COMMERCIAL PRODUCTS
7008 Northland Drive
Suite 150
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(877) 215-RAIL (7245)

Project name: 42” Signature Balcony Railing
Creation date: 3/18/19
Last revision: 11/23/21
Revision: 1

I hereby certify that the following pages of this report were prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the states shown on the following pages.

Anthony J Barnes, PE
11/23/21

Anthony J Barnes
Digitally signed by Anthony J Barnes
DN: C=US, E=tbarnes@trexcommercial, CN=Anthony J Barnes
Reason: I am the author of this document
Date: 2021.11.23 14:35:48-06'00'

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1 State Certifications

Alabama	34664	Oklahoma	27838
Arizona	63922	Oregon	93346PE
Arkansas	18157	Pennsylvania	PE082756
California	84471	Rhode Island	12533
Colorado	PE.0049211	South Carolina	33939
Connecticut	PEN.0032950	South Dakota	13915
Florida	77515	Tennessee	00117639
Georgia	PE039214	Texas	PE 117821
Idaho	P-17222	Utah	9163877-2202
Indiana	PE11400345	Virginia	402054114
Iowa	22527	Washington	51729
Kansas	PE26251	Washington, DC	PE907658
Kentucky	33339	West Virginia	23467
Louisiana	39025	Wisconsin	43059-6
Maryland	45817	Wyoming	16000
Massachusetts	51462		
Michigan	6201063081		
Minnesota	51612		
Mississippi	26806		
Missouri	PE2014023010		
Montana	60121		
Nebraska	E-15134		
Nevada	023009		
New Hampshire	15604		
New Jersey	24GE05291300		
New Mexico	24093		
New York	094109		
North Carolina	041703		
North Dakota	PE-9715		
Ohio	79131		

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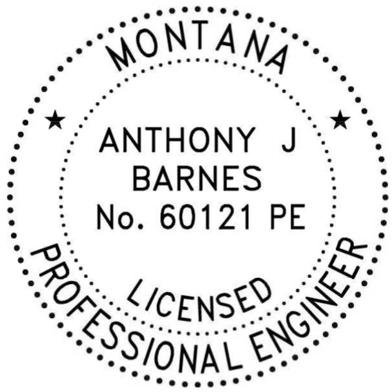

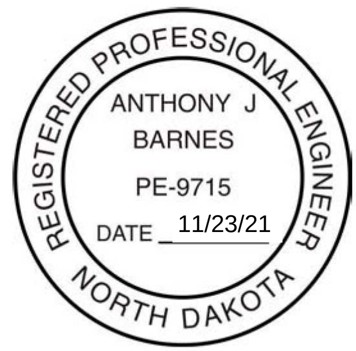

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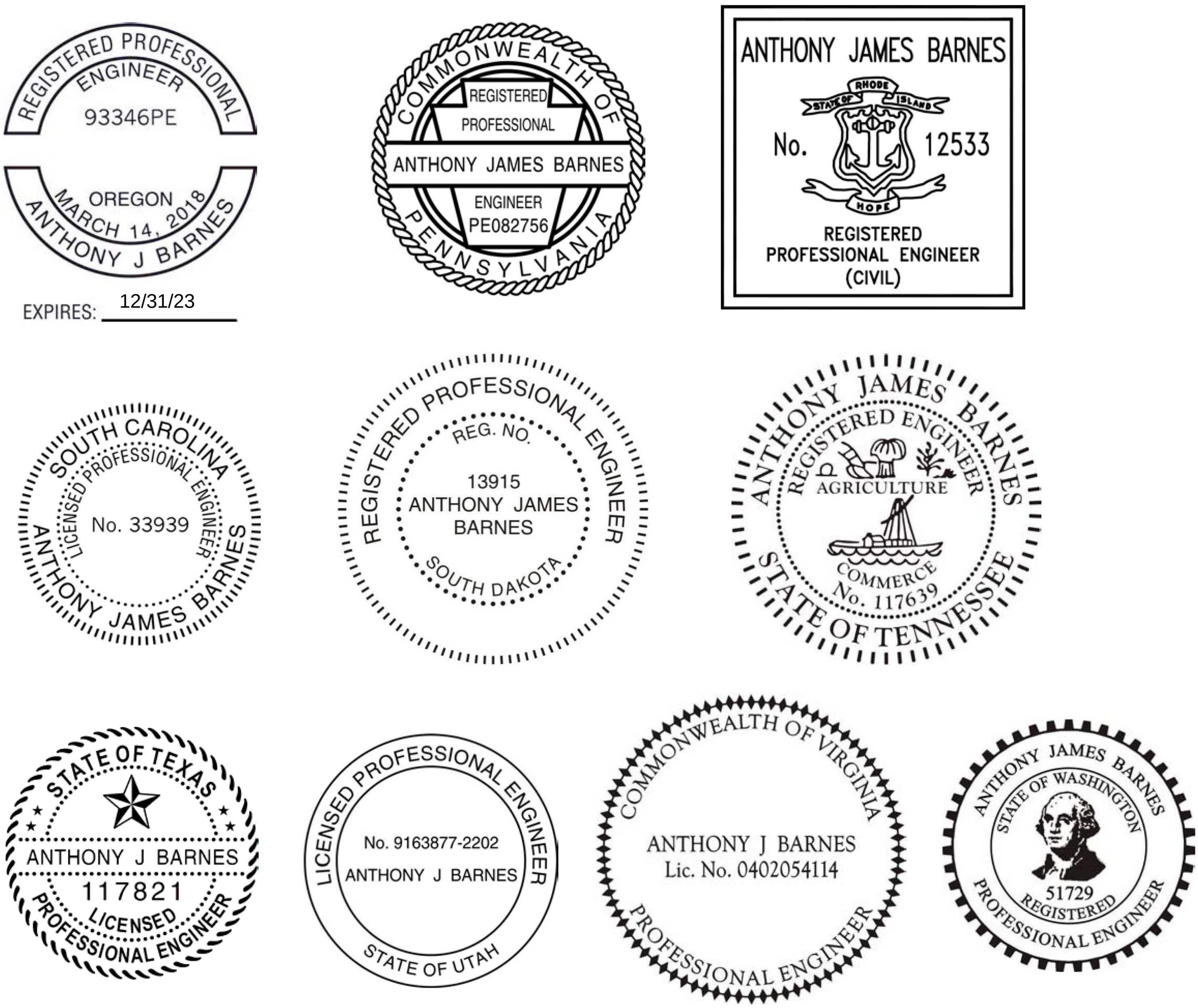
REGISTERED PROFESSIONAL ENGINEER
93346PE
OREGON
MARCH 14, 2018
ANTHONY J BARNES
EXPIRES: 12/31/23
COMMONWEALTH OF PENNSYLVANIA
REGISTERED
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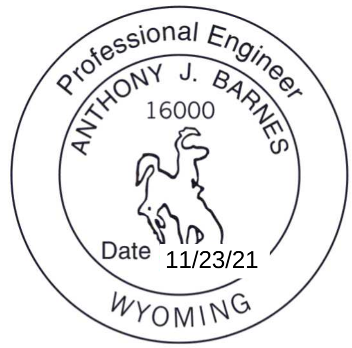

Revision	Description
1	Removed lag screw calcs, added backplate method. Added post strength test data analysis, added Intertek/ATI test report (full) plus CCRR to appendices. Removed tables and replaced with appendix references.

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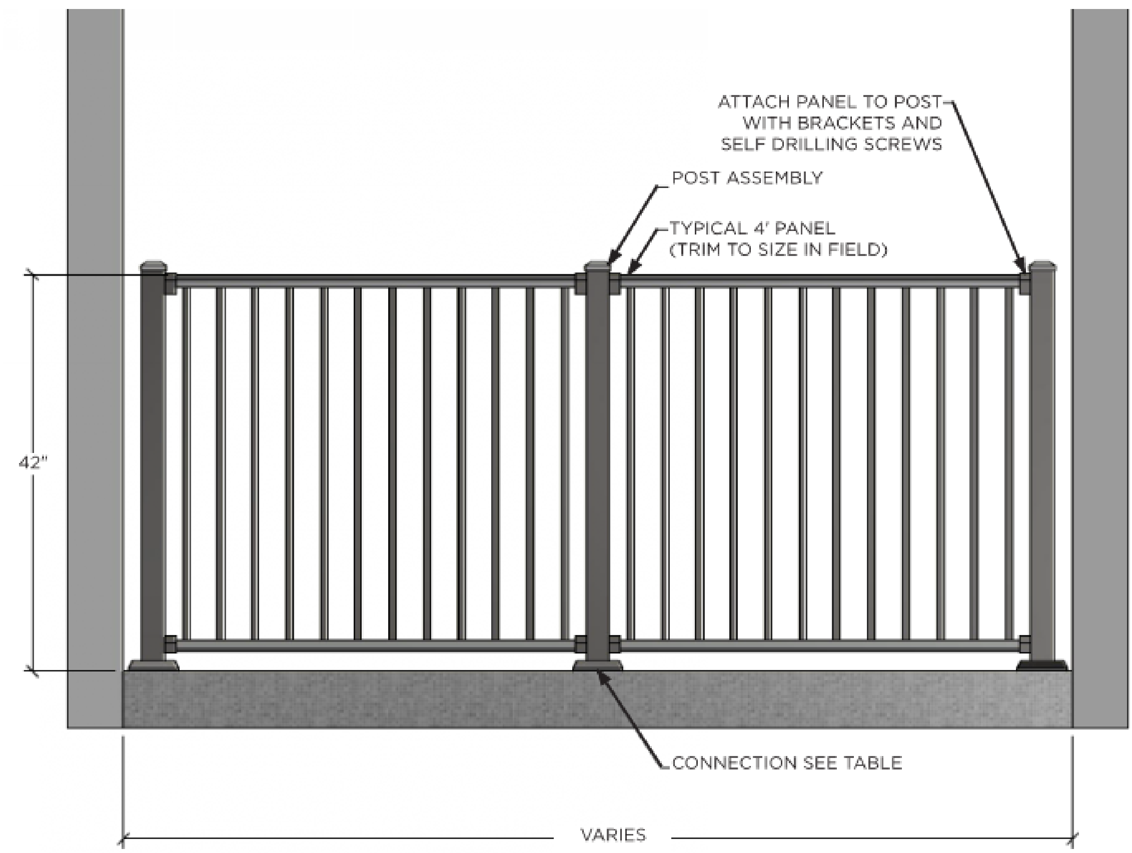
2 Description

This calculation covers the Trex Commercial Products Signature Balcony Railing system. The railing is constructed of aluminum posts, top & bottom rails, and pickets. It can be mounted to concrete or wood. Railing height is 42" with maximum center to center post spacing of 50.5".



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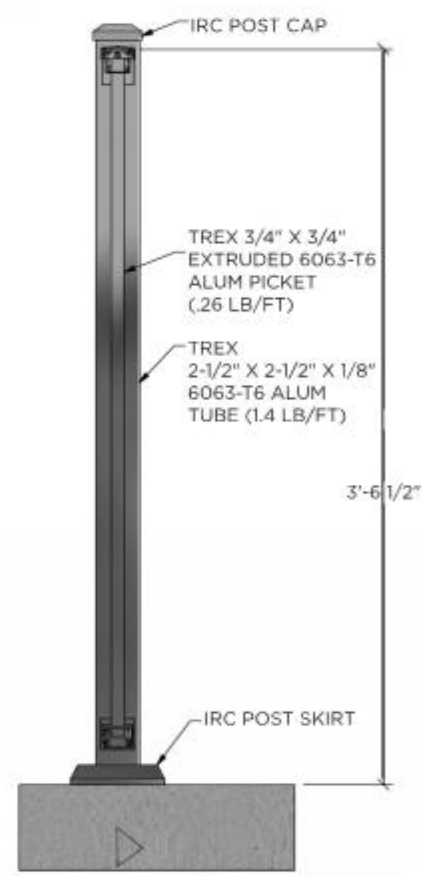

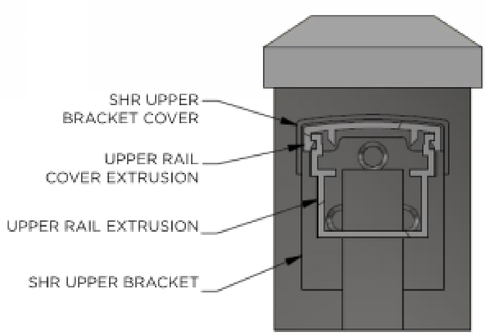

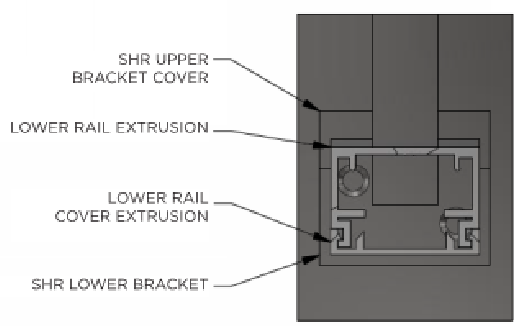

3 Design criteria

3.1 Building codes/standards/project specifications

1) IBC 2015
2) ACI 318-14
3) CCRR-0202 – code compliance report for Trex Signature and Reveal railing which use same components (with exception of infill) as Trex Commercial Products Signature Balcony Rail
4) Intertek/ATI report number C7953.01-119-19, revision 0 dated 7/28/2014

3.2 Design loads

3.2.1 Live loads

Design Criteria	Requirement
Guard/handrail live loads	50 plf per 1607.8.1 distributed load in any direction applied to top rail, **OR** 200 lbf applied at any point at the top of the rail per 1607.8.1.1, **OR** 50 lbf over 1 sf area per 1607.8.1.2

3.2.2 Wind

Rail style is considered open. Live load controls.

3.3 Deflections

Deflection	**Aluminum, steel, stainless steel:** L/60 per minimum requirements of IBC table 1604.3 where L = 2*Length for cantilevers

3.4 Materials Used

Component	Material	Yield	Ultimate
Top rail	6105-T5	35 ksi	38 ksi
Bottom rail	6063-T6	25 ksi	30 ksi
Rail mounting brackets	Zamak 3 cast zinc	32 ksi	41 ksi
Posts	6063-T6	25 ksi (8 ksi)	30 ksi (17 ksi)
Baseplates	6061-T6	35 ksi	38 ksi
Pickets	6063-T52	25 ksi	30 ksi

*Welded properties in parentheses

3.5 Material Testing

Per IBC 2015 1709.3.1, a safety factor of 2.5 is used when performing material testing.

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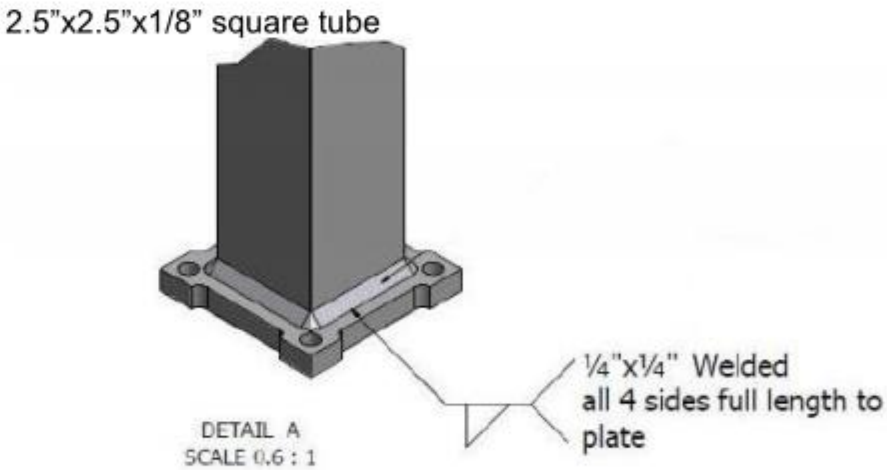
4 <u>Post checks</u>

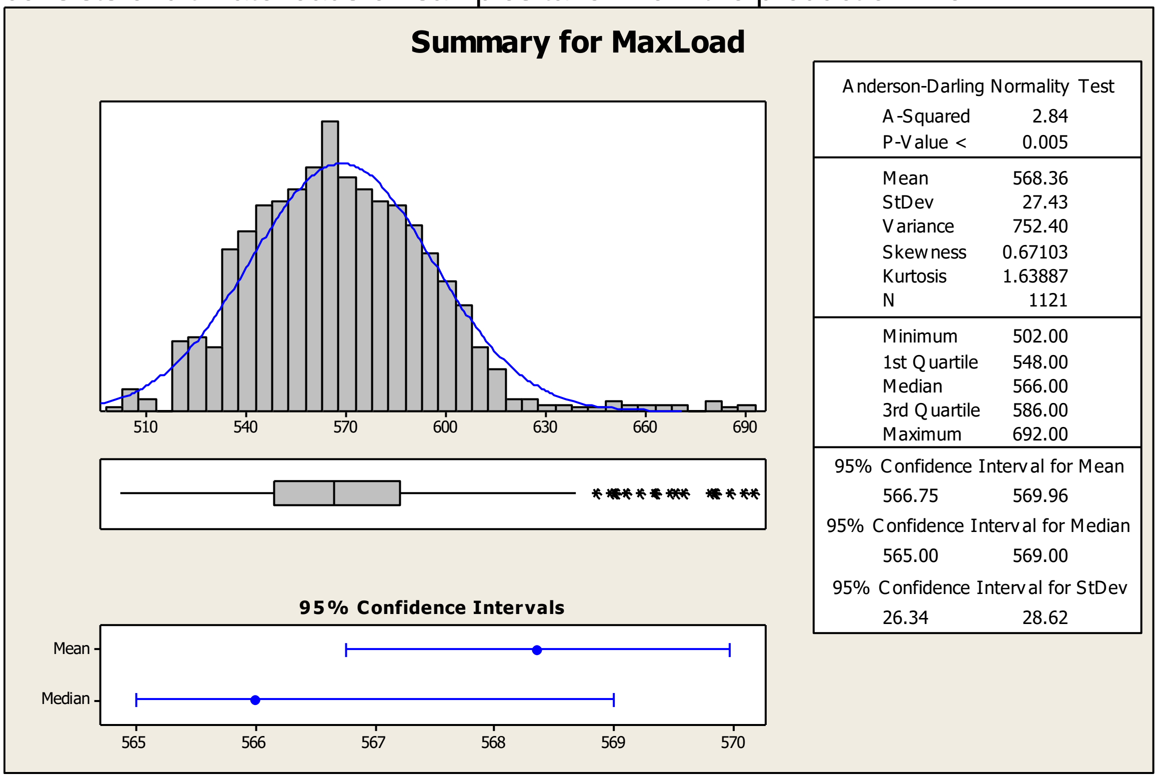
4.1 Aluminum 2-1/2" x 2-1/2" Welded 6063-T6

This covers the post used by Trex in their Signature (IRC) residential railing. This post has a 4"x4" baseplate welded (1/4" fillet by robotic welder) to it. The post/baseplate assembly is tested as a single unit.



All material for post is 6063-T6 with ER5356 wire for welding

Data was taken from 6 months of the Trex assembly line daily tests, which consists of ultimate loads on samples taken from the production line.



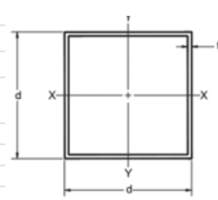
Use 95% C.I. for median:
565 lb / 2.5 FS = 226 lb maximum applied load > 200 lb code specified **OK**
226 lb / 50 lb/ft = 4.52’ = 54” maximum post spacing > 50.5” maximum used **OK**
Deflection:

Limit = 2*L/60 = 2*42.5”/60 = 1.42”

$$\Delta = \frac{PL^3}{3EI} = \frac{(0.226\,k)(42.5")^3}{3(10100\,ksi)(1.12\,in^4)} = 0.51" < 1.42\text{” limit } \textbf{OK}$$

Table 23
SQUARE TUBES

Designation	d in.	t in.	Weight lb/ft	A in²	I_x, I_y in⁴	S_x, S_y in³	r_x, r_y in.	J in⁴	Z_x, Z_y in³	b/t -
RT 2.5 x 2.5 x 0.125	2.5	0.125	1.4	1.19	1.12	0.896	0.971	1.67	1.06	18



5 Top rail, brackets, and fasteners checks

The top rail was tested by Trex to meet IBC and IRC specifications with a 200 lb load applied at midspan of an 8' span, and a 50 lb/ft load (400 lbs total) applied uniformly along the rail. These loads were applied independently, in separate tests.

Results are reported from Architectural Testing report number D7953.01-119-19 revision 0 dated 7/28/2014. The test report is for the Trex Reveal system, which utilizes the same components as does the Trex Commercial Products Signature Balcony Rail system. The tests for the posts are not applicable since the alloy used in testing is a higher strength alloy than is used in production. The alloy used for the top rail in testing (6005-T5) is also different than that used in production (6105-T5) but is the same strength.

See Appendix B for all test results related to top rail, brackets, and fasteners. The test was performed on the Trex Reveal system, which has the same top rail, brackets, and fasteners as the Trex Signature system.

Brackets were tested with 200 lbs * 2.5 FS = 500 lbs direct shear (each).

Top rail was tested with 200 lbs concentrated * 2.5 FS = 500 lbs applied at midspan to induce the maximum bending moment.

Top rail was tested with 400 lbs uniform * 2.5 FS = 1000 lbs.

These tests were conservative; for 8' rail spans. All tests passed, meeting IBC 1709.3.1.

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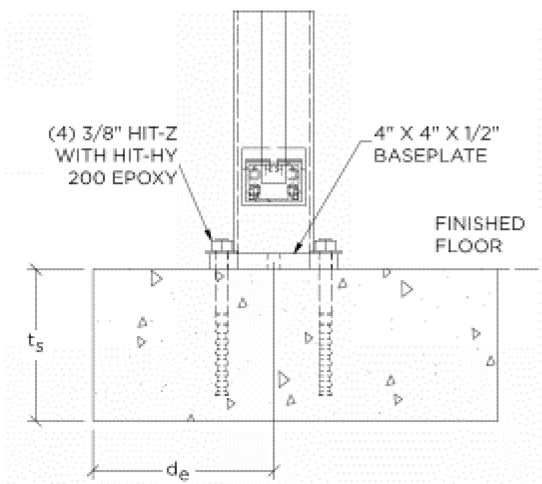
6 Anchorage checks

Slight overages (0-5%) in the calculations are OK as concrete strength is conservative by definition; increases over time. Hilti Profis does not allow Hole Condition 2 to be selected in the software, but it is allowed during installation by cleaning the concrete dust out of the anchor holes. This is reflected in Profis by setting embedment depth manually to 1.25” less than the desired slab thickness per ESR-3187.

6.1 Concrete

LRFD Loads:
V=1.6 * 0.05 k/ft * 50.5”/12 = 0.34 k
M=0.34 k * 42.5” = 14.3 k-in



Concrete Strength	t_s	d_e	Embedment	Flat Post Spacing	Stair Post Spacing
psi	in	in	in	in	in
3000	5	5-1/2	3-3/4	48	42
5000	4	5	2-3/4	48	42

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6.1.1 3000 psi concrete

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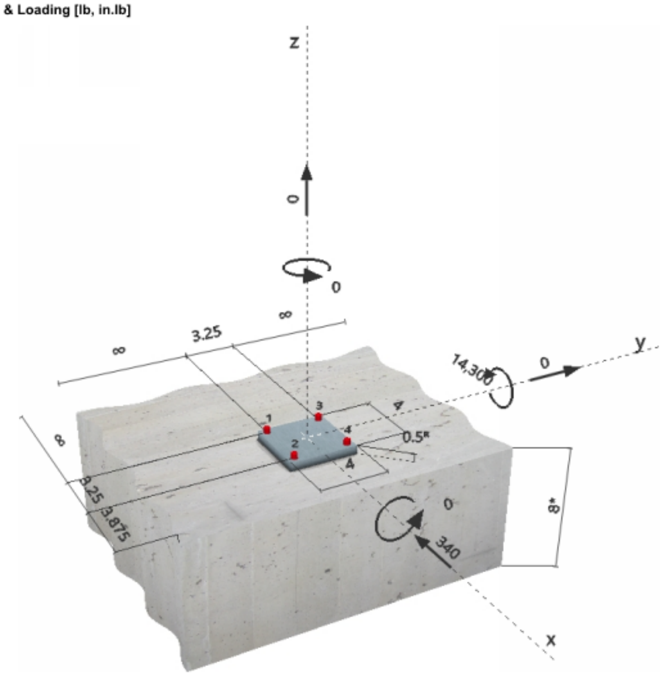
Specifier's comments:

1 Input data

Anchor type and diameter:	**HIT-HY 200 + HIT-Z-R 3/8**
Effective embedment depth:	$h_{ef,act}$ = 3.750 in. ($h_{ef,limit}$ = - in.)
Material:	A4
Evaluation Service Report:	ESR-3187
Issued I Valid:	3/1/2018 | 3/1/2020
Proof:	Design method ACI 318-14 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 4.000 in. x 4.000 in. x 0.500 in.; (Recommended plate thickness: not calculated
Profile:	no profile
Base material:	cracked concrete, 3000, f_c' = 3,000 psi; h = 8.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar

R - The anchor calculation is based on a rigid baseplate assumption.

Geometry [in.] & Loading [lb, in.lb]

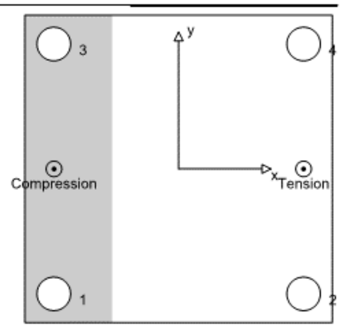


2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	85	-85	0
2	2,202	85	-85	0
3	0	85	-85	0
4	2,202	85	-85	0



max. concrete compressive strain:	0.45 [‰]
max. concrete compressive stress:	1,941 [psi]
resulting tension force in (x/y)=(1.625/0.000):	4,404 [lb]
resulting compression force in (x/y)=(-1.622/0.000):	4,404 [lb]

Anchor forces are calculated based on the assumption of a rigid baseplate.

3 Tension load

	Load N_{ua} [lb]	Capacity ϕN_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	2,202	4,749	47	OK
Pullout Strength*	2,202	5,169	43	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	4,404	4,337	102	not recommended

* anchor having the highest loading   **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value   refer to ICC-ES ESR-3187
$\phi\ N_{sa} \ge N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.08	94,200

Calculations

N_{sa} [lb]
7,306

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
7,306	0.650	4,749	2,202

3.2 Pullout Strength

$N_{pn} = N_p\ \lambda_a$ refer to ICC-ES ESR-3187
$\phi\ N_{pn} \ge N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

λ_a	N_p [lb]
1.000	7,952

Calculations

-
-

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\ N_{pn}$ [lb]	N_{ua} [lb]
7,952	0.650	5,169	2,202

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3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N}\, \psi_{ed,N}\, \psi_{c,N}\, \psi_{cp,N}\, N_b$ ACI 318-14 Eq. (17.4.2.1b)

$\phi\ N_{cbg} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\, e_N}{3\, h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\, \lambda_a \sqrt{f'_c}\, h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
3.750	0.000	0.000	3.875	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
7.250	17	1.000	3,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
137.75	126.56	1.000	1.000	0.907	1.000	6,762

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
6,673	0.650	4,337	4,404

4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	85	2,630	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	340	12,537	3	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = (0.6\, A_{se,V}\, f_{uta})$ refer to ICC-ES ESR-3187

$\phi\, V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$(0.6\, A_{se,V}\, f_{uta})$ [lb]
0.08	94,200	4,384

Calculations

V_{sa} [lb]
4,384

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\, V_{sa}$ [lb]	V_{ua} [lb]
4,384	0.600	2,630	85

4.2 Pryout Strength (Concrete Breakout Strength controls)

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\,\psi_{ed,N}\,\psi_{c,N}\,\psi_{cp,N}\,N_b\right]$ ACI 318-14 Eq. (17.5.3.1b)

$\phi\, V_{cpg} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\, h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\, e_N}{3\, h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5 h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \mathrm{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5 h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\, \lambda_a\, \sqrt{f'_c}\, h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	3.750	0.000	0.000	3.875

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	7.250	17	1.000	3,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
184.88	126.56	1.000	1.000	0.907	1.000	6,762

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\, V_{cpg}$ [lb]	V_{ua} [lb]
17,910	0.700	12,537	340

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5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
1.015	0.032	1.000	88	OK

$\beta_{NV} = (\beta_N + \beta_V) / 1.2 <= 1$

6 Warnings

- The anchor design methods in PROFIS Anchor require rigid anchor plates per current regulations (ETAG 001/Annex C, EOTA TR029, etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Anchor calculates the minimum required anchor plate thickness with FEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid base plate assumption is valid is not carried out by PROFIS Anchor. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-14, Section 17.8.1.

Fastening does not meet the design criteria!

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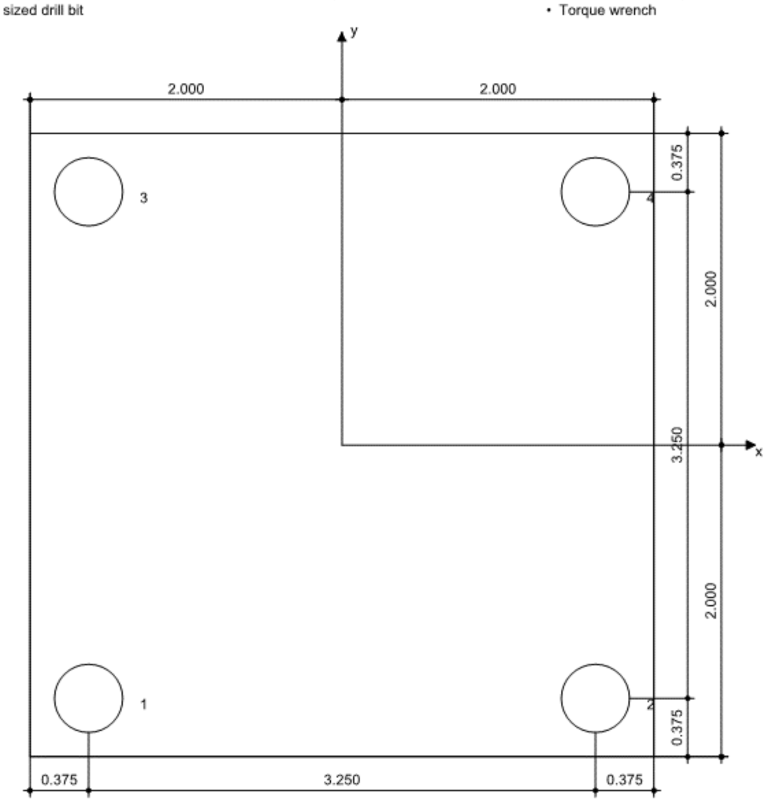
7 Installation data

Anchor plate, steel: -
Profile: no profile
Hole diameter in the fixture (pre-setting) : d_f = 0.438 in.
Hole diameter in the fixture (through fastening) : d_f = 0.500 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Drilling method: Hammer drilled
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: HIT-HY 200 + HIT-Z-R 3/8
Installation torque: 177.015 in.lb
Hole diameter in the base material: 0.438 in.
Hole depth in the base material: 4.750 in.
Minimum thickness of the base material: 6.000 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer • Properly sized drill bit	• No accessory required	• Dispenser including cassette and mixer • Torque wrench



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-1.625	-1.625	-	7.125	-	-
2	1.625	-1.625	-	3.875	-	-
3	-1.625	1.625	-	7.125	-	-
4	1.625	1.625	-	3.875	-	-

6.1.2 5000 psi concrete

www.hilti.us | **Profis Anchor 2.8.0**

Company:		Page:	1
Specifier:		Project:	
Address:		Sub-Project I Pos. No.:	
Phone I Fax:	|	Date:	3/8/2019
E-Mail:			

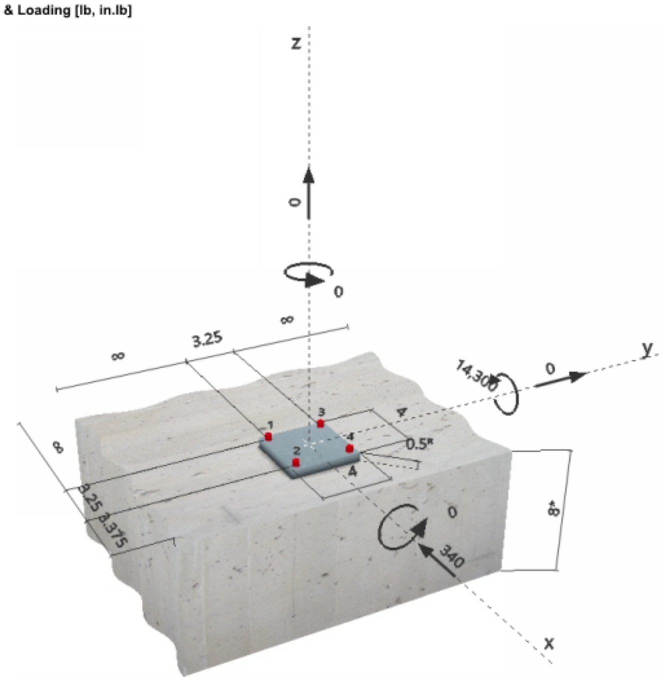
Specifier's comments:

1 Input data

Anchor type and diameter:	**HIT-HY 200 + HIT-Z-R 3/8**
Effective embedment depth:	$h_{ef,act}$ = 2.750 in. ($h_{ef,limit}$ = - in.)
Material:	A4
Evaluation Service Report:	ESR-3187
Issued I Valid:	3/1/2018 | 3/1/2020
Proof:	Design method ACI 318-14 / Chem
Stand-off installation:	e_b = 0.000 in. (no stand-off); t = 0.500 in.
Anchor plate:	l_x x l_y x t = 4.000 in. x 4.000 in. x 0.500 in.; (Recommended plate thickness: not calculated
Profile:	no profile
Base material:	cracked concrete, 5000, f_c' = 5,000 psi; h = 8.000 in., Temp. short/long: 32/32 °F
Installation:	**hammer drilled hole, Installation condition: Dry**
Reinforcement:	tension: condition B, shear: condition B; no supplemental splitting reinforcement present edge reinforcement: none or < No. 4 bar

R - The anchor calculation is based on a rigid baseplate assumption.

Geometry [in.] & Loading [lb, in.lb]



Input data and results must be checked for agreement with the existing conditions and for plausibility!

Company:		Page:	2
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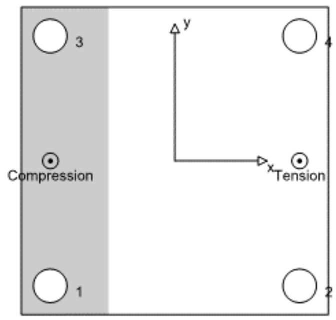
E-Mail:			

2 Load case/Resulting anchor forces

Load case: Design loads

Anchor reactions [lb]
Tension force: (+Tension, -Compression)

Anchor	Tension force	Shear force	Shear force x	Shear force y
1	0	85	-85	0
2	2,202	85	-85	0
3	0	85	-85	0
4	2,202	85	-85	0



max. concrete compressive strain:	0.45 [‰]
max. concrete compressive stress:	1,941 [psi]
resulting tension force in (x/y)=(1.625/0.000):	4,404 [lb]
resulting compression force in (x/y)=(-1.622/0.000):	4,404 [lb]

Anchor forces are calculated based on the assumption of a rigid baseplate.

3 Tension load

	Load N_{ua} [lb]	Capacity ϕ N_n [lb]	Utilization $\beta_N = N_{ua}/\phi N_n$	Status
Steel Strength*	2,202	4,749	47	OK
Pullout Strength*	2,202	5,169	43	OK
Sustained Tension Load Bond Strength*	N/A	N/A	N/A	N/A
Concrete Breakout Strength**	4,404	4,269	104	not recommended

* anchor having the highest loading **anchor group (anchors in tension)

3.1 Steel Strength

N_{sa} = ESR value refer to ICC-ES ESR-3187
$\phi\ N_{sa} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,N}$ [in.^{2}]	f_{uta} [psi]
0.08	94,200

Calculations

N_{sa} [lb]
7,306

Results

N_{sa} [lb]	ϕ_{steel}	$\phi\ N_{sa}$ [lb]	N_{ua} [lb]
7,306	0.650	4,749	2,202

3.2 Pullout Strength

$N_{pn} = N_p\ \lambda_a$ refer to ICC-ES ESR-3187
$\phi\ N_{pn} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

λ_a	N_p [lb]
1.000	7,952

Calculations

-
-

Results

N_{pn} [lb]	$\phi_{concrete}$	$\phi\ N_{pn}$ [lb]	N_{ua} [lb]
7,952	0.650	5,169	2,202

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3.3 Concrete Breakout Strength

$N_{cbg} = \left(\frac{A_{Nc}}{A_{Nc0}}\right) \psi_{ec,N} \psi_{ed,N} \psi_{c,N} \psi_{cp,N} N_b$ ACI 318-14 Eq. (17.4.2.1b)

$\phi\ N_{cbg} \geq N_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1 + \frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3 \left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]	$\psi_{c,N}$
2.750	0.000	0.000	3.375	1.000

c_{ac} [in.]	k_c	λ_a	f'_c [psi]
4.125	17	1.000	5,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
86.25	68.06	1.000	1.000	0.945	1.000	5,482

Results

N_{cbg} [lb]	$\phi_{concrete}$	$\phi\ N_{cbg}$ [lb]	N_{ua} [lb]
6,568	0.650	4,269	4,404

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4 Shear load

	Load V_{ua} [lb]	Capacity ϕV_n [lb]	Utilization $\beta_V = V_{ua}/\phi V_n$	Status
Steel Strength*	85	2,630	4	OK
Steel failure (with lever arm)*	N/A	N/A	N/A	N/A
Pryout Strength (Concrete Breakout Strength controls)**	340	13,180	3	OK
Concrete edge failure in direction **	N/A	N/A	N/A	N/A

* anchor having the highest loading **anchor group (relevant anchors)

4.1 Steel Strength

$V_{sa} = (0.6\ A_{se,V}\ f_{uta})$ refer to ICC-ES ESR-3187

$\phi\ V_{steel} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

Variables

$A_{se,V}$ [in.^{2}]	f_{uta} [psi]	$(0.6\ A_{se,V}\ f_{uta})$ [lb]
0.08	94,200	4,384

Calculations

V_{sa} [lb]
4,384

Results

V_{sa} [lb]	ϕ_{steel}	$\phi\ V_{sa}$ [lb]	V_{ua} [lb]
4,384	0.600	2,630	85

4.2 Pryout Strength (Concrete Breakout Strength controls)

$V_{cpg} = k_{cp}\left[\left(\frac{A_{Nc}}{A_{Nc0}}\right)\psi_{ec,N}\ \psi_{ed,N}\ \psi_{c,N}\ \psi_{cp,N}\ N_b\right]$ ACI 318-14 Eq. (17.5.3.1b)

$\phi\ V_{cpg} \geq V_{ua}$ ACI 318-14 Table 17.3.1.1

A_{Nc} see ACI 318-14, Section 17.4.2.1, Fig. R 17.4.2.1(b)

$A_{Nc0} = 9\ h_{ef}^2$ ACI 318-14 Eq. (17.4.2.1c)

$\psi_{ec,N} = \left(\frac{1}{1+\frac{2\ e_N}{3\ h_{ef}}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.4)

$\psi_{ed,N} = 0.7 + 0.3\left(\frac{c_{a,min}}{1.5h_{ef}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.5b)

$\psi_{cp,N} = \text{MAX}\left(\frac{c_{a,min}}{c_{ac}}, \frac{1.5h_{ef}}{c_{ac}}\right) \leq 1.0$ ACI 318-14 Eq. (17.4.2.7b)

$N_b = k_c\ \lambda_a\ \sqrt{f'_c}\ h_{ef}^{1.5}$ ACI 318-14 Eq. (17.4.2.2a)

Variables

k_{cp}	h_{ef} [in.]	$e_{c1,N}$ [in.]	$e_{c2,N}$ [in.]	$c_{a,min}$ [in.]
2	2.750	0.000	0.000	3.375

$\psi_{c,N}$	c_{ac} [in.]	k_c	λ_a	f'_c [psi]
1.000	4.125	17	1.000	5,000

Calculations

A_{Nc} [in.^{2}]	A_{Nc0} [in.^{2}]	$\psi_{ec1,N}$	$\psi_{ec2,N}$	$\psi_{ed,N}$	$\psi_{cp,N}$	N_b [lb]
123.63	68.06	1.000	1.000	0.945	1.000	5,482

Results

V_{cpg} [lb]	$\phi_{concrete}$	$\phi\ V_{cpg}$ [lb]	V_{ua} [lb]
18,828	0.700	13,180	340

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5 Combined tension and shear loads

β_N	β_V	ζ	Utilization $\beta_{N,V}$ [%]	Status
1.032	0.032	1.000	89	OK

$\beta_{NV} = (\beta_N + \beta_V) / 1.2 <= 1$

6 Warnings

- The anchor design methods in PROFIS Anchor require rigid anchor plates per current regulations (ETAG 001/Annex C, EOTA TR029, etc.). This means load re-distribution on the anchors due to elastic deformations of the anchor plate are not considered - the anchor plate is assumed to be sufficiently stiff, in order not to be deformed when subjected to the design loading. PROFIS Anchor calculates the minimum required anchor plate thickness with FEM to limit the stress of the anchor plate based on the assumptions explained above. The proof if the rigid base plate assumption is valid is not carried out by PROFIS Anchor. Input data and results must be checked for agreement with the existing conditions and for plausibility!
- Condition A applies when supplementary reinforcement is used. The Φ factor is increased for non-steel Design Strengths except Pullout Strength and Pryout strength. Condition B applies when supplementary reinforcement is not used and for Pullout Strength and Pryout Strength. Refer to your local standard.
- Design Strengths of adhesive anchor systems are influenced by the cleaning method. Refer to the INSTRUCTIONS FOR USE given in the Evaluation Service Report for cleaning and installation instructions
- Checking the transfer of loads into the base material and the shear resistance are required in accordance with ACI 318 or the relevant standard!
- Installation of Hilti adhesive anchor systems shall be performed by personnel trained to install Hilti adhesive anchors. Reference ACI 318-14, Section 17.8.1.

Fastening does not meet the design criteria!

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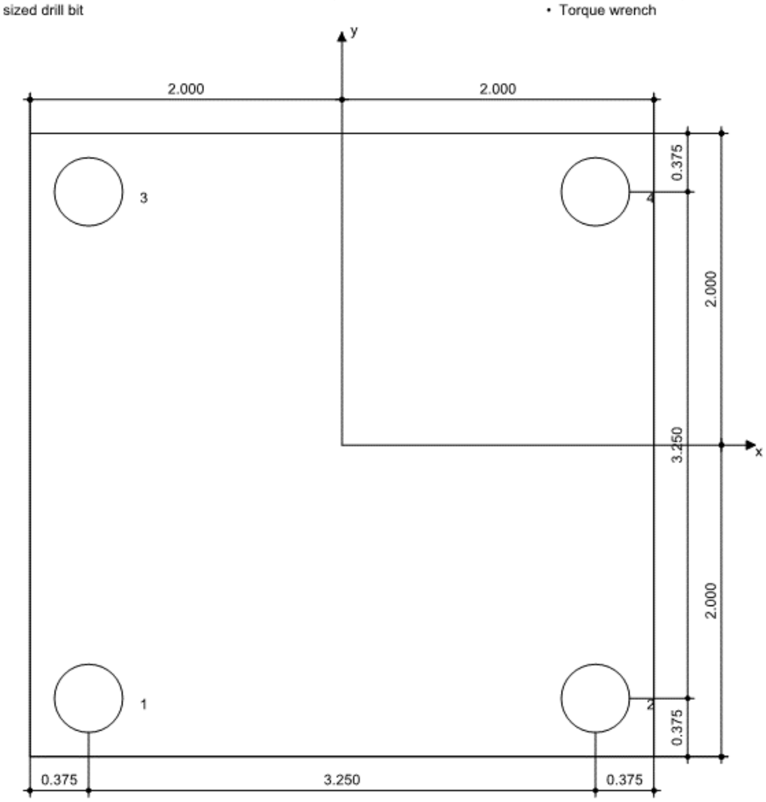
7 Installation data

Anchor plate, steel: -
Profile: no profile
Hole diameter in the fixture (pre-setting) : d_f = 0.438 in.
Hole diameter in the fixture (through fastening) : d_f = 0.500 in.
Plate thickness (input): 0.500 in.
Recommended plate thickness: not calculated
Drilling method: Hammer drilled
Cleaning: No cleaning of the drilled hole is required

Anchor type and diameter: HIT-HY 200 + HIT-Z-R 3/8
Installation torque: 177.015 in.lb
Hole diameter in the base material: 0.438 in.
Hole depth in the base material: 3.750 in.
Minimum thickness of the base material: 5.000 in.

7.1 Recommended accessories

Drilling	Cleaning	Setting
• Suitable Rotary Hammer	• No accessory required	• Dispenser including cassette and mixer
• Properly sized drill bit		• Torque wrench



Coordinates Anchor in.

Anchor	x	y	c_{-x}	c_{+x}	c_{-y}	c_{+y}
1	-1.625	-1.625	-	6.625	-	-
2	1.625	-1.625	-	3.375	-	-
3	-1.625	1.625	-	6.625	-	-
4	1.625	1.625	-	3.375	-	-

6.2 Wood

See Appendix B for all test results related to attachment to wood by through-bolting with aluminum backplate. The test was performed on the Trex Reveal system, which has the same backplate as the Trex Signature system.

The backplate does not appear to have yielded, suggesting it has ample reserve capacity beyond the test loads that were applied.

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7 Picket checks

Pickets are required to resist a 50 psf load over any 12”x12” area. For testing, a safety factor of 2.5 was used, resulting in 125 lbs applied over a 12”x12” area. The pickets were found to be adequate.

See Appendix B for all test results related to pickets. The test was performed on the Trex Reveal system, which has the same pickets / balusters as the Trex Signature system.

8 Appendix A – Code Compliance Research Report CCRR-0202

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Code Compliance Research Report CCRR-0202

Issue Date: 02-21-2014
Revision Date: 02-27-2019
Renewal Date: 02-21-2020

DIVISION: 05 00 00 - METALS
Section: 05 52 00 – Metal Railings

REPORT HOLDER:
Trex Company, Inc.
160 Exeter Drive
Winchester, VA 22603
(540) 542-6300
www.Trex.com

REPORT SUBJECT:
Trex® Signature® Railing
Trex® Reveal™ Railing

1.0 SCOPE OF EVALUATION

1.1 This Research Report addresses compliance with the following Codes:

- 2015 and 2012 *International Residential Code®* (IRC)

1.2 *Trex® Signature®* and *Trex® Reveal™* Railing have been evaluated for the following properties (see Table 1):

- Structural Performance

1.3 *Trex® Signature®* and *Trex® Reveal™* Railing have been evaluated for the following uses (see Table 2):

- The *Trex® Reveal™* railing system is a guard or guardrail under the definitions of the referenced codes. It is intended for use at or near the open sides of elevated walking areas of buildings and walkways as required by the codes. *Trex® Signature®* Railing is an alternative name for *Trex® Reveal™* Railing.
- Guards are provided as level guards for level walking areas such as decks, balconies, and porches.
- Level guards are provided with rail lengths up to 96 inches in length (measured between the inside of support posts) and an installed height of 42 inches. See Table 2 for qualified configurations.

2.0 STATEMENT OF COMPLIANCE

Trex® Signature® and *Trex® Reveal™* Railing comply with the Codes listed in Section 1.1, for the properties stated in Section 1.2 and uses stated in Section 1.3, when installed as described in this report, including the Conditions of Use stated in Section 6.

3.0 DESCRIPTION

3.1 The *Trex® Signature® / Trex® Reveal™* Railing is an assemblage of extruded aluminum materials, stainless steel fasteners, and cast Zamak 3 bracket materials.

3.2 The guardrail system includes a top rail, bottom rail, balusters, structural aluminum post, rail-to-post brackets, and decorative moldings and post caps.

3.3 Each of the top and bottom aluminum rails are routed to accept various infill components described in Section 3.4.

3.3.1 The top rail is an extruded aluminum rail with internal longitudinal ribs, dimensions of 1.75 inches wide by 1.44 inches tall. See Figure 1. A PVC rail insert is used as a baluster retainer.

3.3.2 The bottom rail is an extruded aluminum rail with internal longitudinal ribs, dimensions of 1.75 inches wide by 1.25 inches tall. See Figure 2. A PVC rail insert is used as a baluster retainer.

3.4 The infill area utilizes aluminum square or round balusters (See Figure 3).

3.5 Aluminum post supports consist of a 2.5 inch square by 0.125 inch wall extruded aluminum tube. The tube is connected to a 4 inch square by 1/2 inch thick aluminum base plate via a 1/4 inch continuous fillet weld on all four sides. See Figure 7.

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3.6 An IRC Crossover post is an intermediate post that permits the uninterrupted connection of two top rails without the interruption of the post profile above the top railings. It consists of a 2.5 inch square by 0.125 inch wall extruded tube. The tube is connected to a 4 inch square by ½ inch thick aluminum base plate via a ¼ inch continuous fillet weld on all four sides. See Figure 8.

3.7 A support block is installed between the lower rail and the deck surface midway between supports. See Figure 5.

4.0 PERFORMANCE CHARACTERISTICS

4.1 The guardrail system described in this report has demonstrated the capacity to resist the design loadings specified in Section R301 of the IRC when tested in accordance with ICC-ES AC273.

5.0 INSTALLATION

5.1 The *Trex® Signature® / Trex® Reveal™* Railing must be installed in accordance with the manufacturer's published installation instructions, the applicable Code, and this Research Report. A copy of the manufacturer's instructions must be available on the jobsite during installation.

5.2 The top and bottom rails are attached directly to structural posts utilizing cast Zamak 3 mounting brackets via mechanical fasteners. See Figure 6 and Table 3.

5.3 Aluminum balusters are inserted into routed holes in the aluminum rails and secured via PVC rail inserts that are installed internally to the rails. See Figure 3 and 4.

5.4 The *Trex® Signature® / Trex® Reveal™* Railing is attached to 2.5 inches square aluminum post mounts which may be surface mounted to a wood deck.

5.4.1 The *Trex® Signature® / Trex® Reveal™* Railing 2.5 inch post mount may be mounted to a wood deck in accordance with the details in Figure 9.

5.4.2 A minimum of four 3/8 inch diameter, 6 inch long anchor bolts must be used and located in the four pre-drilled holes in the structural post base plate.

5.4.3 Pressure-treated 2x8 Southern Yellow Pine (specific gravity 0.50 or better) boards are used as blocking under the post location and are fastened between the joists with #10 x 3 inch wood screws in accordance with the National Design Specification for Wood Construction (ANSI/AWC NDS-2012). See Figure 9 for spacing and quantities.

5.4.4 A 3/8 inch thick, 4.5 inch square aluminum back plate is installed on the underside of the wood blocking as illustrated in Figure 9. This aluminum plate shall be factory painted or given a heavy coat of alkali-resistant bituminous paint to provide separation between any wood, fiberboard, or other porous material that absorbs water and the aluminum.

5.5 Decking shall be Trex® Transcend® deck boards (solid or grooved) or decking equivalent in compressive strength. Hollow, ribbed or decking that is of less compressive strength is not suitable for post mount installation.

6.0 CONDITIONS OF USE

6.1 Installation must comply with this Research Report, the manufacturer's published installation instructions, and the applicable Code. In the event of a conflict, this report governs.

6.2 Attachment of guardrail systems described herein to conventional wood supports is outside the scope of this report.

6.3 Where required by the building official, engineering calculations and details shall be provided. The calculations shall verify that the anchorage and supporting structure complies with the building code for the type and condition of the supporting construction.

6.4 Stainless steel shim plates are used to prevent direct contact between the structural post base plate and supporting structure.

6.5 Compatibility of fasteners and other metallic components with the supporting structure, including chemically treated wood, is outside the scope of this report.

6.6 The *Trex® Signature® / Trex® Reveal™* Railing is manufactured under a quality control program with inspections.

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7.0 SUPPORTING EVIDENCE

7.1 Drawings and installation instructions submitted by Trex Company, Inc.

7.2 Reports of testing demonstrating compliance with the performance requirements of ICC-ES AC273, Acceptance Criteria for Handrails and Guards, revised March 2016.

7.3 Documentation of an Intertek approved quality control system for the manufacturing of products recognized in this report.

8.0 IDENTIFICATION

The *Trex® Signature® / Trex® Reveal™* Railing is identified with the manufacturer's name (Trex Company, Inc.), address and telephone number, the product name (*Trex® Signature® / Trex® Reveal™* Railing), the statement "For Use in One- and Two-Family Dwellings Only.", the Intertek Mark as shown below, and the Code Compliance Research Report number (CCRR-0202).

CODE COMPLIANCE
Intertek
CCRR-0202

9.0 OTHER CODES

This section is not applicable.

10.0 CODE COMPLIANCE RESEARCH REPORT USE

10.1 Approval of building products and/or materials can only be granted by a building official having legal authority in the specific jurisdiction where approval is sought.

10.2 Code Compliance Research Reports shall not be used in any manner that implies an endorsement of the product by Intertek.

10.3 Reference to the https://bpdirectory.intertek.com is recommended to ascertain the current version and status of this report.

TABLE 1 - PROPERTIES EVALUATED

PROPERTY	2015/2012 IRC SECTION
Structural Performance	R301.5

TABLE 2 – CODE OCCUPANCY CLASSIFICATION

Guardrail System	Type	Maximum Guardrail Dimensions (1)	Support Post Mount System		Code Occupancy Classification
Trex® Signature®/ Trex® Reveal™ Railing System	Level	96 inches by 42 inches	2.5 inch Aluminum Post Mount (Figure 7)	Mounted to surface of wood deck(2)	The use of this product shall be limited to exterior or interior use as a guard system for dwellings constructed in accordance with the IRC (One- and Two- Family Dwellings).

(1) Guardrails are qualified up to and including the listed maximum guardrail system dimensions for use in the referenced Code Occupancy Classification. Guardrail lengths are actual railing lengths, i.e. clear space between supports for level rails. Guardrail height is walking surface to top of top rail. Minimum installed height shall be 36 inches.

(2) The 2.5 inch aluminum post mount attachment to surface of wood deck must be in accordance with the wood deck support blocking as depicted in Figure 9. Decking shall be Trex® Transcend® deck boards (solid or grooved) or decking equivalent in compressive strength. Hollow, ribbed or decking that is of less compressive strength is not suitable for post mount installation.

TABLE 3 - *TREX® SIGNATURE® / TREX® REVEAL™* RAILING FASTENER SCHEDULE

Connection	Fastener
Top Rail Bracket to Post	Three #10-16 by 5/8 inch pan-head, self-drilling stainless steel screws
Bottom Rail Bracket to Post	Two #10-16 by 5/8 inch pan-head, self-drilling stainless steel screws
Top Rail Bracket to Rail	
Bottom Rail Bracket to Rail	One #10-16 by 5/8 inch pan-head, self-drilling stainless steel screws
Picket to Rail	The picket at the midpoint of rail length is attached to the top and bottom rails using two #8-15 x 1.25 inch pan-head, stainless steel screws through screw bosses.
Foot Block to Bottom Rail	One #12-11 by 1.25 inch pan-head self-drilling stainless steel screws
Top Rail to Crossover Post	5/16" Diameter x 2" bolt and nut into Wedge Plate (see Figure 8)
Top Rail to Crossover Adapter	#10 x 5/8" long self-drilling screw each side of adapter into railing (see Figure 8)

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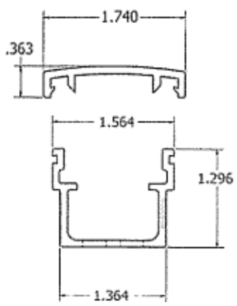

FIGURE 1 – TOP RAIL

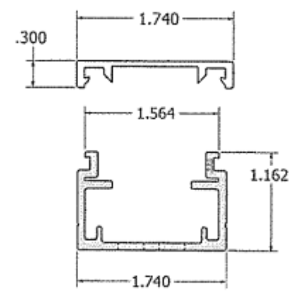

FIGURE 2 – BOTTOM RAIL

0.75 Round

0.75" Square

FIGURE 3 – ALUMINUM BALUSTERS

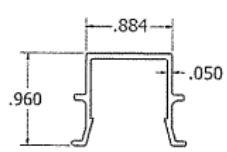

FIGURE 4 – PVC RAIL INSERT

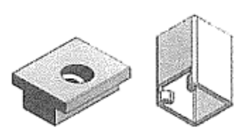

FIGURE 5 – TWO PIECE RAILING SUPPORT

Top Mount

Bottom Mount

FIGURE 6 – ZAMAK 3 CAST MOUNTING BRACKETS

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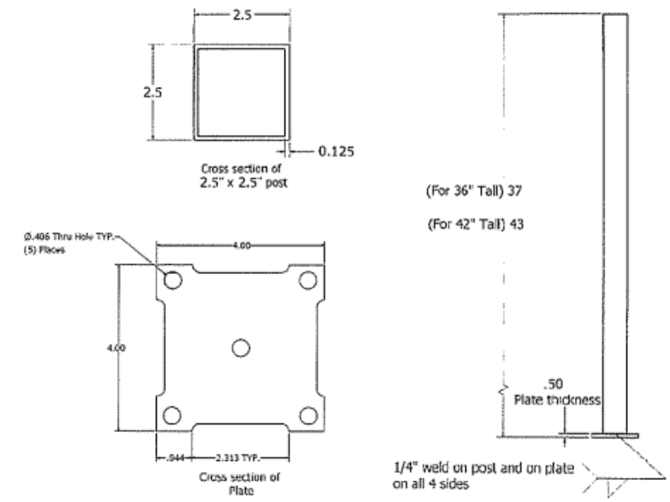


FIGURE 7 – 2.5 INCH SQUARE ALUMINUM SUPPORT POST

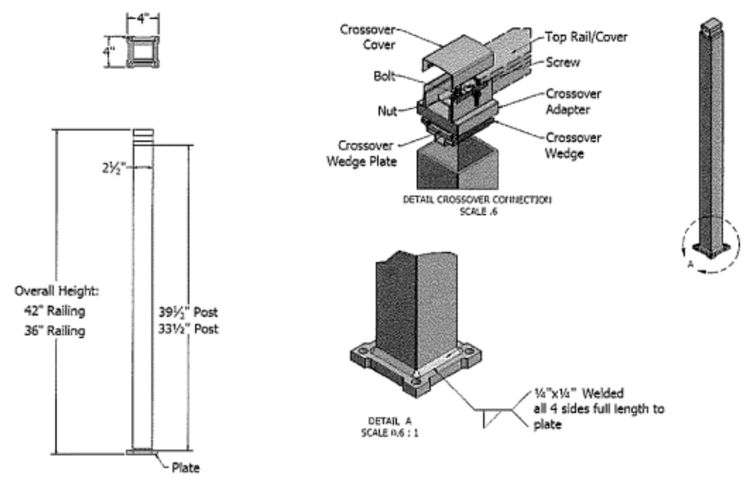
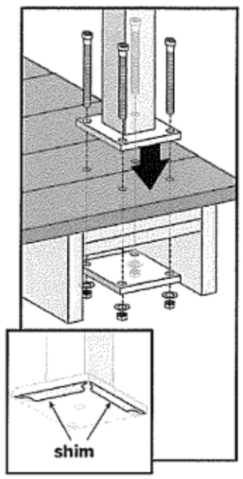
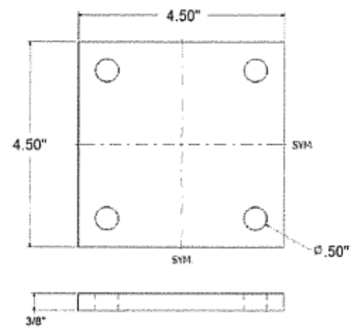


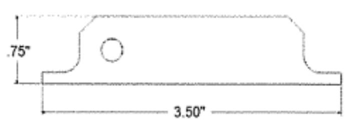
FIGURE 8 - TREX® CROSSOVER POST ASSEMBLY



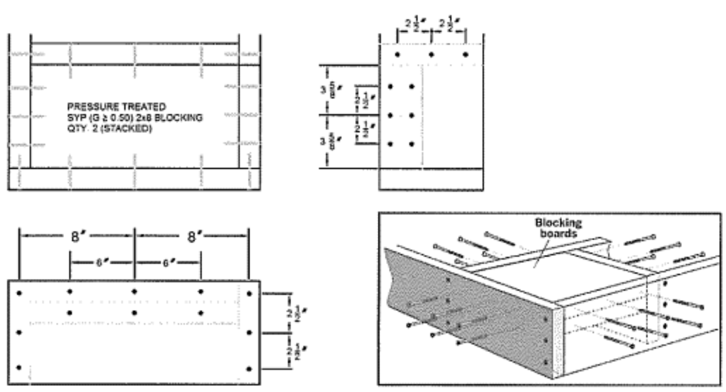
Wood Deck Install Detail



Aluminum Back Plate



Stainless Steel Shim Plates



Wood Blocking Detail

FIGURE 9 – POST MOUNT INSTALLATION ON WOOD DECK

9 Appendix B – Test Report (Intertek/ATI) D7953.01-119-19-R0 for Trex Reveal

TEST REPORT

Rendered to:

TREX COMPANY, INC.

For:

Trex® Reveal™
Aluminum Railing System

Report No.: **D7953.01-119-19**
Report Date: **07/28/14**
Test Record Retention Date: **05/19/18**

Intertek | Architectural Testing

TEST REPORT

D7953.01-119-19
July 28, 2014

TABLE OF CONTENTS

7008 Northland Drive
Suite 150
Minneapolis, MN 55428
(877) 215-RAIL (7245)

TEST REPORT

Rendered to:

TREX COMPANY, INC.
160 Exeter Drive
Winchester, Virginia 22603-8614

Report No.:	D7953.01-119-19
Test Date:	05/16/14
Through:	05/19/14
Report Date:	07/28/14
Test Record Retention Date:	05/19/18

1.0 General Information

1.1 Product

8 ft by 42 in *Reveal Railing®* with redesigned 2-1/2 in Aluminum Post Mount and Crossover Assembly

1.2 Project Description

Architectural Testing was contracted by Trex Company, Inc. to perform structural testing on their 8 ft by 42 in *Reveal Railing®* with redesigned 2-1/2 in aluminum post mount and crossover assembly. This report is in conjunction with Architectural Testing Project No. C7526.01-119-19, which includes test results of the post mount connection to the support structure as well as the balusters. The purpose of the testing is code compliance evaluation in accordance with the following criteria:

ICC-ES™ AC273 (Approved, January 2012), *Acceptance Criteria for Handrails and Guards*

ICC-ES™ AC273-08 was developed by the ICC Evaluation Service, Inc. (ICC-ES™) as acceptance criteria to evaluate compliance with the following building codes:

2012 *International Building Code®*, International Code Council

2012 *International Residential Code®*, International Code Council

1.3 Limitations

All tests performed were to evaluate structural performance of the railing assembly to carry and transfer imposed loads to the supports (posts). The test specimen evaluated included the pickets, rails, rail brackets, posts, and attachment to the supporting structure. Anchorage of support posts to the supporting structure is not included in the scope of this testing and would need to be evaluated separately.

1.4 Qualifications

Architectural Testing has demonstrated compliance with ANS/ISO/IEC Standard 17025 and is consequently accredited as a Testing Laboratory (TL-144) by International Accreditation Service, Inc. for all testing reported herein.

1.5 Product Description

The *Reveal Railing* guardrail system is comprised of extruded aluminum rails, pickets, and posts. Drawings are included in Appendix A to verify the overall dimensions and other pertinent information of the tested product, its components, and any constructed assemblies.

1.6 Product Sampling

All *Reveal Railing* guardrail system components were marked DIG(510)050214-43 and initialed with permanent marker as an indication that they were selected by NTA (independent inspection agency). The sampling was completed on 05/12/14. See photograph in Appendix B for typical sampling mark.

1.7 Witnessing

Mr. Glenn Muse, Mr. Kyle Lancaster, and Mr. Steven Phillips (05/16/14 only) from Trex Company, Inc. were present for testing conducted and reported herein.

1.8 Conditions of Testing

Unless otherwise indicated, all testing reported herein was conducted in a laboratory set to maintain temperature in the range of 68 ± 4ºF and humidity in the range of 50 ± 5% RH.

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2.0 Structural Performance Testing of Assembled Railing Systems

Re: ICC-ES™ AC273 - Section 4.2.1

2.1 General

Railing assemblies were tested in a self-contained structural frame designed to accommodate anchorage of a rail assembly and application of the required test loads. The specimen was loaded using an electric winch mounted to a rigid steel test frame. High strength steel cables, nylon straps, and load distribution beams were used to impose test loads on the specimen. Applied load was measured using an electronic load cell located in-line with the loading system. Deflections were measured to the nearest 0.01 in using electronic linear displacement transducers.

2.2 Railing Assembly Description

The *Reveal Rail* systems consisted of aluminum top and bottom rails, that contained a PVC insert, with spaced pickets between the rail members. The railing systems had an overall top rail length (inside of post to inside of post) of 96 in with an overall rail height (top of top rail to bottom of bottom rail) of 42 in. The top rail attached to a die-cast zinc crossover bracket. The bottom rails attached to die-cast zinc collar brackets. See Section 2.4 Fastening Schedule for connection details. An aluminum support block was placed at the center of the bottom rail for testing. See drawings in Appendix A and photographs in Appendix B for additional details.

2.3 Series / Model

The test specimen components were supplied by Digger Specialties, Inc. and were assembled by representatives of Trex Company, Inc.

Top Rail: Two piece, 1.44 in high by 1.75 in wide by 0.09 in wall, domed rectangular profile, 6005-T5 aluminum extrusion with internal longitudinal ribs and 6063-T6 aluminum extrusion top cap

Bottom Rail: Two pieces, 1.25 in high by 1.75 in wide by 0.09 in wall, rectangular profile, 6063-T6 aluminum extrusion with two internal longitudinal ribs and 6063-T6 aluminum extrusion top cap

Top and Bottom Rail Insert: 1 in high by 1.15 in wide by 0.065 in thick by full rail length, "U" shaped profile, rigid PVC extrusion (non-structural)

Baluster: 3/4 in square by 0.05 in wall, hollow 6063-T52 aluminum extrusion

Foot Block: Two pieces, 1-3/8 in square aluminum extrusion with attachment block

Top Rail Crossover Bracket: 1.62 in high by 2.50 in wide by 2.50 in long, Zamak 3 aluminum die-cast, crossover bracket.

Bottom Rail Bracket: 1.38 in high by 2 in wide by 1.19 in long, Zamak 3 aluminum die-cast, collar bracket

Post Mount: 2-1/2 in square by 0.125 in wall 6005-T5 aluminum tubular extrusion, with 0.25 in continuous fillet welded to a 4 in square by 1/2 in thick 6061-T6 aluminum plate with: Four 0.4 in dia. holes on 3-1/4 in centers for anchors and one 0.4 in dia center hole. For structural tests the post mounts were tested individually surfaced mounted to a mock wood deck fabricated by representative from Trex Company, Inc.

Wood Deck: 2x8 preservative treated Southern Pine joists, vertical blocking and horizontal blocking; nominal 1 in x 5.5 in *Trex Transcend*® decking; #10 x 2-1/2 in deck screws were used to fasten deck boards to joists. See drawing in Appendix A and photographs in Appendix B for additional details.

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2.4 Fastening Schedule

Connection	Fastener
Top Rail Bracket to Post	One 5/16-18 x 2 in stainless steel bolt, with a crossover wedge and crossover wedge plate into the top of the post
Bottom Rail Bracket to Post	Two #10-16 by 5/8 in square drive, pan-head, self-drilling, stainless steel screws
Top Rail Bracket to Rail	
Bottom Rail Bracket to Rail	One #10-16 by 5/8 in square drive, pan-head, self-drilling, zinc-coated steel screws
Picket to Rail	Inserted in 0.8 in square or diameter routed hole and held tight with PVC Rail Insert; center baluster attached to top and bottom rail using two #8-15 x 1-1/4" square drive, pan-head, stainless steel screws through screw bosses
Foot Block to Bottom Rail	One #12-11 by 1-1/4 in square drive, pan-head, self-drilling, zinc-coated steel screws
Post Mount to Wood Substructure	Four 3/8 in by 6 in hex-head galvanized steel bolts with washer and nuts along with a 4-1/2 in square by 3/8 in thick aluminum plate

See drawings in Appendix A and photographs in Appendix B for additional details.

2.5 Test Setup

The railing assembly was installed and tested as a single railing section by directly securing (surface-mounting) the base of the post mounts to rigid steel channels. The railing was assembled by Trex Company Inc. employees. Transducers mounted to an independent reference frame were located to record movement of reference points on the railing system components (ends and mid-point) to determine net component deflections. See photographs in Appendix B for test setups.

2.6 Test Procedure

Testing and evaluation was performed in accordance with Section 4.2.1 of ICC-ES™ AC273. The test specimen was inspected prior to testing to verify size and general condition of the materials, assembly, and installation. No potentially compromising defects were observed. One specimen was used for all load tests which were performed in the order reported. Each design load test was performed using the following procedure:

1. Zeroed transducers and load cell at zero load;
2. Increased load to specified test load in no less than ten seconds; and
3. Held test load for no less than one minute.

2.7 Test Results

Unless otherwise noted, all loads and displacement measurements were normal to the rail (horizontal). The test results apply only to the railing assembly between supports and anchorage to the support.

Key to Test Results Tables:

Load Level: Target test load

Test Load: Actual applied load at the designated load level (target). Where more than one value is reported, the test load was the range (min. - max.) that was held during the time indicated in the test.

Elapsed Time (E.T.): The amount of time into the test with zero established at the beginning of the loading procedure. Where more than one value is reported, the time was the range (start-end) that the designated load level was reached and sustained.

Test Series No. 1
96 in by 42 in *Trex Reveal* Level Guardrail System
with 3/4 in Square Aluminum Balusters
IBC - All Use Groups / ICC-ES™ AC273

Test No. 1 - Test Date: 05/16/14 **Design Load: 50 plf Applied on a 45° Diagonal** **50 plf x 96 in ÷ 12 in/ft = 400 lb Uniform Load on Top Rail**			
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Result**
1000 lb (2.50 x D.L.)	995 - 1014 [1]	01-11 - 02:13	Sustained load equal to or greater than 1,000 lb for one full minute without failure

[1] *During the 2.5x D.L. hold, the load dropped below 1000 lb for a total of 5 seconds.*

2.7 Test Results (Continued)

Test Series No. 1 (Continued)

Test No. 2 - Test Date: 05/16/14 Design Load: 200 lb Concentrated Load at Mid-Span of Top Rail						
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Displacement (in)**			
			End	**Mid**	**End**	**Net [1]**
200 lb (D.L.)	203	00:33	0.46	2.21	0.44	1.75
500 lb (2.50 x D.L.)	501 - 509	00:53 - 01:53	**Result**: Withstood load equal to or greater than 500 lb for one full minute without failure			

Deflection Evaluation:
Maximum rail deflection at 203 lb = 1.75 in on an 8 ft rail (96 in)
Limits per AC273 [2]: $\left(\frac{h}{24}+\frac{l}{96}\right)=\left(\frac{36}{24}+\frac{96}{96}\right)= 2.50" > 1.75" \therefore\ ok$

[1] *Each end displacement was measured at the center of the support. Net displacement was the rail displacement relative to the supports.*

[2] *Deflection limit calculations are based on worse case 36" railing height to satisfy One- and Two-Family Dwelling requirements*

Test No. 3 - Test Date: 05/16/14 Design Load: 200 lb Concentrated Load at Both Ends of Top Rail (Brackets)			
Load Level [1]	**Test Load (lb)**	**E.T. (min:sec)**	**Result**
1000 lb (2.50 x D.L.) x 2	990 - 1027 [2]	01:03 - 02:04	Each end withstood load equal to or greater than 500 lb for one full minute without failure

[1] *Load was imposed on both ends of rail using a spreader beam; therefore, loads were doubled.*

[2] *During the 2.5x D.L. hold, the load dropped below 1000 lb for a total of 4 seconds.*

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2.7 Test Results (Continued)

Test Series No. 1 (Continued)

Test No. 4 - Test Date: 05/16/14 **Design Load: 50 plf Applied on a 45° Diagonal** **50 plf x 96 in ÷ 12 in/ft = 400 lb Uniform Load on Top Rail**			
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Result**
1000 lb (2.50 x D.L.)	1000 - 1013	01:10 - 02:11	Sustained load equal to or greater than 1,000 lb for one full minute without failure

Test No. 5 - Test Date: 05/16/14 **Design Load: 200 lb Concentrated Load at Mid-Span of Top Rail**						
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Displacement (in)**			
			End	**Mid**	**End**	**Net** [1]
200 lb (D.L.)	200	00:22	0.42	2.09	0.47	1.65
500 lb (2.50 x D.L.)	501 - 512	00:35 - 01:36	**Result**: Withstood load equal to or greater than 500 lb for one full minute without failure			

Deflection Evaluation:
Maximum rail deflection at 200 lb = 1.65 in on an 8 ft rail (96 in)
Limits per AC273 [2]: $\left(\frac{h}{24}+\frac{l}{96}\right)=\left(\frac{36}{24}+\frac{96}{96}\right)=2.50" > 1.65" \therefore\ ok$

[1] *Each end displacement was measured at the center of the support. Net displacement was the rail displacement relative to the supports.*
[2] *Deflection limit calculations are based on worse case 36" railing height to satisfy One- and Two-Family Dwelling requirements*

Test No. 6 - Test Date: 05/16/14 **Design Load: 200 lb Concentrated Load at Both Ends of Top Rail (Brackets)**			
Load Level [1]	**Test Load (lb)**	**E.T. (min:sec)**	**Result**
1000 lb (2.50 x D.L.) x 2	999 - 1020 [2]	0.50 - 1:51	Each end withstood load equal to or greater than 500 lb for one full minute without failure

[1] *Load was imposed on both ends of rail using a spreader beam; therefore, loads were doubled.*
[2] *During the 2.5x D.L. hold, the load dropped below 1,000 lb for a total of 2 seconds.*

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2.7 Test Results (Continued)

Test Series No. 2
***Trex Reveal* Aluminum Post Mount Installed in Simulated Wood Deck**
IBC - All Use Groups / ICC-ES™ AC273

Specimen No. 1 of 3

Test No. 1 - Test Date: 05/19/14 Design Load: 200 lb Concentrated Load at Top of Post Mount (42 in High)			
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Displacement (in)**
200 lb (D.L.)	206	00:26	1.34
500 lb (2.50 x D.L.)	500 - 508	00:45 - 01:59	**Result**: Withstood load equal to or greater than 500 lb for one full minute without failure

Deflection Evaluation:
Maximum post deflection at 206 lb = 1.34 in on a post mount with the load applied at 42".
Limits per AC273 [1]: $\frac{h}{12} = \frac{36}{12} = 3.00" > 1.34" \therefore \ ok$

[1] *Deflection limit calculations are based on worse case 36" railing height to satisfy One- and Two-Family Dwelling requirements.*

Specimen No. 2 of 3

Test No. 1 - Test Date: 05/19/14 Design Load: 200 lb Concentrated Load at Top of Post Mount (42 in High)			
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Displacement (in)**
200 lb (D.L.)	201	00:37	0.95
500 lb (2.50 x D.L.)	497 - 511	00:52 - 02:21	**Result**: Withstood load equal to or greater than 500 lb for one full minute without failure

Deflection Evaluation:
Maximum post deflection at 201 lb = 0.95 in on a on a post mount with the load applied at 42".
Limits per AC273 [1]: $\frac{h}{12} = \frac{36}{12} = 3.00" > 0.95" \therefore \ ok$

[1] *Deflection limit calculations are based on worse case 36" railing height to satisfy One- and Two-Family Dwelling requirements.*

2.7 Test Results (Continued)

Test Series No. 2 (Continued)

Specimen No. 3 of 3

Test No. 1 - Test Date: 05/19/14 Design Load: 200 lb Concentrated Load at Top of Post Mount (42 in High)			
Load Level	**Test Load (lb)**	**E.T. (min:sec)**	**Displacement (in)**
200 lb (D.L.)	201	00:25	1.11
500 lb (2.50 x D.L.)	500 - 513	00:53 - 02:03	**Result**: Withstood load equal to or greater than 500 lb for one full minute without failure
Deflection Evaluation: Maximum post deflection at 201 lb = 1.11 in on a on a post mount with the load applied at 42". Limits per AC273 [1]: $\frac{h}{12} = \frac{36}{12} = 3.00" > 1.11" \therefore\ ok$			

[1] *Deflection limit calculations are based on worse case 36" railing height to satisfy One- and Two-Family Dwelling requirements.*

2.8 Summary and Conclusions

The 8 ft by 42 in *Trex Reveal* level aluminum guardrail system reported herein met the structural performance requirements of Section 4.2.1 of ICC-ES™ AC273 as installed between adequate supports with guardrail details and Occupancy Classification as shown in the following table.

Reference	Guardrail Type	Baluster	Support Posts	Code Occupancy Classification
Test Series No. 1	Level	3/4" Square Aluminum Balusters or 3/4" Diameter Round Aluminum Balusters	N/A [1]	IBC - All Use Groups
Test Series No. 2			*Trex Reveal* Post Mount (Wood or Concrete Applications)	IRC - One- and Two-Family Dwellings

[1] *A post condition for supporting the 8 ft by 42 in Trex Reveal level aluminum guardrail system for IBC - All Use Groups was not within the scope of this test program and would therefore be subject to evaluation and approval by the building code official.*

Anchorage of support posts to the concrete supporting structure is not included in the scope of this testing and would need to be evaluated separately.

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3.0 Closing Statement

Architectural Testing will service this report for the entire test record retention period. Test records that are retained such as detailed drawings, datasheets, representative samples of test specimens, or other pertinent project documentation will be retained by Architectural Testing, Inc. for the entire test record retention period.

Results obtained are tested values and were secured using the designated test methods. This report does not constitute certification of this product nor an opinion or endorsement by this laboratory. It is the exclusive property of the client so named herein and relates only to the specimens tested. This report may not be reproduced, except in full, without the written approval of Architectural Testing, Inc.

For ARCHITECTURAL TESTING, INC.:

Digitally Signed by: Steve Neff

Steven A. Neff
Technician II
Structural Systems Testing

Digitally Signed by: Travis Hoover

Travis A. Hoover
Program Manager
Structural Systems Testing

SAN:san/jas

Attachments (pages): This report is complete only when all attachments listed are included.
  Appendix A - Drawings (21)
  Appendix B - Photographs (4)

Revision Log

Rev. #	Date	Page(s)	Revision(s)
0	07/28/14	N/A	Original report issue

APPENDIX A

Drawings

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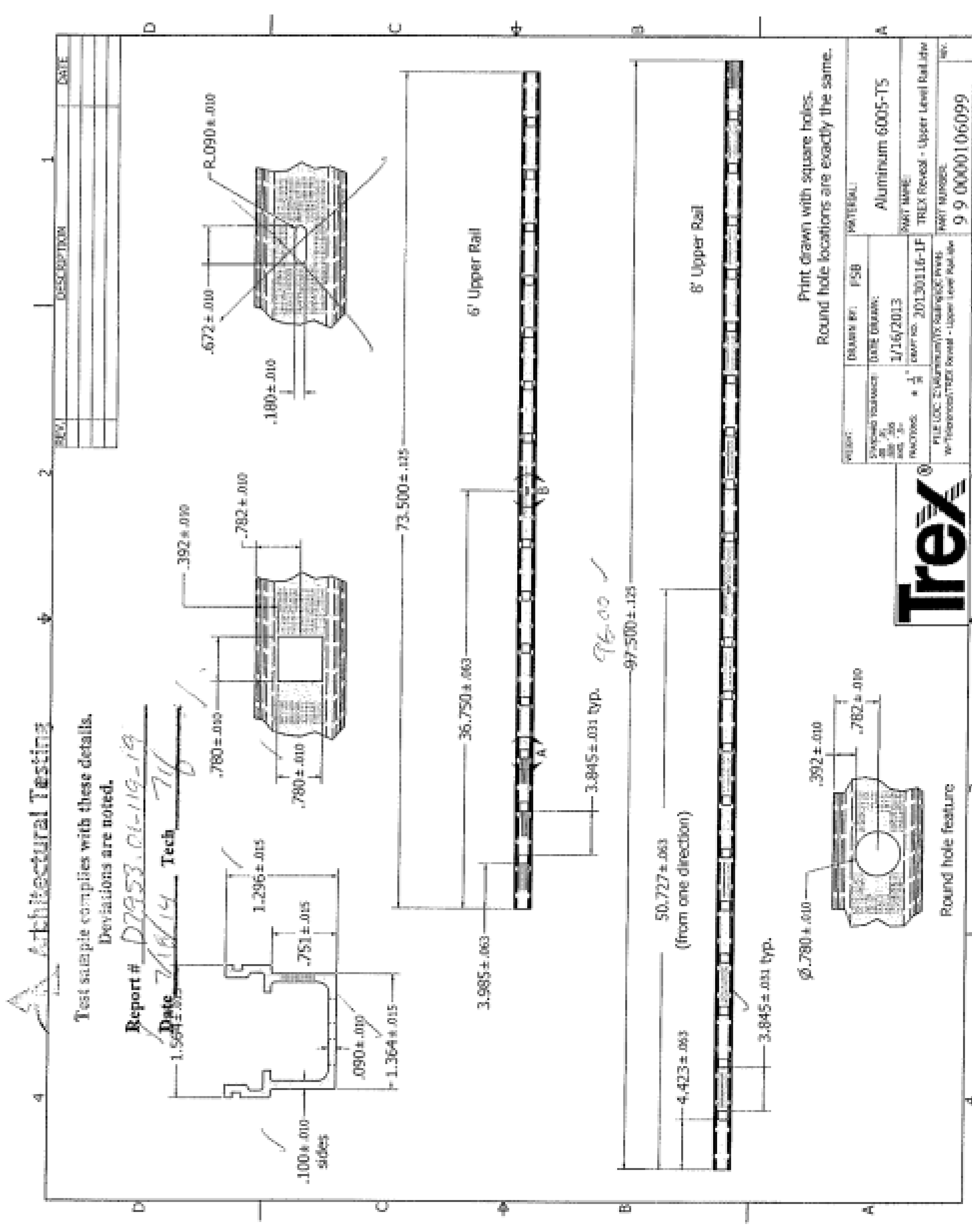

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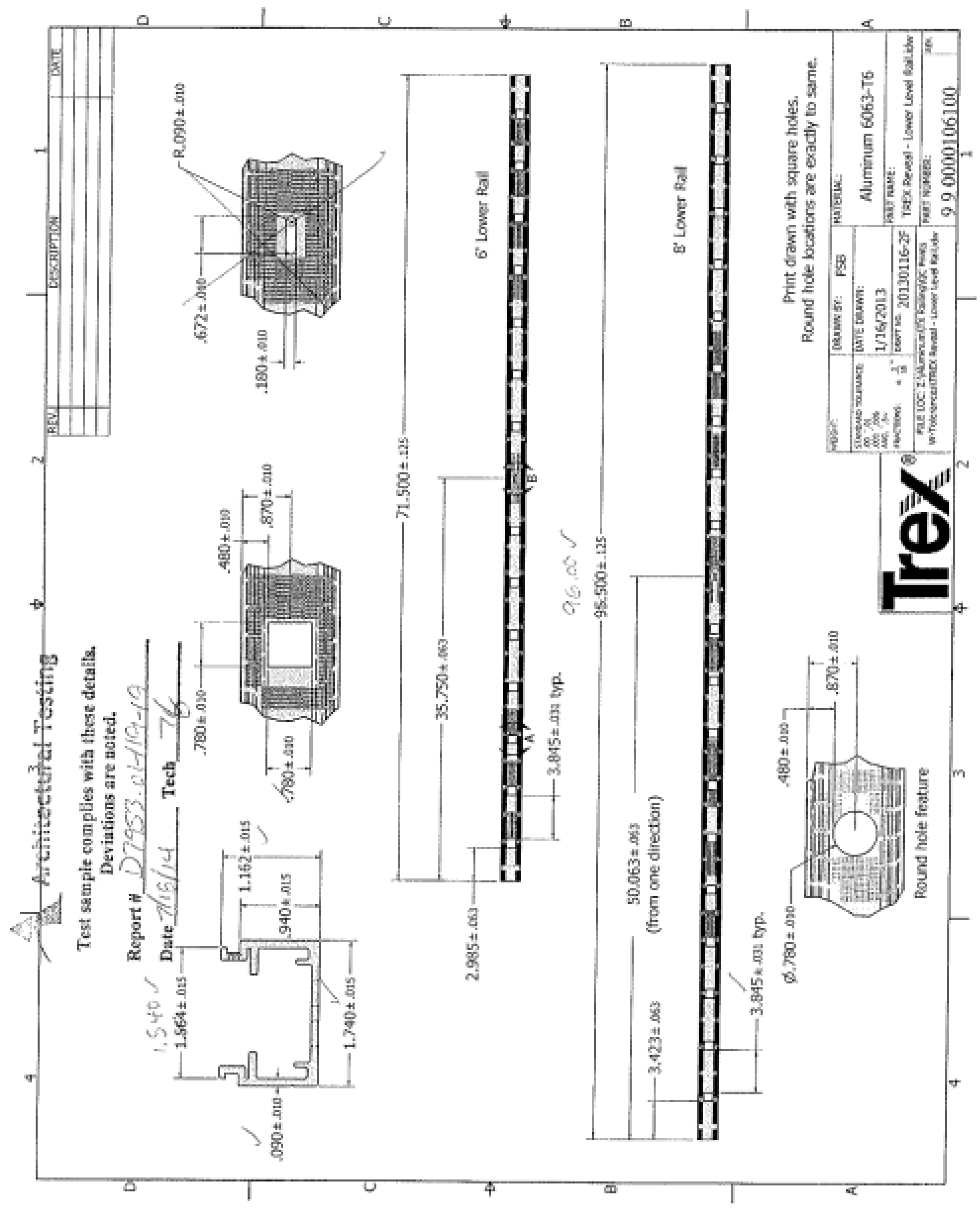

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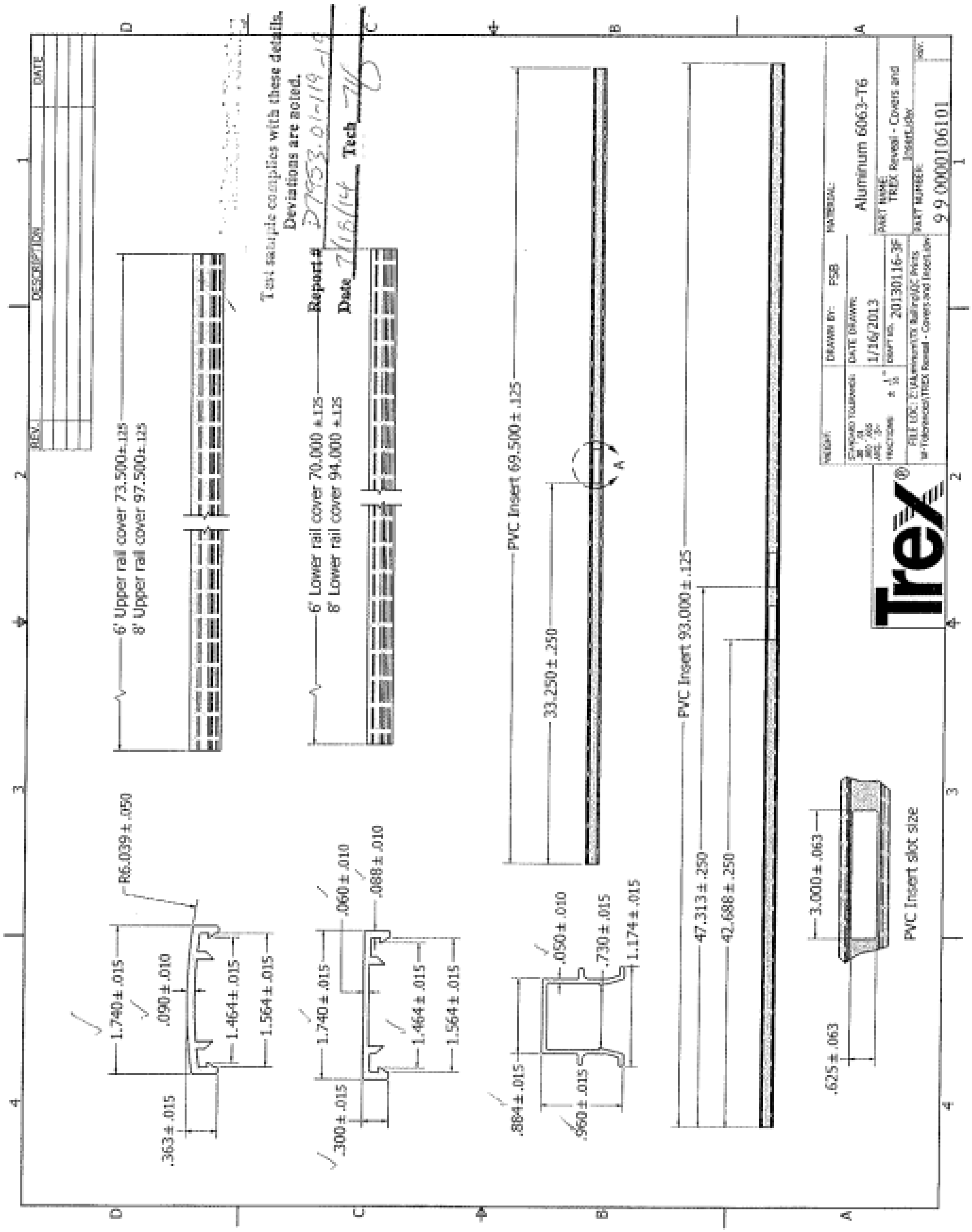

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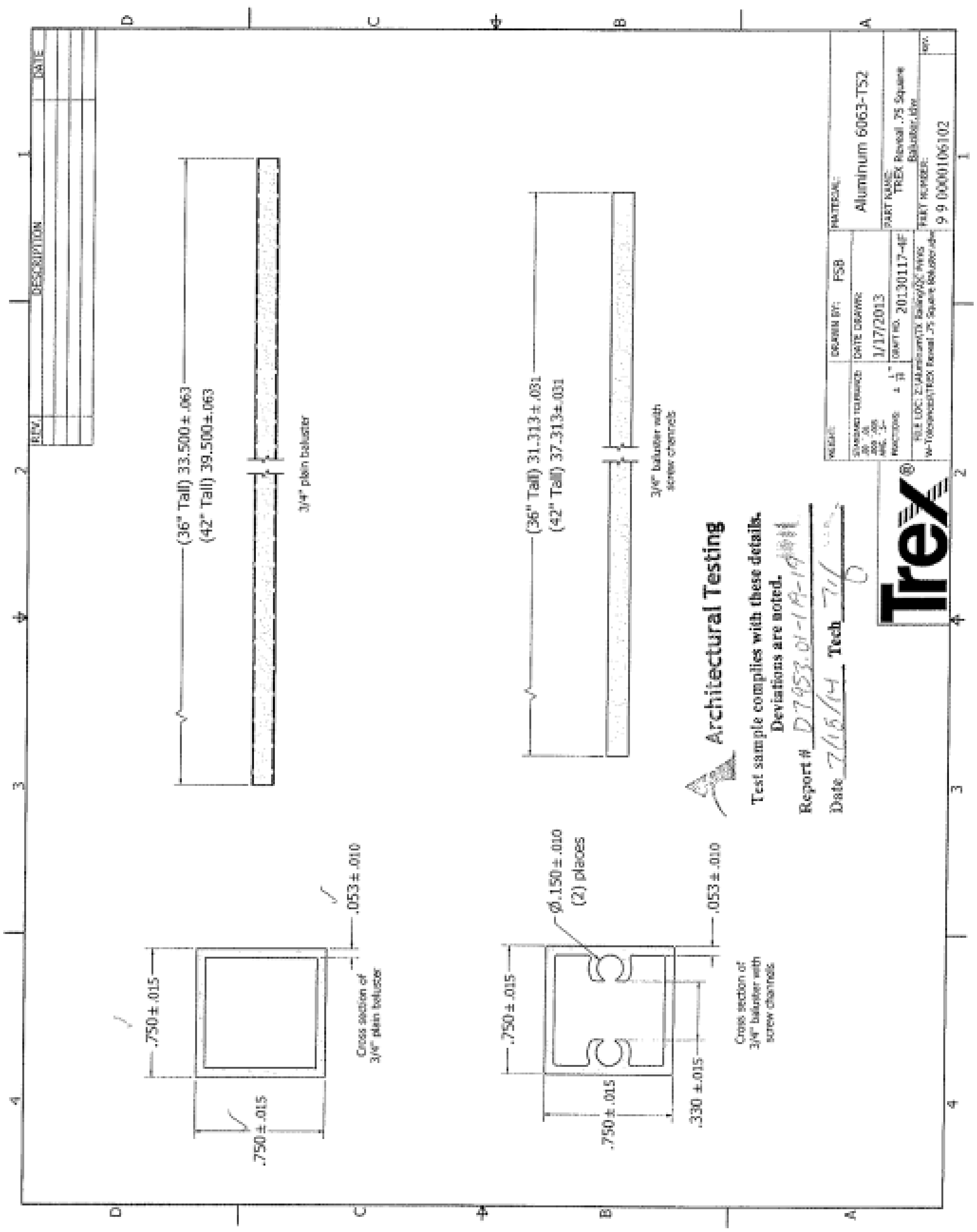

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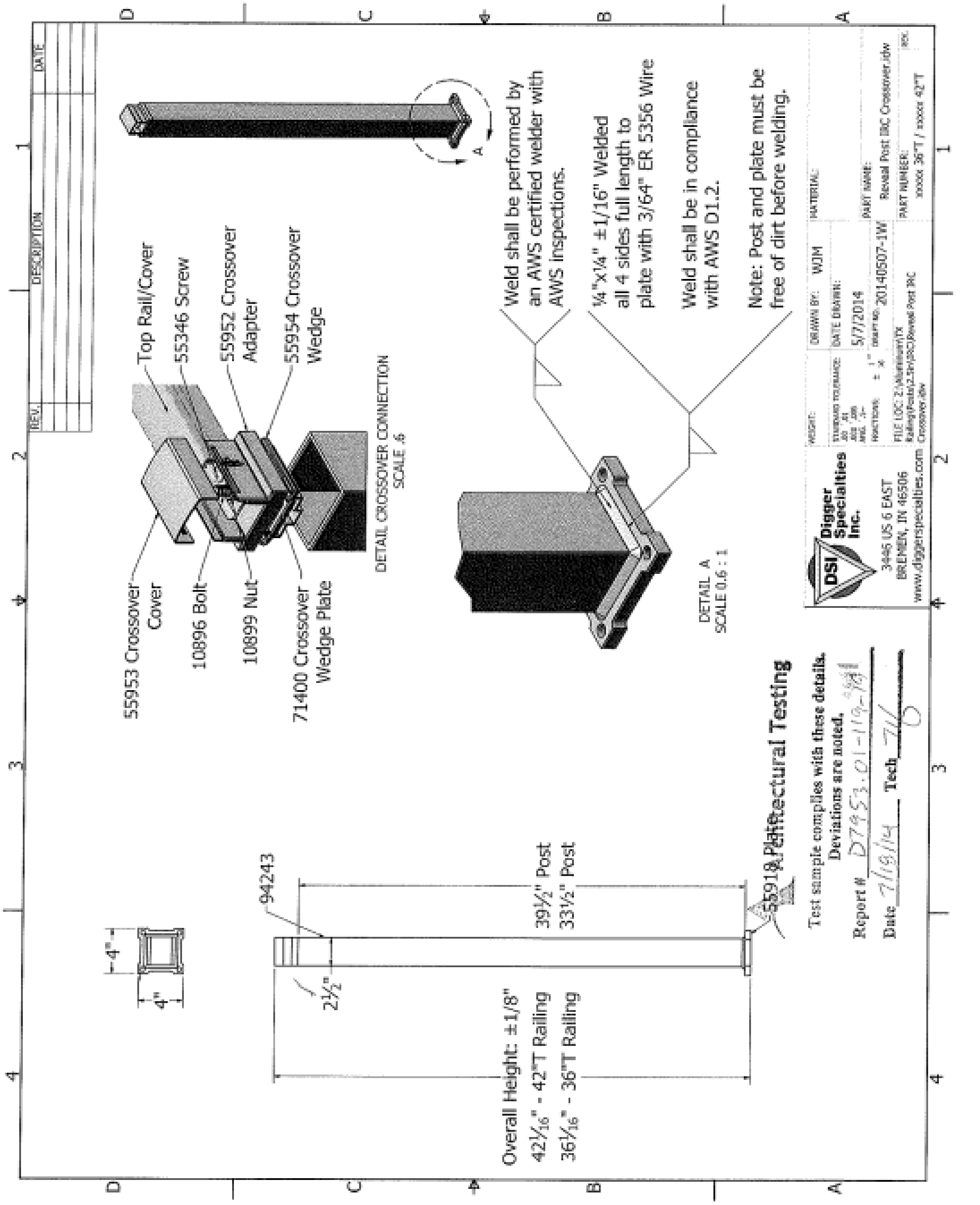

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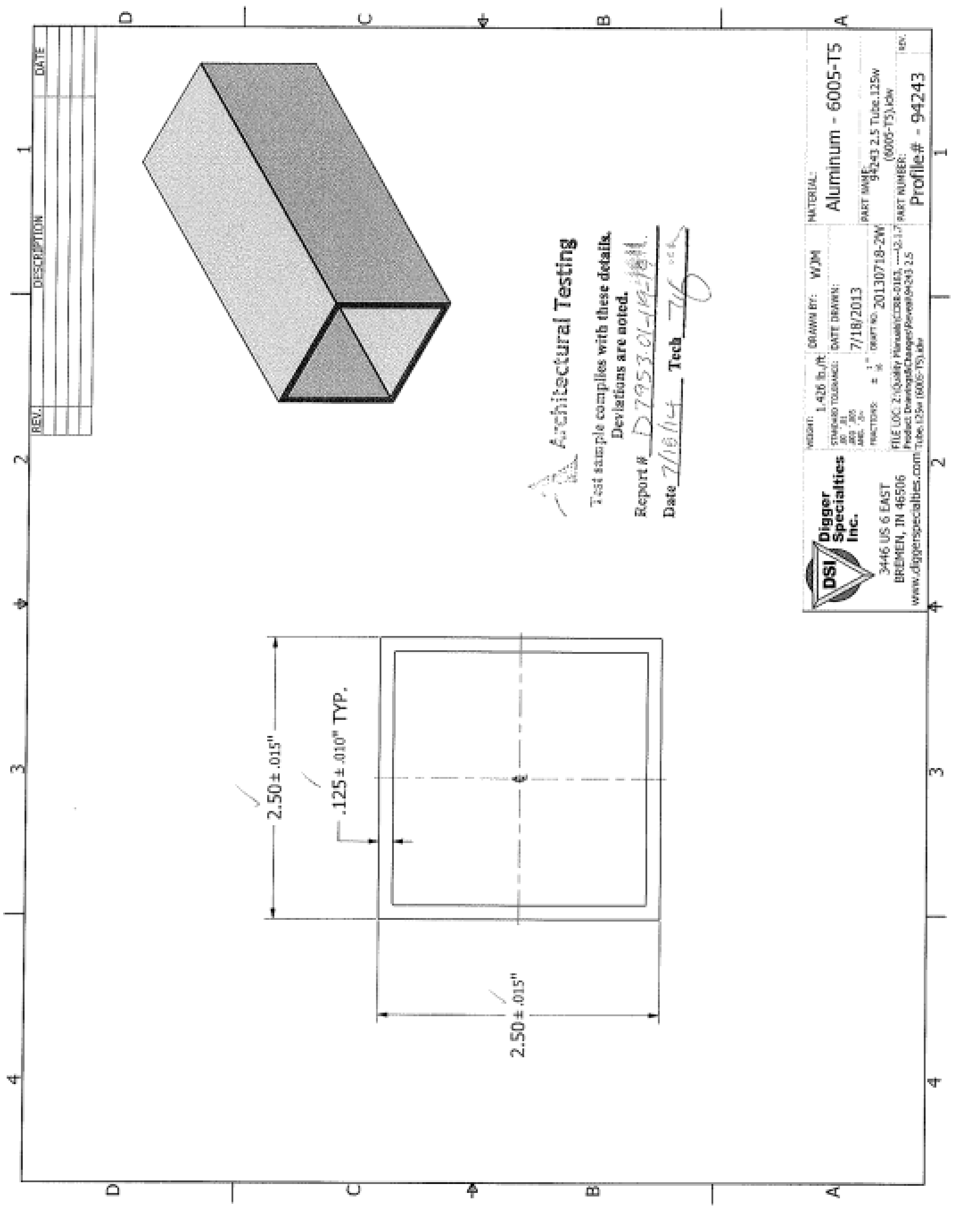

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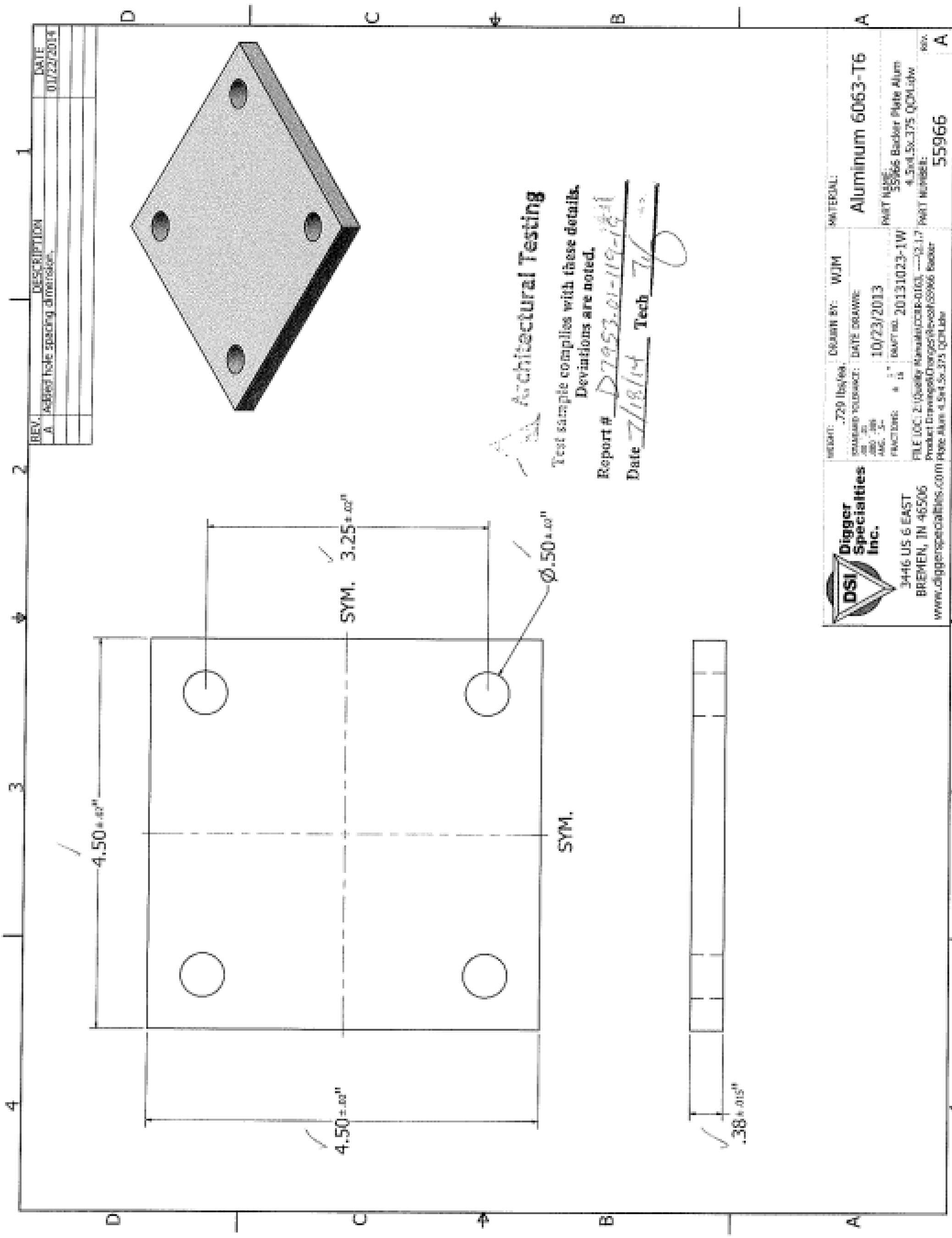

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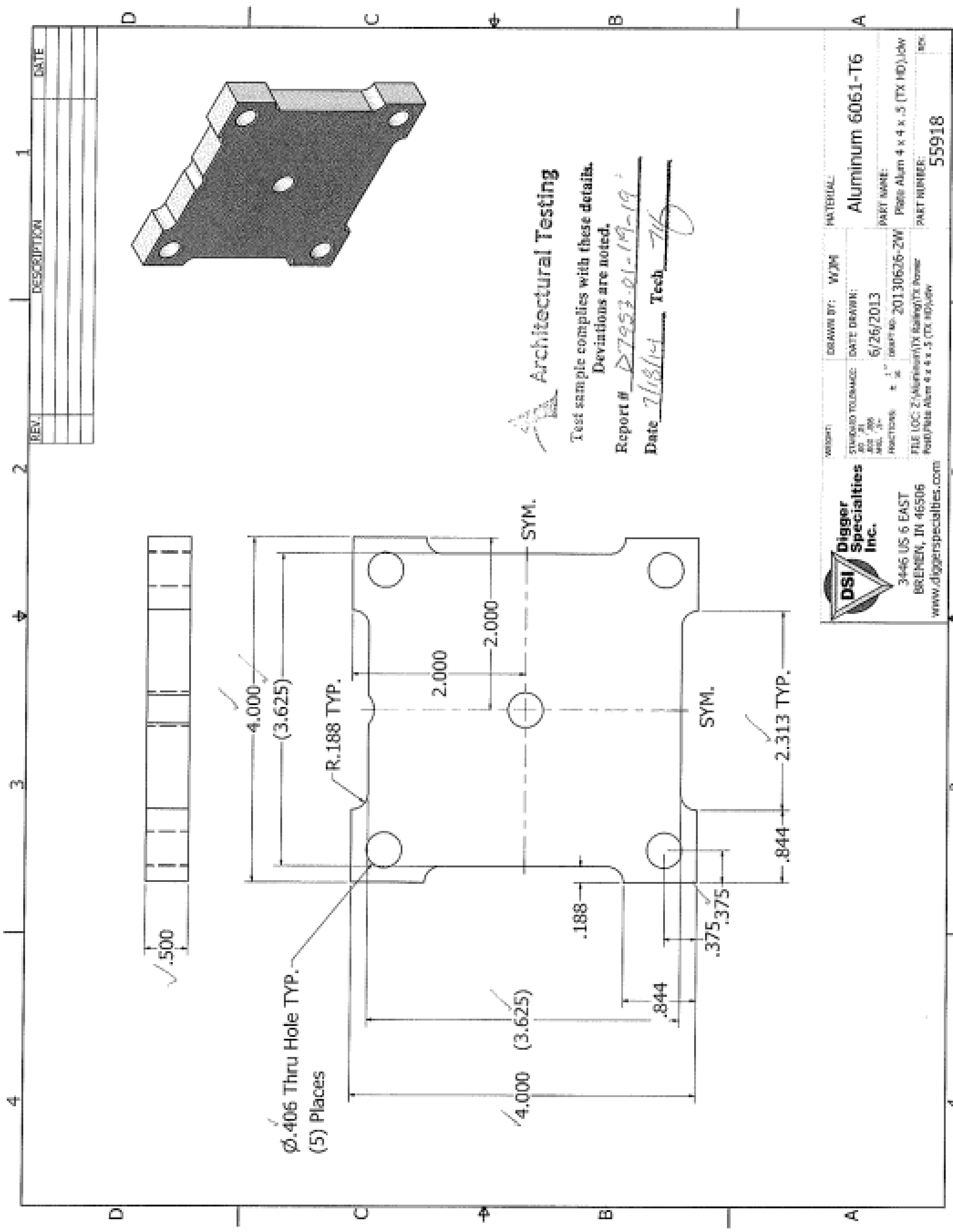

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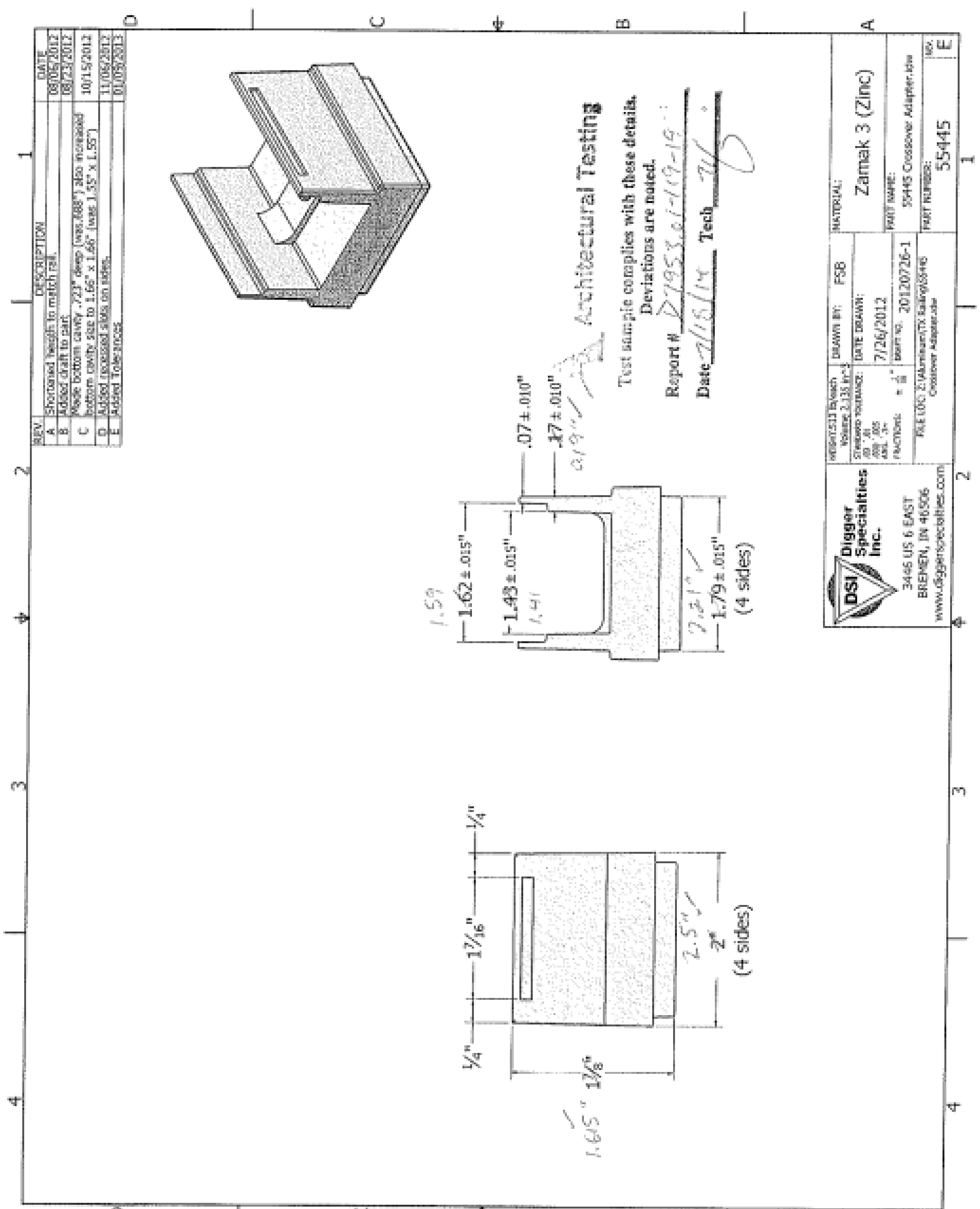

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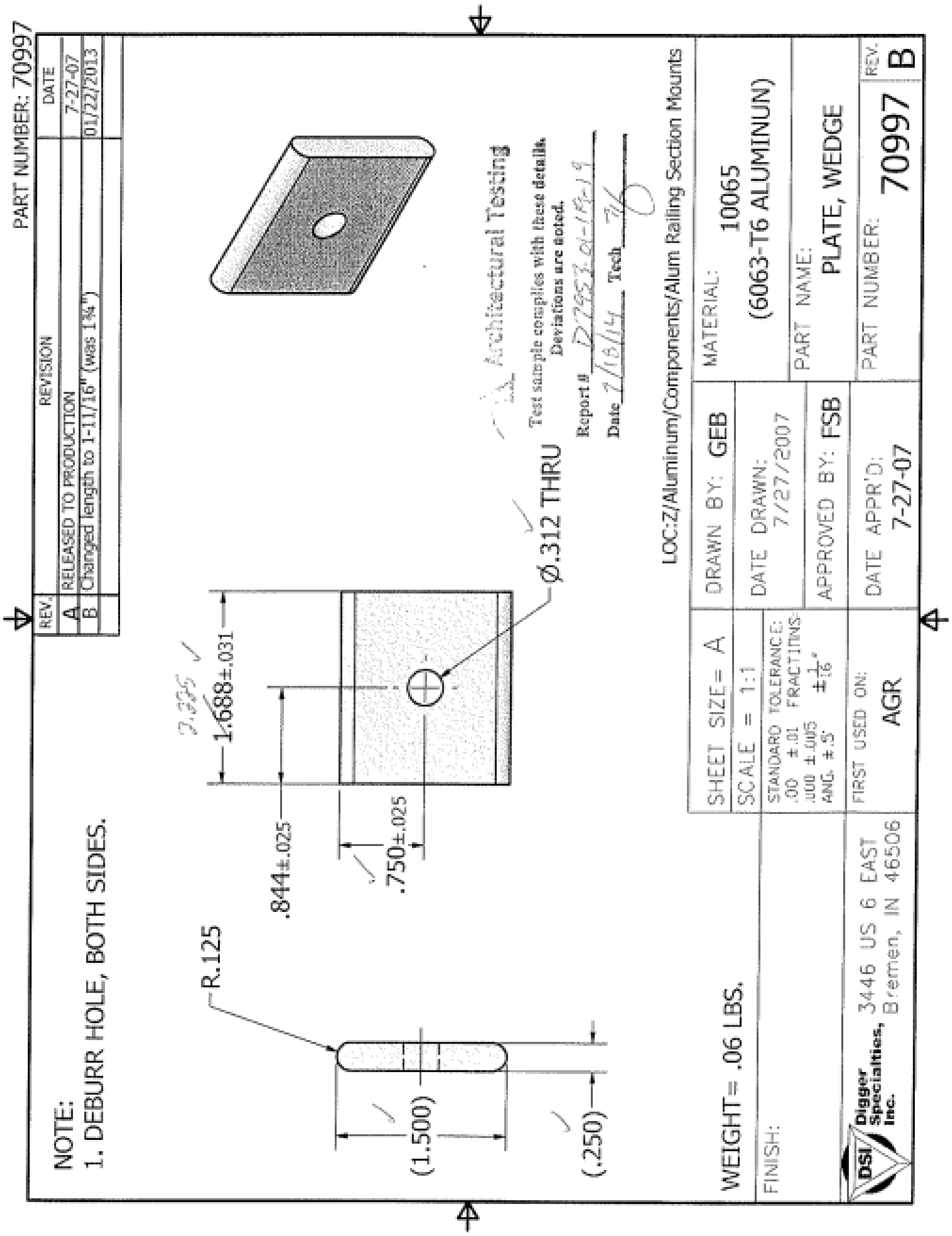

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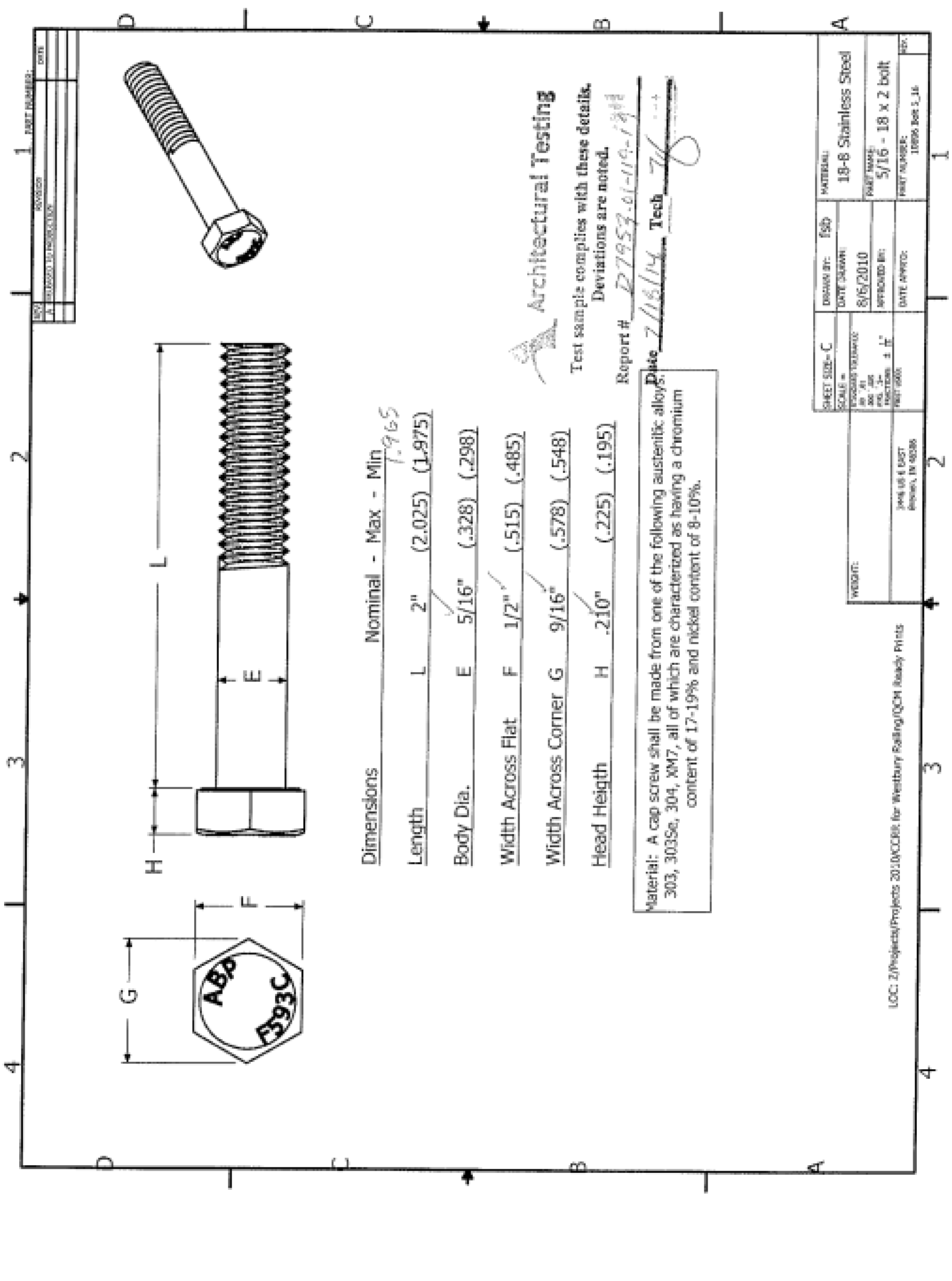

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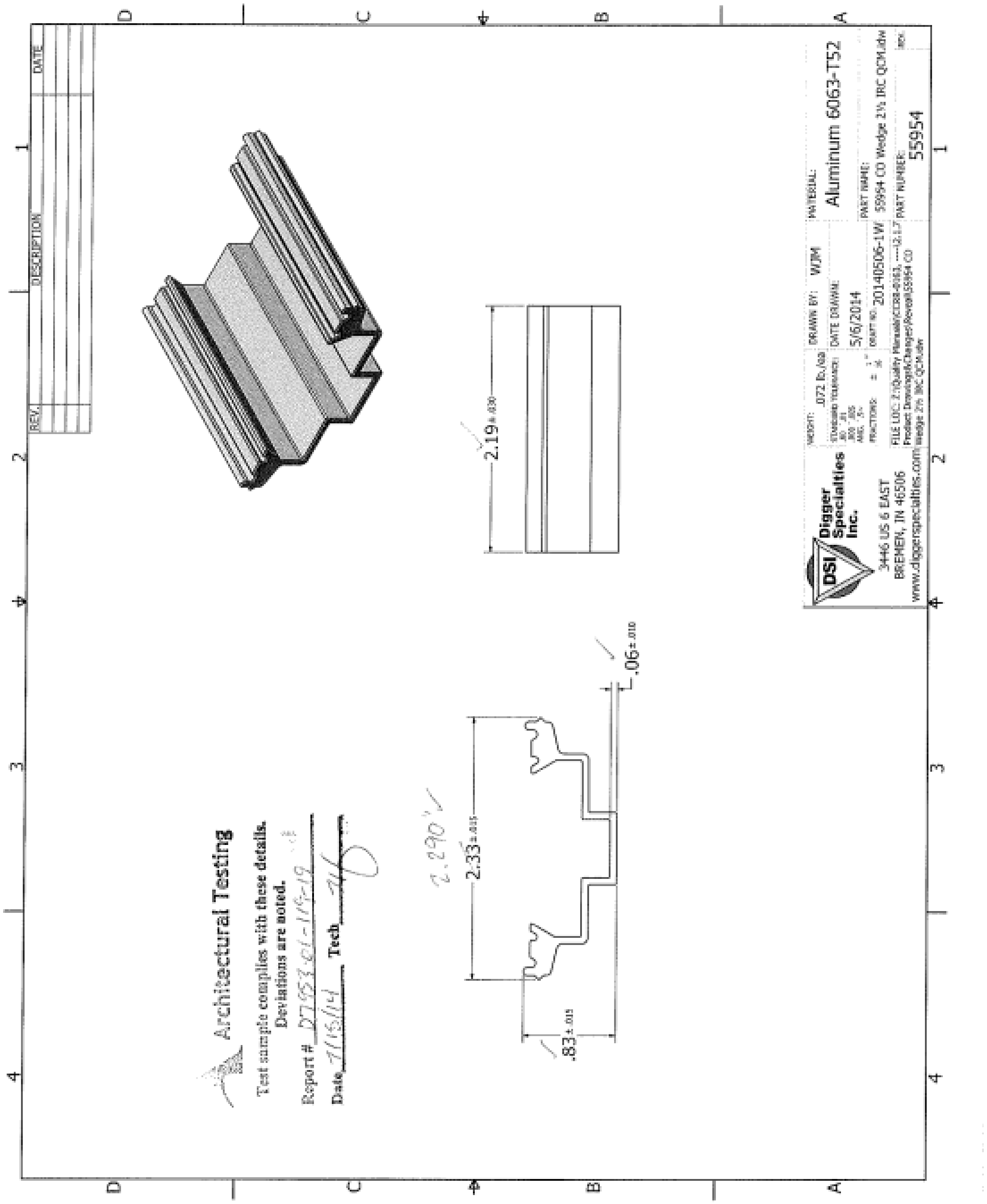

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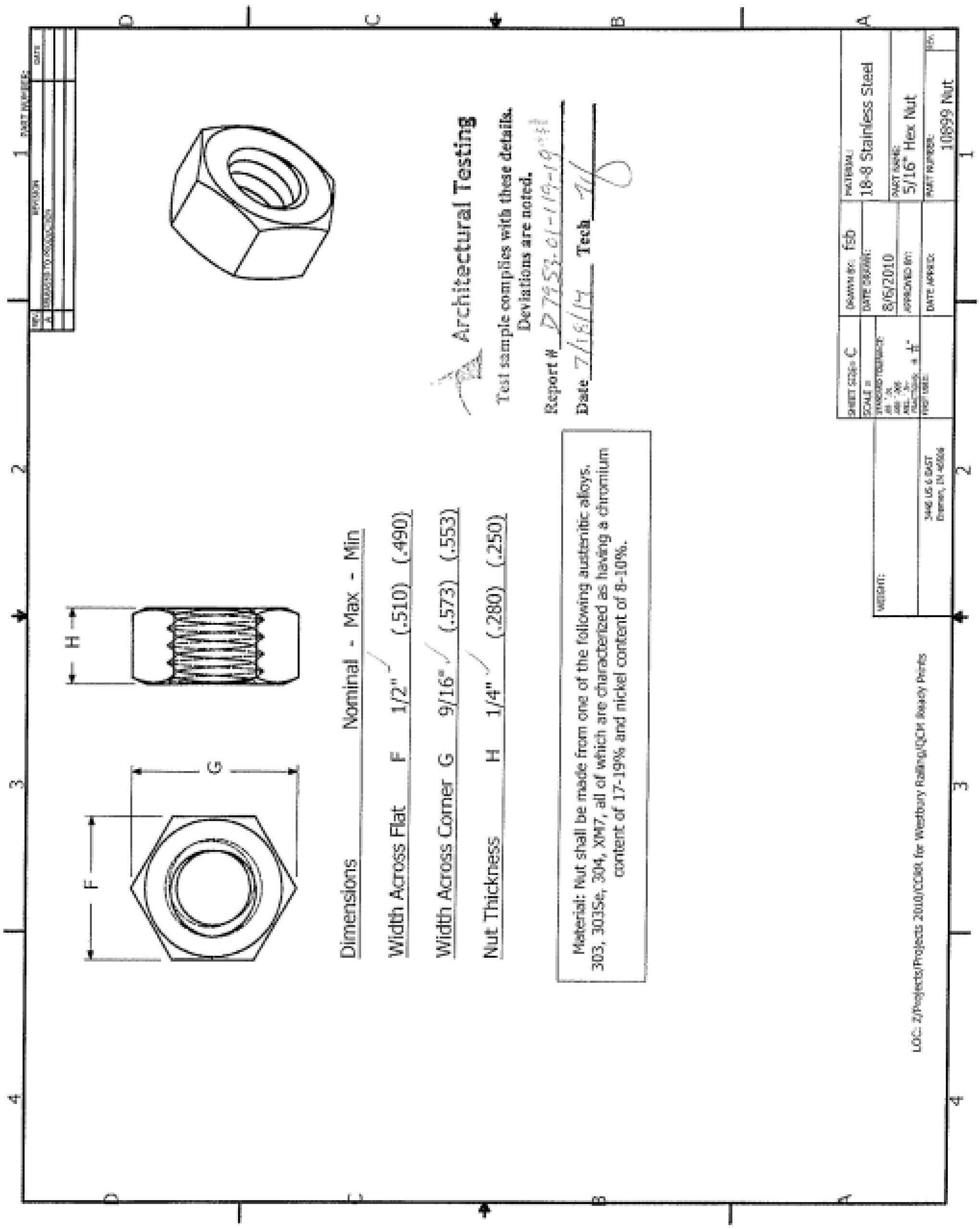

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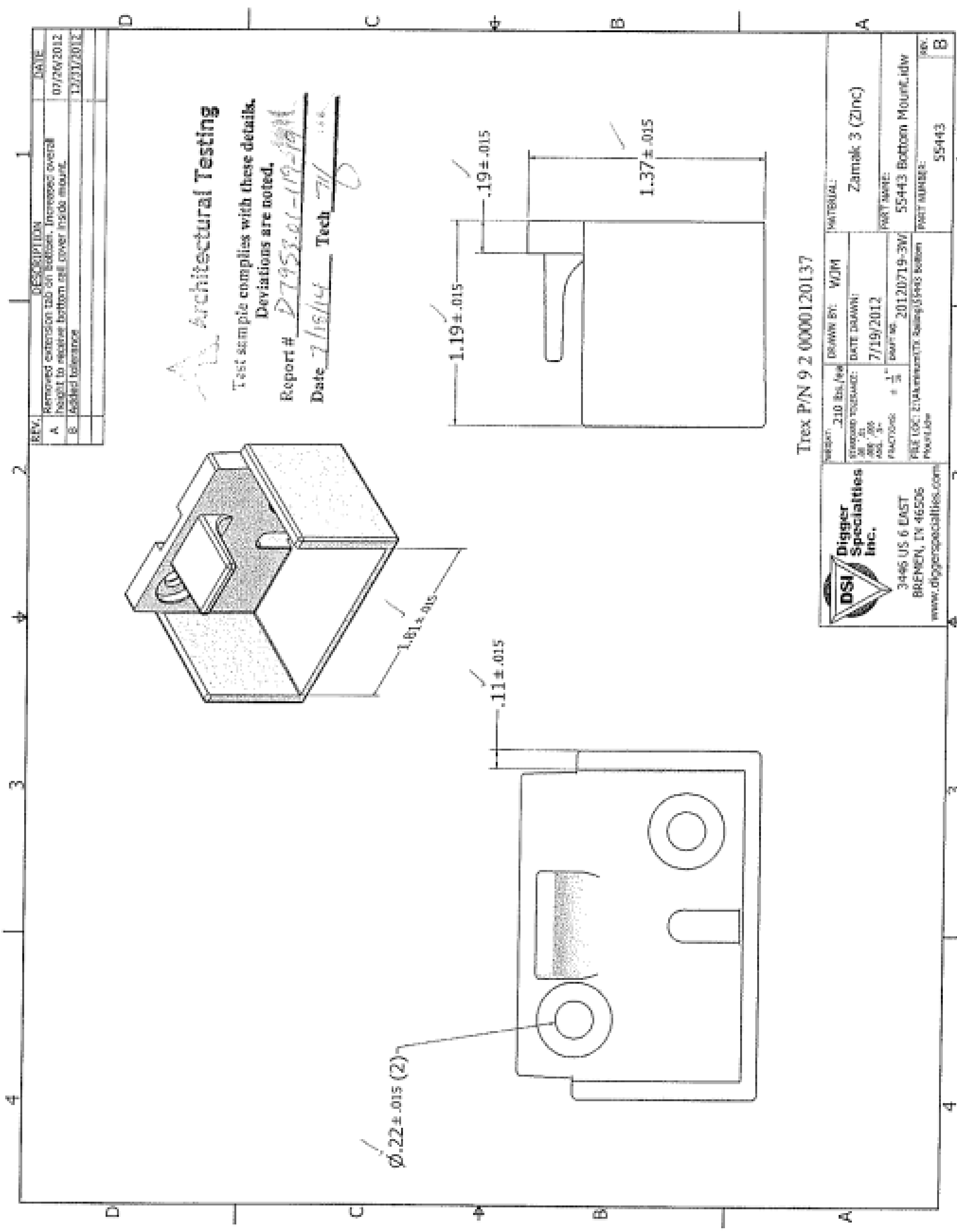

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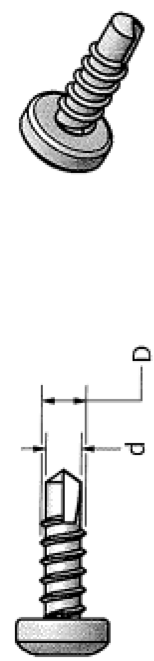
PART NUMBER:

REV.	REVISION	DATE
A	RELEASED TO PRODUCTION	
B	Listed allowable alloys	02-17-2011



Nominal Size	10
Basic Screw Diameter	.185
Threads Per Inch	16
Major Diameter	(D) .18
Minor Diameter	(d) .14
Tolerance on length	±.05
Tolerance on Major/Minor Diameter	±.02

Architectural Testing
Test sample complies with these details.
Deviations are noted.
Report # D7953.01-119-19
Date 7/18/14 Tech

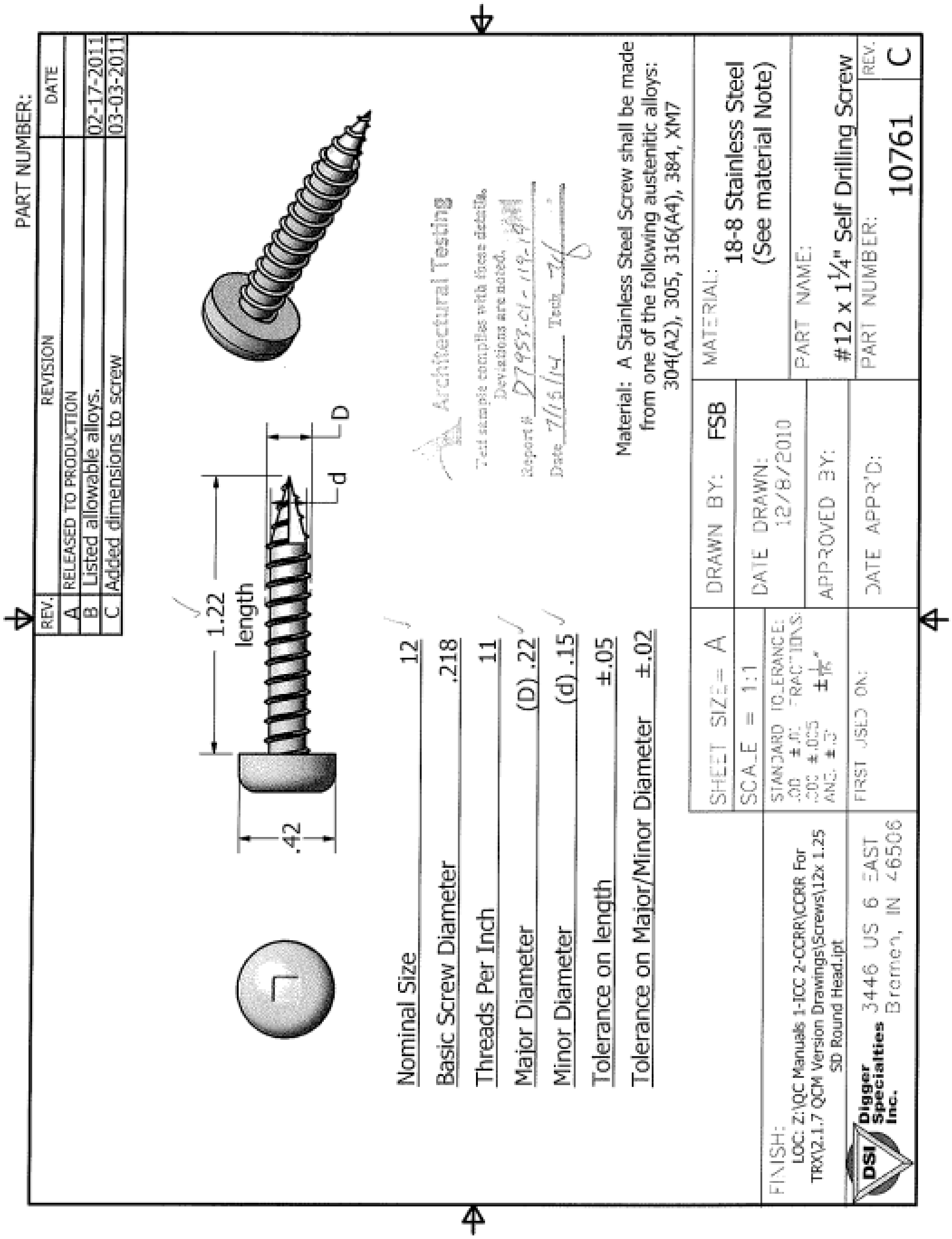
Material: A Stainless Steel Screw shall be made from one of the following austenitic alloys: 304(A2), 305, 316(A4), 384, XM7

SHEET SIZE= A	DRAWN BY: FSB	MATERIAL: 18-8 Stainless Steel (See material note)
SCALE = 1:1	DATE DRAWN: 7/20/2010	
STANDARD TOLERANCE: .00 ±.01 .000 ±.005 ANG. ±.3° FRACTIONS ±1/16"	APPROVED BY:	PART NAME: #10 x 5/8" Self Drilling Screw
FIRST USED ON: Westbury	DATE APPR'D:	PART NUMBER: 55346 REV. B

FINISH:
Z:\QC Manuals 1-ICC 2-CCRR\CCRR WestBury & TREX\Screws QCM Ready\10 x .625 TEK Pan Head.idw

DSI Digger Specialties, Inc. 3446 US 6 EAST Bremen, IN 46506

7008 Northland Drive
Suite 150
Minneapolis, MN 55428
(877) 215-RAIL (7245)



Author: JJJ

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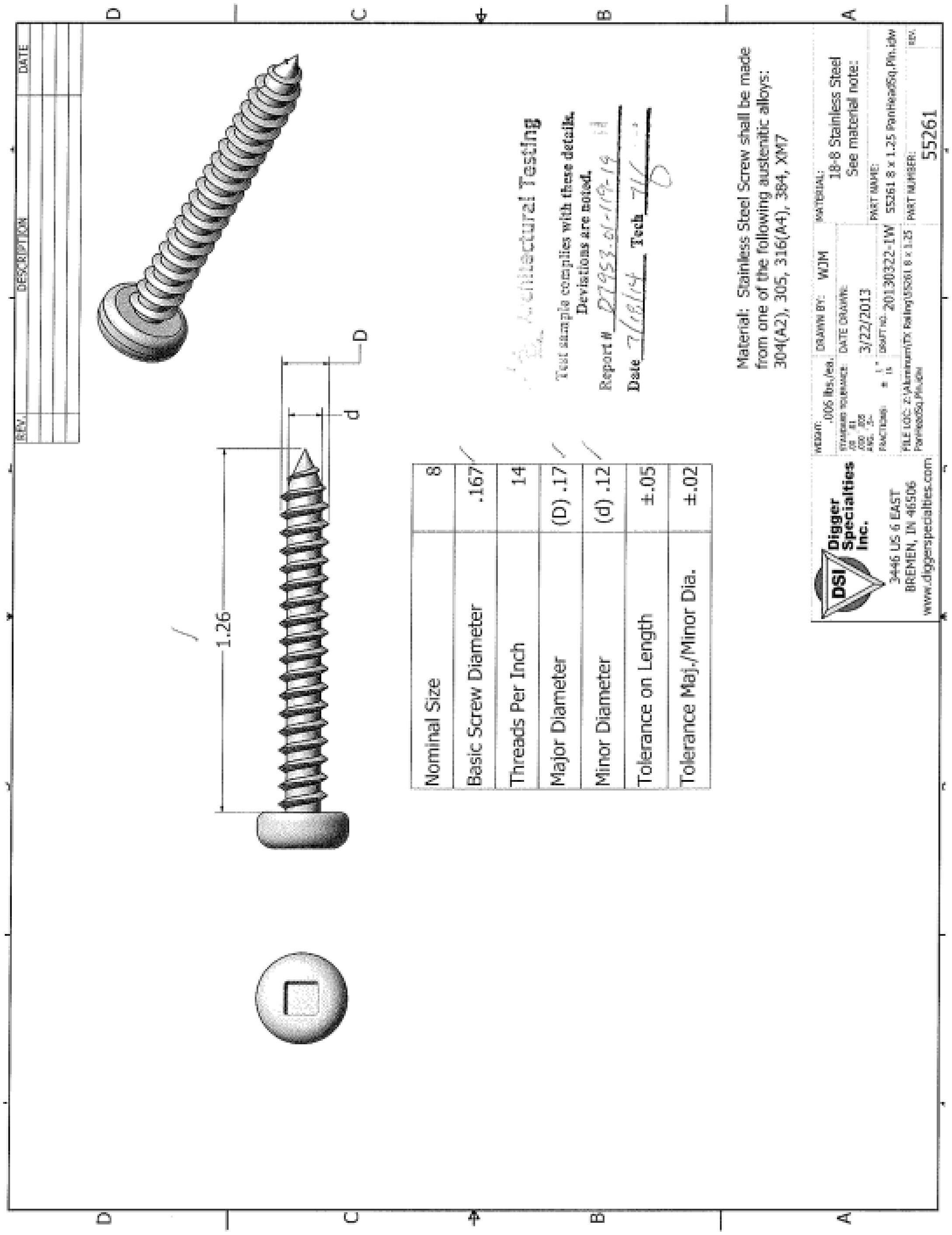

Nominal Size	8
Basic Screw Diameter	.167
Threads Per Inch	14
Major Diameter	(D) .17
Minor Diameter	(d) .12
Tolerance on Length	±.05
Tolerance Maj./Minor Dia.	±.02

Author: JJJ

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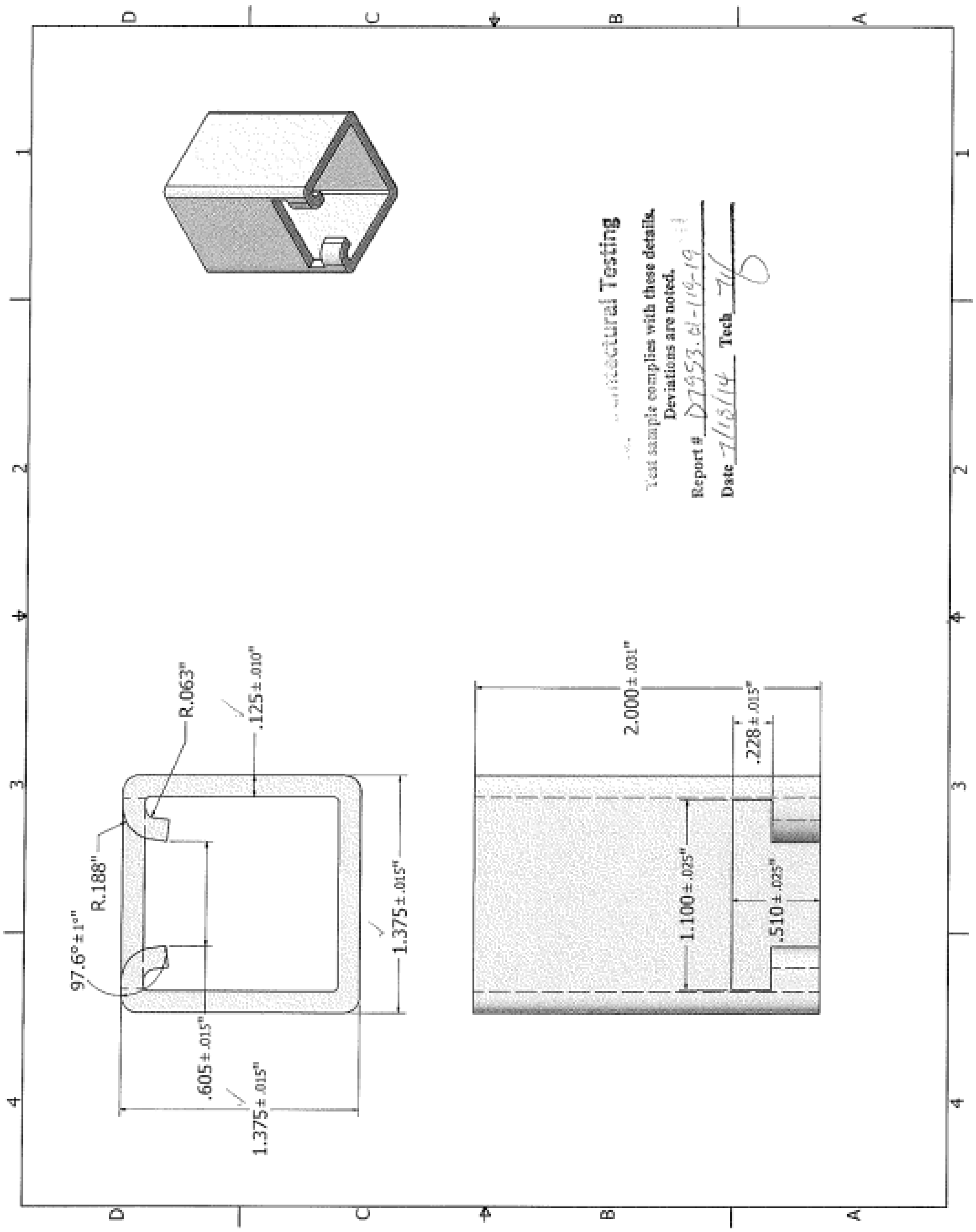

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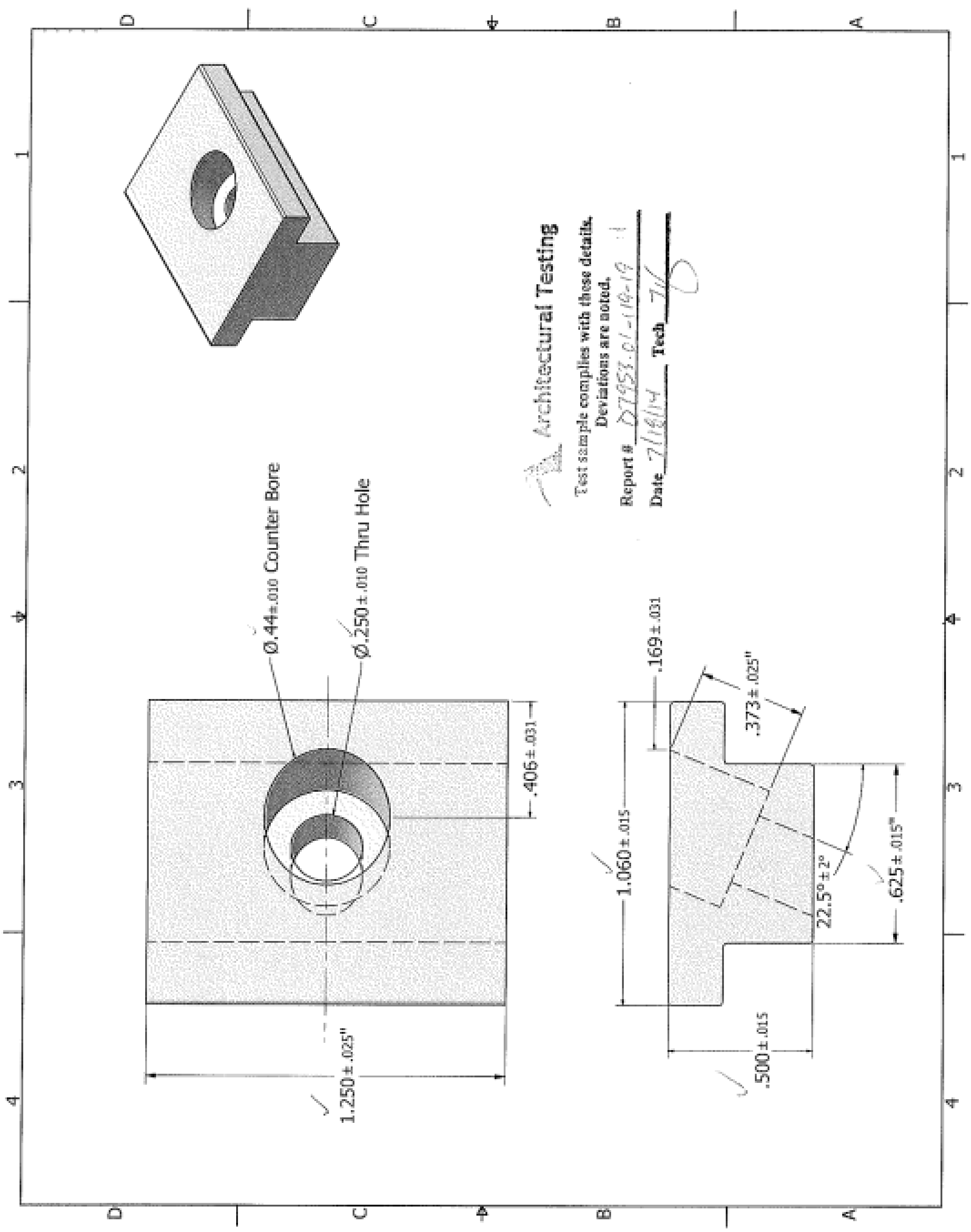

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TREX® REVEAL™ POST

Installation Instructions for Pressure Treated Wood Framing

LOCATION AND INSTALLATION OF POSTS

TREX REVEAL™

IMPORTANT NOTES:

- ***EACH POST MUST BE ATTACHED PER DETAILED DESCRIPTIONS LISTED BELOW TO ENSURE A CODE COMPLIANT AND SAFE INSTALLATION.***
- *ALWAYS REFER TO YOUR LOCAL BUILDING CODE OFFICIAL PRIOR TO INSTALLING ANY RAILING SYSTEM TO ENSURE ALL CODE AND SAFETY REQUIREMENTS ARE MET. TREX® CANNOT BE HELD RESPONSIBLE FOR IMPROPER OR NON-RECOMMENDED INSTALLATIONS.*
- *WHEN INSTALLING REVEAL POSTS ON ACQ OR CCA SURFACES, USE AN APPROPRIATE ISOLATION BARRIER BETWEEN POST AND SURFACE (CONTACT LOCAL BUILDING CODE OFFICIAL IF REQUIRED).*
- *FOR INSTALLING STANDARD REVEAL POST AND/OR REVEAL CROSSOVER POSTS, SEE BELOW.*
- *FOR PRESSURE TREATED POSTS, POST SLEEVES, AND SKIRTS, SEE DETAILED INSTRUCTIONS PROVIDED WITH REVEAL RAILING KITS.*

TOOLS AND MATERIALS NEEDED

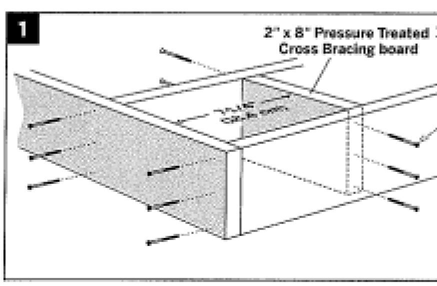
- Drill and/or screw gun
- 1/2" (1.27 cm) drill bit for wood
- Blocking - 2" x 8" (5.1 cm x 20.3 cm) pressure treated Southern Yellow Pine or equivalent
- Qty 36 (per post) - 3" pressure treated compatible wood screws

CODE APPROVED POST APPLICATIONS

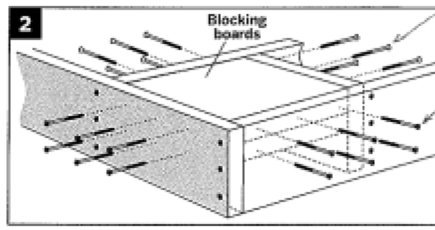
Post size	2" x 2" — 2x2 Post	2.5" x 2.5" — 2.5x2.5 Post
< 30" height decking	Approved	Approved
IRC Approved	Not Approved	Approved
IBC Aprroved	Not Approved	Not Approved

RAILING CONFIGURATIONS

Corner Post Installation

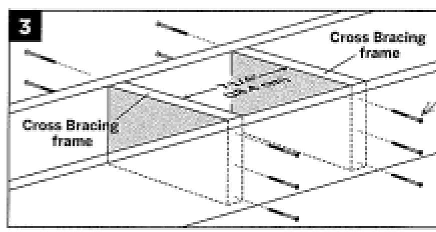


#10x3" 1. Install 2" x 8" (5.1 cm x 20.3 cm) cross bracing frame in between joists at 7 1/4" (18.4 cm). Attach a total of twelve 3" (7.6 cm) pressure treated compatible screws (not provided) as shown in figure 1.



2. Install two 2" x 8" (5.1 cm x 20.3 cm) boards as blocking under post location. Securely attach #10x3" blocking using a total of (24) 3" (7.6 cm) pressure treated compatible screws (not provided) as shown in figure 2.

Line Post Installation



#10x3" 3. Install two 2" x 8" (5.1 cm x 20.3 cm) cross bracing frames in between joists at 7 1/4" (18.4 cm). Attach a total of twelve 3" (7.6 cm) pressure treated compatible screws (not provided) as shown in figure 3.

Architectural Testing
Test sample complies with these details. Deviations are noted.
Report # D7953.01-119-19
Date 7/18/14 Tech

1

Have Questions?
1-800-BUY-TREX

NOTE: *Construction methods are always improving. Please ensure you have the most up-to-date installation instructions by visiting:* **trex.com**

TR-REVEAL-0813

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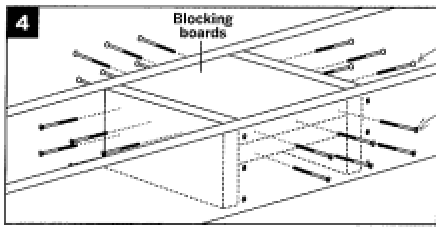
TREX® REVEAL™ POST

Installation Instructions for Pressure Treated Wood Framing

LOCATION AND INSTALLATION OF POSTS/CONTINUED

TREX REVEAL™

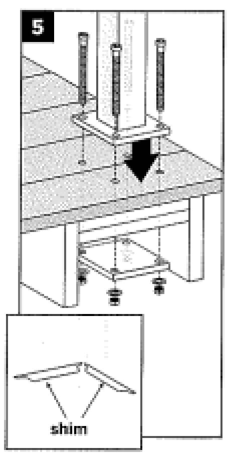


4. Install two 2" x 8" (5.1 cm x 20.3 cm) boards as blocking under post location. Securely attach blocking using a total of 24 3" (7.6 cm) pressure treated compatible screws (not provided) as shown in figure 4.

5. ***NOTE:*** *RIM JOIST REMOVED TO SHOW PROPER ATTACHMENT OF HARDWARE.*

   Level posts if necessary using stainless steel leveling shims (provided). Ensure that post is placed on decking surface so that it clears the rim joist and there is enough clearance on the underside blocking for the back plate to be installed.

   Attach posts using four 3/8" x 6" (0.95 cm x 15.2 cm) stainless steel hex cap bolts, washers, and nuts, along with using metal back plate on underside of blocking. Metal back plate **MUST** be installed under the decking to ensure this will meet code compliance. (Hardware for deck surface mounting can be ordered as separate item from Trex.)



Architectural Testing
Test sample complies with these details.
Deviations are noted.
Report # D7953.01-119-19
Date 7/18/14 Tech

Have Questions?
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APPENDIX B

Photographs

Intertek | Architectural Testing

Photo No. 1
Typical Sampling Mark

Photo No. 2
Uniform Test Load at 45°

Photo No. 3
Concentrated Load Test at Mid-Span of Top Rail

Photo No. 4
Concentrated Load Test at Ends of Top Rail (Brackets)

Photo No. 5
Post Mount Installation in Wood Deck - Wood Deck Underside Detail

Photo No. 6
Concentrated Load Test at Top of Post

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Photo No. 7
Top Rail to Post Mount Connection (Crossover Bracket)