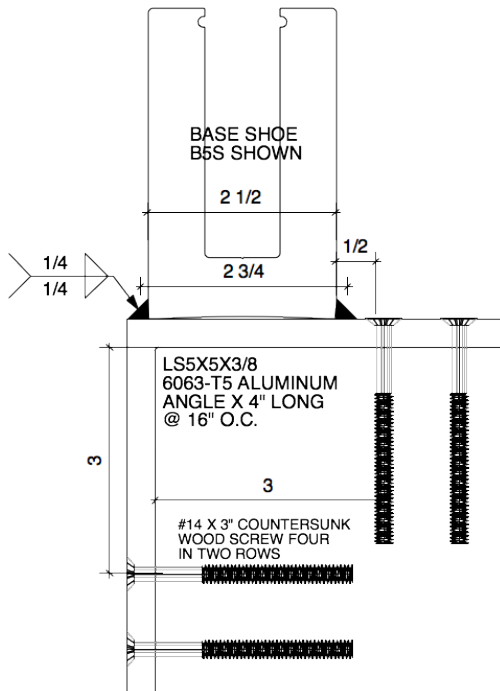


FIGURE 3—ALUMINUM BRACKET TO WOOD
(Dimensions are in inches; 1 inch = 25.4 mm)

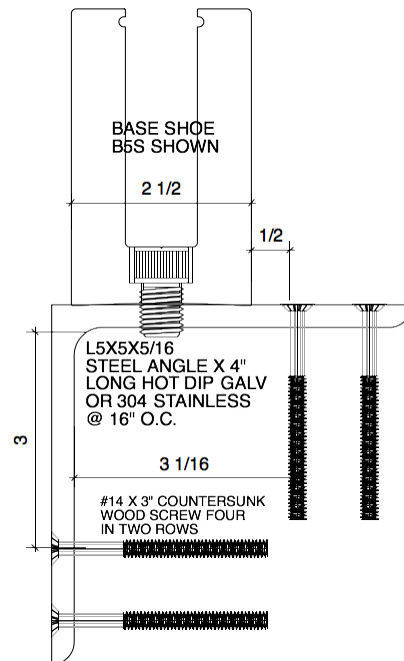


FIGURE 4—STEEL BRACKET TO WOOD
(Dimensions are in inches; 1 inch = 25.4 mm)

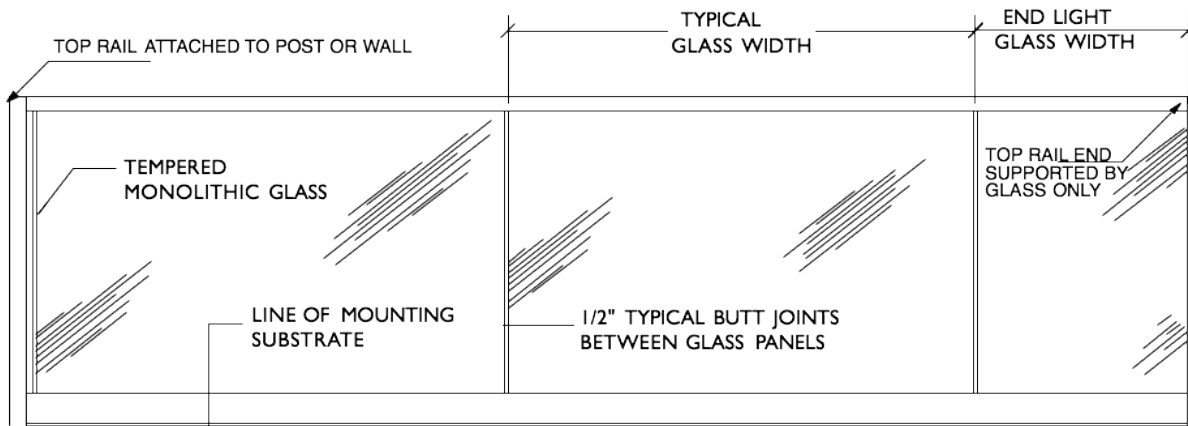


FIGURE 5—TOP RAIL SUPPORT OPTIONS

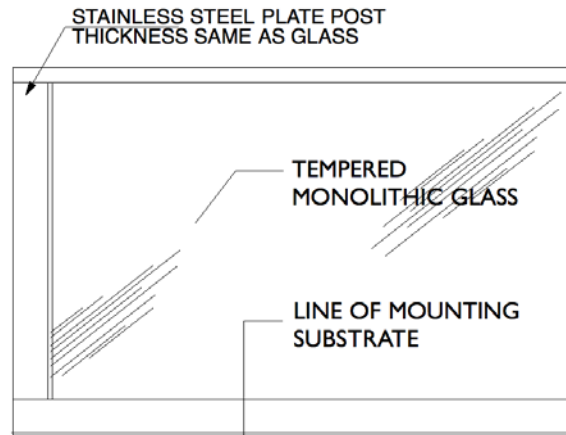
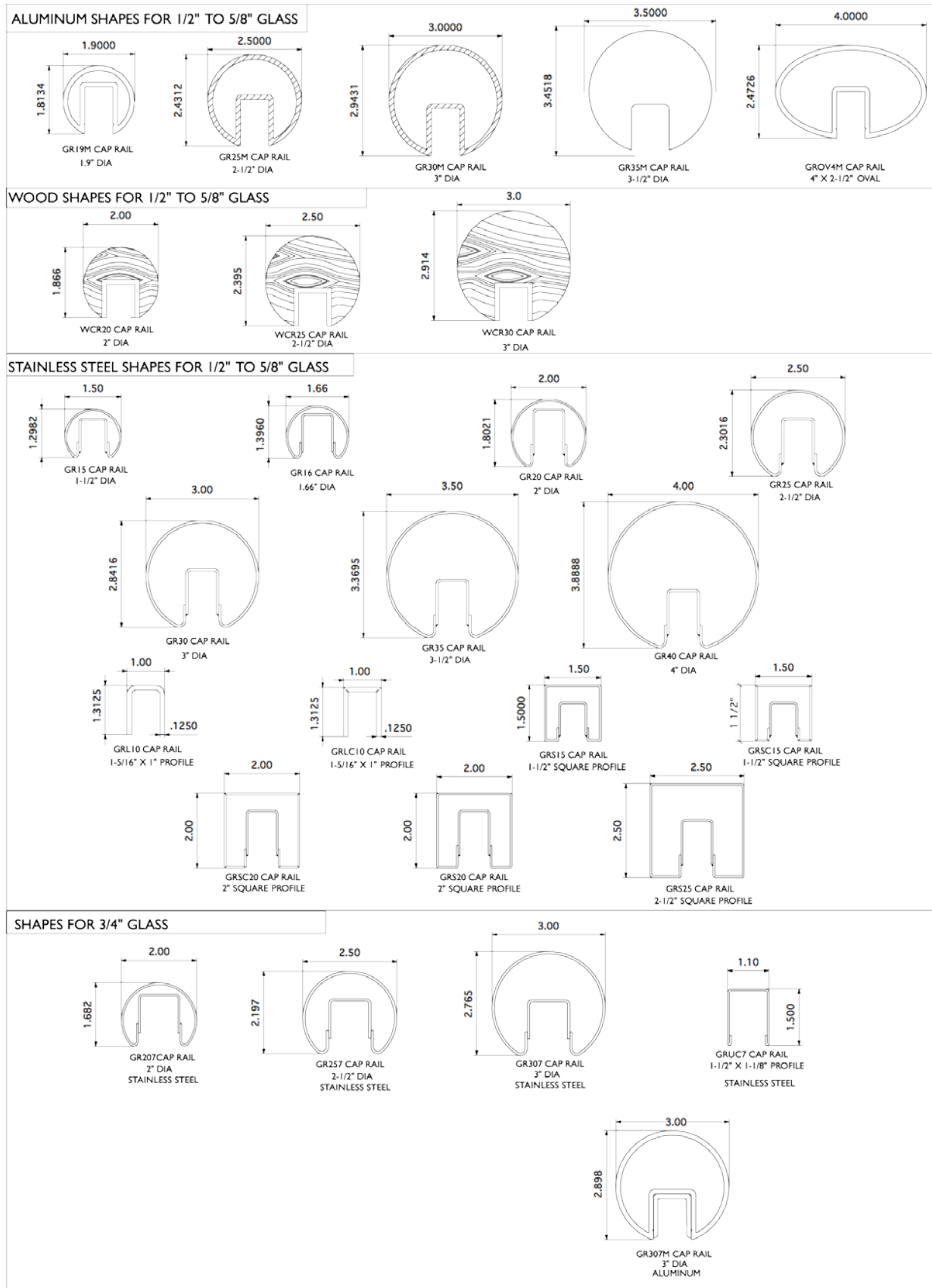
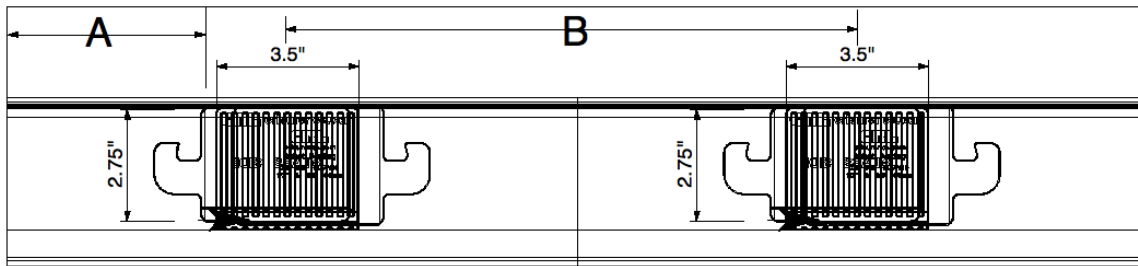
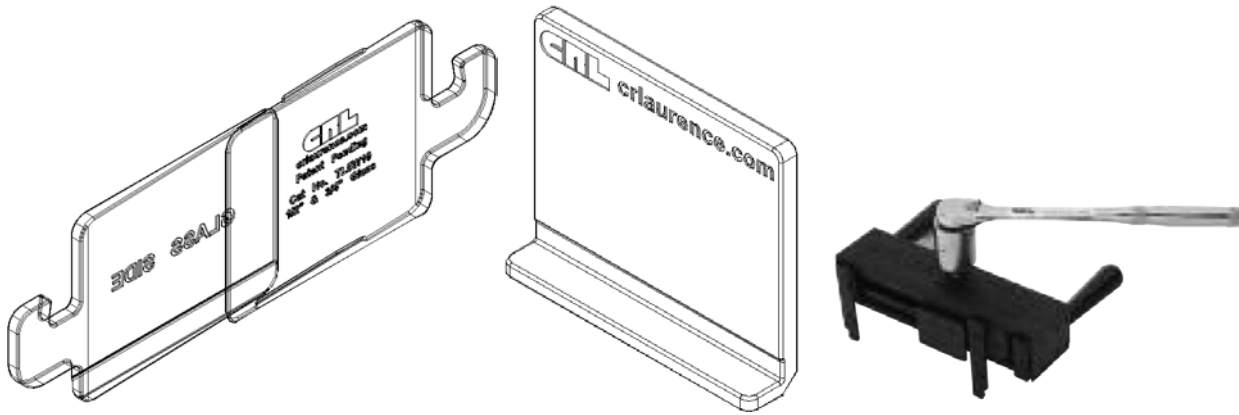


FIGURE 6—TOP RAIL SUPPORTED BY END PLATE POST



For SI: 1 inch = 25.4 mm.
Dimensions are in inches.

FIGURE 7—TOP RAIL PROFILES



For 1/2-inch Fully Tempered Glass maximum glass light height = 42-inch:
 Edge Distance: 2-inches $\leq A \leq 8^{5/8}$ -inches; 51 mm $\leq A \leq 219$ mm
 Center to center spacing: 7-inches $\leq B \leq 14$ -inches; 178 mm $\leq B \leq 356$ mm

Panel Width/Required quantity of Taper-Loc® Plates:

6-inches to 14-inches (152 to 356 mm)	1 TL Plate
14-inches to 28-inches (356 to 711 mm)	2 TL Plates
28-inches to 42-inches (711 to 1,067 mm)	3 TL Plates
42-inches to 56-inches (1,067 to 1,422 mm)	4 TL Plates
56-inches to 70-inches (1,422 to 1,778 mm)	5 TL Plates
70-inches to 84-inches (1,778 to 2,134 mm)	6 TL Plates
84-inches to 96-inches (2,134 to 2,438 mm)	7 TL Plates

Adjustments to spacing:

- For glass light heights over 42-inches A_{max} and B_{max} must be reduced proportionally.
 - $A_{max} = 8^{5/8} * (42/h)$
 - $B_{max} = 14 * (42/h)$
 - h = glass height
 - For glass light heights under 42-inches A_{max} and B_{max} must not be increased.
 - A_{min} and B_{min} are for ease of installation and can be further reduced as long as proper installation is achieved.
 - For glass thicknesses greater than 1/2" A_{max} and B_{max} may be increased as follows:
 - 5/8-inch Glass
 - Edge Distance: 2-inches $\leq A \leq 13.5$ "
 - Center to center spacing: 7" $\leq B \leq 21$ "
 - 3/4-inch Glass
 - Edge Distance: 2-inches $\leq A \leq 19$ "
 - Center to center spacing: 7" $\leq B \leq 31$ "
- For SI: 1 inch = 25.4 mm.

FIGURE 8—TAPER-LOC® SHOE SETTING PLATE

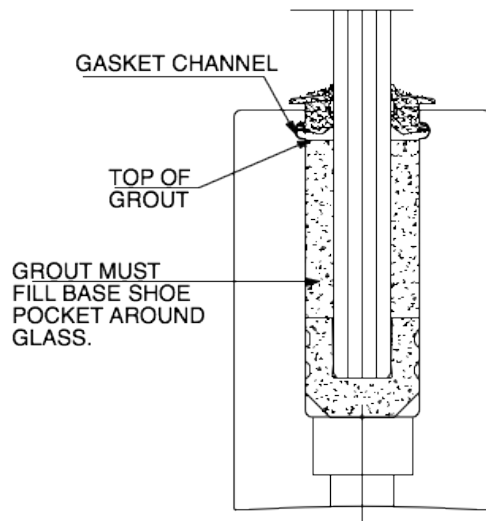


FIGURE 9—WET GLAZING

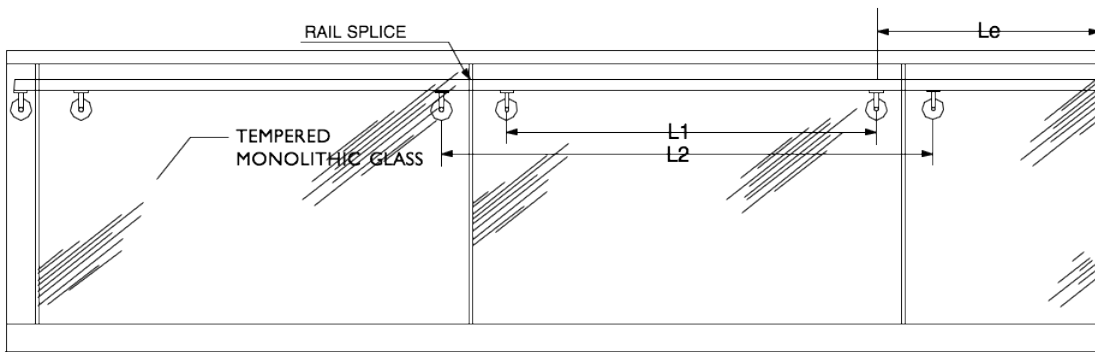


FIGURE 10—TOP RAIL SUPPORT OPTIONS

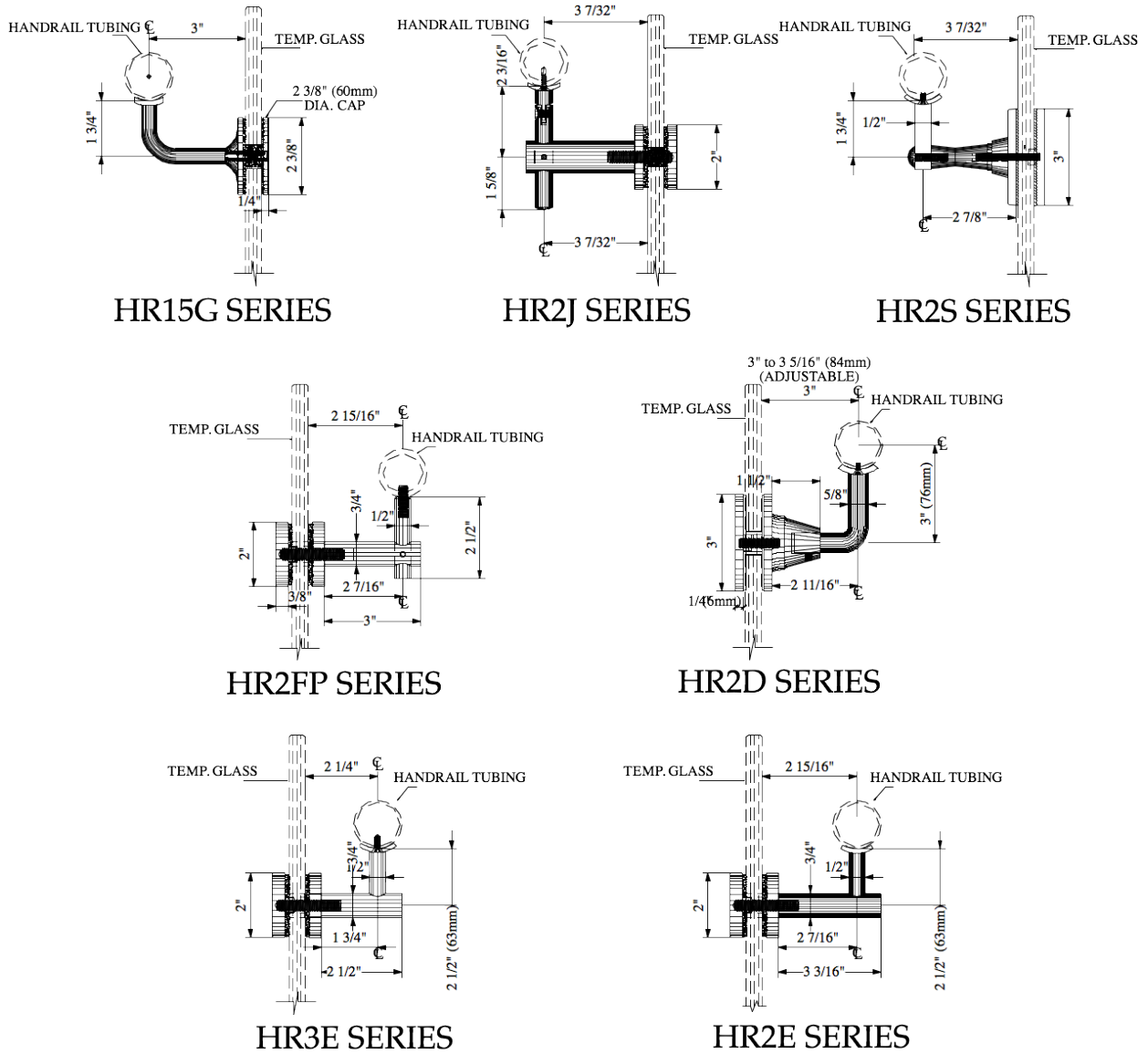


FIGURE 11—HANDRAIL BRACKETS'

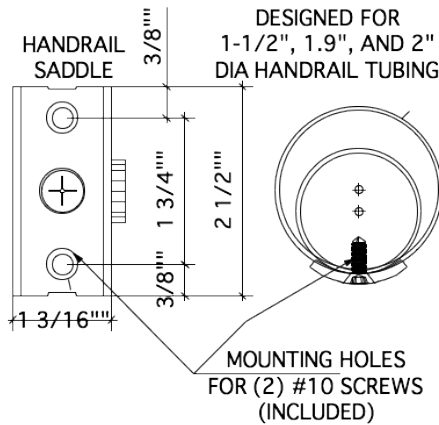


FIGURE 12—HANDRAIL ATTACHMENT

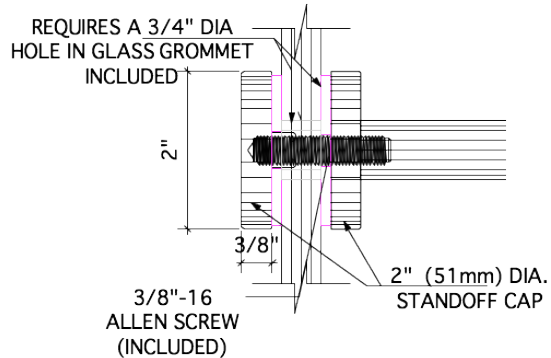


FIGURE 13—HANDRAIL ATTACHMENT TO GLASS

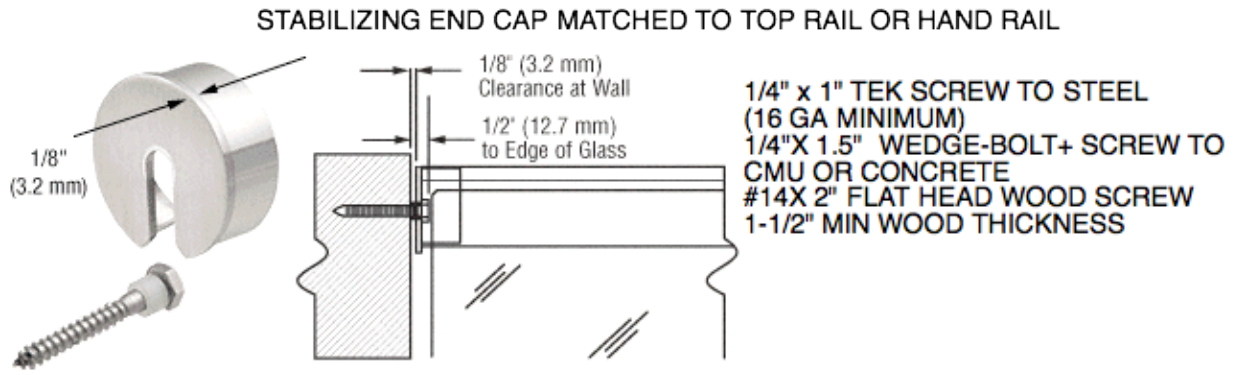


FIGURE 14—STABILIZING END CAP

DIVISION: 05 00 00—METALS

Section: 05 52 00—Metal Railings

Section: 05 73 13—Glazed Decorative Metal Railings

DIVISION: 08 00 00—OPENINGS

Section: 08 81 00—Glass Glazing

Section: 08 88 00—Special Function Glazing

DIVISION: 32 00 00—EXTERIOR IMPROVEMENTS

Section: 32 35 00—Screening Devices

REPORT HOLDER:

C.R. LAURENCE COMPANY, INC.

EVALUATION SUBJECT:**GRS™ GLASS BALUSTRADE GUARD SYSTEM FOR MONOLITHIC TEMPERED GLASS APPLICATIONS****1.0 REPORT PURPOSE AND SCOPE****Purpose:**

The purpose of this evaluation report supplement is to indicate that the GRS™ Glass Balustrade Guard System for Monolithic Tempered Glass Applications, described in ICC-ES evaluation report ESR-3269, has also been evaluated for compliance with the codes noted below.

Applicable code editions:

- 2016 *California Building Code*® (CBC)

For evaluation of applicable chapters adopted by the California Office of Statewide Health Planning and Development (OSHPD) and Division of State Architect (DSA), see Sections 2.1.1 and 2.1.2 below.

- 2016 *California Residential Code*® (CRC)

2.0 CONCLUSIONS**2.1 CBC:**

The GRS™ Glass Balustrade Guard System for Monolithic Tempered Glass Applications, described in Sections 2.0 through 7.0 of the evaluation report ESR-3269, complies with CBC Chapters 10 and 24, provided the design and installation are in accordance with the 2015 *International Building Code*® (IBC) provisions noted in the evaluation report and the additional requirements of CBC Chapters 10, 16 and 24, as applicable.

2.1.1 OSHPD:

The applicable OSHPD Sections of the CBC are beyond the scope of this supplement.

2.1.2 DSA:

The applicable DSA Sections of the CBC are beyond the scope of this supplement.

2.2 CRC:

The GRS™ Glass Balustrade Guard System for Monolithic Tempered Glass Applications, described in Sections 2.0 through 7.0 of the evaluation report ESR-3269, complies with CRC Chapter 3, provided the design and installation are in accordance with the 2015 *International Residential Code*® (IRC) provisions noted in the evaluation report.

This supplement expires concurrently with the evaluation report, reissued November 2021 and revised March 2022.