

INSTALLATION MANUAL (HiE-SxxxVG/VI, IEC)

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1. General Information

- This Installation manual contains information regarding the installation and the safe handling method of the photovoltaic module (hereafter referred to as “**module**”) supplied by Hyundai Energy Solutions Co., Ltd. (hereafter referred to as “**HES**”).
- HiE-SxxxVG: 340 pieces, 385-410W, 1500V
HiE-SxxxVI: 408 pieces, 465-490W, 1500V
- System users and installers should read and understand this manual before handling, installing the module. Please contact Customer Support department or our local representatives for more detailed information.
- Before installing solar photovoltaic systems, mechanical and electrical requirements for the total system should be checked as well. Keep this manual in a safe place for future reference.
- The installer should consider every safety precautions specified in this manual and local codes when installing a module.
- HES modules are tested and certified for installation worldwide. Different regions may have different regulations for solar PV installations. In this manual, hereafter “IEC only” is used to refer to regions where IEC standard applies, e.g. Europe, Middle East, most of Asia Pacific countries; “UL only” is used to refer to regions where UL standard applies, e.g. United States, Canada; all other references are global.

1.1 **NOTICE**

- Installing solar photovoltaic systems requires specialized skills and knowledge. Thus, before installation, wiring, and operation of photovoltaic modules, system users and installer should understand and conform to this manual.
- Installation and wiring should only be performed and supervised by qualified persons.
- Each module has a junction box for permanent cable connection. HES can provide customers with fitted cables for easy installation. Installers should secure the safe installation status including all electrical hazards.

1.2 **DANGER**

- Installers should secure the installation status, without limitation, including the risk of electric shock.
- Backsheet of PV module should be kept safe from any damage or scratch to prevent mechanical or electric shock.
- Do not disassemble or remove any part of a PV module. Such actions may cause electric shock, fire or damage.
- Keep safety regulations for all components used in the system, including wiring and cables, connectors, charging regulators, inverters, storage batteries and rechargeable batteries, etc.

1.3 WARNING

- Before installation, recommend preventing the module from exposure to direct sunlight or other light source. (If modules are exposed directly to sunlight without connection, each module generates over DC 30V, which is potentially hazardous.)
- Modules are heavy. Be sure to have more than two persons with anti-slip gloves on carry each PV module. Do not throw and drop PV modules.
- Do not sit, stand, step, walk and/or jump on the module, including the frames.
- Do not drop or place objects on the modules. Do not place excessive loads on the modules or twist the module frame.
- All installation equipment and PV modules must be kept in dry condition during installation.
- Check the current and the voltage before connecting the line. There is potential hazard in case of higher voltage in series connection and higher current in parallel connection.
- All PV modules must be earthed by using earth device. Safety check for all other parts of systems should be finished before installation to prevent any electric hazard.
- Do not use any damaged PV module, where it may cause fire, electric shock or injury.
- Do not focus light on a PV module, where it may cause fire and damage.
- Do not touch live parts of wires, cables, connectors, or junction boxes, in order to prevent electric shock and injury. Be sure the circuit breaker is off if it's applicable. Always use appropriate safety equipment. (Insulated tools, insulating gloves, etc.)
- Do not re-arrange bypass diodes, where it may cause electric shock and injury.
- Do not disconnect the cable when the load to module is engaged.
- Check applied Class for module after installing the module.
- Do not remove any labels.

1.4 CAUTION

- In order to prevent any performance drop, damage, or incapability, do not use paint and adhesive material to the module surface.
- Do not leave modules in places where flammable gases can be generated or collected.
- Do not leave un-fixed and unsafe PV modules unattended.
- Do not wear metallic rings, watchbands, ear, nose, lip rings or other metallic devices while installing photovoltaic systems.
- Installers should be careful of module's sharp parts(ex: the edges of module)

1.5 General Safety

The following requirements should be kept during installation and inspection.

- Check the inspection requirements by authorized personnel.
- When installing the system, abide by all local, regional and national statutory regulations.
- System designer and installers should secure safe installation of PV modules. All installation must be conformed to all fire safety regulations. Additional structures can be applied for installation. If additional equipment is applied, it is necessary to check the fuse status, earth error and system isolation.
- Do not use different types of PV module in a same module array.
- Abide by the safety regulations for all other components within the total system.

2. Transportation, Storage and Unpacking

- Modules are packaged vertically. They should also be vertical during transportation.
- Check tension of banding tapes before transportation. Be cautious of abnormal shock for vehicles and modules which might cause module damage and cell crack during transportation. Store the modules safely in a dry and cool environment.
- Do not stack or move more than two packages of modules which are stacked vertically.
- Workers are recommended to keep some distance from the package when one worker cuts banding tapes. Don't lift the package after removing banding tapes.
- After unpacking, please visually check if there is no problem on modules. Install modules and components without any defect.
- When carrying modules, do not hold cables or junction box. Carry by holding frames with two hands.
- Carry one module at one time.

3. Installation Environment

3.1 General

- Before installing and operating HES PV system, installer and operator should follow the requirements specified in this manual.
- Do not drill additional holes in the frame of the modules. This additional hole will void the warranty. Refer to the mounting profile in Picture 1.
- Secure the module using mounting holes provided and stainless corrosion resistant material. Locking washers should be used for long-term security.
- Appropriate materials should be used for mounting structure in order to prevent the module frame, mounting structure from corrosion.
- When installing the system, it is necessary to avoid any shade caused by buildings or trees nearby.
- For more information about the installation, please contact HES or local representatives for more detailed information.

3.2 Notes on Installation

- Space between PV module frames and installation objects is necessary for cooling air circulation. Do not seal this space. Minimum 115mm of standoff height is necessary.
- The minimum distance between two fixed modules for linear thermal expansion of the module frame supports should be 10 mm. Nevertheless, the recommended distance between two modules is 30 mm to allow wind circulation, in order to reduce pressure loads and improve module ventilation.
- The minimum distance between a module frame and a sidewall of clamp for linear thermal expansion of the module frame supports should be 1.5 mm, in order to reduce pressure loads.
- All the junctions on the conductive connection must be fixed. Metal containing iron in the conductive connection should be made with stainless steel or be treated against corrosion by anodizing, spray-painting, or galvanization to prevent rusting and corrosion.
- Modules that feature antireflective coated glass are prone to visible finger print marks if touched on the front glass surface. HES recommends handling modules with gloves or limiting touching of the front surface. Any finger print marks resulting from installation will naturally disappear over time or can be reduced by following the washing guidelines in Section 6.2.
- Do not install PV modules horizontally. Horizontal installation can cause performance drop of PV modules. HES recommends mounting modules at a 12.5° tilt or greater.

3.3 Installation Site

PV modules will be operated under General Operation Condition (GOC). Do not install PV module at site beyond General Operation Conditions or under specific condition.

1) General Site Conditions

The site condition for the sea level and wind load should be matched the following requirements.

- (1) Sea level of site : Below 1,000 m (3,280 ft)
- (2) Maximum Instantaneous wind Speed (design load, safety factor = 1.5)
 - Below 2,400Pa or 3,600Pa on the front module surface
 - Below 1,600Pa or 2,400Pa on the back module surface

※ If the wind strength is not over than 2,400Pa (2,400 N/m², 245 kg/m², 50 lb/ft²), the installation

site over 1,000m (3,280ft) above sea level is permitted.

- ※ Installations under the condition of wind strength specified above are allowed only when the methods of installations comply with Module Installation Instruction (Appendix 1.)

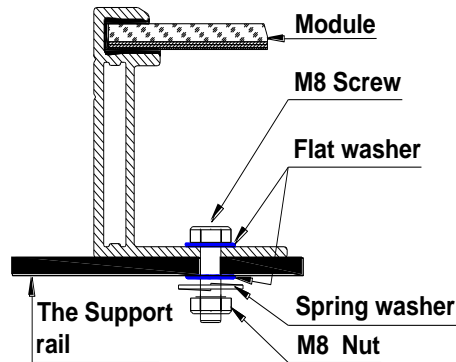
2) Specific Site Condition

The following actual site condition should be checked for adequate installations.

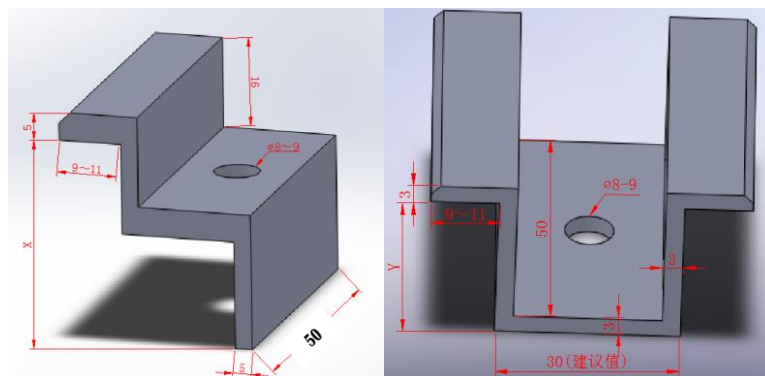
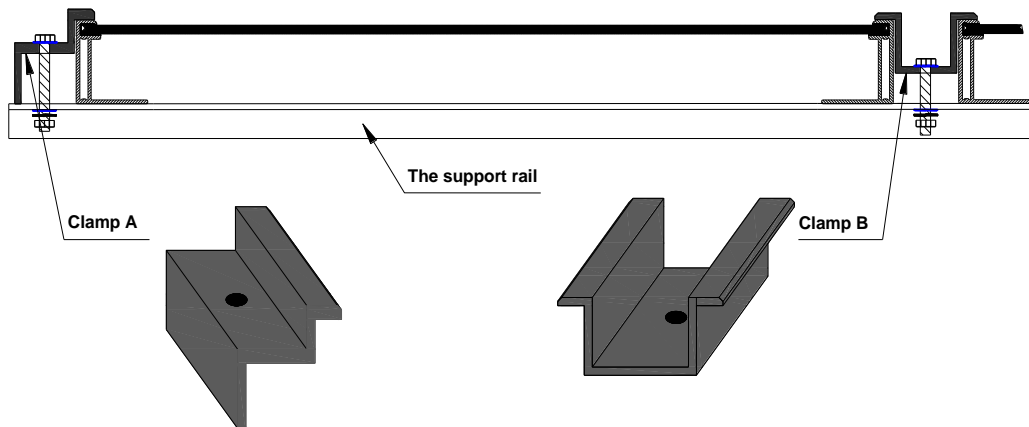
- Hail, heavy snow, and sand are to be considered as important factors related to module damage and power output decline.
- HES recommend installing lightning rods in lightning-expected areas and SPD (Surge Protection Device) for surge.
- Air pollution, chemical gas, acid rain, and smoke are important factors to be considered.
- Do not use PV modules in place of normal roofing.
- PV modules are not recommended to be installed where salt-mist will hit directly. When PV modules are installed within 7km from a body of salt water, the installer should check for salt damage at the proposed install location and implement salt-mist corrosion prevention measures. These measures include but are not limited to: not scratching the corrosion-resistant coating of the modules and mounting system, installing modules at a minimum tilt of 12.5 degrees and advising the system owner to inspect the system regularly such as every 3 months to check the system for signs of corrosion and to clean any accumulated dust or salt from the system.
- PV modules shall not be immersed in water and shall not be continually exposure to water from a sprinkler, fountain, etc.
- PV modules shall not be installed in sulfurous area near sulfurous volcano and sulfurous spring.
- If PV modules are installed near factory or plant area, they can be polluted by fumes and the pollution may not be cleaned. Thus the installer should consider and check the installation area and the distance from factory or plant area.
- If PV modules are installed in damp environments, the installer should check the installation area to see if there is a possibility that moss grows in PV modules.
- In a harsh, hot, and humid environment, HES recommends using (-) grounding to inverters.
- Do not install PV modules indoors or on moving objects.

4. Installation

- Generally modules are fixed using mounting holes or clamp hardware.
- Each module must be securely fixed at a minimum of 4 – 8 points on two each side of long frame.
- The mounting design must be certified by a registered professional engineer. The mounting design and procedures shall comply with local electrical and building codes.
- Mounting hardware is not provided by HES.
- Mounting hardware like those in Picture 1 & 2 is highly recommended by clamping or bolt & nut mounting (Torque level: 16 N·m for bolting method, 8 N·m for clamping). The material of bolts and nuts are recommended as stainless steel.
- Area of module frame fastened by each clamp shall be no less than 400 mm². (*clamp length ≥50mm, the clamped width of module frame shall be in this area: 8-11mm*)
- Detailed mounting method is described in 'module installation instruction' in the Appendix 1.



Picture 1. Installation Method using stainless steel bolt & nut



Picture 2. Mounting Hardware (Clamp)

5. Wiring

5.1 General

- All wiring should be matched with acceptable regional and local electrical codes.
- All wiring work should be done by certified and authorized engineers.
- All wiring should be connected safely in order to prevent any hazard.
- All PV modules for one serial connection must be identical in terms of output and in types.
- Do not connect PV modules directly in parallel without the combine box.

5.2 Module Wiring

- System voltage should not exceed the maximum system voltage of module.
- The maximum number of modules in parallel connection depends on inverter's capacity.
- PV modules are not designed to be connected to load directly. Therefore, a proper inverter must be connected.
- Bypass diodes are installed on the modules at the factory. Wrong connection may cause damage to the bypass diodes, cable and junction box.
- The value of Isc and Voc marked on modules should be multiplied by 1.25 when determining module voltage ratings, conductor current ratings, fuse size and the size of controls to the PV output

5.3 Array Wiring

'Array' is defined as a module arrangement with combined electrical connection. The array must be insulated to resist against the possible maximum open-circuit voltage. Also, solar irradiation-proof copper wires must be used for array wiring. Installers must check the local electrical specifications. In order to prevent cable drooping, installers should fix cable using wire or duct.

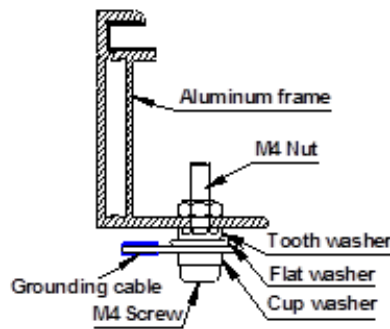
5.4 Earth Ground Wiring

To prevent electric shock and fire, an earthing must be done on the frames of PV modules and array. The array frame must be earthed according to local codes.

There is an earthing hole in the module frame; by using these holes, an earth conductor and the module frame must be connected and earthed. (See picture 3)

Common grounding hardware (nuts, bolts, star washers, split-ring lock washer, flat washers and the like) is used to attach a listed grounding/bonding device. The attachment must be made in conformance with the grounding device manufacturer's instructions.

Common hardware items such as nuts, bolts, star washers, lock washers and the like have not been evaluated for electrical conductivity or for use as grounding devices and should be used only for maintaining mechanical connections and holding electrical grounding devices in the proper position for electrical conductivity. Such device, where supplied with the module and evaluated through the requirements in UL 1703, may be used for grounding connections in accordance with the instructions provided with the module.



Picture 3. Grounding Hardware(Torque level: 2-3 N·m)

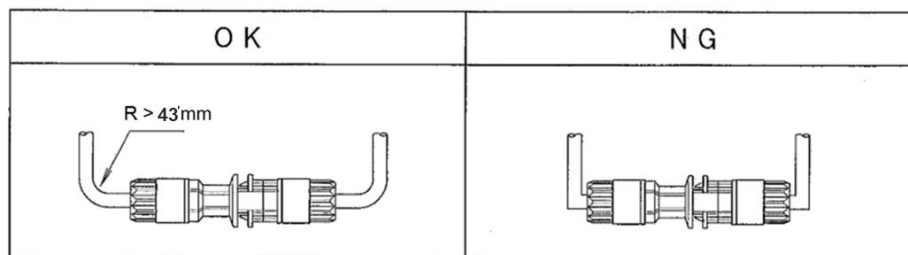
5.5 Module Terminations

The installer should connect cables using the same cable connector equipped in each PV module. For more information about electrical connection, contact an authorized engineer of HES. HES does not give warranty for the case of using connectors which are not approved by HES.

5.6 Junction Box & Terminals

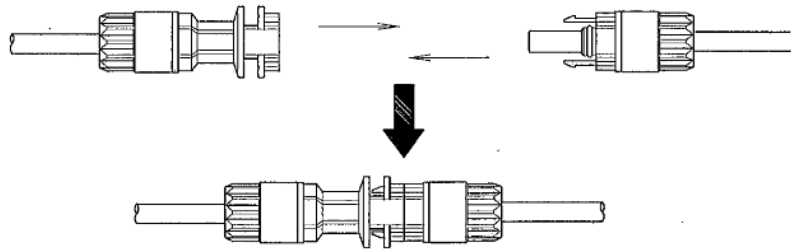
A PV module has the plus and minus connectors and a junction box with bypass diodes. On the junction box, the polarity is clearly marked.

- 1) Protection Degree : IP67
- 2) Temperature Range : -40°C ~ +90°C
- 3) Wire Size : 4.0mm² (AWG 12)
- 4) The cable must not be bent or crushed on the direct exit of the cable screw joint. A minimum bending radius 43mm must be maintained. The cable must be routed in a way that tensile stress on the conductor or connections is prevented. (Picture 4)



Picture 4. Cable Routing

- 5) When connect connectors, insert connector until locking hook catches the holder and clicks. Pull each connector gently and make sure connectors are not disconnected. (Picture 5)
- 6) Do not give between the connector and cable a strong pull (over 10kg).
- 7) Do not apply external stress to the body of connector. Do not place the connectors in water.
- 8) When same series modules with different connectors are installed together, make sure those two connectors are compatible.



Picture 5. Connect connectors

- 9) If the connectors need to be disconnected, installer should use the exclusive tool to disconnect them after safety measure such as cut-off of connection band.
- 10) Connected cables and connectors should be fixed.
- 11) Action against contamination or corrosion should be enacted on disconnected connectors.

5.7 Conduit

For conduit application, it is necessary to follow the regulation for outdoor installation of conduit. All fixing parts should be protected from any damage and moisture.

5.8 Diode

When there is partial shade on a PV module, reverse-voltage can occur inside PV module. In order to protect this phenomenon, the diodes are normally installed in the Junction Box. HES PV modules are equipped with bypass diodes. If installer wishes to change into other diodes, the installer should inform an authorized engineer of HES.

| Object | Manufacturer | Type | Technical Data |
|---------------|--|--|--|
| Junction Box | Zhejiang Renhe Photovoltaic Technology Co., Ltd. | GF26xy | Max. Voltage=1500 V (DC) Rated current = 15 A RTI = 110 °C |
| Bypass diodes | | PST6020 | Tj max = 200°C If = 20A |
| | | PST4530/T | Tj max = 200°C If = 20A |
| Cable | | H1Z2Z2-K 1 x4.0 mm ² | Rated voltage = 1500VDC |
| Connectors | Staubli | 05-8 | Rated voltage = 1500VDC Rated current = 30A |
| | | PV-KST4-EVO 2/xy_UR PV-KBT4-EVO 2/xy_UR | Rated Voltage = 1500VDC Rated Current = 45A (4.0mm ²) |

| Object | Manufacturer | Type | Technical Data |
|---------------|--|---------------------------------|---|
| Junction Box | Tongwei solar(Hefei) Co., Ltd. | PVJB-TW-S/001 | Max. Voltage=1500 V (DC) Rated current = 15 A RTI = 110 °C |
| Bypass diodes | Changzhou Starsea Electronics | PST6020 | Tj max = 200°C If = 20A |
| | Yangzhou Yangjie Electronic Technology | GF3045MG | Tj max = 200°C If = 30A |
| Cable | Zhejiang Renhe Photovoltaic Technology Co., Ltd. | H1Z2Z2-K 1 x4.0 mm ² | Rated voltage = 1500VDC |
| Connectors | | 05-8 | Rated voltage = 1500VDC Rated current = 30A |
| | | Staubli | PV-KST4-EVO 2/xy_UR PV-KBT4-EVO 2/xy_UR |

6. Operation and Maintenance

It is required to perform regular inspection and maintenance of the modules, especially within warranty scope. It is the user's responsibility to report to the supplier regarding the damages found.

6.1 Cautions

- Do not conduct electrical work such as opening junction boxes or separation of connectors without a qualified expert.
- Before electrical work, remove any metal material from body and wear protection equipment for insulation.
- To minimize output decline, remove any substance near the PV modules such as grass, moss, and vine.
- Any chemical which is not approved by HES shall not contact PV modules.

6.2 Cleaning

- Recommend maintaining module glass surface clean as possible to improve module power efficiency and long life.
- HES modules are designed for long life and require very little maintenance. Under most weather conditions, normal rainfall is sufficient to keep the module glass surface clean.
- For AR coating HES modules utilize special materials to increase energy harvest. Always use clean gloves when handling the module, never touch the glass with bare hands.
- If dirt build-up becomes excessive, clean the glass surface with room temperature water and soft materials without potential risks of scratch. Do not use water with high pressure for cleaning. Do not use harsh cleaning materials such as scouring powder, steel wool, scrapers, blades, or other sharp instruments to clean the glass surface of the module. Use of such materials or cleaning will invalidate the product warranty.
- Do not clean the backside of the module. If backside cleaning is necessary, please contact local representatives for more detailed information.
- PV modules will be "self-clean" as effectively as modules mounted at a 15° tilt or greater.

6.3 Visual Inspection of Modules

- Inspect the modules visually to find whether there are appearance defects, the following need to be paid more attention especially:
 - 1) Whether the glass is broken
 - 2) Corrosion along the cells' bus-bar
 - 3) Whether there is burning vestige on the Backsheet.

6.4 Inspection of connector and Cable

In order to ensure proper operation of the system, please check all wiring connections and the condition of the wire insulation periodically.

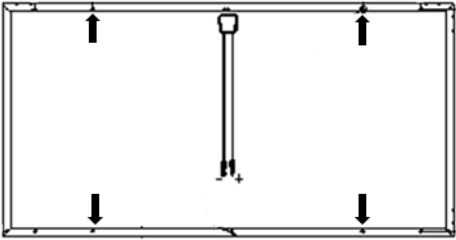
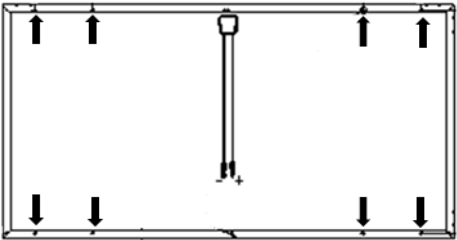
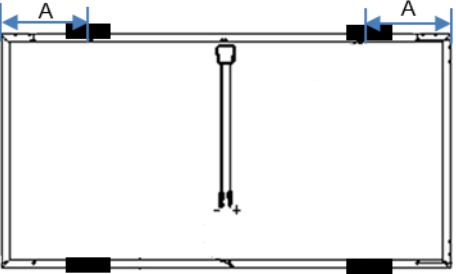
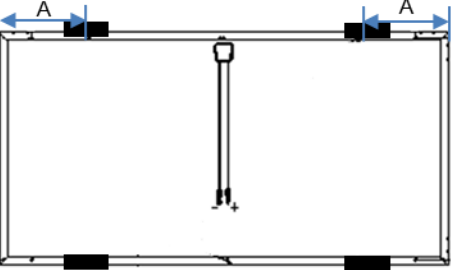
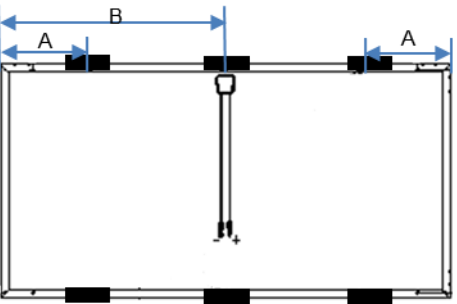
7. Disposal

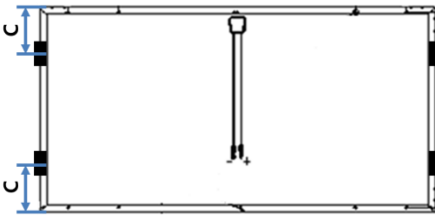
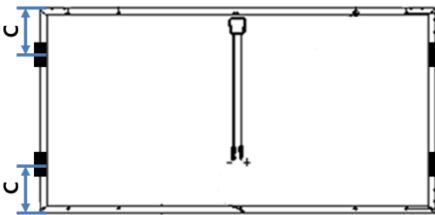
- Users shall dispose of modules according to local disposal regulations.
- Contact HES for more detailed information related to disposal and recycling.

8. Disclaimer of Liability

- 1) HES do not have any responsibility and liability for clause as below.
 - Loss, damage, injury or expense resulting from improper installation, handling or use. The installation techniques, handling and use of this product are beyond company control.
 - Infringement of any third party's patent or right that is caused by using HES modules.
 - Loss, damage, injury or expense resulting from any factor that is unsuspected the module was produced or shipped.
- 2) HES reserves the rights for any change the technical specification including the PV production, the specifications, or the product information sheets without prior notice.

Appendix 1) Module Installation Instruction (Front / Back Design Load, Safety factor = 1.5)

| Method | | VG | VI |
|----------------|---|---|--|
| Bolting | |  <p>4 Bolts : 3600/1600 Pa</p> |  <p>8 Bolts : 3600/1600 Pa</p> |
| | Clamping ■ :Clamping area ※ Min. Clamp Width: 50mm | on Long Bar  <p>A: 345±50mm 3600/1600Pa</p> <p>Overlap of Clamp with Al frame : 9-11mm</p> |  <p>A: 410±50mm Design load 2400/1066Pa</p> <p>Overlap of Clamp with Al frame : 9-11mm</p>  <p>A: 410±50mm, B: 1028±50mm Design load 3600/1600Pa</p> <p>Overlap of Clamp with Al frame : 9-11mm</p> |

| | | | |
|--|-------------------------|--|--|
| | <p>on Short Bar</p> |  <p>C: 228±50mm 2400/1066 Pa</p> <p>Overlap of Clamp with Al frame : 7-8mm</p> |  <p>C: 228±50mm 2400/1066 Pa</p> <p>Overlap of Clamp with Al frame : 7-8mm</p> |
|--|-------------------------|--|--|

Note 1) Certified by TUV-NORD

2) The Mounting method has been qualified by HES, and the mechanical load tests are based on IEC61215 ed.2.

Appendix 2) Module Electrical Performance

· Electrical Characteristics : HiE-SxxxVG

| Item | HiE-SxxxVG (xxx: Maximum Power Value) | | | | | |
|----------------------------------|---------------------------------------|-------|-------|-------|-------|-------|
| Maximum Power at STC(Pmax) [W] | 385 | 390 | 395 | 400 | 405 | 410 |
| Voltage at Pmax (Vmpp) [V] | 38.4 | 38.5 | 38.5 | 38.6 | 38.7 | 38.8 |
| Current at Pmax (Impp) [A] | 10.03 | 10.13 | 10.26 | 10.36 | 10.47 | 10.57 |
| Open circuit voltage (Voc) [V] | 46.2 | 46.3 | 46.3 | 46.4 | 46.5 | 46.6 |
| Short circuit current (Isc) [A] | 10.82 | 10.87 | 10.92 | 10.97 | 11.02 | 11.07 |
| Module efficiency [%] | 19.6 | 19.9 | 20.2 | 20.4 | 20.7 | 20.9 |
| Maximum Series Fuse Rating [A] | 20 | | | | | |
| Temp. coefficient of Pmpp [%/°C] | -0.34 | | | | | |
| Temp. coefficient of Voc [%/°C] | -0.27 | | | | | |
| Temp. coefficient of Isc [%/°C] | 0.04 | | | | | |
| Output tolerance [W] | +5 / 0 | | | | | |
| Maximum system voltage [Vdc] | 1,500 (IEC) | | | | | |
| Cell quantity in series [pcs] | 340 | | | | | |
| Bypass diodes [pcs] | 2 | | | | | |
| Cell Type | Mono-crystalline Silicon Cell | | | | | |
| Electrical protection class | Class II | | | | | |
| Fire rating | Class C (IEC) | | | | | |

· Electrical Characteristics : HiE-SxxxVI

| Item | HiE-SxxxVI (xxx: Maximum Power Value) | | | | | |
|----------------------------------|---------------------------------------|-------|-------|-------|-------|-------|
| Maximum Power at STC(Pmax) [W] | 465 | 470 | 475 | 480 | 485 | 490 |
| Voltage at Pmax (Vmpp) [V] | 38.5 | 38.6 | 38.7 | 38.8 | 38.8 | 38.9 |
| Current at Pmax (Impp) [A] | 12.08 | 12.18 | 12.27 | 12.37 | 12.50 | 12.60 |
| Open circuit voltage (Voc) [V] | 46.3 | 46.4 | 46.5 | 46.6 | 46.6 | 46.7 |
| Short circuit current (Isc) [A] | 12.96 | 13.04 | 13.10 | 13.16 | 13.22 | 13.28 |
| Module efficiency [%] | 19.8 | 20.1 | 20.3 | 20.5 | 20.7 | 20.9 |
| Maximum Series Fuse Rating [A] | 20 | | | | | |
| Temp. coefficient of Pmpp [%/°C] | -0.34 | | | | | |
| Temp. coefficient of Voc [%/°C] | -0.27 | | | | | |
| Temp. coefficient of Isc [%/°C] | 0.04 | | | | | |
| Output tolerance [W] | +5 / 0 | | | | | |
| Maximum system voltage [Vdc] | 1,500 (IEC) | | | | | |
| Cell quantity in series [pcs] | 408 | | | | | |
| Bypass diodes [pcs] | 2 | | | | | |
| Cell Type | Mono-crystalline Silicon Cell | | | | | |
| Electrical protection class | Class II | | | | | |
| Fire rating | Class C (IEC) | | | | | |