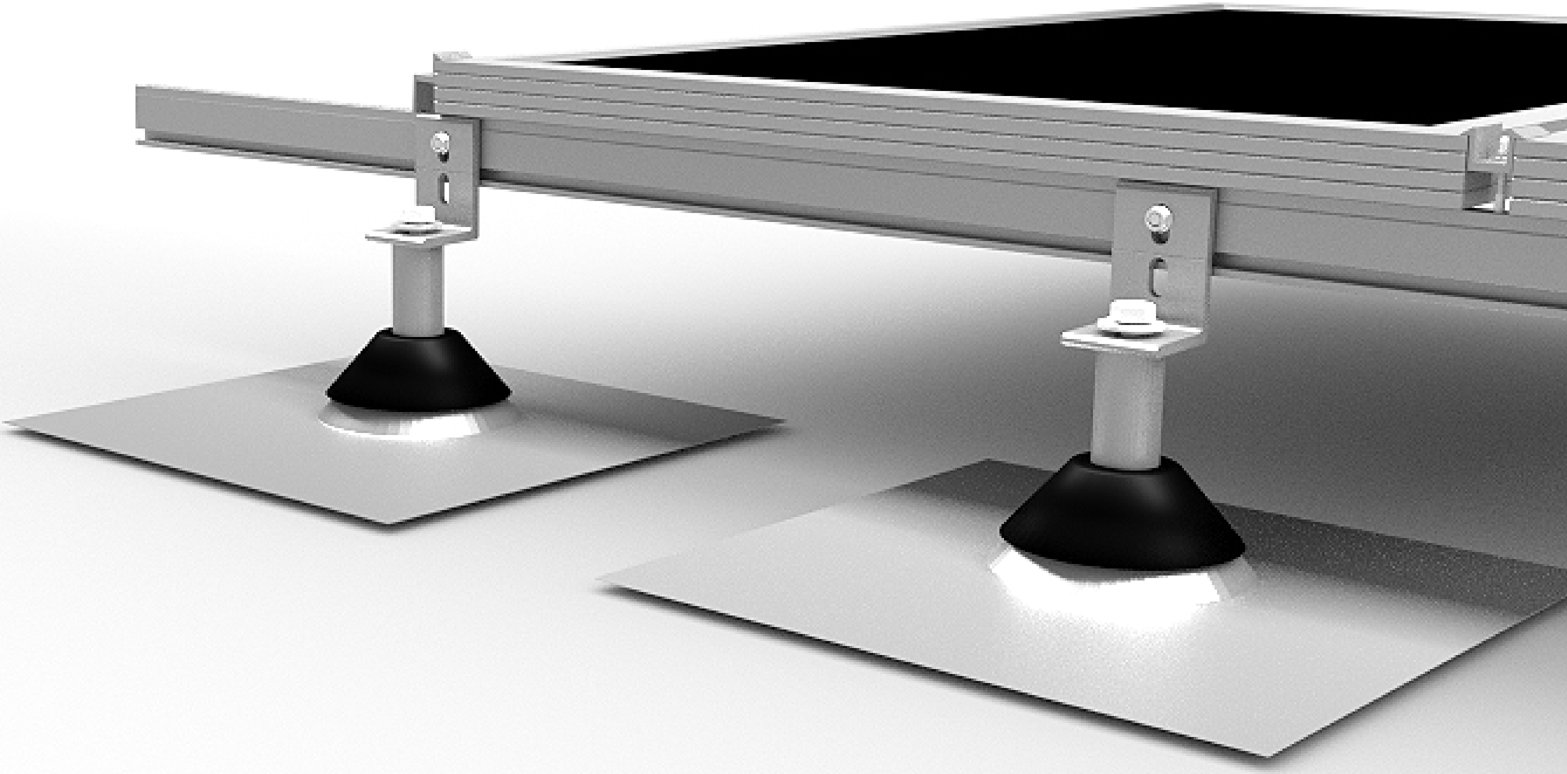
SOLAR WAREHOUSE

Version 15.01.v1

SWH Solar Racking Installation Guide



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i. Installer's Responsibilities

Please review this manual thoroughly before installing your SWH solar racking system. This manual provides (1) supporting documentation for building permit applications relating to SWH solar racking system, and (2) planning and assembly instructions for SWH products. When installed in accordance with this manual, SWH PV Mounting system will be structurally adequate and will meet the structural requirements of the IBC 2012, ASCE 7-10 and California Building Code 2013 (collectively refered to as "the Code"). Solar Warehouse also provides a limited warranty on SWH products as attached to the end of this manual.

The installer is solely responsible for:

- Complying with all applicable local or national building codes, including any that may supersede this manual;
- Ensuring that SWH and other products are appropriate for the particular installation and the installation environment;
- Ensuring that the roof, its rafters, connections, and other structural support members can support the array under all code level loading conditions (this total building assembly is referred to as the building structure);
- Using only SWH parts and installer-supplied parts as specified by SWH (substitution of parts may void the warranty and invalidate the letters of certification in all SWH publications);
- Ensuring that lag screws have adequate pullout strength and shear capacities as installed;
- Verifying the strength of any alternate mounting used in lieu of the lag screws;
- Maintaining the waterproof integrity of the roof, including selection of appropriate flashing;
- Ensuring safe installation of all electrical aspects of the PV array;
- 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 factor should be confirmed with the local building official or a licensed professional engineer.

Part I. Procedure to Calculate Total Design Wind Load

[1.1.] Using the Low Rise Buildings (Simplified) Method - ASCE 7-10

The procedure to determine Design Wind Load is specified by the American Society of Civil Engineers and referenced in the International Building Code 2012 and California Building Code 2013. For purposes of this document, the values, equations and procedures used in this document reference ASCE 7-10, Minimum Design Loads for Buildings and Other Structures. Please refer to ASCE 7-10 if you have any questions about the definitions or procedures presented in this manual. SWH solar racking system uses Part 2, The Simplified Method, for low rise buildings to calculate the Design Wind Load for pressures on components and cladding in this document. The method described in this document is valid for flush, no tilt, SWH applications on either roofs or walls. Flush is defined as panels 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 panels.

This method is not approved for open structure calculations. Applications of these procedures is subject to the following ASCE 7-10 limitations:

1. The building height must be less than 60 feet, $h < 60$. See note for determining h in the next section. For installations on structures greater than 60 feet, contact your local design professional.
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 does not conform to these requirements please contact your local professional engineer.

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 7-10 for more clarification on the use of Part 2.

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

$$p_{net}\,(psf) = \lambda K_{zt}\, p_{net30}$$

p_{net} (psf) = Design Wind Load

λ = adjustment factor for building height and exposure category

K_{zt} = Topographic Factor = 1

p_{net30} (psf) = net design wind pressure for Exposure B, at height = 30 feet

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 flat roof buildings or mean roof height for pitched roof buildings

Roof Pitch (degrees)

This manual will help you determine:

Effective Wind Area (sf) = minimum total continuous area of modules being installed (Step 4)

Roof Zone = the area of the roof you are installing the pv system according to Step 5.

Roof Zone Dimension = a (ft) (Step 5)

Exposure Category (Step 3)

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Step 1. Determine risk category

Buildings and other structures shall be classified, based on the risk to human life, health and welfare associated with their damage or failure by nature of their occupancy or use. For the purpose of applying flood, wind, snow, ice, and earthquake provisions. See Table 1 below.

Table 1: Risk Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent a low risk to human life in the event of failure.	I
All buildings and other structures except those listed in Risk Categories I, III, and IV.	II
· Buildings and other structures, the failure of which could pose a substantial risk to human life · Buildings and other structures, not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure. · Buildings and other structures, not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where their quantity exceeds a threshold quantity established by authority having jurisdiction and is sufficient to pose a threat to the public if released.	III
· Buildings and other structures designated as essential facilities. · Buildings and other structures, the failure of which could pose a substantial hazard to the community. · Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous chemicals or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity exceeds a threshold quantity established by the authority having jurisdiction to be dangerous to the public if released and is sufficient to pose a threat to the public if released.[a] · Buildings and other structures required to maintain the functionality of other Risk Category IV structures.	IV

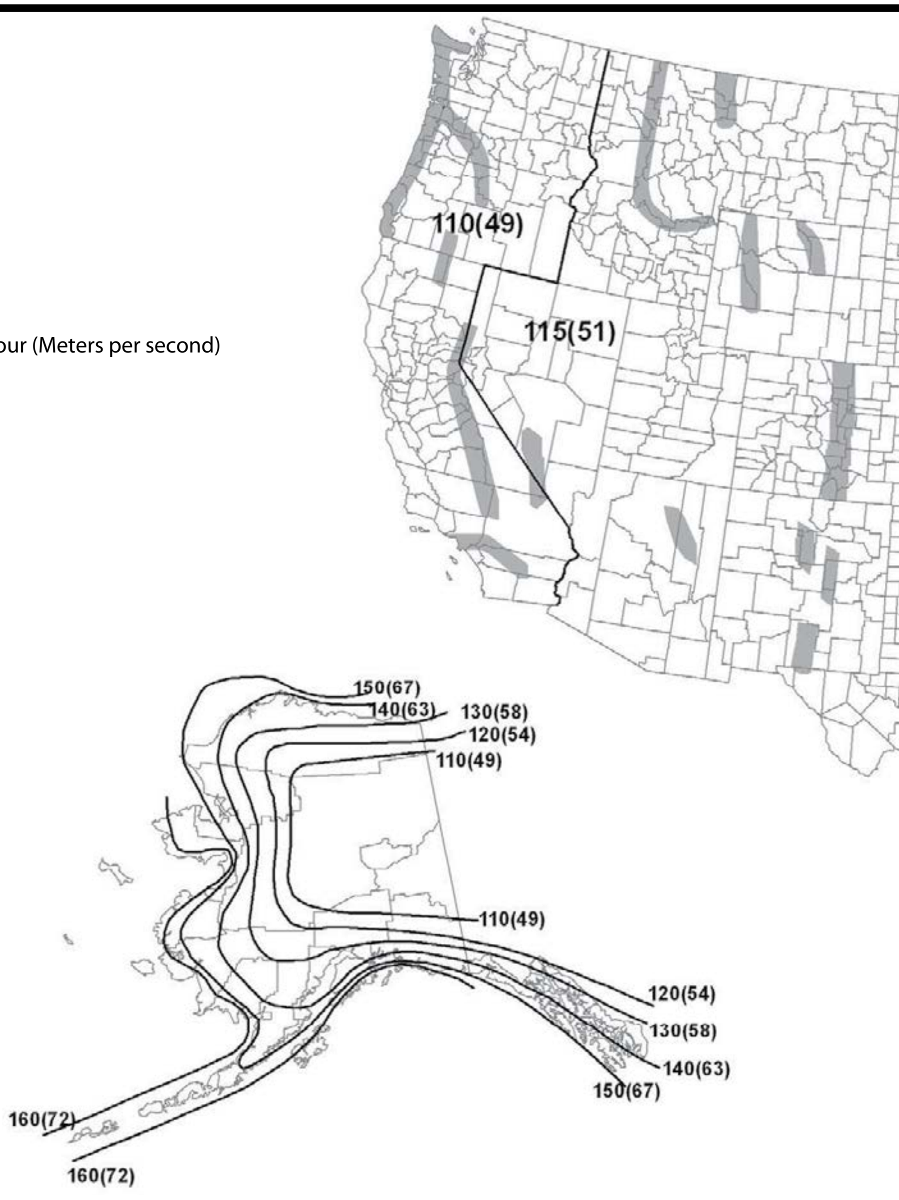
[a]Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for classification to a lower Risk Category if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 of ASCE 7-10 that a release of the substances is commensurate with the risk associated with that Risk Category.

Step 2. Determine the Basic Wind Speed, V (mph)

Determine the basic wind speed, V (mph) by consulting your local department or by locating your installation on the maps in Figures 26.5 1A through 1C, pages 6 -11. Please note that the wind speeds are dependent on the Risk (Occupancy) category determined in Step 1.

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

FIGURE 26.5-1A Basic Wind Speeds for Risk Category II Buildings and Other Structures

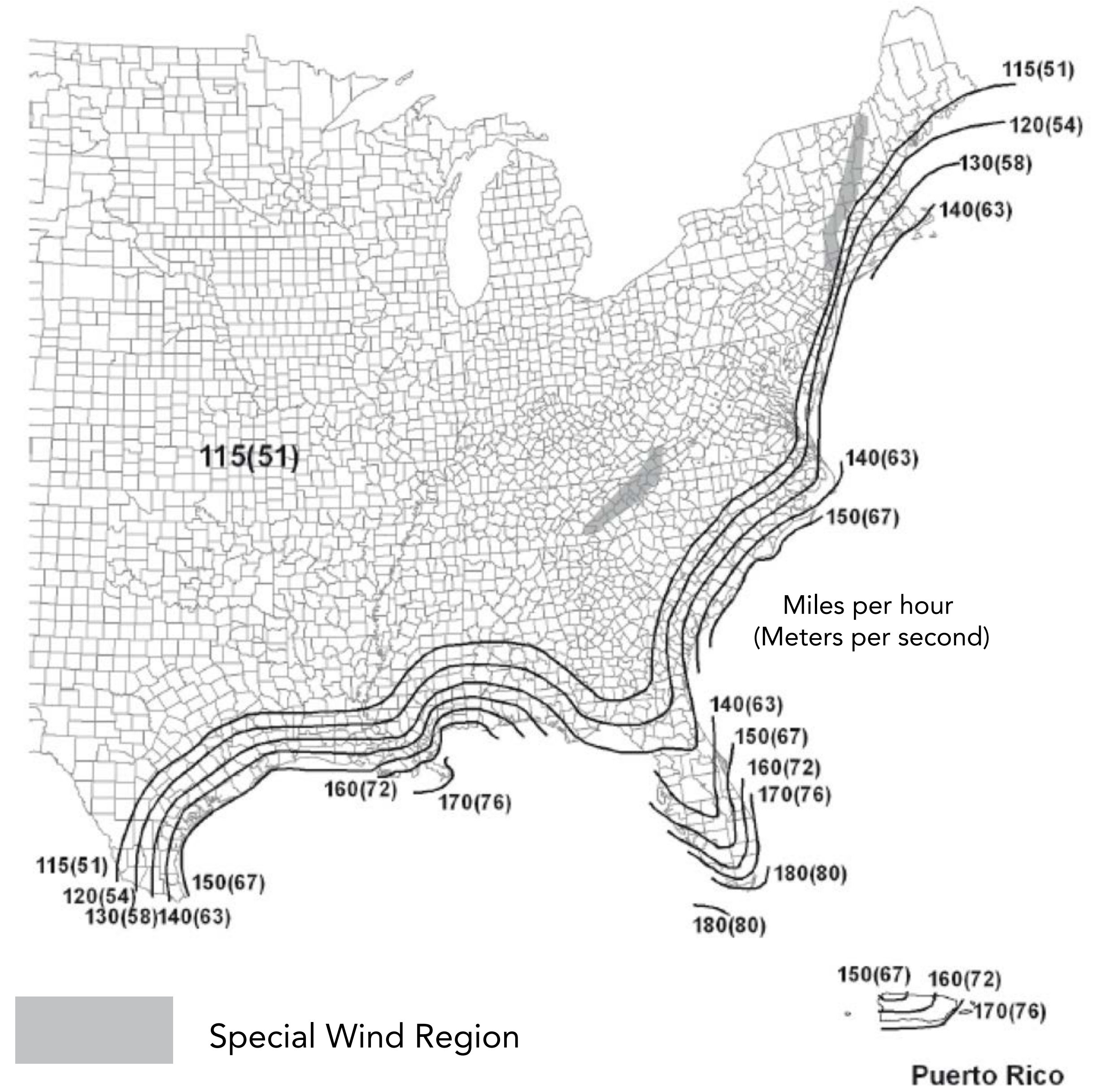


Notes:
1. Values are design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 7% probability of exceedance in 50 years (annual exceedance probability = 0.00143, MRI = 700 years).

Source: ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, Chapter 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

FIGURE 26.5-1A (Continued) Basic Wind Speeds for Risk Category II Buildings and Other Structures

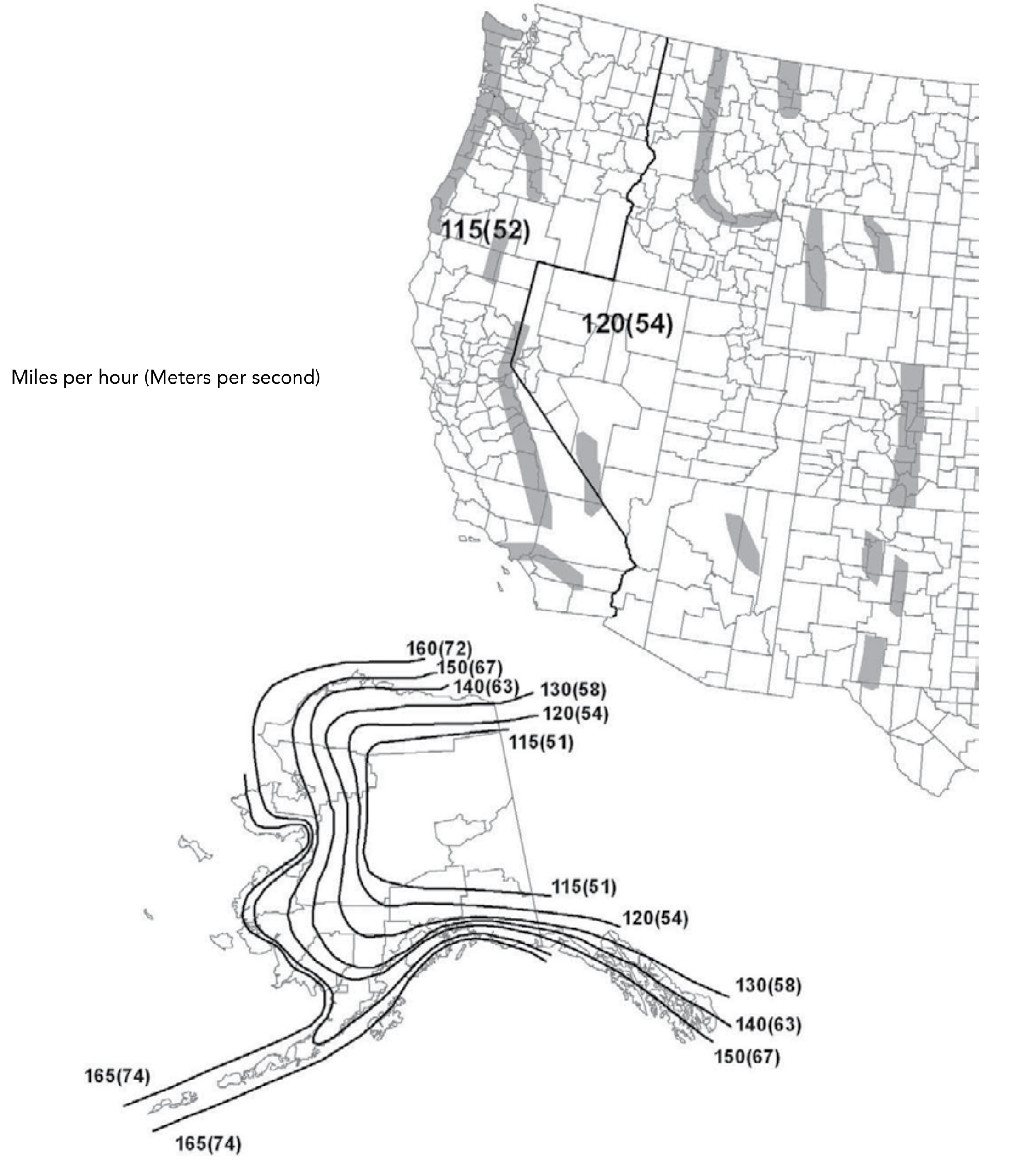


Location	Vmph	(m/s)
Guam	195	(87)
Virgin Islands	165	(74)
America Samoa	160	(72)
Hawaii- Special Wind Region Statewide	130	(58)

Source: ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, Chapter 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

FIGURE 26.5-1B Basic Wind Speeds for Risk Category III and IV Buildings and Other Structures

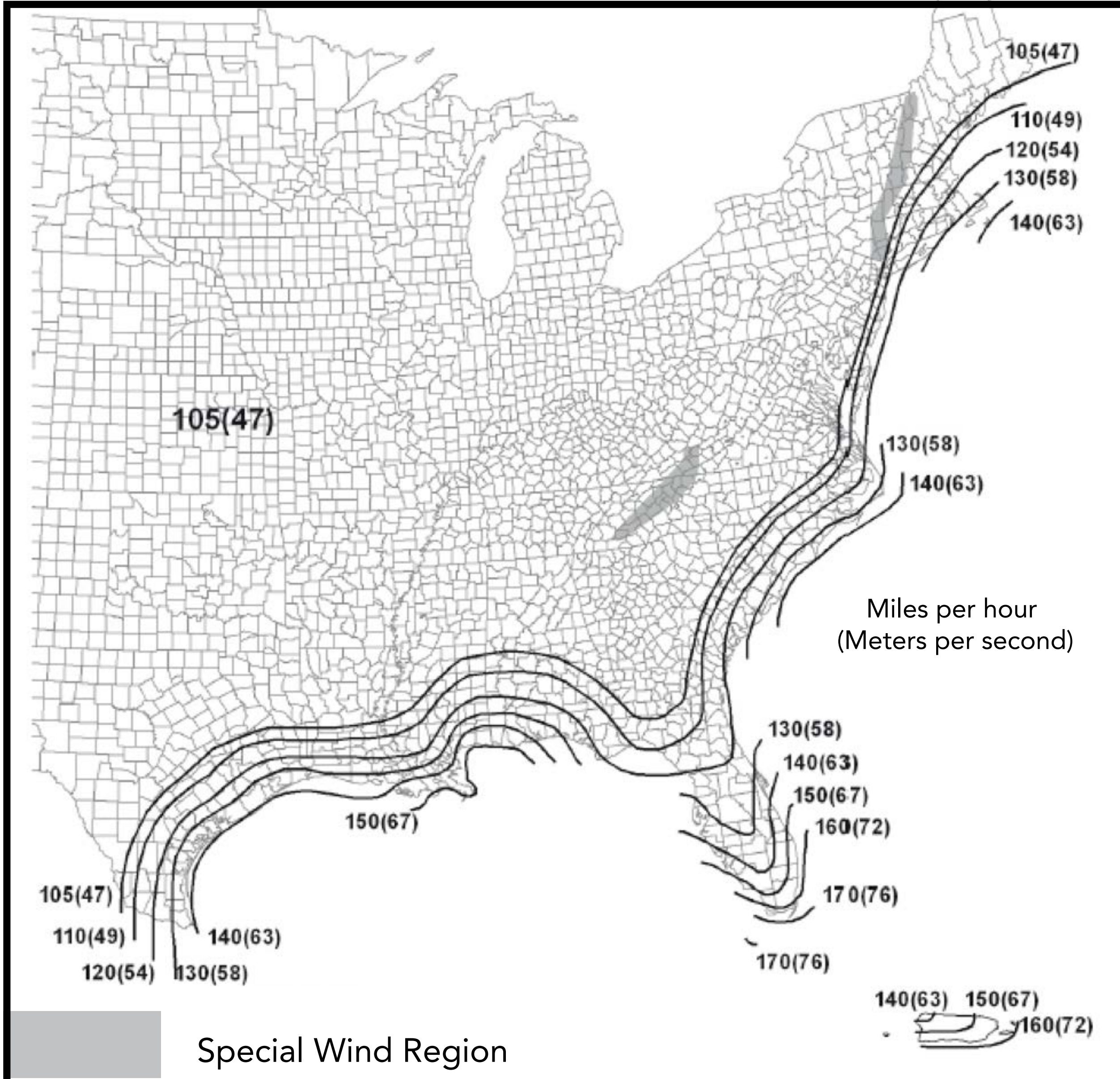


Notes:
1. Values are design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 3% probability of exceedance in 50 years (annual exceedance probability = 0.000588, MRI = 1700 years).

Source: ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, Chapter 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

FIGURE 26.5-1B (Continued) Basic Wind Speeds for Risk Category III and IV Buildings and Other Structures

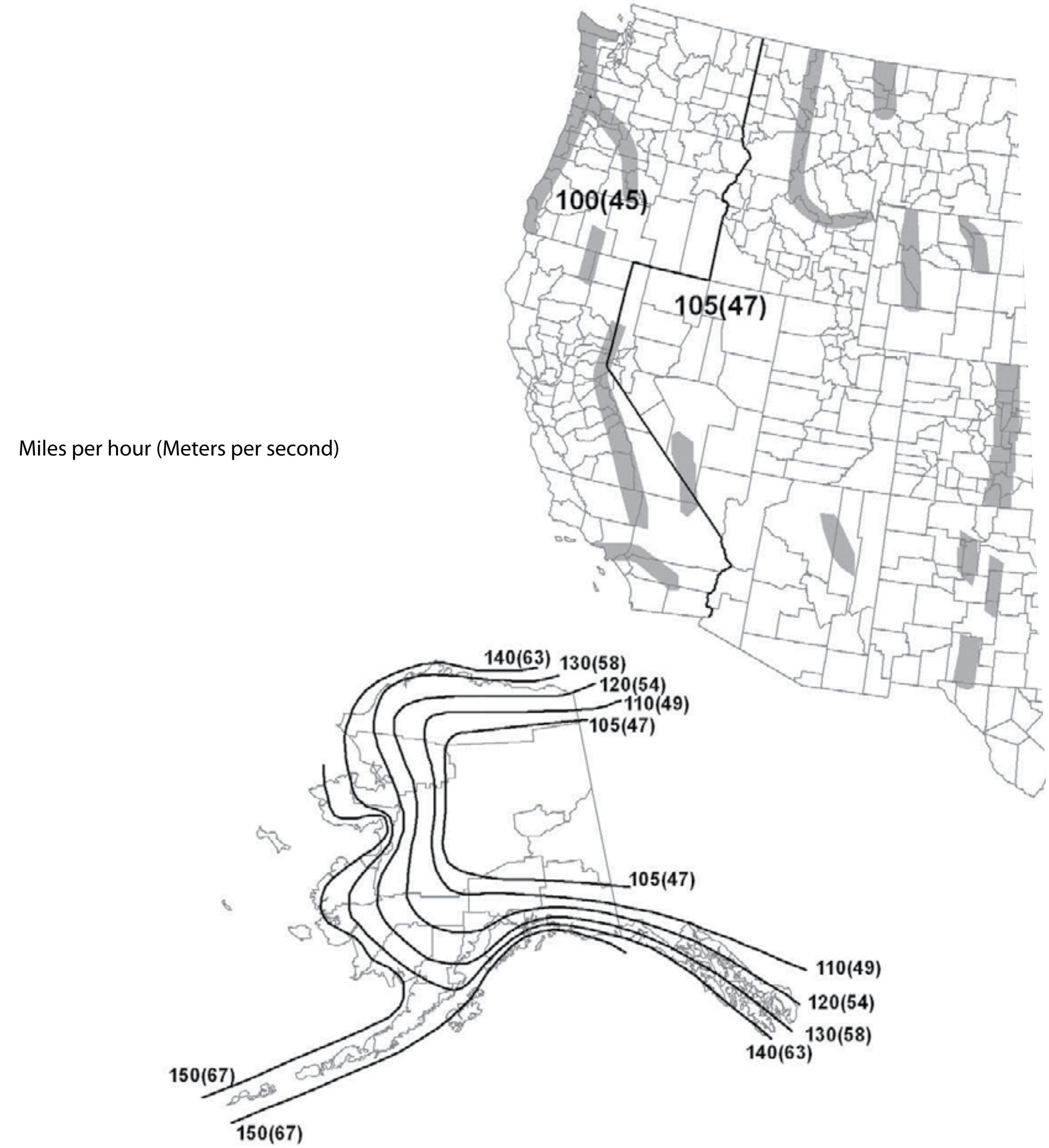


Location	Vmph	(m/s)
Guam	180	(80)
Virgin Islands	150	(67)
America Samoa	150	(67)
Hawaii- Special Wind Region Statewide	115	(51)

Source: ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, Chapter 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

FIGURE 26.5-1C Basic Wind Speeds for Risk Category I Buildings and Other Structures

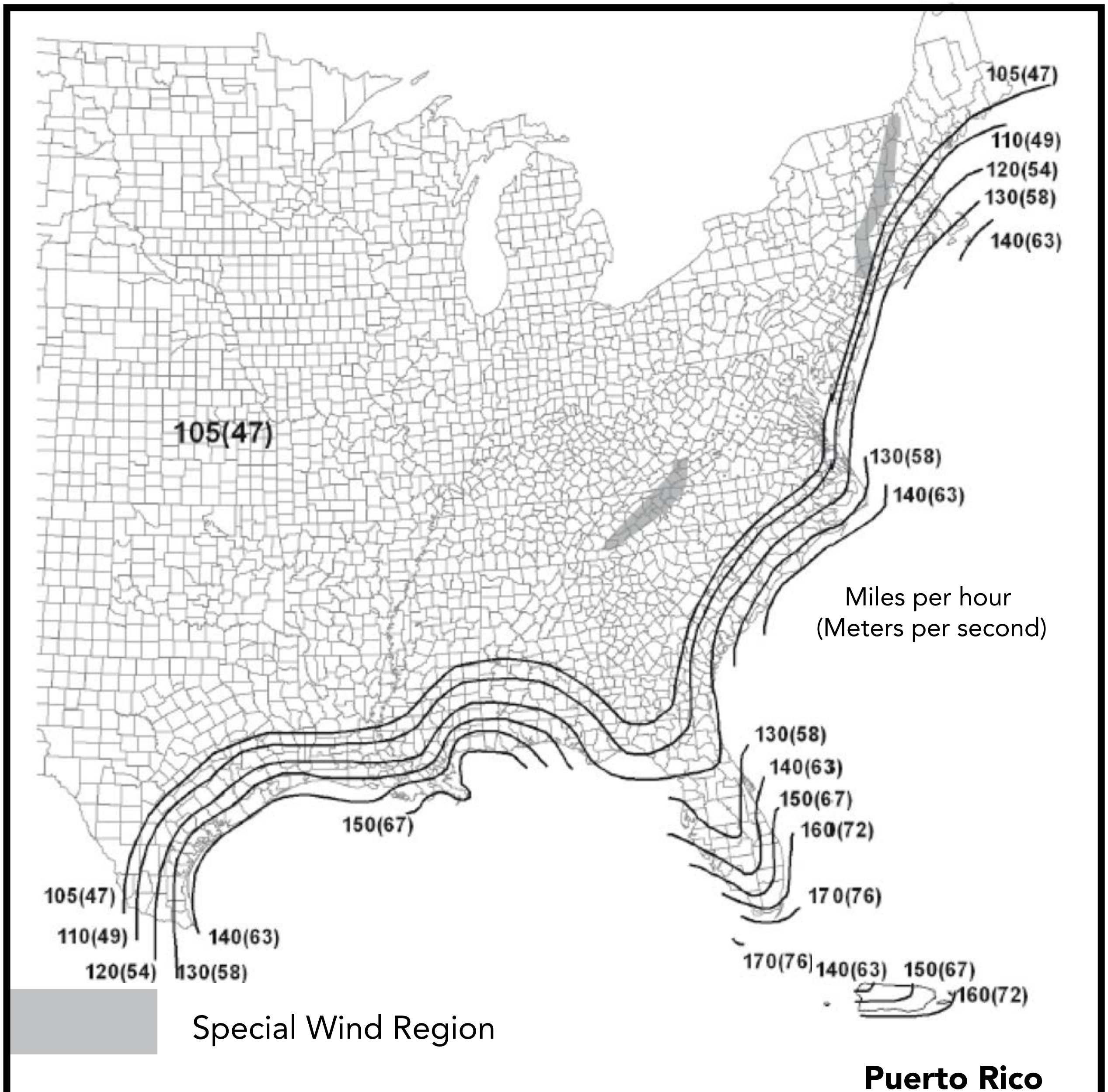


Notes:
1. Values are design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10m) above ground for Exposure C category.
2. Linear interpolation between contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.
5. Wind speeds correspond to approximately a 15% probability of exceedance in 50 years (annual exceedance probability = 0.00333, MRI = 300 years).

Source: ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, Chapter 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

FIGURE 26.5-1C (Continued) Basic Wind Speeds for Risk Category I Buildings and Other Structures



Location	Vmph	(m/s)
Guam	180	(80)
Virgin Islands	150	(67)
America Samoa	150	(67)
Hawaii- Special Wind Region Statewide	115	(51)

Source: ASCE 7-10 Minimum Design Loads for Buildings and Other Structures, Chapter 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Step 3. Determine Wind Load Parameters

Step 3a: Determine the proper Exposure Category (B, C, or D) for the project by using the following definitions for Surface Roughness Categories.
ASCE 7-10 defines wind surface roughness categories as follows:
Surface Roughness B: Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.

Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m). This category includes flat open country and grasslands.

Surface Roughness D: Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice.

Step 3b: Determine the Topographic Factor, K_{zt}
For the purposes of this code compliance document, the Topographic Factor, K_{zt}, is taken as equal to one (1) as per Section 26.8-2 or as determined by Figure 26.8-1 in ASCE 7-10. Also shown in pages 12-13.

Step 4. Determine 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. If the smallest area of continuous modules exceeds 100 sq ft, use 100 sq ft, if less round down to values available in Table 3, page 17.

Step 5. Determine the appropriate roof zone for the installation.

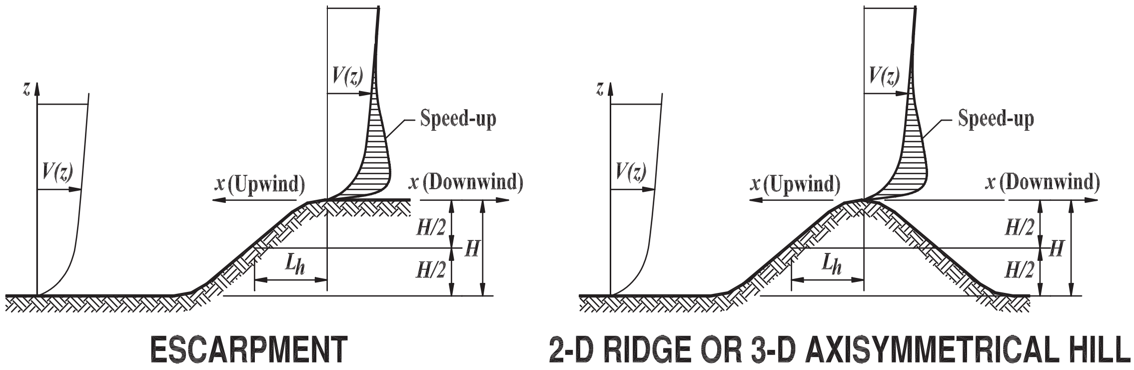
The Design Wind Load will vary based on where the installation is located on a roof. Arrays may be located in more than one roof zone.

Using Table 2, page 15, determine the Roof Zone Dimension Length, a (ft) , according to the width and height of the building on which you are installing the pv system.

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Figure 26.8-1 WIND LOADS: GENERAL REQUIREMENTS

Topographic Factor, K_{zt}



Topographic Multipliers for Exposure C

H/L_h	K_1 Multiplier: 2-D Ridge	K_1 Multiplier: 2-D Escarp.	K_1 Multiplier: 3-D Axisym. Hill	x/L_h	K_2 Multiplier: 2-D Escarp.	K_2 Multiplier: All Other Cases	z/L_h	K_3 Multiplier: 2-D Ridge	K_3 Multiplier: 2-D Escarp.	K_3 Multiplier: 3-D Axisym. Hill
0.20	0.29	0.17	0.21	0.00	1.00	1.00	0.00	1.00	1.00	1.00
0.25	0.36	0.21	0.26	0.50	0.88	0.67	0.10	0.74	0.78	0.67
0.30	0.43	0.26	0.32	1.00	0.75	0.33	0.20	0.55	0.61	0.45
0.35	0.51	0.30	0.37	1.50	0.63	0.00	0.30	0.41	0.47	0.30
0.40	0.58	0.34	0.42	2.00	0.50	0.00	0.40	0.30	0.37	0.20
0.45	0.65	0.38	0.47	2.50	0.38	0.00	0.50	0.22	0.29	0.14
0.50	0.72	0.43	0.53	3.00	0.25	0.00	0.60	0.17	0.22	0.09
				3.50	0.13	0.00	0.70	0.12	0.17	0.06
				4.00	0.00	0.00	0.80	0.09	0.14	0.04
							0.90	0.07	0.11	0.03
							1.00	0.05	0.08	0.02
							1.50	0.01	0.02	0.00
							2.00	0.00	0.00	0.00

Notes:

1. For values of H/L_h, x/L_h and z/L_h other than those shown, linear interpolation is permitted.
2. For $H/L_h > 0.5$, assume $H/L_h = 0.5$ for evaluating K_1 and substitute 2H for L_h for evaluating K_2 and K_3.
3. Multipliers are based on the assumption that wind approaches the hill or escarpment along the direction of maximum slope.
4. Notation:
   - H: Height of hill or escarpment relative to the upwind terrain, in feet (meters).
   - L_h: Distance upwind of crest to where the difference in ground elevation is half the height of hill or escarpment, in feet (meters).
   - K_1: Factor to account for shape of topographic feature and maximum speed-up effect.
   - K_2: Factor to account for reduction in speed-up with distance upwind or downwind of crest.
   - K_3: Factor to account for reduction in speed-up with height above local terrain.
   - x: Distance (upwind or downwind) from the crest to the building site, in feet (meters).
   - z: Height above ground surface at building site, in feet (meters).
   - μ: Horizontal attenuation factor.
   - γ: Height attenuation factor.

Source: ASCE-7-10 Chapter 26, page 26

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Figure 26.8-1 (cont'd) **WIND LOADS: GENERAL REQUIREMENTS**

Topographic Factor, K_{zt}

Equations:

$$K_{zt} = (1 + K_1 K_2 K_3)^2$$

K_1 determined from table below

$$K_2 = \left(1 - \frac{|x|}{\mu L_h}\right)$$

$$K_3 = e^{-\gamma z/L_h}$$

Parameters for Speed-Up Over Hills and Escarpments

Hill Shape	$K_1/(H/L_h)$			g	m	
	Exposure				Upwind of Crest	Downwind of Crest
	B	C	D			
2-dimensional ridges (or valleys with negative H in $K_1/(H/L_h)$)	1.30	1.45	1.55	3	1.5	1.5
2-dimensional escarpments	0.75	0.85	0.95	2.5	1.5	4
3-dimensional axisym. hill	0.95	1.05	1.15	4	1.5	1.5

Source: ASCE-7-10 Chapter 26, page 253

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Table 2. Determine Roof/Wall Zone, dimension (**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.

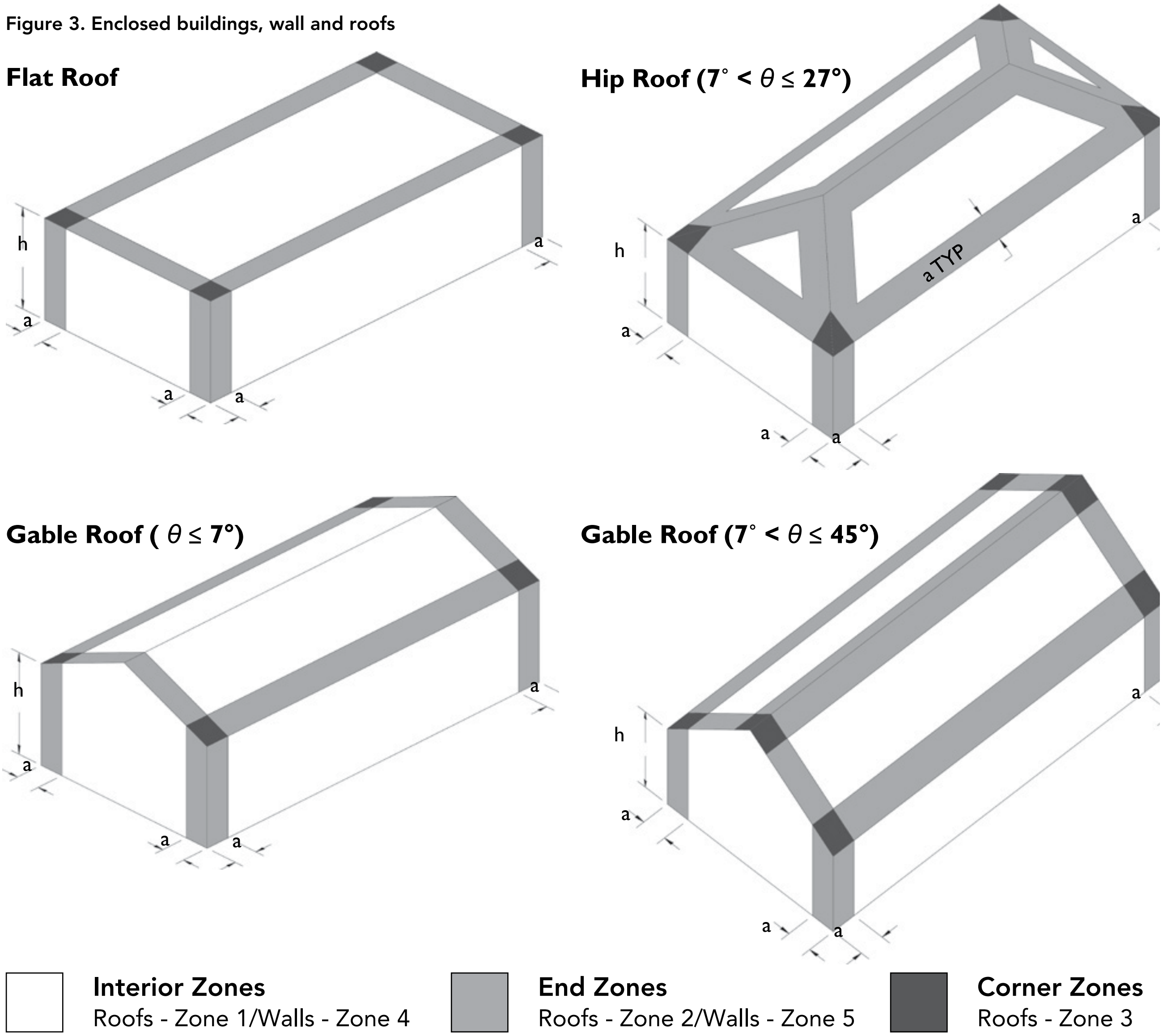
Roof Height (ft)	*Least Horizontal Dimension (ft)*																		
	10	***15***	***20***	***25***	***30***	***40***	***50***	***60***	***70***	***80***	***90***	***100***	***125***	***150***	***175***	***200***	***300***	***400***	***500***
10	3	3	3	3	3	4	4	4	4	4	4	4	5	6	7	8	12	16	20
15	3	3	3	3	3	4	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

Step 5. Determine the appropriate roof zone for the installation (continued)

Using the Roof Zone Dimension Length, a, determine the roof zone locations according to your roof type, gable, hip or monoslope. Determine in which roof zone your pv system is located, Zone 1, 2, or 3 according to Figure 3, page 16.

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Figure 3. Enclosed buildings, wall and roofs



Source: ASCE/SEI 7-10, Minimum Design Loads for Buildings and Other Structures, Chapter 30, p. 345.

Step 6. Determine Net Design Wind
Pressure, p_{net30} (psf)

Using the Effective Wind Area (Step 4), Roof Zone Location (Step 5), and Basic Wind Speed (Step 2), look up the appropriate Net Design Wind Pressure in Table 3, page 17. 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 4, page 18. Both downforce and uplift pressures must be considered in overall design. Refer to Section II, Step 1 for applying downforce and uplift pressures. Positive values are acting toward the surface. Negative values are acting away from the surface.

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Components and Cladding – Method 1	h ≤ 60 ft.
Figure 30.5-1 (cont'd) — Design Wind Pressures	Walls & Roofs
Enclosed Buildings	

Net Design Wind Pressure, p_{net30} (psf) *(Exposure B at h = 30 ft.)*

	Zone	Effective wind area (sf)	Basic Wind Speed V (mph) 110		115		120		130		140		150		160		180		200	
Roof 0 to 7 degrees	1	10	8.9	-21.8	9.7	-23.8	10.5	-25.9	12.4	-30.4	14.3	-35.3	16.5	-40.5	18.7	-46.1	23.7	-58.3	29.3	-72.0
	1	20	8.3	-21.2	9.1	-23.2	9.9	-25.2	11.6	-29.6	13.4	-34.4	15.4	-39.4	17.6	-44.9	22.2	-56.8	27.4	-70.1
	1	50	7.6	-20.5	8.3	-22.4	9.0	-24.4	10.6	-28.6	12.3	-33.2	14.1	-38.1	16.0	-43.3	20.3	-54.8	25.0	-67.7
	1	100	7.0	-19.9	7.7	-21.8	8.3	-23.7	9.8	-27.8	11.4	-32.3	13.0	-37.0	14.8	-42.1	18.8	-53.3	23.2	-65.9
	2	10	8.9	-36.5	9.7	-39.9	10.5	-43.5	12.4	-51.0	14.3	-59.2	16.5	-67.9	18.7	-77.3	23.7	-97.8	29.3	-120.7
	2	20	8.3	-32.6	9.1	-35.7	9.9	-38.8	11.6	-45.6	13.4	-52.9	15.4	-60.7	17.6	-69.0	22.2	-87.4	27.4	-107.9
	2	50	7.6	-27.5	8.3	-30.1	9.0	-32.7	10.6	-38.4	12.3	-44.5	14.1	-51.1	16.0	-58.2	20.3	-73.6	25.0	-90.9
	2	100	7.0	-23.6	7.7	-25.8	8.3	-28.1	9.8	-33.0	11.4	-38.2	13.0	-43.9	14.8	-50.0	18.8	-63.2	23.2	-78.1
	3	10	8.9	-55.0	9.7	-60.1	10.5	-65.4	12.4	-76.8	14.3	-89.0	16.5	-102.2	18.7	-116.3	23.7	-147.2	29.3	-181.7
	3	20	8.3	-45.5	9.1	-49.8	9.9	-54.2	11.6	-63.6	13.4	-73.8	15.4	-84.7	17.6	-96.3	22.2	-121.9	27.4	-150.5
	3	50	7.6	-33.1	8.3	-36.1	9.0	-39.3	10.6	-46.2	12.3	-53.5	14.1	-61.5	16.0	-69.9	20.3	-88.5	25.0	-109.3
	3	100	7.0	-23.6	7.7	-25.8	8.3	-28.1	9.8	-33.0	11.4	-38.2	13.0	-43.9	14.8	-50.0	18.8	-63.2	23.2	-78.1
Roof > 7 to 27 degrees	1	10	12.5	-19.9	13.7	-21.8	14.9	-23.7	17.5	-27.8	20.3	-32.3	23.3	-37.0	26.5	-42.1	33.6	-53.3	41.5	-65.9
	1	20	11.4	-19.4	12.5	-21.2	13.6	-23.0	16.0	-27.0	18.5	-31.4	21.3	-36.0	24.2	-41.0	30.6	-51.9	37.8	-64.0
	1	50	10.0	-18.6	10.9	-20.4	11.9	-22.2	13.9	-26.0	16.1	-30.2	18.5	-34.6	21.1	-39.4	26.7	-49.9	32.9	-61.6
	1	100	8.9	-18.1	9.7	-19.8	10.5	-21.5	12.4	-25.2	14.3	-29.3	16.5	-33.6	18.7	-38.2	23.7	-48.4	29.3	-59.8
	2	10	12.5	-34.7	13.7	-37.9	14.9	-41.3	17.5	-48.4	20.3	-56.2	23.3	-64.5	26.5	-73.4	33.6	-92.9	41.5	-114.6
	2	20	11.4	-31.9	12.5	-34.9	13.6	-38.0	16.0	-44.6	18.5	-51.7	21.3	-59.3	24.2	-67.5	30.6	-85.4	37.8	-105.5
	2	50	10.0	-28.2	10.9	-30.9	11.9	-33.6	13.9	-39.4	16.1	-45.7	18.5	-52.5	21.1	-59.7	26.7	-75.6	32.9	-93.3
	2	100	8.9	-25.5	9.7	-27.8	10.5	-30.3	12.4	-35.6	14.3	-41.2	16.5	-47.3	18.7	-53.9	23.7	-68.2	29.3	-84.2
	3	10	12.5	-51.3	13.7	-56.0	14.9	-61.0	17.5	-71.6	20.3	-83.1	23.3	-95.4	26.5	-108.5	33.6	-137.3	41.5	-169.5
	3	20	11.4	-47.9	12.5	-52.4	13.6	-57.1	16.0	-67.0	18.5	-77.7	21.3	-89.2	24.2	-101.4	30.6	-128.4	37.8	-158.5
	3	50	10.0	-43.5	10.9	-47.6	11.9	-51.8	13.9	-60.8	16.1	-70.5	18.5	-81.0	21.1	-92.1	26.7	-116.6	32.9	-143.9
	3	100	8.9	-40.2	9.7	-44.0	10.5	-47.9	12.4	-56.2	14.3	-65.1	16.5	-74.8	18.7	-85.1	23.7	-107.7	29.3	-132.9
Roof > 27 to 45 degrees	1	10	19.9	-21.8	21.8	-23.8	23.7	-25.9	27.8	-30.4	32.3	-35.3	37.0	-40.5	42.1	-46.1	53.3	-58.3	65.9	-72.0
	1	20	19.4	-20.7	21.2	-22.6	23.0	-24.6	27.0	-28.9	31.4	-33.5	36.0	-38.4	41.0	-43.7	51.9	-55.3	64.0	-68.3
	1	50	18.6	-19.2	20.4	-21.0	22.2	-22.8	26.0	-26.8	30.2	-31.1	34.6	-35.7	39.4	-40.6	49.9	-51.4	61.6	-63.4
	1	100	18.1	-18.1	19.8	-19.8	21.5	-21.5	25.2	-25.2	29.3	-29.3	33.6	-33.6	38.2	-38.2	48.4	-48.4	59.8	-59.8
	2	10	19.9	-25.5	21.8	-27.8	23.7	-30.3	27.8	-35.6	32.3	-41.2	37.0	-47.3	42.1	-53.9	53.3	-68.2	65.9	-84.2
	2	20	19.4	-24.3	21.2	-26.6	23.0	-29.0	27.0	-34.0	31.4	-39.4	36.0	-45.3	41.0	-51.5	51.9	-65.2	64.0	-80.5
	2	50	18.6	-22.9	20.4	-25.0	22.2	-27.2	26.0	-32.0	30.2	-37.1	34.6	-42.5	39.4	-48.4	49.9	-61.3	61.6	-75.6
	2	100	18.1	-21.8	19.8	-23.8	21.5	-25.9	25.2	-30.4	29.3	-35.3	33.6	-40.5	38.2	-46.1	48.4	-58.3	59.8	-72.0
	3	10	19.9	-25.5	21.8	-27.8	23.7	-30.3	27.8	-35.6	32.3	-41.2	37.0	-47.3	42.1	-53.9	53.3	-68.2	65.9	-84.2
	3	20	19.4	-24.3	21.2	-26.6	23.0	-29.0	27.0	-34.0	31.4	-39.4	36.0	-45.3	41.0	-51.5	51.9	-65.2	64.0	-80.5
	3	50	18.6	-22.9	20.4	-25.0	22.2	-27.2	26.0	-32.0	30.2	-37.1	34.6	-42.5	39.4	-48.4	49.9	-61.3	61.6	-75.6
	3	100	18.1	-21.8	19.8	-23.8	21.5	-25.9	25.2	-30.4	29.3	-35.3	33.6	-40.5	38.2	-46.1	48.4	-58.3	59.8	-72.0
Wall	4	10	21.8	-23.6	23.8	-25.8	25.9	-28.1	30.4	-33.0	35.3	-38.2	40.5	-43.9	46.1	-50.0	58.3	-63.2	72.0	-78.1
	4	20	20.8	-22.6	22.7	-24.7	24.7	-26.9	29.0	-31.6	33.7	-36.7	38.7	-42.1	44.0	-47.9	55.7	-60.6	68.7	-74.8
	4	50	19.5	-21.3	21.3	-23.3	23.2	-25.4	27.2	-29.8	31.6	-34.6	36.2	-39.7	41.2	-45.1	52.2	-57.1	64.4	-70.5
	4	100	18.5	-20.4	20.2	-22.2	22.0	-24.2	25.9	-28.4	30.0	-33.0	34.4	-37.8	39.2	-43.1	49.6	-54.5	61.2	-67.3
	4	500	16.2	-18.1	17.7	-19.8	19.3	-21.5	22.7	-25.2	26.3	-29.3	30.2	-33.6	34.3	-38.2	43.5	-48.4	53.7	-59.8
	5	10	21.8	-29.1	23.8	-31.9	25.9	-34.7	30.4	-40.7	35.3	-47.2	40.5	-54.2	46.1	-61.7	58.3	-78.0	72.0	-96.3
	5	20	20.8	-27.2	22.7	-29.7	24.7	-32.4	29.0	-38.0	33.7	-44.0	38.7	-50.5	44.0	-57.5	55.7	-72.8	68.7	-89.9
	5	50	19.5	-24.6	21.3	-26.9	23.2	-29.3	27.2	-34.3	31.6	-39.8	36.2	-45.7	41.2	-52.0	52.2	-65.8	64.4	-81.3
	5	100	18.5	-22.6	20.2	-24.7	22.0	-26.9	25.9	-31.6	30.0	-36.7	34.4	-42.1	39.2	-47.9	49.6	-60.6	61.2	-74.8
	5	500	16.2	-18.1	17.7	-19.8	19.3	-21.5	22.7	-25.2	26.3	-29.3	30.2	-33.6	34.3	-38.2	43.5	-48.4	53.7	-59.8

Note: For effective areas between the those given above the load may be interpolated, otherwise use the load associated with the lower effective area.

Table 3. p_{net30} (psf) Roof and Wall

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Roof Overhang Net Design Wind Pressure , p_{net30} (psf)

(Exposure B at h = 30 ft.)

	Zone	Effective Wind Area (sf)	Basic Wind Speed V (mph) 110	115	130	140	150	160	180	200
Roof 0 to 7 degrees	2	10	-31.4	-34.3	-43.8	-50.8	-58.3	-66.3	-84.0	-103.7
	2	20	-30.8	-33.7	-43.0	-49.9	-57.3	-65.2	-82.5	-101.8
	2	50	-30.1	-32.9	-42.0	-48.7	-55.9	-63.6	-80.5	-99.4
	2	100	-29.5	-32.3	-41.2	-47.8	-54.9	-62.4	-79.0	-97.6
	3	10	-51.6	-56.5	-72.1	-83.7	-96.0	-109.3	-138.3	-170.7
	3	20	-40.5	-44.3	-56.6	-65.7	-75.4	-85.8	-108.6	-134.0
	3	50	-25.9	-28.3	-36.1	-41.9	-48.1	-54.7	-69.3	-85.5
	3	100	-14.8	-16.1	-20.6	-23.9	-27.4	-31.2	-39.5	-48.8
Roof > 7 to 27 degrees	2	10	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	2	20	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	2	50	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	2	100	-40.6	-44.4	-56.7	-65.7	-75.5	-85.9	-108.7	-134.2
	3	10	-68.3	-74.6	-95.3	-110.6	-126.9	-144.4	-182.8	-225.6
	3	20	-61.6	-67.3	-86.0	-99.8	-114.5	-130.3	-164.9	-203.6
	3	50	-52.8	-57.7	-73.7	-85.5	-98.1	-111.7	-141.3	-174.5
	3	100	-46.1	-50.4	-64.4	-74.7	-85.8	-97.6	-123.5	-152.4
Roof > 27 to 45 degrees	2	10	-36.9	-40.3	-51.5	-59.8	-68.6	-78.1	-98.8	-122.0
	2	20	-35.8	-39.1	-50.0	-58.0	-66.5	-75.7	-95.8	-118.3
	2	50	-34.3	-37.5	-47.9	-55.6	-63.8	-72.6	-91.9	-113.4
	2	100	-33.2	-36.3	-46.4	-53.8	-61.7	-70.2	-88.9	-109.8
	3	10	-36.9	-40.3	-51.5	-59.8	-68.6	-78.1	-98.8	-122.0
	3	20	-35.8	-39.1	-50.0	-58.0	-66.5	-75.7	-95.8	-118.3
	3	50	-34.3	-37.5	-47.9	-55.6	-63.8	-72.6	-91.9	-113.4
	3	100	-33.2	-36.3	-46.4	-53.8	-61.7	-70.2	-88.9	-109.8

Table 4. p_{net30} (psf) Roof Overhang

Step 7. Determine adjustment factor for height and exposure category, l

Using the Exposure Category (Step 3) and the roof height, h (ft), look up the adjustment factor for height and exposure (λ) in Table 5, page 19.

[1.2.] Procedure to Calculate Total Design Wind Load per ASCE 7-10

Table 5. Adjustment Factor (λ) for Roof Height & Exposure Category

Mean roof height (ft)	Exposure B	Exposure C	Exposure 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

Step 8. Calculate the adjusted wind pressures, p_{net}, (psf)

Multiply the Net Design Wind Pressure, p_{net30} by the adjustment factor for height and exposure, l, the Topographic Factor, K_{zt}.

Where
l = adjustment factor for building height and exposure (Step 7)
K_{zt} = For the purposes of this code compliance document, the Topographic Factor, K_{zt}, is taken as equal to one (1) as per Section 26.8-2 or as determined by Figure 26.8-1 in ASCE 7-10.
P_{net30} = net design wind pressure for Exposure B, at h = 30 ft (Step 6)

The adjusted wind pressures will be used to select the appropriate SWH rail, rail span and attachment spacing.

Use both the positive (downforce) and the negative (uplift) results from this calculation.

Part II. Procedure to Select Rail Span and Foot Spacing

[2.1.] Using Standard Beam Calculations, Structural Engineering Methodology ASCE 7-10

The procedure to determine the SWH rail span 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. Please refer to **Part I** for more information on beam calculations, equations and assumptions. If beams are installed perpendicular to the eaves on a roof steeper than a 4/12 pitch in an area with a ground snow load greater than 30psf, then additional analysis is required for side loading on the roof attachment and beam.

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, p_{net}. See **Part I** (Procedure to Determine the Design Wind Load) for more information on calculating the *Design Wind Load*.

3. ***Please Note:*** The terms rail span and footing spacing are interchangeable in this document. See **Figure 4** for illustrations.

4. To use **Table 7** the *Dead Load* for your specific installation must be less than 5 psf, including modules and SWH racking systems. If the Dead Load is greater than 5 psf, see your SWH distributor, a local structural engineer or contact SWH. The following procedure will guide you in selecting a SWH rail for a flush mount installation. It will also help determine the design loading imposed by the SWH PV Mounting 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 7-10 2.4.1 (ASD Method equations 3, 5, 6a and 7) by adding the Snow Load, S (psf), Design Wind Load, Pnet (Psf) Step 8 page 19 and the Dead Load (psf). Both Uplift and Downforce Wind Loads calculated in Step 8, Page 18 of section 1.2. must be investigated. Use Table 6 to calculate the Total Design Load for the load cases. Use the maximum absolute value of the three downforce cases and the uplift case for sizing the rail. Use the uplift case only for sizing lag bolts pull out capacities. Use the following equations or Table 6, below.

P (psf) = 1.0D + 1.0S [1] (downforce case 1)

P (psf) = 1.0D + 0.6 p_{net} (downforce case 2)

P (psf) = 1.0D + 0.75S [1] + 0.75(0.6p_{net}) (downforce case 3)

P (psf) = 0.6D + 0.6 p_{net} (uplift)

D = Dead Load (psf)

S = Snow Load (psf)

p_{net} = Design Wind Load (psf) (Positive for downforce, negative for uplift)

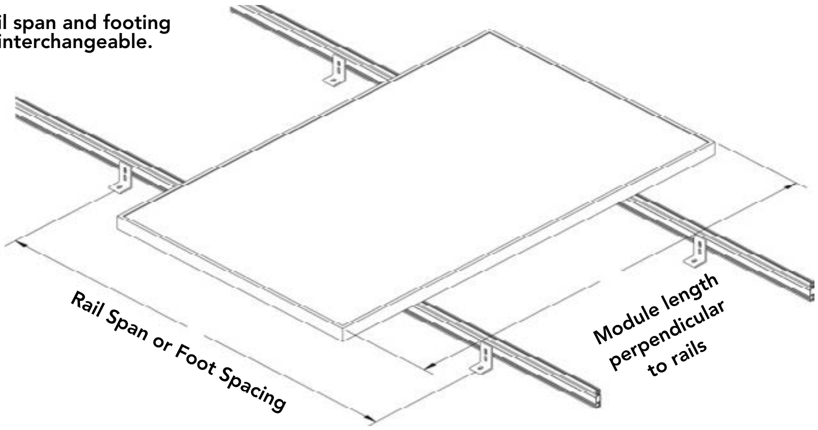
Table 6. ASCE 7-10 Load Combinations

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		0.6 x + ______	0.75 x + ______	0.6 x -	psf
Total Design Load	P					psf

Note: Table to be filled out or attached for evaluation.

[2.1.] Using Standard Beam Calculations, Structural Engineering Methodology ASCE 7-10

Figure 4. Rail span and footing spacing are interchangeable.



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

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 downforce 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 Rail Span/ L-bracket Spacing

Using the *distributed load, w*, from Part II, Step 2, look up the *allowable spans, L*, for SWH Standard rail in Table 7. The L-bracket SWH Series Rail Span Table uses a single L-bracket connection to the roof, wall or stand-off. Please refer to the **Part III** for more installation

Table 7 . L-Foot SWH Rail Span

ST- SWH STANDARD RAIL

Span (ft)	*Distributed Load (pounds/linear foot)*															
	20	25	30	40	50	60	80	100	120	140	160	180	200	220	240	260
2	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST
2.5	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST			
3	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST					
3.5	ST	ST	ST	ST	ST	ST	ST	ST	ST	ST						
4	ST	ST	ST	ST	ST	ST	ST	ST	ST							
4.5	ST	ST	ST	ST	ST	ST	ST	ST								
5	ST	ST	ST	ST	ST	ST	ST	ST								
5.5	ST	ST	ST	ST	ST	ST	ST									
6	ST	ST	ST	ST	ST	ST	ST									
6.5	ST	ST	ST	ST	ST	ST	ST									
7	ST	ST	ST	ST	ST	ST										
7.5	ST	ST	ST	ST	ST	ST										
8	ST	ST	ST	ST	ST	ST										
8.5	ST	ST	ST	ST	ST											
9	ST	ST	ST	ST												
9.5	ST	ST	ST	ST												
10	ST	ST	ST													
10.5	ST	ST	ST													
11	ST	ST														
11.5	ST															
12	ST															

[2.1.] Using Standard Beam Calculations, Structural Engineering Methodology ASCE 7-10

Step 4: Select Rail Type

Selecting a span and rail type affects the price of your installation. Longer spans produce fewer wall or roof penetrations. However, longer spans create higher point load forces on the building structure. A point load force is the amount of force transferred to the building structure at each connection.

It is the installer's responsibility to verify that the building structure is strong enough to support the point load forces.

Step 5: Determine the Downforce Point Load, R (lbs), at each connection based on rail span

When designing the SWH Flush Mount Installation, you must consider the downforce Point Load, R (lbs) on the roof structure.

The *Downforce*, *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)

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 8. Downforce Point Load Calculation

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 3
		/2		
Downforce Point Load:	R		lbs	

[2.1.] Using Standard Beam Calculations, Structural Engineering Methodology ASCE 7-10

Step 6: Determine the Uplift Point Load, R (lbs), at each connection based on rail span

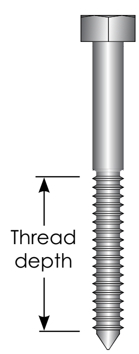
You must also consider the Uplift Point Load, R (lbs), to determine the required lag bolt attachment to the roof (building) structure.

Table 9. 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 3
		/2		
Uplift Point Load:	R		lbs	

Table 10. Lag pull-out (withdrawal) capacities (lbs) in typical roof lumber (ASD)

		Lag screw specifications
	Specific gravity	*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.

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 specifiy 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 with lag screws.*

Use Table 6 to select a lag bolt size and embedment depth to satisfy your Uplift Point Load Force, R (lbs), requirements. Divide the uplift pointload by the withdrawal capacity, this results in inches of 5/16 lagbolt embedded thread depth needed to counteract the uplift force. If other than lag bolt is used (as with a concrete or steel), consult fastener mfr documentation.

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.

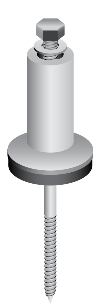
Part III. Installing SWH Solar Racking System:
[3.1] SWH Solar Racking Components

Rail - Used to support PV modules. Aluminum extrusion, anodized silver or black.

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. Aluminum extrusion, anodized silver or black.

Self Grounding Splice - Aluminum anodized silver or black.

L-Bracket - Use to secure rails either through roofing material to building structure or standoffs. Refer to Loading tables for spacing. Short 2"x2" or long 2"x3". Anodized silver or black, extruded aluminum.



Standoff (3.5"H or 5"H) - Use standoffs to increase the height of the array above the roof or to allow for the use of flashings. Use one per L-bracket. Comes with 5/16" x 3.5" lag bolt, 3/8"x1.5" flat washer, 3/8"x1.5" rubber gasket. Mill finish or painted-black.

End Clamp - Top mounting clamp. Different sizes available. Anodized silver or black.

Grounding Clips - Stainless steel clips bond panels to rail. Place under panels and mid clamp.

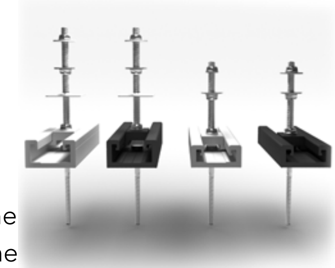
Grounding Bolt - Stainless steel bolt and clip bond rails to grounding wires.

Grounding Lug -Tin-Copper plated aluminum lug for bonding rails to grounding wires.

Mid Clamp - Top mounting clamp one size fits all. Anodized silver or black.

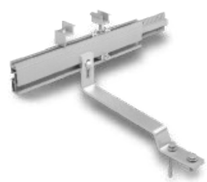
Self Grounding Mid Clamp - Stainless steel, 3 sizes available.

Additional attachment options not shown:



Tile Strut [3.2.4] - Use to mount rail on spanish tile or flat concrete tile. Low Profile 3/4" base height. High Profile 1" base height. Anodized silver or black. 4"or 6" all threaded rod included.

Flashed L Feet [3.2.5]- Use to mount rail on composite shingle roof. Anodized silver or black. Stainless steel hardware and water sealing washer included.



Roof Bar [3.2.6]- Stainlees steel roof bar to mount rail on flat concrete tile roof. Stainless steel hardware included.

Roof Hook [3.2.7]- Use to mount rail on spanish tile or flat concrete tile roof. Stainless steel hardware

Installer supplied materials:
- Waterproof roofing sealant/caulking
- Roof flashing

[3.2] Installing SWH with top mounting clamps

This section covers SWH racking assembly where the installer has elected to use top mounting clamps to secure modules to the rails. It details the procedure for flush mounting SWH systems to a pitched roof

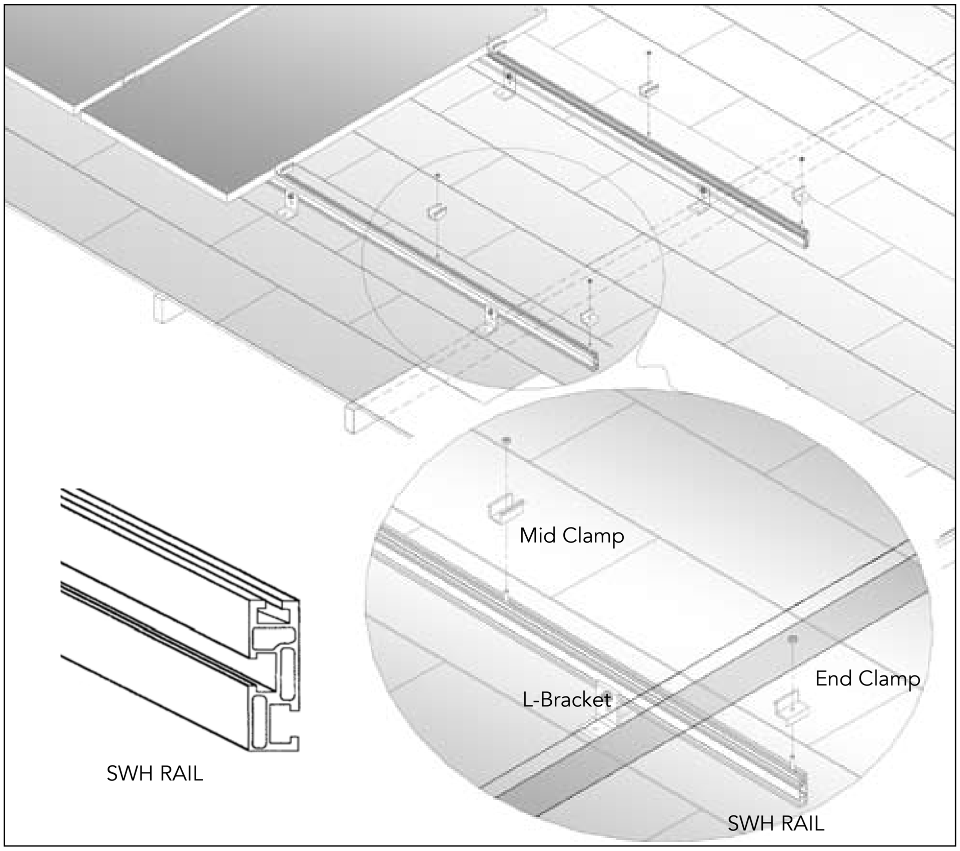


Figure 5. Exploded view of a flush mount installation with L-bracket

TABLE 12. Wrenches and Torque

	Wrench Size	*Recommended Torque (ft-lbs)*
1/4" hardware	7/16"	10* ⚠
3/8" hardware	9/16"	20

⚠ *All top down clamps must be installed with anti-seize to prevent galling and provide uniformity in clamp load. Solar Warehouse recommends Silver Grade LocTite Anti-Seize Item numbers: 38181, 80209,76732,76759,76764, 80206, and 76775, or equivalent. 1/4” - 20 hardware used in conjunction with top down clamps must be installed to 10 ft-lbs of torque. In addition, once the hardware are secured and integrity verified, it is recommended that thread lock be applied.

[3.2.1] Planning your SWH installations

The installation can be laid out with rails parallel to the rafters or perpendicular to the rafters. Note that SWH rails make excellent straight edges for doing layouts. 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 'The Code'.

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 midclamp),
- plus 3 inches (1½ inches for each pair of end clamps).

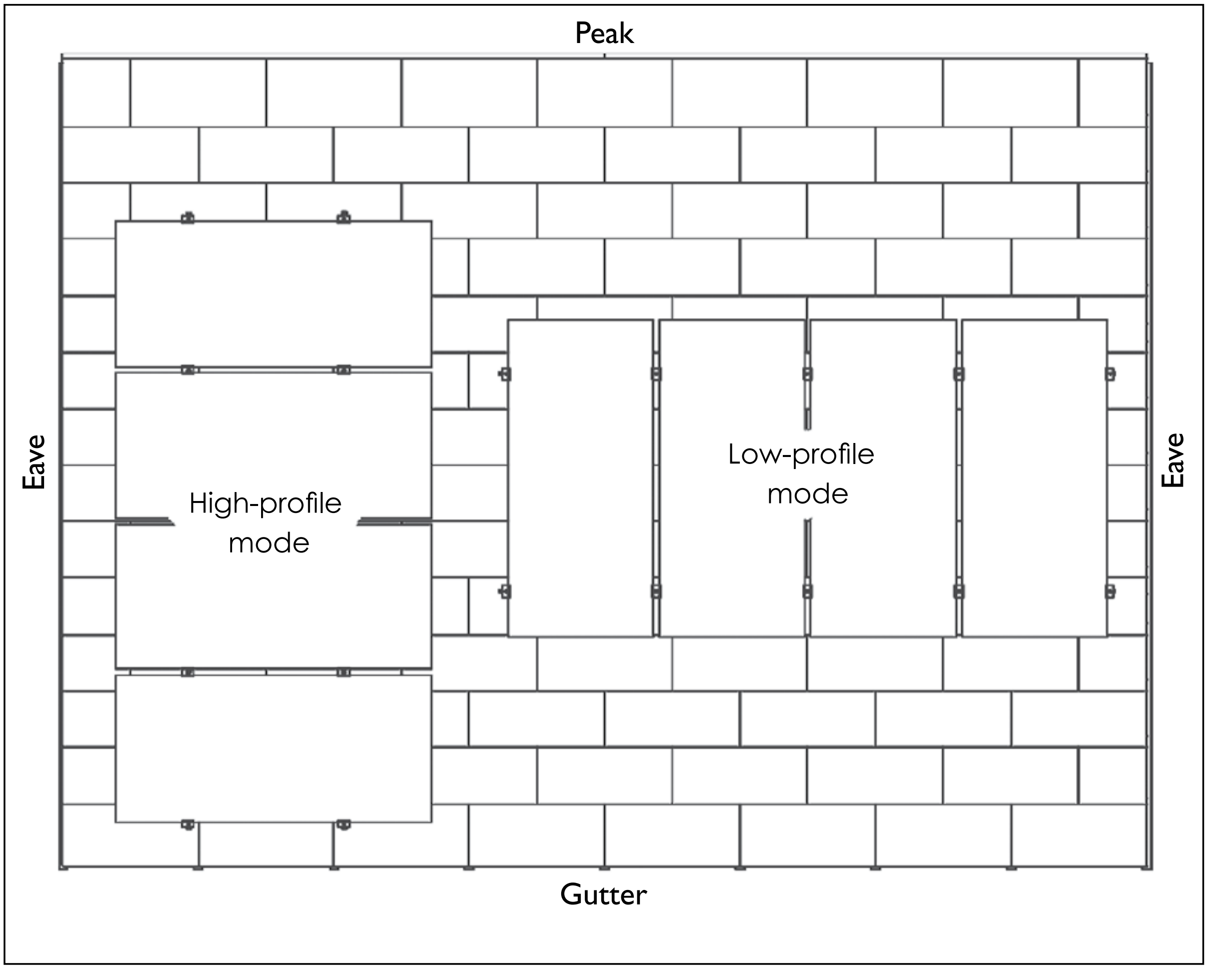


Figure 6. Rails may be placed parallel or perpendicular to rafters.

[3.2.2] Laying out L-Brackets

L-Brackets can be used for attachment through existing roofing material, such as asphalt shingles, sheathing or sheet metal to the building structure.

Use **Figure 7 or 8** below to locate and mark the position of the L-bracket lag screw holes within the installation area.

If multiple rows are to be installed adjacent to one another, it is not likely that each row will be centered above the rafters. Adjust as needed, following the guidelines in **Figure 8** as closely as possible.

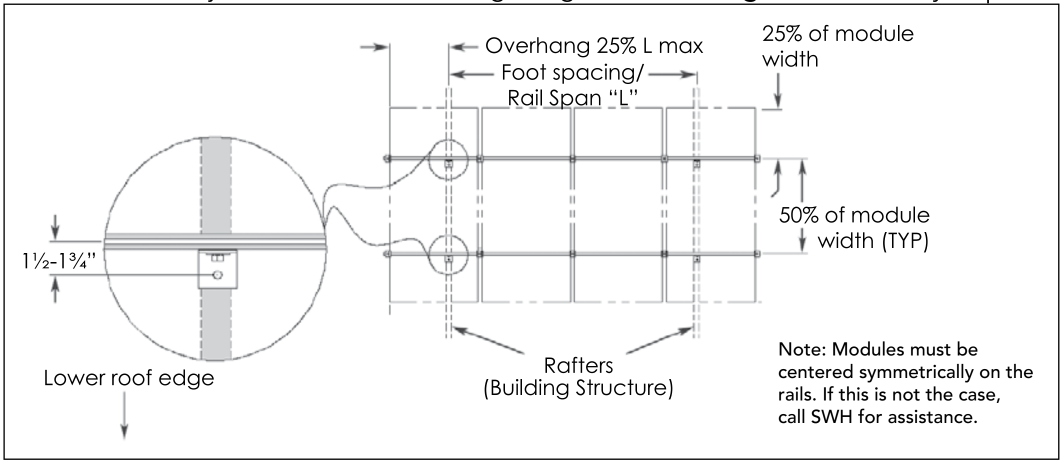


Figure 7. Layout with rails perpendicular to rafters.

Installing L-bracket:

Drill 3/16" pilot holes through the roof into the center of the rafter at each L-bracket lag screw hole location. Squirt sealant into the hole, and on the shafts of the lag screws. Seal the underside of the L-bracket with a suitable sealant. Consult with the company providing the roofing warranty. Securely fasten the L-bracket to the roof with the lag screws. Ensure that the L-bracket face as shown in **Figure 7 and 8**. For greater ventilation, the preferred method is to place the single-slotted square side of the L-bracket against the roof with the double-slotted side perpendicular to the roof. If the installer chooses to mount the L-bracket with the long leg against the roof, the bolt slot closest to the bend must be used.

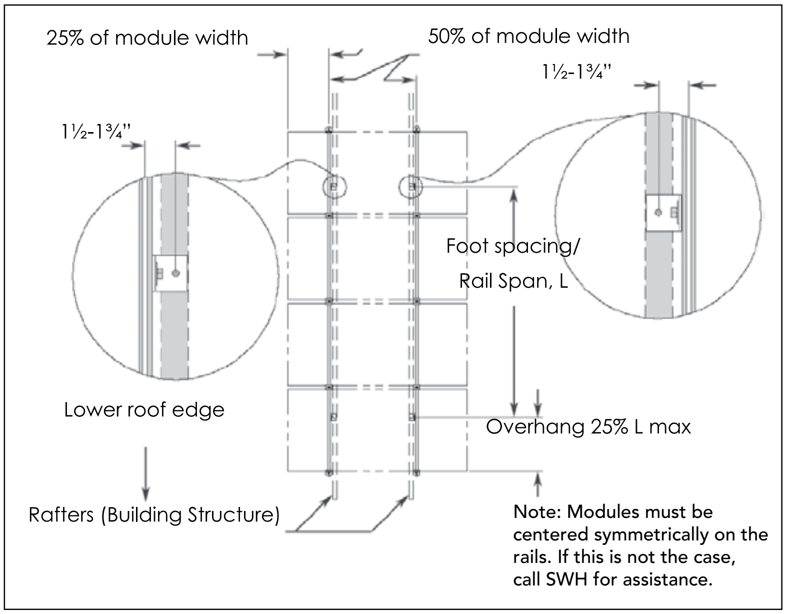


Figure 8. Layout with rails parallel to rafters

[3.2.3] Laying out Standoffs

Standoffs (**Figure 9**) are used to increase the height of the array above the surface of the roof. Pair each standoff with a flashing to seal the lag bolt penetrations to the roof.
Use **Figure 10 or 11** to locate and mark the location of the standoff lag screw 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. The standoffs must be firmly attached to the building structure.

Figure 9. Standoff in conjunction with an L-Bracket.

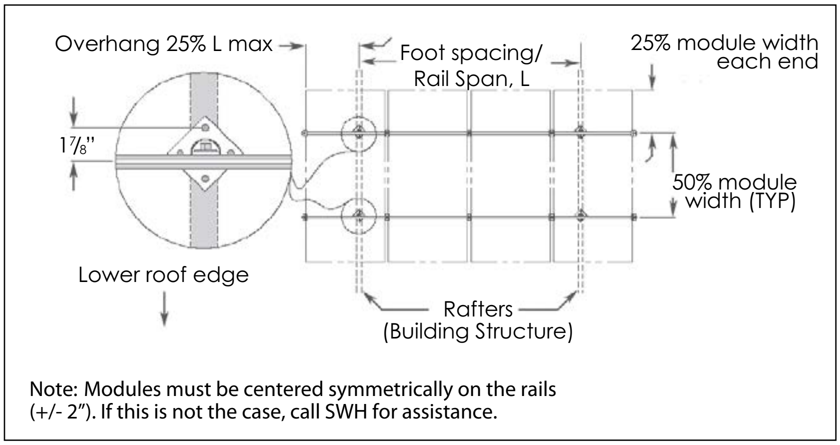


Figure 10. Layout with rails perpendicular to rafters.perpendicular to rafters.

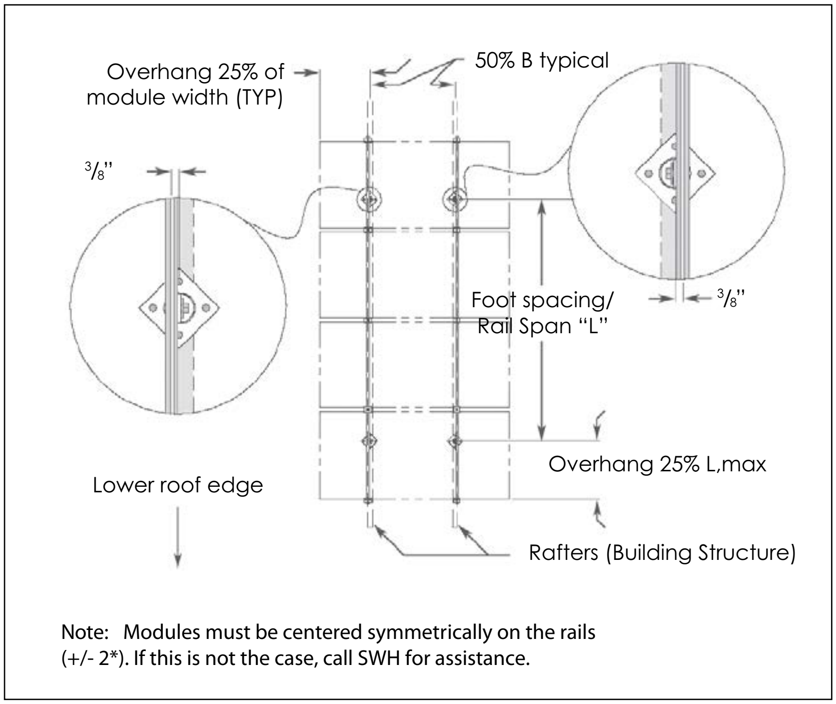


Figure 11. Layout with rails parallel to rafters.

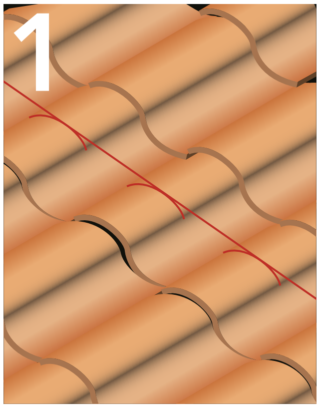
If multiple high-profile rows are to be installed adjacent to each other, it may not be possible for each row to be centered above the rafters. Adjust as needed, following the guidelines of **Fig. 11** as closely as possible.

Installing Standoffs:

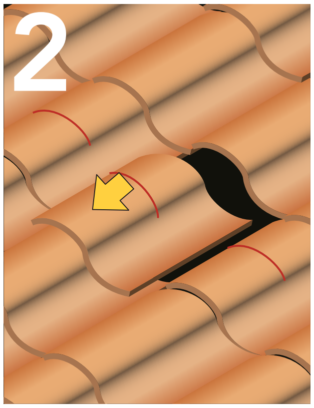
Drill 3/16 inch pilot holes through the underlayment into the center of the rafters at each standoff location. Apply sealant to the hole. Securely fasten 5/16" lag screw with thread top.

SWH aluminum standoffs (1" O.D.) are designed for collared flashings. Install and seal flashings and standoffs using standard building practices or as the company providing roofing warranty directs.

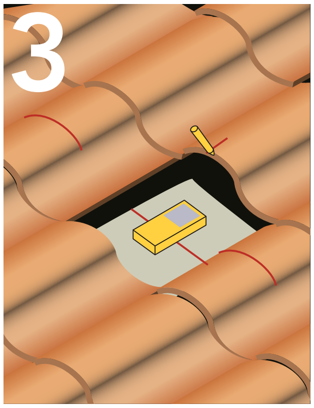
[3.2.4] Tile Strut Installation



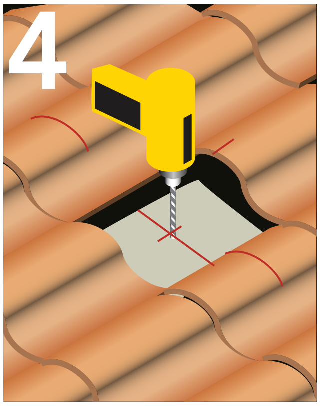
STEP 1: Select a tile above roof rafter.



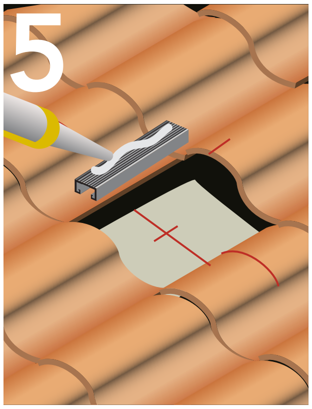
STEP 2: Remove the tile by pushing and pulling the tile, usually held in place by a small nail.



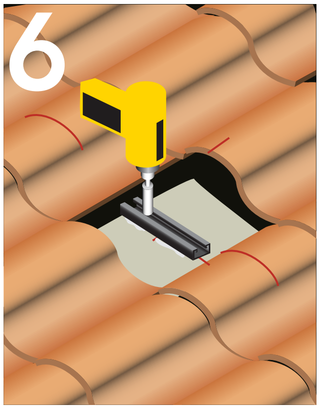
STEP 3: Use an Electric stud finder to locate the rafter center. Mark a reference point on the tile above.



Step 4: Drill several holes to locate the exact center. A 3/16" pilot hole drill bit is recommended.

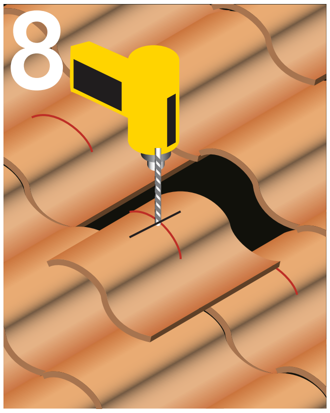


STEP 5: Insert the lag bolt and washer through the Tile Strut and apply fresh sealant to the base.

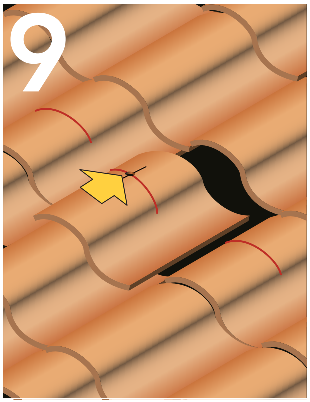


STEP 6: Install lag bolt into the roof using a 1/2"socket drive until lag bolt is seated.

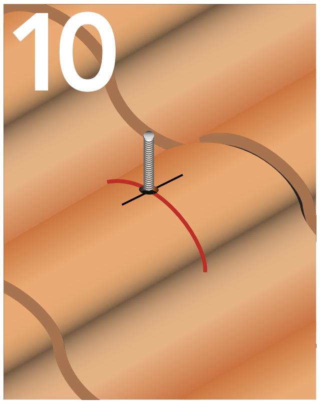
STEP 7. Slide Channel nut to line up with the crown of tile.



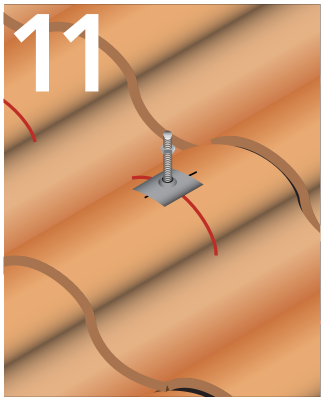
STEP 8. Using 3/8" carbide bit and a rotary hammer, drill through the crown of the tile at the intersection of the chalk line.



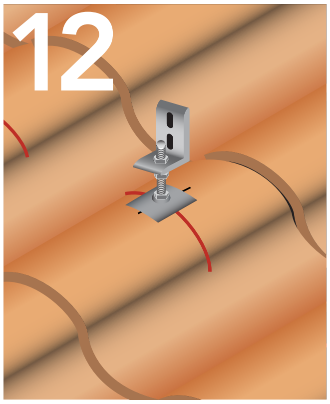
STEP 9: Return tile back to place.



STEP 10: Insert and hand tighten threaded rod.



STEP 11: Using the provided flashing and nut to secure threaded rod. Tighten to 14 ft lbs.

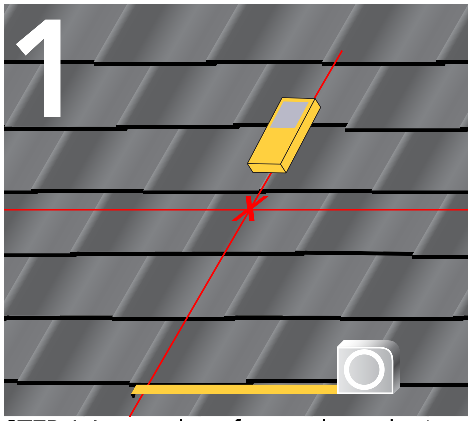


STEP 12: Use two flange nuts to hold L-bracket into place. Use Solar Mount rails to attach to L-brackets.

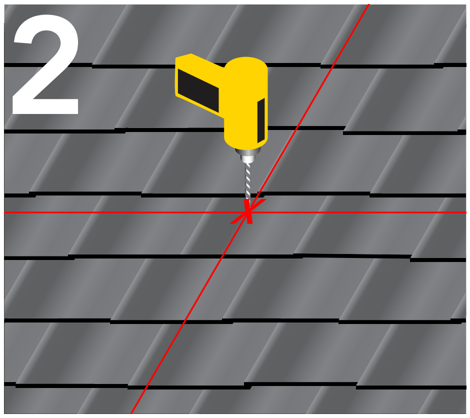
NOTE: Water and debris runs through the lowest point. Always attach points at the peak of the tile.

[3.2.5] Flashed L-feet Installation

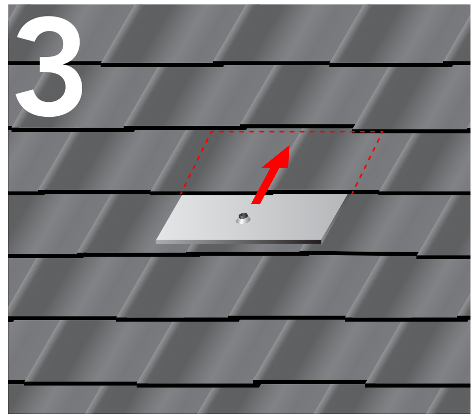
REQUIRED INSTALLATION TOOLS: Tape measure, chalk line, stud finder, caulking gun, sealant compatible with roofing materials, drill with 1/4” long-style bit, socket wrench or impact gun with 5/16” deep socket



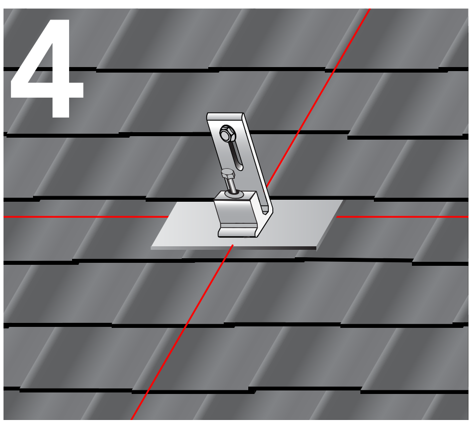
STEP 1: Locate the rafters and snap horizontal and vertical lines to mark installation position for each flashing.



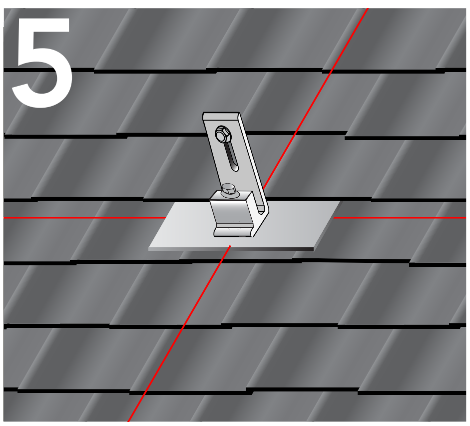
STEP 2: Drill a pilot hole (1/4” diameter) for the lag bolt. Backfill with sealant.



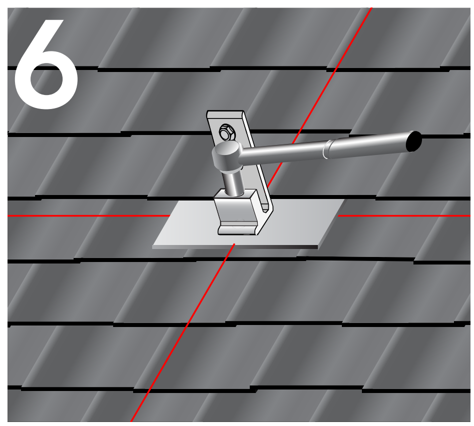
STEP 3: Insert the flashing so the top part is under the next row of shingles and pushed far enough up slope to prevent water infiltration through vertical joint in shingles. Line up flashing hole with pilot hole.



STEP 4: Line up pilot hole with high profile L-feet hole.



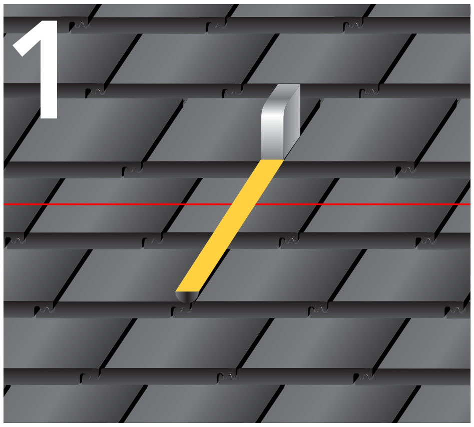
STEP 5: Insert lag bolt through L-feet, flashing and pilot hole.



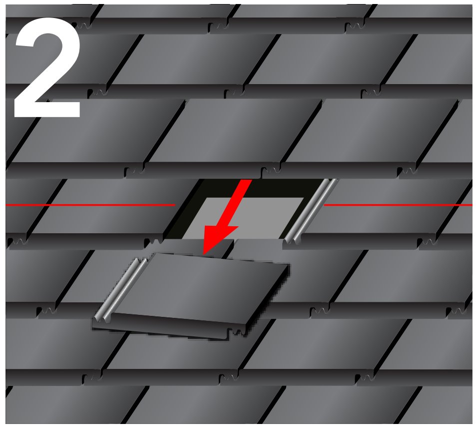
STEP 6: Tighten lag bolt to 100-140 torque inch pounds depending on the type of wood and time of year. If using an impact gun be careful to not over torque the fastener. You may need to stop and use a hand ratchet to finish the installation.

WARNING: Flashed L-feet Products are NOT designed for and should NOT be used to anchor fall protection equipment

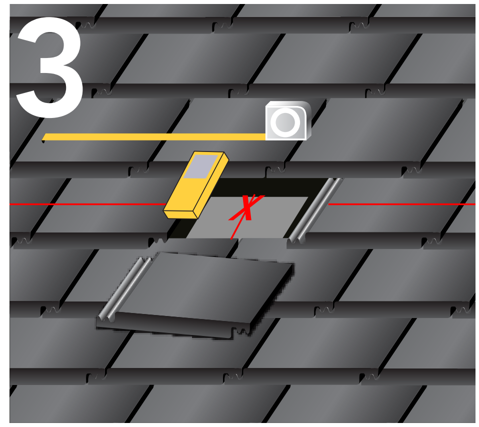
[3.2.6] Roof Bar Installation



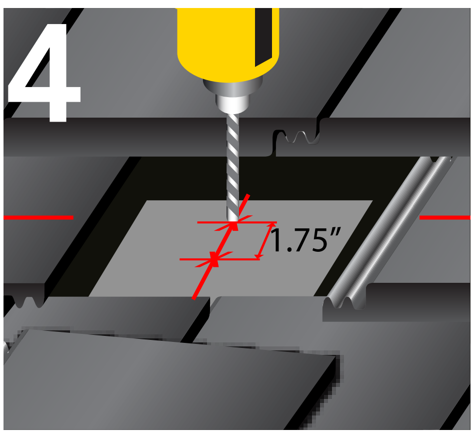
STEP 1: Snap horizontal line with chalk line.



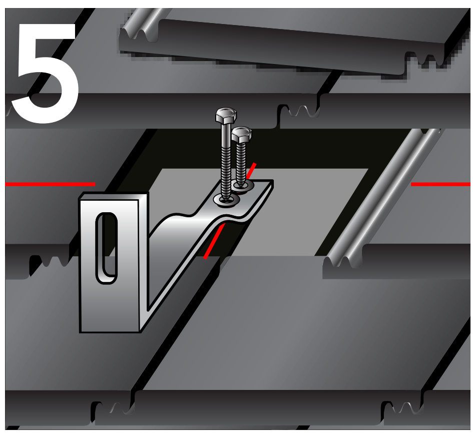
STEP 2: Remove tile.



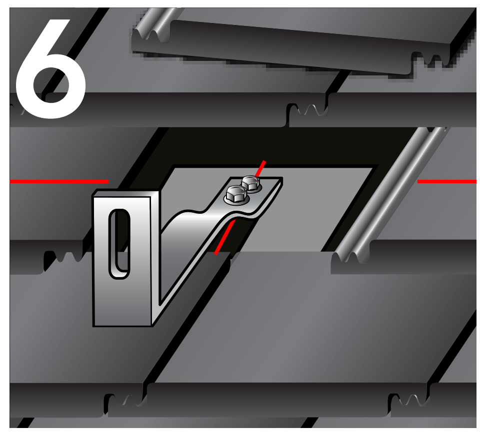
STEP 3: Use studfinder and measuring tape to find rafters.



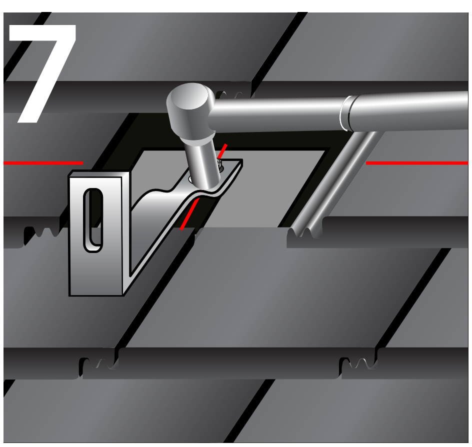
STEP 4: Drill two pilot holes (1/4″ diameter) for the lag bolts 1.75″ apart. Backfill with sealant.



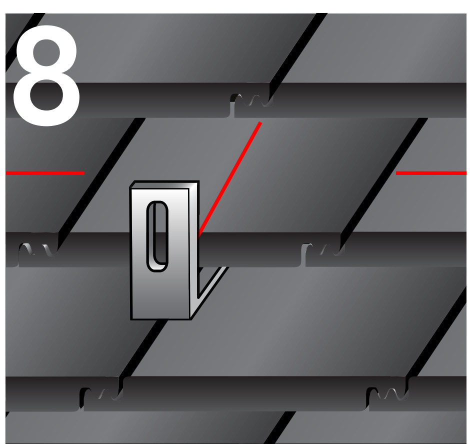
STEP 5: Line up pilot holes witht roof bar holes.



STEP 6: Insert lag bolts through 5/16″ SS flat washers and into rafter.

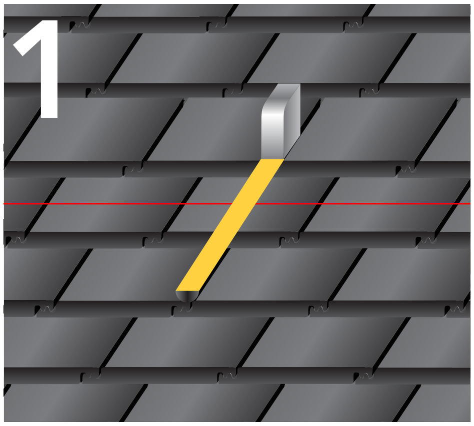


STEP 7: Tighten lag bolts using a 5/16″ socket wrench to between 100-140 inch pounds depending on the type of wood and time of year.

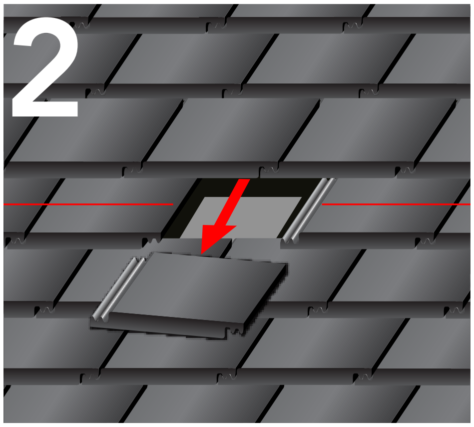


STEP 8: Reinstall tile. Underside of roof tile may have to be notched in order to seat flush onto roof bar.

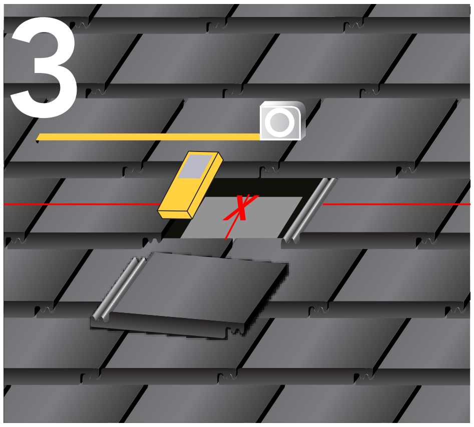
[3.2.7] Roof Hook Installation



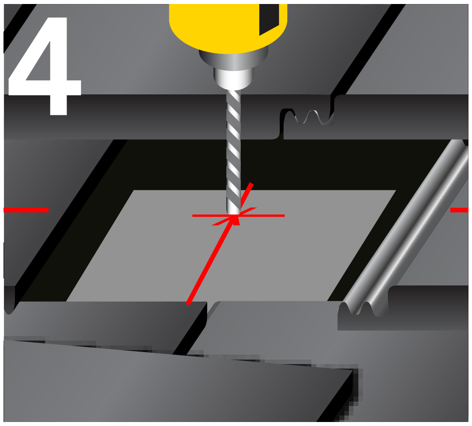
STEP 1: Snap horizontal line with chalk line.



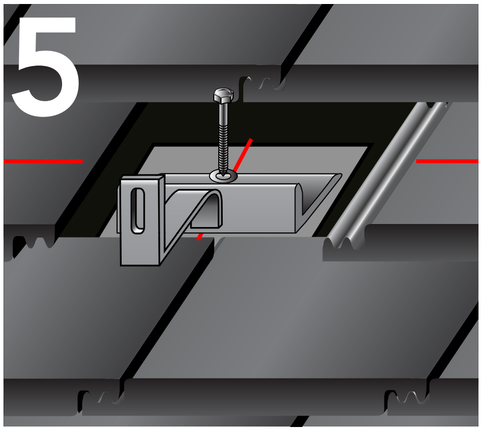
STEP 2: Remove tile.



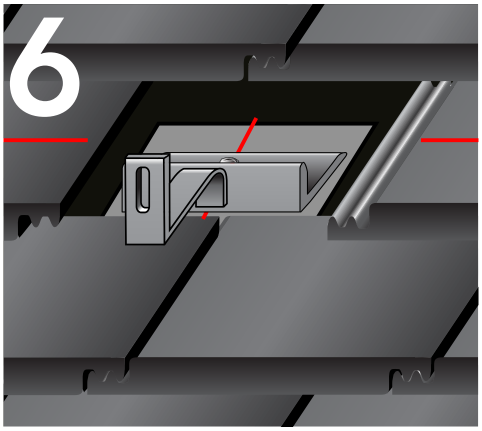
STEP 3: Use studfinder and measuring tape to find rafters



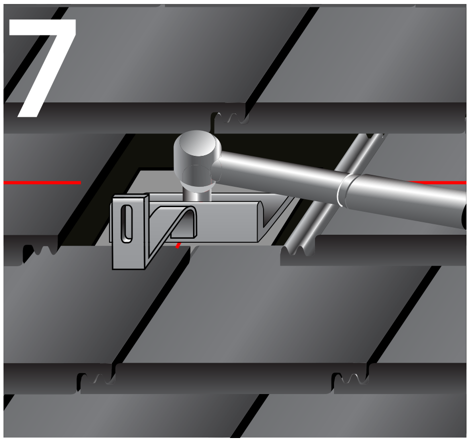
STEP 4: Drill a pilot hole (1/4" diameter). Backfill with sealant.



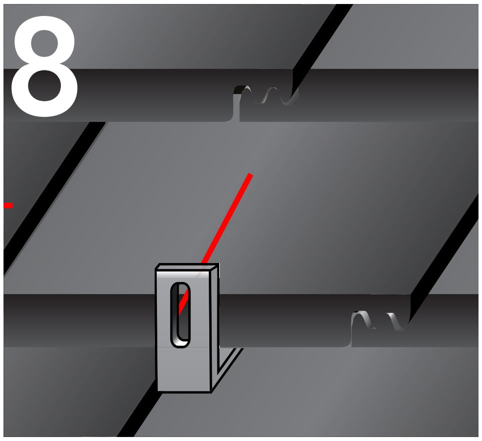
STEP 5: Line up pilot hole with roof bar holes



STEP 6: Insert lag bolt through 5/16" SS flat washer through roof hook and into the rafter.



STEP 7: Tighten lag bolt using a 5/16"socket wrench to between 100-140 inch pounds depending on the type of wood and time of year.



STEP 8: Reinstall Tile. Underside of roof tile may have to be notched in order to seat flush onto roof hook.

[3.2.8] Installing SWH rails and splices

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 uses SWH splice bars or grounding splice plates, attach the rails together (**Fig. 12 & Fig. 13)** before mounting the rails to the footings. Use splice bars only with flush installations or those that use low-profile tilt legs.

Although structural, the joint is not as strong as the rail itself. A rail should always be supported by one footing on ***both*** sides of the splice.

Mounting Rails on Footings: Rails may be attached to either of two mounting holes in the L-bracket (**Fig. 14**). Mount in the lower hole for a low profile, more aesthetically pleasing installation. Mount in the upper hole for a higher profile, which will maximize airflow under the modules. This will cool them more and may enhance performance in hotter climates. Slide the 3/8”-inch mounting bolts into the footing bolt slots. Loosely attach the rails to the footings with the flange nuts. Ensure that the rails are oriented to the footings as shown in **Figure 7, 8, 10, or 11,** whichever is appropriate.

Expansion Joint Used as Thermal Break: Expansion joints prevent buckling of rails due to thermal expansion. Splice bars or grounding splice plates may be used for thermal expansion joints. To create a thermal expansion joint, slide the splice bar or splice plate into the footing slots of both rail lengths. Leave approximately 1⁄2” between the rail segments. Secure the splice bar or splice plate with two screws or bolts on one side only. Footings (such as L-feet or standoffs) should be secured normally on both sides of the splice. No PV module or mounting hardware component should straddle the expansion joint. Modules must clearly end before the joint with mounting hardware terminating on that rail. T-bolts should not be placed less than a distance of 1" from the end of the rail regardless of a splice with the exception of the high profile mode installation for the trim. The next set of modules would then start after the splice with mounting hardware beginning on the next rail. **A thermal break is required every 40 feet of continous connected rail. For additional concerns on thermal breaks in your specific project, please consult a licensed structural engineer.** Bonding connections with splice used as a thermal break - option shown uses two SWH grounding bolt or SWH grounding lug and solid copper wire.

Figure 12: Splice bar attachment

Figure 13: Grounding Splice Plate

Figure 14. Foot-to-rail attachment

Figure 15. Bonding expansion joint

[3.2.9] Installing the modules

Pre-wiring Modules: If modules are the Plug and Play type, no pre-wiring is required, and you can proceed directly to "Installing the First Module" below. If modules have standard J-boxes, each module should be pre-wired with one end of the intermodule cable for ease of installation. For safety reasons, module pre-wiring should not be performed on the roof. Leave covers off J-boxes. They will be installed when the modules are installed on the rails.

Installing the First Module: In high-profile installations, the best practice would be to install a safety bolt (¼"-20 x ½") and flange nut (both installer provided) fastened to the module bolt slot at the aligned (lower) end of each rail. It will prevent the lower end clamps and clamping bolts from sliding out of the rail slot during installation.

If there is a return cable to the inverter, connect it to the first module. Close the J-box cover. Secure the first module with T-bolts and end clamps at the aligned end of each rail. Allow half an inch between the rail ends and the end clamps (**Fig.17**). Finger tighten flange nuts, center and align the module as needed, and securely tighten the flange nuts (10 ft lbs).

You ***MUST USE*** the correct end clamps for the corresponding modules thickness **(Fig.19)**. End clamps have been designed to slightly tilt inwards **(Fig.20).** Incorrect use will lead to structure failure.

You ***Must Use*** same height modules for mid clamps to properly secure modules **(Fig. 21, 22 & 23).**

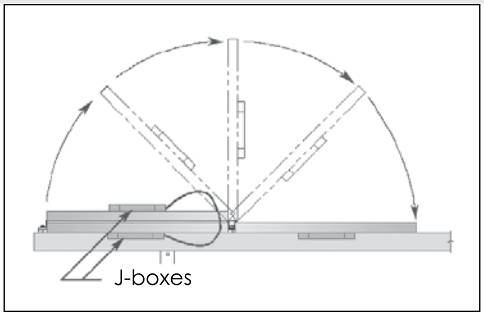


Figure 16

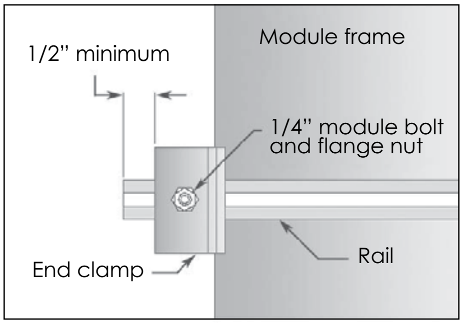


Figure 17

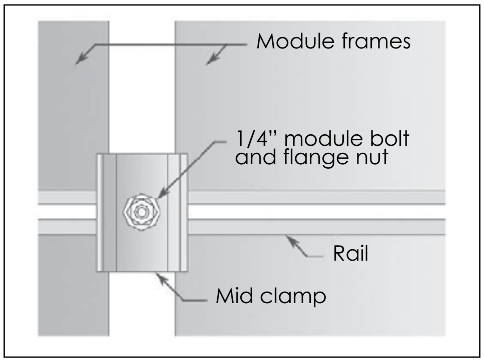


Figure 18

Part Name	Part Number	Range of Heights (mm)	Weight (lbs) (without Hardware)
"C" end clamp	MR-SW-EC-35	34-36	.054
"C" black end clamp	MR-SW-EC-35B	34-36	.054
"K" end clamp	MR-SW-EK-40	39-41	.056
"K black end clamp	MR-SW-EK-40B	39-41	.056
"F" end clamp	MR-SW-EF-45	44-46	.058
"F" black end clamp	MR-SW-EF-45B	44-46	.058
"E" end clamp	MR-SW-EE-50	49-51	.060
"E" black end clamp	MR-SW-EE-50B	49-51	.060

Figure 19. End Clamp Sizes

Figure 20. Check End Clamp Fit

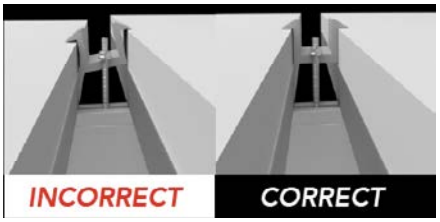


Figure 21. Check Mid Clamp Fit

MODEL #	T-BOLT LENGTH	MODULE HEIGHT
EA-SW-GM-25B	50MM	<=32mm
EA-SW-GM-25K	60MM	33-42mm
EA-SW-GM-25E	70MM	43-50 mm

Figure 22 Grounding Mid Clamp Sizes

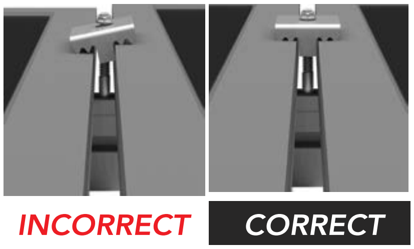


Figure 23. Check Grounding Mid Clamp Fit

SWH SIDE MOUNT GROUNDING BOLT

MFG-PN: EA-SW-GB-01

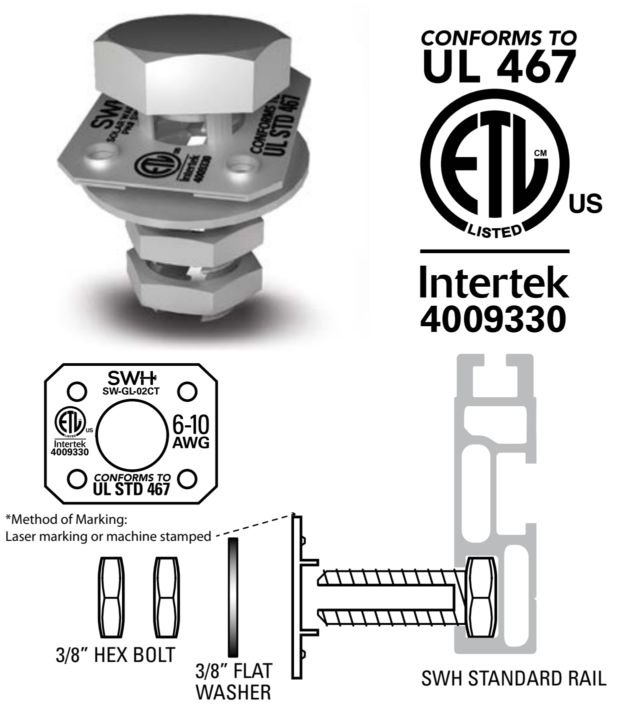


Figure 24. Slide SW-GB-01 grounding bolt into side mounting slot of rail. Torque nut to 10 ft-lbs. Nibs will penetrate rail anodization and create grounding path through rail.

*NOT TO SCALE

SWH TOP MOUNT GROUNDING CLIP

MFG-PN: EA-SW-GC-01

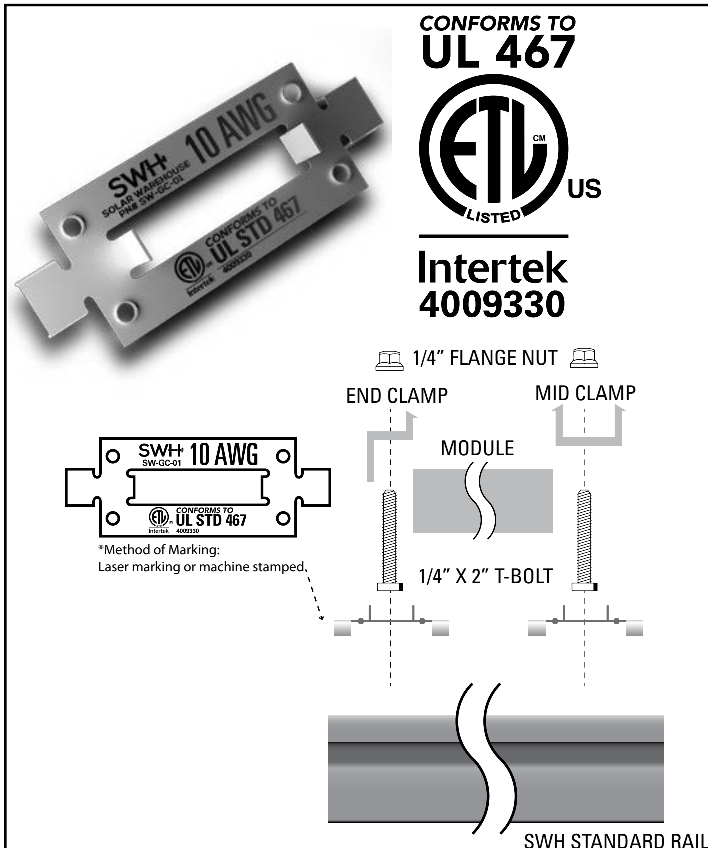


Figure 25. Slide or drop SW-GC-01 grounding clip into top mounting slot of rail. Torque mid clamps in place to 10 ft-lbs. Nibs will penetrate rail and module anodization and create grounding path through rail.

*NOT TO SCALE

SWH COPPER-TIN PLATED GROUNDING LUG

Part No. EA-SW-GL-02CT

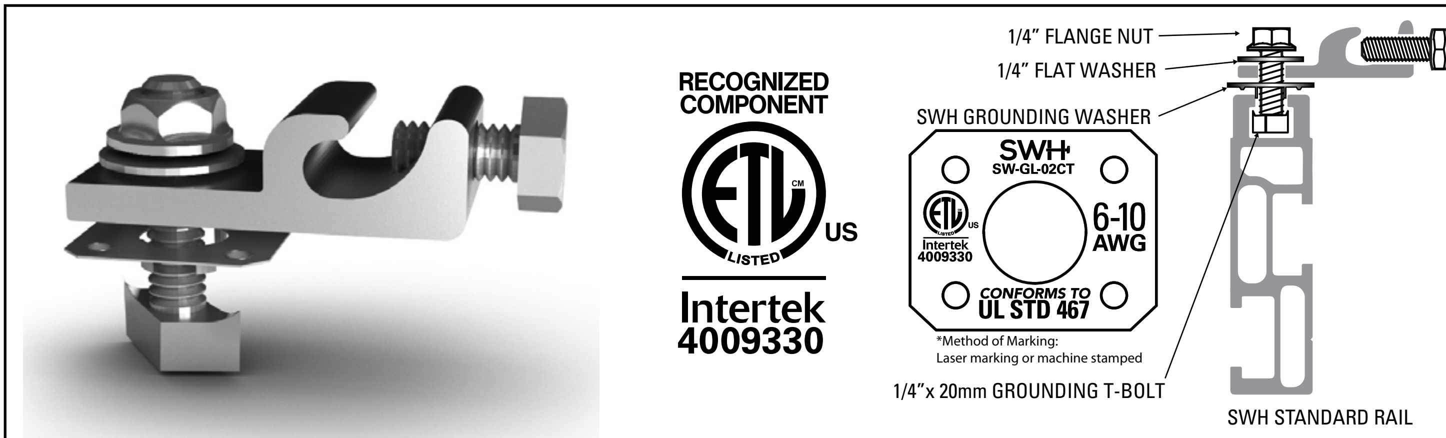
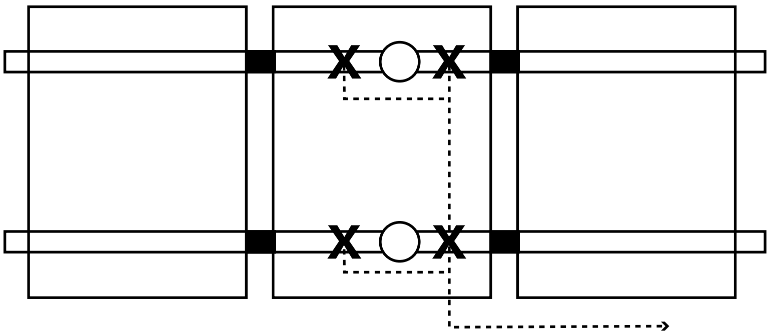


Figure 26. Slide or drop SW-GL-02CT grounding lug into top mounting slot of rail. Torque lug in place to 8 ft-lbs. Nibs will penetrate rail anodization and create grounding path through rail.

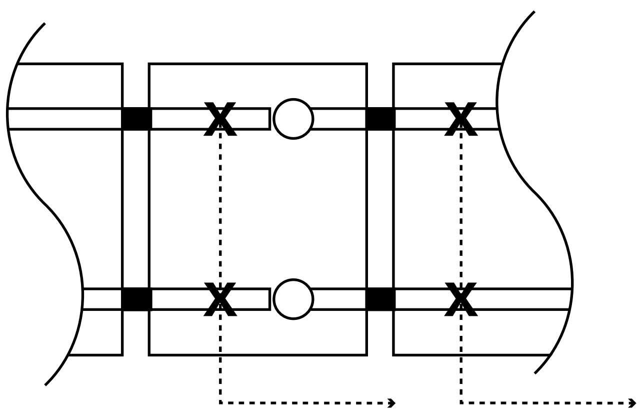
*NOT TO SCALE

All wire sizes, unless noted otherwise, are American Wire Gauge (AWG)

[3.3] Installing SWH grounding clips, bolts and lugs



SINGLE GROUND WIRE
FOR ENTIRE ARRAY



ALTERNATE WIRING FOR
IN-LINE SPLICES

Figure 27. Place grounding bolts or grounding lugs on both sides of splice with 6-10 AWG copper wire loop as shown. If using single ground wire method, be sure wiring between rails is not taut.

KEY

- PV Module
- SWH STANDARD RAIL
- GROUNDING CLIP
- SPLICE
- X GROUNDING BOLT/LUG
- ------- COPPER WIRE

[3.4] Installer Warning and Notice

NOTICE!

Please carefully read and understand the provided installation manual before installing, wiring, or operating our product in your PV system. Failure to follow all instructions and conditions could possibly damage the product and above all, lead to serious injury or death. **PV system and SWH Solar Racking installations must comply with National Electrical Code and installer is solely responsible for code and safety compliances and their consequences.**

WARNING!

PV modules generate electricity when exposed to light and are electrically live when mounted. This DC electricity can pose danger to the installer, user, and/or property. Any contact with electrically active module terminals can result in arcing; leading to shocks, fires, burns, and/or death. Use caution around utility power lines that may be near the work area. Never work in wet or windy conditions. Lighting is a hazard to any work with metal, never work when lighting is present. Insure good earth-bonding as part of a lighting protection system.

DANGER!

Electrical shock potential of PV modules increases with higher parallel currents and series voltage connections. The PV installer must assume all inherent risk of property damage and/or personal injury related to the mishandling of PV modules during installation and maintenance. Skilled, Licensed Electricians must conduct all electrical installation procedures. All work must comply with all national, state and local installation procedures, product and safety standards. These standards include but are not limited to applicable National Electrical Code (NEC®) sections, UL Standards, OSHA Regulations, State or Local Fire Marshall Codes, NFPA 70E. Installation must comply with NEC 250 (Grounding and Bonding), NEC 690 (Solar Photovoltaic Systems), CSA 22.1 (Safety Standard for Electrical Installations), Canadian Electrical Code Part 1, and all other applicable state, provincial, and local electrical code requirements. ***SWH Solar Racking Systems*** must be used with UL1703 listed equipment including but not limited to; PV modules, combiners and disconnects.

DANGER!

Avoid electrical injuries by preventing the accidental or unintentional release of hazardous energy. Proper Lockout/Tag out procedures will limit this danger. All Personnel must use caution when working in and around PV arrays. Proper PPE worn at all times will also limit this danger. Modules produce electricity when exposed to light. To avoid electric shock and injury, completely cover the front of the module with an opaque material before making any electrical connections. Lock out / tag out and disconnect the PV system from all electrical energy before any maintenance or cleaning. NEVER disconnect or connect modules under load. Never disconnect the earth bond to the array.

[3.4] Installer Warning and Notice

DANGER!

When installing SWH Solar Racking Systems on roofs a falling hazard is present. Proper fall protection will limit this danger. Never work in wet or windy conditions. Secure tools and materials from falling, and insure personnel below exercise caution from work overhead. Follow all OSHA guidelines for working on roofs, with ladders, and insure general safety conditions exist.

DANGER!

DANGER
Electric shock risk

The Installer of ***SWH Solar Racking Systems*** must provide the components necessary for the final connections to the grounding electrode system. Typically the installation will incorporate a grounding electrode (ground rod), appropriately sized copper wire, rated wire connectors, and grounding lugs which are out-door rated for this purpose. Many PV installations contain more than one mounting array. Such cases call for electrically bonding each of the different arrays together. It is only necessary to connect individual racks together from one single point to another single point. Only use stainless steel hardware when connecting harnesses or jumpers to the mounting system.

Take care to prevent copper wires from directly contacting aluminum, as this will cause corrosion. The use of anti-oxidant grease is highly recommended to prevent ground wire terminal corrosion.

Use mechanically sound methods to secure ground/ bond wires to ***SWH Solar Racking Systems*** thus ensuring electrical continuity at all times. Conductors must meet or exceed the requirements of the NEC. Always refer to your local AHJ (Authority Having Jurisdiction) when sizing conductors, fuses, inverters, and other Balance of System (BOS) components. Where common grounding hardware (nuts, bolts, star washers, spilt-ring lock washers, flat washers and the like) are used to attach a listed grounding/bonding device, the attachment must be made in conformance with the grounding device manufacturer's instructions.

SOLAR WAREHOUSE

MANUFACTURER'S LIMITED STRUCTURAL PERFORMANCE WARRANTY

Solar Warehouse warrants to the buyer ("Buyer") at the original installation site ("Site") that any of the components (the "Product") purchased from Solar Warehouse shall be free from structural defects in material, workmanship and performance, as referenced in the Solar Warehouse Product Information, for a period of ten (10) years, except for the anodized finish, in which the finish shall be free from visible peeling, cracking or chalking under normal atmospheric conditions for a period of five (5) years ("Finish Warranty"), from the earlier of 1) the date in which the installation of the product on site was substantially completed, or 2) 120 days after the purchase of the Product by the original Buyer of the Product ("Warranty Period"). Buyer may transfer this Warranty to subsequent owners, or if Buyer is a contractor to the property owner. In this Warranty, the term "Buyer" refers to the original buyer and any subsequent transferee of which Solar Warehouse has advance notice. Proof of purchase is required. The Finish Warranty does not apply to any foreign residue deposited on the finish. All installations in corrosive atmospheric conditions are excluded. The Finish Warranty is VOID if the practices specified by AAMA 609 & 610-02 – "Cleaning and Maintenance for Architecturally Finished Aluminum" (www.aamanet.org) are not followed by Purchaser. This Limited Warranty covers only the Product, and not PV modules, electrical components and/or wiring used in connection with the Product or any other materials not provided by Solar Warehouse. This Warranty does not cover damage to the Product that occurs during its shipment, storage, and installation, or from any force majeure acts including fire, flood, earthquake, storm, hurricane or other natural disaster, war, terrorist activities, acts of foreign enemies and criminal acts. This Limited Warranty shall be void if, A) installation of the Product is not performed in accordance with the Solar Warehouse Product Information, B) if the Product has been modified, repaired, or reworked in a manner not previously authorized by Solar Warehouse in writing, or C) the Product is installed in an environment for which it was not designed, each as determined by Solar Warehouse, at Solar Warehouse's sole discretion. If, within the Warranty Period, the Product shall be proven in Solar Warehouse sole discretion to be defective, then Solar Warehouse shall repair or replace the defective Product, or any part thereof, at Solar Warehouse's option. Any such repair or replacement does not cause the beginning of new warranty terms, nor shall the Warranty Period of this Limited Warranty be extended. Solar Warehouse's aggregate liability under this Limited Warranty shall not exceed the original Purchase Price of the Product. Buyer shall bear all costs of shipment or transportation related to the repair or replacement of the defective product. Such repair or replacement shall be Buyer's sole remedy under this Limited Warranty and shall fulfill all of Solar Warehouse's obligations with respect to this Limited Warranty. EXCEPT FOR THE LIMITED WARRANTY EXPRESSED ABOVE, SOLAR WAREHOUSE MAKES NO REPRESENTATION OR WARRANTY OF ANY KIND WHATSOEVER AND HEREBY DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, COURSE OF DEALING AND USAGE OF TRADE.

SOLAR WAREHOUSE SHALL NOT BE LIABLE FOR LOSS OF USE, REVENUE OR PROFIT, OR FOR INDIRECT, SPECIAL, PUNITIVE, LIQUIDATED, INCIDENTAL OR CONSEQUENTIAL DAMAGES, OR FOR ANY OTHER LOSS OR COST OF A SIMILAR TYPE, OR FOR CLAIMS BY BUYER FOR DAMAGES OF BUYER'S CUSTOMERS, CLAIMS OF A SIMILAR TYPE, OR FOR CLAIMS BY BUYER FOR DAMAGES OF BUYER'S CUSTOMERS, CLAIMS OF THIRD PARTIES OR INJURY TO PERSONS OR PROPERTY ARISING OUT OF ANY DEFECT IN THE PRODUCT COVERED BY THIS WARRANTY. ALL SUCH DAMAGES AND EXPENSES ARE HEREBY EXCLUDED.

For warranty service claims, please contact Solar Warehouse at info@esolarwarehouse.com