



BOCA ENGINEERING CO.

STRUCTURAL TECHNOLOGIES · DESIGN · TESTING · CODE EVALUATION

B.C. BUILDING CODE

ENGINEERING EVALUATION REPORT

Date	Dec 31, 2021
File No.	0078-3-3-0095
For	Trex Company, Inc.
Address	160 Exeter Dr., Winchester, VA 22603-8605

Subject

Trex Signature® Railing

Evaluation Scope

This report is provided to assist registered design professionals and building officials in Canada with determining compliance to the performance objectives in the named building codes.

The material(s) and system(s) described herein have been evaluated to the 2018 British Columbia Building Code (BCBC), Division A, Section 1.2.1.1.(1)(a) for compliance with the applicable acceptable solutions in Division B, for buildings classified under Part 3/4/5 and Part 9 construction.

CSI DIVISION: 05 00 00 METALS
SUBDIVISION: 05 52 00 Metal Railings

CODE SECTIONS AND STANDARDS:

<u>BCBC Div. B Section</u>	<u>Description</u>	<u>Referenced Standard or Div. B Section¹</u>	<u>Year</u>
3.3.1.18	All Floor Areas, Guards	3.3.4.7, 3.3.5.10	2015
3.3.4.7	Residential Occupancy, Stairs, Ramps, Landings, Handrails and Guards for Dwelling Units	9.8	2015
3.3.5.10	Industrial Occupancy, Guards	-	-
3.4.6.6	Types of Exit Facilities, Guards	3.3.4.7, 3.3.5.10	2015
4.1.1.5.(1)	Structural Loads and Procedures, Design Basis	-	-
4.1.3.2.(2)	Limit States Design, Strength and Stability	Table 4.1.3.2.-A	2015
4.1.3.4	Limit States Design, Serviceability	4.1.3.5	2015
4.1.3.5	Limit States Design, Deflection	-	-
4.1.5.14	Loads on Guards and Handrails	-	-
4.1.7	Wind Load	-	-
4.3.5.1	Design Basis for Aluminum	CSA S157	2005

<u>BCBC Div. B Section</u>	<u>Description</u>	<u>Referenced Standard or Div. B Section¹</u>	<u>Year</u>
9.4.1.1.(1)(c)(i)	Structural Design Requirements and Application Limits	Part 4	2015
9.8.8.2	Loads on Guards	Table 9.8.8.2	2015



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9.8.8.3	Height of Guards	-	-
9.8.8.5	Openings in Guards	-	-
9.8.8.6	Design of Guards to Not Facilitate Climbing	-	-

1. Only the applicable reference standards and code sections cited in the main body text are listed. (-) indicates that the main body text covers the full explanation of the objective.

TABLE 1: OCCUPANCY CLASSIFICATION COMPLIANCE

System	In-Fill Description	Post Description	2018 BCBC Div. B Sections			
			3.3.4.7	3.3.5.10	9.8	9.8
			Group C Residential	Group F Industrial	Part 9 Housing & Small Buildings, All guards	Part 9 Housing & Small Buildings, Max 2 dwelling
Signature	Aluminum Railing	Standard	Yes	Yes	Yes	Yes
		Post Mount	Yes	Yes	Yes	Yes

Compliance Statement: Trex Signature® Railing, when installed as described in this report, has demonstrated compliance with the listed sections of the 2018 British Columbia Building Code. Design and performance information can be found in Section 2 of this report.

This report has been prepared and reviewed on behalf of Boca Engineering Co. by:

Christopher Bowness, P.Eng., P.E.

2021-12-31
Date



EGBC Permit to Practice No. 1002012

Evaluation

1.0 PRODUCT DESCRIPTION:

Trex Signature® Railing is a guardrail system comprised of aluminum rails, balusters and posts (optionally with wood-plastic composite post sleeves), and zinc brackets.

In-Fill Description	Post Configuration	No. of Footblocks	Span Between Posts	Guardrail Height
Aluminum Railing	Standard	1 [†]	Up to 96" (2,438 mm) Load-case Specific	42" (1,067 mm)
	Post Mount	1 [†]		

[†] Footblocks are positioned at the midspan of the bottom rail.

In the standard configuration, the railing assembly is installed between two aluminum posts, with the top and bottom rail brackets fastened directly to the posts.



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In the post mount configuration, the railing assembly is installed between two aluminum posts concealed by wood-plastic composite post sleeves, which slide over two post mount spacers fastened to the top and bottom of each post. In this configuration, the top and bottom rail brackets are fastened to the post mount spacers through the post sleeves.

Posts are welded to an aluminum baseplate with pilot holes ready to attach to the substructure.

See the attachments section at the end of this report for loading-case specific allowable post spacings, component specifications, connection details, component diagrams, and assembly drawings.

2.0 TECHNICAL EVALUATION:

2.1 INSTALLATION

- 2.1.1 Trex Signature® Railing components with fasteners are supplied as a package. Components are manufactured to size, ready for assembly at the jobsite. Post baseplates are prepared ready with bolt holes for surface mounting to a code-compliant framing sub-structure by methods specific to the building project design. Attachment to sub-structure methods are not covered in this design evaluation.
- 2.1.2 Manufacturer's published installation instructions are available online at: <https://www.trex.com/trex-owners/customer-support/downloads/#productinstall>.
- 2.1.3 Manufacturer's installation instructions, building code, and additional details in this report are to be followed.

2.2 MATERIALS PROPERTIES

The structural components of the guard system comply with the materials specifications within:

Aluminum Components: CSA S157-05, *Strength Design in Aluminum*.

Steel Fasteners: CSA S16-14, *Design of Steel Structures*.

2.3 CODE SECTIONS REVIEW

BCBC Div. B Section

Description

3.3.1.18

All Floor Areas, Guards

Trex Signature® Railing conforms to the dimensional and functional requirements, and the structural loading requirements, for the floor area occupancy classifications shown in Table 1 of this report.

There are no intermediate horizontal components within the infill and the system does not facilitate climbing, for where article 3.1.8.18.(4) applies when guards are protecting a level located more than one storey or 4.2 m above the adjacent level.

3.3.4.7

Residential Occupancy, Stairs, Ramps, Landings, Handrails and Guards for Dwelling Units

The requirement is for Part 3 residential occupancy guards to conform to the requirements of Section 9.8. See this report commentary to BCBC 9.8.

3.3.5.10

Industrial Occupancy, Guards

Trex Signature® Railing conforms to the dimensional, functional and structural loading requirements of this Code section.



3.4.6.6

Types of Exit Facilities, Guards

Trex Signature® Railing conforms to the dimensional, functional and structural loading requirements of this Code section for the occupancy classifications in Table 1 of this report.

4.1.1.5.(1)

Structural Loads and Procedures, Design Basis

The structural components in this guard system have been evaluated in accordance with materials design standards referenced within Part 4.

4.1.3.2.(2)

Limit States Design, Strength and Stability

Limit states load combinations of Table 4.1.3.2-A have been considered in this design evaluation. The common maximum loading case scenario is found to be Case 2.

Section F.24 of User’s Guide – NBC 2015, Structural Commentaries directs that guards are to be designed with load combinations for ultimate limit states.

Design load combinations used in this evaluation are:

Ultimate (ULS): 1.5L + 0.4W

Service (SLS): 1.0L + (0.75)0.4W

4.1.3.4

Limit States Design, Serviceability

Fatigue, deflection, and temperature and moisture effects serviceability limits states have been considered in the design analysis.

4.1.3.5

Limit States Design, Deflection

The deflection limits have been determined in accordance with ASTM E985-06, *Standard Specification of Permanent Metal Railing Systems and Rails for Buildings*, which is recommended for use in Section F.23 of User’s Guide – NBC 2015, Structural Commentaries Part 4 of Division B.

4.1.5.14

Loads on Guards and Handrails

Table 2: Design Loading and Deflection Limits			
Sub-section	Load Type ⁽¹⁾	Design Service Live Load	Deflection Limit 8-ft post spacing
4.1.5.14.(3)	Infill Lower Center	0.5 kN (112 lb), over 100 mm sq.	-
4.1.5.14.(3)	Infill Middle Center	0.5 kN (112 lb), over 100 mm sq.	-
4.1.5.14.(1)(c)	Horizontal Uniform Load Along Top Rail	0.75 kN/m (52 lb/ft)	70 mm (2.75 in)
4.1.5.14.(6)	Vertical Uniform Load Along Top Rail	1.5 kN/m (102.7 lb/ft)	25 mm (1 in)
4.1.5.14.(1)(c)	Concentrated Load at Midspan of Top Rail (horiz)	1.0 kN (224 lb)	70 mm (2.75 in)
4.1.5.14.(1)(c)	Concentrated Load at Top Rail Adjacent to Post (horiz)	1.0 kN (224 lb)	-
4.1.5.14.(1)(c)	Concentrated Load at Top of Single Post (horiz)	1.0 kN (224 lb)	89 mm (3.5 in)

1. 4.1.5.14 states that these forces need not be considered to act simultaneously.

The structural design analysis has been carried out in accordance with CSA S157-05 and ASTM E985-13. An expanded discussion of the design procedure is provided in Attachment 3.



The deflection limits measured at service level loads are found not to exceed the deflection limits determined in accordance with BCBC 4.1.3.5 shown in Table 2 of this report.

The system is able to resist an ultimate load of 2.25 times the service level live load for each loading type shown in Table 2 of this report. Following CSA S157-05 Section 13.3.1.2, the 2.25 test load factor equates to the live load factor divided by the effective resistance factor.

The rail system shape geometry and strength are the same in the inward and outward direction, satisfying the loading criteria of BCBC 4.1.5.14.(2).

The loading criteria of BCBC 4.1.5.14.(4) does not apply for the occupancy classifications sited in this report.

The reaction at the guard post base imparted to the building's main structure from the maximum loading scenario is an ultimate-level (factored) moment of 2.18 kN-m, which may be reduced to 1.58 kN-m for installations of only 2-posts. The site-specific base attachment must be designed to transfer this moment to the structure.

4.1.7 Wind Load

A nominal wind load of p 1.0 kPa ($q_{1/50}$ 0.63 kPa in rough terrain at 3-storey height) has been applied in the design model with applicable factors as per BCBC 4.1.7.1.(5)(a), Static Procedure for secondary structural members.

4.3.5.1 Design Basis for Aluminum

The design analysis has been carried out in accordance with and complies with CSA S157-05, *Strength Design in Aluminum*.

<u>BCBC Div. B</u>	<u>Description</u>
<u>Section</u>	

9.4.1.1.(1)(c)(i)	Structural Design Requirements and Application Limits
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	The design methodology in this evaluation for determining conformance to Part 9 has been performed in accordance with BCBC 9.4.1.1.(1)(c)(i) using the loads and deflection limits specified in Part 9.
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9.8.8.2	Loads on Guards
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	Trex Signature® Railing is designed to resist the minimum specified loads for all of the guard types listed in BCBC Table 9.8.8.2, as detailed in Table 1 of this report.
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9.8.8.3	Height of Guards
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	The top rail height of Trex Signature® Railing is nominally 1070 mm (42 inches).
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9.8.8.5	Openings in Guards
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	The openings between the intermediate infill members and between the bottom rail and deck surface of Trex Signature® Railing does not exceed 100 mm (4 inches).
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9.8.8.6 Design of Guards to Not Facilitate Climbing

There are no intermediate horizontal components within the infill and the system does not facilitate climbing, for where article 9.8.8.6 applies when guards are protecting a level located more than one storey or 4.2 m above the adjacent level.

3.0 LIMITATIONS:

- 3.1 This Evaluation is for the base code requirements of the building system as addressed in this report. In some building applications, additional performance objectives may be required by Code which must be addressed in the building design for those specific cases.
- 3.2 Design calculations, drawings, and special inspections are to be furnished for building projects by registered professionals as required by the respective jurisdictional authorities and Codes.
- 3.3 The design evaluation of Trex Signature® Railing is of the guard system components only, installed as described in this report. Attachment of the post baseplate to the main building structure has not been detailed or evaluated within the scope of this evaluation. The post-base reaction forces (in units of moment) for design of those elements has been discussed in comments to BCBC section 4.1.5.14, and labeled on the system configuration drawing.
- 3.4 Strength and performance values apply to temperature at deck surface ranging from -29°C to 52°C.

4.0 FIRE CLASSIFICATIONS:

Aluminum components of the guard system are a *non-combustible* material as defined in BCBC, Div A, 1.4.1.2.

Wood-plastic composite post sleeve components of the guard system are a *combustible* material as defined in BCBC, Div A, 1.4.1.2.

Wood-plastic composite post sleeve components tested to CAN/ULC S102.2 have a Flame Spread Index of 40.

5.0 QUALITY ASSURANCE ENTITY:

The products evaluated in this report are surveyed at the approved manufacturing locations with third-party quality assurance inspections and product certification labeling by QAI Laboratories Inc.

6.0 MANUFACTURING PLANTS:

The manufacturing plants of guard rail systems covered in this evaluation are located in the following city/state locations: Winchester, VA.

7.0 LABELING:

Labeling shall be in accordance with the requirements of and bear the certification mark of the Accredited Quality Assurance Agency.

8.0 EVALUATION RENEWALS:

This Evaluation Report expires Dec 31, 2022, open to renewal, and is valid until such time as the named product(s) changes, the Quality Assurance Agency changes, the report is amended, or provisions of the Code that relate to the product change.



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9.0 REFERENCE TESTING AND EVALUATION DOCUMENTS:

<u>Entity</u>	<u>Entity Accreditation</u> ¹	<u>Standards</u>	<u>Report No.</u>	<u>Issue Date</u>
Trex	Note 2	ASTM E935-13	190301-BA-1	2019-07-19
Intertek	IAS TL 144	ASTM E935-13	i1676.01-119-19-R0 ³	2019-07-16
Right Testing Labs	IAS TL 859	CAN/ULC S102.2-18	RTL0028-1	2020-03-27
QAI	SCC 10024	Quality Assurance	B1109-1	2018-07-31

1. Testing, certification, evaluation, and inspection agencies referenced have been verified to be accredited by Standards Council of Canada (www.scc.ca) or International Accreditation Service (www.iasonline.org) for the applicable scope, in good standing on the date of the evaluation, in accordance with ISO 17025 and ISO 17020 international standards for testing and inspection bodies.
2. Testing performed at manufacturer's R & D test facility witnessed by Boca Engineering Co.
3. Ultimate strength test of post, verified procedure is in accordance with ASTM E935-13.

10.0 CERTIFICATION OF INDEPENDENCE:

- 10.1 Boca Engineering Co., its employees and shareholders, do not have, nor do they intend to or will acquire, a financial interest in any company manufacturing or distributing products that they evaluate.
- 10.2 Boca Engineering Co. is not owned, operated or controlled by any company manufacturing or distributing products that they evaluate.

11.0 EVALUATION REPORT TERMS:

This report is a general evaluation of the building code section requirements as identified and applies only to the samples that were evaluated. It does not imply any endorsement or warranty, nor that the signatory Engineer is the Designer of Record of any construction project for which the information is used.

ATTACHMENTS:

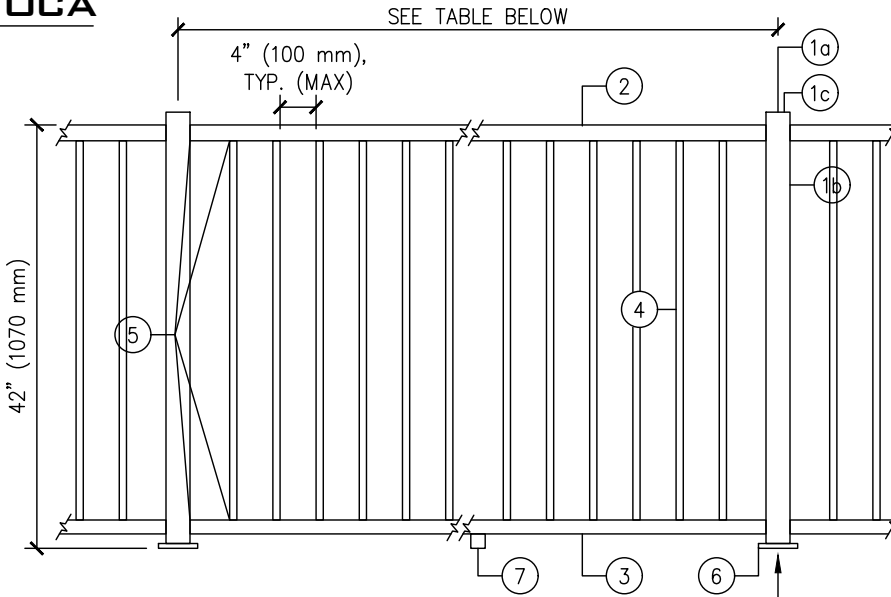
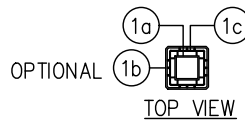
1. Components Specifications _____ (pg 8)
2. Allowable Post Spacing, Assembly and Component Drawings _____ (pg 9 - 13)
3. Limit States Design Procedure _____ (pg 14)



ATTACHMENTS 1 & 2: COMPONENTS SPECIFICATIONS AND ASSEMBLY DRAWINGS

Table 3: Trex Signature® Aluminum Railing, Components Specifications	
Component	Description
Top rail (two pieces)	1.565"-wide × 1.296"-high × 95.5"-long, "U"-shaped, extruded aluminum (6105-T5) channel with 1.74"-wide × 0.363"-high, rounded, extruded aluminum (6063-T6) snap-on cap (overall dimensions: 1.74" wide × 1.45" high)
Bottom rail (two pieces)	1.74"-wide × 1.162"-high × 95.5"-long, "U"-shaped, extruded aluminum (6063-T6) channel with 1.74"-wide × 0.3"-high, flat, extruded aluminum (6063-T6) snap-on cap (overall dimensions: 1.74" wide × 1.23" high)
Balusters	0.75" square × 0.05"-thick (wall) × 39.485"-long, hollow, extruded aluminum (6063-T6) tube
Middle (pinned) baluster	0.76" square × 0.058"-thick (wall) × 37.313"-long, hollow, extruded aluminum (6063-T6) tube with two internal screw bosses running the entire length of the profile
Rail insert	0.884"-wide × 0.96"-high × 93"-long, "U"-shaped, extruded PVC channel
Top rail bracket	Collar-style, die-cast zinc (ZAMAK 3) bracket
Bottom rail bracket	Collar-style, die-cast zinc (ZAMAK 3) bracket
Footblock	1.375" square × 0.125"-thick (wall) × 2"-long, hollow, extruded aluminum (6063-T52) tube
Post	2.5" square × 0.125"-thick (wall) × 42.5"-long, hollow, extruded aluminum (6063-T6) tube welded on all four sides (0.25" × 0.25" fillet weld) using Ø0.045" aluminum (ER5356) wire to 4" square × 0.5"-thick aluminum (6063-T6) baseplate with four Ø0.406" holes spaced 3.25" on center in the corners for anchors and one Ø0.406" hole in the center (overall length: 43")
Post mount spacer	3.63" square × 7"-long, hollow, extruded aluminum (6063-T6) tube with eight internal ribs (two per side) running the entire length of the profile
Post sleeve	4.45" square × 0.15"-thick (wall), hollow, extruded wood-plastic composite tube with 12 internal ribs (three per side) running the entire length of the profile

Table 4: Trex Signature® Aluminum Railing, Fastener Specifications	
Connection	Fastener(s)
Top rail to top rail bracket	(2) #10-16 × 5/8", #2 square drive, pan head, self-drilling, stainless steel screws
Bottom rail to bottom rail bracket	(1) #10-16 × 5/8", #2 square drive, pan head, self-drilling, stainless steel screw
Middle (pinned) baluster to top and bottom rails	(2) #8-15 × 1-1/4", #2 square drive, pan head, stainless steel screws thru slot in rails into screw bosses in baluster
<i>For standard configuration</i>	
Top rail bracket to post	(3) #10-16 × 5/8", #2 square drive, pan head, self-drilling, stainless steel screws
Bottom rail bracket to post	(2) #10-16 × 5/8", #2 square drive, pan head, self-drilling, stainless steel screws
<i>For post mount configuration</i>	
Post mount spacer to post	(1) #10-15 × 1", #2 square drive, flat head, self-drilling, stainless steel screw
Top rail bracket to post mount spacer (thru post sleeve)	(3) #8-15 × 1-1/4", #2 Phillips drive, pan head, stainless steel screws
Bottom rail bracket to post mount spacer (thru post sleeve)	(2) #8-15 × 1-1/4", #2 Phillips drive, pan head, stainless steel screws



SIGNATURE RAILING COMPONENTS	
1a	ALUMINUM POST
1b	WPC POST SLEEVE (OPTIONAL)
1c	ALUMINUM POST MOUNT SPACER
2	ALUMINUM TOP RAIL
3	ALUMINUM BOTTOM RAIL
4	ALUMINUM SQUARE PICKET
5	CONNECTIONS, SEE TEST REPORT
6	BASEPLATE
7	FOOTBLOCK

SEE TREX SIGNATURE ENGINEERING EVALUATION REPORT TABLES 3 AND 4 FOR MATERIAL SPECIFICATIONS

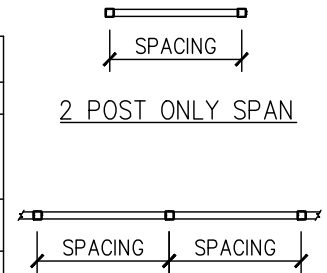
CONNECTION OF BASEPLATE AND SUB-STRUCTURE DETAILS PER PROJECT DESIGN BY OTHERS, TO COMPLY WITH PART 4 AND/OR PART 9 AS ACCEPTABLE TO AHJ. GUARD DESIGN AT MAXIMUM CAPACITY, REACTION MOMENT AT POST BASE AS PER APPLICABLE INSTALLATION IN TABLES BELOW.

1
A SIGNATURE ALUMINUM RAILING, STANDARD OR POST MOUNT
NOT-TO-SCALE

PART 9 BUILDING (MAX 3-STOUREYS, FIELD ZONE, ROUGH TERRAIN) – PICKET IN-FILL SYSTEMS

q _{1/50} (kPa)	p (kPa)	RESIDENTIAL ONE-TWO DWELLINGS				ALL OTHER GUARDS			
		MAXIMUM POST SPACING (mm)		MAXIMUM MOMENT AT POST-BASE CONNECTION (kN-m)		MAXIMUM POST SPACING (mm)		MAXIMUM MOMENT AT POST-BASE CONNECTION (kN-m)	
		2 POST SPAN	3+ POST SPAN	2 POST SPAN	3+ POST SPAN	2 POST SPAN	3+ POST SPAN	2 POST SPAN	3+ POST SPAN
0.63	1.00	2438 ⁽¹⁾	2438 ⁽¹⁾	1.06	2.09	2438 ⁽¹⁾	1727 ⁽¹⁾	1.55	2.18

(1) METRIC TO IMPERIAL CONVERSION: 2438 mm = 8 ft; 1727 mm = 5.66 ft.



PART 3 BUILDINGS – PICKET IN-FILL SYSTEMS

WIND PRESSURE p (NON-FACTORED) AS DETERMINED BY NBCC 4.1.7.3.	p (kPa)	RESIDENTIAL ONE-TWO DWELLINGS				ALL OTHER GUARDS			
		MAXIMUM POST SPACING (mm)		MAXIMUM MOMENT AT POST-BASE CONNECTION (kN-m)		MAXIMUM POST SPACING (mm)		MAXIMUM MOMENT AT POST-BASE CONNECTION (kN-m)	
		2 POST SPAN	3+ POST SPAN	2 POST SPAN	3+ POST SPAN	2 POST SPAN	3+ POST SPAN	2 POST SPAN	3+ POST SPAN
1.00	1.00	2438 ⁽¹⁾	2438 ⁽¹⁾	1.06	2.09	2438 ⁽¹⁾	1727 ⁽¹⁾	1.55	2.18

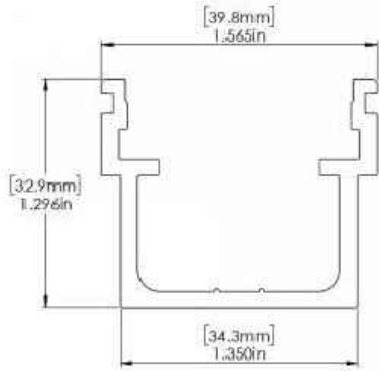
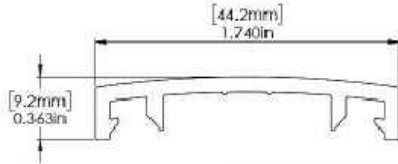
(1) METRIC TO IMPERIAL CONVERSION: 2438 mm = 8 ft; 1727 mm = 5.66 ft.

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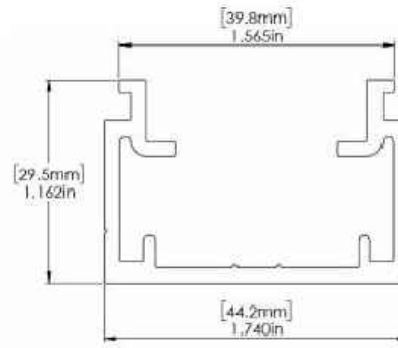
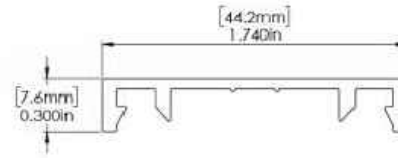
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CLIENT: TREX COMPANY, INC	PROJECT: TREX SIGNATURE RAILING	TITLE: SIGNATURE ALUMINUM RAILING ASSEMBLY AND ALLOWABLE POST SPACING
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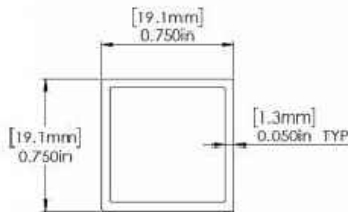
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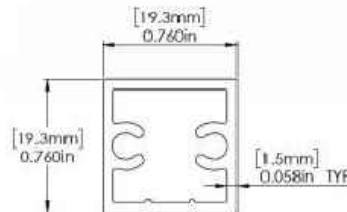
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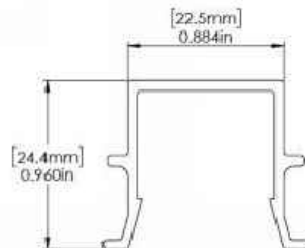
B
3 BOTTOM RAIL
NOT-TO-SCALE



C
2 BALUSTER
NOT-TO-SCALE



D
2 MIDDLE (PINNED) BALUSTER
NOT-TO-SCALE



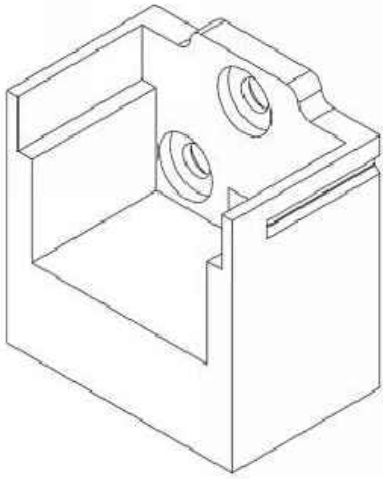
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2 RAIL INSERT
NOT-TO-SCALE

DRAWING FOR TREX
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REPORT – NOT FOR USE
AS CONSTRUCTION DESIGN
DOCUMENTS

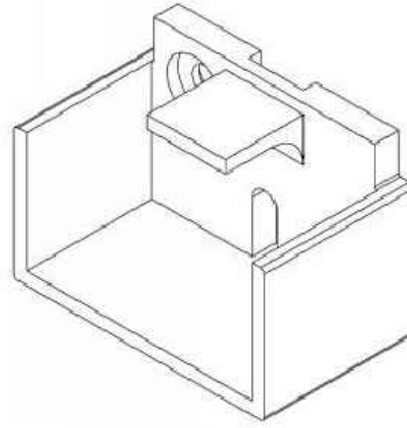
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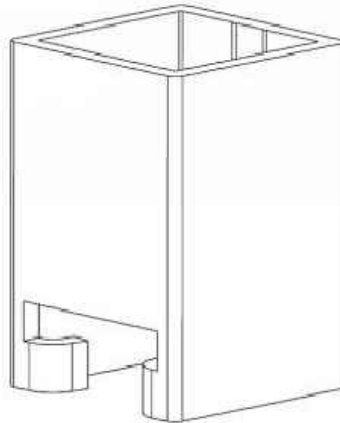
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DATE DECEMBER 31, 2021		DRN CL	
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A
3 — TOP RAIL BRACKET
NOT-TO-SCALE



B
3 — BOTTOM RAIL BRACKET
NOT-TO-SCALE



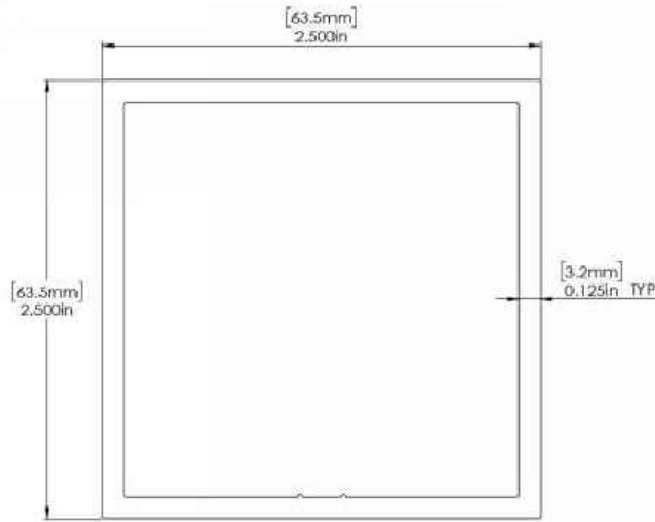
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3 — FOOTBLOCK
NOT-TO-SCALE

DRAWING FOR TREX
SIGNATURE RAILING
ENGINEERING EVALUATION
REPORT – NOT FOR USE
AS CONSTRUCTION DESIGN
DOCUMENTS

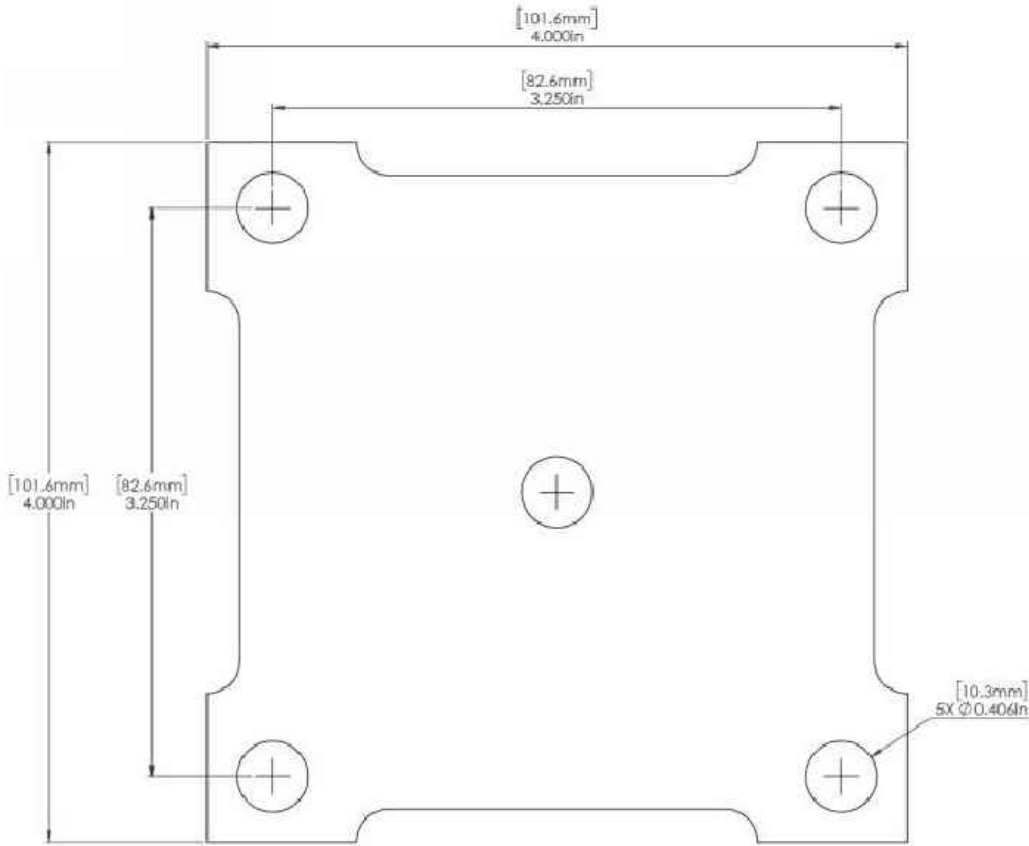
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CLIENT: TREX COMPANY, INC	PROJECT: TREX SIGNATURE RAILING	TITLE: COMPONENT DRAWINGS II
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1	2021/12/31	FOR PUBLICATION	CB
REV	DATE	ISSUE	APP
DRAWING NO. 0078-1-3		DES CB	
DATE DECEMBER 31, 2021		DRN CL	
		CHK CB	



A
4 POST
NOT-TO-SCALE



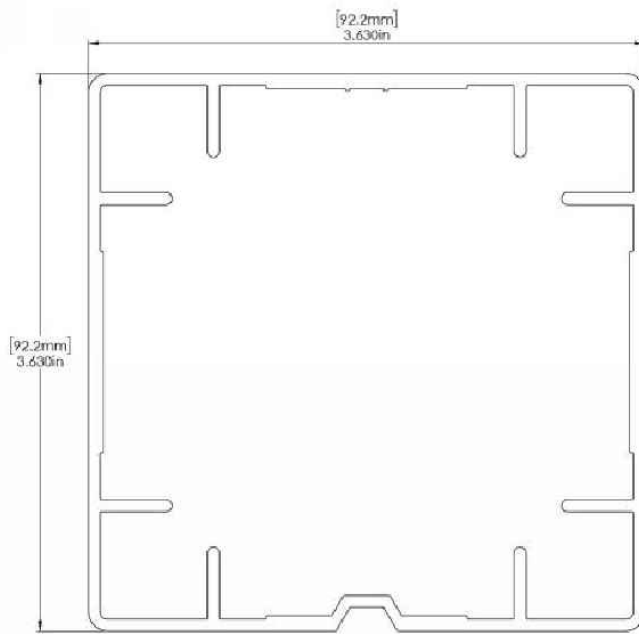
B
4 BASEPLATE
NOT-TO-SCALE

DRAWING FOR TREX
SIGNATURE RAILING
ENGINEERING EVALUATION
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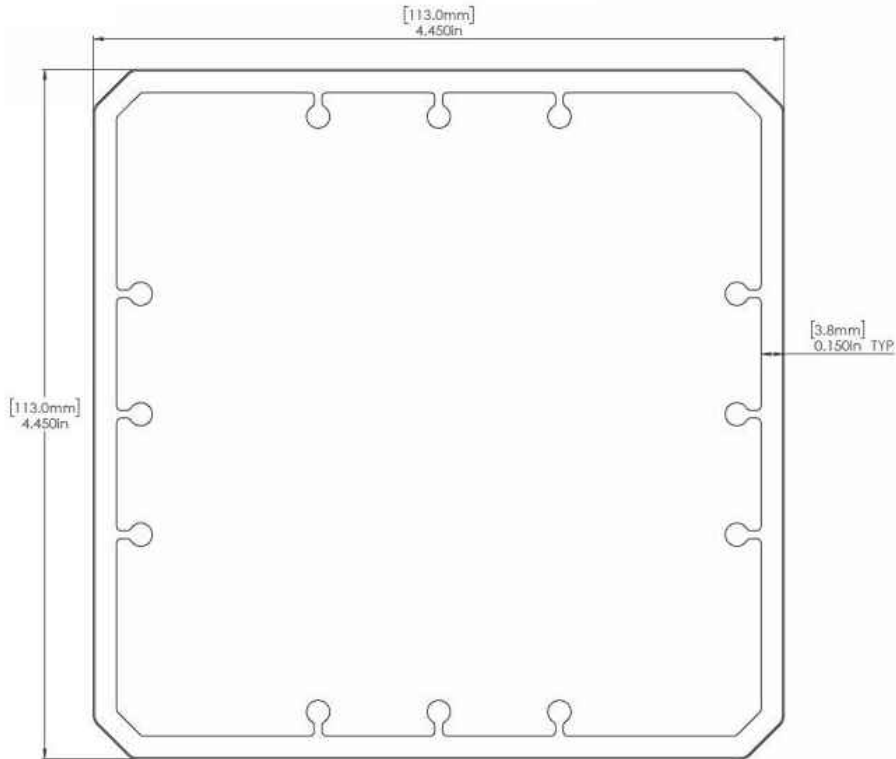
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CLIENT:	PROJECT:	TITLE:
TREX COMPANY, INC	TREX SIGNATURE RAILING	COMPONENT DRAWINGS III

0	2021/12/31	FOR PUBLICATION	CB
REV	DATE	ISSUE	APP
DRAWING NO.		DES	CB
0078-1-4		DRN	CL
DATE	DECEMBER 31, 2021		CHK
			CB



(A)
5 POST MOUNT SPACER
NOT-TO-SCALE



(B)
5 POST SLEEVE
NOT-TO-SCALE

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CLIENT: TREX COMPANY, INC	PROJECT: TREX SIGNATURE RAILING	TITLE: COMPONENT DRAWINGS IV
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1	2021/12/31	FOR PUBLICATION	CB
REV	DATE	ISSUE	APP
DRAWING NO. 0078-1-5		DES CB	
DATE DECEMBER 31, 2021		DRN CL	
		CHK CB	



ATTACHMENT 3: DISCUSSION OF LIMIT STATES DESIGN PROCEDURE

Load Combinations, Load and Resistance Factors, Test Factors

Applying load combinations of live plus wind in solid and open in-fill guard systems is required by the NBCC (see ref. Section F.24 of User's Guide – NBC 2015, Structural Commentaries and CSA A500-16 Section 4.2.3 Load Combinations for normative information).

Design of configured structural systems by strength testing of assemblies with a test load (safety) factor in limit states design necessitates the computation of a test load factor for the respective stress and failure type due to the various loading types of guards. Members are typically stressed to failure in bending or in shear, depending on the placement of the test load with respect to the connection/support of the member.

Test Load Factors are computed by:

$$\text{Test Load Factor} = \frac{\text{Combined Load Factor}}{\text{Resistance Factor}}$$

The resistance factor is taken from the materials standard for the respective stress type (e.g. shear stress on fillet welds: on ultimate, $\Phi_f = 0.67$, as per CSA S157).

With load combinations, the combined load factor is equal to:

$$\text{Combined Load Factor} = \frac{\text{Total Combined Ultimate (Factored) Load}}{\text{Total Combined Service Load}}$$

The test load becomes:

$$\text{Test Load} = (\text{Test Load Factor}) \times (\text{Total Combined Service Load})$$

Aluminum Components

The design analysis of the aluminum components has been carried out in accordance with and complies with CSA S157-05, *Strength Design in Aluminum*, Section 6 Methods of Analysis and Design. More specifically, Section 6.2 Testing, where it states "the adequacy of a structural assembly may be determined by tests in accordance with Section 13." Where Section 13.2.2 states, "... tests shall be conducted to accepted procedures, such as provided by an appropriate ASTM standard..." which is ASTM E935-13, *Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings*.

Following CSA S157-05 Section 13.3.1.2, a 2.25 test load factor equates to the live load factor divided by the maximum effective resistance factor of $\phi_r = 0.67$ at the connections within the guard system for all loading scenarios in the BCBC Part 4 and 9, summarized in Table 2 of the report.

An individual post secured at the base plate was taken in test, past the ultimate factored moment resulting from the maximum tributary reaction load of the factored horizontal uniform load on top rail over multiple spans.

Fasteners

Common corrosion-resistant steel screws are used at the connections. The steel strength properties taken by design to CSA S16-14, *Design of Steel Structures*, are verified for the application by the system testing procedure.

- END -