ENGINEERED POWER SOLUTIONS

1405 SPRING STREET, SUITE 204
PASO ROBLES, CA 93446
(805) 423-1326

STRUCTURAL DOCUMENTATION PACKET

PROJECT:

Renusol MS Roof Mounting System
Generic Structural Packet and Design Charts

CLIENT:

Renusol America, Inc.
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PREPARED BY:

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1/10/18

PACKET EXPIRES 12/31/18
MUST BE RENEWED ANNUALLY

DATE: 1/10/18
EPS PROJECT NUMBER: 18-RNS001

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T.2 – Table of Contents

1.0 – RESULTS & SCOPE OF WORK

1.1 – Overview of Analysis & Results

- **Governing Building Code:**

  2016 *California Building Code (CBC)*

  Based on the 2015 *International Building Code (IBC)* referencing the *Minimum Design Loads for Buildings and Other Structures* by the American Society of Civil Engineers (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 flush mounted 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 and the uplift forces to be resisted by the screws or seam clamps. 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, risk 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.

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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.
  - Wind uplift load to be resisted by seam clamps (specification of clamp and determination of clamp adequacy is by others).
  - Roof snow load limitations to the new clamps on the various design scenarios specified by Renusol.
    - Justification of the structural adequacy of the existing building to support the new PV addition along with any changes in the distribution of wind and snow loads is not within EPS's scope of work and is to be addressed by others.

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- **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 for the MS-LP, HP, or HPF system. If the roof is a standing seam roof and the MS-5X system with seam clamps (such as the ones offered by S-5!) is being used, the load tables in Section 4.0 of this packet provide the clamp loads to be referenced by the engineer responsible for specifying the seam clamps. Design tables that specify the allowable ground snow load that the MS system clamps can be installed under for each scenario 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 (or changes to the design load distribution) imposed by the proposed PV system. This shall be checked separately by a licensed engineer as required by the governing jurisdiction.

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The attached calculations are based on the assumption that the existing metal roof is free of corrosion or other structural deficiencies, and installed per manufacturer specifications. Renusol has informed EPS that the structural aspects of the existing structure(s) affected by this new rooftop PV installation shall be addressed by a licensed professional engineer on a site specific basis as required by the local governing jurisdiction.

If the roof is a standing seam roof and the MS-5X system is being used, the load tables in Section 4.0 shall be referenced for determining the worst case uplift and compression load at each clamp. Since the capacity of the seam clamp is dependent on the specific standing seam roof profile and the clamp being used, it is the responsibility of others to design, specify, and approve the seam clamp being used and to ensure the seam clamp has an allowable capacity (including adequate safety factors) to resist the worst-case imposed design loads as listed in the load tables in Section 4.0. Seam clamp capacities (such as the ones offered by S-5!) are per the clamp manufacturer and shall be reviewed by a licensed design professional in relation to each project (not within EPS's scope of work).

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.

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2.0 – DESIGN RESULTS AND SUMMARY TABLES

2.1 – Design Scenarios (Parameters)

- **Varying Design Parameters:**
  - Size and Weight of Module[1]:
    - 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 Risk Category[2]:
    - II
    - III
  - Roof Pitch[3]:
    - 0° → 7°
    - 7° → 27°
    - 27° → 45°
  - Design Wind Speed[2] (3 Second Gust Speed in MPH):
    - 115, 120, 140, 150, 160, 170 (ASCE 7-10)
  - Thickness (gage) of metal roof:
    - 26 gage
    - 24 gage (or thicker)
  - Roof Zone[4] (location of modules on roof):
    - Zone 1 (Interior Zone)
    - Zone 2 (Edge Zone)
    - Zone 3 (Corner Zone)
  - Ground Snow Load[2] (p_g)

- **Constant Design Parameters:**
  - Wind Design Parameters:
    - Topographic Factor[2,5] (K_{zt}): 1.00
    - Wind Directionality Factor[2] (K_d): 0.85
    - Building Height[7]: 30 ft. or less
  - Snow Design Parameters:
    - Exposure Factor[8] (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. Roof shall be single Gable/Hip type roof only. Stepped, Monoslope, Sawtooth, Domed, and Multispan Gable Roofs are not included.

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.

2.2 – Design Summary Tables

ASCE 7-10 [5] – Renusol MS Screw Quantities for the MS-LP, HP, and HPF Systems[6] – 60 Cell Modules

Exposure B

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	3	N.G.	2	2	3
120	2	4	N.G.	2	3	4
140	3	N.G.	N.G.	2	3	N.G.
150	3	N.G.	N.G.	2	4	N.G.
160	4	N.G.	N.G.	2	4	N.G.
170	4	N.G.	N.G.	3	N.G.	N.G.

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	3	N.G.	2	2	3
120	2	3	N.G.	2	2	3
140	3	N.G.	N.G.	2	3	N.G.
150	3	N.G.	N.G.	2	4	N.G.
160	3	N.G.	N.G.	2	4	N.G.
170	4	N.G.	N.G.	3	4	N.G.

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	2	2	2	2	2
120	2	3	3	2	2	2
140	3	3	3	2	2	2
150	3	4	4	2	3	3
160	4	4	4	3	3	3
170	4	N.G.	N.G.	3	3	3

Exposure C

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	3	N.G.	N.G.	2	3	N.G.
120	3	N.G.	N.G.	2	3	N.G.
140	4	N.G.	N.G.	3	4	N.G.
150	4	N.G.	N.G.	3	N.G.	N.G.
160	N.G.	N.G.	N.G.	3	N.G.	N.G.
170	N.G.	N.G.	N.G.	4	N.G.	N.G.

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	4	N.G.	2	3	4
120	3	N.G.	N.G.	2	3	N.G.
140	4	N.G.	N.G.	2	4	N.G.
150	4	N.G.	N.G.	3	N.G.	N.G.
160	4	N.G.	N.G.	3	N.G.	N.G.
170	N.G.	N.G.	N.G.	3	N.G.	N.G.

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	3	3	3	2	2	2
120	3	3	3	2	2	2
140	4	N.G.	N.G.	3	3	3
150	4	N.G.	N.G.	3	4	4
160	N.G.	N.G.	N.G.	3	4	4
170	N.G.	N.G.	N.G.	N.G.	N.G.	N.G.

Design Summary Table Notes:

1) Tables refer to quantity of EJOT EJOFAST bi-metal self-drilling screws (JF3). Screws shall be installed per corresponding ICC-ES evaluation report (report number 0276). See Appendix for further information.

2) N.G. stands for "No Good". Design scenarios with "N.G." specified may have design loads in excess of the allowable capacity of 4 screws and require a site specific analysis.

3) The gage quantities (26 and 24) refer 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 not addressed by this packet.

4) Please see Section 3.1 of this packet for further information on Roof Zones.

5) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

6) See Section 4.0 for loads to be used with the MS-5X seam clamp design (clamp design and specification by others).

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ASCE 7-10 [5] – Renusol MS Screw Quantities for the MS-LP, HP, and HPF Systems[6] – 72 Cell Modules

Exposure B

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	4	N.G.	2	3	4
120	2	4	N.G.	2	3	4
140	3	N.G.	N.G.	2	4	N.G.
150	4	N.G.	N.G.	3	4	N.G.
160	4	N.G.	N.G.	3	N.G.	N.G.
170	N.G.	N.G.	N.G.	3	N.G.	N.G.

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	4	N.G.	2	3	4
120	2	4	N.G.	2	3	4
140	3	N.G.	N.G.	2	4	N.G.
150	3	N.G.	N.G.	2	4	N.G.
160	4	N.G.	N.G.	3	N.G.	N.G.
170	4	N.G.	N.G.	3	N.G.	N.G.

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	2	3	3	2	2	2
120	2	3	3	2	2	2
140	3	4	4	2	3	3
150	4	4	4	3	3	3
160	4	N.G.	N.G.	3	3	3
170	N.G.	N.G.	N.G.	3	4	4

Exposure C

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	3	N.G.	N.G.	2	4	N.G.
120	3	N.G.	N.G.	2	4	N.G.
140	4	N.G.	N.G.	3	N.G.	N.G.
150	N.G.	N.G.	N.G.	3	N.G.	N.G.
160	N.G.	N.G.	N.G.	4	N.G.	N.G.
170	N.G.	N.G.	N.G.	4	N.G.	N.G.

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	3	N.G.	N.G.	2	3	N.G.
120	3	N.G.	N.G.	2	4	N.G.
140	4	N.G.	N.G.	3	N.G.	N.G.
150	N.G.	N.G.	N.G.	3	N.G.	N.G.
160	N.G.	N.G.	N.G.	3	N.G.	N.G.
170	N.G.	N.G.	N.G.	4	N.G.	N.G.

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Quantity of Screws Per Bracket: 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	3	4	4	2	3	3
120	3	4	4	2	3	3
140	4	N.G.	N.G.	3	4	4
150	N.G.	N.G.	N.G.	3	4	4
160	N.G.	N.G.	N.G.	N.G.	N.G.	N.G.
170	N.G.	N.G.	N.G.	N.G.	N.G.	N.G.

Design Summary Table Notes:

1) Tables refer to quantity of EJOT EJOFAST bi-metal self-drilling screws (JF3). Screws shall be installed per corresponding ICC-ES evaluation report (report number 0276). See Appendix for further information.

2) N.G. stands for "No Good". Design scenarios with "N.G." specified may have design loads in excess of the allowable capacity of 4 screws and require a site specific analysis.

3) The gage quantities (26 and 24) refer 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 not addressed by this packet.

4) Please see Section 3.1 of this packet for further information on Roof Zones.

5) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

6) See Section 4.0 for loads to be used with the MS-5X seam clamp design (clamp design and specification by others).

ASCE 7-10 [4] – Allowable Ground Snow Load (P_g) – 60 Cell Modules

Exposure B, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	35	35	35	35	35	35
140	35	35	35	35	35	35
150	35	35	35	35	35	35
160	35	35	35	35	35	35
170	35	35	35	35	35	35

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	35	35	35	35	35	35
140	35	35	35	35	35	35
150	35	35	35	35	35	35
160	35	35	35	35	35	35
170	30	30	30	30	30	30

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	45	45	45	45	45	45
120	40	40	40	40	40	40
140	35	35	35	35	35	35
150	30	30	30	30	30	30
160	30	30	30	30	30	30
170	15	15	15	15	15	15

Exposure C, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	35	35	35	35	35	35
140	35	35	35	35	35	35
150	35	35	35	35	35	35
160	35	35	35	35	35	35
170	35	35	35	35	35	35

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	35	35	35	35	35	35
140	30	30	30	30	30	30
150	30	30	30	30	30	30
160	30	30	30	30	30	30
170	25	25	25	25	25	25

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	30	30	30	30	30	30
140	15	15	15	15	15	15
150	15	15	15	15	15	15
160	10	10	10	10	10	10
170	NG	NG	NG	NG	NG	NG

Exposure B, Occupancy III

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	35	35	35	35	35	35
140	35	35	35	35	35	35
150	35	35	35	35	35	35
160	35	35	35	35	35	35
170	35	35	35	35	35	35

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	35	35	35	35	35	35
120	35	35	35	35	35	35
140	35	30	30	30	30	30
150	35	35	35	35	35	35
160	35	35	35	35	35	35
170	30	30	30	30	30	30

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	40	40	40	40	40	40
120	35	35	35	35	35	35
140	25	25	25	25	25	25
150	25	25	25	25	25	25
160	15	15	15	15	15	15
170	15	15	15	15	15	15

Design Summary Table Notes:

1) Tables refer to ground snow (p_g) load allowed per loading scenario based on the worst-case compression forces supported by each clamp (limited to 300 lbs. per clamp). See section 3.5 for further information.

2) The values above may be conservative 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) Structural justification of the existing structure to support the new PV system and any changes to the distribution of wind and snow load to the existing roof is not included in this analysis and shall be addressed by others.

4) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

ASCE 7-10 [4] – Allowable Ground Snow Load (P_g) – 72 Cell Modules

Exposure B, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	30	30	30	30	30	30
120	30	30	30	30	30	30
140	30	30	30	30	30	30
150	30	30	30	30	30	30
160	30	30	30	30	30	30
170	30	30	30	30	30	30

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	30	30	30	30	30	30
120	30	30	30	30	30	30
140	30	30	30	30	30	30
150	25	25	25	25	25	25
160	25	25	25	25	25	25
170	25	25	25	25	25	25

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	35	35	35	35	35	35
120	30	30	30	30	30	30
140	15	15	15	15	15	15
150	15	15	15	15	15	15
160	10	10	10	10	10	10
170	10	10	10	10	10	10

Exposure C, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	30	30	30	30	30	30
120	30	30	30	30	30	30
140	30	30	30	30	30	30
150	30	30	30	30	30	30
160	25	25	25	25	25	25
170	25	25	25	25	25	25

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	30	30	30	30	30	30
120	25	25	25	25	25	25
140	25	25	25	25	25	25
150	15	15	15	15	15	15
160	15	15	15	15	15	15
170	15	15	15	15	15	15

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	15	15	15	15	15	15
120	15	15	15	15	15	15
140	10	10	10	10	10	10
150	5	5	5	5	5	5
160	NG	NG	NG	NG	NG	NG
170	NG	NG	NG	NG	NG	NG

Exposure B, Occupancy III

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	30	30	30	30	30	30
120	30	30	30	30	30	30
140	30	30	30	30	30	30
150	30	30	30	30	30	30
160	30	30	30	30	30	30
170	30	30	30	30	30	30

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Allowable Ground Snow (pg) Load (psf) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	30	30	30	30	30	30
120	30	30	30	30	30	30
140	30	30	30	30	30	30
150	25	25	25	25	25	25
160	25	25	25	25	25	25
170	15	15	15	15	15	15

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	25	25	25	25	25	25
120	25	25	25	25	25	25
140	15	15	15	15	15	15
150	10	10	10	10	10	10
160	10	10	10	10	10	10
170	5	5	5	5	5	5

Design Summary Table Notes:

1) Tables refer to ground snow (p_g) load allowed per loading scenario based on the worst-case compression forces supported by each clamp (limited to 300 lbs. per clamp). See section 3.5 for further information.

2) The values above may be conservative 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) Structural justification of the existing structure to support the new PV system and any changes to the distribution of wind and snow load to the existing roof is not included in this analysis and shall be addressed by others.

4) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

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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 (MS-LP, HP, and HPF Systems) and standing seam roofing (MS-5X System) using a series of clamps that attach to a clamp base which is screwed directly into the rib of the sheet roofing or clamps to the seams of standing seam roofing using seam clamps (design by others). Clamp bases occur at each of the four (4) corners of the modules giving end clamps a tributary area of ¼ of a modules and middle clamps a tributary area of ¼ of a module on each side for a total tributary are of ½ 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 7-10*
  - *Module Type:* *60-Cell Modules*
  - *Wind Exposure Category:* *C*
  - *Building Risk Category:* *II*
  - *Roof Pitch:* *14° (3:12)*
  - *Building Footprint:* *100 ft. x 50 ft.*
  - *Steel Sheet Roof Thickness:* *24 Gage*
  - *Building Ht.:* *30 ft. (grade to highest point of PV installation)*
  - *Design Wind Speed:* *115 MPH*
  - *Design Ground Snow Load:* *40 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.

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3.1 – Roof Zones

Wind forces are determined in accordance with ASCE 7-10 Section 30.9. In accordance with Figures 30.4-2A, B, & C, the roof has been broken up into (3) zones, 1, 2, & 3. See Figure 1a, 1b, & 1c below.

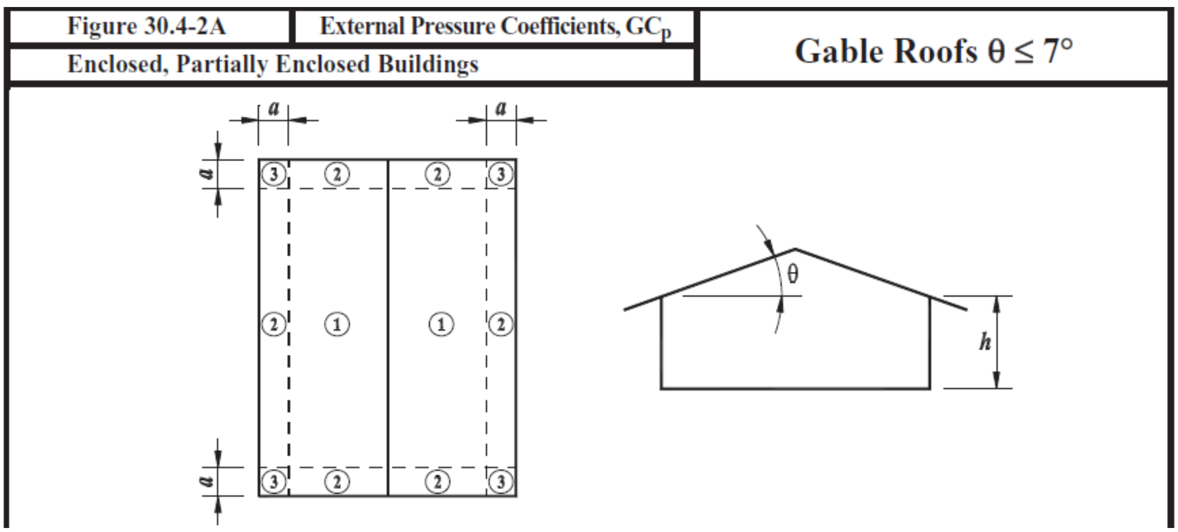

Figure 1a – Roof Zones 0° to 7°

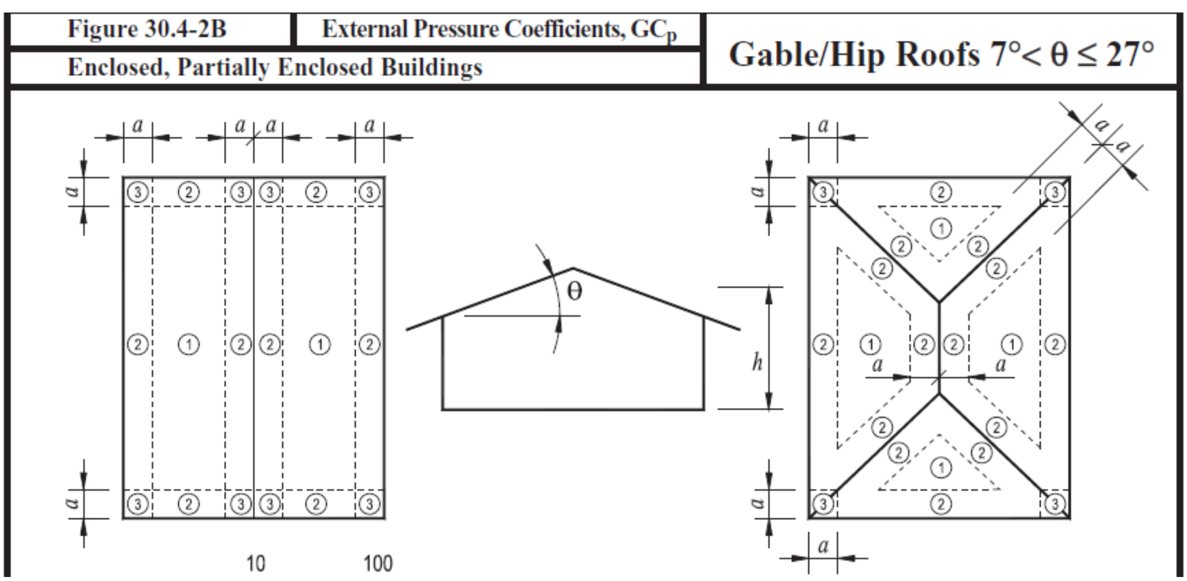

Figure 1b – Roof Zones 7° to 27°

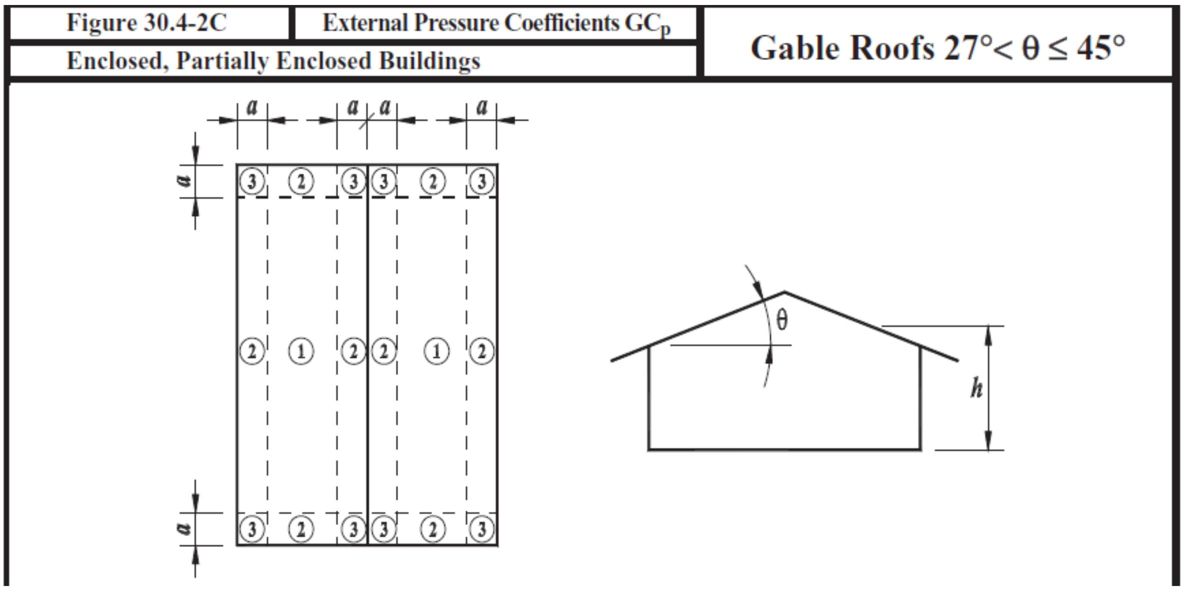

Figure 1c: Roof Zones 27° to 45°

Overhang conditions and overhang wind zones are <u>not</u> supported by this package.

For hip roofs with θ ≤ 25°, Zone 3 shall be treated as Zone 2 per note 7 of Figure 30.4-2B.

The terms “a” and “h” are determined in accordance with notes 7, 8, and 6 of Figures 30.4-2A, B, and C respectively:

- 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 ≤ 10°

See complete list of Notes of Figures 30.4-2A, B, and C for additional clarification.

Example Scenario Calculation:

*a: Smaller of 0.1*50 ft. = 5.0 ft. or 0.4*30 ft. = 12 ft. but not less than 0.04*50 ft. = 2 ft. or 3 ft.*

➔ *Therefore a = 5.0 ft.*

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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 ½ a module, this would equate to ½ 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 25° pitch.*
> *Mid clamps support 0.5* 40 lbs. = 20 lbs.*
> *Tilt of 7° is the lowest in category but 0° conservatively used*
> *20 lbs. * cos(0°) = 20 lbs.*

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3.3 – Wind Uplift Forces

Per Section 30.4, the wind velocity pressure is determined by Equation Eq. 30.4-1:

- $p = q_h[(GC_p) - (GC_{pi})]$ (psf)

Where q_h, the velocity pressure evaluated at height h, is given by Section 30.3.2 and Equation 30.3-1:

- $q_h = 0.00256 K_z K_{zt} K_d V^2$ (ASCE 7-10)
  - K_z = Velocity Pressure Exposure Coefficient per 30.3.1
    - 0.70 used for Exposure B
    - 0.98 used for Exposure C
  - K_{zt} = Topographic Factor per 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 26.6-1
    - 0.85 used in all cases
  - V = 3 Second Gust Wind Speed per Fig. 26.5-1 or local jurisdiction

GC_p is the external pressure coefficient given in Figure 30.4-2A through C.
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_p):
  - Building Zone 1 (Interior Zone):
    - 0° → 7° -1.0
    - 7° → 27° -0.9
    - 27° → 45°: -1.0
  - Building Zone 2 (Edge):
    - 0° → 7° -1.8
    - 7° → 27° -1.7
    - 27° → 45°: -1.2

- Building Zone 3 (Corner Zone):
  - 0° → 7° -2.8
  - 7° → 27° -2.6
  - 27° → 45°: -1.2

- Downward (All Zones):
  - 0° → 7° 0.3
  - 7° → 27° 0.5
  - 27° → 45°: 0.9

Example Scenario Calculation:

$q_h = 0.00256(0.98)(1.0)(0.85)(115)^2 =$ ***28.2 psf***

With a 14° tilt, this produces wind forces of:

- *Zone 1:*
  - *Uplift Force: 28.2 psf * -0.9 =* ***-25.38 psf***
- *Zone 2:*
  - *Uplift Force: 28.2 psf * -1.7 =* ***-47.94 psf***
- *Zone 3:*
  - *Uplift Force: 28.2 psf * -2.6 =* ***-73.32 psf***
- *Downward:*
  - *Downward Force: 28.2psf * 0.5 =* ***14.1 psf***

Based on the area of a 60 cell module (17.76 ft^2) the maximum wind forces imposed on the modules have been calculated on a per module basis:

- *Zone 1:*
  - *Uplift Force: -25.38 psf * 17.76 ft^2 =* ***-450.7 lbs./module***
- *Zone 2:*
  - *Uplift Force: -47.94 psf * 17.76 ft^2 =* ***-851.4 lbs./module***
- *Zone 3:*
  - *Uplift Force: -73.32 psf * 17.76 ft^2 =* ***-1302.2 lbs./module***
- *Downward:*
  - *Downward Force: 14.1 psf * 17.76 ft^2 =* ***250.4 lbs./module***

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

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Per clamp base, the following loads are calculated:

- *Zone1:*
  - *Uplift Force: -450.7 lbs. * 0.5 =* ***-225.4 lbs./base***
- *Zone 2:*
  - *Uplift Force: -851.4 lbs. * 0.5 =* ***-425.7 lbs./base***
- *Zone 3:*
  - *Uplift Force: -1302.2 lbs. * 0.5 =* ***-651.1 lbs./base***
- *Downward:*
  - *Downward Force: 250.4 * 0.5 =* ***125.2 lbs./base***

Using the worst-case wind uplift basic load combination (allowable stress design) of 0.6D+0.6W as dictated in 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:

- *Zone 1 :*
  - *Uplift Force: (0.6) * -225.4 lbs. + 0.6*(20 lbs.)*cos(27) =* ***-124.6 lbs.***
- *Zone2:*
  - *Uplift Force: (0.6) * -425.7 lbs. + 0.6*(20 lbs.)*cos(27) =* ***-244.8 lbs.***
- *Zone3:*
  - *Uplift Force: (0.6) * -651.1 lbs. + 0.6*(20 lbs.)*cos(27) =* ***-380.0 lbs.***
- *Downward:*
  - *Downwards Force: (0.6) * 125.2 lbs. + 1.0*(20 lbs.)*cos(7) =* ***95.0 lbs.***

Note: Even though the example scenario tilt is 14°, a tilt of 27° has been used for uplift and 7° for downward as these would be the most conservative for the 7° → 27° pitch category.

3.4 – Allowable Screw Capacity

The screws to be used with the MS-LP, HP, and HPF 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 24 gage roof:

- *Zone 1:*
  - *-113.9 lbs. / 99 lbs. = 1.15 screws →* ***Use a min. of (2) screws per base***
- *Zone 2:*
  - *-234.1 lbs. / 99 lbs. = 2.36 screws →* ***Use a min. of (3) screws per base***
- *Zone 3:*
  - *-369.3 lbs. / 99 lbs. = 3.73 screws →* ***Use a min. of (4) screws per base***

Note: It is assumed the original roof sheet anchorage to the existing roof joists/members was designed and installed to support the solar panel design loads as dictated by the governing building code. An analysis of the roofing to roof framing connection is not within EPS's scope of work and is the responsibility of others (along with the checking the structural adequacy of all other aspects of the existing building affected by the PV addition).

It is also to be noted that the JF3 Screw allowable capacity is the governing element as (4) screws has an allowable capacity of 396 lbs. which, by inspection, is much less than the capacity of the 5/16" mid/end clamp bolt and the clamp aluminum in shear.

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.

EPS has limited the compression capacity of the clamps to 300 lbs. to match the requirements of Table 4-1 of ASCE 7 which requires that roofs are designed for a concentrated Roof Live Load of 300 lbs. at any location suject to maintenance workers. 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). This limit is in reference to the clamp capacity only and does not address limitations of the existing building roofing or structural components which may further limit the clamp point loads. Justification of the building's structural adequacy to support the PV load points (included changes to the distribution of wind and snow load) are not within EPS's scope of work and shall be addressed by others.

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

- $p_s = C_s * p_f$ — Eq. 7.4-1
  - Slope Factor C_s: — Figure 7-2
    - Slopes < 27°: 1.00
    - Slopes ≥ 27° but ≤ 45°: 0.81
  - Flat Roof Snow Load $p_f = 0.7 * C_e * C_t * I * p_g$ — Eq.7.3-1
    - Exposure Factor Ce: 1.0 — Table 7-2
    - Thermal Factor Ct: 1.2 — Table 7-3
    - Snow Importance Factor (I): — 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:

*Sloped Roof Snow = 1.00*p_f*

*Where p_f = 0.7*1.0*1.2*1.0*35 psf = 29.4 psf*

*But not less than 1.0*20psf = 20 psf → Use 29.4 psf*

*Sloped Roof Snow = 1.00*29.4 psf = 29.4 psf*

*Snow Load per Clamp Base = 29.4 psf * 17.76 ft^2 / 2 =* ***261.1 lbs./base***

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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 govering compression load combination will be from one of the following load combinations per Section 2.4.1:

- 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: 261.1 lbs.
W: 125.2 lbs.

Load Combination:

- *D = 20 lbs.*
- *D+S = 20 lbs. + 261.1 lbs. =* ***281 lbs.***
- *D+0.6W = 20 lbs +(0.6*125.2 lbs.) = 95 lbs*
- *D+0.75S+0.75(0.6W) = 20lbs+0.75(261.1)+0.75(0.6*125.2 lbs) = 272 lbs*

281 lbs. is less than 300 lbs.; therefore the design load is within the allowable capacity of the clamp in compression.

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

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4.0 – Calculation Tables

ASCE 7-10 [3] – Uplift Tables – 60 Cell Modules

Exposure B

0° --> 7°

ASCE 7-10	Uplift Force on Brackets (lbs.)					
	26-Gage			24-Gage		
Wind Speed (MPH)	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	-95.4	-181.3	-288.6	-101.4	-181.3	-288.6
120	-105.0	-198.5	-315.4	-105.0	-198.5	-315.4
140	-147.2	-274.4	-433.5	-147.2	-274.4	-433.5
150	-170.7	-316.8	-499.4	-170.7	-316.8	-499.4
160	-195.9	-362.1	-569.9	-195.9	-362.1	-569.9
170	-222.7	-410.3	-644.9	-222.7	-410.3	-644.9

7° --> 27°

ASCE 7-10	Uplift Force on Brackets (lbs.)					
	26-Gage			24-Gage		
Wind Speed (MPH)	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	-85.9	-171.8	-268.4	-85.9	-171.8	-268.4
120	-94.5	-188.0	-293.2	-94.5	-188.0	-293.2
140	-132.5	-259.8	-402.9	-132.5	-259.8	-402.9
150	-153.7	-299.8	-464.1	-153.7	-299.8	-464.1
160	-176.3	-342.5	-529.6	-176.3	-342.5	-529.6
170	-200.4	-388.1	-599.2	-200.4	-388.1	-599.2

27° --> 45°

ASCE 7-10	Uplift Force on Brackets (lbs.)					
	26-Gage			24-Gage		
Wind Speed (MPH)	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	-98.9	-120.3	-120.3	-98.9	-120.3	-120.3
120	-108.4	-131.8	-131.8	-108.4	-131.8	-131.8
140	-150.6	-182.4	-182.4	-150.6	-182.4	-182.4
150	-174.1	-210.7	-210.7	-174.1	-210.7	-210.7
160	-199.3	-240.9	-240.9	-199.3	-240.9	-240.9
170	-226.1	-273.0	-273.0	-226.1	-273.0	-273.0

Exposure C

0° --> 7°

ASCE 7-10	Uplift Force on Brackets (lbs.)					
	26-Gage			24-Gage		
Wind Speed (MPH)	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	-138.4	-258.6	-408.9	-138.4	-258.6	-408.9
120	-152.6	-282.6	-446.3	-151.7	-282.6	-446.3
140	-211.6	-389.0	-611.7	-210.8	-389.0	-611.7
150	-244.6	-448.3	-704.0	-243.8	-448.3	-704.0
160	-279.8	-511.7	-802.6	-279.0	-511.7	-802.6
170	-317.3	-579.2	-907.6	-316.5	-579.2	-907.6

7° --> 27°

ASCE 7-10	Uplift Force on Brackets (lbs.)					
	26-Gage			24-Gage		
Wind Speed (MPH)	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	-124.6	-244.8	-380.0	-124.6	-244.8	-380.0
120	-136.6	-267.5	-414.7	-136.6	-267.5	-414.7
140	-189.8	-367.9	-568.4	-189.8	-367.9	-568.4
150	-219.4	-424.0	-654.1	-219.4	-424.0	-654.1
160	-251.1	-483.8	-745.6	-251.1	-483.8	-745.6
170	-284.9	-547.6	-843.1	-284.9	-547.6	-843.1

27° --> 45°

ASCE 7-10	Uplift Force on Brackets (lbs.)					
	26-Gage			24-Gage		
Wind Speed (MPH)	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	-141.8	-171.8	-171.8	-141.8	-171.8	-171.8
120	-155.1	-187.9	-187.9	-155.1	-187.9	-187.9
140	-214.2	-258.8	-258.8	-214.2	-258.8	-258.8
150	-247.2	-298.3	-298.3	-247.2	-298.3	-298.3
160	-282.4	-340.6	-340.6	-282.4	-340.6	-340.6
170	-319.9	-385.6	-385.6	-319.9	-385.6	-385.6

Design Summary Table Notes:

1) Worst-case uplift forces are normal to the module face and are based on the 0.6D+0.6W load combination.

2) Please see Section 3.1 of this packet for further information on Roof Zones.

3) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

ASCE 7-10 [3] – Uplift Tables – 72 Cell Modules

Exposure B

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Uplift Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	-109.3	-210.8	-337.7	-109.3	-210.8	-337.7
120	-120.6	-231.1	-369.3	-120.6	-231.1	-369.3
140	-170.5	-320.9	-508.9	-170.5	-320.9	-508.9
150	-198.3	-371.0	-586.8	-198.3	-371.0	-586.8
160	-228.0	-424.5	-670.1	-228.0	-424.5	-670.1
170	-259.7	-481.5	-758.8	-259.7	-481.5	-758.8

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Uplift Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	-98.4	-199.9	-314.1	-98.4	-199.9	-314.1
120	-108.6	-219.1	-343.4	-108.6	-219.1	-343.4
140	-153.5	-303.9	-473.1	-153.5	-303.9	-473.1
150	-178.5	-351.2	-545.5	-178.5	-351.2	-545.5
160	-205.3	-401.8	-622.8	-205.3	-401.8	-622.8
170	-233.8	-455.6	-705.1	-233.8	-455.6	-705.1

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Uplift Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	-114.4	-139.7	-139.7	-114.4	-139.7	-139.7
120	-125.6	-153.3	-153.3	-125.6	-153.3	-153.3
140	-175.5	-213.1	-213.1	-175.5	-213.1	-213.1
150	-203.3	-246.5	-246.5	-203.3	-246.5	-246.5
160	-233.1	-282.2	-282.2	-233.1	-282.2	-282.2
170	-264.7	-320.2	-320.2	-264.7	-320.2	-320.2

Exposure C

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Uplift Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	-160.1	-302.2	-479.8	-160.1	-302.2	-479.8
120	-175.8	-330.6	-524.0	-175.8	-330.6	-524.0
140	-245.7	-456.3	-719.6	-245.7	-456.3	-719.6
150	-284.6	-526.4	-828.6	-284.6	-526.4	-828.6
160	-326.3	-601.4	-945.2	-326.3	-601.4	-945.2
170	-370.6	-681.1	-1069.3	-370.6	-681.1	-1069.3

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Uplift Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	-144.1	-286.2	-446.1	-144.1	-286.2	-446.1
120	-158.3	-313.0	-487.1	-158.3	-313.0	-487.1
140	-221.2	-431.8	-668.7	-221.2	-431.8	-668.7
150	-256.2	-498.0	-770.0	-256.2	-498.0	-770.0
160	-293.7	-568.8	-878.2	-293.7	-568.8	-878.2
170	-333.6	-644.1	-993.5	-333.6	-644.1	-993.5

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Uplift Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	-165.1	-200.6	-200.6	-165.1	-200.6	-200.6
120	-180.9	-219.6	-219.6	-180.9	-219.6	-219.6
140	-250.7	-303.4	-303.4	-250.7	-303.4	-303.4
150	-289.7	-350.1	-350.1	-289.7	-350.1	-350.1
160	-331.3	-400.1	-400.1	-331.3	-400.1	-400.1
170	-375.7	-453.3	-453.3	-375.7	-453.3	-453.3

Design Summary Table Notes:

1) Worst-case uplift forces are normal to the module face and are based on the 0.6D+0.6W load combination.

2) Please see Section 3.1 of this packet for further information on Roof Zones.

3) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

ENGINEERED POWER SOLUTIONS

1405 SPRING STREET, SUITE 204
PASO ROBLES, CA 93446
(805) 423-1326

ASCE 7-10 [3] – Governing Compression Tables (ASD Load Combinations) – 60 Cell Modules

Exposure B, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	281	281	281	281	281	281
120	281	281	281	281	281	281
140	281	281	281	281	281	281
150	281	281	281	281	281	281
160	281	281	281	281	281	281
170	281	281	281	281	281	281

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	281	281	281	281	281	281
120	281	281	281	281	281	281
140	281	281	281	281	281	281
150	284	284	284	284	284	284
160	294	294	294	294	294	294
170	276	276	276	276	276	276

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	294	294	294	294	294	294
120	278	278	278	278	278	278
140	284	284	284	284	284	284
150	277	277	277	277	277	277
160	294	294	294	294	294	294
170	276	276	276	276	276	276

Exposure C, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	281	281	281	281	281	281
120	281	281	281	281	281	281
140	281	281	281	281	281	281
150	281	281	281	281	281	281
160	281	281	281	281	281	281
170	290	290	290	290	290	290

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	281	281	281	281	281	281
120	281	281	281	281	281	281
140	271	271	271	271	271	271
150	284	284	284	284	284	284
160	297	297	297	297	297	297
170	283	283	283	283	283	283

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	278	278	278	278	278	278
120	264	264	264	264	264	264
140	268	268	268	268	268	268
150	290	290	290	290	290	290
160	281	281	281	281	281	281
170	NG	NG	NG	NG	NG	NG

Exposure B, Occupancy III

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	281	281	281	281	281	281
120	281	281	281	281	281	281
140	281	281	281	281	281	281
150	281	281	281	281	281	281
160	281	281	281	281	281	281
170	281	281	281	281	281	281

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	281	281	281	281	281	281
120	281	281	281	281	281	281
140	281	247	247	247	247	247
150	284	284	284	284	284	284
160	294	294	294	294	294	294
170	276	276	276	276	276	276

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.) 26-Gage Zone 1	26-Gage Zone 2	26-Gage Zone 3	24-Gage Zone 1	24-Gage Zone 2	24-Gage Zone 3
115	272	272	272	272	272	272
120	255	255	255	255	255	255
140	272	272	272	272	272	272
150	288	288	288	288	288	288
160	268	268	268	268	268	268
170	286	286	286	286	286	286

Design Summary Table Notes:

1) Worst-case compression forces are normal to the module face and are based on the worst-case combination of D; D+0.6W; D+S; or D+0.75(0.6W)+0.75S

2) Please see Section 3.1 of this packet for further information on Roof Zones.

3) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

ENGINEERED POWER SOLUTIONS

1405 SPRING STREET, SUITE 204
PASO ROBLES, CA 93446
(805) 423-1326

ASCE 7-10 [3] – Governing Compression Tables (ASD Load Combinations) – 72 Cell Modules

Exposure B, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	294	294	294	294	294	294
120	294	294	294	294	294	294
140	294	294	294	294	294	294
150	294	294	294	294	294	294
160	294	294	294	294	294	294
170	294	294	294	294	294	294

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	294	294	294	294	294	294
120	294	294	294	294	294	294
140	298	298	298	298	298	298
150	276	276	276	276	276	276
160	287	287	287	287	287	287
170	299	299	299	299	299	299

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	299	299	299	299	299	299
120	280	280	280	280	280	280
140	271	271	271	271	271	271
150	290	290	290	290	290	290
160	271	271	271	271	271	271
170	292	292	292	292	292	292

Exposure C, Occupancy II

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	294	294	294	294	294	294
120	294	294	294	294	294	294
140	294	294	294	294	294	294
150	296	296	296	296	296	296
160	272	272	272	272	272	272
170	282	282	282	282	282	282

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	294	294	294	294	294	294
120	267	267	267	267	267	267
140	293	293	293	293	293	293
150	261	261	261	261	261	261
160	276	276	276	276	276	276
170	293	293	293	293	293	293

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	264	264	264	264	264	264
120	275	275	275	275	275	275
140	283	283	283	283	283	283
150	298	298	298	298	298	298
160	NG	NG	NG	NG	NG	NG
170	NG	NG	NG	NG	NG	NG

Exposure B, Occupancy III

0° --> 7°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	294	294	294	294	294	294
120	294	294	294	294	294	294
140	294	294	294	294	294	294
150	294	294	294	294	294	294
160	294	294	294	294	294	294
170	294	294	294	294	294	294

7° --> 27°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	294	294	294	294	294	294
120	294	294	294	294	294	294
140	298	298	298	298	298	298
150	283	283	283	283	283	283
160	295	295	295	295	295	295
170	263	263	263	263	263	263

27° --> 45°

ASCE 7-10 Wind Speed (MPH)	Compression Force on Brackets (lbs.)					
	26-Gage			24-Gage		
	Zone 1	Zone 2	Zone 3	Zone 1	Zone 2	Zone 3
115	285	285	285	285	285	285
120	293	293	293	293	293	293
140	283	283	283	283	283	283
150	259	259	259	259	259	259
160	279	279	279	279	279	279
170	276	276	276	276	276	276

Design Summary Table Notes:

1) Worst-case compression forces are normal to the module face and are based on the worst-case combination of D; D+0.6W; D+S; or D+0.75(0.6W)+0.75S

2) Please see Section 3.1 of this packet for further information on Roof Zones.

3) Refer to Wind Speed Conversion Table in the Appendix to determine Equivalent ASCE 7-05 Wind Speed.

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PASO ROBLES, CA 93446
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APPENDIX

(FOR REFERENCE ONLY)

ENGINEERED POWER SOLUTIONS

1405 SPRING STREET, SUITE 204
PASO ROBLES, CA 93446
(805) 423-1326

Wind Speed Conversion Table

(ASCE 7-10 to ASCE 7-05)

ASCE 7-10 Wind Speed (MPH)	ASCE 7-05 Wind Speed (MPH)	
	Risk Cat. II	Risk Cat. III
115	89	83
120	93	86
140	108	101
150	116	108
160	124	115
170	131	122

Wind Speed Conversion Table Notes:

1) Check with the governing jurisdiction regarding the current adopted code requirements regarding ASCE 7-10 vs. 7-05 wind speeds.

1) The table above provides general guidance for wind speed conversions between the 7-10 and 7-05 codes. Consult with a licensed engineer regarding any questions regarding wind speed conversion or site specific analysis.

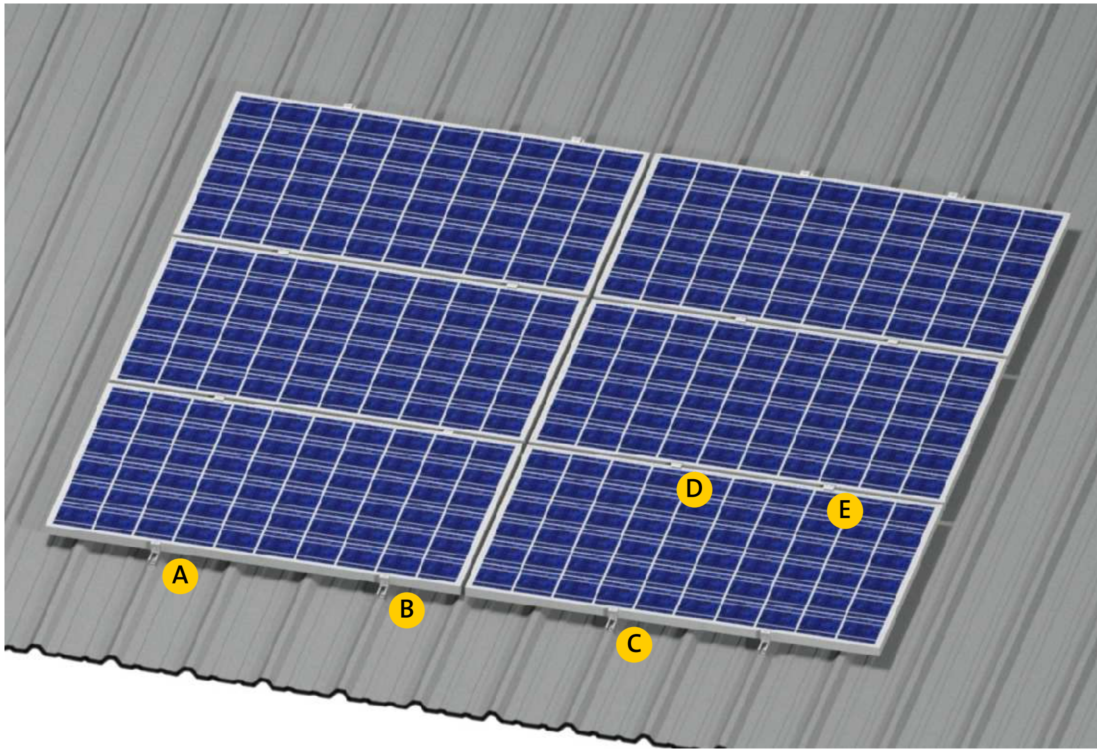
OVERVIEW

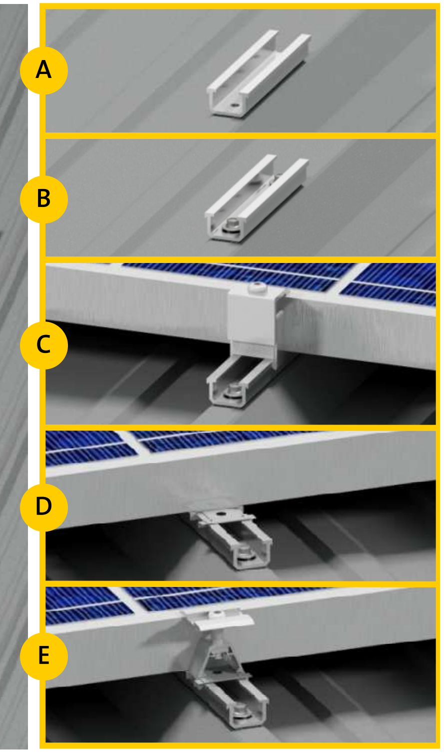
The Renusol MS system has been developed to easily install PV modules on steel trapezoidal sheet metal roofs. The system uses proprietary "one size fits all" clamps for all module thicknesses ranging between 30-50 mm.

Please refer to Renusol MS Design Guide for system layout and grounding instructions.

Please read this guide carefully before starting the installation. Always follow proper safety precautions and check local building codes to ensure compliance.

Please check for the latest versions of the installation guide at www.renusolamerica.com.





REQUIREMENTS

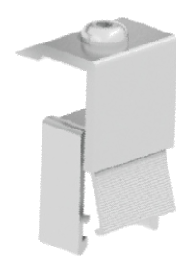
1. 5 mm Allen (hex) Wrench
2. Cordless Drill with Torque Adjustability
3. 5/16" Socket Driver

SYSTEM COMPONENTS LIST

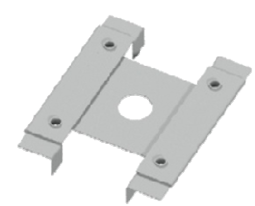
A Clamp Base

B Screw

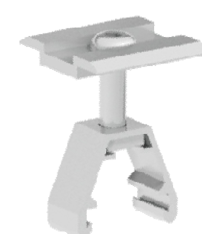
C End Clamp



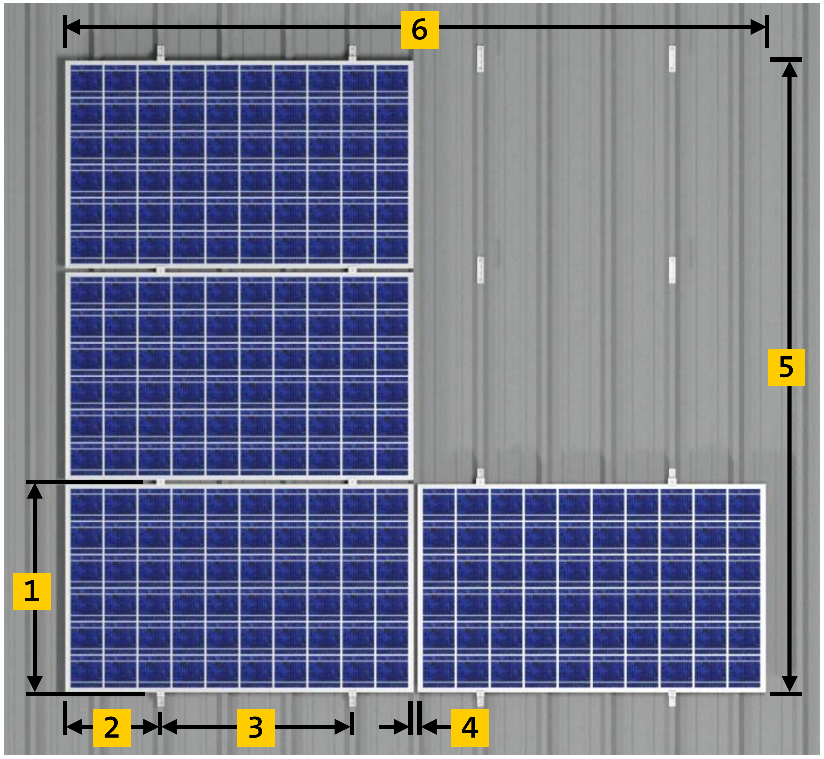
D WEEB-CCR



E Mid Clamp



LAYOUT



Plan the layout of the components per the dimensions below

1. Module width + 0.75”
2. Approximately ¼ module length (verify allowable clamping locations in module manufacturer’s installation guide)
3. Spacing of MS Clamp Bases varies with the peak distance of the trapezoidal roof panels
4. 0.75” minimum
5. Quantity of modules in the vertical direction x (module width + 0.75”)
6. Quantity of modules in the horizontal direction x (module Length + 4)

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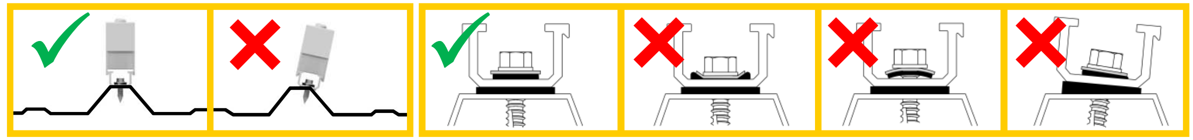
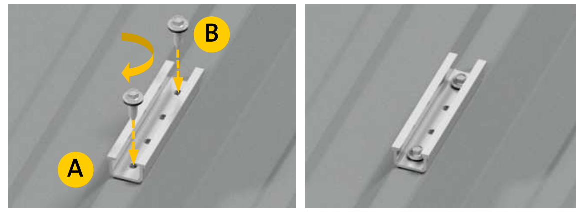
www.renusolamerica.com
+1 877-847-8919

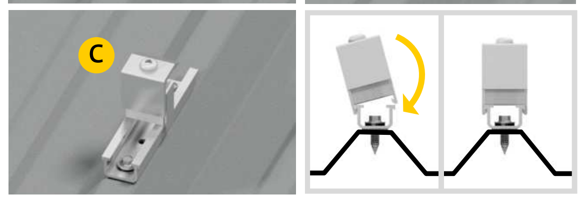
ASSEMBLY





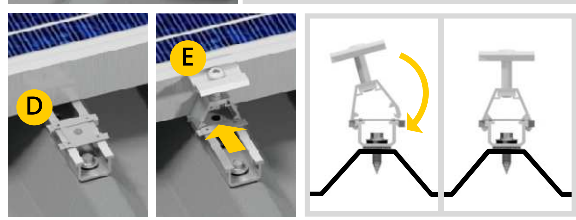
Step 1. Clamp Base & Screws
Place A Clamp Bases on center of trapezoidal peaks. Fasten all A Clamp Bases to the roof using B Screws (See precautions in images above).

Refer to Renusol MS Design Guide for locations of Clamp Bases and required number of screws.



Step 2. End Clamps
Snap C End Clamp onto middle of A Clamp Base. Repeat this step along the entire bottom edge of 1st row.

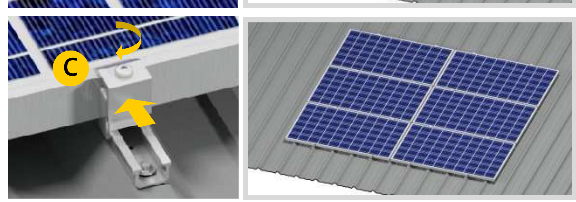
Step 3. Panels (1st Row)
Slide the 1st row of modules against the C End Clamps and tighten to 8 ft.-lbs.



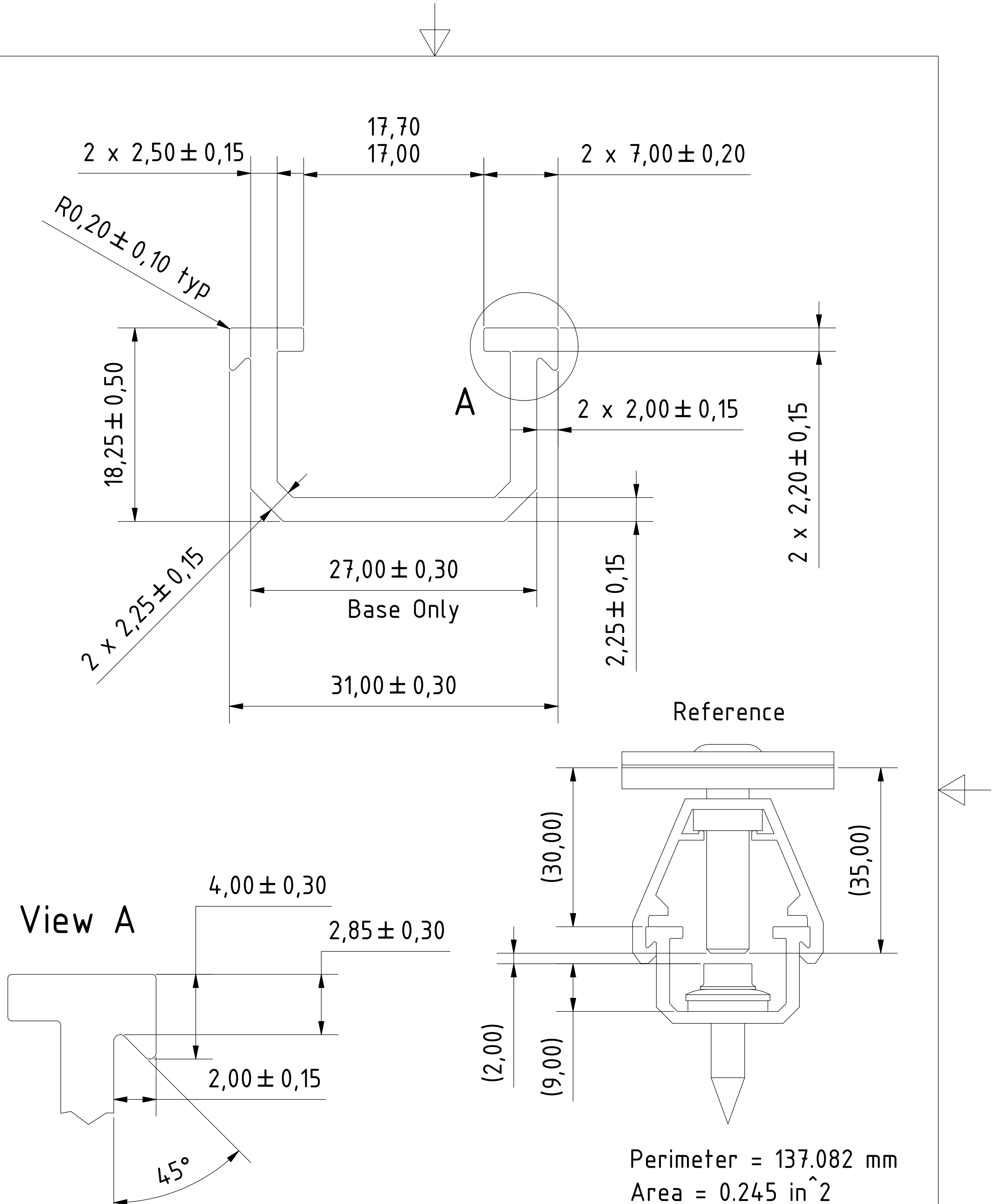
Step 4. WEEB-CCR & Mid Clamp
Place the D WEEB-CCR on A Base Clamp. Snap on E Mid Clamp over D WEEB-CCR and slide assembly against module. Repeat this step for the top edge of entire row of modules.

Step 5. Panels (2nd Row)
Slide the 2nd row of modules into place and tighten the E Mid Clamps to 10 ft.-lbs.

Repeat steps 4-5 for the remainder of the array.



Step 6. End Clamps (top of array)
Snap C End Clamp onto the A Clamp Base and tighten to 8 ft.-lbs. Repeat this step across the entire top row of modules.



Section Properties

Ix (cm⁴)		ix (cm)	
Wx(cm³)		iy (cm)	
Iy (cm⁴)		A (cm²)	
Wy(cm³)			

Rev	Description	Date	Name

Renusol Solar Mounting Systems

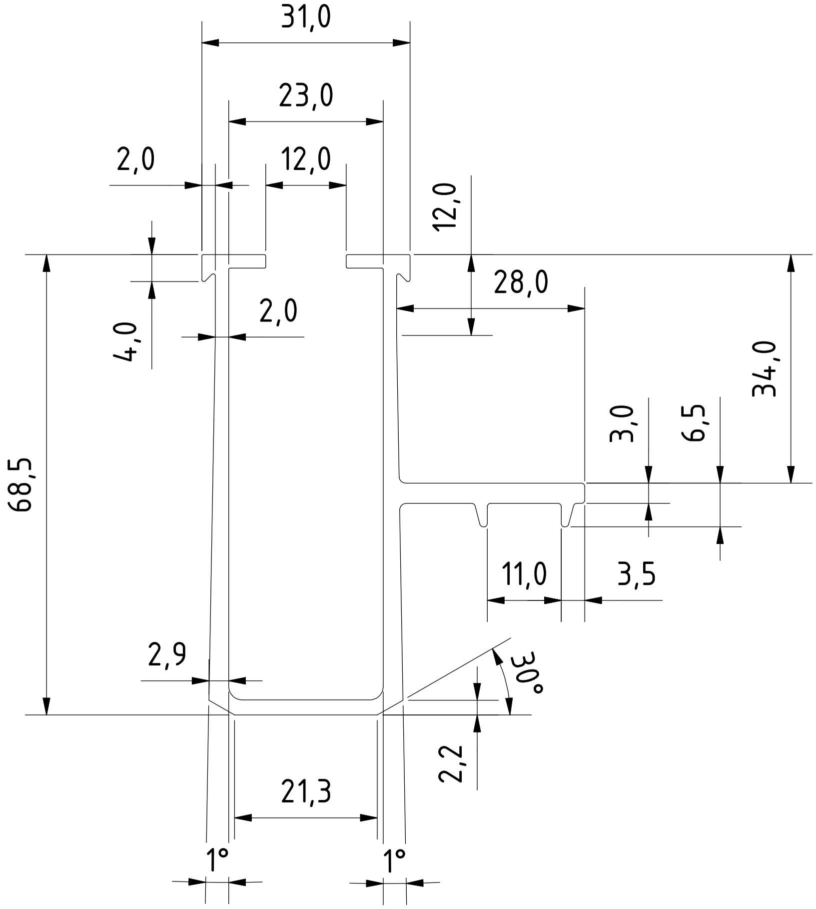
Tolerances according to EN 12020-2

Date	Name
6/12/2013	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 = 417.42 mm
Area = 0.781 in^2

Section Properties			
Ix (cm⁴)		ix (cm)	
Wx(cm³)		iy (cm)	
Iy (cm⁴)		A (cm²)	
Wy(cm³)			

Rev	Description	Date	Name

Renusol Solar Mounting Systems

Tolerances according to EN 12020-2

Date	Name
1/5/2015	dhughes

Renusol America
1292 Logan Circle NW
Atlanta, GA 30318

Scale:

Weight: 0.937 lb/ft

Material: EN AW6063 T6

Part Number: TBD

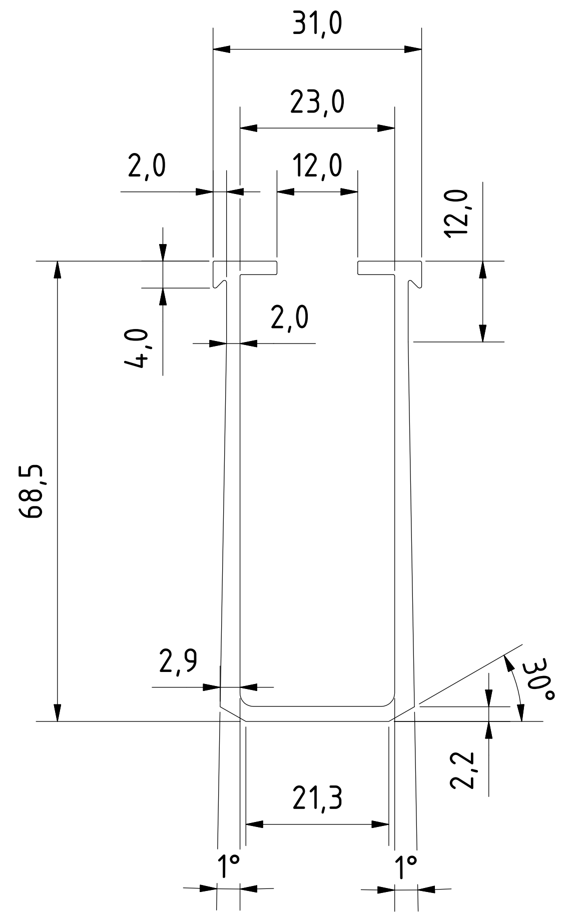
Title: MS 2.0 concept 1a, profile

Drawing Number: 01052015.1a

Sheet: 1 / 1

Sheet Size: A4

NO EXPOSED EDGES



Perimeter = 352.467 mm
Area = 0.636 in^2

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	Name
1/5/2015	dhughes

Renusol America
1292 Logan Circle NW
Atlanta, GA 30318

Scale:

Weight: 0.763 lb/ft

Material: EN AW6063 T6

Part Number: TBD

Title: MS 2.0 concept 2a, profile

Drawing Number: 01052015.2a

Sheet: 1 / 1

Sheet Size: A4

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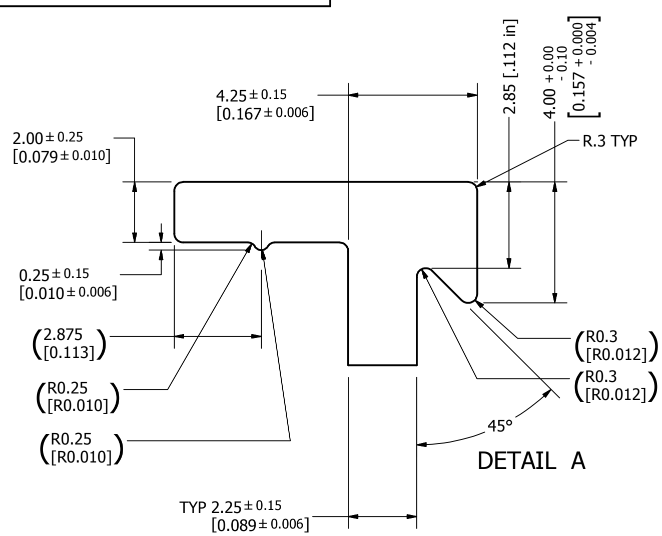
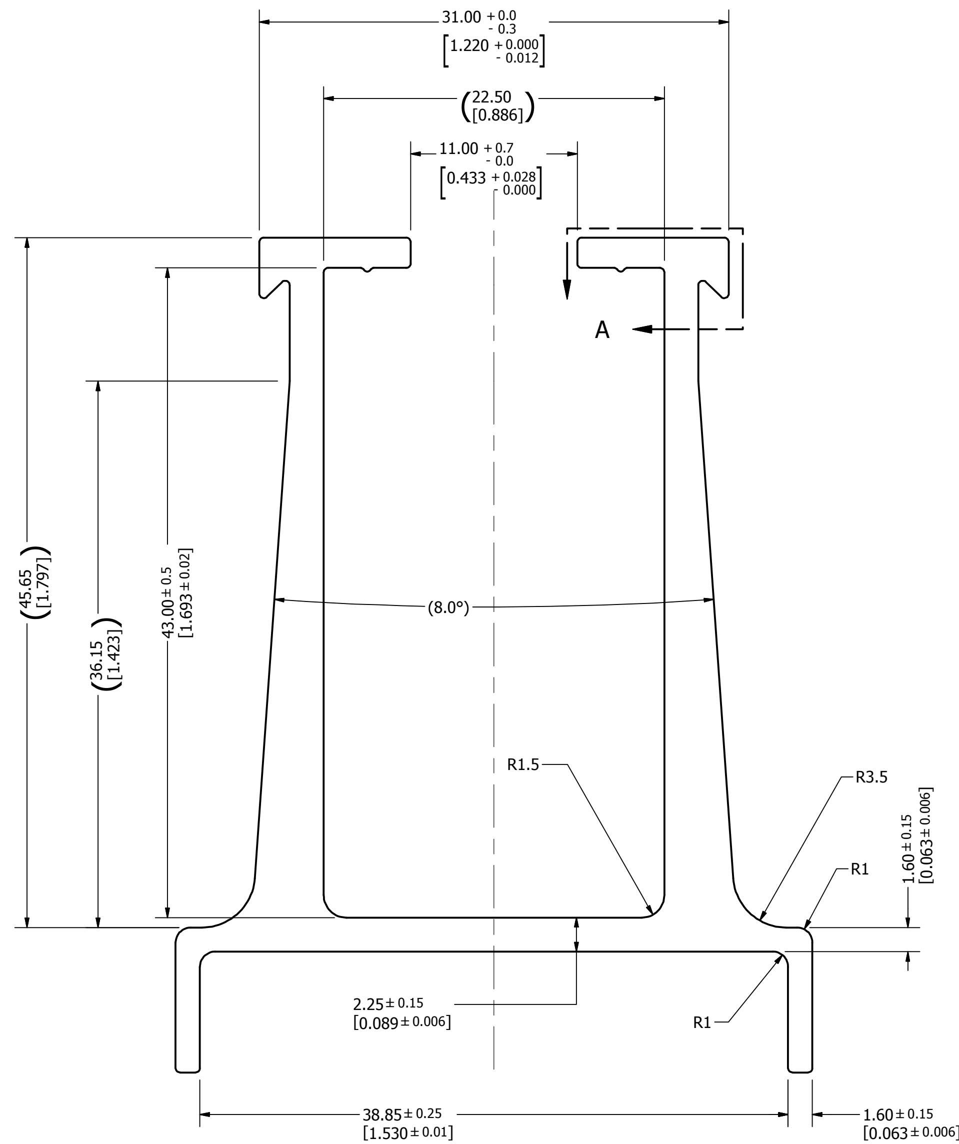
Title: MS-5X Profile		
Part Number: 401102		
Material: 6063-T6 Aluminum, Mill Finish		
Units: mm [in]	Perimeter: 320.7 mm	Weight: 0.813 LB/FT
Drawn by: hhutchinson	Date: 5/1/2017	
Produced From Part Number:		



DETAIL A



REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	05/01/2017	H HUTCHINSON

Renusol
Solar Mounting Systems

Renusol America, Inc.
1292 Logan Circle
Atlanta, GA 30318
+1-877-847-8919
info@RensolAmerica.com

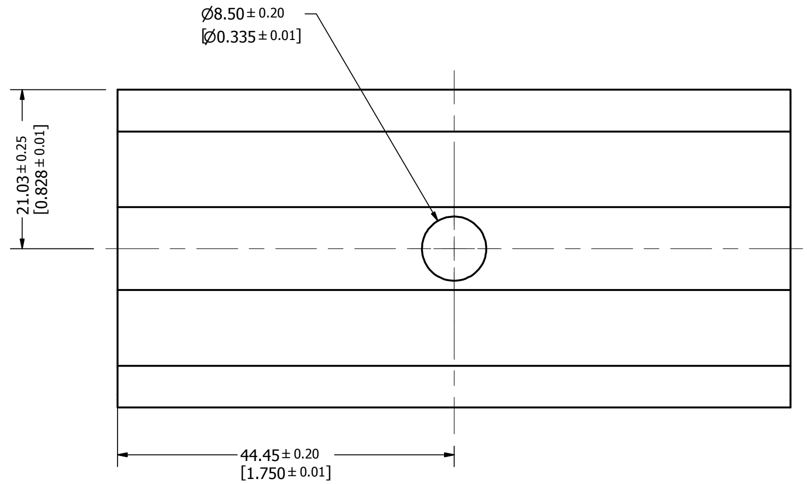
Title:
MS-5X Clamp Base

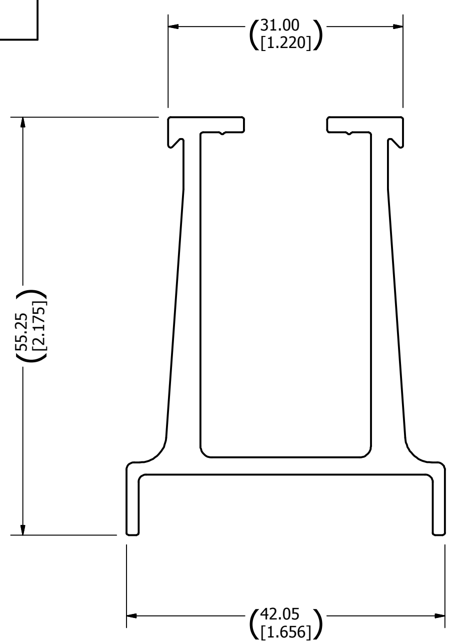
Part Number:
401104

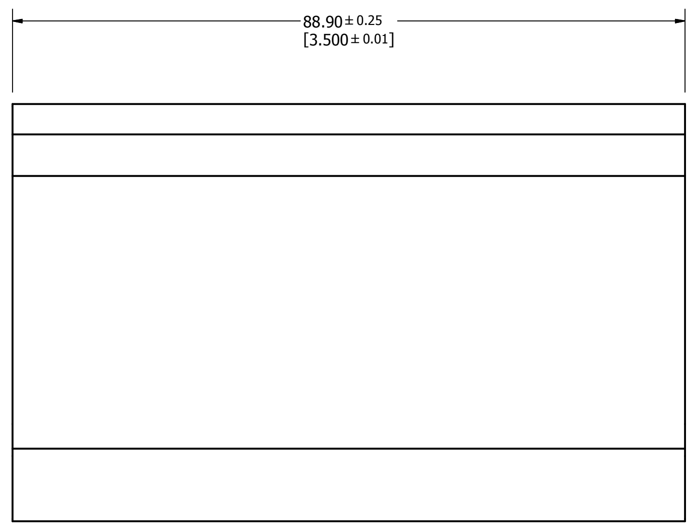
Material:
6063-T6 Aluminum, Mill Finish

Units:	Perimeter:	Weight:
mm [in]		0.107 kg
Drawn by: hhutchinson	Date: 5/1/2017	

Produced From Part Number:







REVISION HISTORY			
REV	DESCRIPTION	DATE	APPROVED
A	INITIAL RELEASE	05/01/2017	H HUTCHINSON

EVALUATION SUBJECT:
EJOT EJOFAST® bi-metal SELF-DRILLING SCREWS JF3

REPORT HOLDER:
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CSI Division: 05 – METALS
CSI Section: 050523 – Metal Fastenings

1.0 SCOPE OF EVALUATION

1.1 Compliance to the following codes & regulations:
- 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 February 2016

1.3 Properties assessed:
- Structural

2.0 PRODUCT USE

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 complying with IBC Sections 2210 and 2211 in thicknesses ranging from No. 20 gage to No. 26 gage.

3.0 PRODUCT 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 of this report provides a description of the screws recognized in this report.

3.2 Material information

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. The screws comply with Corrosion Protection Performance Classification Code Fe/Zn 3A in accordance with ASTM F1941-10.

3.2.2 Cold-Formed Steel Members: Connected members (sheet metal) shall 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 NO.	MINIMUM NOMINAL THICKNESS (mils)	DESIGN THICKNESS (in.)	MINIMUM YIELD STRESS (psi)	MINIMUM TENSILE STRESS (psi)
26 gage	16	0.017	33,000	45,000
24 gage	22	0.023	33,000	45,000
22 gage	27	0.028	33,000	45,000
20 gage	32	0.034	33,000	45,000

For SI 1 mil = 0.0254 mm, 1 inch = 25.4 mm, 1 psi = 0.006895 MPa

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

4.2 Installation: Installation of the EJOT EJOFAST® bi-metal self-drilling screws shall be in accordance with AISI S100, the manufacturer's published installation instructions and this report. The manufacturer's published installation instructions shall be available at the jobsite at all times during the installation. The minimum spacing between the centers of fasteners shall be three times the diameter of the screw in accordance with Section E4.1 of AISI S100, and the minimum distance shall be 1.5 times the diameter of the screw from the center of a fastener to the edge of any connected part in accordance with Section E4.2 of AISI S100.

The screws shall be installed perpendicular to the work surface using a tool with maximum recommended speed of 2,500 rpm. The screw shall penetrate through the supporting steel with a minimum of three threads protruding past the back side of the steel not in contact with the screw head.

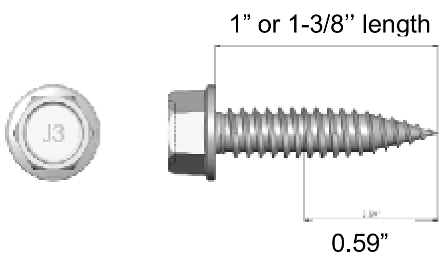

Figure 1 - EJOT EJOFAST® bi-metal SELF-DRILLING SCREW JF3

5.0 LIMITATIONS

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 shall be installed in accordance with AISI S100, the manufacturer's published installation instructions and this report. Where conflict exists between these three documents, the more restrictive shall govern.

5.2 The allowable strengths (ASD) specified in Section 4.1 of this report shall not be increased when the screws are used to resist wind or seismic force.

5.3 The bi-metal screws shall be suitable for the intended use, as determined by a registered design professional.

5.4 Calculations to verify conformance with this report shall 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 statues of the jurisdiction in which the project is proposed.

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

6.0 SUBSTANTIATING DATA

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-276).

or

IAPMO ER #276

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For additional information about this evaluation report please visit www.uniform-es.org or email at info@uniform-es.org

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, Φ = 0.5. For ASD, Ω = 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, Φ = 0.6 and Ω = 2.7. For 24 gage, Φ = 0.6 and Ω = 2.5.
For 22 gage, Φ = 0.6 and Ω = 2.5. For 20 gage, Φ = 0.5 and Ω = 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, Φ = 0.5 and Ω = 3.0. For 24 gage, Φ = 0.6 and Ω = 2.7.
For 22 gage, Φ = 0.6 and Ω = 2.7. For 20 gage, Φ = 0.5 and Ω = 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, Φ = 0.6 and Ω = 2.7.