

Attn: Corey Geiger, COO, IronRidge Inc.

Date: November 19th, 2018

Re: Structural Certification for IronRidge *Flat Roof Attachment (FRA)*

This letter addresses the structural capacity of the IronRidge *Flat Roof Attachment (FRA)* for use as a roof attachment for flush or tilt mounted PV solar systems. *FRA* is a deck mounted component directly fastened to and supported by the underlying structural roof deck. *FRA* consists of a circular die-casted aluminum base, an optional membrane flashing, and a centered 3/8" stainless steel connection bolt used to secure compatible rail mounting brackets including the IronRidge Tilt Kit (North and South) and L-Foot. Assembly of *FRA*, chosen rail mounting brackets, and accompanying hardware shall be installed in accordance with IronRidge's Flat Roof Attachment installation manual. Full assembly details are shown in Exhibit-0017.

The stated capacities in this letter apply to the assembly of *FRA* and a particular rail mounting bracket with no consideration of the connection of the assembly to the underlying roof deck or the assembly connection to the above supported rail system. The capacities are based on mechanical load testing using a Universal Instron Test Unit or by using structural design code based analysis. The testing and analytical work conform to the following building codes and design standards:

Mechanical load testing standards:

ASTM B 557-10, Standard Test Method for Tension Testing Wrought and Cast Aluminum and Magnesium-Alloy Products

ASTM A370-13, Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM D1761-12, Standard Test Methods for Mechanical Fasteners in Wood

ICC-428, Acceptance Criteria for Modular framing Systems Used to Support Photovoltaic (PV) Modules

Analytical method standards:

ADM-2015, Aluminum Design Manual

AISC Design Guide 27-2013: Structural Stainless Steel

AISC 360-10, Specification for Structural Steel Buildings

For each load direction reported for the particular *FRA* assembly shown in Figures 1 through 3, the tabulated nominal capacities based on mechanical load testing were the average of peak loads observed in the specified load direction. The witnessed ultimate failure mode was also documented accordingly. The calculated nominal resistances per analysis are defined by the referenced structural code for the most critical failure mode described in the tables below. The safety factor provided is associated with the reported failure mode and used to derive the allowable capacity for the specified load direction.

The recorded test observations along with the analytical results are presented in Tables 1 through 3 for *FRA* South Tilt Kit Assembly, *FRA* North Tilt Kit Assembly, and *FRA* L-Foot Assembly, respectively.

Table 1 IronRidge FRA South Tilt Kit Assembly Allowable Capacities ⁽¹⁾							
Load Direction	Specimen Quantity ⁽²⁾	Nominal Resistance per Load Tests (lbs) ⁽³⁾	Deviation of Test Results ⁽⁴⁾	Nominal Resistance per Analysis (lbs) ⁽⁵⁾	Critical Failure Mode ⁽⁶⁾	Safety Factor ⁽⁷⁾	Allowable Capacity (lbs)
Uplift Load Perpendicular to Roof Surface	5	4722	4%	-	Top angle rupture at the interface where it is bolted to the bottom angle.	1.95	2421
Compression Load Perpendicular to Roof Surface	5	3489	16%	-	Bottom angle rupture along the edge of bolt hole at its base.	1.95	1789
Lateral Load Parallel to Roof Surface Downslope	5	1014	8%	-	Yielding occur to the base of the bottom angle.	1.65	615
Lateral Load Parallel to Roof Surface Across Slope	-	-	-	381	Bottom angle rupture along the edge of bolt hole at its base.	1.95	195

Table 2 IronRidge FRA North Tilt Kit Assembly Allowable Capacities ⁽¹⁾							
Load Direction	Specimen Quantity ⁽²⁾	Nominal Resistance per Load Tests (lbs) ⁽³⁾	Deviation of Test Results ⁽⁴⁾	Nominal Resistance per Analysis (lbs) ⁽⁵⁾	Critical Failure Mode ⁽⁶⁾	Safety Factor ⁽⁷⁾	Allowable Capacity (lbs)
Uplift Load Perpendicular to Roof Surface	5	7160	3%	-	U foot rupture at the bottom along its center line.	1.95	3672
Compression Load Perpendicular to Roof Surface	-	-	-	9120	Bearing failure of the bolt holes on U-Foot vertical legs.	2.0	4560
Lateral Load Parallel to Roof Surface Downslope	5	3007	6%	-	U foot rupture at the bottom along its center line.	1.95	1542

Note to Table 2: The entirety of cross-slope lateral load is taken by South Tilt Kit due to its high lateral stiffness compared to the North Tilt Kit. Please refer to Table 1 for South Kit cross-slope capacity.

Table 3 IronRidge FRA L-Foot Assembly Allowable Capacities ⁽¹⁾							
Load Direction	Specimen Quantity ⁽²⁾	Nominal Resistance per Load Tests (lbs) ⁽³⁾	Deviation of Test Results ⁽⁴⁾	Nominal Resistance per Analysis (lbs) ⁽⁵⁾	Critical Failure Mode ⁽⁶⁾	Safety Factor ⁽⁷⁾	Allowable Capacity (lbs)
Uplift Load Perpendicular to Roof Surface	5	5290	12%	-	Head of the 3/8" bolt, which connect L foot to FRA base, rupture.	2.0	2645
Compression Load Perpendicular to Roof Surface	-	-	-	8407	Vertical leg of L foot rupture at the bottom of the vertical slot.	1.95	4311
Lateral Load Parallel to Roof Surface Downslope	-	-	-	652	Yielding occur to the root of the L foot.	1.65	395
Lateral Load Parallel to Roof Surface Across Slope	5	1579	10%	-	L-Foot rupture at bottom of vertical slot on loaded half of vertical leg.	1.95	810

Notes:

- (1) The allowable capacities presented are associated with the loading conditions for the respective assembly depicted in Figures 1 through 3.
- (2) The quantity recorded represents the number of completed Instron tests and does not apply to the analytical method.
- (3) The nominal resistance is the average of the recorded peak loads for the respective load direction and does not apply to the analytical method.
- (4) Deviation of the test results reflects the highest or the lowest test value from the group mean for the particular load direction and does not apply to the analytical method.
- (5) Nominal resistance is the lowest nominal capacity among the different failure modes. The capacity is calculated following the equations prescribed by the specific structural code as shown on Page 1.
- (6) For the mechanical load testing, the documented critical failure mode is the observed result of the test specimen. For analytical method, the critical failure mode is associated with the condition which produces the least capacity of the assembly.
- (7) Safety Factor is associated with the respective failure modes determined by the specific code as shown on Page 1.

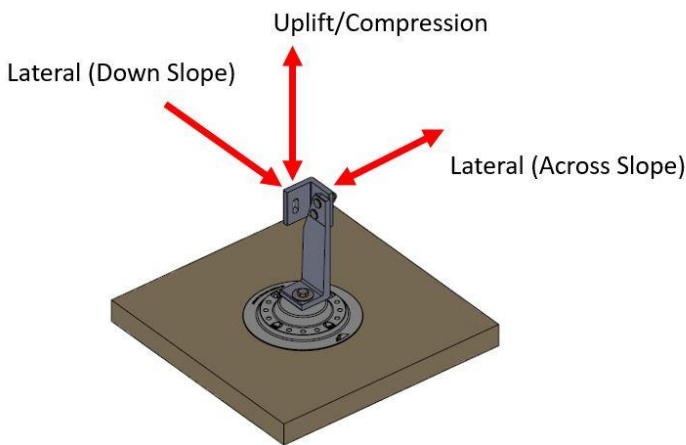


Figure 1: South Tilt Kit

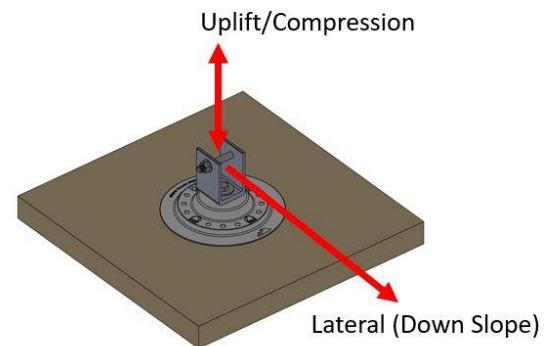


Figure 2: North Tilt Kit

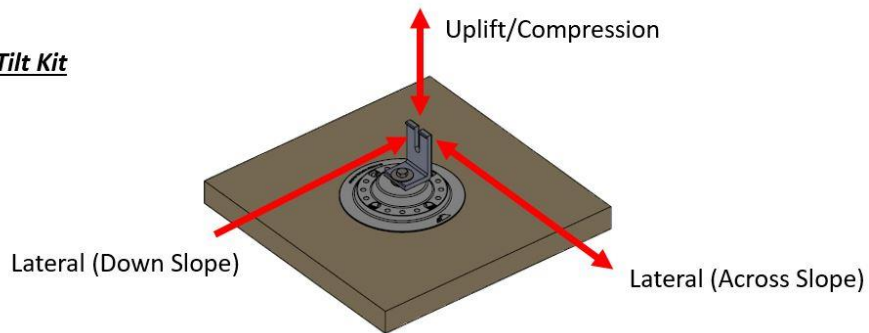
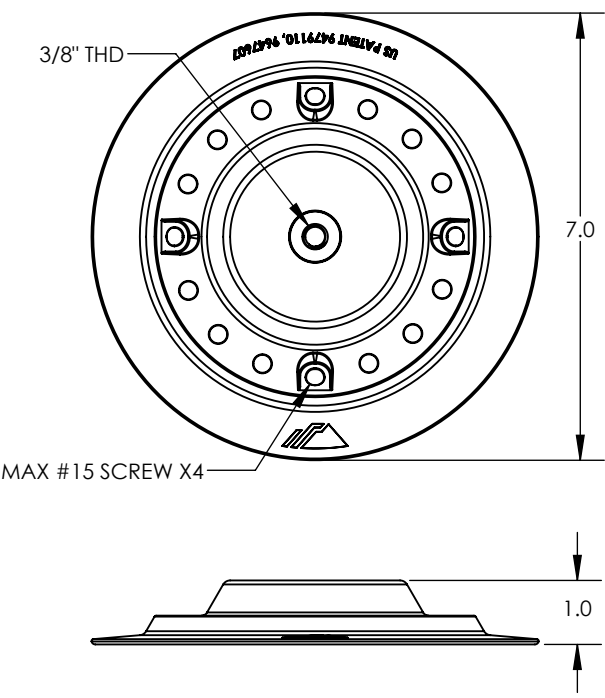
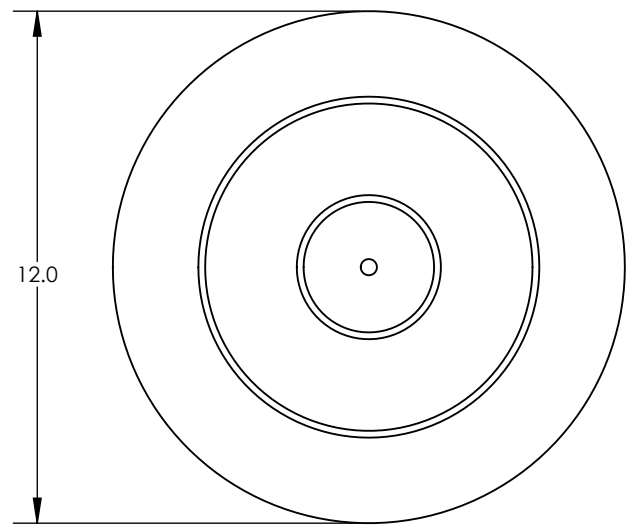
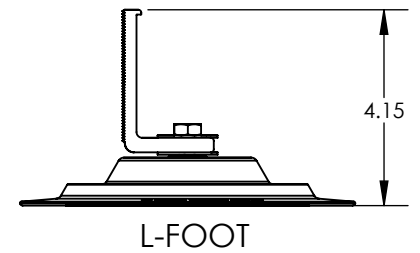
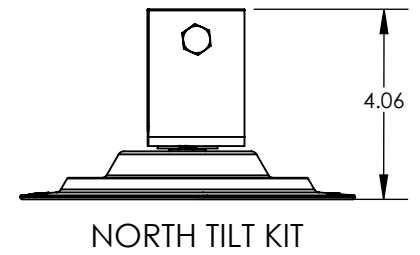
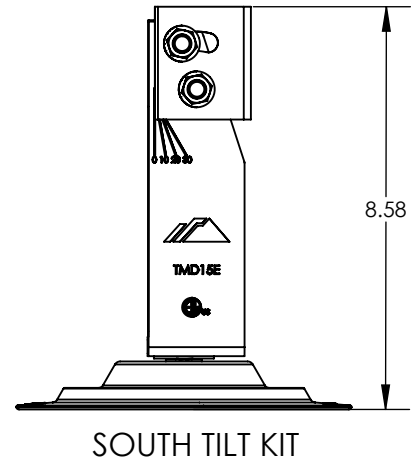
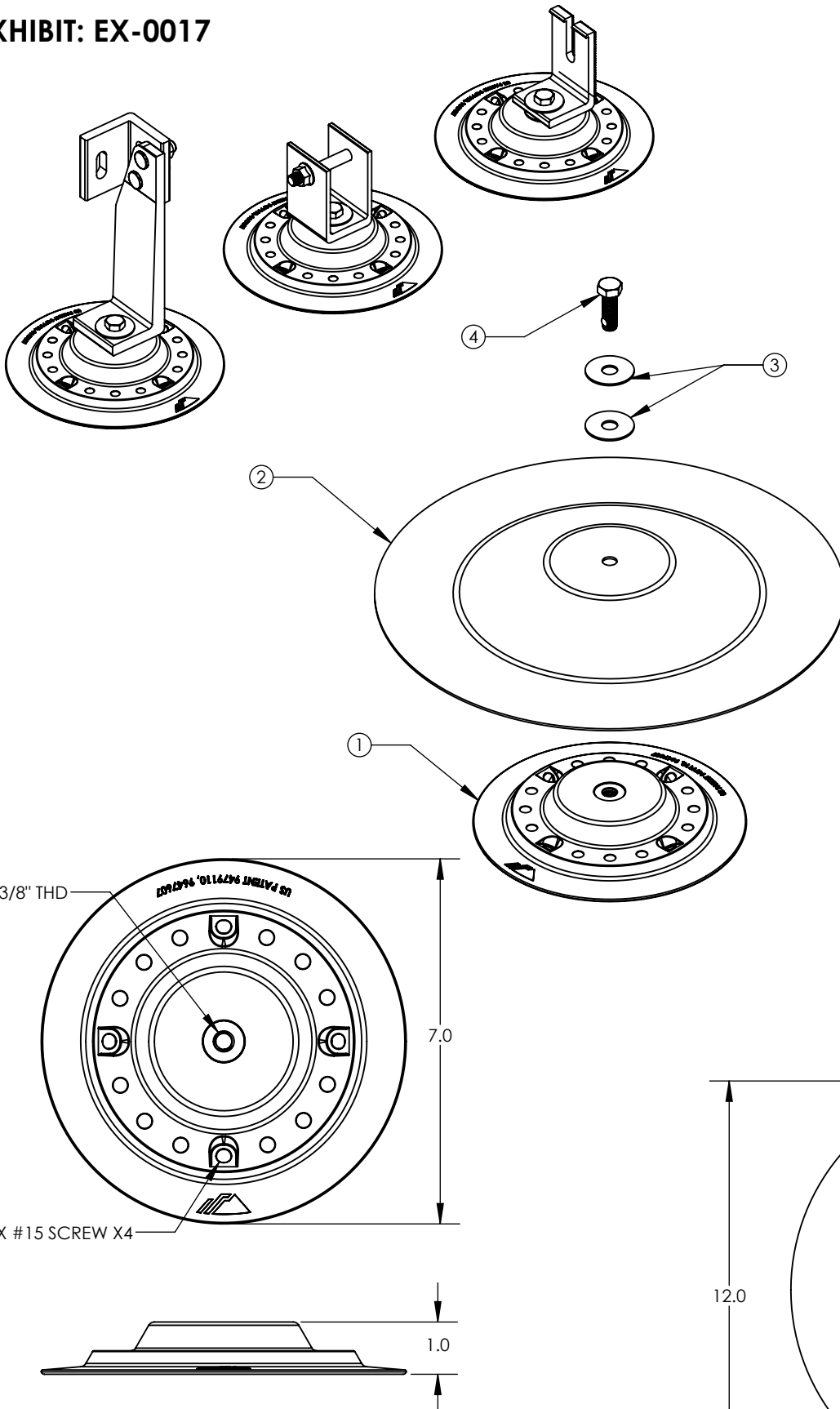


Figure 3: L-Foot

Sincerely,



Gang Xuan, SE
 Senior Structural Engineer



ITEM NO.	DESCRIPTION
1	FLAT ROOF ATTACH, BASE
2	FLAT ROOF ATTACH, MEMBRANE
3	WASHER, FLAT 3/8" X 1.25" OD SS
4	BOLT, 3/8-16 X 1.125" HEX, SS

IRONRIDGE

ASSY, Flat Roof Attachment
DWG. NO. EX-0017