

ENGINEERED POWER SOLUTIONS
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STRUCTURAL DOCUMENTATION PACKET

PROJECT:

Renusol MS Roof Mounting System
Generic Structural Packet and Design Charts

CLIENT:

Renusol America, Inc.
1292 Logan Circle NW
Atlanta, GA 30318

PREPARED BY:

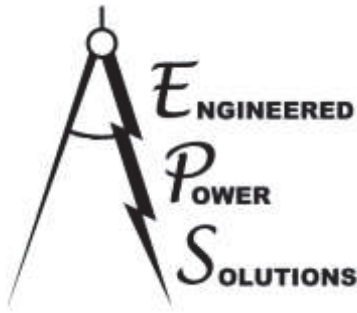
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PACKET EXPIRES 12/31/16
MUST BE RENEWED ANNUALLY

DATE: 3/11/15

EPS PROJECT NUMBER: 13-RNS001



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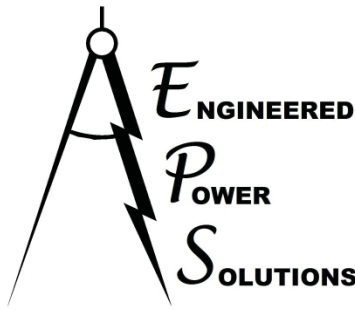
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1.0 – RESULTS & SCOPE OF WORK

1.1 – Overview of Analysis & Results

- Governing Building Code:

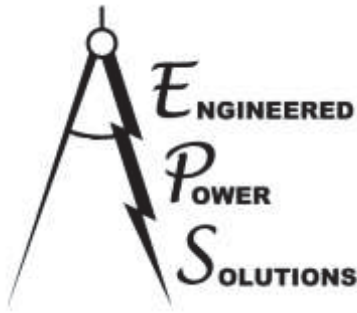
International Building Code (IBC)

Referencing the Minimum Design Loads for Buildings and Other Structures by the American Society of Civil Engineers (ASCE 7). [Because this packet is used in multiple states, results are provided for both ASCE 7-05 and ASCE 7-10]

- Project Description:

The project consists of the design of the structural roof anchorage for the proposed roof mounting system (Renusol MS Solar Mounting System) for Photovoltaic (PV) modules on trapezoidal metal sheet roofs. The solar designer, Renusol America Inc. (Renusol) has contracted Engineered Power Solutions (EPS) to address the structural aspects of the anchorage, mainly the specification of the number of screws used at each clamp base. Renusol has specified a number of common design scenarios that EPS has used to determine the design loads at the clamp bases. These scenarios include roof tilt, design wind speed, wind exposure category, design ground snow load, thickness (gage) of the metal roofing, size and weight of the modules, occupancy category of the existing structure, and location of the modules on the roof. Renusol has also specified a number of design assumptions that remain constant for all scenarios which are discussed in further detail on the following pages.

Because this product is to be used in multiple states which may be governed by different building codes, Renusol has requested that EPS provide design charts using both ASCE 7-05 and ASCE 7-10.

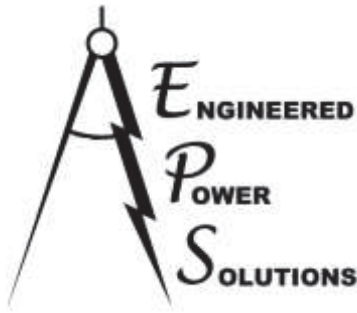


1.2 – Scope of Work, Results, and Limitations

- **Scope of Work:**

EPS has been hired by Renusol to address the following items:

- Determination of the specified design loads on the clamp bases including dead loads, wind loads, snow loads, seismic loads, etc.
- Determination of the number of EJOT EJOFAST screws to be specified at each clamp base as required by the specific design scenario.
- Roof snow load limitations to the existing roof based on the various design scenarios specified by Renusol.

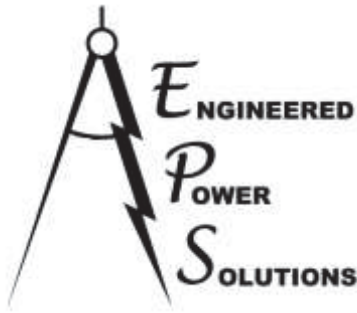


- **Results:**

The results of this analysis are presented on the following pages in the form of design summary tables based on the design scenarios provided by Renusol. The final results are specified as the number of EJOT EJOFAST screws required at each clamp base under each specific scenario. Design tables that specify the allowable ground snow load that the MS system can be installed under for each scenario without further analysis on the existing roof/structure are also provided.

- **Limitations and Assumptions:**

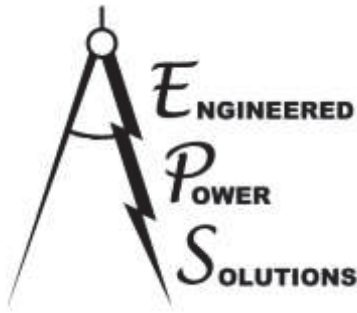
This Structural Documentation Packet is not in reference of any specific project and only addresses the anchorage requirements of the MS Roof Mounting System for the generic design assumptions shown in this packet. Sites with design scenarios which differ and/or are outside the scenarios specified in this packet must be addressed by a licensed design professional on a site specific basis. Any changes to the required design results given in the following result design tables such as screw quantities, type, installation requirements, etc. must be approved in writing by EPS prior to implementation. EPS has not checked and is not responsible for the structural adequacy of the existing structure nor is EPS responsible for the existing structure's ability to support the design loads imposed by the proposed PV system. Renusol has informed EPS that the structural aspects of the existing structure(s) affected by this new rooftop PV installation will be addressed by a licensed professional engineer on a site specific basis as required by the local governing jurisdiction. All non-structural issues including but not limited to waterproofing, corrosion protection, electrical, and mechanical issues are not the responsibility of EPS and must be addressed by the solar designer, installer, and/or owner before PV installation begins.



2.0 – DESIGN RESULTS AND SUMMARY TABLES

2.1 – Design Scenarios (Parameters)

- **Varying Design Parameters:**
 - Size and Weight of Module¹:
 - 60-cell modules:
 - 65.55" x 39.02" / 40 lbs.
 - 72-cell modules:
 - 77.56" x 38.98" / 59 lbs.
 - Wind Exposure Category^{2,6}:
 - Exposure "B"
 - Exposure "C"
 - Building Occupancy Category²:
 - II
 - III
 - Roof Pitch³:
 - 1:12 to 5:12
 - 6:12 to 12:12
 - Design Wind Speed² (3 Second Gust Speed in MPH):
 - 90, 100, 110, 120, 135, 150 (ASCE 7-05)
 - 115, 120, 140, 150, 160, 170 (ASCE 7-10)
 - Thickness (gage) of metal roof:
 - 26 gage
 - 24 gage (or thicker)
 - Roof Zone⁴ (location of modules on roof):
 - Edge Zone
 - Mid Zone
 - Ground Snow Load² (p_g)
- **Constant Design Parameters:**
 - Wind Design Parameters:
 - Topographic Factor^{2,5} (K_{zt}): 1.00
 - Wind Directionality Factor² (K_d): 0.85
 - Building Height⁷: 30 ft. or less
 - Snow Design Parameters:
 - Exposure Factor⁸ (C_e): 1.0
 - Thermal Factor (C_t): 1.2



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Design Parameter Notes:

- 1) Modules of different sizes and/or weights than those specified shall be checked individually.
- 2) It is the solar designer/installer or owner's responsibility to determine the site specific design parameters of each site based on the current governing building code and/or local jurisdiction's requirements.
- 3) Roof Pitch determines various other design parameters such as wind external pressure coefficients (GC_{pf}), Snow Slope Factor (C_s), and the portion of gravity loads that are applied vertically and horizontally.
- 4) Please see section 3.1 of this packet for further information on Roof Zones.
- 5) The site is assumed to have no topographic effects, i.e. it is not on a bluff, cliff, mesa, escarpment, upper half of a hill, or any other condition as described in the governing building code that would require a Topographic Factor other than 1.00.
- 6) Wind Exposure Categories considered are "B" and "C" as defined in ASCE 7. Wind Exposure Category "D" (sites overlooking bodies of water, mudflats, saltflats, and/or ice) has not been considered in this analysis. A site specific analysis is required for Wind Exposure "D" sites.
- 7) The building height listed is defined as the distance between the highest point of the PV system and grade. If the building has varying grade elevations, the lowest grade elevation shall be used. Projects where the height is greater than 30 ft. require a site specific analysis.
- 8) It is assumed the roof is "Partially Exposed" as described in ASCE 7. This assumption is conservative for buildings with "Fully Exposed" roofs. For buildings with "Sheltered" roofs, a site specific analysis is required.

ASCE 7-05 – Renusol MS Screw Quantities – 60 Cell Modules

Exposure C, Occupancy II									
Roof Pitch 1:12 to 5:12									
Quantity of Screws Per Bracket		24-Gage		26-Gage		24-Gage		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	4	3	3	2
	2	2	2	2	2	N.G.	3	3	2
	3	3	3	3	3	N.G.	4	4	3
	3	4	4	4	4	N.G.	N.G.	N.G.	3
Roof Pitch 6:12 to 12:12									
Quantity of Screws Per Bracket		24-Gage		26-Gage		24-Gage		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
	2	2	2	2	2	2	2	2	2
	2	2	2	2	2	2	2	2	2
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	4	3	3	2
	3	2	2	2	2	N.G.	3	3	2

Exposure B, Occupancy III									
Roof Pitch 1:12 to 5:12									
Quantity of Screws Per Bracket		24-Gage		26-Gage		24-Gage		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	4	3	3	2
	2	2	2	2	2	N.G.	3	3	2
	3	3	3	3	3	N.G.	4	4	3
	3	4	4	4	4	N.G.	N.G.	N.G.	3
Roof Pitch 6:12 to 12:12									
Quantity of Screws Per Bracket		24-Gage		26-Gage		24-Gage		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
	2	2	2	2	2	2	2	2	2
	2	2	2	2	2	2	2	2	2
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	3	2	2	2
	2	2	2	2	2	4	3	3	2
	3	2	2	2	2	N.G.	3	3	2

FAST bi-metal self-drilling screws (JF3). Screws shall be installed per corresponding ICC-ES evaluation report (report number 0276). See Appendix for further information scenarios with "N.G." specified may have design loads in excess of the allowable capacity of 4 screws and require a site specific analysis.

ASCE 7-05 – Renusol MS Screw Quantities – 72 Cell Modules

Quantity of Screws Per Bracket			
6-Gage	24-Gage		Quant
	Mid Zone	Edge Zone	
2	2	2	3
2	2	2	3
2	2	2	4
3	3	3	4
3	3	3	N.G.
4	4	4	N.G.

Quantity of Screws Per Bracket			
6-Gage	24-Gage		Quant
	Mid Zone	Edge Zone	
2	2	2	3
2	2	2	3
2	2	2	4
3	3	3	N.G.
3	3	3	N.G.
4	4	4	N.G.

Exposure B, Occupancy III			
Roof Pitch 1:12 to 5:12			
ASCE 7-05 Wind Speed (MPH)	26-Gage		26-Gage Edge Zone
	Edge Zone	Mid Zone	
90	3	2	3
100	4	2	3
110	N.G.	3	4
120	N.G.	4	4
135	N.G.	4	N.G.
150	N.G.	N.G.	N.G.

FAST bi-metal self-drilling screws (JF3). Screws shall be installed per corresponding ICC-ES evaluation report (report number 0276). See Appendix for further information on scenarios with “N.G.” specified may have design loads in excess of the allowable capacity of 4 screws and require a site specific analysis. Roofs with a thicker gage than 24 may conservatively use the results shown for a 24 gage roof. Roofs with a thinner gage than 26 are or further information on Roof Zones.

ASCE 7-10 – Renusol MS Screw Quantities – 72 Cell Modules

Exposure C									
Roof Pitch 1:12 to 5:12									
ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket				Quantity of Screws Per Bracket				
	6-Gage		24-Gage		26-Gage		24-Gage		
	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	
115	2	2	2	2	3	2	3	2	
120	2	2	2	2	3	2	3	2	
140	2	2	3	2	4	3	4	3	
150	2	2	4	2	N.G.	3	N.G.	3	
160	3	4	4	3	N.G.	4	N.G.	4	
170	3	N.G.	N.G.	3	N.G.	4	N.G.	4	
Roof Pitch 6:12 to 12:12									
ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket				Quantity of Screws Per Bracket				
	6-Gage		24-Gage		26-Gage		24-Gage		
	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	
115	2	2	2	2	2	2	2	2	
120	2	2	2	2	2	2	2	2	
140	2	2	2	2	3	2	3	2	
150	2	2	2	2	3	2	3	2	
160	2	2	3	2	4	3	4	3	
170	2	2	3	2	4	3	4	3	

FAST bi-metal self-drilling screws (JF5). Screws shall be installed per corresponding ICC-ES evaluation report (report number 0276). See Appendix for further information.

Scenarios with “N.G.” specified may have design loads in excess of the allowable capacity of 4 screws and require a site specific analysis.

to the thickness of the metal roofing. Roofs with a thicker gage than 24 may conservatively use the results shown for a 24 gage roof. Roofs with a thinner gage than 26 are or further information on Roof Zones.

ASCE 7-05 – Allowable Ground Snow Load (P_g) – 60 Cell Modules

Exposure C, Occupancy II				Exposure B, Occupancy III			
Roof Pitch 1:12 to 5:12				Roof Pitch 1:12 to 5:12			
Allowable Ground Snow (p_g) Load (psf)		24-Gage		Allowable Ground Snow (p_g) Load (psf)		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	26-Gage	Mid Zone	Edge Zone	Mid Zone
	35	35	35	35	35	35	35
	35	35	35	35	35	35	35
	35	35	35	35	35	35	35
	35	35	35	35	35	35	35
	35	35	35	35	35	35	35
	35	35	35	35	35	35	35
Roof Pitch 6:12 to 12:12				Roof Pitch 6:12 to 12:12			
Allowable Ground Snow (p_g) Load (psf)		24-Gage		Allowable Ground Snow (p_g) Load (psf)		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	26-Gage	Mid Zone	Edge Zone	Mid Zone
	50	50	50	50	50	50	50
	50	50	50	50	50	50	50
	50	50	50	50	50	50	50
	50	50	50	50	50	50	50
	50	50	50	50	50	50	50
	50	50	50	45	50	45	50
ASCE 7-05				ASCE 7-05			
Wind Speed (MPH)				Wind Speed (MPH)			
	90	90	90	90	90	90	90
	100	100	100	100	100	100	100
	110	110	110	110	110	110	110
	120	120	120	120	120	120	120
	135	135	135	135	135	135	135
	150	150	150	150	150	150	150

allowed per loading scenario based on the worst-case compression forces transferred to the roof. See section 3.5 for further information.
 e for certain roof tilts. Higher ground snow loads may be allowed based on the exact roof tilt but a site specific analysis is required to determine this.

ASCE 7-05 – Allowable Ground Snow Load (P_g) – 72 Cell Modules

Exposure C, Occupancy II									
Roof Pitch 1:12 to 5:12									
ASCE 7-05		Allowable Ground Snow (p_g) Load (psf)				24-Gage			
Wind Speed (MPH)		26-Gage		24-Gage		26-Gage		24-Gage	
		Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
90		30	30	30	30	30	30	30	30
100		30	30	30	30	30	30	30	30
110		30	30	30	30	30	30	30	30
120		30	30	30	30	30	30	30	30
135		30	30	30	30	30	30	30	30
150		30	30	30	30	30	30	30	30
Roof Pitch 6:12 to 12:12									
ASCE 7-05		Allowable Ground Snow (p_g) Load (psf)				24-Gage			
Wind Speed (MPH)		26-Gage		24-Gage		26-Gage		24-Gage	
		Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
90		40	40	40	40	40	40	40	40
100		40	40	40	40	40	40	40	40
110		40	40	40	40	40	40	40	40
120		40	40	40	40	40	40	40	40
135		40	40	40	40	40	40	40	40
150		35	40	40	35	40	40	35	40

Exposure B, Occupancy III									
Roof Pitch 1:12 to 5:12									
ASCE 7-05		Allowable Ground Snow (p_g) Load (psf)				26-Gage			
Wind Speed (MPH)		26-Gage		24-Gage		26-Gage		24-Gage	
		Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
90		30	30	30	30	30	30	30	30
100		30	30	30	30	30	30	30	30
110		30	30	30	30	30	30	30	30
120		30	30	30	30	30	30	30	30
135		30	30	30	30	30	30	30	30
150		30	30	30	30	30	30	30	30
Roof Pitch 6:12 to 12:12									
ASCE 7-05		Allowable Ground Snow (p_g) Load (psf)				26-Gage			
Wind Speed (MPH)		26-Gage		24-Gage		26-Gage		24-Gage	
		Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
90		40	40	40	40	40	40	40	40
100		40	40	40	40	40	40	40	40
110		40	40	40	40	40	40	40	40
120		40	40	40	40	40	40	40	40
135		40	40	40	40	40	40	40	40
150		35	40	40	35	40	40	35	40

allowed per loading scenario based on the worst-case compression forces transferred to the roof. See section 3.5 for further information.
 e for certain roof tilts. Higher ground snow loads may be allowed based on the exact roof tilt but a site specific analysis is required to determine this.

ASCE 7-10 – Allowable Ground Snow Load (P_g) – 60 Cell Modules

Exposure C, Occupancy II		Exposure B, Occupancy III	
Roof Pitch 1:12 to 5:12			
Allowable Ground Snow (p_g) Load (psf)		Allowable Ground Snow (p_g) Load (psf)	
6-Gage	24-Gage	26-Gage	24-Gage
Mid Zone	Mid Zone	Edge Zone	Mid Zone
35	35	35	35
35	35	35	35
35	35	35	35
35	35	35	35
35	35	35	35
35	35	35	35
Roof Pitch 6:12 to 12:12			
Allowable Ground Snow (p_g) Load (psf)		Allowable Ground Snow (p_g) Load (psf)	
6-Gage	24-Gage	26-Gage	24-Gage
Mid Zone	Mid Zone	Edge Zone	Mid Zone
50	50	50	50
50	50	50	50
50	50	50	50
50	50	50	50
50	50	50	50
50	50	50	50
Roof Pitch 1:12 to 5:12			
ASCE 7-10		ASCE 7-10	
Wind Speed (MPH)		Wind Speed (MPH)	
115		115	
120		120	
140		140	
150		150	
160		160	
170		170	
Roof Pitch 6:12 to 12:12			
ASCE 7-10		ASCE 7-10	
Wind Speed (MPH)		Wind Speed (MPH)	
115		115	
120		120	
140		140	
150		150	
160		160	
170		170	
Allowability			
26-Gage		26-Gage	
Edge Zone		Edge Zone	
30		45	
30		45	
30		45	
30		45	
30		45	
30		45	

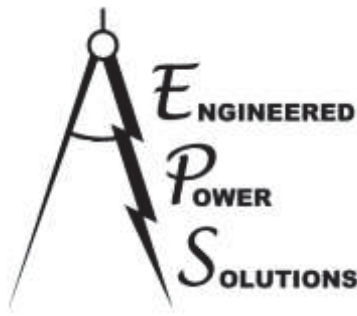
allowed per loading scenario based on the worst-case compression forces transferred to the roof. See section 3.5 for further information.
 e for certain roof tilts. Higher ground snow loads may be allowed based on the exact roof tilt but a site specific analysis is required to determine this.

ASCE 7-10 – Allowable Ground Snow Load (P_g) – 72 Cell Modules

Exposure C, Occupancy II									
Roof Pitch 1:12 to 5:12									
Allowable Ground Snow (p_g) Load (psf)		24-Gage		26-Gage		24-Gage		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
	30	30	30	30	30	30	30	30	30
	30	30	30	30	30	30	30	30	30
	30	30	30	30	30	30	30	30	30
	30	30	30	30	30	30	30	30	30
	30	30	30	30	30	30	30	30	30
Roof Pitch 6:12 to 12:12									
Allowable Ground Snow (p_g) Load (psf)		24-Gage		26-Gage		24-Gage		26-Gage	
6-Gage	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone
	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40	40
	40	40	40	40	40	40	40	40	40
Roof Pitch 1:12 to 5:12									
ASCE 7-10		Wind Speed (MPH)		115		120		140	
ASCE 7-10		Wind Speed (MPH)		150		160		170	
ASCE 7-10		Wind Speed (MPH)		115		120		140	
ASCE 7-10		Wind Speed (MPH)		150		160		170	
Roof Pitch 6:12 to 12:12									
ASCE 7-10		Wind Speed (MPH)		115		120		140	
ASCE 7-10		Wind Speed (MPH)		150		160		170	
ASCE 7-10		Wind Speed (MPH)		115		120		140	
ASCE 7-10		Wind Speed (MPH)		150		160		170	

allowed per loading scenario based on the worst-case compression forces transferred to the roof. See section 3.5 for further information.

for certain roof tilts. Higher ground snow loads may be allowed based on the exact roof tilt but a site specific analysis is required to determine this.



3.0 – Renusol MS Roof Mounting System Calculations

The Renusol MS Roof Mounting System anchors the PV modules to the roofs of structures with trapezoidal steel sheet roofing using a series of clamps that attach to a clamp base which is screwed directly into the rib of the sheet roofing. Clamp bases occur at each of the four (4) corners of the modules giving end clamps a tributary area of $\frac{1}{4}$ of a modules and middle clamps a tributary area of $\frac{1}{4}$ of a module on each side for a total tributary are of $\frac{1}{2}$ of a module. The following sections address the various design loads and parameters provided by Renusol to be addressed in this packet. The results for all scenarios are provided in the previous tables. The following pages provide descriptions of the design methodology used as well as an example calculation using a specific set of parameters.

For the example calculations, a set of parameters have been chosen which may or may not represent an actual in-field scenario but will illustrate the design processed used for all provided parameters/scenarios.

- Example Scenario Design Parameters:
 - *Local Code:* IBC referencing ASCE 7-05
 - *Module Type:* 60-Cell Modules
 - *Wind Exposure Category:* C
 - *Building Occupancy:* II
 - *Roof Pitch:* 3:12 ($\approx 14^\circ$)
 - *Building Footprint:* 100 ft. x 50 ft.
 - *Steel Sheet Roof Thickness:* 26 Gage
 - *Building Ht.:* 25 ft. (grade to highest point of PV installation)
 - *Design Wind Speed:* 90 MPH
 - *Design Ground Snow Load:* 20 psf

Note: It is the solar designer/installer or owner's responsibility to determine the site specific design parameters of each site based on the current governing building code and/or local jurisdiction's requirements. EPS is not responsible for incorrect use of the summary tables or using incorrect design parameters.

3.1 – Roof Zones

Wind forces are determined in accordance with ASCE 7-05 (or ASCE 7-10) Section 6.5.12.2 (7-10: Section 28.4.1) which is the recommended method by the Solar America Board for Codes and Standards for flush roof-mounted PV systems. In accordance with Figure 6-10 (Figure 28.4-1), the roof has been broken up into zones, most notably a roof “Edge Zone” and a “Mid-Roof Zone”. See Figure 1 below.

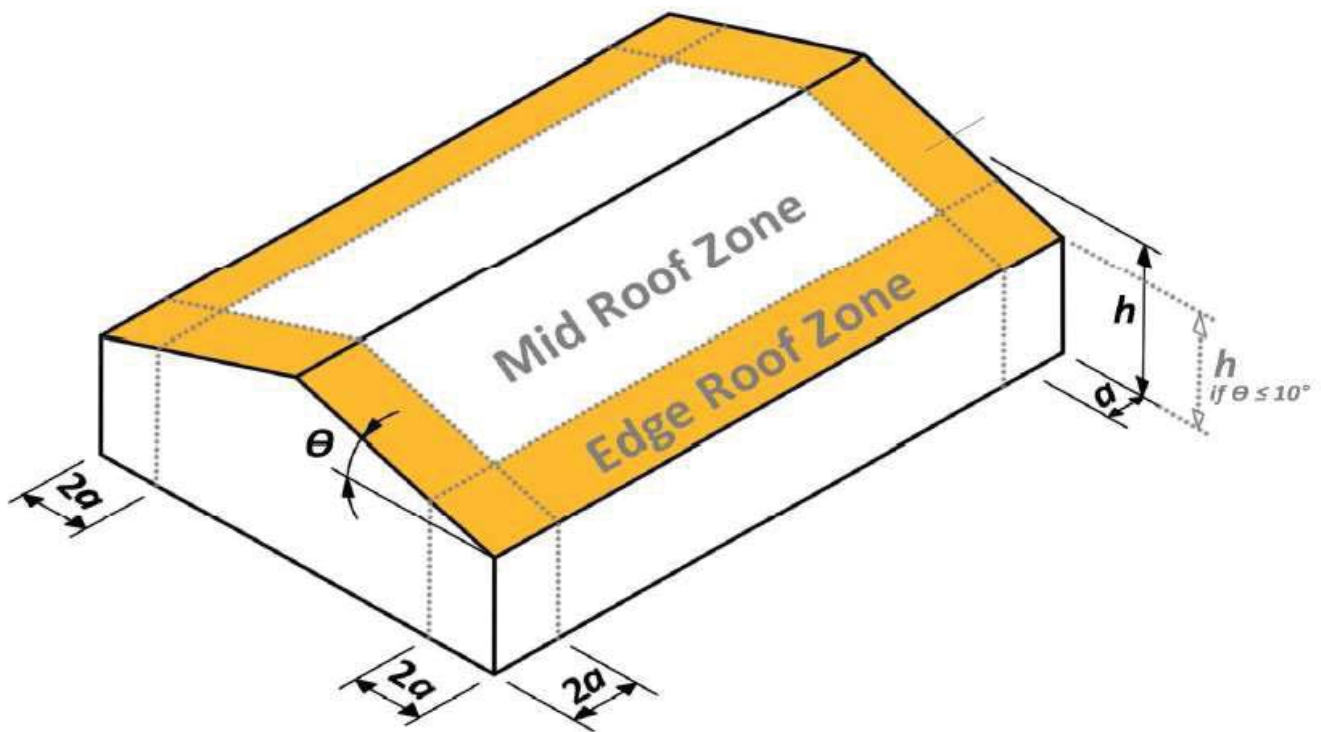


Figure 1: Roof Zones

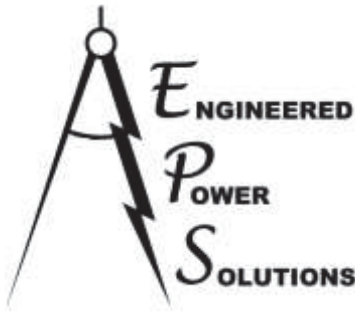
The term “a” is determined in accordance with note 9 of Figure 6-10 (Figure 28.4-1):

- a: 10 percent of least horizontal dimension or $0.4h$, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft.
- h: Mean roof height (ft.) except eave height shall be used for roof tilts $\leq 10^\circ$.

Example Scenario Calculation:

a: Smaller of $0.1 \cdot 50 \text{ ft.} = 5.0 \text{ ft.}$ or $0.4 \cdot 25 \text{ ft.} = 10 \text{ ft.}$ but not less than $0.04 \cdot 50 \text{ ft.} = 2 \text{ ft.}$ or 3 ft.

→ Therefore $a = 5.0 \text{ ft.}$ and the roof edge zone would be $2a = 10.0 \text{ ft.}$



3.2 – Dead Loads

The dead load supported by each clamp base consists of the weight of the modules used over the tributary area of the base clamp. Using a typical middle (mid) clamp tributary area of $\frac{1}{2}$ a module, this would equate to $\frac{1}{2}$ of the module weight. The 60 cell modules are assumed to weigh 40 lbs. and the 72 cell modules are assumed to weigh 59 lbs. The pitch of the roof affects how much of this load is applied to the clamp base vertically and how much is applied horizontally. For the design table uplift calculations, the lowest tilt in each roof pitch range has been used.

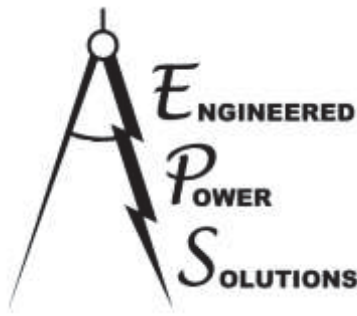
Example Scenario Calculation:

60 cell module (40 lbs.) on a 3:12 pitch.

*Mid clamps support $0.5 * 40 \text{ lbs.} = 20 \text{ lbs.}$*

Tilt of 1:12 is the lowest in category but 0° conservatively used

*$20 \text{ lbs.} * \cos(0^\circ) = 20 \text{ lbs.}$*



3.3 – Wind Uplift Forces

Per Section 6.5.12.2, (Section 28.4.1), the wind velocity pressure is determined by Equation 6-18 (Eq. 28.4-1):

$$p = q_h[(GC_{pf}) - (GC_{pi})] \text{ (psf)}$$

Where q_h , the velocity pressure evaluated at height h , is given by Section 6.5.10 (27.3.2) and Equation 6-15 (Eq. 27.3-1):

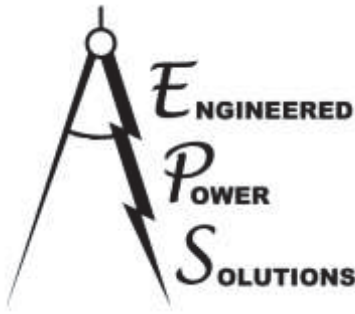
- $q_h = 0.00256K_zK_{zt}K_dV^2I$ (ASCE 7-05)
- $q_h = 0.00256K_zK_{zt}K_dV^2$ (ASCE 7-10)
 - K_z = Velocity Pressure Exposure Coefficient per Table 6-3 (28.3-1)
 - 0.70 used for Exposure B
 - 0.98 used for Exposure C
 - K_{zt} = Topographic Factor per Eq. 6-3 & Fig. 6-4 (Eq. 26.8-1 & Fig. 26.8-1)
 - These packets assume no topographic factor ($K_{zt} = 1.00$)
 - K_d = Wind Directionality Factor per Table 6-4 (26.6-1)
 - 0.85 used in all cases
 - V = 3 Second Gust Wind Speed per Fig. 6-1 (26.5-1) or local jurisdiction
 - I = Wind Importance Factor per Table 6-1 (ASCE 7-05 only)
 - 1.00 used for Occupancy Category II Buildings
 - 1.15 used for Occupancy Category III Buildings

GC_{pf} is the external pressure coefficient given in Figure 6-10 (28.4-1).

GC_{pi} is the internal pressure coefficient which in the case of this racking system is zero since air is able to flow freely above and below the modules.

The GC_{pf} Coefficients are broken up by roof tilt and building surface location (mid or edge zones). Each zone has an associated worst-case uplift coefficient as well as a worst-case downward coefficient (discussed in more detail later in this packet).

- External Pressure Coefficients (GC_{pf}):
 - Building Surface 2 and 3 (Mid Zone)
 - Roof Tilt 0:12 to 5:12 (0° to 22.6°): -0.69
 - Roof Tilt 6:12 to 12:12 (26.6° to 45°): -0.48
 - Downward (compression) case: 0.21
 - Building Surface 2E and 3E (Edge Zone)
 - Roof Tilt 0:12 to 5:12 (0° to 22.6°): -1.07
 - Roof Tilt 6:12 to 12:12 (26.6° to 45°): -0.69
 - Downward (compression) case: 0.27



Example Scenario Calculation:

$$q_h = 0.00256(0.98)(1.0)(0.85)(90)^2(1.0) = 17.27 \text{ psf}$$

With a 3:12 tilt, this produces wind uplift forces of:

- *Mid-Roof Zone:*
 - *Uplift Force: 17.27 psf * -0.69 = -11.92 psf*
- *Edge Zone:*
 - *Uplift Force: 17.27 psf * -1.07 = -18.48 psf*

Based on the area of a 60 cell module (17.76 ft²) the maximum uplift forces imposed on the modules have been calculated on a per module basis:

- *Mid-Roof Zone:*
 - *Uplift Force: -11.92 psf * 17.76 ft² = -212 lbs./module*
- *Edge Zone:*
 - *Uplift Force: -18.48 psf * 17.76 ft² = -328 lbs./module*

Note: Wind loads act normal to the surface (away for uplift; towards for compression)

Per clamp base, the following loads are calculated:

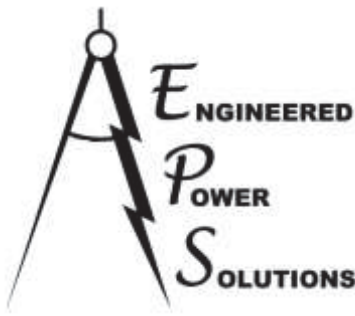
- *Mid-Roof Zone:*
 - *Uplift Force: -212 lbs. * 0.5 = -106 lbs./base*
- *Edge Zone:*
 - *Uplift Force: -328 lbs. * 0.5 = -164 lbs./base*

Using the worst-case wind uplift basic load combination (allowable stress design) of 0.6D+W (0.6D+0.6W) as dictated in Section 2.4.1 (Section 2.4.1) provides the governing wind uplift design load per base. Because the wind loads are calculated normal to the module, the dead loads must be broken into components to determine the dead load normal to the module.

Example Scenario Calculation:

- *Mid-Roof Zone:*
 - *Uplift Force: -106 lbs. + 0.6*(40 lbs.)*cos(22.62) = -83.7 lbs.*
- *Edge Zone:*
 - *Uplift Force: -164 lbs. + 0.6*(40 lbs.)*cos(22.62) = -142.0 lbs.*

Note: Even though the example scenario tilt is 3:12 (14.04°) a tilt of 5:12 (22.62°) has been used as this would be the most conservative for the 1:12 to 5:12 pitch category.



3.4 – Allowable Screw Capacity

The screws to be used with this product are the EJOT EJOFAST bi-metal self-drilling screws (JF3). They are to be installed in accordance with their current Evaluation Report (Report Number 0276) which is provided in the appendix of this packet for reference.

As listed in the Evaluation Report, the product is rated for the following allowable design values:

- JF3 Screw Tensile Strength (Allowable Strength (ASD Level)):
 - 24 Gage Roofing: 99 lbs.
 - 26 Gage Roofing: 63 lbs.
- JF3 Screw Shear Strength (Allowable Strength (ASD Level)):
 - 24 Gage Roofing: 236 lbs.
 - 26 Gage Roofing: 119 lbs.

Dividing the worst-case uplift forces at each clamp base by the allowable capacity of the screws determines the number of screws needed at each clamp base (each clamp base can accommodate between 2 and 4 screws).

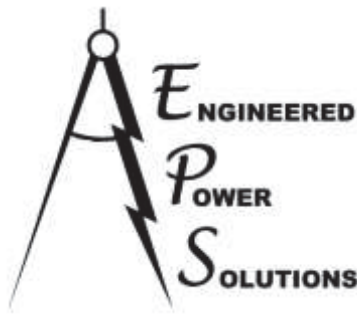
Example Scenario Calculation:

With a 26 gage roof:

- *Mid-Roof Zone:*
 - $-83.7 \text{ lbs.} / 63 \text{ lbs.} = 1.33 \text{ screws} \rightarrow \text{Use a min. of (2) screws per base}$
- *Edge Zone:*
 - $-142.0 \text{ lbs.} / 63 \text{ lbs.} = 2.25 \text{ screws} \rightarrow \text{Use a min. of (3) screws per base}$

Note: The addition of this flush mounted PV system does not affect the internal pressure coefficients of the existing roof and the external pressure coefficients will remain the same since the system is flush mounted to the roof. Therefore this racking system does not increase the loads on the roofing-to-substructure attachments.

It is assumed the original roof sheet anchorage to the existing roof joists/members was designed and installed correctly for the worst-case wind uplift pressures (internal and external) as dictated by the governing building code.



3.5 – Ground Snow Load Capacity

It is always assumed that the existing building was designed correctly for the site specific design snow loads per the governing building code. The addition of a new rooftop PV system (mounted flush with the roof) does not change the amount of snow that falls on the roof but it can change how the snow load is distributed to the roof as the modules transfer the snow loads as numerous point loads through the clamp bases rather than an area load over the roof.

The design Roof Live Load is interchangeable with the design Roof Snow Load as noted in the load combinations. Table 4-1 of ASCE 7 requires that roofs are designed for a concentrated Roof Live Load of 300 lbs. at any location subject to maintenance workers. Because Roof Live Loads and Snow Loads are interchangeable it can be assumed that the roof should have been originally designed for a 300 lb. point load due to Roof Live Load or Snow Loads. Therefore, in order to keep the roof stresses within the original design intent, the maximum compression point load allowed on the existing roof at any clamp base is 300 lbs. Based on this limit, the allowable ground snow load can be calculated for each scenario (while also taking into account compression loads due to dead load and downward wind forces).

The sloped roof snow load (p_s) is determined as follows:

- $p_s = C_s * p_f$ Eq. 7-2 (Eq. 7.4-1)
 - Slope Factor C_s : Figure 7-2
 - Slopes up to 15° (≈3:12): 1.00
 - 26.6° (≈6:12): 0.79
 - 45° (12:12): 0.48
 - Flat Roof Snow Load $p_f = 0.7 * C_e * C_t * I * p_g$ Eq. 7-1 (Eq.7.3-1)
 - Exposure Factor C_e : 1.0 Table 7-2
 - Thermal Factor C_t : 1.2 Table 7-3
 - Snow Importance Factor (I): Table 7-4 (Table 1.5-2)
 - Occ. Cat. II 1.0
 - Occ. Cat. III 1.1

But not less than $(I) * p_g$ when p_g is 20 psf or less
 Or $20 * (I)$ when p_g exceeds 20 psf

Example Scenario Calculation:

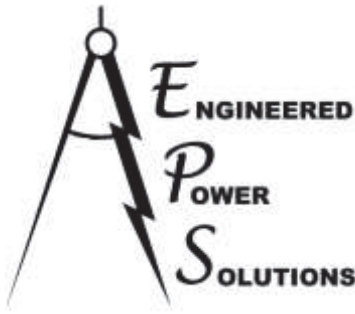
$$\text{Sloped Roof Snow} = 1.00 * p_f$$

$$\text{Where } p_f = 0.7 * 1.0 * 1.2 * 1.0 * 20 \text{ psf} = 16.8 \text{ psf}$$

$$\text{But not less than } 1.0 * 20 \text{ psf} = 20 \text{ psf} \rightarrow \text{Use } 20 \text{ psf}$$

$$\text{Sloped Roof Snow} = 1.00 * 20 \text{ psf} = 20 \text{ psf}$$

$$\text{Snow Load per Clamp Base} = 20 \text{ psf} * 17.76 \text{ ft}^2 / 2 = 177.6 \text{ lbs./base}$$



3.6 – Combined Compression Loads

The governing compression (downward) loads at the clamp bases are from one of multiple load combinations. The governing load combination is dependant on the specific design parameters but the governing compression load combination will be from one of the following load combinations per Section 2.4.1:

- ASCE 7-05:
 - D
 - D+S
 - D+W
 - $D+0.75S+0.75W$

- ASCE 7-10:
 - D
 - D+S
 - D+0.6W
 - $D+0.75S+0.75(0.6W)$

Example Scenario Calculation:

Compressive loads at Clamp Base:

D: 20 lbs.

S: 177.6 lbs.

W: 0 lbs. (no downward pressure possible per Figure 6-10 (28.4-1))

Worst-Case Load Combination: $D+S = 20 \text{ lbs.} + 177.6 \text{ lbs.} = 197.6 \text{ lbs.}$

197.6 lbs. is less than 300 lbs.; therefore the addition of the proposed MS system will not produce loads on the existing roof greater than what the existing roof should have been originally designed for.

The following pages provide the resultant loads for all of the design parameters/scenarios under the various load cases.

ASCE 7-05 – Uplift Tables – 60 Cell Modules

Exposure C, Occupancy II																																						
Roof Pitch 1:12 to 5:12																																						
Uplift Force on Brackets (lbs.)			24-Gage			26-Gage			24-Gage			26-Gage																										
6-Gage			Mid Zone			Edge Zone			Mid Zone			Edge Zone																										
Wind Speed (MPH)			90			100			110			120			135			150																				
			-53.5	-71.2	-90.8	-112.3	-148.0	-187.9	-95.1	-122.6	-153.0	-186.3	-241.6	-303.5	-142.0	-180.5	-223.0	-269.7	-347.2	-433.8	-83.7	-108.5	-136.0	-166.0	-216.0	-271.9	-142.0	-180.5	-223.0	-269.7	-347.2	-433.8	-83.7	-108.5	-136.0	-166.0	-216.0	-271.9
Roof Pitch 6:12 to 12:12																																						
6-Gage			Mid Zone			Edge Zone			Mid Zone			Edge Zone																										
Wind Speed (MPH)			90			100			110			120			135			150																				
			-35.6	-48.0	-61.6	-76.5	-101.4	-129.1	-58.6	-76.4	-96.0	-117.4	-153.1	-193.0	-88.9	-113.7	-141.1	-171.2	-221.2	-277.1	-56.7	-73.9	-93.0	-113.9	-148.7	-187.6	-88.9	-113.7	-141.1	-171.2	-221.2	-277.1	-56.7	-73.9	-93.0	-113.9	-148.7	-187.6

Exposure B, Occupancy III																																						
Roof Pitch 1:12 to 5:12																																						
Uplift Force on Brackets (lbs.)			24-Gage			26-Gage			24-Gage			26-Gage																										
6-Gage			Mid Zone			Edge Zone			Mid Zone			Edge Zone																										
Wind Speed (MPH)			90			100			110			120			135			150																				
			-53.5	-71.2	-90.8	-112.3	-148.0	-187.9	-95.1	-122.6	-153.0	-186.3	-241.6	-303.5	-142.0	-180.5	-223.0	-269.7	-347.2	-433.8	-83.7	-108.5	-136.0	-166.0	-216.0	-271.9	-142.0	-180.5	-223.0	-269.7	-347.2	-433.8	-83.7	-108.5	-136.0	-166.0	-216.0	-271.9
Roof Pitch 6:12 to 12:12																																						
6-Gage			Mid Zone			Edge Zone			Mid Zone			Edge Zone																										
Wind Speed (MPH)			90			100			110			120			135			150																				
			-35.6	-48.0	-61.6	-76.5	-101.4	-129.1	-58.6	-76.4	-96.0	-117.4	-153.1	-193.0	-88.9	-113.7	-141.1	-171.2	-221.2	-277.1	-56.7	-73.9	-93.0	-113.9	-148.7	-187.6	-88.9	-113.7	-141.1	-171.2	-221.2	-277.1	-56.7	-73.9	-93.0	-113.9	-148.7	-187.6

the module face and are based on the 0.6D+W load combination.
 or further information on Roof Zones.

ASCE 7-05 – Uplift Tables – 72 Cell Modules

Uplift Force on Brackets (lbs.)			
6-Gage	24-Gage		Mid Zone
	Edge Zone	Mid Zone	
9	-56.7	-105.9	-56.7
4	-77.7	-138.4	-77.7
3	-100.8	-174.3	-100.8
7	-126.2	-213.7	-126.2
1	-168.4	-279.1	-168.4
3	-215.6	-352.3	-215.6

Uplift Force on Brackets (lbs.)			
26-Gage	24-Gage		Mid Zone
	Edge Zone	Mid Zone	
9	-161.3	-92.4	-92.4
100	-206.9	-121.8	-121.8
110	-257.2	-154.2	-154.2
120	-312.2	-189.7	-189.7
135	-403.9	-248.8	-248.8
150	-506.3	-314.9	-314.9

Uplift			
26-Gage	24-Gage		Mid Zone
	Edge Zone	Mid Zone	
9	-77.7	-105.9	-77.7
4	-100.8	-138.4	-100.8
3	-126.2	-174.3	-126.2
7	-168.4	-213.7	-168.4
1	-215.6	-279.1	-215.6
3	-262.8	-352.3	-262.8

Exposure C, Occupancy II

Roof Pitch 1:12 to 5:12

ASCE 7-05 Wind Speed (MPH)	26-Gage		24-Gage	
	Edge Zone	Mid Zone	Edge Zone	Mid Zone
90	-161.3	-92.4	-161.3	-92.4
100	-206.9	-121.8	-206.9	-121.8
110	-257.2	-154.2	-257.2	-154.2
120	-312.2	-189.7	-312.2	-189.7
135	-403.9	-248.8	-403.9	-248.8
150	-506.3	-314.9	-506.3	-314.9

Roof Pitch 6:12 to 12:12

ASCE 7-05 Wind Speed (MPH)	26-Gage		24-Gage	
	Edge Zone	Mid Zone	Edge Zone	Mid Zone
90	-100.1	-62.0	-100.1	-62.0
100	-129.4	-82.4	-129.4	-82.4
110	-161.9	-105.0	-161.9	-105.0
120	-197.4	-129.7	-197.4	-129.7
135	-256.5	-170.8	-256.5	-170.8
150	-322.5	-216.7	-322.5	-216.7

Exposure B, Occupancy III

Roof Pitch 1:12 to 5:12

ASCE 7-05 Wind Speed (MPH)	26-Gage		Edge Zone
	Edge Zone	Mid Zone	
90	-126.7	-164.1	-126.7
100	-164.1	-205.4	-164.1
110	-205.4	-250.7	-205.4
120	-250.7	-325.9	-250.7
135	-325.9	-410.0	-325.9
150	-410.0	-506.3	-410.0

Roof Pitch 6:12 to 12:12

ASCE 7-05 Wind Speed (MPH)	26-Gage		Edge Zone
	Edge Zone	Mid Zone	
90	-77.7	-101.8	-77.7
100	-101.8	-128.5	-101.8
110	-128.5	-157.7	-128.5
120	-157.7	-206.2	-157.7
135	-206.2	-260.4	-206.2
150	-260.4	-322.5	-260.4

the module face and are based on the 0.6D+W load combination.

for further information on Roof Zones.

ASCE 7-10 – Uplift Tables – 60 Cell Modules

Uplift Force on Brackets (lbs.)		24-Gage	
		Edge Zone	Mid Zone
6-Gage			
Line	Mid Zone	Edge Zone	Mid Zone
1	-51.9	-92.7	-51.9
2	-58.5	-102.9	-58.5
3	-87.6	-148.1	-87.6
4	-103.9	-173.3	-103.9
5	-121.2	-200.2	-121.2
6	-139.7	-228.8	-139.7

Uplift Force on Brackets (lbs.)		24-Gage	
		Edge Zone	Mid Zone
6-Gage			
Line	Mid Zone	Edge Zone	Mid Zone
1	-34.6	-57.1	-34.6
2	-39.1	-63.7	-39.1
3	-59.4	-92.8	-59.4
4	-70.7	-109.0	-70.7
5	-82.8	-126.4	-82.8
6	-95.6	-144.9	-95.6

Uplift Force on Brackets (lbs.)		26-Gage		24-Gage	
		Edge Zone	Mid Zone	Edge Zone	Mid Zone
Roof Pitch 1:12 to 5:12					
ASCE 7-10					
Wind Speed (MPH)		Edge Zone	Mid Zone	Edge Zone	Mid Zone
115		-138.6	-81.5	-138.6	-81.5
120		-152.9	-90.8	-152.9	-90.8
140		-216.2	-131.5	-216.2	-131.5
150		-251.4	-154.3	-251.4	-154.3
160		-289.1	-178.6	-289.1	-178.6
170		-329.2	-204.4	-329.2	-204.4

Uplift Force on Brackets (lbs.)		26-Gage		24-Gage	
		Edge Zone	Mid Zone	Edge Zone	Mid Zone
Roof Pitch 6:12 to 12:12					
ASCE 7-10					
Wind Speed (MPH)		Edge Zone	Mid Zone	Edge Zone	Mid Zone
115		-86.7	-55.2	-86.7	-55.2
120		-95.9	-61.6	-95.9	-61.6
140		-136.7	-89.9	-136.7	-89.9
150		-159.4	-105.8	-159.4	-105.8
160		-183.8	-122.7	-183.8	-122.7
170		-209.6	-140.7	-209.6	-140.7

the module face and are based on the 0.6D+0.6W load combination.

for further information on Roof Zones.

ASCE 7-10 – Uplift Tables – 72 Cell Modules

Uplift Force on Brackets (lbs.)		24-Gage	
		Edge Zone	Mid Zone
1	-54.9	-103.1	-54.9
1	-62.6	-115.1	-62.6
5	-97.1	-168.5	-97.1
3	-116.3	-198.3	-116.3
1	-136.8	-230.1	-136.8
0	-158.6	-264.0	-158.6

Uplift Force on Brackets (lbs.)		24-Gage	
		Edge Zone	Mid Zone
1	-35.9	-62.5	-35.9
1	-41.3	-70.3	-41.3
7	-65.2	-104.7	-65.2
9	-78.6	-123.9	-78.6
1	-92.9	-144.4	-92.9
3	-108.1	-166.3	-108.1

ASCE 7-10	Uplift Force on Brackets (lbs.)		24-Gage	
	Edge Zone	Mid Zone	Edge Zone	Mid Zone
115	-157.4	-89.9	-157.4	-89.9
120	-174.3	-100.8	-174.3	-100.8
140	-249.0	-149.0	-249.0	-149.0
150	-290.7	-175.8	-290.7	-175.8
160	-335.2	-204.6	-335.2	-204.6
170	-382.7	-235.2	-382.7	-235.2

ASCE 7-10	Uplift Force on Brackets (lbs.)		24-Gage	
	Edge Zone	Mid Zone	Edge Zone	Mid Zone
115	-97.5	-60.2	-97.5	-60.2
120	-108.4	-67.8	-108.4	-67.8
140	-156.6	-101.3	-156.6	-101.3
150	-183.5	-120.0	-183.5	-120.0
160	-212.2	-140.0	-212.2	-140.0
170	-242.8	-161.3	-242.8	-161.3

the module face and are based on the 0.6D+0.6W load combination.

for further information on Roof Zones.

ASCE 7-05 – Governing Compression Tables – 60 Cell Modules

Exposure C, Occupancy II									
Roof Pitch 1:12 to 5:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6
100	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6
110	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6
120	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6
135	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6
150	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6	197.6
Roof Pitch 6:12 to 12:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	176.8	176.8	176.8	176.8	176.8	176.8	176.8	176.8	176.8
100	176.8	176.8	176.8	176.8	176.8	176.8	176.8	176.8	176.8
110	176.8	176.8	176.8	176.8	183.4	176.8	183.4	176.8	176.8
120	176.8	176.8	176.8	176.8	192.3	180.0	192.3	180.0	180.0
135	176.8	176.8	187.0	191.4	206.9	191.4	206.9	191.4	191.4
150	185.0	198.7	198.7	204.1	223.3	204.1	223.3	204.1	204.1
Exposure B, Occupancy III									
Roof Pitch 1:12 to 5:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4
100	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4
110	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4
120	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4
135	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4
150	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4	215.4
Roof Pitch 6:12 to 12:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6
100	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6
110	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6
120	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6
135	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6
150	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6	192.6

Normal to the module face and are based on the worst-case combination of D; D+W; D+S; or D+0.75W+0.75S

For further information on Roof Zones.

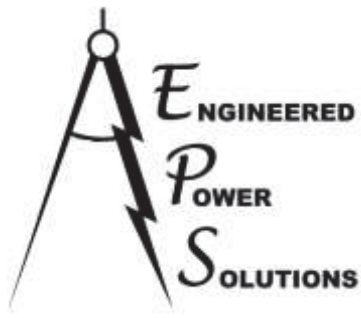
ASCE 7-05 – Governing Compression Tables – 72 Cell Modules

Exposure C, Occupancy II									
Roof Pitch 1:12 to 5:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5
100	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5
110	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5
120	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5
135	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5
150	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5	239.5
Roof Pitch 6:12 to 12:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	214.2	214.2	214.2	214.2	214.2	214.2	214.2	214.2	214.2
100	214.2	214.2	214.2	214.2	214.2	214.2	214.2	214.2	214.2
110	214.2	214.2	222.1	214.2	222.1	214.2	222.1	214.2	214.2
120	214.2	214.2	232.5	218.0	232.5	218.0	232.5	218.0	218.0
135	214.2	214.2	249.8	231.5	249.8	231.5	249.8	231.5	231.5
150	223.9	240.1	269.2	246.5	269.2	246.5	269.2	246.5	246.5

Exposure B, Occupancy III									
Roof Pitch 1:12 to 5:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4
100	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4
110	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4
120	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4
135	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4
150	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4	260.4
Roof Pitch 6:12 to 12:12									
Compression Force on Brackets (lbs.)		24-Gage		26-Gage		24-Gage		26-Gage	
Wind Speed (MPH)	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone	Mid Zone	Edge Zone
90	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9
100	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9
110	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9
120	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9
135	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9
150	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9	232.9

Normal to the module face and are based on the worst-case combination of D; D+W; D+S; or D+0.75W+0.75S

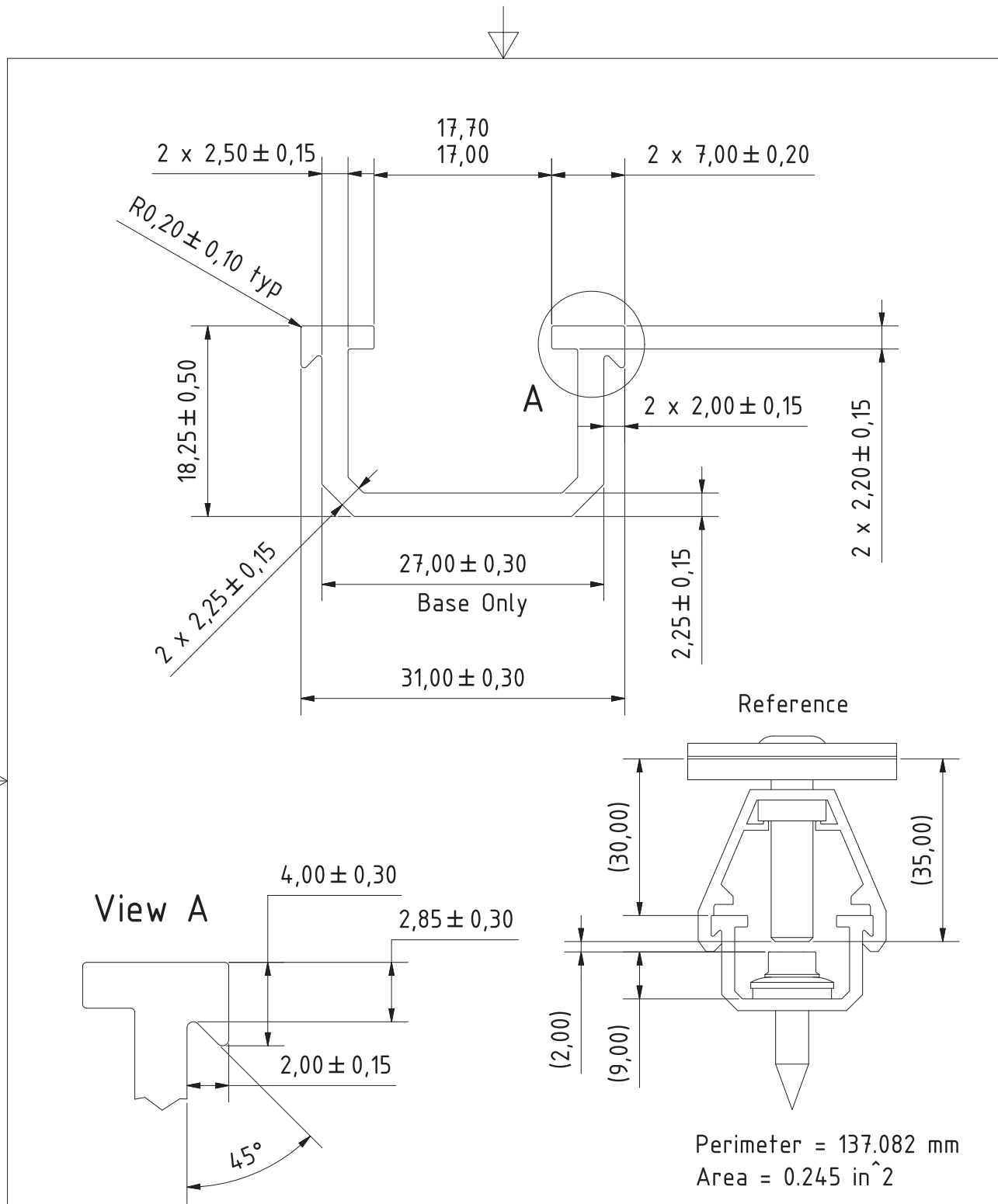
for further information on Roof Zones.



ENGINEERED POWER SOLUTIONS
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APPENDIX
(FOR REFERENCE ONLY)



Section Properties			
Ix (cm ⁴)		ix (cm)	
Wx(cm ³)		iy (cm)	
Iy (cm ⁴)		A (cm ²)	
Wy(cm ³)			
Rev	Description	Date	Name

Renusol
Solar Mounting Systems

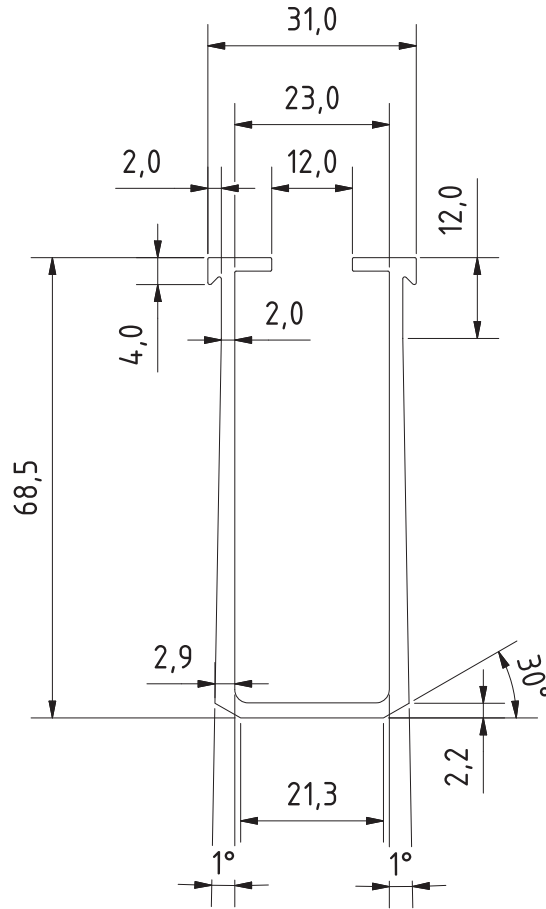
Tolerances according to EN 12020-2

Date: 6/12/2013
Name: dhughes



Renusol America
1292 Logan Circle NW
Atlanta, GA 30318

Scale:	1 : 1	Weight:	0.288 lbs/ft
Material:	EN AW6063 T6		
Part Number:	TBD		
Title:	Renusol MS Rail		
Drawing Number:	TBD	Sheet:	1 / 1
		Sheet Size:	A4

NO EXPOSED EDGES



Perimeter = 352.467 mm
Area = 0.636 in²

Section Properties					Scale:	Weight: 0.763 lb/ft
ix (cm ⁴)		ix (cm)			Material:	EN AW6063 T6
Wy (cm ⁴)		iy (cm)		Part Number:	TBD	
Wx (cm ³)		A (cm ²)		Title:	MS 2.0 concept 2a, profile	
ly (cm ⁴)				Drawing Number:	01052015.2a	Sheet: 1 / 1
Wy (cm ³)						Sheet Size: A4
				 Tolerances according to EN 12020-2 Date: 1/5/2015 Name: dhughes		
				Renusol America 1292 Logan Circle NW Atlanta, GA 30318		
Rev	Description	Date	Name			

EVALUATION REPORT



Report Number: 0276
Originally Issued: 01/2013
Valid Through: 01/2014

DIVISION: 05 – METALS
Section 050523 – Metal Fastenings

REPORT HOLDER:

EJOT BAUBEFESTIGUNGEN GmbH
In der Stockwiese 35
57334 Bad Laasphe
Germany
www.ejot-usa.com
bau@ejot.de

EVALUATION SUBJECT:

EJOT EJOFAST® bi-metal SELF-DRILLING SCREWS JF3

1.0 EVALUATION SCOPE

1.1 Compliance with the following codes

- 2012 International Building Code® (2012 IBC)
- 2009 International Building Code® (2009 IBC)

1.2 Evaluated in accordance with

- ICC-ES Acceptance Criteria for Tapping Screw Fasteners (AC118), approved June 2012

1.3 Property evaluated

- Structural

2.0 USES

The EJOT EJOFAST® bi-metal self-drilling screws are used to resist shear and tension loads in engineered connections for cold-formed steel to cold formed-steel construction with thicknesses ranging from 20ga to 26ga.

3.0 DESCRIPTION

3.1 Product Information: The EJOT EJOFAST® bi-metal self-drilling screws, illustrated in Figure 1 of this report are No. 12 self-drilling screws. The screws have a nominal major shank diameter of 0.217 inch (5.5 mm) and nominal minor shank diameter of 0.161 inch (4.1 mm) with 17 threads per inch. The screws include a hex washer head with a 0.413 inch (10.5 mm) nominal diameter, and a custom drill point. Screws are 1 inch (25 mm) in length. Table 1 provides a description of the screws recognized in this report.

3.2 Material

3.2.1 Screws: The screws described in this report are manufactured from stainless steel conforming to ASTM 304 and in the area of the drill point from carbon steel

conforming to ASTM A 510, Grade 1022, and hardened through induction, and coated with zinc coating.

3.2.2 Cold-Formed Steel Members: Connected members (sheet metal) covered in this report must be manufactured from materials in compliance with the American Iron and Steel Institute *North American Specification for the Design of Cold-Formed Steel Structural Members* (AISI S100). Loads provided in this report are based on the following material properties:

MEMBER THICKNESS DESIGNATION	DESIGN THICKNESS (in.)	MINIMUM YIELD STRESS (psi)	MINIMUM TENSILE STRESS (psi)
26 gage	0.017	33,000	45,000
24 gage	0.023	33,000	45,000
22 gage	0.028	33,000	45,000
20 gage	0.034	33,000	45,000

4.0 DESIGN AND INSTALLATION

4.1 Design:

The nominal, design, and allowable shear and tensile strengths of the screws are provided in Table 2. The nominal shear strength, P_{ss} , and nominal tensile strength, P_{ts} , of the screws are the average ultimate values from testing. The tabulated LRFD design strength and ASD allowable strength values are based on a resistance factor, Φ , and a safety factor, Ω , as defined in AISI S100.

The nominal density, and allowable strengths for shear, pull-over, and pull-out of steel-to-steel connections are provided in Tables 3, 4, and 5, respectively. The resistance factors and safety factors used to determine the LRFD and ASD strengths are determined in accordance with AISI S100.

For connections subject to shear, the lesser of the fastener shear strength (Table 2) and the connection shear strength (Table 3) must be used for design. For connections subject to tension, the least of the tension strength of screws (Table 2), connection pull-over strength (Table 4) and connection pull-out strength (Table 5) must be used for design. Connections subject to combined tension and shear loading must be designed in accordance with Section E4.5 of AISI S100, using strength values found in this report.

The values in the tables are based on a minimum spacing between the centers of fasteners of three times the diameter of the screw, and a minimum distance of 1.5 times the diameter of the screw from the center of a fastener to the edge of any connected part.

EVALUATION REPORT



Report Number: 0276
Originally Issued: 01/2013
Valid Through: 01/2014

4.2 Installation:

Installation of the EJOT EJOFAST® bi-metal self-drilling screws must be in accordance with AISI S100, the manufacturer's published installation instructions and this report. The manufacturer's published installation instructions must be available at the jobsite at all times during the installation.

The screws must be installed perpendicular to the work surface using a tool with maximum recommended speed of 2,500 rpm. The screw must penetrate through the supporting steel with a minimum of three threads protruding past the back side of the supporting steel.

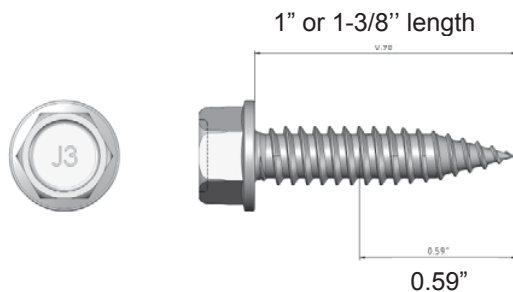


Figure 1 - EJOT EJOFAST® bi-metal SELF-DRILLING SCREW JF3

5.0 CONDITIONS OF USE

The EJOT EJOFAST® bi-metal self-drilling screws described in this report are in compliance with, or are acceptable alternatives to what is specified in, those codes listed in Section 1.0 of this report subject to the following conditions:

- 5.1 Screws must be installed in accordance with AISI S100, the manufacturer's published installation instructions and this report. Where conflict exists between these three documents, this report shall govern. Otherwise, the most restrictive requirement shall cover.
- 5.2 The allowable strengths (ASD) specified in Section 4.1 may not be increased when the screws are used to resist wind or seismic force.
- 5.3 The bi-metal screws must be suitable for the intended use, as determined by a registered design professional.
- 5.4 Calculations to verify conformance with this report must be submitted to the code official for review and approval. The calculations and applicable drawings are to be prepared by a registered design

professional when required by the statutes of the jurisdiction in which the project is proposed.

- 5.5 The connected members must be checked for rupture in accordance with Section E5 of AISI S100.

6.0 EVIDENCE SUBMITTED

Data in accordance with ICC-ES *Acceptance Criteria for Tapping Screw Fasteners (AC118)*, approved June 2012, including test results from laboratories in compliance with ISO/IEC 17025.

7.0 IDENTIFICATION

The EJOT EJOFAST® bi-metal self-drilling screws described in this report are identified with "J3" on the top surface of the screw head, as shown in Figure 1. Packages of screws are labeled with the report holder's name (EJOT), the brand name (EJOFAST®), the model number (JF3-2-5.5X25 or JF3-2-5.5X35), the screw quantity in the package, and the number of the evaluation report (ER-0276).

Richard Beck, PE, CBO, MCP
Director of Uniform Evaluation Service

GP Russ Chaney
CEO, The IAPMO Group

EVALUATION REPORT



Report Number: 0276
 Originally Issued: 01/2013
 Valid Through: 01/2014

Table 1 - Self-Drilling Screw Specifications

Model No.	Designation	Size	Nominal Diameter (mm)	Nominal Screw Length (mm)	Head Style	Nominal Point Length (mm)
EJOT EJOFAST® JF3	5.5 (#12 X 17)	5.5 x 25 (#12 x 1")	5.5 (0.217")	25 (1")	Hex Washer	15 (0.591")
EJOT EJOFAST® JF3	5.5 (#12 X 17)	5.5 x 35 (#12 x 1 3/8")	5.5 (0.217")	35 (1 3/8")	Hex Washer	15 (0.591")

Table 2 - Self-Drilling Screw Strengths (lbs)

Model No.	Nominal Strength		Design Strength (LRFD)		Allowable Strength (ASD)	
	Shear (P _{ss})	Tension (P _{ts})	Shear (P _{ss})	Tension (P _{ts})	Shear (P _{ss})	Tension (P _{ts})
EJOT EJOFAST® JF3	1912	2732	956	1366	637	911

Note - For LRFD, $\Phi = 0.5$. For ASD, $\Omega = 3.0$.

**Table 3 - Self-Drilling Screw Lap-Joint Connection
 Shear Strength limited by Tilting and Bearing (lbs)**

Model No.	Strength	Minimum base steel thickness			
		26 gage	24 gage	22 gage	20 gage
EJOT EJOFAST® JF3	Nominal Strength, P _{ns}	490	745	1018	1056
	Design Strength (LRFD), ΦP_{ns}	190	377	459	442
	Allowable Strength (ASD), P _{ns} / Ω	119	236	287	282

Notes: For 26 gage, $\Phi = 0.6$ and $\Omega = 2.7$. For 24 gage, $\Phi = 0.6$ and $\Omega = 2.5$.
 For 22 gage, $\Phi = 0.6$ and $\Omega = 2.5$. For 20 gage, $\Phi = 0.5$ and $\Omega = 3.0$.

**Table 4 - Self-Drilling Screw Lap-Joint Connection
 Tensile Strength limited by Pull-Over (lbs)**

Model No.	Strength	Minimum base steel thickness of member not in Contact with screw head			
		26 gage	24 gage	22 gage	20 gage
EJOT EJOFAST® JF3	Nominal Strength, P _{ns}	473	775	888	1188
	Design Strength (LRFD), ΦP_{ns}	169	366	373	496
	Allowable Strength (ASD), P _{ns} / Ω	106	229	233	317

Notes: For 26 gage, $\Phi = 0.5$ and $\Omega = 3.0$. For 24 gage, $\Phi = 0.6$ and $\Omega = 2.7$.
 For 22 gage, $\Phi = 0.6$ and $\Omega = 2.7$. For 20 gage, $\Phi = 0.5$ and $\Omega = 3.0$.

**Table 5 - Self-Drilling Screw Lap-Joint Connection
 Tensile Strength limited by Pull-Out (lbs)**

Model No.	Strength	Minimum base steel thickness of member not in Contact with screw head			
		26 gage	24 gage	22 gage	20 gage
EJOT EJOFAST® JF3	Nominal Strength, P _{ns}	259	334	464	497
	Design Strength (LRFD), ΦP_{ns}	101	158	196	235
	Allowable Strength (ASD), P _{ns} / Ω	63	99	122	147

Note - For all thicknesses, $\Phi = 0.6$ and $\Omega = 2.7$.