PVAC Module
Rack Installation Instructions

Manual Revision E

IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS!

READ ALL INFORMATION CONTAINED IN THIS MANUAL BEFORE USING OR INSTALLING THIS PRODUCT.

THIS MANUAL CONTAINS IMPORTANT INSTRUCTIONS FOR THE EXELTECH PVAC MODULE RACKING SYSTEM THAT SHALL BE FOLLOWED DURING INSTALLATION. FAILURE TO FOLLOW THESE INSTRUCTIONS COULD LEAD TO SERIOUS INJURY OR DEATH, OR DAMAGE TO EQUIPMENT OR PROPERTY.

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I. DISCLAIMER

Exeltech assumes no responsibility and disclaims any liability for any loss, damage or expense associated with the installation, use or maintenance of Exeltech solar modules. Liability of Exeltech is strictly limited to the written warranty for the product. Exeltech reserves the right to make changes to all product specifications and to this manual without previous notice.

The installer is solely responsible for:

- Complying with all applicable local or national building codes, including any that may supersede this manual. This includes structural requirements of the IBC 2006, IBC 2003, ASCE 7-02, ASCE 7-05 and California Building Code.
- Ensuring that Exeltech and other products are appropriate for the particular installation and the installation environment.
- Ensuring that the building structures' roof, rafters, connections, and other structural support members can support the array under all code level loading conditions.
- Using only Exeltech parts as specified by Exeltech (substitution of parts may void the warranty and invalidate the letters of certification in all Exeltech publications).
- Verifying the strength of any alternate mounting.
- Maintaining waterproof integrity of the roof, including selection of appropriate flashing.
- Ensuring lag screws have adequate pullout strength and shear capacities as installed.

II. SAFETY

SAFETY SYMBOLS USED IN THIS MANUAL

SYMBOL	ASSOCIATED TERM	WHAT IT MEANS
	WARNING!	Calls attention to a potentially hazardous situation, which if not avoided, could lead to death or serious injury, and/or damage to equipment and property.
	CAUTION!	Indicates a potentially dangerous situation that may result in minor or moderate injury. May also be used to alert against unsafe practices.
	WARNING!	References information pertaining to voltages in or around the unit that are capable of causing injury or death.
	NOTE!	Designates important information required for proper installation.

<u>IMPORTANT!</u>

FAILURE TO HEED THESE SYMBOLS AND THE DOCUMENTATION THEY REFERENCE COULD RESULT IN DEATH OR SERIOUS INJURY, OR DAMAGE TO YOUR PROPERTY.

III. General Information

- Exeltech PVAC Modules produce hazardous AC electrical currents that may cause bodily harm and possibly even death.
- Avoid electrical hazards when installing, wiring, operating and maintaining your solar modules.
- Read all installation instructions completely before installing, using, and maintaining your solar modules.
- Follow all safety precautions of all other system components.
- Ensuring safe installation of all electrical aspects of the PV array. Parameters such as snow loading, wind speed, exposure and topographic factor should be confirmed with the local building officials or a licensed professional engineer.
- Do not drop, bend or allow objects to fall onto modules. The face of the modules are manufactured of tempered glass may shatter if exposed to pressure.
- Do not stand on the modules.
- Do not place equipment on solar module.
- Use extreme caution and proper roof safety when installing and maintaining your solar system.
- Do not drill or cut holes in solar module frames or wiring.
- Do not use artificially concentrated sunlight to illuminate the solar modules.
- Do not disassemble the module or remove any part or label installed by Exeltech. Doing so will void the manufacturer's warranty.
- Do not install the solar module where chemical or gas vapors are present.
- Be sure the construction or structures where the modules are being installed can support the weight of the modules.
- For modules mounted on roofs, special construction or supports may be required prior to installation.

IV. Wind Load Design Procedure

The procedure to determine design wind load is specified by the American Society of Civil Engineers and referenced in the International Building Code 2006. For purposes of this document, the values, equations and procedures used in this document reference ASCE 7-05, Minimum Design Loads for Buildings and Other Structures.

Please refer to ASCE 7-05 if you have any questions about the definitions or procedures presented in this manual.

Simplified Method: (This method is not approved for open structure calculations)

This method is valid for flush, no tilt, on either roofs or walls. Flush is defined as PV modules parallel to the surface (or with no more than 3" difference between ends of assembly) with no more than 10" space between the roof surface, and the bottom of the PV modules.

Applications of these procedures are subject to the following ASCE 7-05 limitations:

1. The building height must be less than 60 feet, h < 60. See note for determining h in the next section.

2. The building must be enclosed, not an open or partially enclosed structure, for example a carport.

3. The building is regular shaped with no unusual geometrical irregularity in spatial form, for example a geodesic dome.

4. The building is not in an extreme geographic location such as a narrow canyon or steep cliff.

5. The building has a flat or gable roof with a pitch less than 45 degrees or a hip roof with a pitch less than 27 degrees.

6. If your installation is outside the United States or does not meet all of these limitations, consult a local professional engineer or your local building authority. Consult ASCE 7-05 for more clarification. Lower design wind loads may be obtained by applying Method II from ASCE 7-05. Consult with a licensed engineer if you want to use Method II procedures.

7. The equation for determining the Design Wind Load for components and cladding is:

   pnet (psf) = λKztI pnet30
   pnet (psf) = Design Wind Load
   λ = adjustment factor for height and exposure category
   Kzt = Topographic Factor at mean roof height, h (ft)
   I = Importance Factor
   pnet30 (psf) = net design wind pressure for Exposure B, at height = 30, I = 1

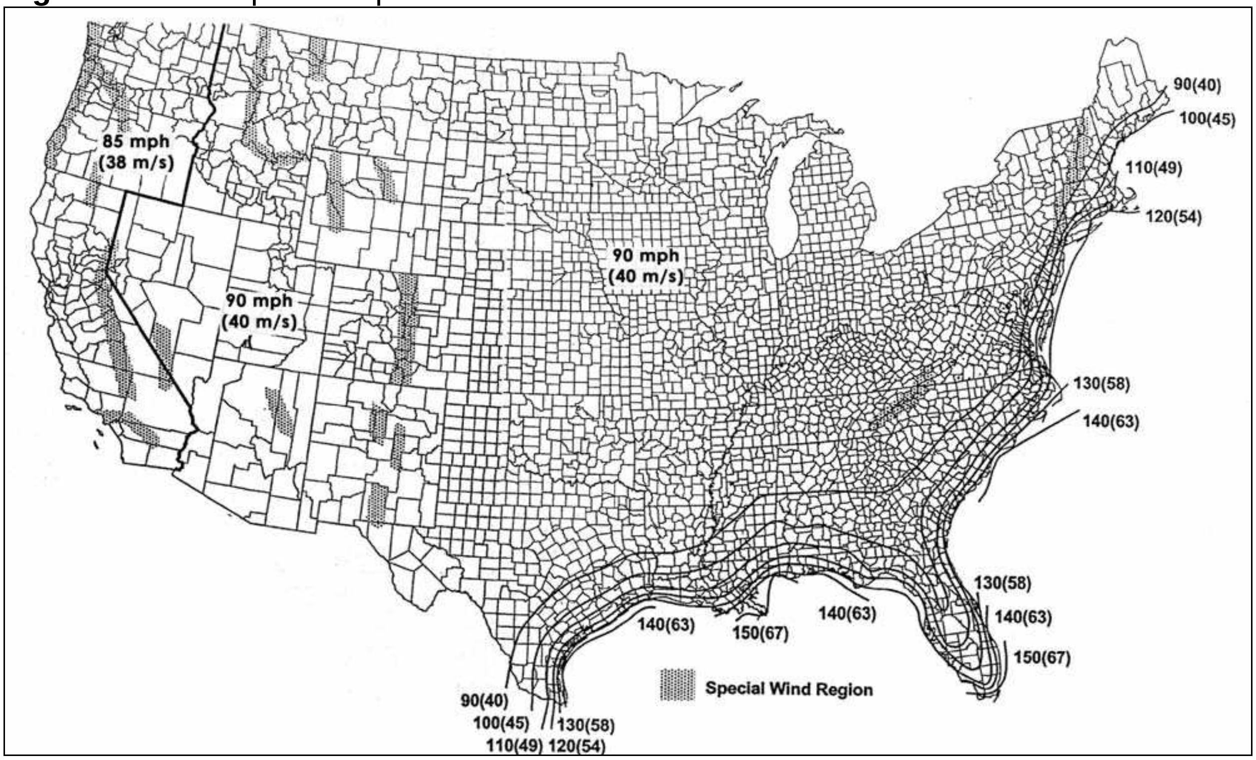
You will also need to know the following information:

- Basic Wind Speed = V (mph), the largest 3 second gust of wind in the last 50 years.
- h (ft) = total roof height for fl at roof buildings or mean roof height for pitched roof buildings.
- Effective Wind Area (sf) = minimum total continuous area of modules being installed.
- Roof Zone = the area of the roof you are installing the PV
- Roof Zone Setback Length = a (ft)
- Roof Pitch (degrees)
- Exposure Category

Step 1: Determine Basic Wind Speed, V (mph)

Determine your Basic Wind Speed by locating your installation location on the following map.

Figure 1: Wind Speed Map



Step 2: Determining Effective Wind Area

Determine the smallest area of continuous modules you will be installing. This is the smallest area tributary (contributing load) to a support or to a simple-span of rail. That area is the Effective Wind Area, the total area of the fewest number of modules on a run of rails.

Step 3: Determine Roof/Wall Zone

The Design Wind Load will vary based on where the installation is located on a roof. Arrays may be located in more than one roof zone.

Using Table 1, determine the Roof Zone Setback Length, a (ft), according to the width and height of the building on which you are installing the PV system.

Table-1: Determine Roof/Wall Zone, length (**a**) according to building width and height.

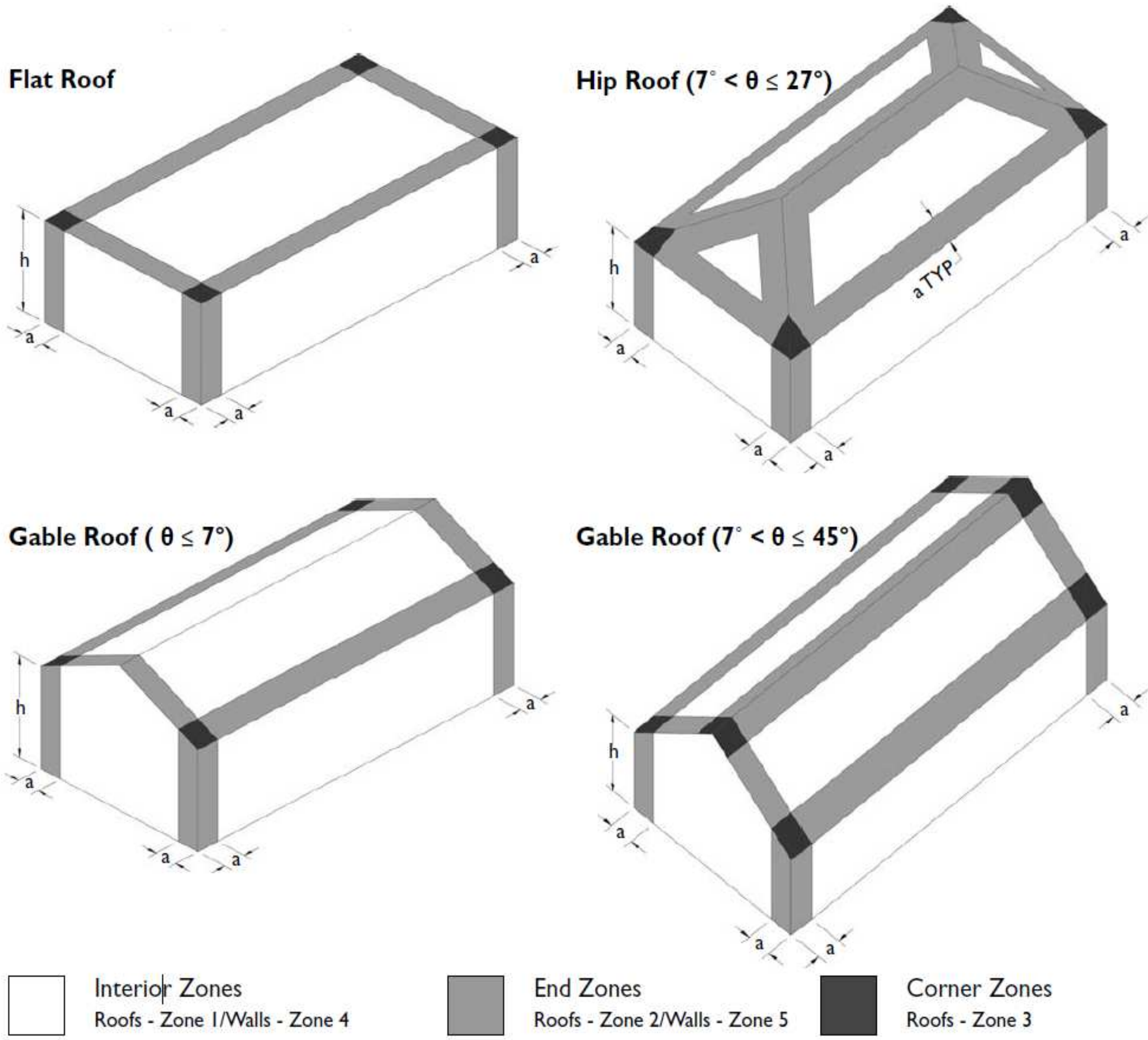
a = 10 percent of the least horizontal dimension or 0.4h, whichever is smaller, but not less than either 4% of the least horizontal dimension or 3 ft of the building.

Using *Roof Zone Setback Length*, a, determine the roof zone locations according to your roof type, gable, hip or mono-slope. Determine in which roof zone your PV system is located, Zone 1, 2, or 3 according to **Figure- 2**.

Table- 1: Determine Roof/Wall Zone

Roof Height in ft.	Least Horizontal Dimension (ft)																		
	10	15	20	25	30	40	50	60	70	80	90	100	125	150	175	200	300	400	500
10	3	3	3	3	3	4	4	4	4	4	4	4	5	6	7	8	12	16	20
15	3	3	3	3	3	4	5	6	6	6	6	6	6	6	7	8	12	16	20
20	3	3	3	3	3	4	5	6	7	8	8	8	8	8	8	8	12	16	20
25	3	3	3	3	3	4	5	6	7	8	9	10	10	10	10	10	12	16	20
30	3	3	3	3	3	4	5	6	7	8	9	10	12	12	12	12	12	16	20
35	3	3	3	3	3	4	5	6	7	8	9	10	12.5	14	14	14	14	16	20
40	3	3	3	3	3	4	5	6	7	8	9	10	12.5	15	16	16	16	16	20
45	3	3	3	3	3	4	5	6	7	8	9	10	12.5	15	17.5	18	18	18	20
50	3	3	3	3	3	4	5	6	7	8	9	10	12.5	15	17.5	20	20	20	20
60	3	3	3	3	3	4	5	6	7	8	9	10	12.5	15	17.5	20	24	24	24

Figure- 2: Enclosed buildings, wall and roofs



Source: ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, Chapter 6, p. 41.

Step 4: Determine *Net Design Wind Pressure, pnet30 (psf)*

Use the *Effective Wind Area* (Step 2), *Roof Zone Location* (Step 3), and *Basic Wind Speed* (Step 1), to look up the appropriate *Net Design Wind Pressure* in Table 2, page 6. Use the *Effective Wind Area* value in the table which is smaller than the value calculated in Step 2. If the installation is located on a roof overhang, use Table 3, page 7.

Both down-force and uplift pressures must be considered in overall design. Refer to Section II, Step 1 for applying down-force and uplift pressures. Positive values are acting toward the surface. Negative values are acting away from the surface.

Table- 2: pnet30 (psf) Roof and Wall

Basic Wind Speed V (mph)

	Zone	Effective Wind Area (sf)	90		100		110		120		130		140		150		170	
			Downforce	Uplift	Downforce	Uplift	Downforce	Uplift	Downforce	Uplift	Downforce	Uplift	Downforce	Uplift	Downforce	Uplift	Downforce	Uplift
Roof 0 to 7 degrees	1	10	5.9	-14.6	7.3	-18.0	8.9	-21.8	10.5	-25.9	12.4	-30.4	14.3	-35.3	16.5	-40.5	21.1	-52.0
	1	20	5.6	-14.2	6.9	-17.5	8.3	-21.2	9.9	-25.2	11.6	-29.6	13.4	-34.4	15.4	-39.4	19.8	-50.7
	1	50	5.1	-13.7	6.3	-16.9	7.6	-20.5	9.0	-24.4	10.6	-28.6	12.3	-33.2	14.1	-38.1	18.1	-48.9
	1	100	4.7	-13.3	5.8	-16.5	7.0	-19.9	8.3	-23.7	9.8	-27.8	11.4	-32.3	13.0	-37.0	16.7	-47.6
	2	10	5.9	-24.4	7.3	-30.2	8.9	-36.5	10.5	-43.5	12.4	-51.0	14.3	-59.2	16.5	-67.9	21.1	-87.2
	2	20	5.6	-21.8	6.9	-27.0	8.3	-32.6	9.9	-38.8	11.6	-45.6	13.4	-52.9	15.4	-60.7	19.8	-78.0
	2	50	5.1	-18.4	6.3	-22.7	7.6	-27.5	9.0	-32.7	10.6	-38.4	12.3	-44.5	14.1	-51.1	18.1	-65.7
	2	100	4.7	-15.8	5.8	-19.5	7.0	-23.6	8.3	-28.1	9.8	-33.0	11.4	-38.2	13.0	-43.9	16.7	-56.4
	3	10	5.9	-36.8	7.3	-45.4	8.9	-55.0	10.5	-65.4	12.4	-76.8	14.3	-89.0	16.5	-102.2	21.1	-131.3
	3	20	5.6	-30.5	6.9	-37.6	8.3	-45.5	9.9	-54.2	11.6	-63.6	13.4	-73.8	15.4	-84.7	19.8	-108.7
	3	50	5.1	-22.1	6.3	-27.3	7.6	-33.1	9.0	-39.3	10.6	-46.2	12.3	-53.5	14.1	-61.5	18.1	-78.9
	3	100	4.7	-15.8	5.8	-19.5	7.0	-23.6	8.3	-28.1	9.8	-33.0	11.4	-38.2	13.0	-43.9	16.7	-56.4
Roof >7 to 27degrees	1	10	8.4	-13.3	10.4	-16.5	12.5	-19.9	14.9	-23.7	17.5	-27.8	20.3	-32.3	23.3	-37.0	30.0	-47.6
	1	20	7.7	-13.0	9.4	-16.0	11.4	-19.4	13.6	-23.0	16.0	-27.0	18.5	-31.4	21.3	-36.0	27.3	-46.3
	1	50	6.7	-12.5	8.2	-15.4	10.0	-18.6	11.9	-22.2	13.9	-26.0	16.1	-30.2	18.5	-34.6	23.8	-44.5
	1	100	5.9	-12.1	7.3	-14.9	8.9	-18.1	10.5	-21.5	12.4	-25.2	14.3	-29.3	16.5	-33.6	21.1	-43.2
	2	10	8.4	-23.2	10.4	-28.7	12.5	-34.7	14.9	-41.3	17.5	-48.4	20.3	-56.2	23.3	-64.5	30.0	-82.8
	2	20	7.7	-21.4	9.4	-26.4	11.4	-31.9	13.6	-38.0	16.0	-44.6	18.5	-51.7	21.3	-59.3	27.3	-76.2
	2	50	6.7	-18.9	8.2	-23.3	10.0	-28.2	11.9	-33.6	13.9	-39.4	16.1	-45.7	18.5	-52.5	23.8	-67.4
	2	100	5.9	-17.0	7.3	-21.0	8.9	-25.5	10.5	-30.3	12.4	-35.6	14.3	-41.2	16.5	-47.3	21.1	-60.8
	3	10	8.4	-34.3	10.4	-42.4	12.5	-51.3	14.9	-61.0	17.5	-71.6	20.3	-83.1	23.3	-95.4	30.0	-122.5
	3	20	7.7	-32.1	9.4	-39.6	11.4	-47.9	13.6	-57.1	16.0	-67.0	18.5	-77.7	21.3	-89.2	27.3	-114.5
	3	50	6.7	-29.1	8.2	-36.0	10.0	-43.5	11.9	-51.8	13.9	-60.8	16.1	-70.5	18.5	-81.0	23.8	-104.0
	3	100	5.9	-26.9	7.3	-33.2	8.9	-40.2	10.5	-47.9	12.4	-56.2	14.3	-65.1	16.5	-74.8	21.1	-96.0
Roof >27 to 45 degrees	1	10	13.3	-14.6	16.5	-18.0	19.9	-21.8	23.7	-25.9	27.8	-30.4	32.3	-35.3	37.0	-40.5	47.6	-52.0
	1	20	13.0	-13.8	16.0	-17.1	19.4	-20.7	23.0	-24.6	27.0	-28.9	31.4	-33.5	36.0	-38.4	46.3	-49.3
	1	50	12.5	-12.8	15.4	-15.9	18.6	-19.2	22.2	-22.8	26.0	-26.8	30.2	-31.1	34.6	-35.7	44.5	-45.8
	1	100	12.1	-12.1	14.9	-14.9	18.1	-18.1	21.5	-21.5	25.2	-25.2	29.3	-29.3	33.6	-33.6	43.2	-43.2
	2	10	13.3	-17.0	16.5	-21.0	19.9	-25.5	23.7	-30.3	27.8	-35.6	32.3	-41.2	37.0	-47.3	47.6	-60.8
	2	20	13.0	-16.3	16.0	-20.1	19.4	-24.3	23.0	-29.0	27.0	-34.0	31.4	-39.4	36.0	-45.3	46.3	-58.1
	2	50	12.5	-15.3	15.4	-18.9	18.6	-22.9	22.2	-27.2	26.0	-32.0	30.2	-37.1	34.6	-42.5	44.5	-54.6
	2	100	12.1	-14.6	14.9	-18.0	18.1	-21.8	21.5	-25.9	25.2	-30.4	29.3	-35.3	33.6	40.5	43.2	-52.0
	3	10	13.3	-17.0	16.5	-21.0	19.9	-25.5	23.7	-30.3	27.8	-35.6	32.3	-41.2	37.0	-47.3	47.6	-60.8
	3	20	13.0	-16.3	16.0	-20.1	19.4	-24.3	23.0	-29.0	27.0	-34.0	31.4	-39.4	36.0	-45.3	46.3	-58.1
	3	50	12.5	-15.3	15.4	-18.9	18.6	-22.9	22.2	-27.2	26.0	-32.0	30.2	-37.1	34.6	-42.5	44.5	-54.6
	3	100	12.1	-14.6	14.9	-18.0	18.1	-21.8	21.5	-25.9	25.2	-30.4	29.3	-35.3	33.6	-40.5	43.2	-52.0
Wall	4	10	14.6	-15.8	18.0	-19.5	21.8	-23.6	25.9	-28.1	30.4	-33.0	35.3	-38.2	40.5	-43.9	52.0	-56.4
	4	20	13.9	-15.1	17.2	-18.7	20.8	-22.6	24.7	-26.9	29.0	-31.6	33.7	-36.7	38.7	-42.1	49.6	-54.1
	4	50	13.0	-14.3	16.1	-17.6	19.5	-21.3	23.2	-25.4	27.2	-29.8	31.6	-34.6	36.2	-39.7	46.6	-51.0
	4	100	12.4	-13.6	15.3	-16.8	18.5	-20.4	22.0	-24.2	25.9	-28.4	30.0	-33.0	34.4	-37.8	44.2	-48.6
	4	500	10.9	-12.1	13.4	-14.9	16.2	-18.1	19.3	-21.5	22.7	-25.2	26.3	-29.3	30.2	-33.6	38.8	-43.2
	5	10	14.6	-19.5	18.0	-24.1	21.8	-29.1	25.9	-34.7	30.4	-40.7	35.3	-47.2	40.5	-54.2	52.0	-69.6
	5	20	13.9	-18.2	17.2	-22.5	20.8	-27.2	24.7	-32.4	29.0	-38.0	33.7	-44.0	38.7	-50.5	49.6	-64.9
	5	50	13.0	-16.5	16.1	-20.3	19.5	-24.6	23.2	-29.3	27.2	-34.3	31.6	-39.8	36.2	-45.7	46.6	-58.7
	5	100	12.4	-15.1	15.3	-18.7	18.5	-22.6	22.0	-26.9	25.9	-31.6	30.0	-36.7	34.4	-42.1	44.2	-54.1
	5	500	10.9	-12.1	13.4	-14.9	16.2	-18.1	19.3	-21.5	22.7	-25.2	26.3	-29.3	30.2	-33.6	38.8	-43.2

Source: ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, Chapter 6, Figure 6-3, p. 42-43.

Table-3: pnet30 (psf) Roof Overhan**g**

	Zone	Effective Wind Area (sf)	Basic Wind Speed, V (mph) 90	100	110	120	130	140	150	170
Roof 0 to 7 degrees	2	10	-21.0	-25.9	-31.4	-37.3	-43.8	-50.8	-58.3	-74.9
	2	20	-20.6	-25.5	-30.8	-36.7	-43.0	-49.9	-57.3	-73.6
	2	50	-20.1	-24.9	-30.1	-35.8	-42.0	-48.7	-55.9	-71.8
	2	100	-19.8	-24.4	-29.5	-35.1	-41.2	-47.8	-54.9	-70.5
	3	10	-34.6	-42.7	-51.6	-61.5	-72.1	-83.7	-96.0	-123.4
	3	20	-27.1	-33.5	-40.5	-48.3	-56.6	-65.7	-75.4	-96.8
	3	50	-17.3	-21.4	-25.9	-30.8	-36.1	-41.9	-48.1	-61.8
	3	100	-10.0	-12.2	-14.8	-17.6	-20.6	-23.9	-27.4	-35.2
Roof >7 to 27degrees	2	10	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	2	20	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	2	50	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	2	100	-27.2	-33.5	-40.6	-48.3	-56.7	-65.7	-75.5	-96.9
	3	10	-45.7	-56.4	-68.3	-81.2	-95.3	-110.6	-126.9	-163.0
	3	20	-41.2	-50.9	-61.6	-73.3	-86.0	-99.8	-114.5	-147.1
	3	50	-35.3	-43.6	-52.8	-62.8	-73.7	-85.5	-98.1	-126.1
	3	100	-30.9	-38.1	-46.1	-54.9	-64.4	-74.7	-85.8	-110.1
Roof >27 to 45degrees	2	10	-24.7	-30.5	-36.9	-43.9	-51.5	-59.8	-68.6	-88.1
	2	20	-24.0	-29.6	-35.8	-42.6	-50.0	-58.0	-66.5	-85.5
	2	50	-23.0	-28.4	-34.3	-40.8	-47.9	-55.6	-63.8	-82.0
	2	100	-22.2	-27.4	-33.2	-39.5	-46.4	-53.8	-61.7	-79.3
	3	10	-24.7	-30.5	-36.9	-43.9	-51.5	-59.8	-68.6	-88.1
	3	20	-24.0	-29.6	-35.8	-42.6	-50.0	-58.0	-66.5	-85.5
	3	50	-23.0	-28.4	-34.3	-40.8	-47.9	-55.6	-63.8	-82.0
	3	100	-22.2	-27.4	-33.2	-39.5	-46.4	-53.8	-61.7	-79.3

Source: ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, Chapter 6, p. 44.

Step 5: Determine the Topographic Factor, Kzt

For the purposes of this code compliance document, the Topographic Factor, Kzt, is taken as equal to one (1), meaning, the installation is surrounded by level ground (less than 10% slope). If the installation is not surrounded by level ground, please consult ASCE 7-05, Section 6.5.7 and the local building authority to determine the Topographic Factor.

Step 6: Determine Exposure Category (B, C, D)

Determine the Exposure Category by using the following definitions for Exposure Categories.

The ASCE/SEI 7-05* defines wind exposure categories as follows:

Exposure-B is urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single family dwellings.

Exposure-C has open terrain with scattered obstructions having heights generally less than 30 feet. This category includes flat open country, grasslands, and all water surfaces in hurricane prone regions.

Exposure-D has flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.

Also see **ASCE 7-05 pages 287-291** for further explanation and explanatory photographs, and confirm your selection with the local building authority.

Step 7: Determine adjustment factor for height and exposure category, λ

Using the Exposure Category (Step 6) and the roof height, h (ft), look up the adjustment factor for height and exposure in **Table- 4.**

Table 4. Adjustment Factor (λ) for Roof Height & Exposure Category

Mean roof height (ft)	*Exposure*		
	B	*C*	*D*
15	1.00	1.21	1.47
20	1.00	1.29	1.55
25	1.00	1.35	1.61
30	1.00	1.40	1.66
35	1.05	1.45	1.70
40	1.09	1.49	1.74
45	1.12	1.53	1.78
50	1.16	1.56	1.81
55	1.19	1.59	1.84
60	1.22	1.62	1.87

Source: ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, Chapter 6, Figure 6-3, p. 44.

Step 8: Determine the Importance Factor, I

Determine if the installation is in a hurricane prone region. Look up the Importance Factor, I, Table 6, page 9, using the occupancy category description and the hurricane prone region status.

Step 9: Calculate the Design Wind Load, pnet (psf)

Multiply the Net Design Wind Pressure, pnet30 (psf)(Step 4) by the adjustment factor for height and exposure, λ (Step 7),the Topographic Factor, Kzt (Step 5), and the Importance Factor, I (Step 8) using the following equation:

P_{net} (psf) = $\lambda * K_{zt} * I * \rho net30$

P_{net} (psf) = Design Wind Load (10 psf minimum)

λ = adjustment factor for height and exposure category (Step 7)

K_{zt} = Topographic Factor at mean roof height, h (ft) (Step 5)

I = Importance Factor (Step 8)

ρnet30 (psf) = net design wind pressure for Exposure B, at height = 30, I = 1 (Step 4)

Use **Table-5** below to calculate Design Wind Load.

Table 5. Worksheet for Components and Cladding Wind Load Calculation: IBC 2006, ASCE 7-05

Variable Description	*Symbol*	*Value*	*Unit*	*Step*	*Reference*
Building Height	h		ft		
Building, Least Horizontal Dimension			ft		
Roof Pitch			degrees		
Exposure Category				6	
Basic Wind Speed	V		mph	1	Figure 1
Effective Wind Area			sf	2	
Roof Zone Setback Length	a		ft	3	Table 1
Roof Zone Location				3	Figure 2
Net Design Wind Pressure	p_{net30}		psf	4	Table 2, 3
Topographic Factor	K_{zt}	x		5	
Adjustment factor for height and exposure category	λ	x		7	Table 4
Importance Factor	I	x		8	Table 5
Total Design Wind Load	p_{net}		psf	9	

Table 6. Occupancy Category Importance Factor

Category	Category Description	Building Type Examples	Non-Hurricane Prone Regions and Hurricane Prone Regions with Basic Wind Speed, V = 85-100 mph, and Alaska	Hurricane Prone Regions with Basic Wind Speed, V > 100mph
I	Buildings and other structures that represent a low hazard to human life in the event of failure, including, but limited to:	Agricultural facilities Certain Temporary facilities Minor Storage facilities	0.87	0.77
II	All buildings and other structures except those listed in Occupancy Categories I, III, and IV.		1	1
III	Buildings and other structures that represent a substantial hazard to human life in the event of a failure, including, but not limited to:	Buildings where more than 300 people congregate Schools with a capacity more than 250 Day Cares with a capacity more than 150 Buildings for colleges with a capacity more than 500 Health Care facilities with a capacity more than 50 or more resident patients Jails and Detention Facilities Power Generating Stations Water and Sewage Treatment Facilities Telecommunication Centers Buildings that manufacture or house hazardous materials	1.15	1.15
IV	Buildings and other structures designated as essential facilities, including, but not limited to:	Hospitals and other health care facilities having surgery or emergency treatment Fire, rescue, ambulance and police stations Designated earthquake, hurricane, or other emergency shelters Designated emergency preparedness communication, and operation centers Power generating stations and other public utility facilities required in an emergency Ancillary structures required for operation of Occupancy Category IV structures Aviation control towers, air traffic control centers, and emergency aircraft hangars Water storage facilities and pump structures required to maintain water pressure for fire suppression Buildings and other structures having critical national defense functions	1.15	1.15

Source: IBC 2006, Table 1604.5, Occupancy Category of Buildings and other structures, p. 281; ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures, Table 6-1, p. 77

V. Rail Span Calculation (Structural Engineering Methodology)

This procedure will assist you to determine the rail span. It uses standard beam calculations and structural engineering methodology. The beam calculations are based on a simply supported beam conservatively, ignoring the reductions allowed for supports of continuous beams over multiple supports.

Note: In using this document, obtaining correct results is dependent upon the following.

1. Obtain the *Snow Load* for your area from your local building official.
2. Obtain the *Design Wind Load, pnet*. See Part IV (Wind Load Design Procedure) for more information on calculating the *Design Wind Load*.

The following procedure will assist you determining the design loading imposed by the PV Racking assembly that the building structure must be capable of supporting.

Step 1: Determine the *Total Design Load*

The *Total Design Load, P (psf)* is determined using ASCE 7-05 2.4.1 (ASD Method equations 3,5,6 and 7) by adding the *Snow Load*1, S (psf), *Design Wind Load*, *pnet (psf)* from **Part IV, Step 9** and the *Dead Load (psf)*. Both Uplift and Down-force Wind Loads calculated in Step 9 of Part 1 must be investigated. Use Table 7 to calculate the Total Design Load for the load cases. Use the maximum absolute value of the three down-force cases and the uplift case for sizing the rail. Use the uplift case only for sizing lag bolts pull out capacities (Part II, Step 6).

P (psf) = 1.0D + 1.0S1 (down-force case 1)

P (psf) = 1.0D + 1.0pnet (down-force case 2)

P (psf) = 1.0D + 0.75S1 + 0.75pnet (down-force case 3)

P (psf) = 0.6D + 1.0pnet (uplift)

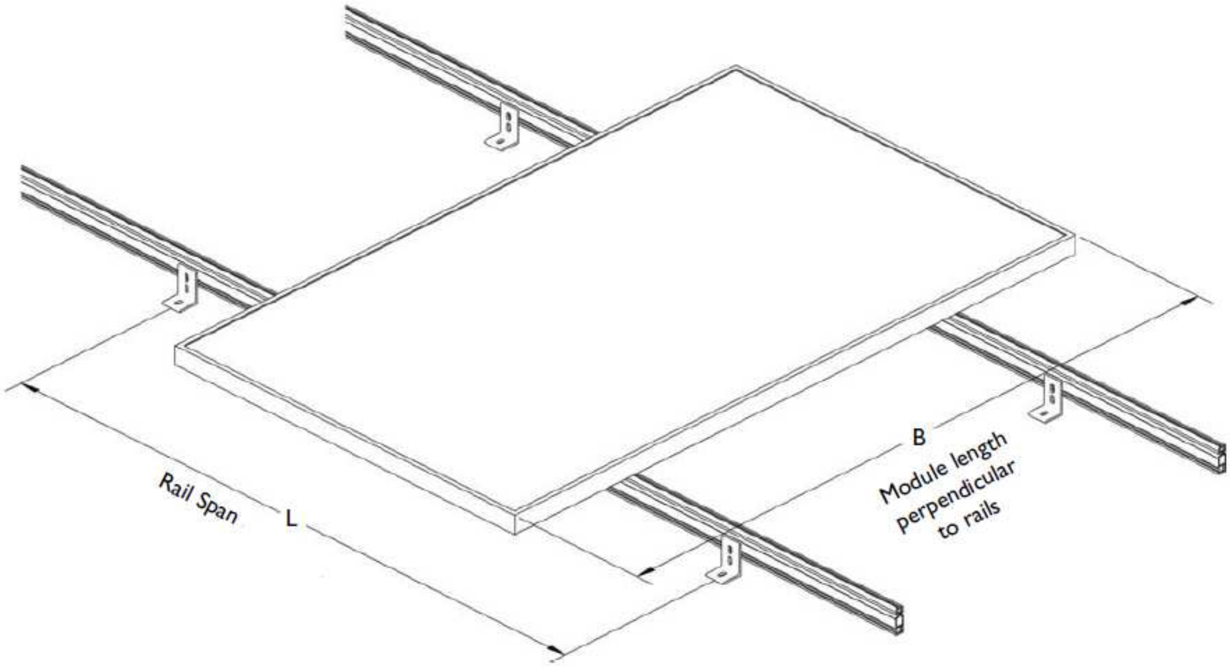
D = Dead Load (psf)

S = Snow Load (psf)

pnet = Design Wind Load (psf) (Positive for down-force, negative for uplift)

Snow Load Reduction - The snow load can be reduced according to Chapter 7 of ASCE 7-05. The reduction is a function of the roof slope, Exposure Factor, Importance Factor and Thermal Factor. Please refer to Chapter 7 of ASCE 7-05 for more information.

Figure-3: Rail Spacing



Note: Modules must be centered symmetrically on the rails (+/- 2*), as shown in Figure 3.

Table -7: ASCE 7 ASD Load Combinations

Description	Variable	Downforce Case 1	Downforce Case 2	Downforce Case 3	Uplift	units
Dead Load	D	1.0 x	1.0 x	1.0 x	0.6 x	psf
Snow Load	S	1.0 x + ______		0.75 x + ______		psf
Design Wind Load	Pnet		1.0 x + ______	0.75 x + ______	1.0 x -	psf
Total Design Load	P					psf

Note: Table to be filled out or attached for evaluation

Step 2: Determine the *Distributed Load on the rail, w (plf)*

Determine the *Distributed Load, w (plf)*, by multiplying the module length, B (ft), by the *Total Design Load, P (psf)* and dividing by two. Use the maximum absolute value of the three down-force cases and the Uplift Case. We assume each module is supported by two rails.
w = PB/2

w = Distributed Load (pounds per linear foot, plf)

B = Module Length Perpendicular to Rails (ft)

P = Total Design Pressure (pounds per square foot, psf)

Step 3: Determine the Down-force Point Load, R (lbs), at each connection based on rail span

When designing a flush mount Installation, you must consider the down-force Point Load, R (lbs) on the roof structure.

The *Down-force*, *Point Load, R (lbs)*, is determined by multiplying the *Total Design Load, P (psf)* (Step 1) by the *Rail Span, L (ft)* (Step 3) and the *Module Length Perpendicular to the Rails, B (ft)* divided by two.

R (lbs) = PLB/2

R = Point Load (lbs)

P = Total Design Load (psf)

L = Rail Span (ft)

B = Module Length Perpendicular to Rails (ft)

Note: It is the installer's responsibility to verify that the building structure is strong enough to support the maximum point loads calculated according to Step 5.

Table- 10: Down-force Point Load Calculations

Total Design Load (downforce) (max of case 1, 2 or 3)	P		psf	Step 1
Module length perpendicular to rails	B	x	ft	
Rail Span	L	x	ft	Step 4
		/2		
Downforce Point Load	R		lbs	

Step 4: Determine the Uplift Point Load, R (lbs), at each connection based on rail span

You must also consider the Uplift Point Load, R (lbs), to determine the required lag bolt attachment to the roof (building) structure.

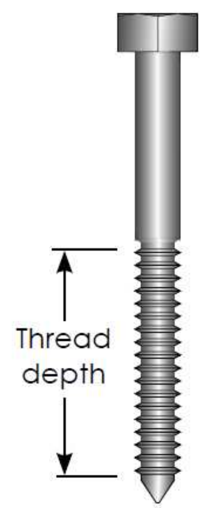
Table -11: Uplift Point Load Calculation

Total Design Load (uplift)	P		psf	Step 1
Module length perpendicular to rails	B	x	ft	
Rail Span	L	x	ft	Step 4
		/2		
Uplift Point Load	R		lbs	

Use **Table-12** to select a lag bolt size and embedment depth to satisfy your Uplift Point Load Force, R (lbs), requirements.
It is the installer's responsibility to verify that the substructure and attachment method is strong enough to support the maximum point loads calculated according to Step 5 and Step 6.

Table- 12: Lag pull-out (withdrawal) capacities (lbs) in typical roof lumber (ASD)

	Specific gravity	*Lag screw specifications* *$^5/_{16}$" shaft,* per inch thread depth*
Douglas Fir, Larch	**0.50**	**266**
Douglas Fir, South	**0.46**	**235**
Engelmann Spruce, Lodgepole Pine (MSR 1650 f & higher)	**0.46**	**235**
Hem, Fir, Redwood (close grain)	**0.43**	**212**
Hem, Fir (North)	**0.46**	**235**
Southern Pine	**0.55**	**307**
Spruce, Pine, Fir	**0.42**	**205**
Spruce, Pine, Fir (E of 2 million psi and higher grades of MSR and MEL)	**0.50**	**266**



Sources: American Wood Council, NDS 2005, Table 11.2A, 11.3.2A

Lag Bolt Installation Notes:

1. Thread must be embedded in the side grain of a rafter or other structural member integral with the building structure.
2. Lag bolts must be located in the middle third of the structural member.
3. These values are not valid for wet service.
4. This table does not include shear capacities. If necessary, contact a local engineer to specify lag bolt size with regard to shear forces.
5. Install lag bolts with head and washer flush to surface (no gap). Do not over-torque.
6. Withdrawal design values for lag screw connections shall be multiplied by applicable adjustment factors if necessary. See Table 10.3.1 in the American Wood Council NDS for Wood Construction.

*Use flat washers and Star Washers with lag screws.

NOTE! The installer is solely responsible for:

1) Complying with all applicable local or national building codes, including any that may supersede this manual;
2) Ensuring that the roof, its rafters, connections, and other structural support members can support the array under all code-level loading conditions;
3) Using only those parts supplied with the mounting kits for mounting and attachment of the PV AC Modules to the rack frames;
4) Ensuring that lag screws have adequate pull-out strength and shear capacities as installed;
5) Maintaining the waterproof integrity of the roof, including selection of appropriate flashing;
6) Ensuring safe installation of all electrical aspects of the PV AC Module array; and
7) Ensuring correct and appropriate design parameters are used in determining the design loading used for design of the specific installation. Parameters such as snow loading, wind speed, exposure and topographic factors should be confirmed with a local building official or licensed professional engineer.

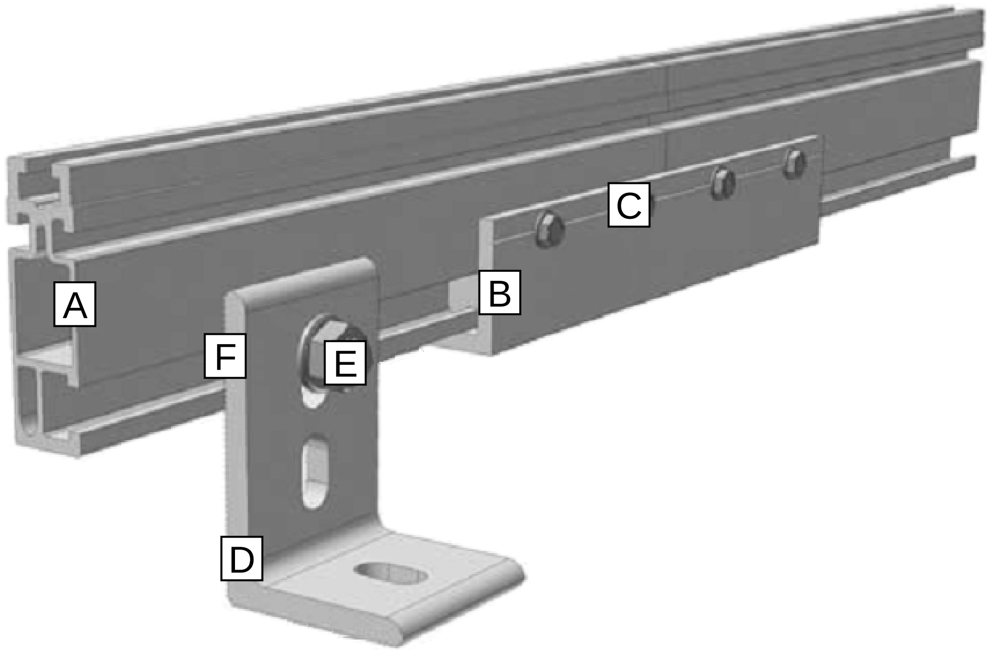
WARNING! Do not install PV AC Modules in areas where flammable materials or explosive vapors may exist.

Unpacking and Inspection

Open the package and confirm that the product conforms to your order. If any problems or discrepancies are noted, contact your dealer or distributor immediately.

VI. Parts Identification:

Figure- 4: PV AC Module Mounting Rack (Partial Rack Assembly Shown)



A. **Rail** – Supports PV modules. Use two per row of modules. 6105-T5 aluminum extrusion, anodized.

B. **Rail splice** – Joins and aligns rail sections into single length of rail. It can form either a rigid or thermal expansion joint, 8 inches long, predrilled. 6105-T5 aluminum extrusion, anodized.

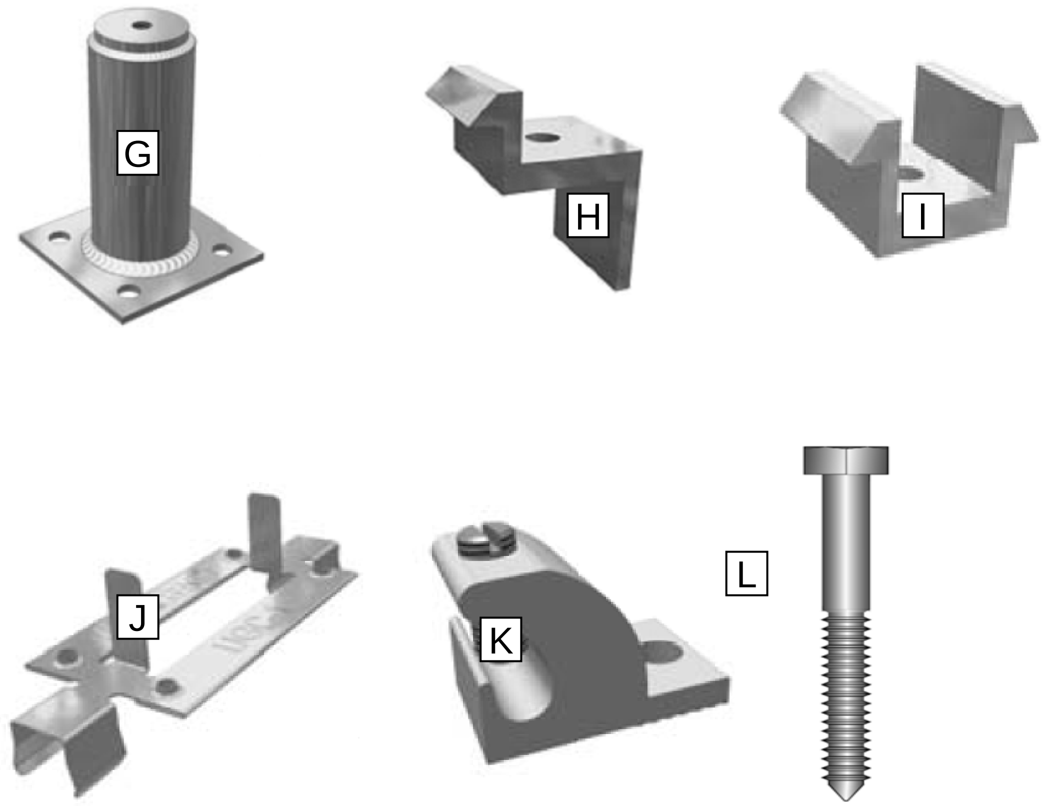
C. **Self-drilling screw** – (No. 10 x ¾") – Use 4 per rigid splice or 2 per expansion joint. Galvanized steel.

D. **L-foot** – Use to secure rails either through roofing material to building structure or standoffs. Refer to loading tables for spacing. Note: Please contact Exeltech for use and specification of double L-foot.

E. **L-foot bolt** (3/8" x ¾") – Use one per L-foot to secure rail to L-foot. 18-8A2 stainless steel.

F. **Flange nut** (3/8 ") – Use one per L-foot to secure rail to L-foot. 18-8A2 stainless steel.

Figure- 5: Mounting Hardware (continued)



G. Flattop standoff (optional) (3/8 “) – Use to increase the height of the array above the surface of the roof or to allow for the use of flashings. Use one per L-foot.

H. Side Clamp – Use to clamp modules at ends of array to racking system.

I. Center Clamp – Use between modules to clamp modules to racking system.

J. Grounding Clamp- A – Module to Module.

K. Grounding Clamp- B – Module to Racking System.

L. Lag bolt– Attaches L-feet or standoffs to roof rafter.

Table- 13: PVAC Module Racking Kit Part Quantities

Modules	End clamps	Mid clamps	¼″ module clamp bolts	¼″x ⅝″ safety bolts	¼″ flange nuts
2	4	2	6	2	8
3	4	4	8	2	10
4	4	6	10	2	12
5	4	8	12	2	14
6	4	10	14	2	16
7	4	12	16	2	18
8	4	14	18	2	20

VII. Planning Your Exeltech PVAC Module Installation

Note: The PVAC Module may be mounted in any orientation. (See Figure-6) The location selected must comply with the National Electric Code and your local safety and building codes.

SELECTING A MOUNTING LOCATION

Installer Notes:

- Hardware used with clamps must be installed to 10 ft-lbs torque and must be installed with anti-seize to prevent galling and provide uniformity in clamp load.
- The installation can be laid out with rails parallel to the rafters or perpendicular to the rafters.
- Center the installation area over the structural members as much as possible.
- Leave enough room to safely move around the array during installation. Some building codes require minimum clearances around such installations, and the user should be directed to also check local building codes.
- The width of the installation area equals the length of one module.
- The length of the installation area is equal to the total width of the modules, plus 1 inch for each space between modules (for center clamp), plus 3 inches (1½ inches for each pair of end clamps).

- Use a sealant appropriate for your roofing material when sealing lag bolt holes and using flashing on roof tops.

Figure- 5: Mounting Hardware Orientation

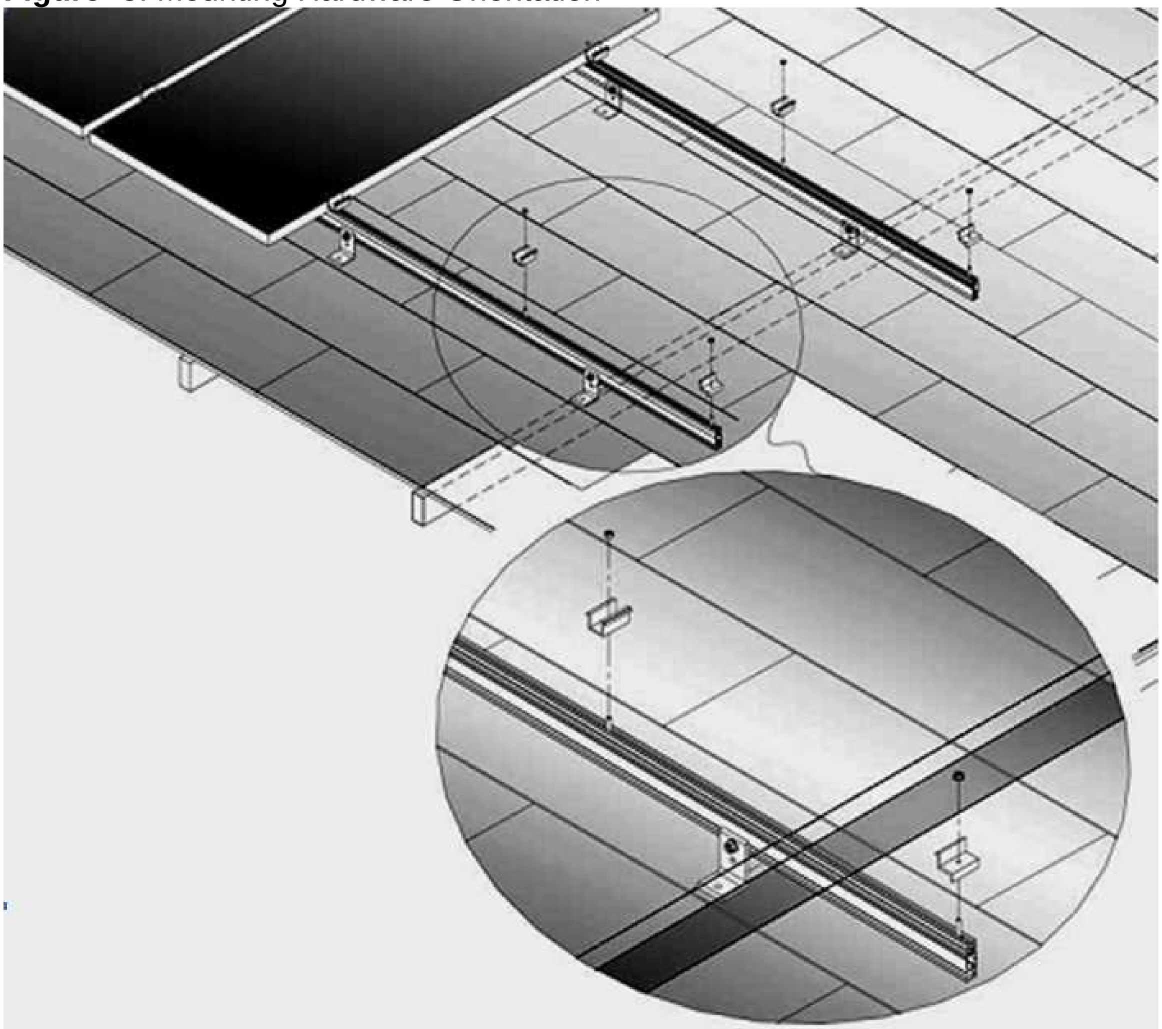
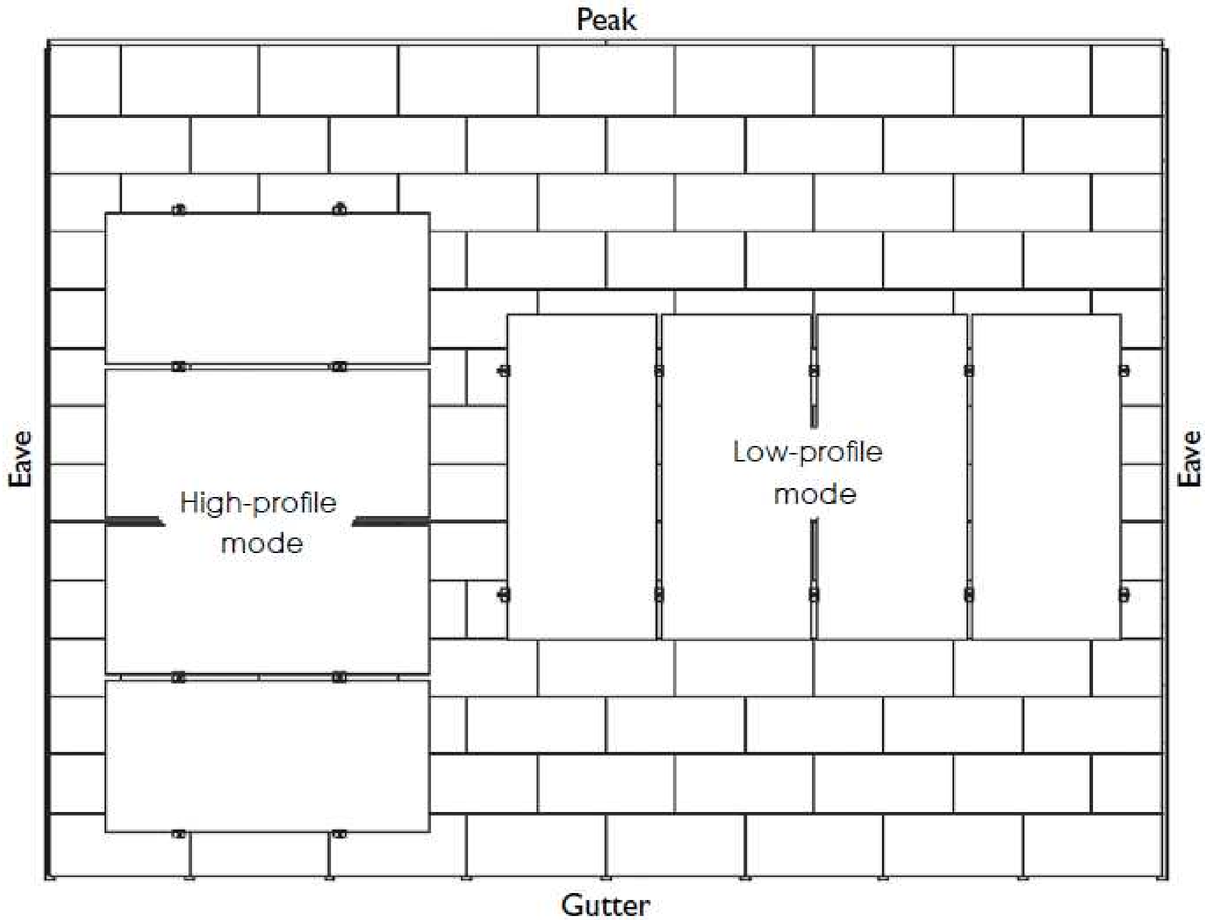


Figure- 6: Rail Placement



L-Feet Layout

- L-feet (Figure 4-A) can be used to attach rails directly through existing roofing material. This includes asphalt shingles, sheathing or sheet metal to the building structure.
- Use Figure 7 or 8 to assist in locating and marking the position of the L-feet lag screw holes.
- When installing multiple rows adjacent to each other, it may not be possible to place each row centered above every rafter, is not likely that each row will be centered above the rafters.
- Adjust rails as needed, following the guidelines in Figure 8 as closely as possible.

Stand-off Layout (Optional)

For increased ventilation, stand-offs (Figure 5-G) are used to increase the height of the array above the surface of the roof.

- Use a flashing with each stand-off to seal the lag bolt penetrations to the roof.
- Use Figure 7 or 8 to locate and mark the locations of the standoff lag bolt holes within the installation area.

- Remove the tile or shake underneath each standoff location, exposing the roofing underlayment.
- Ensure that the standoff base lies flat on the underlayment, but remove no more material than required for the flashings to be installed properly.
- If multiple high-profile rows are to be installed adjacent to each other, it may not be possible for each row to be centered above the rafters.
- Adjust as needed, following the guidelines of Fig. 8 as closely as possible.

Figure 7: Horizontal Railing (Perpendicular to Rafters)

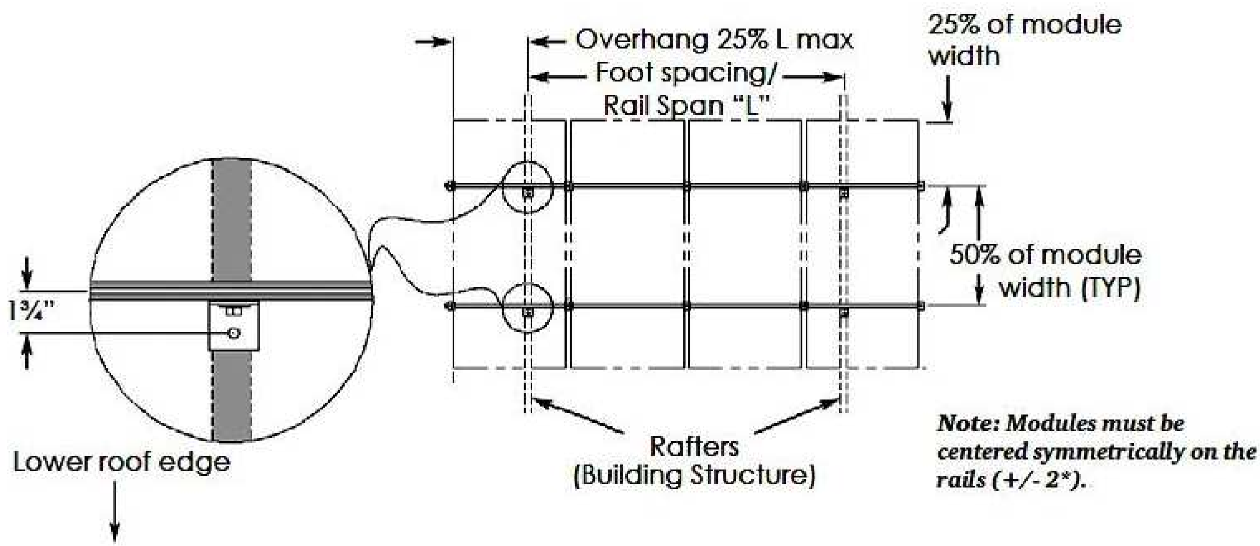
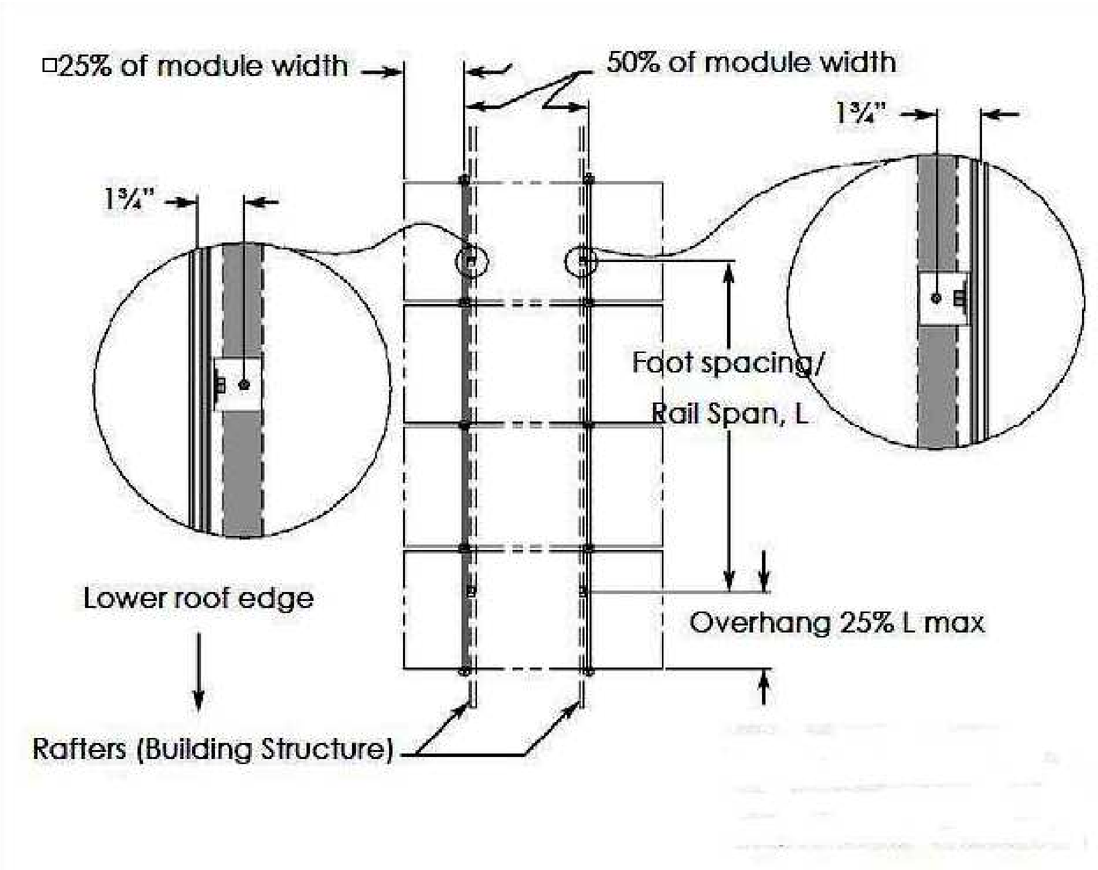


Figure 8: Vertical Railing (Parallel to Rafters)



VIII. Installing the PV Racking System

Installing L-feet

Note: With any solar installation, locating the centers of the rafters is critical. Use a quality 'stud finder' to assist in locating rafters.

- After locating a rafter, mark the exact location. Use a power drill to drill a 3/16 pilot hole through the roof into the center of the rafter at each L-foot lag bolt hole location.
- Apply sealant into the hole, and on the threads of the lag screw. Apply sealant to the underside of each L-foot.
- Fasten the L-feet to the roof with the lag screws, washer, and star washer. Ensure that the L-feet face as shown in Figure 8 and 9. The preferred method is to place the single-slotted square side of the L-foot against the roof with the double-slotted side perpendicular to the roof. If the installer chooses to mount the L-foot with the long leg against the roof, the bolt slot closest to the bend must be used.

Installing Standoffs (Optional)

Note: With any solar installation, locating the centers of the rafters is critical. Use a quality ‘stud finder’ to assist in locating rafters.
Use the Standoffs in conjunction with the L-Feet.

- Drill 3/16 inch pilot holes through the underlayment into the center of the rafters at each standoff location. Securely fasten each standoff to the rafters with the two 5/16” lag bolts.
- Ensure that the standoffs face as shown in Figure 8 or 9. The standoffs are designed for use with standard collared flashings.
- Install and seal flashings and standoffs using standard building practices or as the company providing roofing warranty directs.

Railing

- Keep rail slots free of roofing grit or other debris. Foreign matter will cause bolts to bind as they slide in the slots.
- **Installing Splices -** If your installation requires using splice bars (Figure 4-B), attach the rails together (Figure 4) before mounting the rails to the footings.
- Use splice bars only with flush installations or low profile installations (See Figure 6).
- A rail should always be supported by more than one footing on both sides of the splice.
- To avoid thermal expansion issues, DO NOT use more than one splice per rail.

Mounting Rails onto Stand-offs / L- Feet

Note: Rails may be attached to either of the two mounting holes in the L-feet (Fig. 4-D).

- For a lower profile (aesthetically pleasing) look, mount the lower hole in the L-foot.

- Mount in the upper hole for a higher profile, which will maximize airflow under the modules and will enhance performance of the system.

Note: Solar modules are more energy efficient (produce more energy) in cooler climates.

- Slide the 3/8-inch mounting bolts, washers, and star washers into the footing bolt slots.

- Loosely attach the rails to the footings with the flange nuts.

- Verify the rails are oriented to the footings as shown in Figure 5, 6, and 7, 8

Aligning the Rail Ends

- Align the first pair of rail ends to the edge of the installation area **(Figure 7 or Figure 8)**. The opposite pair of rail ends will overhang the side of the installation area.
- Do not trim them off until the installation is complete. If the rails are perpendicular to the rafters **(Figure 7),** either end of the rails can be aligned, but the first module must be installed at the aligned end. If the rails are parallel to the rafters **(Figure 8),** the aligned end of the rails must face the lower edge of the roof.
- Securely tighten all hardware after alignment is complete (20 ft lbs).

IX. Grounding the Racking System

- The Exeltech PVAC Module System is an Alternating Current (AC) **<u>ONLY</u>** system.
- The National Electric Code requires most electrical systems to be grounded. See NEC Article 250, “Grounding and Bonding”.
- NEC Article 690, Part V covers particular grounding for PV systems.
- For PV AC systems, the grounding electrode system requirements are established in the NEC, Article 690, Part III.
- When grounding the racking system, use Grounding Clamp-B, **(Figure 4-K)**.
- When grounding Module-to-Module, use Grounding Clamp-A, **(Figure 4-J)**.
- When grounding the racking system to the Modules, attach the grounding clamp by using the holes provided on the rear of the PV frame.

- **<u>DO NOT ATTACH ANY GROUND CONDUCTORS TO THE AC MODULE ON THE REAR OF THE PVAC MODULES. EXELTECH PVAC MODULES ARE GOUNDED INTERNALLY ACCORDING TO NEC, ARTICLE 690, PART III, AND ARE CERTIFIED AS SUCH TO THE UL1741 SAFETY STANDARD.</u>**

NOTE: Mount modules to the rails as soon as possible. Large temperature changes may bow the rails within a few hours if module placement is delayed.

This completes the racking installation instructions for Exeltech’s PVAC Modules.