SolarPega & SolarPegaF Series

PV Module Installation Manual

Shandong ZKFN Solar Technology Co., Ltd.

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1. Manual Overview and Responsibility Statement

1.1 Scope of Manual

This manual is the official installation guide issued by Shandong ZKFN Solar Technology Co., Ltd. (hereinafter referred to as “ZKFN Solar”) for the SolarPega series (SolarPega, SolarPegaL) and SolarPegaF series (SolarPegaF, SolarPegaFL) TOPCon light-weight crystalline silicon PV modules (hereinafter referred to as “modules”). This manual covers the entire lifecycle specifications from product selection, arrival and unloading, storage, unpacking, installation and construction, electrical connection, and subsequent operation and maintenance.

This manual is intended for system integrators, installers, and professionally qualified personnel engaged in the installation, commissioning, and maintenance of the above-mentioned series of modules. Any individual responsible for handling, installing, or operating this product has the responsibility to read, understand, and comply with the requirements in this manual prior to operation. Failure to comply with the operational procedures, safety instructions, and technical specifications set forth in this manual may result in serious personal injury or property damage. Installation and operation of solar modules require professional skills; only professionals may perform such work. Please read the safety and installation instructions before using and operating the modules. Installers must correspondingly inform end customers (or consumers) of these points.

The core module models covered by this manual include:

- SolarPega (1.6mm front glass, no back frame): ZKFN-G2-220B xxx, etc.
- SolarPega L (1.1mm front glass, no back frame): ZKFN-G2-120B xxx, etc.
- SolarPegaF (1.6mm front glass, with back frame): ZKFN-G2-222B xxx, etc.
- SolarPegaF L (1.1mm front glass, with back frame): ZKFN-G2-122B xxx, etc.

1.2 Disclaimer

1. ZKFN Solar reserves the right to modify this manual without prior notice due to product technology upgrades, process improvements, or standard updates. The latest version will be published simultaneously on the ZKFN Solar official website download center. Customers and installers are responsible for proactively ensuring the use of the latest version. Any operational deviations resulting from the use of outdated versions shall be borne by the user.
2. Failure to follow the requirements specified in the installation manual (including changes published on ZKFN Solar’s official website at the time of installation) during module installation will void the limited product warranty provided to the customer.
3. ZKFN Solar makes no warranties, express or implied, regarding any information contained in this manual. Users and installers must complete a site technical survey to ensure that the provided installation methods comply with local laws and building standards.

4. ZKFN Solar does not provide any accessories for BIPV mounting systems. If needed, please consult professional mounting system manufacturers. ZKFN Solar assumes no responsibility for the quality of any mounting systems or their accessories.

1.3 Scope of Liability

1. Regardless of whether module installation follows the installation manual (including changes published on ZKFN Solar's official website), ZKFN Solar shall not be held legally liable for any damages arising during installation, including but not limited to module handling, personal injury, or property loss resulting from system installation.
2. In case of inconsistencies between different language versions of this manual, the Chinese version shall prevail.
3. This manual is provided for installation guidance only and does not constitute any warranty, whether express or implied.

1.4 Warranty Warning Terms

1. ZKFN Solar provides a 15-year product warranty and a 30-year linear power guarantee for all SolarPega and SolarPegaF series products. Specific warranty scope, claims procedures, and exceptions shall be governed by the official warranty documents accompanying the product at the time of purchase.
2. Key auxiliary materials used with the modules, such as clamps, structural adhesive, and MC4-compatible connectors, must be models recommended or certified by ZKFN Solar to ensure overall system compatibility, reliability, and safety. Damage to products or systems caused by the use of non-certified hardware is not covered under warranty.

1.5 Technical Support Information

To obtain more detailed technical support documents, engage in project-specific solution consultation, or request recommendations for abnormal installation surfaces, please contact ZKFN Solar through the following official channels:

- Service Hotline:(+86) 400 6768 100 (Office Hours: 8:30-17:30, Beijing Time)
- Technical Support Email: tech-support@zkfnsolar.com
- Official Website: www.zkfnsolar.com
- Manufacturing Base Address: Building 1, Xinshenglin, Lvhaihui Intelligent Manufacturing Industrial Park, Jining Economic Development Zone, Jining City, Shandong Province

2. Safety Operation Specifications

2.1 General Safety Warnings

1. All installation work must comply fully with local regulations and applicable national or international electrical standards.
2. Electric Shock and Burn Risk: PV modules are DC power generation equipment. When their surface is exposed to light, even without circuit connection, DC voltage is present at the positive and negative terminals and connectors. Multiple modules connected in series form a PV array whose voltage can reach levels hazardous to personal safety. Personnel without professional training or authorization are prohibited from touching module terminals, connectors, or exposed live parts in any manner. Contact with live parts may cause severe burns or fatal electric shock.
3. No Live-Load Operation: Before any module installation, replacement, wiring, or system modification, the DC and AC sides must be completely de-energized, with strict anti-reclosure and de-energization verification measures. Under no circumstances shall connectors or electrical connections be disconnected under load, as this produces hazardous and destructive DC arcs that may cause fire, equipment damage, and serious personal injury.
4. Damaged Module Handling: Do not use modules with visible damage, including but not limited to surface penetration, cracking, backsheet scratches or penetration, junction box cracking, or internal water ingress. Damaged modules cannot be repaired and present extremely high leakage and electric shock risks with completely compromised insulation. Do not disassemble modules, remove component parts, or modify bypass diode wiring for any reason. Module junction box covers must remain closed at all times.
5. Short-Circuit Risk of Positive and Negative Poles: :Do not directly connect the positive and negative connectors of a single module, as this will cause a module short circuit. Before installation, inspect and ensure all connector insulating caps or sealing rings are intact and properly installed to prevent short circuits caused by insulation failure, which could lead to fire or electric shock.
6. Environmental and Electrical Parameter Limits:The designed stable operating ambient temperature range for modules is -40°C to +85°C. The maximum system open-circuit voltage must not exceed the maximum system voltage of DC 1500V indicated on the module product label under any expected minimum ambient temperature. Operation beyond rated parameters is prohibited.
7. Fire Safety:In the event of a fire at the installation or O&M site, and where conditions permit without personal danger, the entire PV system power (including DC and AC sides) must be disconnected first, then extinguish using dry powder, CO_2, or other non-conductive fire extinguishing media according to electrical fire safety regulations. Do not use water or foam to directly flush modules or electrical systems before disconnecting power.

8. Application Class and Warning: This series of modules is Application Class A (equivalent to IEC 61730-1 Safety Class II), suitable for systems accessible to the public. When the system open-circuit voltage exceeds 50V, prominent “Electric Shock Hazard” warning signs must be installed near string connection devices, inverters, and other easily accessible locations according to safety regulations.

2.2 General Personnel Safety Requirements

1. Qualification Requirements: All personnel responsible for PV system installation, wiring, commissioning, and maintenance must complete professional PV system installation training, hold relevant valid qualification certificates, and be fully familiar with all safety regulations in this manual and relevant local government regulations.
2. Two-Person Work System:To minimize the risks of single-person operations (such as accidental electric shock, falls from height, etc.), all on-site installation, handling, and wiring operations must be carried out by at least two persons working together. High-risk operations by a single person are prohibited.
3. Personal Protective Equipment (PPE):Personnel must properly wear certified personal protective equipment during operations, including but not limited to: anti-slip protective gloves, long-sleeve insulated work clothing, anti-impact insulated shoes. When working on roof edges or any area with fall risk (height difference exceeding 2 meters), a double-hook shock-absorbing safety harness must be worn at all times and securely attached to an independently installed lifeline or anchor point, with fall protection barriers or safety nets installed below the work area.
4. Tools and Jewelry: Only tools meeting safety standards with intact insulation shall be used. Wearing any metal jewelry such as watches, rings, necklaces, bracelets, etc., is prohibited during work, as such items may cause unintended current conduction leading to short-circuit risk, or scratch the module surface during handling.

5. Adverse Weather: Outdoor installation, hoisting, or wiring operations are prohibited in rain, snow, fog, thunderstorms, or when on-site instantaneous wind speed reaches or exceeds Level 4 (wind speed approximately 7.9 m/s). Humid environments significantly increase electric shock risk. Installers must ensure all modules, tools, and electrical connection points are clean and dry before proceeding.

6. Area Control: The construction site and temporary module storage area must be clearly marked with warning signs and barriers. Unauthorized personnel, children, or other unrelated persons are prohibited from entering to prevent accidents.
7. Light Exposure Protection: Light Exposure Protection: At any time, even when modules are not connected to a complete system, they constitute a power source when exposed to light. Do not directly touch junction boxes, cable ends, or metal contacts inside connectors with bare hands without protection.

2.3 General Prohibited Operations

To ensure module performance, personnel safety, and warranty validity, the following are prohibited:

1. Physical Damage and Coating:Do not scratch, strike, bend, or impact the front or back of modules with sharp objects. Do not apply paint, adhesives, tape, or any form of coating on any area of the module surface. Do not drill, cut, or grind any part of the module (unless prior written confirmation is obtained from ZKFN Solar's professional technical personnel).
2. Cable and Connector Damage:Do not scratch, cut, squeeze, or pull the module's cables and connectors in any manner. Do not expose cables and connectors to direct sunlight or water for extended periods without proper protection.
3. Handling and Pressure:Do not press on the cell area when handling. Do not lift, carry, or drag modules by grasping the junction box, lead wires, or connectors. Modules must be handled with both hands. Do not press, stand, walk, climb, or jump irregularly on the module surface. Do not allow modules to collide, rub, or impact with any hard or sharp objects.
4. Artificial Light Concentration: Do not use mirrors, magnifying glasses, lenses, or other optical devices to concentrate additional sunlight or artificial light onto the module surface.

5. Water Immersion and Stacking:Do not place modules in areas prone to water accumulation or continuous humidity for extended or permanent periods. During all storage, handling, and installation stages, do not place modules with back facing upward, stack, or compress modules.

6. Surface Contamination and Shading: Do not apply structural adhesive, sealant, or any foreign matter to the effective light-receiving area of cells during installation. After module installation, ensure all output cables and jumpers are routed clearly and securely fastened. Do not allow wires, clamps, or other objects to shade the effective light-receiving area of cells.
7. Pollution Sources and Fire Hazards: Do not install modules near vents or exhaust outlets that continuously emit oil fumes, dust, or chemically corrosive gases. Do not install modules near open flames or flammable/explosive materials.
8. Disturbance After Installation:Modules installed with structural adhesive must not be disturbed within a certain period after bonding (refer to Annex 2), including but not limited to moving modules, connecting cables, applying external force, or standing on modules for other operations. Do not lift and re-adhere modules after adhesive curing.
9. Improper Loading: After module installation and testing, do not place any heavy objects, tools, or objects with sharp fulcrums on the module surface to avoid long-term pressure damage.
10. Lightning Protection:To reduce the risk of indirect lightning strikes, avoid creating loops in system design. If modules are installed in areas with frequent lightning activity, lightning protection must be provided for the modules.
11. Prevent Loosening:Modules must be securely fixed to withstand all possible loads, including wind and snow loads. Module loosening pulling on connection cables, leading to insulation failure, leakage, and arcing, is a significant risk in distributed PV systems.
12. Disassembly Prohibition:Do not disassemble modules or remove any component parts of the module. Damaged junction boxes and connectors present potential electrical hazards and laceration risks.

3. Product Specifications and Core Performance Parameters

3.1 Product Series and Model Description

This manual comprehensively covers ZKFN Solar's two core light-weight module product lines: the SolarPega series (without back frame) and the SolarPegaF series (with back frame). Product naming rule: ZKFN SolarPega series are named as ZKFN Light-weight module, followed by a 2-digit code consisting of F and L. The presence of F indicates the module has a back frame; the absence of F indicates no back frame. The presence of L indicates the glass thickness is 1.1mm; the absence of L indicates 1.6mm glass thickness. There are four main products, all equipped with TSR-Armor™ technology. The characteristics and internal model definitions for each series are as follows:

Product Series	Internal Model Code	Glass Thickness	Back Frame	Power Range
SolarPega	ZKFN-G2-220B 520	1.6mm	No	510~520W
SolarPegaL	ZKFN-G2-120B 510	1.1mm	No	500~510W
SolarPegaF	ZKFN-G2-222B 520	1.6mm	Yes (Composite Material)	510~520W

Product Series	Internal Model Code	Glass Thickness	Back Frame	Power Range
SolarPegaFL	ZKFN-G2-122B 510	1.1mm	Yes (Composite Material)	500~510W

xxx represents the rated output power under STC (Standard Test Conditions); see Annex 3 for other extended models.

- SolarPega / SolarPegaL (without back frame): The core installation method is direct structural adhesive bonding, requiring no mounting frame or rails, suitable for T-type, corrugated steel tile roofs and flat roof waterproof membrane roofs.
- SolarPegaF / SolarPegaFL (with back frame): Featuring a high-strength glass-fiber resin composite back frame and Quick-Clamp fixture fast installation, supporting non-destructive disassembly, suitable for various steel tile roofs (including standing seam, angle-ridge types) and flat roof scenarios

3.2 Core Electrical Performance Parameters

Parameter Item	SolarPega / SolarPegaF (510-520W)	SolarPegaL / SolarPegaFL (500-510W)
Peak Power Range (Pmax)	510~520W	500~510W
Module Efficiency	Up to 23.4%	Up to 22.9%
Power Tolerance	0~+5W	0~+5W
First Year Power Degradation	≤1%	≤1%
Annual Power Degradation (Year 2-30)	≤0.4%	≤0.4%
Peak Power Temperature Coefficient (γ)	-0.33%/°C	-0.33%/°C
Open-Circuit Voltage Temperature Coeff. (α)	-0.27%/°C	-0.27%/°C
Short-Circuit Current Temperature Coeff. (β)	+0.045%/°C	+0.045%/°C
Nominal Operating Cell Temperature (NOCT)	45±2°C	45±2°C
Maximum System Voltage	DC 1500V	DC 1500V
Maximum Series Fuse Rating	25A	25A

(STC Conditions: Irradiance 1000W/m², Air Mass AM 1.5, Cell Temperature 25°C, Test Tolerance ±3%)

Note: Supplementary Explanation: Due to normal operating conditions such as specific low temperatures and high irradiance, the actual output open-circuit voltage and short-circuit current of modules may be significantly higher than STC nominal values. Therefore, in electrical system design, the nominal Isc and Voc values must be multiplied by a factor of 1.25 for engineering design.

3.3 Core Mechanical Performance Parameters

The following table summarizes the key structural and physical characteristics of each series, which are the basis for on-site handling, installation decisions, and mechanical load assessment.

Parameter Item	SolarPega	SolarPegaL	SolarPegaF	SolarPegaFL
Module Dimensions	1957×1130×2.7 mm	1957×1130×2.2mm	1961×1134×25.5 mm	1961×1134×25.5mm
Front Cover	1.6mm heat-strengthened glass	1.1mm ultra-thin tempered glass	1.6mm heat-strengthened glass	1.1mm ultra-thin tempered glass
Frame	None	None	Glass-fiber resin composite	Glass-fiber resin composite
Module Weight	Approx. 13.0 kg	Approx. 10.0 kg	Approx. 16.2 kg	Approx. 13.0 kg
Cell Specification	TOPCon Cell 182.3×105mm			
Junction Box Specification	3-part, IP68			
Output Cable	4mm², length 400mm, customizable			
Connector	MC4 Compatible			
Static Mechanical Load	3600Pa / 2400Pa	2400Pa / 2400Pa	3600Pa / 2400Pa	2400Pa / 2400Pa
Wind Resistance Level	Level 17			
Hail Test	Diameter 25mm, Impact speed 23m/ss			
Core Performance Features	Flexible, adhesive installation	Flexible, adhesive installation, 6-bypass anti-hot-spot	Back frame, quick-install, easy removal	Back frame, quick-install, easy removal, 6-bypass anti-hot-spot

3.4 Installation Tilt Angle and Site Selection Specifications

1. Installation Site Requirements

   - ZKFN Solar SolarPega series modules are recommended for installation in operating ambient temperatures of -40°C to +40°C, this being the monthly average minimum and maximum temperature of the installation site. The extreme operating ambient temperature for modules is -40°C to +85°C.
   - Modules should be installed in locations with sufficient sunlight exposure and ensure no shading at any time. Although modules are equipped with bypass diodes, shadow shading will still affect optimal performance and operational safety.

- The working environment humidity should preferably be below 85% RH. Do not install modules in locations that may be flooded.
- Do not install modules in locations prone to generating or accumulating combustible gases; do not install modules in environments with excessive hail, snow, sand, smoke, air pollution, soot, etc.
- Modules have passed IEC 61701 salt mist corrosion testing, but corrosion may still occur at connection points. ZKFN Solar recommends installation at a distance of > 500m from the coastline for seaside installations, and is not recommended for direct deep-sea/full seawater immersion environments. Near-sea installations require confirmation and approval from ZKFN Solar before proceeding.
- The installation altitude for modules is ≤ 2000m.
- Ensure that the wind or snow pressure on modules after installation does not exceed the maximum allowable load.
- When modules are loaded on the roof, a load verification of the roof must be carried out, and a construction organization plan compliant with specifications must be developed.

2. Tilt Angle Selection Requirements
   - Recommended Minimum Tilt: It is recommended that the module installation tilt be ≥ 5°. This tilt design ensures effective rainwater flushing, easy dust removal by rainwater, proper drainage, and prevents long-term water accumulation leaving marks on the glass, affecting appearance and performance.
   - Series/Parallel Consistency: Modules connected in series should be installed with the same orientation and angle. Different orientations or angles may result in varying solar radiation received by each module, causing output power loss.
   - Steel Tile Tilt: When the steel tile roof tilt is > 25°, double-sided tape must be used to assist structural adhesive positioning and anti-slip.
   - Installation Ambient Temperature: The ambient temperature during structural adhesive construction should be between 5°C and 35°C. The recommended minimum installation temperature is 4.4°C or higher.

4. Unloading, Transportation, and Storage Specifications

4.1 General Protection Requirements

1. Original Packaging Protection: All modules must be kept in ZKFN Solar's original paper or wooden packaging boxes until officially installed on the support structure. All necessary measures must be taken to ensure packaging boxes are protected from external force damage, impact, or tipping during transportation, handling, and storage.

2. Safe Operation and Load Limits: Stepping, standing, climbing, jumping, or placing heavy objects on packaging boxes or modules is prohibited. Colliding or squeezing packaging boxes in any manner is prohibited. Packaging boxes must not be placed or transported in a non-vertical (tilted or sideways) orientation. Any improper transportation or installation behavior may cause internal micro-cracks in modules, leading to warranty voidance.

No impact on the container

No tilting / Keep upright

3. Moisture Protection and Ventilation: Modules must be kept in a dry, well-ventilated environment throughout the entire process from factory to installation. Modules and their packaging must not be exposed to rain or moisture. If temporary outdoor storage is required due to construction needs, the storage area must be well-drained, and the packaging must be tightly covered and reinforced with waterproof tarpaulin to prevent wind or moisture ingress.
4. Correct Manual Handling Posture: Handling modules requires teamwork and must be completed by 2 or more persons working together. Single-person operation is prohibited. When handling, both hands must steadily grip the long-side edge of the module or the white non-power-generation area of the module body. Prohibited handling methods include: gripping only the junction box, grabbing lead wires, or holding the module by the short side with one hand to lift, support, or drag the module.
5. Stacking Restrictions: When manually handling exposed modules, no more than 1 piece may be carried at a time. When temporary stacking of modules awaiting installation is necessary at the work area, proper anti-tipping and anti-scratch measures must be taken.

4.2 Packaging Label Descriptions

All operation diagrams and warning signs printed on the outer packaging are mandatory safety instructions. Installers have the obligation to read, understand, and strictly comply before operation. The main label meanings are explained below:

1. Environmental Label: ( ) :Product complies with all WEEE Directive requirements of 28 EU member states. Do not discard modules carelessly; they must be specially recycled.
2. Fragile Item ( ) : Handle with care using proper methods; do not drop from height or handle roughly to prevent micro-cracks or direct damage from strong vibration.

3. This Side Up () : During transportation, handling, and storage, packaging boxes must always be kept upright as shown. Inverting or laying on the side is prohibited to prevent excessive deformation and edge stress on modules.

4. Keep Dry() : Packaging and modules must be protected in a dry environment at all times. Direct exposure to rain, snow, or excessive humidity is prohibited to prevent cardboard softening and connector corrosion from moisture.

5. No Stepping () : Applying any concentrated load (such as stepping, standing, or placing heavy objects) on packaging boxes or unpacked modules will cause permanent product damage.

6. Stacking Layer Limit () : Indicates the maximum stacking layers allowed for packaging boxes under static storage conditions. In warehouses or environments without vibration sources, the static stacking limit for this series of lightweight module packaging boxes is a maximum of 2 layers.

4.3 Unloading Operation Specifications

4.3.1 Crane Unloading Specifications

1. Safe Lifting Gear: When using a crane for unloading, specialized lifting tools confirmed by ZKFN Solar technical staff or flexible grid lifting slings with equivalent moment arms must be used. Before lifting, select lifting ropes or slings with sufficient safety factor based on total cargo weight and inspect their integrity
2. Lifting Rules:Adjust the sling position on the pallet to ensure balanced center of gravity during lifting. The lifting arm must be raised, lowered, and rotated slowly and uniformly. When the packaging box approaches the ground, two persons at each end must steady the box for precise, gentle placement on leveled, firm, hard ground.
3. Batch Limit: Lifting is permitted for a maximum of 1 pallet of modules at a time. For short-side vertical packaging, a maximum of 2 pallets horizontally can be lifted at a time. Cut off the pallet stacking straps before lifting.
4. Environmental Limits: Hoisting operations are prohibited under severe weather conditions including wind force exceeding Level 6 (>13.8 m/s), moderate rain or above, and heavy snow.

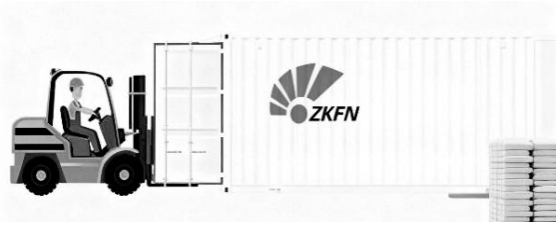
4.3.2 Forklift Unloading Specifications

1. Equipment Selection:Select a forklift with sufficient load capacity and mast/forks in good condition based on the weight and size of module packaging boxes. Forklift forks should have adjustable spacing function. Adjust spacing before operation to be as close as possible to the reinforced corner posts on both sides of the pallet. Forklift mast height ≥ 1.7m, mast width ≥ 1.5m.

2. Precise Operation: :When forking, ensure forks are fully horizontally inserted under the pallet to a depth of at least 3/4 of the pallet depth. The front of the forklift mast or contact surface with packaging must be pre-installed or lined with EPE (expanded polyethylene) or thick rubber pads. Direct contact between the forklift's metal mast or forks and the module packaging box is prohibited.
3. Visibility and Safety:If the module pallet packaging blocks the forklift driver's forward view during transport, the forklift must be driven in reverse at low speed with a signal person directing.
4. Dual-Side Unloading: When unloading a transport flatbed truck with a forklift, unloading should be carried out from both sides of the vehicle.

4.3.3 Container Unloading Special Responsibilities

1. Operator Qualifications and Discipline: Forklift operators entering containers must have verified container operation experience and professional qualifications, be familiar with forklift operation specifications and PV module characteristics, and maintain high concentration during operations.



2. Cargo Fixing and Center of Gravity Control: PV module packaging boxes must be securely fixed on the forklift to prevent sliding, tilting, or falling during transport over bumps.
3. Space Planning and Safety Limits: Before entering a container, plan the space inside in advance to ensure sufficient room for the PV module packaging box, avoiding operational difficulties or collisions with container walls or other items due to insufficient space.
4. Smooth Loading/Unloading:When forking and placing PV module packaging boxes, movements must be steady and slow, avoiding sudden braking or sharp turns to prevent damage from strong vibration.
5. Weight Limit: Be aware of the load limits of the forklift and container, ensuring the weight of the PV module packaging box is within the allowable range.

4.4 Secondary Transport Requirements

1. Original Packaging Principle: Original factory outer packaging must be retained and used for any form of long-distance secondary transport or outdoor storage exceeding one week. For land transport, after loading, use ropes or straps of sufficient strength to secure the bottom layer packaging to the truck bed. For standard flatbed transport, maximum stacking is 2 layers of standard pallets. Cutting original factory strapping bands for any reason is prohibited.

2. On-Site Transfer Prohibitions: For short-distance transfer from on-site warehouse to installation location, removing original packaging is also prohibited, and only single-layer transport is permitted. Use of electric tricycles or other unstable vehicles for module transfer is prohibited. Simply bundling modules with rope, single-person carrying on back or shoulder, or dragging modules by pulling output cables or junction boxes is prohibited.

4.5 Storage Specifications

1. Storage Environment Requirements:Warehouses must meet basic requirements of ventilation, dryness, and freedom from corrosive industrial gases. Recommended storage environment: relative humidity < 70%, temperature maintained within -20°C to +50°C, avoiding condensation from extreme temperature differences.
2. Stacking Restrictions: In warehouses with hard flooring, lightweight module packaging boxes are specified for static stacking only, with a maximum of 2 pallet layers. This applies to both project site warehouses and regular storage. Any form of excessive stacking, packaging box compression, or elevated equipment impact on packaging is prohibited.
3. Outdoor Temporary Storage Precautions: When temporary outdoor storage without cover is unavoidable due to construction scheduling, the storage period shall not exceed 7 days. All module packaging boxes must be placed on elevated, well-drained, flat ground without water accumulation risk, completely covered with waterproof tarpaulin of adequate size and secured with heavy objects. For short-term storage at the project site, place modules in a ventilated, dry, non-water-accumulating area, prohibit stacking, cover modules with tarpaulin, and secure with cloth or mesh straps.

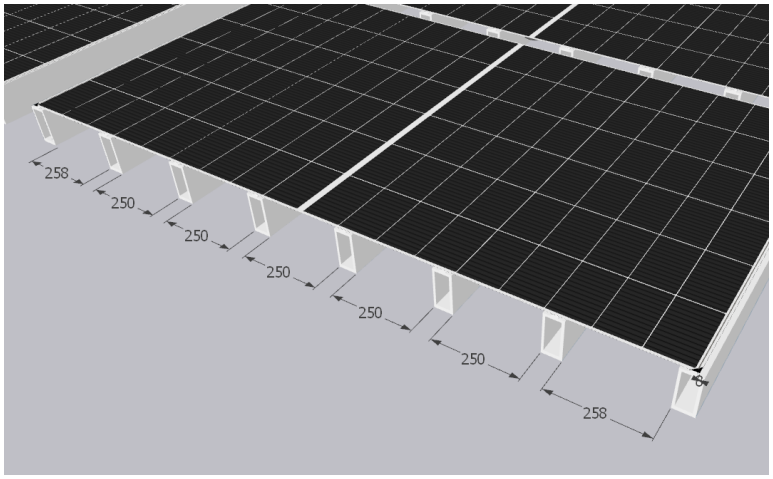
4.6 Module Stepping Requirements

ZKFN Solar SolarPega and SolarPegaF series modules can be stepped on under certain conditions without causing module damage. If stepping is necessary, strictly follow the requirements below:

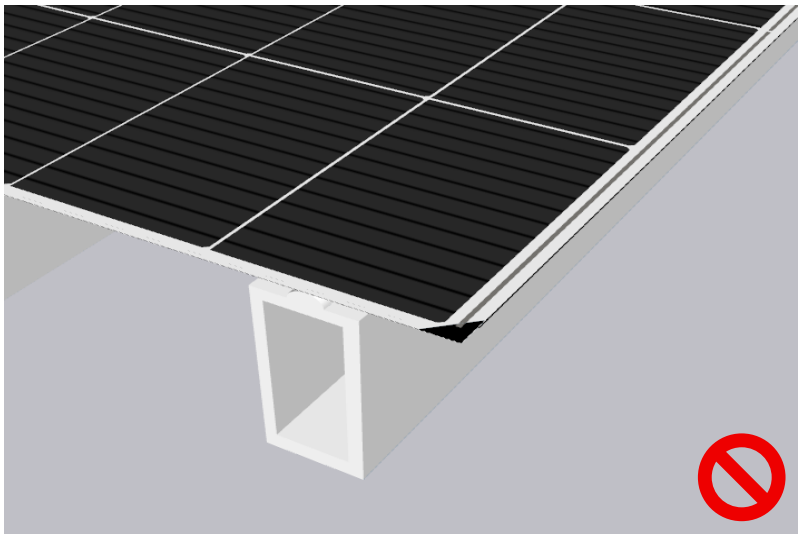
4.6.1 Installation Requirements

1. SolarPega Series Stepping Installation Requirements

- 8 square tubes must be used as the core support for the module, evenly spaced along the long side of the module. The length of each square tube must match the short side dimension of the module, and the tube ends must exceed the module width by 5~8mm;



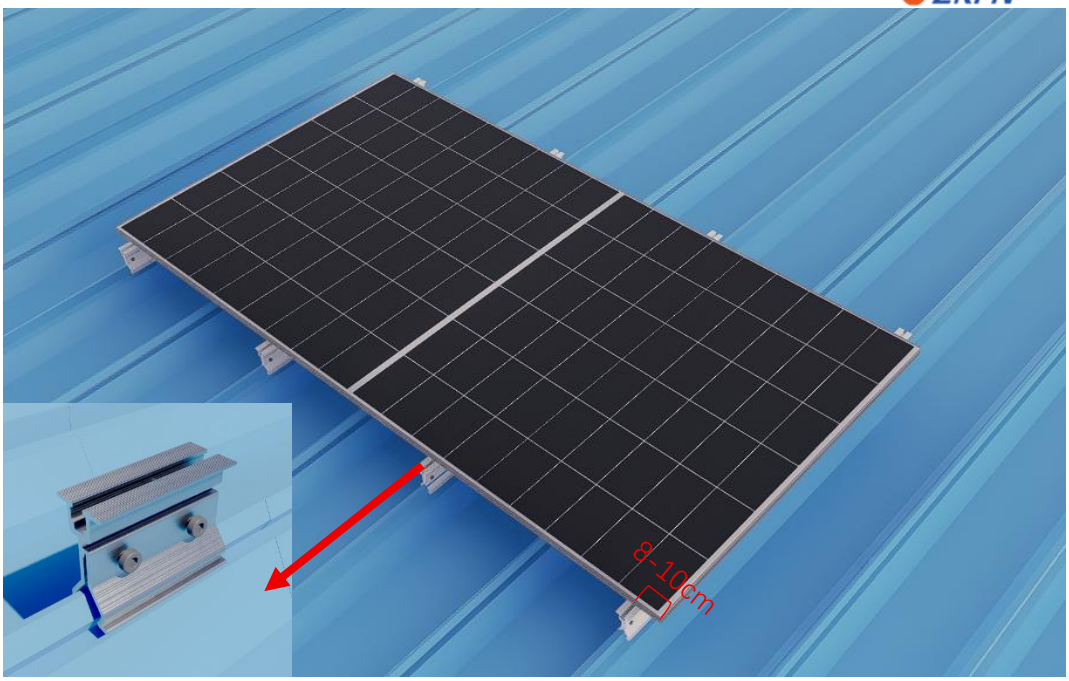
- The short side edge of the module must cover 1/2~2/3 of the width of the outermost square tube. It is strictly forbidden for the module edge to extend beyond the outer edge of the square tube, and there must be no insufficient overlap or unsupported areas.



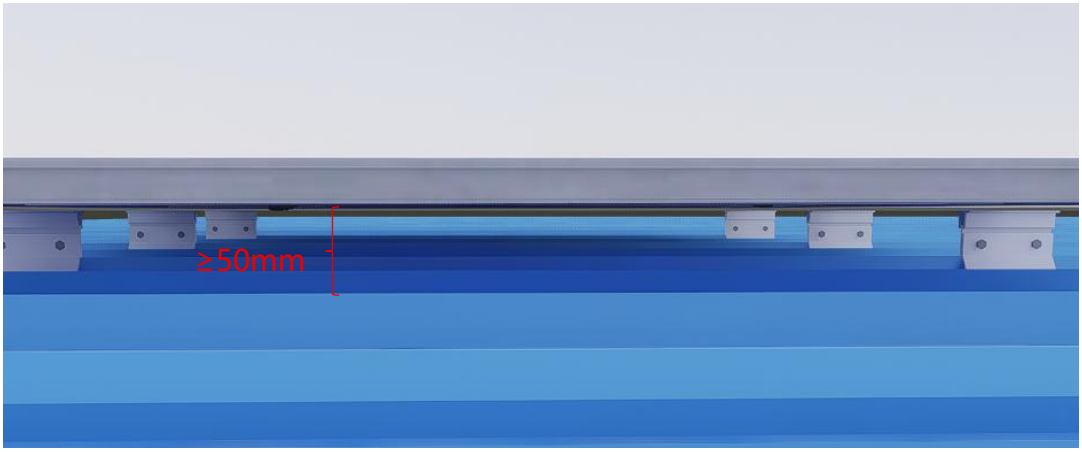
- All supporting square tubes must be fully bonded and fixed to the installation substrate below using specialized structural adhesive, with continuous, full adhesive surface, no hollows, no debonding. After module installation, the overall surface must be flat, without warping or localized suspended areas.
- The installation substrate below the module must be flat, stable, possessing sufficient structural rigidity and load-bearing capacity, without deformation or settlement when stepped on. The flatness error of the substrate must be controlled within ±2mm/m.

2. SolarPegaF Series Installation Requirements

- Each module must have 8 uniformly distributed support fixing points, symmetrically arranged along both long sides, with 4 points per side. The support points use compatible Quick-clamp rail clamps (as shown) for locking fixation.



- For the clamps at the outermost ends of the module long side, the center distance from the module short side edge must be 8~10 cm. The remaining clamps on the same long side must be evenly spaced between the two edge clamps, ensuring overall uniform force distribution on the module.
- All clamps must be firmly fixed to the installation substrate, with locking structures fully tightened, free of looseness, offset, or deformation. After module installation, the overall surface must be horizontal without warping or force-bearing suspended areas.
- The suspended distance below the module must be ≥50mm, i.e., the lowest point of the module must be ≥50mm from the highest point of the steel tile corrugation.
- The installation surface below the module must be flat and stable, possessing sufficient structural rigidity and load-bearing capacity, without deformation or settlement when stepped on. The flatness error of the clamp support surface must be controlled within ±2mm/m.

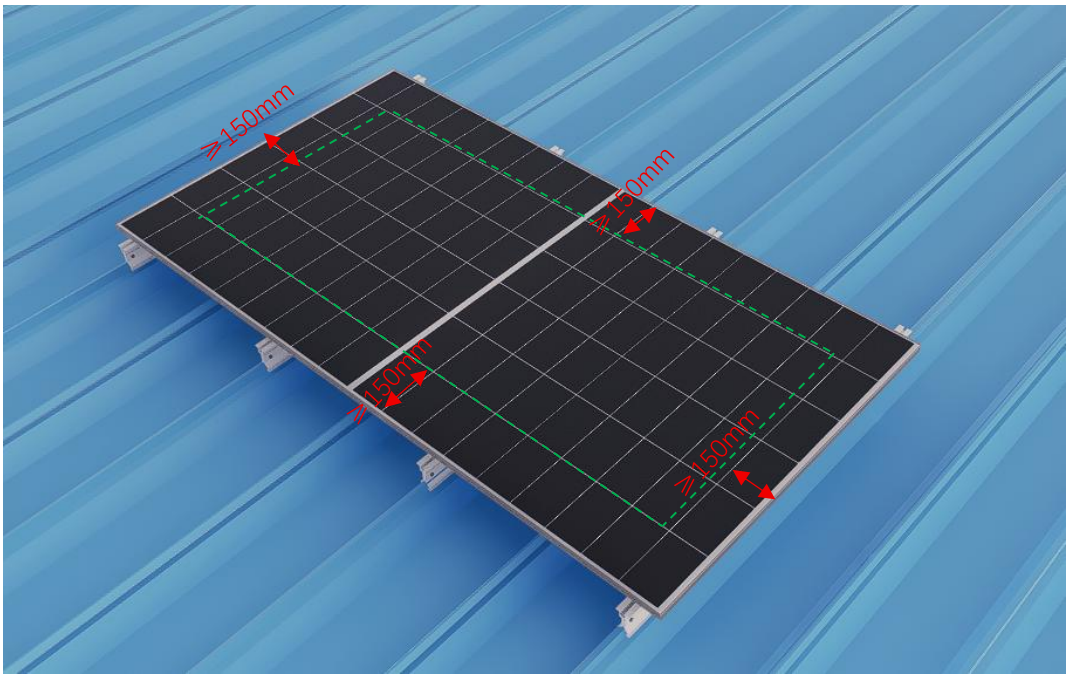


4.6.2 Personnel Requirements

- Personnel stepping on modules must weigh < 80 kg.
- Must wear rubber-soled safety shoes or soft-soled insulated shoes. The following footwear is strictly prohibited: high heels, hard-soled leather shoes, spiked shoes, or any other footwear that may damage the module surface.

4.6.3 Stepping Position Requirements

- Permitted Stepping Area: Central area of the module, at a distance of ≥150mm from the module edges.



- Strictly Prohibited Stepping Areas: Module perimeter edges, module connection/support points with the mounting structure, and module seams.

4.6.4 Operational Specification Requirements

- Before stepping, the system must be de-energized to prevent accidents.
- Permitted: Slow walking, stationary standing.
- Prohibited: Jumping, bouncing, stomping, forceful stepping, running.
- Multiple persons standing on the same module simultaneously is strictly prohibited. Only 1 person is allowed to step on each module at a time. Stepping duration should be minimized; leave the module surface immediately after completing the task.

4.6.5 Other Requirements

- Stepping on modules is strictly prohibited during rainy or snowy days or when the module surface is wet.
- Visually inspect modules for cracks or damage before stepping; if abnormalities are found, stepping is prohibited.

- Workers must wear safety harnesses and other fall protection equipment for work at height.
- When carrying tools, use tool bags. Placing tools directly on the module surface is strictly prohibited.

> Warning: SolarPegaL and SolarPegaFL, due to their front glass thickness being only 1.1mm, are not permitted to be stepped on, even though ZKFN Solar internal test results show stepping does not cause cell micro-cracks or module failure.

5. Unpacking Operation Guide

5.1 Unpacking Safety Requirements

> Warning - Unpacking Weather Threshold: Outdoor unpacking is prohibited in rain, snow, or fog conditions. Moisture will rapidly soften cardboard boxes and cause loss of structural strength, potentially leading to module sliding damage or personnel injury. When on-site instantaneous wind speed reaches or exceeds Level 4 (>7.9 m/s), all unpacking and module handling operations must cease immediately.

- Unpacking Space Conditions: Select a completely level and firm ground area as the unpacking zone. Ensure the packaging box can be placed horizontally and stably, with all four corners firmly on the ground, without tipping risk. When removing packaging panels, use appropriate pry bar tools rather than pulling by hand to prevent modules from tipping over.
- Hand Protection and Clean Operations: All personnel must wear cut-resistant, anti-slip work gloves when unpacking and handling modules. This protects workers from cuts by packaging panels and strapping bands, and prevents oil and sweat from hands from contaminating the module backsheet (affecting bonding performance) or leaving fingerprints on the front sheet.
- Document and Information Preservation: Logistics and product information labels are often attached to outer packaging boxes. Record or photograph this information before unpacking. After opening, locate and safekeep the packing list, certificate of quality, and serial number corresponding table inside the box.
- “Open and Install” Principle: All modules unpacked must be fully installed. No stacking at the project site.

5.2 Standard Unpacking Procedure

1. Remove Outer Packaging: Use tools to cut and remove all longitudinal and transverse strapping bands from the outside of the packaging box, then cut and peel off the stretch film from top to bottom.
2. Information Verification: Before unpacking, verify the packing list against the contents inside and outside the box according to external label information, confirming model, power rating, quantity, and batch consistency.
3. Open Box and Remove Cover: Open the packaging box top seal, vertically lift the entire box cover structure and the internal anti-vibration top plate placed above the

modules, placing them aside.

4. Remove Side Panels and Fillers: Sequentially remove the front packaging panel facing the modules, then remove filler materials such as EVA buffer strips placed above the modules.
5. Remove Modules Individually: In pairs, stand on the same side or opposite sides of the box, firmly grip the long-side white area of the top module, apply even force, and pull it vertically upward from the box smoothly, then transfer directly to the designated EPE or wooden pallet in the construction stacking area.
6. Temporary Stacking: Sequentially stack modules in a safe location adjacent to the installation point. When operating, junction boxes should point in the same direction. Insert original EVA foam strips between upper and lower modules. Under no circumstances should stacking height exceed 5 pieces.

Special Note for SolarPegaF / SolarPegaFL Series: Due to the integrated composite back frame, overall thickness (25.5mm) and structural rigidity are greater. When grasping, two persons must cooperate to hold the long-side vertical edge of the module back frame. Extra attention to coordination and stability is needed during two-person handling. When temporarily stacking, ensure the contact points of the back frame are accurately on the EPE foam strips below. Direct point contact of the back frame on the cell area of the module below is strictly prohibited.

5.3 Remaining Module Repacking Procedure

If the entire box of modules cannot be fully used on the same day due to construction plan changes, they must be strictly repacked into the original packaging box following the standard procedure below. Discarding or leaving them scattered is prohibited:

1. Place modules back in the box, junction boxes one up one down, backsheets facing each other.
2. Place the upper EVA strips on the modules, with one EVA strip gap holding two modules.
3. Reinstall the outer packaging, cover plate, and box top cover.
4. Re-bandage with strapping bands.
5. Cover the outermost layer with a rain cover and clearly mark “Opened - Not Fully Installed” status.

> Note: 1. Strapping band tension should not be excessive: When re-bandaging with a strapping tool, maintain moderate tension sufficient to securely fix the box and cover without movement. Do not over-tighten strapping bands to avoid pressure transfer through the cover to the top layer module cells, causing micro-cracks. 2. If storage exceeds 3 days, the packaging box must be moved to a dry, rain-protected indoor environment..

6. Application Scenario Selection and Module Installation Solutions

6.1 General Installation Requirements

1. Installation Preparation and Site Environment Control

- Basic Site Requirements: The module installation work area must be kept dry, safe, and free of obstacles, meeting spatial and safety conditions for standardized construction.
- Module Storage and Unpacking Management: For whole boxes of modules not yet formally entering the installation process, the original sealed packaging must remain intact and unopened. Once modules are removed from the box, they must immediately undergo standardized installation operations, strictly enforcing the “open and install” principle to avoid performance degradation or appearance damage caused by prolonged exposure of modules.
- Construction Weather and Environment Control: Module installation operations must be carried out during continuous clear, sunny daytime. Core processes involving structural adhesive bonding or clamp fixture fastening must be performed under clear weather conditions. Throughout the entire operation, modules must not be handled, nor electrical connectors made, in rain, fog, high humidity, or condensing environments to eliminate safety hazards and installation quality defects.

2. Structural Design and Load Safety Requirements

- Load Calculation Rules: The load parameters provided in this manual are standard test loads. The actual design load must be determined comprehensively based on the installation building structure, project application standards, geographic and meteorological conditions of the installation site, and local laws and regulations. Mechanical load verification must meet a safety factor of no less than 1.5. The calculation formula is: Mechanical Load = Design Load × 1.5 Safety Factor.
- Liability Boundary Statement: The verification and confirmation of the project design load must be completed by a qualified professional supplier or registered engineer to ensure the load design complies with local regulations and actual project conditions.
- Extreme Load Verification: The module installation system must pass specific verification for local extreme wind and snow load conditions. When using column-type installations, the selected columns and supporting structures must undergo load verification synchronously to ensure wind and snow loads on the modules do not exceed the maximum allowable values for the product, while also avoiding additional stress caused by thermal expansion of the supporting structure that could damage the modules.

3. Support Structure and Installation System Technical Requirements

- Material and Access Requirements: Module support structures must be made from durable, corrosion-resistant, UV-resistant materials. Certified third-party tested support structure products that meet project design requirements must be used.

Non-standard, uncertified mounts and supporting materials are strictly prohibited.

- Structural Strength Requirements: The module installation method and mounting system must have sufficient structural rigidity and strength to meet usage requirements under all preset design load conditions, ensuring the long-term structural safety of the modules in service.
- Clamp Installation Specifications: When using clamp-type fixtures, the technical requirements of the clamp supplier must be strictly followed. The maximum applied pressure of a single clamp must not exceed 20MPa, to prevent irreversible damage such as module frame deformation or glass cracking due to excessive pressure.
- Module Installation Specifications
  - Modules must be securely installed on the support structure. The frame is strictly prohibited from bearing lateral tension and pressure to prevent frame detachment, glass crushing, and other failures.
  - An installation gap of no less than 20 mm must be reserved between adjacent modules to avoid damage caused by compressive stress from module thermal expansion.
  - Modules can be installed horizontally or vertically. Throughout the installation process, ensure that module frame drainage holes are not blocked.
  - A safety gap must be reserved between the module backside and the mount/building structure to prevent the back-side components from touching or squeezing the module backsheet and internal circuits when the module surface is subjected to external pressure.
- Anti-Shading Installation Requirements: In areas with heavy winter snowfall, the installation height of the support system must be reasonably designed to ensure the lowest edge of the module is not covered by snow under all conditions. Additionally, the minimum module installation height must be ensured to avoid shading from surrounding plants or trees.

4. Specialized Roof Installation Technical Specifications

- General Roof Installation Requirements
  - Structural Review and Safety Control: Before module installation, a specialized review of the roof structure's load-bearing capacity must be completed to confirm that the roof structure is reasonable and safety redundancy meets installation load requirements. The roof area designated for module installation must have completed sealing treatment to eliminate leakage risks. Overlapping module installation or exceeding roof boundaries is strictly prohibited.
  - Ventilation Gap Requirements: A sufficient ventilation and heat dissipation gap must be reserved between the roof plane and the module plane. Under normal conditions, the minimum clear distance shall not be less than 30mm. A higher value may be adopted as per local current regulations for special areas, but must not fall below the mandatory regulatory minimum.
  - Drainage System Full Lifecycle Protection: Throughout the entire process of module installation, cleaning, and O&M, structural adhesive, installation

materials, and other foreign objects must not block roof drainage holes or module frame drainage holes, ensuring unobstructed drainage systems.

- Steel Tile Roof Specialized Installation Requirements
  - Installation Exclusion Zone Control: PV modules are strictly prohibited from being installed on skylight areas of steel tile roofs.
  - Installation Surface Pre-treatment Specifications: (i) When using structural adhesive bonding installation, the pre-treatment quality of the installation surface directly determines the bonding success rate and long-term module service life, representing a core quality control point with its impact accounting for no less than 85%. (ii) Before installation, comprehensively verify the integrity of the roof substrate, confirming no aging, rust, chalking, peeling, blistering, or other defects. Areas with rust must first undergo rust removal treatment. (iii) Use the cleaners specified in Annex 1 of this manual to thoroughly degrease and decontaminate the installation surface, ensuring the tile surface is clean, tidy, and free of foreign matter, providing a qualified substrate for structural adhesive bonding and ensuring bond strength meets standards.
  - Tile Surface Obstacle Handling: If there are rivets on the steel tile corrugation crests that affect module installation fit, they must be ground down or removed in advance to ensure the module is installed properly with uniform force distribution.

6.2 Full-Scenario Product Selection Guide

Correct product selection is the foundation of project success. Please follow the preferred product type selection based on scenario characteristics.

1. Scenarios Preferring SolarPega / SolarPegaL Series (Structural Adhesive Bonding Solution)

When the following conditions are simultaneously met, the SolarPega no-back-frame series' direct structural adhesive bonding solution is the most economical and efficient choice:

- The roof substrate is T-type or corrugated steel tile with corrugation pitch ≤ 350mm, smooth surface, no rivet protrusions on crests, and no irreparable corrosion pits.
- The roof is a flat waterproof membrane roof with intact substrate and no blistering or peeling.

2. Scenarios Preferring SolarPegaF / SolarPegaFL Series (Clamp/Quick-Install Solution) When any of the following situations occur, the SolarPegaF with-back-frame series' Quick-Clamp fixture installation is the preferred solution:

- The roof is of standing seam, angle-ridge type, or other tile profiles that can accommodate clamps but cannot provide a continuous flat surface for structural adhesive bonding.
- The project has a clear future requirement for non-destructive module disassembly, such as the need for periodic roof inspection or replacement.
- Flat roof concrete or waterproof membrane scenarios using mount + clamp system installation.
- Tight construction schedules requiring rapid batch installation and flexible subsequent maintenance.

3. Selection Between Ultra-Thin (L/FL) and Standard Types

- SolarPegaL / SolarPegaFL (1.1mm ultra-thin tempered glass): Lighter weight (10.0 kg / 13.0 kg), suitable for scenarios sensitive to roof load-bearing capacity and with high lightweight requirements (e.g., old industrial/commercial plants, agricultural buildings, projects requiring high transport convenience).
- SolarPega / SolarPegaF (1.6mm coated semi-tempered glass): Higher front static load (3600Pa), suitable for areas with high mechanical loads such as strong wind or heavy snow.

6.3 Installation Precautions

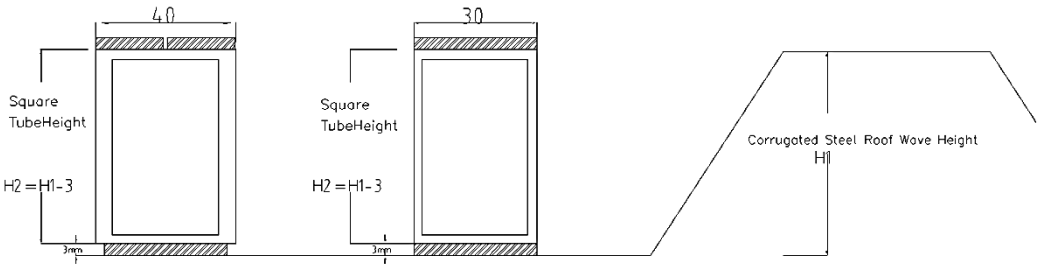
This section supplements key operational points not fully covered in the general installation requirements above. The installation supervisor must check each item before work begins; only proceed when all items pass:

- Module Installation Orientation and Shadow Avoidance: SolarPega and SolarPegaF series modules allow horizontal or vertical installation. Any obstacles around the

installation surface (such as parapet walls, ventilators, monitor roofs, pipes, equipment rooms, etc.) must not cast shadow shading on the module surface.

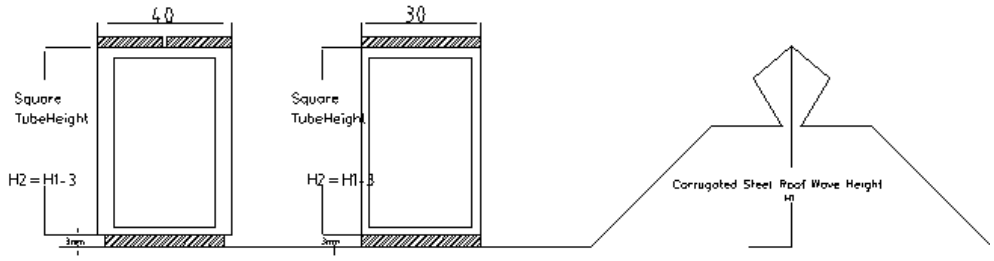
- Steel Tile Roof Pre-Inspection: During steel tile structure installation, ensure the tile surface is clean, tidy, and free of foreign matter. Treat rusted areas with rust removal to ensure structural adhesive bond strength.
- Two-Person Teamwork: Single-person independent operation is strictly prohibited throughout the module installation process. Operations must always be performed by a team of 2 or more persons working together.
- Cable Fixing and Anti-Aging: After module installation, all output cables and jumpers must be securely fastened with dedicated cable clips or UV-resistant cable ties. No wiring must shade the effective light-receiving area of cells. Cables must not sag, accumulate water, or be exposed to direct sunlight for extended periods.
- Rain and Strong Wind Prohibition: Module installation or electrical operations are prohibited when the installation area is wet or wind speed reaches a level affecting safe operation. For modules installed with structural adhesive bonding, ensure the adhesive application and placement processes are completed entirely in clear weather.
- Wind Uplift Zone Avoidance: Installation positions must be professionally planned to actively avoid areas with significant wind uplift effects such as roof corners, eaves edges, and skylight peripheries, preventing modules from bearing negative wind pressure exceeding design values under extreme weather.
- Anti-Loosening Measures and Cable Protection: Surface friction alone must not be relied upon as the sole measure to prevent loosening of electrical or mechanical connections. The area around connection terminals must be kept clean and free of debris to prevent mechanical wear or stress on conductor insulation.
- Jumper Fastening: Module terminal cables and added jumpers must be provided with mechanical protection using flexible conduit or UV-resistant PVC tubing. When connecting jumpers, use dedicated crimping tools for fastening. Connections must be fully and securely mated. Loose or poor connections are strictly prohibited.
- Module Frame Detachment Prevention: For the with-back-frame SolarPegaF / SolarPegaFL series, to prevent module detachment after installation, the matching clamps provided by ZKFN Solar must be selected.
- Connector Specification Matching: Field extension cables or patch cables connected to module cables must use connectors of the same manufacturer, same model, and equivalent specification as the module connector. Mixing different brands or series is prohibited.
- Leveling Square Tube Dimension Determination

T-type:



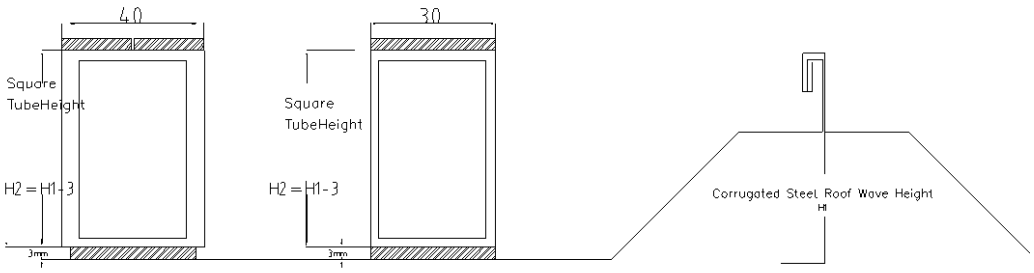
Dimensions Above: B = 30mm, H2 = (H1 - 3mm) ± 2mm

angle-ridge:



Dimensions Above: B = 30mm, H2 = (H1 - 3mm) ± 2mm

standing seam:



Dimensions Above: B = 30mm, H2 = (H1 - 3mm) ± 2mm

6.4 SolarPega / SolarPegaL Series Module Installation Solutions

The core installation method for the SolarPega / SolarPegaL series is direct structural adhesive bonding installation, requiring no mounting frame or rails, suitable for T-type steel tiles,

corrugated steel tiles, flat roof waterproof membranes, and other scenarios. The detailed installation guidance is as follows.

6.4.1 Pre-Installation Preparation

1. Consumables and tool preparation: Structural adhesive, glue gun, lint-free cloth, specified substrate cleaner, ink line, construction alignment line, plastic roller, square tube (for overhang scenarios), construction tools, insulated tools, safety protective equipment.

Electric glue gun 	Structural adhesive 
Ink line 	Lint-free cloth 
Soft drum 	Padded square tube 

2. General Bonding Area Requirement:

Module bonding area should be: ≥ 800 cm^2 (Under this condition, the typical design maximum tensile resistance of a single module is 1771 kg (17.4 kN)).

3. General Installation Precautions:

- Module installation is prohibited when wind force ≥ Level 4.
- Module installation is prohibited in rainy or snowy weather.

- The installation surface must be kept dry, free of foreign matter.
- After adhesive application, install the module as quickly as possible within 5 minutes to prevent surface skinning of the structural adhesive affecting bond strength.

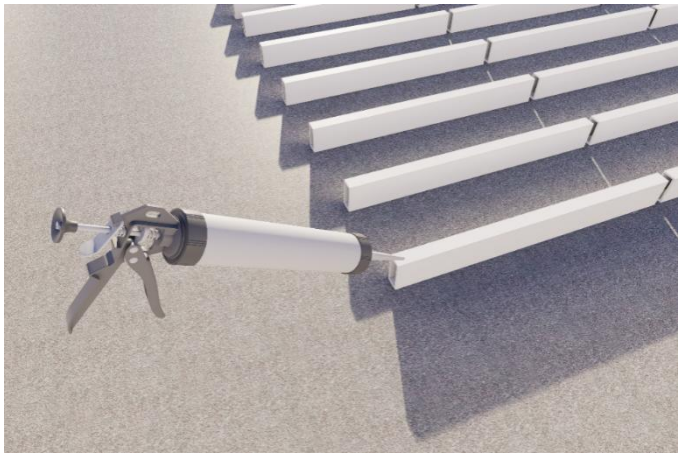
6.4.2 Flat Roof Waterproof Membrane Installation Solution

(1) Pre-Installation Conditions

- Roof waterproof membrane has no aging, debonding, peeling, or blistering. Substrate is flat.
- Single-point adhesion to base ≥ 40 kg (single-point area: 4×4 cm^2).
- Installation area free of permanent shading from parapet walls, equipment rooms, surrounding buildings, etc.

(2) Installation Procedure

1. Positioning and Layout: Based on design drawings and on-site shadow verification results, mark square tube bonding reference lines on the roof. Ensure square tubes on the same roof are placed parallel with uniform spacing. After bonding, the top surfaces of all square tubes must be on the same horizontal plane. (i) Each module uses no fewer than 6 square tube supports, evenly distributed along the module length direction.
2. Cleaning Treatment: Wipe the square tubes and roof bonding areas with a lint-free cloth soaked in cleaner to remove dust, oil, and debris. Ensure surfaces are dry and clean.
3. Square Tube Bonding: According to design positioning, cut the glue nozzle at an angle. Extrude triangular adhesive strips (approx. 10 mm wide, 8 mm high) along the square tube bonding positions at a uniform speed of about 10 cm/s. Then press the square tube firmly onto the adhesive strips.



4. Adhesive Application on Top of Square Tubes: After the square tubes are positioned and bonded, apply another continuous triangular adhesive strip (approx. 10 mm wide, 8 mm high) along the centerline on top of the square tubes, using an application speed of about 10 cm/s.

5. Module Placement (Golden 5 Minutes): Module placement must be completed within 5 minutes after adhesive application. Two persons face each other, grasp the white edges of the module with both hands, lower their center of gravity, and precisely place the module into the bonding area using a “position the reference edge first, then slowly lower flat” method, ensuring it is perfectly horizontal and level. Do not lift and reposition after placement.

6. Curing Protection: After bonding is complete, do not disturb for 24 hours (refer to Annex 2 for specific curing time).

6.4.3 Steel Tile Roof Installation Solution

(1) Tile Type Compatibility and Bonding Method Selection

Steel Tile Type	Recommended Bonding Method	Module Installation Orientation (Long Side)
T-type Steel Tile	Direct bonding + square tube support	Perpendicular to corrugation
Corrugated Steel Tile	Direct bonding	Perpendicular to corrugation
Angle-Ridge Steel Tile	Must use square tube bonding	Perpendicular to corrugation
Standing Seam Steel Tile	Must use square tube bonding	Perpendicular to corrugation

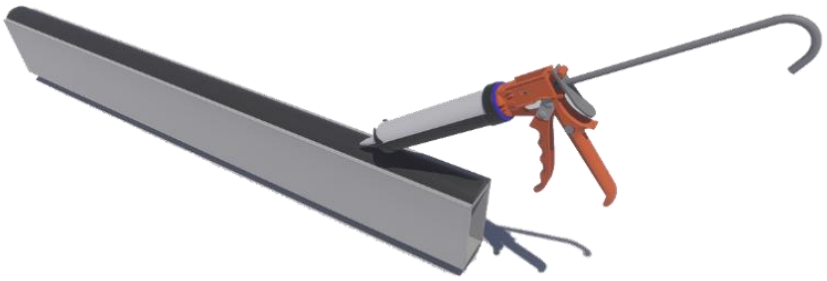
Note: Module bonding area should be ≥ 800 cm^2. Under satisfied bonding area conditions, the typical design maximum tensile resistance is 1771 kg (17.4 kN).

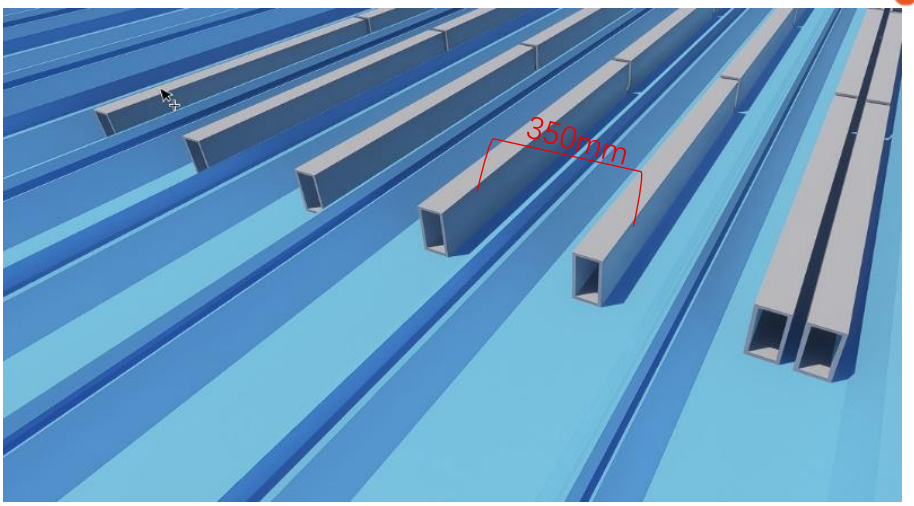
(2) General Construction Procedure

1. Roof Pre-Treatment: Use the specified cleaner to thoroughly clean the roof bonding area, removing dust, oil, rust, and debris. Ensure the bonding surface is dry, clean, and flat. Steel tiles with rust must first undergo rust removal and refurbishment. Installation on roofs with peeling, softened, or collapsed paint is prohibited.
2. Layout and Positioning: Based on design drawings and on-site shadow verification results, mark square tube bonding reference lines in the valleys of the steel tiles. Ensure square tubes on the same roof are placed parallel with uniform spacing. After bonding, the top surfaces of all square tubes must be on the same horizontal plane.

    - (i) Each module uses no fewer than 6 square tube supports, evenly distributed along the module length direction.
    - (ii) If the square tube position interferes with a corrugation crest, the tube position may be adjusted appropriately.
    - (iii) If there are seams from ridge to eave, the seam must be between modules. A single module must not span across a seam.

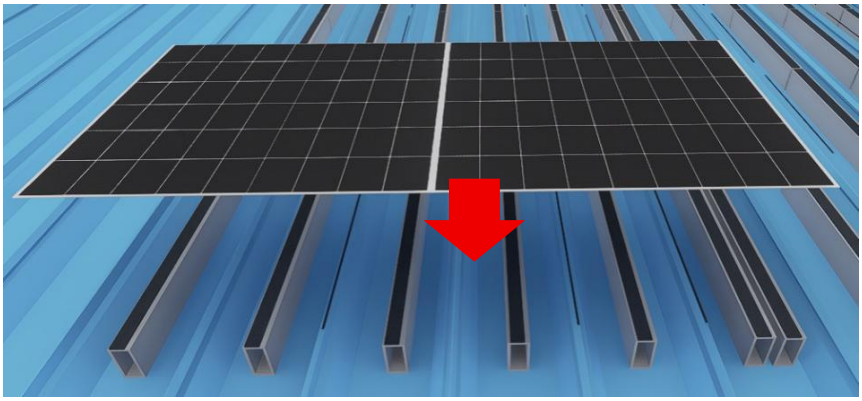
3. Square Tube Bonding (Applicable to angle-ridge, standing seam, and auxiliary T-type scenarios): (i) Apply continuous, uniform adhesive in the steel tile valleys. Spot or segmented adhesive application is prohibited. (ii) Bond square tubes: Tube width ≥ 30mm. (iii) Structural adhesive length L_2 equals module width. (iv) Apply adhesive evenly on the top surface of the square tubes.



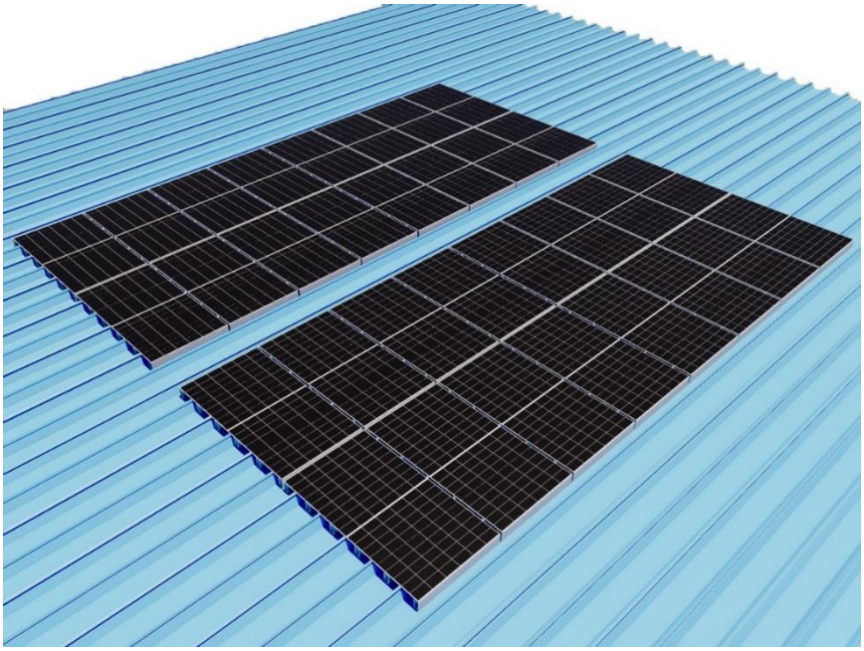


4. Adhesive Application on Top of Square Tubes: Cut the glue nozzle at an angle. Extrude triangular adhesive strips (approx. 10 mm wide, 8 mm high) at a uniform speed of about 10 cm/s along the top of the square tubes.

5. Module Installation: Place the SolarPega / SolarPegaL module on the square tubes. Use a soft roller to apply uniform rolling pressure to ensure full contact of the adhesive strips.



6. Post-Installation Inspection Ensure modules are horizontal and vertical, free of suspended edges, with no adhesive overflow contaminating cells.



(3) Corrugated Steel Tile Specific Requirements

- Due to the curved surface of corrugated tiles, structural adhesive should be applied at the highest point line of each crest.
- Position to avoid shadow areas and roof seams. Seams must be placed between modules.
- Corrugations must be straight, with no rivet protrusions on crests. Existing rivets on corrugations must be ground down or removed beforehand.
- Horizontal installation (module long side perpendicular to corrugation) or vertical installation (long side parallel to corrugation) can be selected.

(4) Angle-Ridge/Standing Seam Specific Warning

Warning - Important Notice: Angle-ridge steel tiles have inherent defects of crest height deviation and insufficient effective bonding width on corrugations. Standing seam steel tiles are interlocking seam structures, with no continuous flat large-area bonding substrate. Both tile types are strictly prohibited from direct bonding installation. The SolarPega/PegaL + square tube leveling support solution must be used, or prefer the SolarPegaF/PegaFL clamp solution..

6.5 SolarPegaF / SolarPegaFL Series Module Installation Solutions

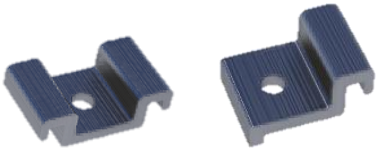
The core installation method for the SolarPegaF / SolarPegaFL series is back frame + Quick-Clamp fixture fast installation, requiring no rails, enabling non-destructive quick module removal, suitable for all scenarios including steel tile roofs and flat roofs.

6.5.1 Pre-Installation Preparation

- Roof Substrate Inspection: Check steel tile/flat roof substrate condition. Steel tiles must have no softening, depression, or severe corrosion. Roof must be level without significant height difference. Module installation on skylights is prohibited.

- Site Survey and Shadow Assessment: Comprehensively assess all shading sources including parapet walls, ventilators, monitor roofs, camera poles, equipment, etc. Use sunlight simulation to confirm the module installation area has no year-round permanent fixed shading.
- Clamp and Roof Compatibility Verification: Ensure the model of clamps to be used matches the on-site steel tile profile. Refer to Annex 4.
- Tool Calibration: A calibrated digital torque wrench within its validity period must be used. For M8 bolts used for clamp fastening, the final tightening torque must be strictly set to 15~20 N·m (Reference: GB 50205-2020). Insufficient torque leads to fixing failure; excessive torque may crush or damage the module's composite back frame.
- Positioning and Layout: According to design drawings, use an ink line to mark positions for clamps and bases, ensuring even division, horizontal and vertical alignment.

- Tool and Consumable Preparation:

Torque wrench 	PV clamps 
Quick-clamp clamps 	hex bolts 
ink line 	

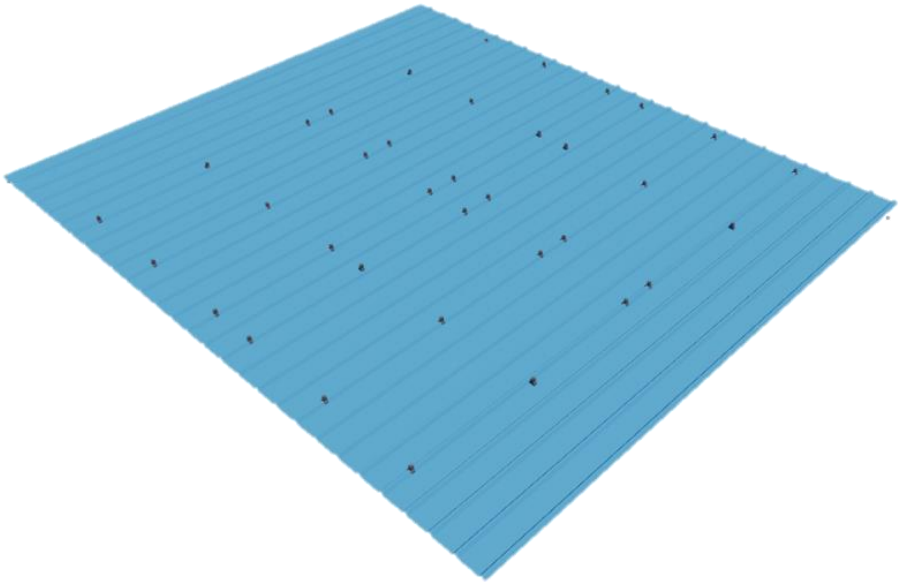
6.5.2 Steel Tile Roof Clamp Installation Solution (Quick-Clamp)

(1) Pre-Installation Conditions

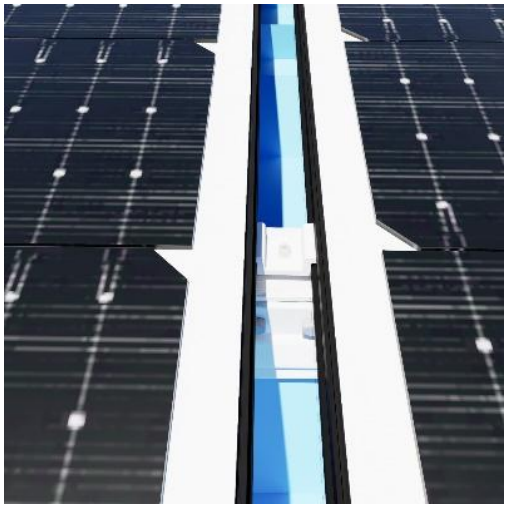
- Applicable to all mainstream tile types (T-type, corrugated, angle-ridge, standing seam, round standing seam).
- Installation environment is clean, no debris affecting clamp stability.

(2) Installation Procedure

1. Clamp Positioning and Fixing: Position clamps according to drawings. Clamp spacing should be evenly divided. The center point of clamps at both ends should be approx. 10~15 cm from the module short side edge.



2. First Clamp Installation: Strictly following the spacing in the design drawings, place and fix the first dedicated clamp. For T-type tiles, use self-tapping screws or structural adhesive for auxiliary fixing. For angle-ridge and standing seam types, use locking bolts to clamp the tile ribs.




3. Laying the First Reference Module: Two persons handle a SolarPegaF / SolarPegaFL module, placing it onto the clamps according to clamp positioning.
4. Clamp Fastening: Fix clamp bolt nuts and tighten using a torque wrench, torque standard 15~20 N·m.
5. Batch Installation: For subsequent modules, use the previous one as a reference, repeating the process: “Place module → Place clamp → Tighten → Inspect.”
6. When installing middle clamps, use PV construction gantry or PV construction foam pads for protection.

(3) Key Installation Points

- Two persons coordinate module handling, placing smoothly onto clamps. Do not grasp junction boxes or cables for handling. Do not impact or drop modules.
- Use a torque wrench to tighten bolts, tightening torque standard 15~20 N·m. Over-tightening or insufficient tightening is prohibited.
- Module installation must be horizontal and vertical. Module spacing follows design drawings, standard spacing ≥20mm, ensuring clamps can properly press the module back frame.
- Before installing the next module, connect the connectors of the previous module in advance.
- After single module installation, check clamp and clamp tightening status to ensure no looseness or misalignment.

7. Connection and Cabling Work Specifications

7.1 Cable Routing and Fixing Requirements

- System Cable Specification: Except for module output cables, all on-site DC main cables must be TÜV or equivalent authority certified 1500V PV-specific cables, copper conductor, cross-section no less than 4mm², temperature rating no less than 90°C, with excellent UV resistance and anti-aging properties.

- Anti-Shading Routing Principle: The primary responsibility of cabling is “No Shading”. All cable routing paths must be precisely planned and securely fastened using dedicated C-type stainless steel cable clips or UV-resistant nylon cable ties on the module back frame, square tubes, or back sheet cable fixing channels. Cables must not be suspended, swinging, or directly placed on the roof forming water accumulation bends under any working condition.
- Connector Protection: All connectors plugged within strings or between strings are not allowed to lie flat or hang touching metal roofs, steel tile crests, or dust/water accumulation surfaces. They must be secured with dedicated connector protective sleeves and cable clips elevated on crossbeams behind the modules.
  - Keep connectors dry and clean. Ensure connector nuts are tightened before connection.
  - Prevent moisture, dust, organisms, and other foreign matter from entering connectors.
  - Do not connect if the connector is wet or contaminated.
  - Connectors do not have waterproof function without being mated.
  - Modules should be connected promptly after installation. Connected connectors must meet IP68 requirements.
  - Avoid direct sunlight exposure and water immersion of connectors.
  - Incorrect connection may produce arcing and electric shock.
  - Do not connect different connector models together.
- Minimum Bend Radius: When routing cables around corners, the minimum bend radius requirement must be strictly observed. Typically, this value is 10 to 12 times the cable outer diameter (OD). Excessive bending can damage the internal copper core, increase resistance, and create potential hot spots.

7.2 Grounding Specifications

1. Module Grounding Exemption: Given that the design of all SolarPega/PegaL and SolarPegaF/PegaFL series modules does not employ any non-insulated external metal frame (border), the modules themselves constitute a complete Class II insulation structure. Therefore, no explicit grounding treatment is required for any part of the module body.
2. System Grounding Design: This exemption does not alter the lightning protection grounding requirements of the PV system.

8. Electrical Installation Work Instructions

8.1 General Electrical Installation Requirements

1. Certified Personnel and De-energized Operation: Electrical installation and wiring work is limited to authorized personnel with electrician certification. Before work, ensure DC and AC switches are in the OFF position, implement an

effective LOTO (Lockout/Tagout) procedure, and verify no voltage with a mul timeter before proceeding.

2. Application of Design Correction Factor 1.25: A safety design factor must be used when configuring system circuit breakers, fuses, cable ampacity, and in verter maximum input voltage. All calculations should be based on the limit values of Voc multiplied by 1.25, Isc multiplied by 1.25 from the module sp ecification sheet.
3. Arc Fault Protection (AFCI): To address potential DC arc and fire risks, the i nverter or multi-function shutoff device selected for the power station must have and activate an available AFCI (Arc Fault Circuit Interrupter) function.

8.2 Module Series/Parallel Connection Specifications

1. String Homogeneity Principle: In one MPPT tracking channel, only modules that are exactly identical are allowed: same model, same batch, same installation tilt and orientation. Violation of this principle will result in severe internal mismatch losses due to operating point mismatch.
2. Extreme Voltage Calculation: When connecting modules in series, the open-circuit voltage must be corrected using the historically lowest temperature recorded by the local meteorological bureau, ensuring the total open-circuit voltage of the string under any possible minimum temperature is less than the inverter's maximum DC input voltage.
3. Reverse Polarity Hazard Warning: If two parallel strings are connected with reverse polarity (positive to negative), a massive forced circulation current is immediately generated, which can irreversibly burn out the module's bypass diodes and junction box within milliseconds.

8.3 Fuse Selection and Installation Requirements

1. Overcurrent Protection Limits: Module technical data indicates the maximum series fuse rating is 25A. As this is a limit value for this flexible module, in any scenario with more than 2 strings in parallel, each individual string must be series-connected with a 25A DC-specific PV fuse.
2. Independent Polarity Protection: Fuse holders must be configured on both positive and negative wires. A solution using a single common fuse after multi-circuit busbar connection is not recommended.

8.4 Connector Use and Protection Specifications

1. Prohibition on Mixing Different Manufacturers and Models:

> Warning - Important Notice: Throughout the DC side of the PV system, from module output cables, field-made jumpers (string extension cables), to combiner box and inverter inputs, any location requiring connection must ensure male and female connectors come from the same manufacturer and belong to the same product model

series. Connectors from different manufacturers (including so-called “MC4 compatible” brands), and even different product lines within the same manufacturer, differ in insulation material formulation, metal contact pin precision outer diameter tolerance, plating process, spring clamping force, and sealing ring material. Mixing connectors of different manufacturers or models is a very dangerous non-standard practice, resulting in the following consequences:

- Incomplete Engagement: Male and female tolerance mismatch prevents complete mechanical locking and sealing, leaving microscopic gaps.
- Moisture Ingress and Electrochemical Corrosion: Microscopic gaps in outdoor high-humidity, rain, and condensation environments create a “capillary effect” drawing in moisture, causing galvanic reactions at the contact surfaces of different metals, accelerating contact corrosion.
- Abnormal Contact Resistance Increase: Corrosion and insufficient contact stress cause contact resistance to multiply, resulting in abnormal heating at the connection point. Heat further accelerates material aging, creating a vicious cycle.
- DC Arc and Fire: Ultimately, severely degraded or near-loosened connection points, under high-voltage DC current, will sustain continuous arcing. The high temperature is sufficient to melt the connector housing, ignite surrounding combustibles, directly causing catastrophic electrical fire.

  Therefore, the project department must centrally procure connectors of the same batch, brand, and model for all on-site wiring, and it is forbidden to mix connectors from different sources for cost-saving or convenience purposes.

2. No Substitutes: During construction, using electrical tape, wire caps, or connectors of different series or brands for so-called “connection” or “repair” of any connector in this system is prohibited. If found, they must all be cut off and replaced.
3. Final Engagement Check: When engaging connectors, a distinct “click” sound must be heard, and then try to pull in the opposite direction with force to ensure it cannot be disengaged, indicating silver-plated contacts have achieved complete engagement and self-locking.

9. Operation and Maintenance Specifications

Modules require regular inspection and maintenance, especially during the warranty period. To ensure optimal module performance, ZKFN Solar recommends the followin g maintenance measures (Refer to the “ZKFN Solar Light-weight module SolarPega & SolarPega F Series O&M Manual” for details):

9.1 Routine Inspection

1. Module Visual Inspection: (i) Check for module damage. (ii) Check for sharp objects contacting the module surface.

2. Shadow Check: Check if modules are shaded by obstacles or foreign objects. Avoid shading from newly grown trees, newly erected poles, etc.
3. Structural Integrity Check: Check for debonding of the special adhesive between modules and the roof, and whether clamp/fastening screws are loose. Adjust or repair promptly.

9.2 Module Cleaning Specifications

1. Regular Cleaning: Dust or dirt accumulation on module surfaces reduces power output. Clean regularly to maintain surface cleanliness. Generally, clean at least once a month, increasing frequency under harsh environmental conditions.
2. Safe Timing and Water Volume: First rinse with clean water, then dry with a soft cloth. Do not use corrosive solvents or hard objects to wipe PV modules. Clean PV modules under irradiance below 200W/m². Do not clean PV modules under wind conditions above Level 4, heavy rain, or heavy snow.

   Warning - Important Notice: If it is necessary to walk on modules for urgent O&M, ensure installation followed the walkable installation scheme. For modules not installed according to the walkable installation scheme, absolutely do not walk, stand, or sit on modules for cleaning or O&M..

4. Water Prohibition Areas: Do not use high-pressure water jets to directly flush junction box seams and connectors at close range at any time.

9.3 Electrical System Periodic Inspection Requirements

Module Connector and Cable Inspection:

(i) Special inspection recommended every six months. (ii) Check PV wiring for signs of aging, including possible rodent damage, weather aging, and whether all connectors are tightly connected and corrosion-free. (iii) Pay special attention to connector thermal infrared temperature. If one connector in a pair is a few degrees hotter than the other or than the circuit conductor, this is a sign of increased contact resistance. Power off, open and check if spring contacts have lost elasticity or become oxidized. Faulty connector pairs must be cut off and replaced entirely.

10. Annexes

Annex 1: Recommended Cleaners for Different Roof Substrates

Roof Type	Recommended Cleaner Name
Square tubes, PVC, Asphalt, EPDM and other plastic flexible roofs	China: RA-1033 Professional Plastic Cleaner; Overseas: Use non-corrosive cleaner recommended by roofing material manufacturer
Steel tile, glass roof, metal roof types	90% Isopropyl Alcohol + 10% Deionized Water, mix well before use. Do not use solvents containing ketones or aromatic hydrocarbons

Use the above cleaners or those recommended by the roofing material supplier.

Annex 2: Structural Adhesive Construction Specifications

Nozzle Trimming Standard: Standard angle-cut nozzle. At an extrusion speed of 10 cm/s, it should form a full standard strip of 10 mm width and 8 mm height.

Adhesive Application Prohibitions: Except for continuous operation, segmented, spot, or zigzag adhesive application within a bonding area is prohibited. Adhesive application speed must be uniform with the glue gun trigger pull.

Curing and Load Relationship: The following data serve as the basis for construction organization design. When ambient temperature is below 5°C, the surface drying time and final strength establishment time of structural adhesive will increase exponentially. Typically, at least 48 hours of undisturbed curing is required.

Ambient Temperature Range	Recommended Minimum Curing Time (Undisturbed)
25°C - 40°C	24 hours
10°C - 25°C	48 hours

Ambient Temperature Range	Recommended Minimum Curing Time (Undisturbed)
0°C - 10°C	72 hours
Below 0°C	Installation not recommended

Rolling Operation Correct vs. Incorrect Comparison:

Comparison Item	Correct Operation	Incorrect Operation
Adhesive Strip Height	Height > 8mm (Correct)	Height < 5mm (Poor adhesive wetting)
Rolling Method	Use plastic roller for uniform rolling	Excessive rolling / No rolling / Twisting module after rolling
Pressing Method	Roll non-cell area of module	Press on cells directly by hand for stabilization

Annex 3: List of Items Corrosive/Damaging to PV Connectors

Strictly manage the chemical safety data sheets (MSDS) of all installation auxiliary materials. Before using any non-listed chemical near connectors, complete chemical compatibility testing in a laboratory.

Chemical Category	Common construction items prohibited near connectors
Acid/Alkaline Substances	Salt (salt spray), baking soda, caustic soda solution, ammonia, concrete curing agent (containing mineral salts)
Oxidizing Agents	Hydrogen peroxide (H_2O_2), sodium hypochlorite (bleach), potassium permanganate disinfectant tablets
Organic Solvents	Acetone, toluene, xylene, banana oil (paint thinner), high-concentration isopropanol (>90%), nail polish remover, turpentine

Annex 4: Steel Tile Profile and Compatible Clamp Type Reference

Steel Tile Classification	Compatible Clamp Type	Recommended Installation Solution
T-type Steel Tile	T-type dedicated clamp	SolarPega series adhesive installation / SolarPegaF series clamp installation

Steel Tile Classification	Compatible Clamp Type	Recommended Installation Solution
Standing Seam Type	Standing seam dedicated clamp	Prefer SolarPegaF series clamp installation / Partial cases allow SolarPega+Square tube adhesive installation
Angle-Ridge Steel Tile	Angle-ridge dedicated clamp	Prefer SolarPegaF series clamp installation / Partial cases allow SolarPega+Square tube adhesive installation
Corrugated Steel Tile	Corrugated dedicated clamp	SolarPega series adhesive installation / SolarPegaF series clamp installation
Round Standing Seam Type	Round dedicated clamp	Prefer SolarPegaF series clamp installation / Partial cases allow SolarPega+Square tube adhesive installation

The above tile profiles and clamps do not specify specific models or specifications and are for reference only. Contact ZKFN Solar for technical support regarding specific clamp model types and other parameters.

Annex 5: Abnormal Installation Surface Conditions and Treatment Methods

Abnormal Condition	Detailed Description and Risk	Mandatory Treatment and Acceptance Criteria
Severe Steel Tile Corrosion	Surface paint film extensively burst, base steel plate showing layered rust spalling	Direct installation prohibited. Roof must be fully refurbished (spray rust-converting anti-corrosion primer + topcoat) or replace steel tiles
Fine Concrete Dusting	Extremely low surface strength, disintegrates when rubbed with foot. Adhesive will peel off with loose cement layer	Direct installation prohibited. Grind off loose surface layer, clean dust, apply high-permeability moisture-proof primer, allow 24 hours curing before construction
Waterproof Membrane Blistering	Membrane has detached from structural layer. Additional weight and wind suction will accelerate large-area tearing	Direct installation prohibited. Notify membrane manufacturer to cut open and re-weld blister

Abnormal Condition	Detailed Description and Risk	Mandatory Treatment and Acceptance Criteria
		areas. Re-perform pull-out test on repaired areas

> Warning - Important Note: The above methods should be performed under the professional guidance of other manufacturers. The treatment methods here are for reference only.

Annex 6: Summary Table of Module Selection and Installation Methods for Different Roofs

Roof Type	Tile Subtype	Recommended Product Series	Core Installation Requirements
Steel Tile	T-type, Corrugated	SolarPega Series / SolarPegaF Series	SolarPega all series recommended ≥5° tilt. Corrugation pitch ≤350mm, crest width ≥1cm; Bonding area ≥800cm², square tube leveling
Steel Tile	Standing Seam, Angle-Ridge	Prefer SolarPegaF Series	SolarPegaF recommended ≥5° tilt, use clamp fixture installation.
Flat Roof	Waterproof Membrane, Concrete	SolarPega Series / SolarPegaF Series	SolarPega uses square tube installation and all series recommended ≥5° tilt. Support spacing ≤350mm, bonding area ≥800cm². SolarPegaF series recommended ≥5° tilt, use mount, clamp installation

This table is a simplified quick reference guide. Detailed requirements are given in the main body of this manual.

Annex 7: Electrical Parameter Description

No.	Parameter Item	Parameter Value
1	Open-Circuit Voltage Temp. Coeff. α / Max Power Temp. Coeff. γ / Short-Circuit Current Temp. Coeff. β	α = -0.27%/°C, β = -0.33%/°C, δ = +0.045%/°C

No.	Parameter Item	Parameter Value
2	Nominal Operating Cell Temperature (NOCT)	45 ± 2 °C
3	Minimum Cable Cross-Section for PV Module Field Wiring	1 x 4.0 mm²
4	Connector Mating Requirements	Must use connectors of same brand and model as module connectors. Socket must be kept clean, free of moisture or mud before connection
5	Connector Dimensions, Type, Material, and Temperature Rating	EVO2, IP68, -40°C ~ +85°C
6	Terminal Type for Field Wiring	Crimping terminal
7	Recommended Connector Model and Manufacturer	EVO2 Stäubli
8	Connection Method	A: Structural adhesive bonding / B: Clamp
9	Bypass Diode Type	GF5045
10	Installation Temperature Range and Slope Requirements	Installation temperature 5°C to 35°C; When slope >25°, use foam tape to assist adhesive positioning and anti-slip
11	Minimum Mechanical Fixing Method	Use M8 bolts, tightening torque value 15~20 N·m
12	Fire Rating	Class C (UL790 standard)
13	Design Mechanical Load and Safety Factor	Steel tile installation: Positive 3600Pa/1.5, Negative 2400Pa/1.5; Screw fixing: Positive 2400Pa/1.5, Negative 2400Pa/1.5
14	Spotlight Statement	This module does not allow external spotlight illumination on the front or back. Module anomalies or damage caused by light concentration are not covered under warranty

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