Disclaimer

Neither Jinko Solar nor any of its employees make any warranty, express or implied, or assumes any legal liability for the accuracy, completeness, or usefulness of any information herein disclosed. The data contained in this report is based on assessment of sample population and it is based exclusively on the facts which were available at the time of the survey.

No part of this report may be copied or duplicated in any form by any means or redistributed or published without the prior written consent of Jinko Solar but instead should only be used as a reference document.
# Table of Contents

**Executive Summary**........................................................................................................3

**Safety rules**.....................................................................................................................3

1. **Operation & Maintenance Criteria** .................................................................................4
   
   1.1 Introduction .....................................................................................................................4
   
   1.2 Defects criteria .................................................................................................................4
     - 1.2.1 Hot spot ....................................................................................................................4
     - 1.2.2 Disconnected Substring ...........................................................................................5
     - 1.2.3 Delamination ..............................................................................................................6
     - 1.2.4 Glass Breakage ..........................................................................................................7
     - 1.2.5 Junction box issues ....................................................................................................8
     - 1.2.6 Low Performance Defect .........................................................................................9
     - 1.2.7 Major visual defects ..................................................................................................10
     - 1.2.8 Cosmetic Issues .......................................................................................................11
     - 1.2.9 Snail trails ..................................................................................................................12
   
   1.3 Diagnostic tools ..............................................................................................................12
     - 1.3.1 Infrared Imaging .......................................................................................................12
     - 1.3.2 Megohmmer (‘Megger’) Tracing .............................................................................13
     - 1.3.3 IV Curve Testing ......................................................................................................13
     - 1.3.4 DC System Voc Checks ............................................................................................13
     - 1.3.5 DC System Imp Checks ............................................................................................13
   
2. **Module cleaning** ..........................................................................................................14
   
   2.1 Summary .......................................................................................................................14
   
   2.2 Preparation before operating .......................................................................................14
     - 2.2.1 Main Equipment ........................................................................................................14
     - 2.2.2 Auxiliary Tools ........................................................................................................15
     - 2.2.3 Personnel Allocation ................................................................................................15
   
   2.3 Cleaning Method and Procedure .................................................................................15
     - 2.3.1 Fixed Module Cleaning ............................................................................................15
     - 2.3.2 Sun Tracking module cleaning ................................................................................16
   
   2.4 Notice ............................................................................................................................16
     - 2.4.1 Hair brush specification ............................................................................................17
     - 2.4.2 Planning of cleaning cycle and region ......................................................................17
     - 2.4.3 Routine steps of cleaning .........................................................................................17
     - 2.4.4 Module cleaning summary instructions ....................................................................18
   
3. **Claim Submitting Procedure** .......................................................................................19
Executive Summary

- The purpose of this document is to provide O&M guideline including warranty claim procedures to all of our Customers, how to detect the most common defects and how to process them according to our standards.

- This manual is applicable only to the modules installed, connected and covered by the Jinko’s Warranty.

- To ensure the PV modules are installed correctly, please read and follow the installation manual (provided by Jinko) carefully.

- The document will also highlight key operation and maintenance factors to consider to allow for better performance of Jinko’s PV Modules.

- The information in this manual is based on Jinko’s knowledge and experience and is believed to be reliable, but such information including product specification (without limitations) and suggestions do not constitute a warranty, expresses or implied.

Safety rules

Before starting any work please respect all the safety standards:

- PV modules generate DC electrical energy when exposed to sunlight or other light sources. Active parts of module such as terminals can result in burns, sparks, and lethal shock.

- Always wear protective head gear, insulating gloves and safety shoes (with rubber soles).

- Due to the risk of electrical shock, do not perform any work if the terminals of the PV module are wet. Use insulated tools and do not use wet tools.

- During the operation, don’t use sharp tools to wipe the back sheet and glass. It will leave scratches on the module.

- Never disconnect the PV Module connectors under load.

- Do not cut the wires while the module is under load.

- Do not open a Fuse Switch Disconnectors if they do not have protection to mitigate electrical arcing.

- Do not remove any part installed by Jinko Solar or disassemble the module.

- Don’t lift up PV modules using the attached cables or the junction box.
1. Operation & Maintenance Criteria

1.1 Introduction
Prior to commissioning of a Solar PV plant, we recommend that:
- The entire PV system is checked, tested & approved according to the existing local regulations.
- Depending on the local regulations, testing and commissioning of PV plants should be conducted by persons licensed or approved by the regulating authority.
- Operation and maintenance of PV modules should be as specified by Jinko and should adhere to local regulations.

It is also advisable that one should inspect the modules visually to find if there are any visual defects, if there are, the following items should be evaluated:
- If there is any dirt, fallen leaves or bird droppings from the surface, and check if there is damage to the surface of the module.
- If modules are observed having slight cell color differences at different angles, this is a normal phenomenon of modules with anti-reflection coating technology.
- Whether the glass is broken.
- No sharp objects are in contact with the PV module surfaces.
- PV modules are not shaded by unwanted obstacles and; or foreign material.
- Corrosion along the cells’ bus-bar. The corrosion is caused by moisture intrusion thought the module back sheet. Check the back sheet for damage.
- Check whether the back sheet is burnt out.
- Check if screws and mounting brackets are tight, adjust and tighten as necessary.

It’s also recommended to implement the following preventive maintenance every 6 months:
- Check the sealing gels of the junction box for any damage.
- Examine the PV module(s) for signs of deterioration. Check all wiring for possible rodent damage, weathering and that all connections are tight and corrosion free. Check electrical leakage to ground.

1.2 Defects criteria
The subtopics below give information on the Jinko criteria to detect and recognize a possible defect.

1.2.1 Hot spot
A hot-spot occurs in a module when its operating current exceeds the reduced short-circuit current of a shadowed (reverse biased) or faulty cell or group of cells within it.

Procedure
1) Inspect the surface of the solar modules carefully and remove any possible cause of shading and dirt
2) Ensure the PV array is connected and operating
3) Check inverter display or String electrical output
4) Position the camera as perpendicularly as possible to the object being measured
5) Avoid any shading effect during the measurement phase
6) Record module serial number, time, date, picture number, and module location in the array
**General requirement for Infrared Image Camera**

Temperature Measurement Accuracy, within +/- 2 °C,
Camera resolution (infrared), at least 160*120 (19200 Pixels).

**Criteria**

The temperature difference between two adjacent cells within the same module (except junction box) should not be more than 20°C. Jinko will only consider a hot spot when the temperature exceeds 20°C.

![Image of Infrared Image Camera showing temperature differences](image)

*Figure 1: Illustration of hotspot as a result of difference in cell temperature*

Any damage caused by shading, system design, installation, maintenance or force majeure shall void the warranty.

For each affected module please provide the following as a proof of the defect:

- Thermal image with a clear information of the temperature.
- Normal front picture of the module
- Serial number related
- Purchase order / Contract
- Completed claim form

**1.2.2 Disconnected Substring**

**Indicators**

- Measured open circuit voltage (Voc) should be approximately 2/3 or 1/3 of the Voc in STC Conditions when measured with a digital multi meter. This is an approximation and actual readings may vary due to module temperature/ Irradiance level.

- A IV curve should show open circuit voltage (Voc) should be approximately 2/3 or 1/3 of the Voc in STC Conditions when measured with a digital multi meter. This is an approximation and actual readings may vary due to module temperature/ Irradiance level.

- A IR Picture may show one or two substrings with a slightly higher temperature level.
• A IR Picture should show elevated diode temperature as they will be conducting.

![Image of IR Picture]

**Figure 2: Effect of Disconnected Substring**

For each affected module please provide the following as a proof of the defect:

- Thermal image with a clear information of the temperature
- Normal front picture of the module
- Serial number related
- Purchase order / contract
- Completed claim form

### 1.2.3 Delamination

A delamination occurs when the bond between the plastics (on the back) and the glass (on the front) fails. A delamination forming a continuous path between any part of the electrical circuit and the edge of the module is considered as a major defect. Delamination’s are problematic for a solar panel because it may allow air and moisture to penetrate the module potentially causing corrosion, power degradation, optical loss and eventually a failure.
**Figure 3: Module delamination**

**WARNING!** *The delamination of the back sheet may cause exposure to active electrical components, especially when the modules are wet.*

Due to the delamination, moisture can get to the cells which leads to cell corrosion and an ongoing performance loss. Further, the light transmission is reduced.

For each affected module please provide the following as a proof of the defect:

- Clear picture of the defect
- Photo of the whole module
- Serial number related
- Purchase order / Contract
- Completed claim form

**1.2.4 Glass Breakage**

In most cases glass breaks are caused by external conditions such as poor handling during transportation, during installation or by hail and stone throwing.
Glass breakage from Hit

- Clear hit point
- Splintering of glass parts
- Possible deformation of the frame
- Panels with broken glass should be replaced.

Only in case of manufacturing issue Glass Break is considered as a defect.

Spontaneous glass breakage

- No hit point and no deformation of the frame
- Initial point with the contour of a butterfly, radial yield lines

For each affected module please provide the following as a proof of the defect:

- Clear picture of the defect
- Photo of the whole module
- One or more detail photo of the initial point of the glass breakage
- Serial number related
- Purchase order / contract
- Completed claim form

Figure 4: Glass breakage from direct hit

Figure 5: Spontaneous glass breakage

1.1.5 Junction box issues

The junction box makes the electrical connection from the cables to the solar cells in the solar module. Three bypass diodes are in parallel to the cell substrings inside the solar module. Bypass diodes are electric components that in case of partial or complete shading on the modules will conduct thereby short circuiting the shaded sub string.
Faulty bypass diodes or connections due to a manufacturing defect may cause the diodes to overheat and lead to arcing in the junction box. Junction box top temperature should be less than 90 °C under normal operating conditions. Should the junction box temperature exceed 90°C please provide Jinko Solar the following as a proof of the defect for each affected module:

- Junction box Thermal Image
- Normal digital picture of the module’s back-side
- Serial number related
- Purchase order / Contract
- Completed claim form

1.2.6 Low Performance Defect

Should low performance be suspected, we recommend on site I-V curve tests to be completed. I-V curve tracing reveals more about the operating conditions of a PV module or array than any other measurement method. It is also the fastest way to test the performance of a PV module.

The I-V curve (Error! Reference source not found.) represents all the possible operating points (current and voltage) of a PV module under normal operating conditions. The curve starts at the short circuit current and ends at the open circuit voltage. The maximum power point, located at the knee of the I-V curve, is the operating point that delivers the highest output power. It is the job of the inverter to find and operate at that point on the I-V curve, and to adapt as the curve changes with irradiance and temperature. The P-V curve (power versus voltage) reads zero at the ends and a maximum at the knee of the I-V curve. Any impairment – such as shading, soiling, or series resistance – that affects the shape of the I-V curve (Figure 7) will reduce the maximum power and diminish the value of the array as an energy source.
If the performance of the single PV module is under the minimum value guaranteed, Jinko technical team will investigate the root cause and provide support performing site inspection or lab test if needed.

For each affected module please provide the following as a proof of the defect:

- I-V curves report and data
- Technical plant document design (SLD, Layout, Report)
- General pictures of the plant (PV array, Inverters, Mounting system)
- Picture of the affected modules
- Serial number related
- PO / contract
- Completed claim form

### 1.2.7 Major visual defects

Summarizing, the following are considered to be major visual defects:

- Broken, cracked, or torn external surfaces, including superstrates, substrates, frames and junction boxes;
- Bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the installation and/or operation of the module would be impaired;
- A crack in a cell the propagation of which could remove more than 10 % of that cell's area from the electrical circuit of the module;
- Bubbles or delamination forming a continuous path between any part of the electrical circuit and the edge of the module;
- Loss of mechanical integrity, to the extent that the installation and/or operation of the module would be impaired.
For each affected module please provide the following as a proof of the defect:

- General pictures of the solar module in situ
- Picture of the affected area
- Serial number related
- PO / contract
- Completed claim form

### 1.2.8 Cosmetic Issues

General imperfections on the front/rear surface are considered as an appearance effect, and it has no further impact on module power output, performance and reliability.

However, if any module founded with any cosmetic issue and power output is lower than the guaranteed power, Jinko tech technical team will investigate the root cause and provide support performing site inspection or lab test if needed. Please refer to previous section on power loss.

For each affected module please provide the following as a proof of the defect:

- I-V curves report and data
- Technical plant document design (SLD, Layout, Report)
- General pictures of the plant (PV array, Inverters, Mounting system)
- Picture of the affected modules in situ
1.2.9 Snail trails
Jinko Solar confirm and guarantee that the phenomenon of snail trail is only an appearance effect.

It has no further effects on module power output or performance.

However, still if any module founded with snail trail and power output is lower than the guaranteed power, Jinko tech technical team will investigate the root cause and provide support performing site inspection or lab test if needed. Please refer to section on power loss.

![Figure 9: Snail trails in Module cells](image)

For each affected module please provide the following as a proof of the defect:

- I-V curves report and data
- Technical plant document design (SLD, Layout, Report)
- General pictures of the plant (PV array, Inverters, Mounting system)
- Picture of the affected modules in situ
- Picture of the affected area
- Module serial number
- PO / contract
- Completed claim form

1.3 Diagnostic tools

1.3.1 Infrared Imaging
IR imaging should be done with the system operating at peak levels if possible.

Tools include:

- IR Camera (can be with Quadrocopter), such as Fluke PTi120, Ti480 PRO, RSE600, HT-02D.
- Clamp-on ammeter.
1.3. 2 Megohmmeter (‘Megger’) Tracing
Megohmmeter or “megger” testing is a valuable way to identify weakened conductor insulation and loose wiring connections.

- IRT megohmmeter: Megger MIT 1020, CA 6116/7.
- DC clamp-on meter.
- DC voltmeter.

1.3.3 IV Curve Testing
The I-V Curve Tracer is an electrical test for verifying photovoltaic array performance. For each string, the I-V Tracer measures current and power as a function of voltage. These Traces would include:

- Seaward PV 210/200
- HT Instruments IV tracer.
- Solmetric Power analyzer.

1.3.4 DC System Voc Checks
DC voltage checks are done with the system off, but—depending on the system size—voltages of up to 1,500 Vdc may be present. Ideally, test in stable sunlight of more than 750W/m². However, stable conditions more than 200 W/m² still allow for simple comparisons among strings.

Tools include:

- DC Multimeters e.g. Fluke381/376Fc, Mastech 52xx series, Klein voltmeters.
- Irradiance meter.
- Temperature sensor.

1.3.5 DC System Imp Checks
The dc Imp tests are completed with the system running. Full operating voltages and current are present in the combiner boxes. Test should be done in full, stable sunlight. Usually, a minimum stable irradiance of 500 W/m² will allow for accurate comparisons among strings.

Tools include:

- DC clamp meter; Fluke, Mastech MS series, Fluke 376, Klein clamp meters
- Irradiance meter;
- Temperature sensor.

Note:

- The list of tools stated is just a guideline.
- Please refer to the manufacturer’s manual for correct operating procedure for each of the instruments.
2. Module cleaning

2.1 Summary
With the passage of time, dirt and dust may accumulate on the glass surface of the module, reducing the power output of the module. Jinko recommends regular cleaning of modules to ensure maximum power output especially in low rainfall areas. It is important to note below key points while cleaning Jinko’s PV modules.

- Don’t use bare fingers or hands without gloves to touch or handle the glass surface of modules. Wear clean gloves to prevent fingerprints and other dirt from staying on the glass. Fingerprints may not be able to be removed from the ARC-glass.
- It is not allowed to use metal tools such as blades, knives, steel wool and other abrasive materials.
- All types of soft foam materials, non-woven fabrics, whisks, soft sponges, soft brushes and hair brushes may be used.

2.2 Preparation before operating
2.2.1 Main Equipment
Main equipment including: Specially modified water wheel (with water tank, supercharging device etc.) capacity around 10 m³, see below.

*Figure 11: 10m³ Water boozer with clean water

Figure 10: Four-way adapter*
2.2.2 Auxiliary Tools

i) **Four-way adapter**: simple principle can be seen in Figure 10. The sectional area of central discharging tube is 1/2~1/3 of both two sides.

ii) **Water pipe**: 4~6 branched passages, resist compress, outdoor use; Select flexible pipe length according to PV array length, central pipe length is 1/3 of array length, two sides length is ½ of array length, then it can ensure the one-time clean-up at the entire array and work synchronously in the three parts.

iii) **Adjustable nozzle**: Cleaning staff can control the water yield according to the module surface condition, better to save water under the premise of normal cleaning. Nozzle uses sector mode to discharge water.

Long arm adjustable wiper blade: Glass cleaning special tool, see details in Figure 12.

![Cleaning Equipment](image)

*Figure 12: Cleaning Equipment-Long arm adjustable wiper blade*

One set of raincoats, rain pants, rain boots and rubber gloves to proof water, especially important when clean modules in winter.

2.2.3 Personnel Allocation

Total 7 persons, including 3 washing staff, 3 scrapping staff, 1 drive. Since scrapping workload is heavier than other work, should interchange with washing staff.

2.3 Cleaning Method and Procedure

Use sector nozzle to adjust water pressure to clean up the dirt according to site module surface condition, normally 6kg pressure is appropriate. Need to pay special attention to bird droppings and residual EVA as they will cause “hot spot effect”. Under the status of jetting water, use wiper blade to scrap to clean up. Cleaning time can be 9:00 AM at sunny weather during winter and end time can be adjusted according to the outdoor temperature, should prevent accumulation of dirt because of the frozen. During cleaning, stamping on the module, using hard tools like metal to scrap dirt or jetting hot water on the module is strictly prohibited. Oil substances, if any, can be removed by alcohol after the normal clean procedure.

2.3.1 Fixed Module Cleaning

Because of the unified orientation and dip angle for fixed modules, it’s convenient for massive cleaning. See details in Figure 13.
2.3.2 Sun Tracking module cleaning

Sun-tracking module and fixed module cleaning methods are similar, only add one adjusting step to ensure the best cleaning orientation and dip angle on sun-tracking module. Since the array of single axis tracing system and linkage single axis tracing system is short, need operate alternatively between front and back side and be careful to splash water to each other. Because double axis tracing system is higher, need use bigger size pipe to wash intensively. Personnel allocation: total 3 persons, including 1 driver, 1 washing staff, 1 auxiliary staff for righting the pipe, etc. Details can be seen in Figure 14 and Figure 15, can use height tools if necessary.

2.4 Notice

Cleaning should be done thoroughly, if there’s corner pocket remaining (as Figure 16), it will cause serious consequences like “Hot Spot Effect”. Under the normal irradiance, uncleaned corner cell becomes to power consuming unit, sheltered cell becomes to load resistance result in “Hot Spot Effect”. This process will accelerate aging, decrease power output and cause fire if serious.
2.4.2 Hair brush specification

- Materials of special wires for hair brushes: nylon wire 1010;
- Required diameter of special wires for hair brushes for cleaning ARC-glass: 0.1-0.06mm

2.4.3 Planning of cleaning cycle and region

For a large-scale photovoltaic station with large floor area and a large number of modules, the time appropriate for the cleaning operations is short each day; it is necessary to plan the cleaning cycle and divide regions according to the specific circumstances of the electric field so as to complete the cleaning work of the photovoltaic station with less manpower.

The subregion division in the cleaning work should be carried out according to the electrical structure of the photovoltaic station, and should ensure that each of the cleaning work can cover all components connected to a number of combiner boxes or inverters.

2.4.4 Routine steps of cleaning

a) Step 1: Whisking
Deposits such as dry floating dust and leaves on the module surface should be whisked off with a dry whisk or cloth. If there are no other deposits on the module surface, and the module has been cleaned in this step, the following steps may be dispensed with.

b) Step 2: Scraping
If there is hard foreign matter such as dirt, bird droppings, plant branches, leaves, etc., closely attached to the module, the module should be scraped with non-woven fabric or hair brush and must not be scratched with high-hardness objects; if the foreign matter is removed, do not scratch regions without hard deposits.

c) Step 3: Washing
If there are colored substances such as bird droppings, plant juices, etc., on the modules surface, or dust that cannot be whisked off due to high indoor humidity, the colored substances need to be removed by cleaning. The colored substances are generally removed with clean water by spraying the clean water onto the region with pollutants and scraping with a hair brush.
Oily substances, if any, may be removed by coating water blended with alcohol onto the colored region and scraping with a hair brush after the solution penetrates through the pollutants. If necessary, the module may be cleaned with commercial glass cleaner, together with non-woven fabric.

### 2.4.5 Module cleaning summary instructions

- All types of commercial glass cleaners, alcohol/ethanol/methanol may also be used.
- Do not use abrasive powders, abrasive cleaners, scrubber cleaners, polishers, sodium hydroxide, benzene, nitro-thinners, acid or alkali and other chemical substances.
- The pressure of the cleaning water should be less than 690KPa, i.e. most municipal water used as cleaning water. It is not recommended to use water with high mineral content as it may deposit on the glass surface when the water is dry.
- Do not use steam or corrosive chemicals to speed up the cleaning.
- Do not try to clean broken glass or module with broken lines or exposed wires, as it may cause electric shock.
- The module glass cleaning should be done in the early morning, in the evening, at night or on rainy days. At the same time, when cleaning in the morning or evening, select the period when sunshine is not strong.
- Modules in power plant should be cleaned per month at least.
- Before cleaning, it should be applied to the operating manager and recorded.
- Cleaning work should be divided according to responsible area and work respectively.
- The person in charge should be responsible for their work area.
- During cleaning, if find any potential safety hazard like module damage or electric leakage etc., should report and handle timely.
- When cleaning, workers must pay attention to personal safety, equipment safety and water wheel safety to avoid any accident.
- The standard for qualified cleaning is no dust or dirt within 3-meter sight.
- Fill in the module cleaning worksheet after finish for further archiving.
3. Claim Submitting Procedure

To submit a warranty claim please follow these steps:

**Phase A:**

1. Perform the site inspection to detect any possible defect/effect according to our criteria described herein and collect all the info and evidence required.

**Phase B:**

1. Fill in the Excel Claim Form attached. **Every field must be compiled.**
2. Provide pictures and proof of the defect for every claimed panel.
   - In case of electrical/performance defect provide the measurement set-up and picture of the device’s display, IV curves.
   - In case of visual defect please provide different pictures from different perspectives.
   - All photos must be minimum 1MB size, please pay attention about the definition of the photos.
   - Provide SNs of all the claimed modules.
3. Send the package by email/shared folder to your local sales manager
   
   **PS. Email should not be bigger than 20 MB.**

Jinko Solar customer service team will respond in 3 working days.

Technical department will check and provide our analysis in order to provide the best possible solution.

*Note: Read Jinko’s warranty document to understand the warranty terms which are specific to the modules supplied.*