



Starling Madison Lofquist, Inc.
Consulting Structural and Forensic Engineers

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IronRidge
1495 Zephyr Ave
Hayward, CA 94544

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Attn: Mr. David F. Taggart, Vice President Products

Subject: IronRidge XR10 Rail, Roof Flush Mounting System – Structural Analysis

Dear Sir:

We have analyzed the IronRidge XR10 Rail for the subject solar module support system and determined that, for the configurations and criteria described below, it is in compliance with the applicable sections of the following Reference Documents:

Codes: ASCE/SEI 7-10 Min. Design Loads for Buildings & Other Structures

International Building Code 2015 Edition

Other: AC428, Acceptance Criteria for Modular Framing Systems Used to Support PV Modules, dated Effective November 1, 2012 by ICC-ES
Aluminum Design Manual, 2015 Edition

The IronRidge XR10 Rail is an extruded aluminum section with an overall depth of 1.75 in. and a net area of 0.363 sq.in. The rails are used to support solar modules, typically, on the roof of a building. See Exhibit 0010 – attached. The modules are clamped to the rails by the IronRidge Module Mounting Clamps as shown in the attached Exhibit. The rails are attached to aluminum angle brackets that are either attached directly to the roof framing or attached to a stand that is screwed to the roof framing. The rails are mounted across the slope with a small clearance (flush mounting) to the underlying roof structure. The installed solar modules are at the same slope as the underlying roof structure.

All loads are transferred to the roof framing through the angle brackets by simple bi-axial flexure of the rails. The maximum span of the rails is governed by either the mid-span flexural stresses or the deflection requirement that the rail not come into contact with the roof.

The effect of seismic loads (for all design categories A-F) have been determined to be less than the effect due to wind loads in all load conditions and combinations. Therefore, the maximum allowable spans for common load cases are shown in the tables below. Tables 1A-9A are for modules with a maximum long dimension of 67.5 inches and Tables 1B-9B are for modules with a maximum long dimension of 78.5 inches.

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Table 2A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 2 (67.5" Max Module Length)

Exposure	mph	Ground Snow Load									
		0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	73	69	58	54	49	44	40	37	35	33
	105	70	69	58	54	49	44	40	37	35	33
	110	66	66	58	54	49	44	40	37	35	33
	120	61	61	58	54	49	44	40	37	35	33
	130	56	56	56	54	49	44	40	37	35	33
	140	52	52	52	52	49	44	40	37	35	33
	150	48	48	48	48	48	44	40	37	35	33
	160	45	45	45	45	45	44	40	37	35	33
Category C	170	43	43	43	43	43	43	43	40	37	35
	100	62	62	58	54	49	44	40	37	35	33
	105	59	59	58	54	49	44	40	37	35	33
	110	56	56	56	54	49	44	40	37	35	33
	120	51	51	51	51	49	44	40	37	35	33
	130	47	47	47	47	47	44	40	37	35	33
	140	44	44	44	44	44	44	40	37	35	33
	150	41	41	41	41	41	41	40	37	35	33
Category D	160	38	38	38	38	38	38	38	37	35	33
	170	36	36	36	36	36	36	36	36	35	33

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Table 1A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 1 (67.5" Max Module Length)											
Exposure	Wind Speed	Ground Snow Load									
		0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	81	69	58	54	49	44	40	37	35	33
	105	81	69	58	54	49	44	40	37	35	33
	110	81	69	58	54	49	44	40	37	35	33
	120	81	69	58	54	49	44	40	37	35	33
	130	76	69	58	54	49	44	40	37	35	33
	140	70	69	58	54	49	44	40	37	35	33
	150	65	65	58	54	49	44	40	37	35	33
	160	61	61	58	54	49	44	40	37	35	33
Category C	170	57	57	57	54	49	44	40	37	35	33
	100	81	69	58	54	49	44	40	37	35	33
	105	79	69	58	54	49	44	40	37	35	33
	110	76	69	58	54	49	44	40	37	35	33
	120	69	69	58	54	49	44	40	37	35	33
	130	64	64	58	54	49	44	40	37	35	33
	140	59	59	58	54	49	44	40	37	35	33
	150	55	55	55	54	49	44	40	37	35	33
Category D	160	51	51	51	51	49	44	40	37	35	33
	170	48	48	48	48	44	40	37	35	33	33
	100	76	69	58	54	49	44	40	37	35	33
	105	73	69	58	54	49	44	40	37	35	33
	110	69	69	58	54	49	44	40	37	35	33
	120	63	63	58	54	49	44	40	37	35	33
	130	58	58	58	54	49	44	40	37	35	33
	140	54	54	54	54	49	44	40	37	35	33
Category E	150	50	50	50	50	49	44	40	37	35	33
	160	47	47	47	47	44	40	37	35	33	33
	170	44	44	44	44	44	40	37	35	33	33

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Table 4A - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 1 (67.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	75	65	55	49	43	39	35	33	31	29	
	105	75	65	55	49	43	39	35	33	31	29	
	110	75	65	55	49	43	39	35	33	31	29	
	120	75	65	55	49	43	39	35	33	31	29	
	130	75	65	55	49	43	39	35	33	31	29	
	140	71	65	55	49	43	39	35	33	31	29	
	150	66	65	55	49	43	39	35	33	31	29	
	160	62	62	54	48	43	39	35	33	31	29	
Category C	170	59	59	53	47	43	39	35	33	31	29	
	100	75	65	55	49	43	39	35	33	31	29	
	105	75	65	55	49	43	39	35	33	31	29	
	110	75	65	55	49	43	39	35	33	31	29	
	120	70	65	55	49	43	39	35	33	31	29	
	130	65	64	54	48	43	39	35	33	31	29	
	140	60	60	53	48	43	39	35	33	31	29	
	150	56	56	52	47	43	39	35	33	31	29	
Category D	160	53	53	51	46	42	39	35	33	31	29	
	170	50	50	45	41	38	35	33	31	29	29	

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Table 6A - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 3 (67.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	59	59	55	49	43	39	35	33	31	29	
	105	56	56	55	49	43	39	35	33	31	29	
	110	54	54	54	49	43	39	35	33	31	29	
	120	49	49	49	49	43	39	35	33	31	29	
	130	46	46	46	46	43	39	35	33	31	29	
	140	42	42	42	42	42	39	35	33	31	29	
	150	40	40	40	40	40	39	35	33	31	29	
	160	37	37	37	37	37	37	35	33	31	29	
Category C	170	35	35	35	35	35	35	35	33	31	29	
	100	50	50	50	49	43	39	35	33	31	29	
	105	48	48	48	48	43	39	35	33	31	29	
	110	45	45	45	45	43	39	35	33	31	29	
	120	42	42	42	42	42	39	35	33	31	29	
	130	39	39	39	39	39	39	35	33	31	29	
	140	36	36	36	36	36	36	36	33	31	29	
	150	33	33	33	33	33	33	33	33	31	29	
Category D	160	31	31	31	31	31	31	31	31	31	29	
	170	29	29	29	29	29	29	29	29	29	29	

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Table 5A - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 2 (67.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	72	65	55	49	43	39	35	33	31	29	
	105	69	65	55	49	43	39	35	33	31	29	
	110	66	65	55	49	43	39	35	33	31	29	
	120	60	60	55	49	43	39	35	33	31	29	
	130	56	56	55	49	43	39	35	33	31	29	
	140	52	52	52	49	43	39	35	33	31	29	
	150	49	49	49	49	43	39	35	33	31	29	
	160	46	46	46	46	43	39	35	33	31	29	
Category C	170	43	43	43	43	43	39	35	33	31	29	
	100	61	61	55	49	43	39	35	33	31	29	
	105	58	58	55	49	43	39	35	33	31	29	
	110	56	56	55	49	43	39	35	33	31		

Table 8A - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 2 (67.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	72	66	57	51	45	41	38	35	33	31	
	105	72	66	57	51	45	41	38	35	33	31	
	110	71	65	57	50	45	41	38	35	33	31	
	120	67	63	55	49	45	41	38	35	33	31	
	130	64	61	54	48	44	41	38	35	33	31	
	140	60	59	52	47	43	40	38	35	33	31	
	150	56	56	51	46	43	40	37	35	33	31	
	160	53	53	49	45	42	39	37	35	33	31	
Category C	170	50	50	48	44	41	38	36	34	33	31	31
	100	68	63	55	50	45	41	38	35	33	31	
	105	66	62	54	49	45	41	38	35	33	31	
	110	64	61	54	48	44	41	38	35	33	31	
	120	59	58	52	47	43	40	38	35	33	31	
	130	55	55	50	46	42	39	37	35	33	31	
	140	51	51	48	44	41	39	36	35	33	31	
	150	48	48	47	43	40	38	36	34	33	31	
Category D	160	45	45	45	42	39	37	35	33	32	31	
	170	43	43	43	41	38	36	34	33	31	30	
	100	64	61	54	48	44	41	38	35	33	31	
	105	62	60	53	48	44	41	38	35	33	31	
	110	59	58	52	47	43	40	38	35	33	31	
	120	55	55	50	46	42	39	37	35	33	31	
	130	51	51	48	44	41	39	36	35	33	31	
	140	47	47	46	43	40	38	36	34	32	31	
Category D	150	44	44	44	41	39	37	35	33	32	31	
	160	42	42	42	40	38	36	34	33	31	30	
	170	39	39	39	39	37	35	33	32	31	29	

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Table 1B - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 1 (78.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	75	64	54	50	45	41	37	35	32	31	
	105	75	64	54	50	45	41	37	35	32	31	
	110	75	64	54	50	45	41	37	35	32	31	
	120	75	64	54	50	45	41	37	35	32	31	
	130	71	64	54	50	45	41	37	35	32	31	
	140	65	64	54	50	45	41	37	35	32	31	
	150	61	61	54	50	45	41	37	35	32	31	
	160	57	57	54	50	45	41	37	35	32	31	
Category C	170	54	54	54	50	45	41	37	35	32	31	
	100	75	64	54	50	45	41	37	35	32	31	
	105	74	64	54	50	45	41	37	35	32	31	
	110	71	64	54	50	45	41	37	35	32	31	
	120	64	64	54	50	45	41	37	35	32	31	
	130	59	59	54	50	45	41	37	35	32	31	
	140	55	55	54	50	45	41	37	35	32	31	
	150	51	51	51	50	45	41	37	35	32	31	
Category D	160	48	48	48	48	48	48	45	41	37	35	31
	170	45	45	45	45	45	45	41	41	37	35	31

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Table 9A - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 3 (67.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	72	66	57	51	45	41	38	35	33	31	
	105	72	66	57	51	45	41	38	35	33	31	
	110	71	65	57	50	45	41	38</td				

Table 3B - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 3 (78.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	54	54	54	50	45	41	37	35	32	31	
	105	52	52	52	50	45	41	37	35	32	31	
	110	49	49	49	49	45	41	37	35	32	31	
	120	45	45	45	45	45	41	37	35	32	31	
	130	42	42	42	42	42	41	37	35	32	31	
	140	39	39	39	39	39	39	37	35	32	31	
	150	36	36	36	36	36	36	36	35	32	31	
	160	34	34	34	34	34	34	34	34	32	31	
	170	32	32	32	32	32	32	32	32	32	31	
Category C	100	46	46	46	46	45	41	37	35	32	31	
	105	44	44	44	44	44	41	37	35	32	31	
	110	42	42	42	42	42	41	37	35	32	31	
	120	38	38	38	38	38	38	37	35	32	31	
	130	35	35	35	35	35	35	35	35	32	31	
	140	32	32	32	32	32	32	32	32	32	31	
	150	30	30	30	30	30	30	30	30	30	30	
	160	28	28	28	28	28	28	28	28	28	28	
	170*	26	26	26	26	26	26	26	26	26	26	
Category D	100	42	42	42	42	42	41	37	35	32	31	
	105	40	40	40	40	40	40	37	35	32	31	
	110	38	38	38	38	38	38	37	35	32	31	
	120	35	35	35	35	35	35	35	35	32	31	
	130	32	32	32	32	32	32	32	32	32	31	
	140	30	30	30	30	30	30	30	30	30	30	
	150*	28	28	28	28	28	28	28	28	28	28	
	160*	26	26	26	26	26	26	26	26	26	26	
	170*	24	24	24	24	24	24	24	24	24	24	

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Table 5B - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 2 (78.5" Max Module Length)												
XR10 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	67	61	51	45	40	36	33	30	29	27	
	105	64	61	51	45	40	36	33	30	29	27	
	110	61	61	51	45	40	36	33	30	29	27	
	120	56	56	51	45	40	36	33	30	29	27	
	130	52	52	51	45	40	36	33	30	29	27	
	140	49	49	49	45	40	36	33	30	29	27	
	150	45	45	45	45	40	36	33	30	29	27	
	160	43	43	43	43	40	36	33	30	29	27	
	170	40	40	40	40	40	36	33	30	29	27	
Category C	100	57	57	51	45	40	36	33	30	29	27	
	105	55	55	51	45	40	36	33	30	29	27	
	110	52	52	51	45	40	36	33	30	29	27	
	120	48	48	48	45	40	36	33	30	29	27	
	130	44	44	44	44	40	36	33	30	29	27	
	140	41	41	41	41	40	36	33	30	29	27	
	150	38	38	38	38	38	36	33	30	29	27	
	160	36	36	36	36	36	36	33	30	29	27	
	170	34	34	34	34	34	34	33	30	29	27	
Category D	100	53	53	51	45	40	36	33	30	29	27	
	105	50	50	50	45	40	36	33	30	29	27	
	110	48	48	48	45	40	36	33	30	29	27	
	120	44	44	44	44	40	36	33	30	29	27	
	130	41	41	41	41	40	36	33	30	29	27	
	140	38	38	38	38	38	36	33	30	29	27	
	150	35	35	35	35	35	35	33	30	29	27	
	160	33	33	33	33	33	33	33	30	29	27	
	170	31	31	31	31	31	31	31	30	29	27	

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Table 4B - MAXIMUM SPANS (in) - Roof Slope 7
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Table 7B - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 1 (78.5" Max Module Length)											
XR10 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	67	61	53	47	42	38	35	33	31	29
	105	67	61	53	47	42	38	35	33	31	29
	110	66	61	52	47	42	38	35	33	31	29
	120	62	59	51	46	42	38	35	33	31	29
	130	59	57	50	45	41	38	35	33	31	29
	140	56	55	48	44	40	38	35	33	31	29
	150	54	53	47	43	40	37	35	33	31	29
	160	51	51	46	42	39	36	34	32	31	29
Category C	170	49	49	44	41	38	36	34	32	31	29
	100	63	59	51	46	42	38	35	33	31	29
	105	61	58	51	45	42	38	35	33	31	29
	110	59	56	50	45	41	38	35	33	31	29
	120	56	54	48	44	40	37	35	33	31	29
	130	53	52	46	42	39	37	35	33	31	29
	140	50	50	45	41	38	36	34	32	31	29
	150	47	47	43	40	37	35	33	32	30	29
Category D	160	45	45	42	39	36	34	33	31	30	28
	170	42	42	40	38	35	34	32	30	29	28
	100	60	57	50	45	41	38	35	33	31	29
	105	58	55	49	44	41	38	35	33	31	29
	110	56	54	48	44	40	37	35	33	31	29
	120	52	52	46	42	39	37	35	33	31	29
	130	49	49	45	41	38	36	34	32	31	29
	140	46	46	43	40	37	35	33	31	30	29
Category E	150	44	44	41	38	36	34	32	31	30	28
	160	42	42	40	37	35	33	32	30	29	28
	170	39	39	38	36	34	32	31	30	28	27

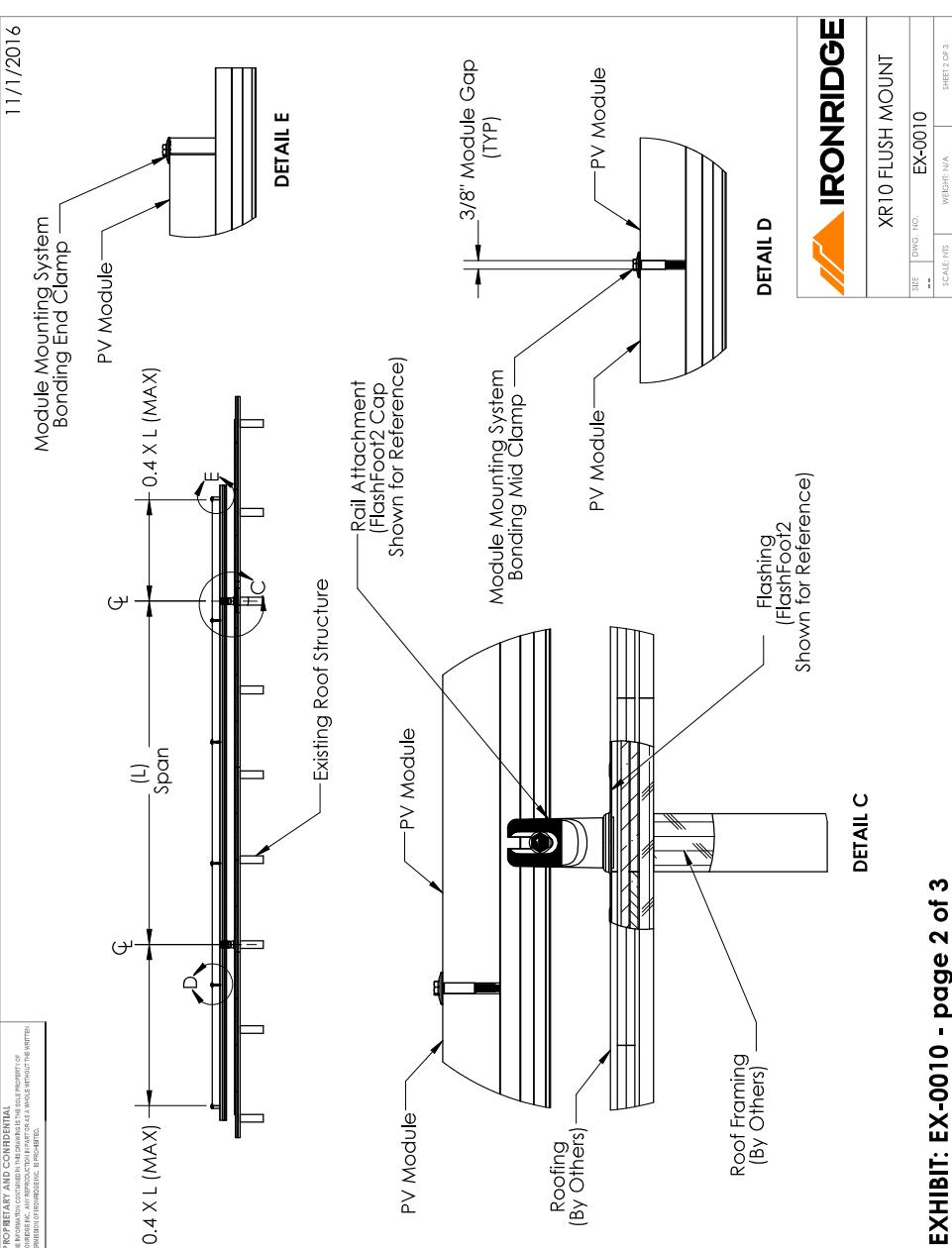
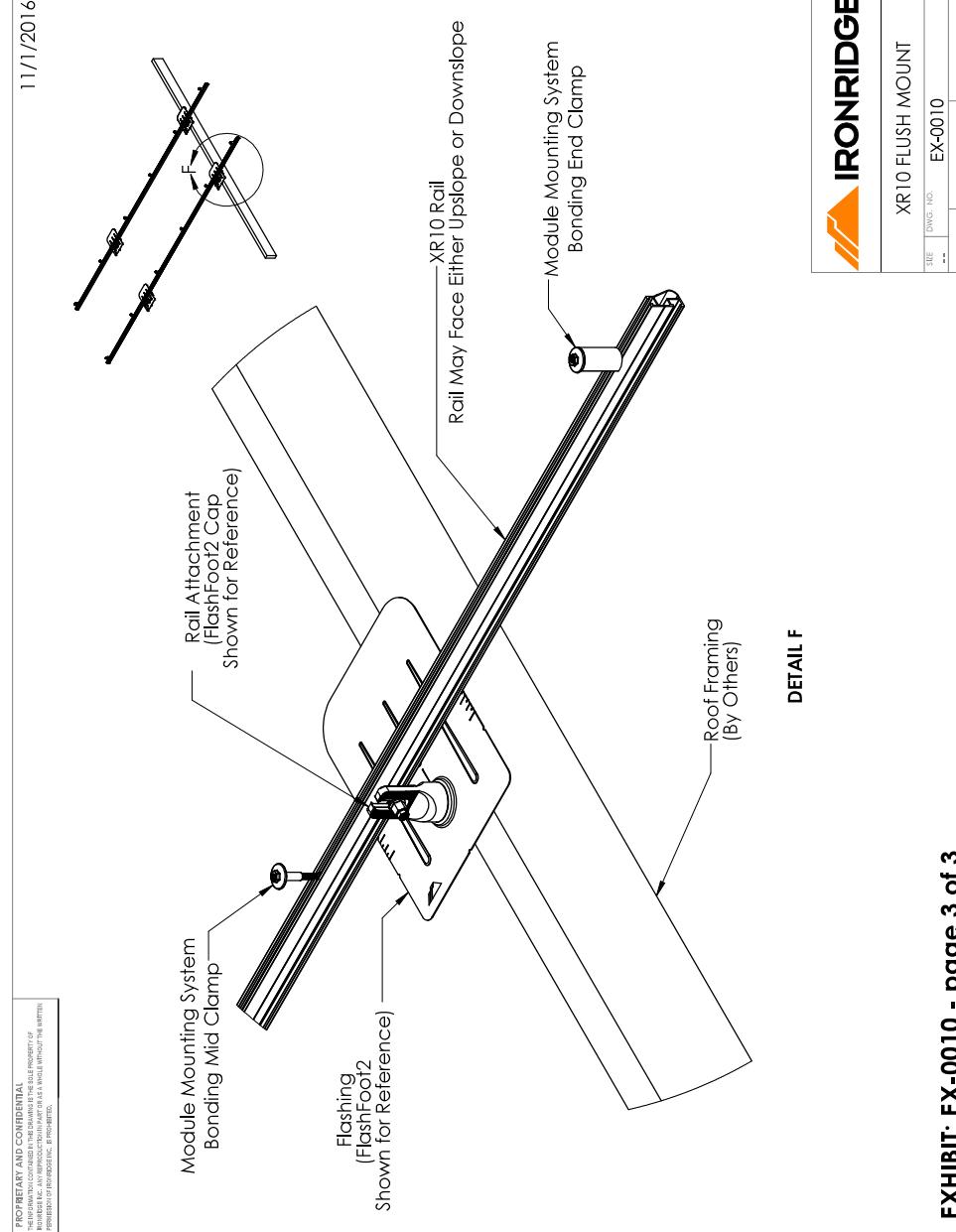
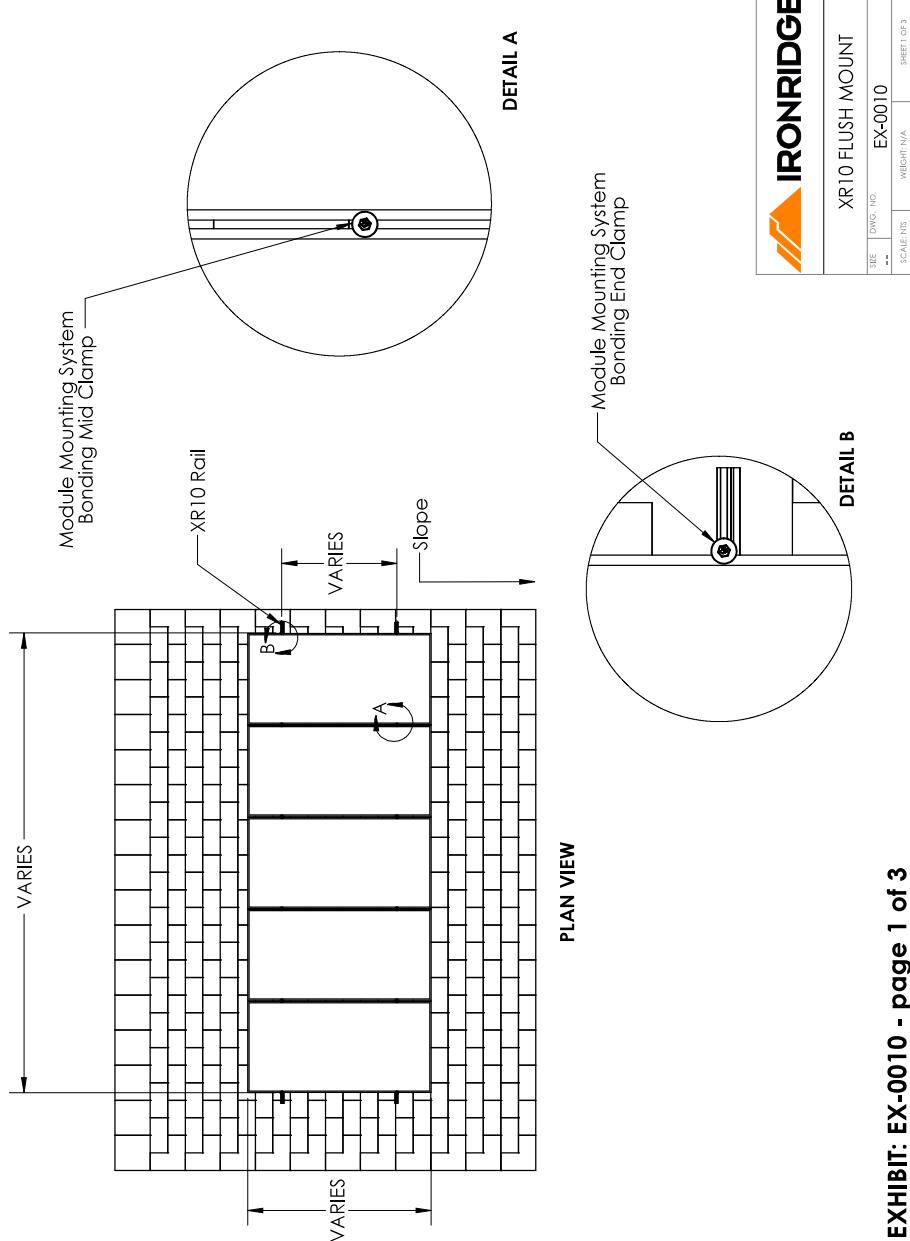
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Table 9B - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 3 (78.5" Max Module Length)											
XR10 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	67	61	53	47	42	38	35	33	31	29
	105	67	61	53	47	42	38	35	33	31	29
	110	66	61	52	47	42	38	35	33	31	29
	120	62	59	51	46	42	38	35	33	31	29
	130	59	57	50	45	41	38	35	33	31	29
	140	56	55	48	44	40	38	35	33	31	29
	150	54	53	47	43	40	37	35	33	31	29
	160	51	51	46	42	39	37	35	33	31	29
Category C	170	47	47	44	41	38	36	34	32	31	29
	100	63	59	51	46	42	38	35	33	31	29
	105	61	58	51	45	42	38	35	33	31	29
	110	59	56	50	45	41	38	35	33	31	29
	120	55	54	48	44	40	37	35	33	31	29
	130	51	51	46	42	39	37	35	33	31	29
	140	48	48	45	41	38	36	34	32	31	29
	150	45	45	43	40	37	35	33	32	30	29
Category D	160	42	42	40	37	35	33	32	30	29	28
	170	37	37	37	36	34	32	31	30	28	27

Notes – see page 20

Table 8B - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 2 (78.5" Max Module Length)											
XR10 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	67	61	53	47	42	38	35	33	31	29
	105	67	61	53	47	42	38	35	33	31	29
	110	66	61	52	47	42	38	35	33	31	29
	120	62	59	51	46	42	38	35	33	31	29
	130	59	57	50	45	41	38	35	33	31	29
	140	56	55	48	44</td						

11/1/2016

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1495 Zephyr Ave
Hayward, CA 94544February 17, 2017
Page 1 of 20

Attn: Mr. David F. Taggart, Vice President Products

Subject: IronRidge XR100 Rail, Roof Flush Mounting System – Structural Analysis

Dear Sir:

We have analyzed the IronRidge XR100 Rail for the subject solar module support system and determined that, for the configurations and criteria described below, it is in compliance with the applicable sections of the following Reference Documents:

Codes: ASCE/SEI 7-10 Min. Design Loads for Buildings & Other Structures
International Building Code 2015 Edition

Other: AC428, Acceptance Criteria for Modular Framing Systems Used to Support PV Modules, dated Effective November 1, 2012 by ICC-ES
Aluminum Design Manual, 2015 Edition

The IronRidge XR100 Rail is an extruded aluminum section with an overall depth of 2.438 in. and a net area of 0.583 sq.in. The rails are used to support solar modules, typically, on the roof of a building. See Exhibit 0011- attached. The modules are clamped to the rails by the IronRidge Module Mounting Clamps as shown in the attached Exhibit. The rails are attached to aluminum angle brackets that are either attached directly to the roof framing or attached to a stand that is screwed to the roof framing. The rails are mounted across the slope with a small clearance (flush mounting) to the underlying roof structure. The installed solar modules are at the same slope as the underlying roof structure.

All loads are transferred to the roof framing through the angle brackets by simple bi-axial flexure of the rails. The maximum span of the rails is governed by either the mid-span flexural stresses or the deflection requirement that the rail not come into contact with the roof.

The effect of seismic loads (for all design categories A-F) have been determined to be less than the effect due to wind loads in all load conditions and combinations. Therefore, the maximum allowable spans for common load cases are shown in the tables below. Tables 1A-9A are for modules with a maximum long dimension of 67.5 inches and Tables 1B-9B are for modules with a maximum long dimension of 78.5 inches.

Table 1A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 1 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	122	104	88	82	73	66	61	56	53	50	
	105	122	104	88	82	73	66	61	56	53	50	
	110	122	104	88	82	73	66	61	56	53	50	
	120	122	104	88	82	73	66	61	56	53	50	
	130	112	104	88	82	73	66	61	56	53	50	
	140	104	104	88	82	73	66	61	56	53	50	
	150	97	97	88	82	73	66	61	56	53	50	
	160	91	91	88	82	73	66	61	56	53	50	
	170	85	85	85	82	73	66	61	56	53	50	
Category C	100	122	104	88	82	73	66	61	56	53	50	
	105	117	104	88	82	73	66	61	56	53	50	
	110	112	104	88	82	73	66	61	56	53	50	
	120	102	102	88	82	73	66	61	56	53	50	
	130	94	94	88	82	73	66	61	56	53	50	
	140	88	88	88	82	73	66	61	56	53	50	
	150	82	82	82	82	73	66	61	56	53	50	
	160	77	77	77	77	73	66	61	56	53	50	
	170	72	72	72	72	72	66	61	56	53	50	
Category D	100	113	104	88	82	73	66	61	56	53	50	
	105	108	104	88	82	73	66	61	56	53	50	
	110	103	103	88	82	73	66	61	56	53	50	
	120	94	94	88	82	73	66	61	56	53	50	
	130	87	87	87	82	73	66	61	56	53	50	
	140	80	80	80	80	73	66	61	56	53	50	
	150	75	75	75	75	73	66	61	56	53	50	
	160	70	70	70	70	70	66	61	56	53	50	
	170	66	66	66	66	66	61	56	53	50		

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Table 3A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 3 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	87	87	87	82	73	66	61	56	53	50	
	105	83	83	83	82	73	66	61	56	53	50	
	110	79	79	79	79	73	66	61	56	53	50	
	120	72	72	72	72	72	66	61	56	53	50	
	130	67	67	67	67	67	66	61	56	53	50	
	140	62	62	62	62	62	62	61	56	53	50	
	150	58	58	58	58	58	58	58	56	53	50	
	160	54	54	54	54	54	54	54	54	53	50	
	170	51	51	51	51	51	51	51	51	51	50	
Category C	100	73	73	73	73	73	73	66	61	56	53	50
	105	70	70	70	70	70	70	66	61	56	53	50
	110	67	67	67	67	67	67	66	61	56	53	50
	120	61	61	61	61	61	61	61	61	56	53	50
	130	56	56	56	56	56	56	56	56	53	50	
	140	52	52	52	52	52	52	52	52	52	50	
	150	49	49	49	49	49	49	49	49	49	49	
	160	46	46	46	46	46	46	46	46	46	46	
	170	43	43	43	43	43	43	43	43	43	43	
Category D	100	67	67	67	67	67	67	66	61	56	53	50
	105	64	64	64	64	64	64	64	61	56	53	50
	110	61	61	61	61	61	61	61	61	56	53	50
	120	56	56	56	56	56	56	56	56	53	50	
	130	52	52	52	52	52	52	52	52	52	50	
	140	48	48	48	48	48	48	48	48	48	48	
	150	45	45	45	45	45	45	45	45	45	45	
	160	42	42	42	42	42	42	42	42	42	42	
	170	40	40	40	40	40	40	40	40	40	40	

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Table 2A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 2 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	

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Table 5A - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 2 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	106	97	83	72	64	58	53	49	46	43	
	105	102	97	83	72	64	58	53	49	46	43	
	110	97	97	83	72	64	58	53	49	46	43	
	120	90	90	83	72	64	58	53	49	46	43	
	130	83	83	83	72	64	58	53	49	46	43	
	140	77	77	77	72	64	58	53	49	46	43	
	150	73	73	73	72	64	58	53	49	46	43	
	160	68	68	68	68	64	58	53	49	46	43	
	170	64	64	64	64	64	58	53	49	46	43	
Category C	100	91	91	83	72	64	58	53	49	46	43	
	105	87	87	83	72	64	58	53	49	46	43	
	110	83	83	83	72	64	58	53	49	46	43	
	120	76	76	76	72	64	58	53	49	46	43	
	130	71	71	71	71	64	58	53	49	46	43	
	140	66	66	66	66	64	58	53	49	46	43	
	150	62	62	62	62	62	58	53	49	46	43	
	160	58	58	58	58	58	53	49	46	43		
	170	55	55	55	55	55	53	49	46	43		
Category D	100	84	84	83	72	64	58	53	49	46	43	
	105	80	80	80	72	64	58	53	49	46	43	
	110	77	77	77	72	64	58	53	49	46	43	
	120	70	70	70	70	64	58	53	49	46	43	
	130	65	65	65	65	64	58	53	49	46	43	
	140	61	61	61	61	61	58	53	49	46	43	
	150	57	57	57	57	57	53	49	46	43		
	160	53	53	53	53	53	53	53	49	46	43	
	170	50	50	50	50	50	50	49	46	43		

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Table 7A - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 1 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	107	98	84	75	67	61	56	52	49	46	
	105	107	98	84	75	67	61	56	52	49	46	
	110	106	97	84	75	67	61	56	52	49	46	
	120	101	94	82	74	67	61	56	52	49	46	
	130	96	91	80	72	66	61	56	52	49	46	
	140	91	88	78	70	65	60	56	52	49	46	
	150	87	85	76	69	64	59	56	52	49	46	
	160	83	82	74	67	62	58	55	52	49	46	
	170	79	79	72	66	61	57	54	51	49	46	
Category C	100	101	94	82	74	67	61	56	52	49	46	
	105	98	93	81	73	67	61	56	52	49	46	
	110	95	91	80	72	66	61	56	52	49	46	
	120	90	87	77	70	65	60	56	52	49	46	
	130	85	84	75	68	63	59	56	52	49	46	
	140	81	80	72	66	62	58	55	52	49	46	
	150	76	76	70	65	60	57	53	51	49	46	
	160	73	73	68	63	59	55	52	50	48	46	
	170	69	69	66	61	57	54	51	49	47	45	
Category D	100	96	91	80	72	66	61	56	52	49	46	
	105	93	89	79	71	65	61	56	52	49	46	
	110	90	87	77	70	65	60	56	52	49	46	
	120	85	83	75	68	63	59	55	52	49	46	
	130	80	80	72	66	61	58	54	52	49	46	
	140	75	75	70	64	60	56	53	51	48	46	
	150	71	71	67	62	58	55	52	50	48	46	
	160	68	68	65	60	57	54	51	49	47	45	
	170	64	64	62	58	55	52	50	48	46	44	

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Table 6A - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 3 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 ps		

Table 9A - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 3 (67.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	107	98	84	75	67	61	56	52	49	46	
	105	107	98	84	75	67	61	56	52	49	46	
	110	106	97	84	75	67	61	56	52	49	46	
	120	101	94	82	74	67	61	56	52	49	46	
	130	94	91	80	72	66	61	56	52	49	46	
	140	88	88	78	70	65	60	56	52	49	46	
	150	83	83	76	69	64	59	56	52	49	46	
	160	78	78	74	67	62	58	55	52	49	46	
	170	74	74	72	66	61	57	54	51	49	46	
Category C	100	101	94	82	74	67	61	56	52	49	46	
	105	98	93	81	73	67	61	56	52	49	46	
	110	94	91	80	72	66	61	56	52	49	46	
	120	87	87	77	70	65	60	56	52	49	46	
	130	81	81	75	68	63	59	56	52	49	46	
	140	76	76	72	66	62	58	55	52	49	46	
	150	71	71	70	65	60	57	53	51	49	46	
	160	67	67	67	63	59	55	52	50	48	46	
	170	64	64	64	61	57	54	51	49	47	45	
Category D	100	95	91	80	72	66	61	56	52	49	46	
	105	91	89	79	71	65	61	56	52	49	46	
	110	87	87	77	70	65	60	56	52	49	46	
	120	81	81	75	68	63	59	55	52	49	46	
	130	75	75	72	66	61	58	54	52	49	46	
	140	70	70	70	64	60	56	53	51	48	46	
	150	66	66	66	62	58	55	52	50	48	46	
	160	62	62	62	60	57	54	51	49	47	45	
	170	59	59	59	58	55	52	50	48	46	44	

Notes – see page 20

Table 2B - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 2 (78.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	101	97	82	74	67	61	56	52	49	46	
	105	96	96	84	75	67	61	56	52	49	46	
	110	92	92	82	75	68	61	56	52	49	46	
	120	84	84	72	72	68	61	56	52	49	46	
	130	78	78	78	76	68	61	56	52	49	46	
	140	72	72	72	72	68	61	56	52	49	46	
	150	67	67	67	67	67	61	56	52	49	46	
	160	63	63	63	63	63	61	56	52	49	46	
	170	59	59	59	59	59	59	56	52	49	46	
Category C	100	85	85	82	76	68	61	56	52	49	46	
	105	81	81	81	76	68	61	56	52	49	46	
	110	77	77	77	76	68	61	56	52	49	46	
	120	71	71	71	71	68	61	56	52	49	46	
	130	66	66	66	66	66	61	56	52	49	46	
	140	61	61	61	61	61	61	56	52	49	46	
	150	57	57	57	57	57	57	56	52	49	46	
	160	53	53	53	53	53	53	52	52	49	46	
	170	50	50	50	50	50	50	50	50	49	46	
Category D	100	78	78	78	76	68	61	56	52	49	46	
	105	75	75	75	75	68	61	56	52	49	46	
	110	71	71	71	71	68	61	56	52	49	46	
	120	65	65	65	65	65	61	56	52	49	46	
	130	60	60	60	60	60	60	56	52	49	46	
	140	56	56	56	56	56	56	56	52	49	46	
	150	52	52	52	52	52	52	52	52	49	46	
	160	49	49	49	49	49	49	49	49	49	46	
	170	46	46	46	46	46	46	46	46	46	46	

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Table 1B -

Table 4B - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 1 (78.5" Max Module Length)

XR100 Rail	Wind Speed	Ground Snow Load										
		0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Exposure	mph	100	105	91	77	67	59	54	49	46	43	40
Category B	105	105	91	77	67	59	54	49	46	43	40	
	110	105	91	77	67	59	54	49	46	43	40	
	120	105	91	77	67	59	54	49	46	43	40	
	130	105	91	77	67	59	54	49	46	43	40	
	140	98	91	77	67	59	54	49	46	43	40	
	150	91	89	76	67	59	54	49	46	43	40	
	160	86	86	75	67	59	54	49	46	43	40	
	170	81	81	74	66	59	54	49	46	43	40	
Category C	100	105	91	77	67	59	54	49	46	43	40	
	105	105	91	77	67	59	54	49	46	43	40	
	110	104	91	77	67	59	54	49	46	43	40	
	120	96	91	77	67	59	54	49	46	43	40	
	130	89	89	76	67	59	54	49	46	43	40	
	140	83	83	74	66	59	54	49	46	43	40	
	150	78	78	73	65	59	54	49	46	43	40	
	160	73	73	71	64	58	54	49	46	43	40	
Category D	170	69	69	69	62	57	53	49	46	43	40	
	100	105	91	77	67	59	54	49	46	43	40	
	105	101	91	77	67	59	54	49	46	43	40	
	110	97	91	77	67	59	54	49	46	43	40	
	120	89	88	76	67	59	54	49	46	43	40	
	130	82	82	74	66	59	54	49	46	43	40	
	140	77	77	72	65	59	54	49	46	43	40	
	150	72	72	70	63	58	54	49	46	43	40	
Category E	160	68	68	68	62	57	53	49	46	43	40	
	170	64	64	64	61	56	52	49	46	43	40	

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Table 6B - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 3 (78.5" Max Module Length)

XR100 Rail	Wind Speed	Ground Snow Load										
		0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Exposure	mph	100	81	81	77	67	59	54	49	46	43	40
Category B	105	78	78	77	67	59	54	49	46	43	40	
	110	74	74	74	67	59	54	49	46	43	40	
	120	68	68	68	67	59	54	49	46	43	40	
	130	63	63	63	63	59	54	49	46	43	40	
	140	59	59	59	59	54	49	46	43	40		
	150	55	55	55	55	55	54	49	46	43	40	
	160	52	52	52	52	52	52	49	46	43	40	
	170	49	49	49	49	49	49	46	43	40		
Category C	100	69	69	69	67	59	54	49	46	43	40	
	105	66	66	66	66	59	54	49	46	43	40	
	110	63	63	63	63	59	54	49	46	43	40	
	120	58	58	58	58	58	54	49	46	43	40	
	130	54	54	54	54	54	54	49	46	43	40	
	140	50	50	50	50	50	50	49	46	43	40	
	150	47	47	47	47	47	47	46	43	40		
	160	44	44	44	44	44	44	44	44	43		
Category D	170*	41	41	41	41	41	41	41	41	41		
	100	64	64	64	64	59	54	49	46	43	40	
	105	61	61	61	61	59	54	49	46	43	40	
	110	58	58	58	58	58	54	49	46	43	40	
	120	54	54	54	54	54	54	54	49	46	43	
	130	49	49	49	49	49	49	49	46	43		
	140	46	46	46	46	46	46	46	46	43		
	150	43	43	43	43	43	43	43	43	43		
Category E	160*	40	40	40	40	40	40	40	40	40		
	170*	38	38	38	38	38	38	38	38	38		

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Table 5B - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 2 (78.5" Max Module Length)

XR100 Rail	Wind Speed	Ground Snow Load									
0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf		

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Table 8B - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 2 (78.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	99	91	78	70	62	56	52	48	45	43	
	105	99	91	78	70	62	56	52	48	45	43	
	110	98	90	78	70	62	56	52	48	45	43	
	120	93	87	76	68	62	56	52	48	45	43	
	130	88	84	74	67	61	56	52	48	45	43	
	140	82	82	72	65	60	56	52	48	45	43	
	150	78	78	70	64	59	55	52	48	45	43	
	160	73	73	68	62	58	54	51	48	45	43	
	170	69	69	66	61	57	53	50	48	45	43	
Category C	100	94	88	76	69	62	56	52	48	45	43	
	105	91	86	75	68	62	56	52	48	45	43	
	110	88	84	74	67	61	56	52	48	45	43	
	120	81	81	72	65	60	56	52	48	45	43	
	130	76	76	70	63	59	55	52	48	45	43	
	140	71	71	67	62	57	54	51	48	45	43	
	150	67	67	65	60	56	52	49	47	45	43	
	160	63	63	63	58	54	51	48	46	44	43	
	170	59	59	59	57	53	50	48	45	44	42	
Category D	100	89	85	74	67	61	56	52	48	45	43	
	105	85	83	73	66	61	56	52	48	45	43	
	110	82	81	72	65	60	56	52	48	45	43	
	120	75	75	69	63	59	55	52	48	45	43	
	130	70	70	67	61	57	53	50	48	45	43	
	140	66	66	65	60	56	52	49	47	45	43	
	150	62	62	62	58	54	51	48	46	44	42	
	160	58	58	58	56	53	50	47	45	43	42	
	170	55	55	55	54	51	48	46	44	42	41	

Notes – see page 20

Notes – Tabulated values are based on the following criteria:

1. Building mean roof height = 30 ft
2. Risk Category 1
3. Solar maximum module long dimension is 67.5 inches for Tables 1A-9A and 78.5 inches for Tables 1B-9B.
4. Provide 2 in. clear between roof and rail
5. End cantilever span (max) = $0.40 \times L_{max}$ from above tables. See Figure A
6. No rail splices in outer 2/3 of end spans, or the middle 1/3 of interior spans based on the installed attachment spacing ($L_{install}$). See Figure A
7. Single simple span(s). Spans listed in the tables above may be multiplied by 1.08 for continuous rails of 3 or more spans.
8. Module Mounting Mid Clamps shall not be installed less than 20 inches from Roof Zone 3 where wind speeds are marked with an * in Tables 3B and 6B.
9. Connection of the rail to the roof structure is the responsibility of the end user of this letter. SML takes no liability for connections of the rail to the roof by others.

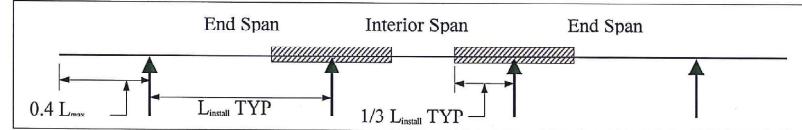


Figure A

L_{max} = Maximum attachment spacing provided in the tables above for the project design criteria

$L_{install}$ = Actual installed attachment spacing

Shaded region = Indicates region of the rail where splice may be installed

Our analysis assumes that the rails, including the connections and associated hardware, are installed in a workmanlike manner in accordance with the "IronRidge Flush Mount Installation Manual" by IronRidge and generally accepted standards of construction practice. Additional information is available at the IronRidge web site, IronRidge.com. Verification of PV Module capacity to support the loads associated with the given array shall be the responsibility of the Contractor or Owner and not IronRidge or Starling Madison Lofquist.

The adequacy of the supporting roof framing is to be determined by others.

Please feel free to contact me at your convenience if you have any questions.

Respectfully yours,

Andrew J. Huselman, P.E.
Licensed Professional Engineer

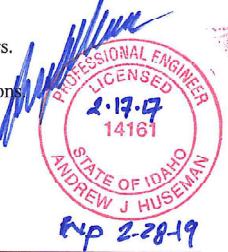
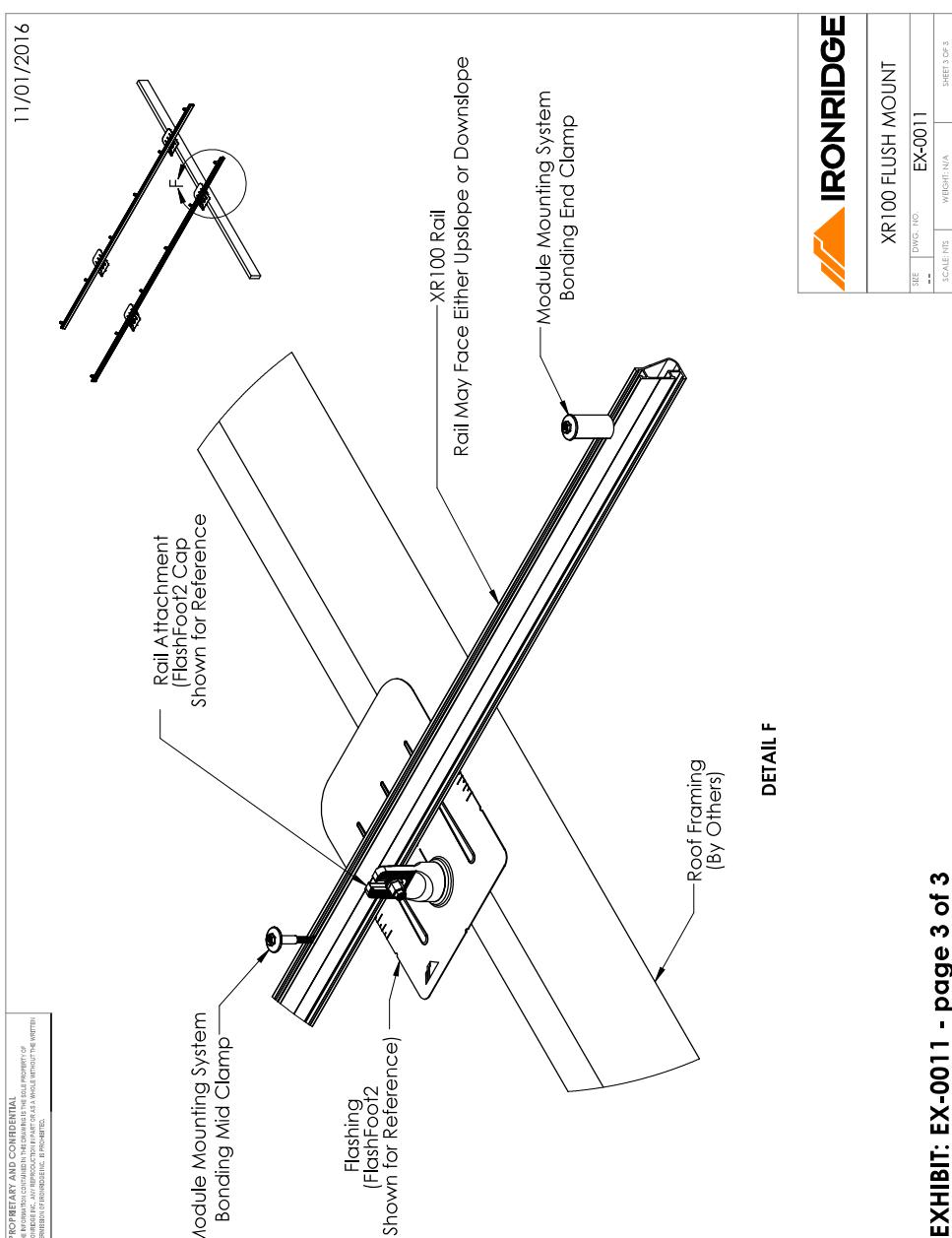
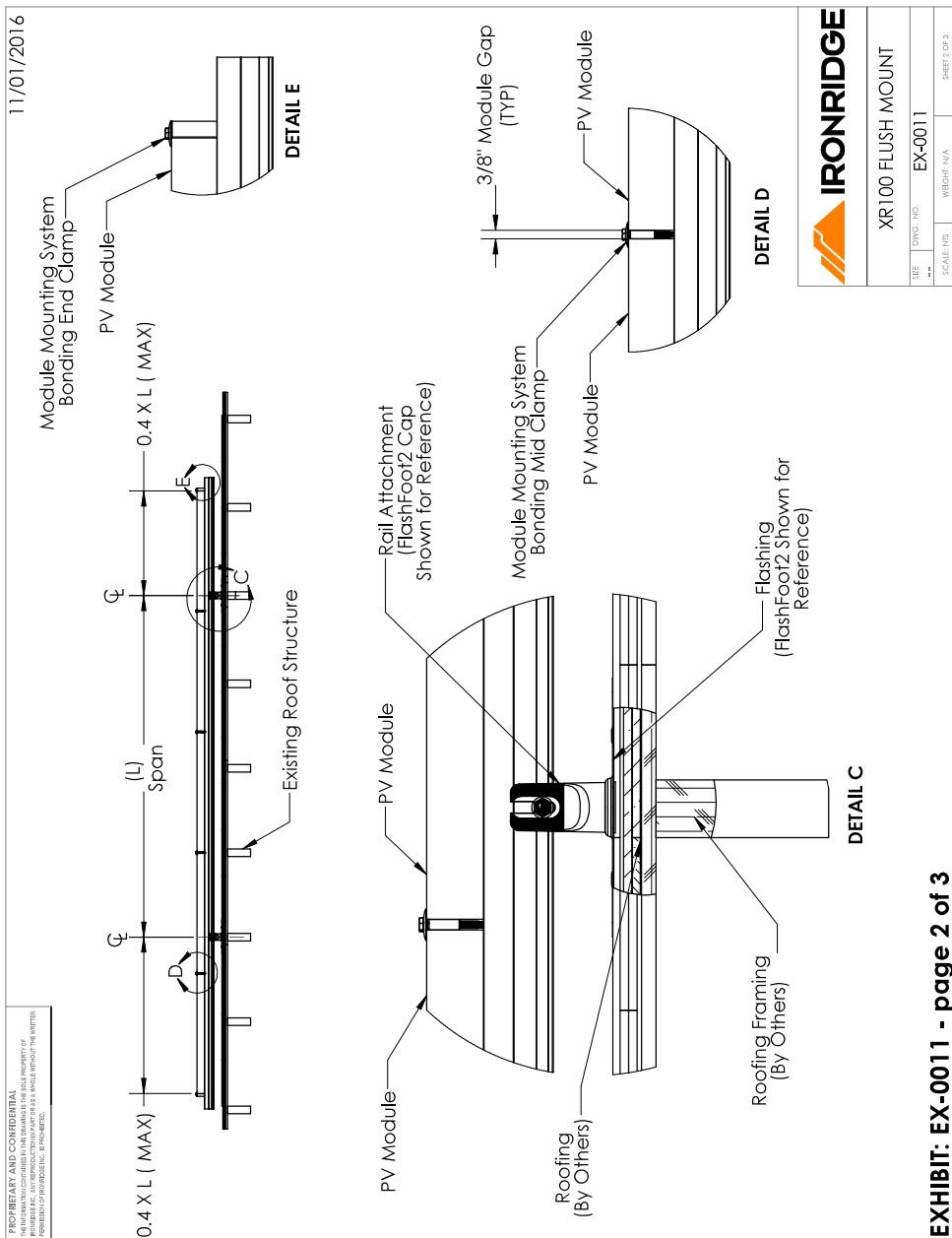


Table 9B - MAXIMUM SPANS (in) - Roof Slope 28° to 45° - Wind Zone 3 (78.5" Max Module Length)												
XR100 Rail	Wind Speed	Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	
Category B	100	99	91	78	70	62	56	52	48	45	43	
	105	99	91	78	70	62	56	52	48	45	43	
	110	98	90	78	70	62	56	52	48	45	43	
	120	93	87	76	68	62	56	52	48	45	43	
	130	88	84	74	67	61	56	52	48	45	43	
	140	82	82	72	65	60	56	52	48	45	43	
	150	78	78	70	64	59	55	52	48	45	43	
	160	73	73	68	62	58	54	51	48	45	43	
	170	69	69	66	61	57	53	50	48	45	43	
Category C	100	94	88	76	69	62	56	52	48	45	43	
	105	91	86	75	68	62	56	52	48	45	43	
	110	88	84	74	67	61	56	52	48	45	43	
	120	81	81	72	65	60	56	52	48	45	43	
	130	76	76	70	63	59	55	52	48	45	43	
	140	71	71	67	62	57	54	51	48	45	43	
	150	67	67	65	60	56	52	50	47	45	43	
	160	63	63	63	58	54	51	49	46	44	43	
	170	59	59	59	57	53	50	48	45	44	42	
Category D	100	89	85	74	67	61	56	52	48	45	43	



Starling Madison Lofquist, Inc.

Consulting Structural and Forensic Engineers

5224 South 39th Street, Phoenix, Arizona 85040
tel: (602) 438-2500 fax: (602) 438-2505 ROC#291316 www.smengl.com

IronRidge
1495 Zephyr Ave
Hayward, CA 94544

February 17, 2017
Page 1 of 20

Attn: Mr. David F. Taggart, Vice President Products

Subject: IronRidge XR1000 Rail, Roof Flush Mounting System – Structural Analysis

Dear Sir:

We have analyzed the IronRidge XR1000 Rail for the subject solar module support system and determined that, for the configurations and criteria described below, it is in compliance with the applicable sections of the following Reference Documents:

Codes: ASCE/SEI 7-10 Min. Design Loads for Buildings & Other Structures
International Building Code 2015 Edition

Other: AC428, Acceptance Criteria for Modular Framing Systems Used to Support PV Modules, dated Effective November 1, 2012 by ICC-ES
Aluminum Design Manual, 2015 Edition

The IronRidge XR1000 Rail is an extruded aluminum section with an overall depth of 3.00 in. and a net area of 0.807 sq.in. The rails are used to support solar modules, typically, on the roof of a building. See Exhibit 0012 – attached. The modules are clamped to the rails by the IronRidge Module Mounting Clamps as shown in the attached Exhibit. The rails are attached to aluminum angle brackets that are either attached directly to the roof framing or attached to a stand that is screwed to the roof framing. The rails are mounted across the slope with small clearance (flush mounting) to the underlying roof structure. The installed solar modules are at the same slope as the underlying roof structure.

All loads are transferred to the roof framing through the angle brackets by simple bi-axial flexure of the rails. The maximum span of the rails is governed by either the mid-span flexural stresses or the deflection requirement that the rail not come into contact with the roof.

The effect of seismic loads (for all design categories A-F) have been determined to be less than the effect due to wind loads in all load conditions and combinations. Therefore, the maximum allowable spans for common load cases are shown in the tables below. Tables 1A-9A are for modules with a maximum long dimension of 67.5 inches and Tables 1B-9B are for modules with a maximum long dimension of 78.5 inches.

Starling Madison Lofquist, Inc.

Consulting Structural and Forensic Engineers

IronRidge
Mr. David F. Taggart
IronRidge XR1000 Rail, Roof Flush Mounting System – Structural Analysis

February 17, 2017
Page 2 of 20

Table 1A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 1 (67.5" Max Module Length)											
XR1000 Rail	Wind Speed	Ground Snow Load									
		Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf
Category B	100	163	138	116	109	97	88	80	75	70	66
	105	163	138	116	109	97	88	80	75	70	66
	110	163	138	116	109	97	88	80	75	70	66
	120	161	138	116	109	97	88	80	75	70	66
	130	148	138	116	109	97	88	80	75	70	66
	140	137	137	116	109	97	88	80	75	70	66
	150	128	128	116	109	97	88	80	75	70	66
Category C	160	120	120	116	109	97	88	80	75	70	66
	170	113	113	113	109	97	88	80	75	70	66
	100	163	138	116	109	97	88	80	75	70	66
	105	155	138	116	109	97	88	80	75	70	66
	110	148	138	116	109	97	88	80	75	70	66
	120	135	135	116	109	97	88	80	75	70	66
	130	125	125	116	109	97	88	80	75	70	66
Category D	140	116	116	116	109	97	88	80	75	70	66
	150	108	108	108	108	97	88	80	75	70	66
	160	101	101	101	101	97	88	80	75	70	66
	170	95	95	95	95	95	88	80	75	70	66
	100	149	138	116	109	97	88	80	75	70	66
	105	142	138	116	109	97	88	80	75	70	66
	110	135	135	116	109	97	88	80	75	70	66
Category E	120	124	124	116	109	97	88	80	75	70	66
	130	114	114	114	109	97	88	80	75	70	66
	140	106	106	106	106	97	88	80	75	70	66
	150	99	99	99	99	97	88	80	75	70	66
	160	93	93	93	93	93	88	80	75	70	66
	170	88	88	88	88	88	88	80	75	70	66

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Starling Madison Lofquist, Inc.

Consulting Structural and Forensic Engineers

		Table 2A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 2 (67.5" Max Module Length)									
XR1000 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	143	138	116	109	97	88	80	75	70	66
	105	136	136	116	109	97	88	80	75	70	66
	110	130	130	116	109	97	88	80	75	70	66
	120	119	119	116	109	97	88	80	75	70	66
	130	110	110	109	97	88	80	75	70	66	
	140	102	102	102	97	88	80	75	70	66	
	150	95	95	95	95	88	80	75	70	66	
	160	89	89	89	89	88	80	75	70	66	
	170	84	84	84	84	84	80	75	70	66	
Category C	100	121	121	116	109	97	88	80	75	70	66
	105	115	115	109	109	97	88	80	75	70	66
	110	110	110	110	109	97	88	80	75	70	66
	120	101	101	101	101	97	88	80	75	70	66
	130	93	93	93	93	93	88	80	75	70	66
	140	86	86	86	86	86	86	80	75	70	66
	150	81	81	81	81	81	81	80	75	70	66
	160	76	76	76	76	76	76	76	75	70	66
	170	71	71	71	71	71	71	71	71	70	66
Category D	100	111	111	111	109	97	88	80	75	70	66
	105	106	106	106	106	97	88	80	75	70	66
	110	101	101	101	101	97	88	80	75	70	66
	120	92	92	92	92	92	88	80	75	70	66
	130	85	85	85	85	85	85	80	75	70	66
	140	79	79	79	79	79	79	79	75	70	66
	150	74	74	74	74	74	74	74	74	70	66
	160	70	70	70	70	70	70	70	70	70	66
	170	65	65	65	65	65	65	65	65	65	65

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		Table 4A - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 1 (67.5" Max Module Length)									
XR1000 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	148	128	109	94	83	75	69	64	60	57
	105	148	128	109	94	83	75	69	64	60	57
	110	148	128	109	94	83	75	69	64	60	57
	120	148	128	109	94	83	75	69	64	60	57
	130	147	128	109	94	83	75	69	64	60	57
	140	137	128	109	94	83	75	69	64	60	57
	150	129	126	108	94	83	75	69	64	60	57
	160	121	121	106	94	83	75	69	64	60	57
	170	115	115	104	93	83	75	69	64	60	57
Category C	100	148	128	109	94	83	75	69	64	60	57
	105	148	128	109	94	83	75	69	64	60	57
	110	147	128	109	94	83	75	69	64	60	57
	120	136	128	109	94	83	75	69	64	60	57
	130	126	125	107	94	83	75	69	64	60	57
	140	117	117	105	93	83	75	69	64	60	57
	150	110	110	103	92	83	75	69	64	60	57
	160	104	104	100	90	82	75	69	64	60	57
	170	98	98	98	88	81	75	69	64	60	57
Category D	100	148	128	109	94	83	75	69	64	60	57
	105	142	128	109	94	83	75	69	64	60	57
	110	136	128	109	94	83	75	69	64	60	57
	120	125	125	107	94	83	75	69	64	60	57
	130	116	116	104	93	83	75	69	64	60	57
	140	109	109	102	91	83	75	69	64	60	57
	150	102	102	100	89	82	75	69	64	60	57
	160	96	96	96	88	80	75	69	64	60	57
	170	90	90	90	90	83	75	69	64	60	57

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		Table 3A - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 3 (67.5" Max Module Length)									
XR1000 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf

XR1000 Rail		Wind Speed										Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	100	115	115	109	94	83	75	69	64	60	57
Category B	100	115	115	109	94	83	75	69	64	60	57	105	110	110	109	94	83	75	69	64	60	57
	110	105	105	105	94	83	75	69	64	60	57	120	97	97	97	94	83	75	69	64	60	57
	130	90	90	90	90	83	75	69	64	60	57	140	83	83	83	83	83	75	69	64	60	57
	150	78	78	78	78	78	75	69	64	60	57	160	73	73	73	73	73	69	64	60	57	170
	69	69	69	69	69	69	69	69	64	60	57	100	98	98	98	94	83	75	69	64	60	57
	105	93	93	93	93	93	83	75	69	64	60	110	89	89	89	89	83	75	69	64	60	57
	120	82	82	82	82	82	75	69	64	60	57	130	76	76	76	76	75	69	64	60	57	140
	71	71	71	71	71	71	71	69	64	60	57	150	66	66	66	66	66	66	64	60	57	170
	62	62	62	62	62	62	62	62	62	60	57	160	59	59	59	59	59	59	59	57	57	170
Category D	100	90	90	90	90	83	75	69	64	60	57	105	86	86	86	86	83	75	69	64	60	57
	110	82	82	82	82	82	75	69	64	60	57	120	76	76	76	76	75	69	64	60	57	130
	70	70	70	70	70	70	70	69	64	60	57	140	65	65	65	65	65	65	64	60	57	150
	61	61	61	61	61	61	61	61	61	60	57	160	57	57	57	57	57	57	57	57	57	170
	54	54	54	54	54	54	54	54	54	54	54	100	90	90	90	90	83	75	69	64	60	57
	105	86	86	86	86	83	75	69	64	60	57	110	82	82	82	82	82	75	69	64	60	57
	120	76	76	76	76	76	75	69	64	60	57	130	70	70	70	70	70	69	64	60	57	140
	65	65	65	65	65	65	65	65	65	60	57	150	61	61	61	61	61	61	61	60	57	160
	57	57	57	57	57	57	57	57	57	57	57	160	54	54	54	54	54	54	54	54	54	170

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XR1000 Rail		Wind Speed										Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	100	140	128	110	98	87	79	72	67	63	60
Category B	105	140	128	110	98	87	79	72	67	63	60	110	139	127	110	98	87	79	72	67	63	60
	120	132	123	107	96	87	79	72	67	63	60	130	126	119	104	94	86	79	72	67	63	60
	140	120	115	102	92	85	79	72	67	63	60	150	114	111	99	90	83	78	72	67	63	60
	160	109	108	97	88	82	76	72	67	63	60	170	98	98	98	94	86	80	75	71	67	63
	100	125	120	105	94	86	79	72	67	63	60	105	129	121	106	95	87	79	72	67	63	60
	110	124	119	104	94	86	79	72	67	63	60	120	115	114	101	92	84	79	72	67	63	60
	130	107	107	98	89	83	78	72	67	63	60	140	100	100	95	87	80	75	71	67	63	60
	150	97	97	97	97	97	97	97	97	97	97	160	82	82	82	79	74	70	67	64	61	59
	170	84	84	84	84	84	84	84	84	84	84	100	133	124	107	96	87	79	72	67	63	60
Category C	100	125	120	105	94	86	79	72	67	63	60	105	129	121	106	95	87	79	72	67	63	60
	110	124	119	104	94	86	79	72	67	63	60	120	119	114	101	92	84	79	72	67	63	60
	130	107	107	98	87	81	76	71	67	63	60	140	101	92	85	79	74	70	67	63	60	150
	150	97	97	97	97	97	97	97	97	97	97	160	91	91	89	82	77	72	69	65	63	60
	170	84	84	84	84	84	84	84	84	84	84	100	133	124	107	96	87	79	72	67	63	60
	100	125	120	105	94	86	79	72	67	63	60	105	129	121	106	95	87	79	72	67	63	60
	110	124	119	104	94	86	79	72	67	63	60</											

		Table 1B - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 1 (78.5" Max Module Length)									
XR1000 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	151	129	108	101	90	81	75	69	65	61
	105	151	129	108	101	90	81	75	69	65	61
	110	151	129	108	101	90	81	75	69	65	61
	120	150	129	108	101	90	81	75	69	65	61
	130	138	129	108	101	90	81	75	69	65	61
	140	128	128	108	101	90	81	75	69	65	61
	150	119	119	108	101	90	81	75	69	65	61
	160	112	112	108	101	90	81	75	69	65	61
Category C	170	105	105	101	90	81	75	69	65	61	61
	100	151	129	108	101	90	81	75	69	65	61
	105	145	129	108	101	90	81	75	69	65	61
	110	138	129	108	101	90	81	75	69	65	61
	120	126	126	108	101	90	81	75	69	65	61
	130	116	116	108	101	90	81	75	69	65	61
	140	108	108	101	90	81	75	69	65	61	61
	150	101	101	101	90	81	75	69	65	61	61
Category D	160	94	94	94	94	90	81	75	69	65	61
	170	89	89	89	89	81	75	69	65	61	61
	100	140	129	108	101	90	81	75	69	65	61
	105	133	129	108	101	90	81	75	69	65	61
	110	127	127	108	101	90	81	75	69	65	61
	120	116	116	108	101	90	81	75	69	65	61
	130	107	107	107	101	90	81	75	69	65	61
	140	99	99	99	99	90	81	75	69	65	61
Category D	150	93	93	93	93	90	81	75	69	65	61
	160	87	87	87	87	81	75	69	65	61	61
	170	82	82	82	82	81	75	69	65	61	61

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		Table 3B - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 3 (78.5" Max Module Length)									
XR1000 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	107	107	107	101	90	81	75	69	65	61
	105	102	102	102	101	90	81	75	69	65	61
	110	97	97	97	97	97	90	81	75	69	65
	120	89	89	89	89	89	89	81	75	69	65
	130	82	82	82	82	82	82	81	75	69	65
	140	76	76	76	76	76	76	76	75	69	65
	150	71	71	71	71	71	71	71	71	69	65
	160	67	67	67	67	67	67	67	67	65	61
Category C	170	63	63	63	63	63	63	63	63	63	61
	100	90	90	90	90	90	90	81	75	69	65
	105	86	86	86	86	86	86	81	75	69	65
	110	82	82	82	82	82	82	81	75	69	65
	120	75	75	75	75	75	75	75	75	69	65
	130	70	70	70	70	70	70	70	70	69	65
	140	65	65	65	65	65	65	65	65	65	61
	150	60	60	60	60	60	60	60	60	60	60
Category D	160	57	57	57	57	57	57	57	57	57	57
	170*	53	53	53	53	53	53	53	53	53	53

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		Table 2B - MAXIMUM SPANS (in) - Roof Slope 0° to 6° - Wind Zone 2 (78.5" Max Module Length)									
XR1000 Rail	Wind Speed	Ground Snow Load									
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf
Category B	100	134	129	108	101	90	81	75	69	65	61
	105	127	127	108	101	90	81	75	69	65	61
	110	121	121	108	101	90	81	75	69	65	61
	120	1									

Table 5B - MAXIMUM SPANS (in) - Roof Slope 7° to 27° - Wind Zone 2 (78.5" Max Module Length)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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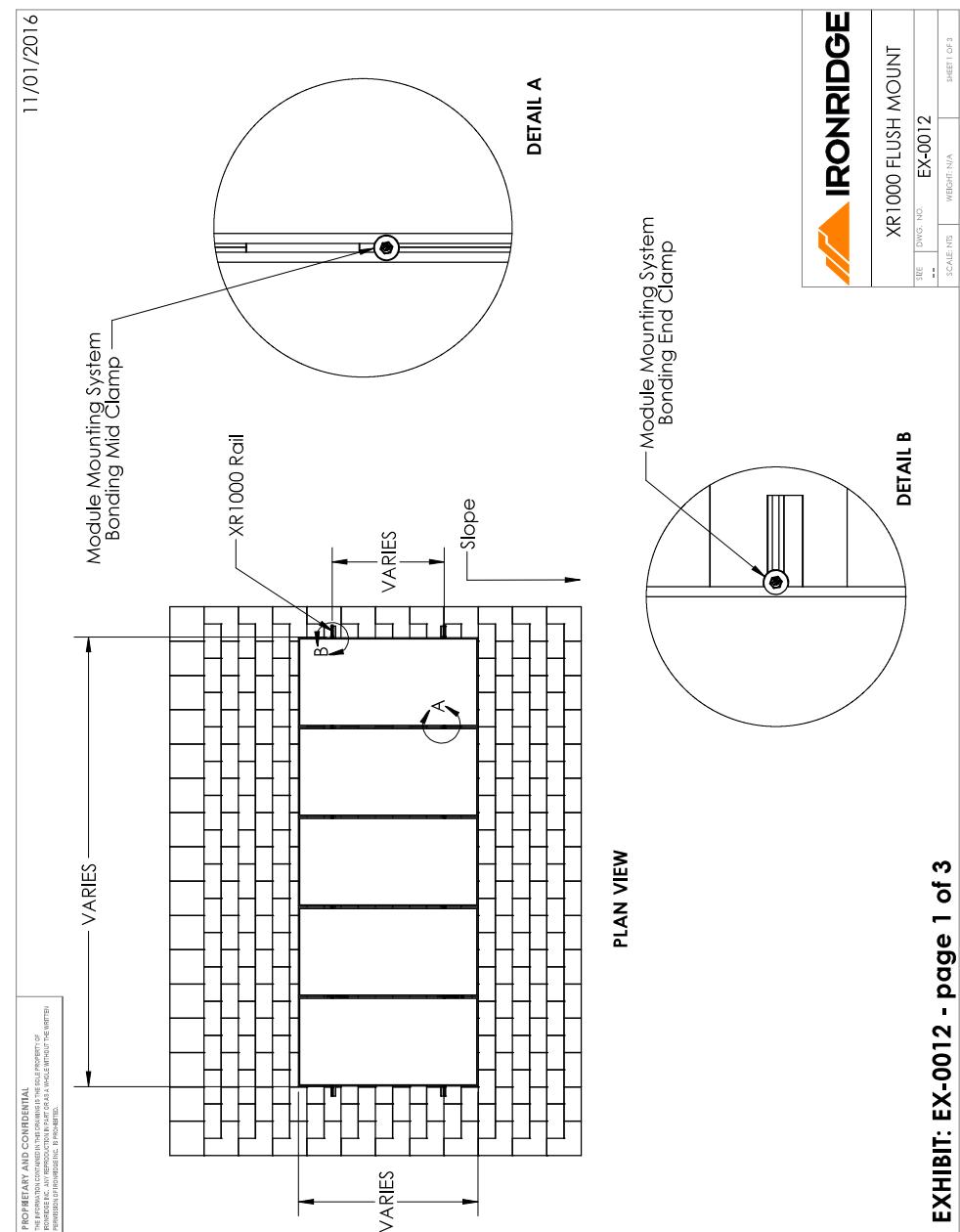
XR1000 Rail		Wind Speed										Ground Snow Load										
Exposure	mph	0 psf	10 psf	20 psf	30 psf	40 psf	50 psf	60 psf	70 psf	80 psf	90 psf	100	110	120	130	140	150	160	170			
Category B	100	130	119	102	91	81	73	67	63	59	56	105	130	119	102	91	81	73	67	63	59	56
	110	129	118	102	91	81	73	67	63	59	56	120	123	114	99	89	81	73	67	63	59	56
	130	116	111	97	87	80	73	67	63	59	56	140	108	107	95	86	79	73	67	63	59	56
	150	102	102	92	84	77	72	67	63	59	56	160	96	96	90	82	76	71	67	63	59	56
	170	91	91	87	80	74	70	66	62	59	56	100	124	115	100	89	81	73	67	63	59	56
	105	120	113	98	88	81	73	67	63	59	56	110	115	111	97	87	80	73	67	63	59	56
	120	107	106	94	85	78	73	67	63	59	56	130	100	100	91	83	77	72	67	63	59	56
	140	93	93	88	81	75	70	66	63	59	56	150	88	88	86	79	73	69	65	62	59	56
Category C	160	83	83	83	77	72	67	64	61	58	56	170	78	78	78	75	70	66	63	60	57	55
	100	116	111	97	88	80	73	67	63	59	56	105	112	109	96	86	79	73	67	63	59	56
	110	107	107	94	85	78	73	67	63	59	56	120	99	99	91	83	77	72	67	63	59	56
	130	92	92	88	81	75	70	66	63	59	56	140	86	86	85	78	73	68	65	62	59	56
	150	81	81	81	76	71	67	63	60	58	55	160	76	76	76	74	69	65	62	59	57	55
	170	72	72	72	72	67	64	61	58	56	54	100	116	111	97	88	80	73	67	63	59	56
	105	112	109	96	86	79	73	67	63	59	56	110	107	107	94	85	78	73	67	63	59	56
	120	99	99	91	83	77	72	67	63	59	56	130	92	92	88	81	75	70	66	63	59	56
Category D	140	86	86	85	78	73	68	65	62	59	56	150	81	81	81	76	71	67	63	60	58	55
	160	76	76	76	74	69	65	62	59	57	55	170	72	72	72	72	67	64	61	58	56	54

Notes – see page 20

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Consulting Structural and Forensic Engineers

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- Notes – Tabulated values are based on the following criteria:
1. Building mean roof height = 30 ft
 2. Risk Category I
 3. Solar maximum module long dimension is 67.5 inches for Tables 1A-9A and 78.5 inches for Tables 1B-9B.
 4. Provide 2 in. clear between roof and rail
 5. End cantilever span (max) = $0.4 \times L_{max}$ from above tables. See Figure A
 6. No rail splices in outer 2/3 of end spans, or the middle 1/3 of interior spans based on the installed attachment spacing ($L_{install}$). See Figure A
 7. Single simple span(s). Spans listed in the tables above may be multiplied by 1.08 for continuous rails of 3 or more spans.
 8. Module Mounting Mid Clamps shall not be installed less than 20 inches from Roof Zone 3 where wind speeds are marked with an * in Tables 3B and 6B.
 9. Connection of the rail to the roof structure is the responsibility of the end user of this letter. SML takes no liability for connections of the rail to the roof by others.

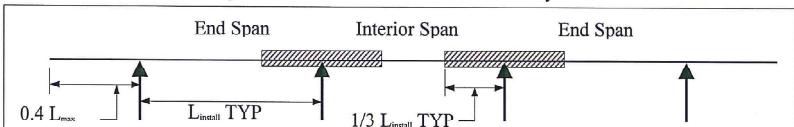


Figure A

L_{max} = Maximum attachment spacing provided in the tables above for the project design criteria

$L_{install}$ = Actual installed attachment spacing

= Indicates region of the rail where splice may be installed

Our analysis assumes that the rails, including the connections and associated hardware, are installed in a workmanlike manner in accordance with the "IronRidge Flush Mount Installation Manual" by IronRidge and generally accepted standards of construction practice. Additional information is available at the IronRidge web site, IronRidge.com. Verification of PV Module capacity to support the loads associated with the given array shall be the responsibility of the Contractor or Owner and not IronRidge or Starling Madison Lofquist.

The adequacy of the supporting roof framing is to be determined by others.

Please feel free to contact me at your convenience if you have any questions.

Respectfully yours,

Andrew J. Huseman, P.E.
Licensed Professional Engineer



Starling Madison Lofquist, Inc.

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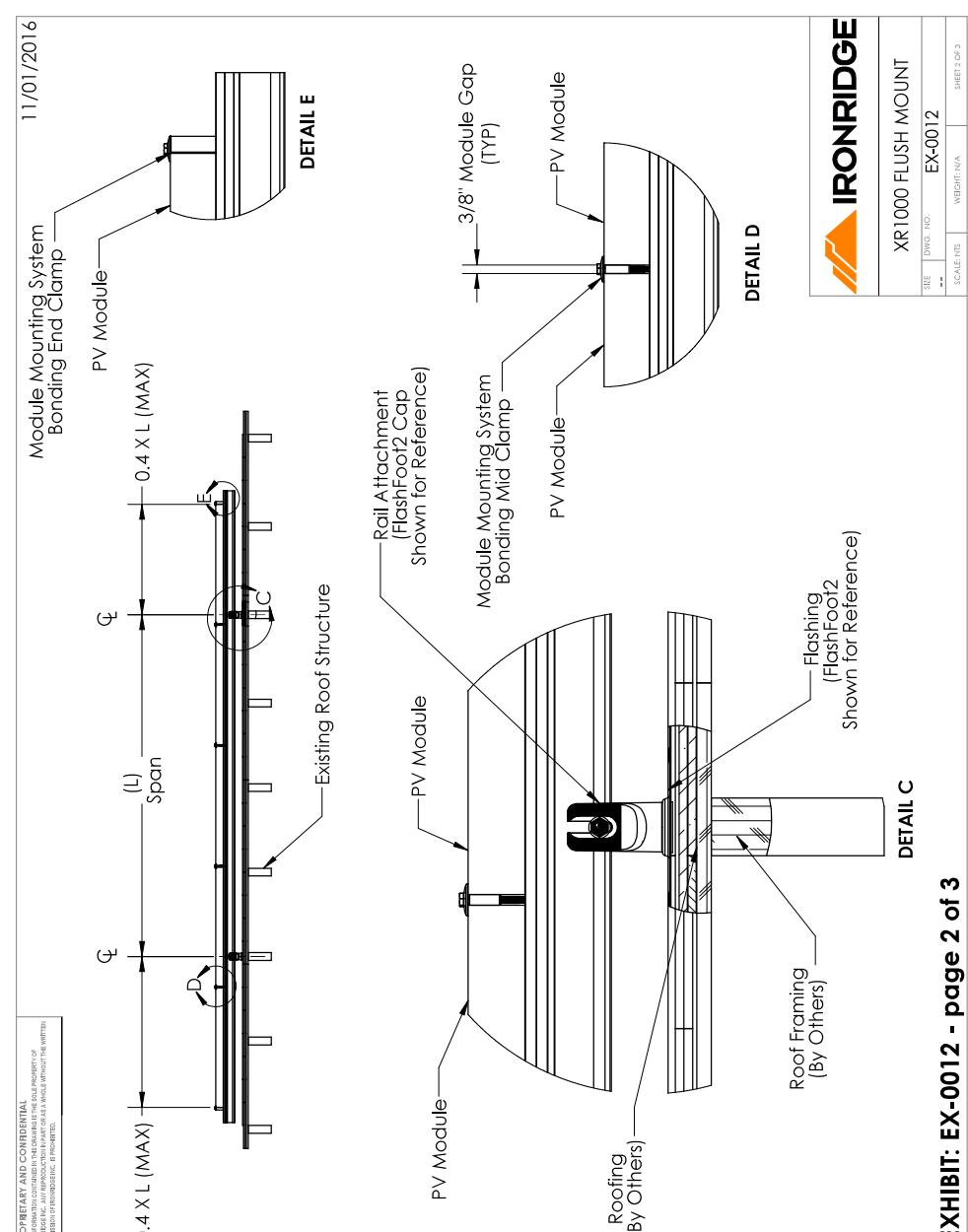
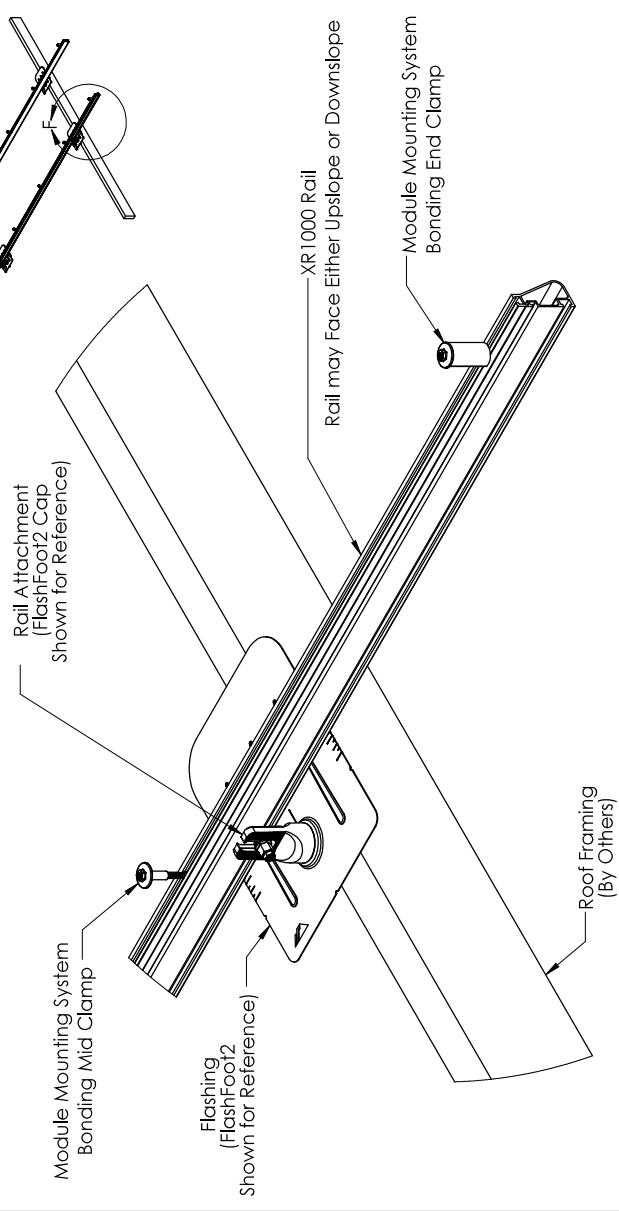


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11/01/2016

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DETAIL F



XR1000 FLUSH MOUNT

SHEET NO. Dwg. No. EX-0012
** 1/16/2012 10/10/2012 SHEET 3 OF 3
SCALE: N/A WEIGHT:N/A

EXHIBIT: EX-0012 - page 3 of 3