Visual Inspection:

1. Environmental & Lighting Conditions

- **Illumination**: Perform inspection under **uniform, diffuse daylight** or artificial light of at least **1000 lux**.
- **Viewing Angle**: Inspect at a **normal (90°) angle** and from various angles for better defect detection.
- **Distance**: Maintain a **distance of about 50 cm (0.5 m)** from the module for general inspection.
- **Surface Cleaning**: Ensure the module surface is **clean and dry** before inspection.

2. Glass Surface & Coating

- No **cracks, chips, or scratches** on the tempered glass.
- No **discoloration or delamination** of the anti-reflective coating.
- No **bubbles, moisture ingress, or dirt accumulation** inside the glass.

3. Solar Cells & Encapsulation

- No **microcracks, broken, or misaligned solar cells** (can be checked using Electroluminescence testing).
- No **burn marks, hotspots, or discoloration** on the cells.
- Even **cell spacing and uniform encapsulation** without air pockets or bubbles.

4. EVA (Encapsulant) & Backsheet

- No yellowing, delamination, or bubbles in the encapsulant.
- Backsheet is intact, without cuts, cracks, or peeling.
- No moisture penetration visible.

5. Frame & Structural Integrity

- Frame should be aligned properly, with no dents, bends, or corrosion.
- No loose screws, missing bolts, or detached parts.
- Properly sealed edges to prevent water ingress.

6. Junction Box & Cables

- Junction box is securely attached and free of cracks or damage.
- MC4 connectors and cables are properly attached and not frayed, exposed, or damaged.
- Bypass diodes are installed correctly with no signs of overheating.

7. Labeling & Markings

- Manufacturer's label is intact with correct module specifications (power rating, voltage, current, certifications).
- Safety and warning labels are clearly visible.
- Serial numbers match factory records.

8. Contamination & Foreign Objects

- No **dirt, dust, or bird droppings** affecting module efficiency.
- No **foreign objects like metal shavings or insects** inside the panel.
- No **trapped moisture or water streaks** inside the module.

IV Characterization (Flash Test) Sun Simulation at STC

The **acceptance criteria** for **IV Characterization (Flash Test)** in **solar PV modules** typically include the following parameters:

1. Electrical Performance Parameters

- Peak Power (Pmax): Must be within the tolerance specified in the datasheet (e.g., ±3% of the rated power).
- **Open Circuit Voltage (Voc):** Should match or be within a small tolerance of the expected value.
- **Short Circuit Current (Isc):** Should be within the expected range, considering measurement uncertainty.
- **Maximum Power Voltage (Vmp) and Current (Imp):** Should align with the expected values.

2. Efficiency and Fill Factor

- Fill Factor (FF): Typically above 70% for good-quality modules.
- Module Efficiency: Must meet or exceed the minimum efficiency specified by the manufacturer or relevant standards.

3. Visual and Physical Inspection

- No visible defects like cracks, delamination, bubbles, or discoloration.

4. Test Conditions Compliance

- Measurements taken under **Standard Test Conditions (STC):**
  - **Irradiance:** 1000 W/m²
  - **Module Temperature:** 25°C
  - **Air Mass (AM):** 1.5
- If measured under different conditions, results should be corrected to STC using appropriate correction factors.

5. Deviation Limits for Batch Acceptance

- The deviation in power output across a batch should be minimal (e.g., <2% variation among modules).
- **Binning Criteria:** Modules are grouped based on power output to ensure uniformity in installations.

6. Compliance with Standards

- Must meet IEC 61215 and IEC 61730 requirements for performance and safety.
- Manufacturer's internal quality standards should be met.

Factory Acceptance Test (FAT) for Electroluminescence (EL) in Solar PV Modules

The **Electroluminescence (EL) test** is a critical quality control test performed during the **Factory Acceptance Test (FAT)** for solar PV modules. It helps detect microcracks, soldering defects, and other hidden defects that are not visible under normal inspection.

1. Purpose of EL Test in FAT

- To identify **microcracks**, **cell defects**, **soldering issues**, and **mechanical damage** that may affect module performance.
- To ensure **uniform current flow** and **proper interconnections** within the module.
- To verify **module quality before shipment** to customers.

2. Acceptance Criteria for EL Test

The following criteria should be met for a module to pass the FAT EL test:

A. Structural Integrity & Cell Quality

- **No Major Microcracks** – Modules should be free from large cracks that can impact power output.
- **No Broken or Disconnected Cells** – All solar cells must be intact and properly connected.
- **No Significant Soldering Defects** – Poor soldering can cause hotspots and reduce module lifespan.
- **Uniform Luminescence** – The module should show a **uniform bright EL image**, indicating even current flow.

B. Defect Tolerance Limits

- **Minor Hairline Cracks** – Acceptable if they do not affect electrical continuity.
- **Edge Chips** – Allowed if they do not extend into active cell areas.
- **Black Spots (Shunts/Dead Cells)** – Not acceptable if they cause significant power loss.
- **Broken Busbars or Interconnect Ribbons** – Modules with disconnected busbars must be rejected.

3. Test Methodology

A. Test Setup

- **Power Supply:** Applies forward bias voltage to activate EL emission.
- **Infrared Camera:** Captures EL images in a dark environment.
- **Software Analysis:** Identifies and quantifies defects.

B. Test Conditions

- **Dark Room Environment** – To ensure clear EL images.
- **Applied Voltage:** Close to module's Voc (open circuit voltage).
- **Camera Resolution:** Sufficient to capture fine defects (e.g., 5MP or higher).

4. Batch Acceptance Criteria

- **Sampling Rate:** 100% testing for high-quality assurance or random sampling based on AQL (Acceptance Quality Limit).
- **Failure Rate:** If defect rate exceeds the allowable limit, re-inspection or corrective actions must be taken.

5. Compliance Standards

- **IEC 60904-13:** Electroluminescence imaging for PV modules.
- **IEC 61215:** Design qualification and type approval for crystalline PV modules.

Defect Type	Description	Acceptable Limit
Microcracks	Thin cracks in solar cells	Allowed if not affecting cell performance.
Disconnected Cells	Cells not emitting EL light	Not acceptable.
Shunts	Dark spots indicating leakage	Not acceptable if large or excessive.
Broken Busbars	Gaps in conductive pathways	Not acceptable.
Edge Chipping	Small breaks at module edges	Allowed if not extending into active cell areas.
Uneven Luminescence	Variation in brightness	Acceptable within specified limits.

Factory Acceptance Test (FAT) – Electrical Isolation Test (Dry Hipot) in Solar PV Modules

The **Electrical Isolation Test (High Potential or Dry Hipot Test)** is a critical quality assurance test for solar PV modules. It ensures that the module's insulation can withstand high voltage stress without breakdown, preventing electrical hazards and leakage currents.

1. Purpose of the Electrical Isolation Test (Dry Hipot)

- Verify that the **insulation between the active circuit and the module frame** is intact.
- Detect **potential insulation defects**, such as poor encapsulation, moisture ingress, or material degradation.
- Ensure compliance with **safety and quality standards (IEC 61215, IEC 61730, UL 1703, UL 61730).**

2. Test Methodology

A. Test Equipment

- **High Voltage DC or AC Source** (Hipot Tester)
- **Insulation Resistance Meter**
- **Test Probes or Clips** (for connecting to module terminals and frame)
- **Enclosed Testing Area** (for safety during high-voltage application)

B. Test Procedure

1. Prepare the Module

- Ensure the module is **clean and dry** to prevent false failures.
- Place the module in a **controlled environment** (typically at 25°C ± 2°C, 50% RH).

2. Connect the Hipot Tester

- **Positive Terminal (+):** Connected to the PV module circuit (either short-circuited across positive and negative terminals or tested individually).
- **Negative Terminal (-):** Connected to the module **frame** (grounded part).

3. Apply Test Voltage

- For **DC Hipot Test:**
  - **1000V system:** Test at **2 × (Uoc max) + 1000V** for **1 minute**.
  - **1500V system:** Test at **2 × (Uoc max) + 2000V** for **1 minute**.
- For **AC Hipot Test:**
  - 50Hz or 60Hz frequency
  - Voltage typically **1500V AC** for 1 minute.

4. Monitor Leakage Current

- Measure the current leaking through the insulation during voltage application.

5. Pass/Fail Criteria

- If **leakage current is within the specified limit** and no **electrical breakdown (flashover or insulation failure)** occurs, the module **passes**.
- If leakage current **exceeds the allowable limit** or breakdown occurs, the module **fails**.

3. FAT Acceptance Criteria for Dry Hipot Test

Parameter	Acceptance Criteria
Test Voltage (DC)	2 × (Uoc max) + 1000V (1000V system) / + 2000V (1500V system)
Test Voltage (AC)	Typically **1500V AC**
Test Duration	1 minute
Maximum Leakage Current	≤50 µA (as per IEC 61730-2)
Breakdown or Flashover	Not Allowed
Insulation Resistance	**40 MΩ** (for 1000V systems)

Factory Acceptance Test (FAT) – Ground Continuity Test for Solar PV Modules

The **Ground Continuity Test** is a critical safety test in the Factory Acceptance Test (FAT) process for solar PV modules. It ensures that the **metallic frame of the module is properly bonded** to ground, minimizing the risk of electrical shock and improving system safety.

1. Purpose of the Ground Continuity Test

- Verify that the **electrical connection between the module frame and the grounding point** is intact.
- Ensure **low resistance** between the frame and grounding terminal to avoid excessive voltage buildup.
- Meet safety and compliance standards such as **IEC 61730-2, UL 1703, and UL 61730**.

2. Test Methodology

A. Test Equipment

- **Low-Resistance Ohmmeter (Milliohm Meter)**
- **Continuity Tester** with buzzer (for quick checks)
- **Four-Wire (Kelvin) Test Probes** (for accurate low-resistance measurement)

B. Test Setup

1. Prepare the PV Module

- Ensure the module is **clean and dry**.

- Place it in a controlled environment (typically **25°C ± 2°C**).

2. Connect the Test Equipment

- One probe is attached to the **earmarked grounding hole or grounding point**.
- The other probe is attached to a **different metallic part of the module frame**.

3. Measure Resistance

- Apply **low voltage (<24V DC or AC)** to avoid damage.
- Measure the **electrical resistance** between the grounding point and the frame.

4. Pass/Fail Criteria

- If **resistance is within acceptable limits**, the module **passes**.
- If resistance is too high (indicating poor grounding), the module **fails**.

3. FAT Acceptance Criteria for Ground Continuity Test

Parameter	Acceptance Criteria
Test Voltage	≤ 24V DC or AC
Maximum Resistance	**≤ 0.1 Ω** (as per IEC 61730-2)
Break in Continuity	Not Allowed
Audible Buzzer Check	Must indicate continuity

Factory Acceptance Test (FAT) – Dimension Check Criteria for Solar PV Modules

The dimension check is an essential quality control step in the Factory Acceptance Test (FAT) for solar PV modules. It ensures that the modules meet the specified mechanical design requirements and are consistent in size for proper installation and system compatibility.

1. Purpose of the Dimension Check

- Ensure the **length, width, and thickness** of the PV module meet the manufacturer's specifications.
- Verify the **flatness, squareness, and uniformity** of module construction.
- Ensure **mounting hole positions** are correctly aligned for proper installation.
- Prevent **mechanical compatibility issues** in solar panel arrays.

2. Test Methodology

A. Equipment Required

- **Digital Caliper** (for precise measurements of small dimensions)
- **Measuring Tape** (for overall module dimensions)
- **Gauge or Template** (for mounting hole position verification)

- **Straight Edge Ruler** (to check flatness and warping)

B. Test Procedure

1. **Module Placement:**
- Place the module on a **flat surface** for accurate measurement.
- Ensure the module is **free from stress or bending** during measurement.

2. **Measure Key Dimensions:**
- **Overall Length (L)**: Measure from edge to edge along the longest side.
- **Overall Width (W)**: Measure across the shorter side.
- **Thickness (T)**: Measure from the backsheet to the front glass surface.
- **Diagonal Lengths**: Compare both diagonals to ensure squareness.

3. **Verify Mounting Holes:**
- Check the **hole-to-hole distance** and **hole diameter** using a template or caliper.

4. **Flatness Check:**
- Use a **straight edge ruler** to detect excessive warping or bending.

Parameter	Acceptance Criteria
Length (L)	±2 mm of specification
Width (W)	±2 mm of specification
Thickness (T)	±1 mm of specification
Diagonal Difference	≤3 mm (to ensure squareness)
Mounting Hole Position	±1 mm tolerance
Flatness	No visible warping beyond 2 mm deviation

Mechanical Load Test for Solar PV Modules

The **Mechanical Load Test** is a critical evaluation of a solar PV module's ability to withstand static and dynamic mechanical stresses such as wind, snow, and handling forces during installation and operation. This test is performed per **IEC 61215** and **IEC 61730** standards to ensure module durability and structural integrity.

1. Purpose of the Mechanical Load Test

- Assess the module's ability to withstand **wind pressure, snow loads, and other environmental forces**.
- Identify potential **glass breakage, frame bending, cell cracks, and interconnection failures**.
- Ensure compliance with **IEC 61215 & IEC 61730** standards.

2. Test Methodology

A. Equipment Required

- **Mechanical Load Testing Machine** (for uniform pressure application)
- **Supporting Frame or Fixture** (to hold the module in a realistic mounting condition)
- **Deflection Measurement Tools** (for frame bending evaluation)
- **Electroluminescence (EL) Imaging System** (to detect microcracks after testing)

B. Test Procedure

1. Pre-Test Inspection

- Conduct a **visual inspection** and **electroluminescence (EL) imaging** to check for pre-existing defects.
- Record **module dimensions and frame condition**.

2. Mounting the Module

- Secure the module on a **rigid mounting structure** to simulate real-world conditions.
- Follow the manufacturer's recommended **clamping positions**.

3. Apply Mechanical Load

- The module is subjected to a **static load** by applying force uniformly over the front and rear sides.
- The standard test load is:
  - **2400 Pa (Pascal) for Wind Load** (equivalent to ~130 km/h wind).
  - **5400 Pa for Snow Load** (for heavy snowfall regions).
- Maintain the load for **60 minutes per cycle**.

4. Cycle Repetitions

- The module undergoes at least **three cycles** of positive and negative pressure loading.
- Optional: **Dynamic load testing** may be performed to simulate real-world wind gusts.

5. Post-Test Evaluation

- **Visual Inspection:** Look for frame deformations, glass cracks, or cell damage.
- **EL Imaging:** Check for **microcracks or interconnection failures**.
- **Power Measurement:** Conduct IV (Flash) Testing to ensure power output is within acceptable limits

3. FAT Acceptance Criteria for Mechanical Load Test.

Parameter	Acceptance Criteria
Load Applied	2400 Pa (wind) / 5400 Pa (snow)
Test Duration	60 minutes per cycle
Frame Deformation	**≤ 3 mm bending** (per IEC 61215)
Glass Breakage	Not allowed
Cell Microcracks	No major cracks (checked via EL imaging)

Power Output Deviation	≤ 5% loss from initial measurement
Electrical Insulation	Must pass electrical isolation test

Robustness of Termination Test for Solar PV Modules

The **Robustness of Termination Test** evaluates the strength and durability of the **junction box, connectors, and cable terminations** in a solar PV module. This test ensures that the electrical terminations can withstand mechanical stress without damage, preventing electrical failures in the field.

1. Purpose of the Robustness of Termination Test

- Ensure the **junction box and cable terminations** can endure mechanical stresses.
- Prevent **connector failures, loose contacts, or breakage** during installation and operation.
- Comply with **IEC 61215 & IEC 61730** mechanical integrity requirements.

2. Test Methodology

A. Equipment Required

- **Tensile Force Testing Machine** (to apply pulling force on cables).
- **Torque Wrench** (to measure rotational force on connectors).
- **Junction Box & Connector Clamping Fixture** (to secure the module during testing).
- **Multimeter & Insulation Tester** (to verify electrical continuity after testing).

B. Test Procedure

1. Pre-Test Inspection

- **Visual inspection** of junction box, cables, and connectors for any defects.
- Measure **initial insulation resistance and continuity**.

2. Mechanical Stress Tests

- **Pull Test (Cable Retention Strength Test)**
  - Apply a **tensile force of 60N (for standard connectors)** or per manufacturer specification.
  - Hold the force for **60 seconds**.
- **Twist Test (Rotational Torque Test)**
  - Apply a **torque of 0.4 Nm** to the connectors for **60 seconds**.
- **Bending Test**
  - Bend the cables **90° in four directions** for **40 cycles**.

3. Post-Test Evaluation

- **Visual Check:** Ensure no damage to cables, junction box, or connectors.

- **Electrical Test:** Measure insulation resistance (**>40 MΩ**) and check for continuity.
- **Pull Force Verification:** Cables must remain securely attached.

3. AT Acceptance Criteria for Robustness of Termination Test

Parameter	Acceptance Criteria
Cable Pull Strength	**≥60N** for 1 min (no detachment)
Connector Torque	**0.4 Nm** for 1 min (no damage)
Bending Cycles	**40 cycles** without failure
Insulation Resistance	>40 MΩ at 500V DC
Electrical Continuity	No open circuits or increased resistance
Junction Box Integrity	No cracks, detachment, or loose contacts

Wet Leakage Test for Solar PV Modules

The **Wet Leakage Test** (also known as **Damp Leakage or Insulation Resistance Test**) is a critical safety test for solar PV modules. It evaluates the insulation integrity under wet conditions to prevent **electric shock hazards and leakage currents** when the module is exposed to rain, humidity, or condensation.

This test is performed according to **IEC 61215 & IEC 61730** standards to ensure **safe operation in outdoor environments**.

1. Purpose of the Wet Leakage Test

- Verify the **electrical insulation** of PV modules under wet conditions.
- Detect **insulation defects** such as microcracks, encapsulation failure, or water ingress.
- Ensure compliance with **IEC 61730-2 & UL 61730** safety standards.

2. Test Methodology

A. Equipment Required

- **High Voltage Insulation Tester (Megohmmeter)**
- **Water Bath or Water Spray System** (with controlled conductivity)
- **Electrodes & Probes** (for applying test voltage)

B. Test Setup

1. **Prepare the Module**

- Clean the module surface and **remove any contaminants**.
- Submerge it in a **water bath (with controlled conductivity ≤100 Ωm)** OR
- Spray water **evenly** over the front glass & frame for 10 minutes.

2. **Apply Test Voltage**

- **Positive Terminal (+):** Connected to **shorted module output terminals (positive and negative together)**.
- **Negative Terminal (-):** Connected to **the water bath or a wet electrode on the module surface**.
- **Voltage Applied:**
- **1000V System:** Test at **1000V DC**
- **1500V System:** Test at **1500V DC**
- **Test Duration: 1 minute**

3. **Measure Insulation Resistance**

- Record the insulation resistance value **in megaohms (MΩ)**.
- Ensure no **arcing, insulation breakdown, or high leakage current**.
- Insulation resistance should be **≥40 MΩ per m²** of module area.
- If the leakage current exceeds the threshold or insulation resistance drops below the acceptable level, the module fails.

Factory Acceptance Test (FAT) Procedure for Light-Induced Degradation (LID) Test of Solar PV Modules

As per IEC 61215-2:2021 (Clause 5.8) – Light-Induced Degradation (LID) Test

1. Objective:

The **Light-Induced Degradation (LID) Test** evaluates the performance degradation of a photovoltaic (PV) module due to exposure to sunlight or artificial light sources. This test ensures that the module's power loss due to LID remains within acceptable limits as per IEC 61215.

2. Test Equipment Required:

- Solar simulator or xenon arc lamp (with AM 1.5 spectrum, 1000 W/m² intensity)
- Temperature-controlled chamber (capable of maintaining 25°C ± 2°C)
- IV curve tracer or power measurement setup
- Data logging system for monitoring power output

3. Test Procedure:

Step 1: Pre-Test Measurement

- Measure and record the initial power output (**P**max_{max}max), open-circuit voltage (**V**oc_{oc}oc), short-circuit current (**I**sc_{sc}sc), and fill factor (FF) of the module under **Standard Test Conditions (STC)** (1000 W/m², 25°C, AM 1.5 spectrum).
- Ensure the module has been stabilized (i.e., no prior exposure to light that could affect measurements).

Step 2: Light Soaking Procedure

- Expose the module to a **light source** with an irradiance of **1000 W/m² ± 10%** under controlled environmental conditions (25°C ± 2°C).
- Maintain the exposure until the total cumulative energy reaches **5 kWh/m²** (typically 10-20 hours of exposure).
- If using a high-intensity light source (e.g., xenon arc lamp), adjust the duration to achieve an equivalent dose.
- Modules can be held at a temperature of **50°C to 60°C** to accelerate degradation, if required.

Step 3: Post-Test Measurement

- After completing the light exposure, allow the module to cool to **25°C ± 2°C**.
- Measure and record the power output (**P**max_{max}max), **V**oc_{oc}oc, **I**sc_{sc}sc, and FF under STC.

4. Acceptance Criteria (Pass/Fail Criteria):

- **Power Degradation (LID Loss):**
  - The reduction in **P**max_{max}max should not exceed **5%** of the initial power value.
  - Some manufacturers specify stricter limits (e.g., ≤2%) based on module design.

- **No Visual Defects:**
  - No visible degradation, discoloration, or delamination after the test.

- **Electrical Safety Compliance:**
  - The module should maintain insulation resistance and electrical integrity as per IEC 61730.

5. Reporting Requirements:

The FAT report should include:

1. **Module Identification:** Model, serial number, manufacturer details.
2. **Test Conditions:** Light source details, irradiance, temperature, and exposure duration.
3. **Pre- and Post-Test Data:**
   - **P**max_{max}max, **V**oc_{oc}oc, **I**sc_{sc}sc, and FF before and after exposure.
   - Percentage of power degradation.
4. **Compliance Status: Pass/Fail status based on acceptance criteria.**

Conclusion:If the **power loss is within the acceptable range (≤5%)** and there are **no visual or electrical defects**, the module passes the **LID FAT test**. Otherwise, it fails and may require process improvements in cell manufacturing to mitigate LID effects.

Factory Acceptance Test (FAT) for Potential Induced Degradation (PID) Test in Solar PV Modules

As per IEC 61215-2:2021 (Clause 5.10) & IEC 62804-1:2015

1. Objective:

The **Potential Induced Degradation (PID) Test** evaluates the long-term reliability of a PV module under high voltage stress and humidity conditions. PID occurs due to leakage currents between the module's active layers and the grounded frame, leading to power loss over time. This test ensures that the module is resistant to PID as per IEC standards.

2. Test Equipment Required:

- Environmental chamber (temperature & humidity controlled)
- High-voltage power supply (up to ±1000V or as per module rating)
- Conductive backing or grounded plate
- IV curve tracer or power measurement setup
- Insulation resistance tester

3. Test Procedure:

Step 1: Pre-Test Measurement

Measure and record the initial power output (Pmax_{max}max), open-circuit voltage (Voc_{oc}oc), short-circuit current (Isc_{sc}sc), and fill factor (FF) under Standard Test Conditions (STC) (1000 W/m², 25°C, AM 1.5 spectrum).

1. Ensure the module has not been exposed to prior PID-related stress.

Step 2: PID Stress Test

1. **Test Conditions:**
- Temperature: 60°C ± 2°C
- Relative Humidity: 85% ± 5%
- Voltage Stress: (–1000V) or system voltage (Umax_{max}max) applied between the module terminals and the grounded frame.
- Duration: 96 hours (or 192 hours if required by manufacturer specifications).

Test Setup:

- Place the module in the **environmental chamber**.
- Apply the **negative voltage** to the module's active layers while keeping the frame grounded.

- Maintain conditions for the required test duration.

Step 3: Post-Test Measurement

- After the PID stress period, allow the module to stabilize to **25°C ± 2°C**.
- Measure and record **P**max_{max}max, **V**oc_{oc}oc, **I**sc_{sc}sc, and **FF** under STC.
- Perform an **insulation resistance test** (must meet IEC 61730 safety standards).
- Visually inspect for any discoloration, delamination, or other physical defects.

4. Acceptance Criteria (Pass/Fail Criteria):

- **Power Degradation (PID Loss):**
  - Maximum power loss must be **≤5%** of the initial **Pmax_{max}max** (stricter limits apply for high-quality modules).
- **No Visual Defects:**
  - No evidence of cell discoloration, microcracks, or delamination.
- **Electrical Safety Compliance:**
  - The module should maintain **insulation resistance** and meet IEC 61730 requirements.

5. Reporting Requirements:

The FAT report should include:

- **Module Identification:** Model, serial number, manufacturer details.
- **Test Conditions:** Temperature, humidity, applied voltage, and test duration.
- **Pre- and Post-Test Data:**

  - **Pmax_{max}max**, **Voc_{oc}oc**, **Isc_{sc}sc**, and **FF** before and after exposure.
  - Percentage of power degradation.

Compliance Status: Pass/Fail status based on acceptance criteria.

Conclusion:

If the **power loss is ≤5%**, the module passes the **PID FAT test**. Any failure may indicate the need for **module design improvements**, such as anti-PID glass coatings, better encapsulation, or changes in cell manufacturing processes.

Site Inspection

Inspecting a solar PV module **is essential for ensuring optimal performance, safety, and longevity. Here are the key** steps involved in the inspection process**:**

1. Visual Inspection

Check for any **physical damage or defects** on the module surface, including:

- **Cracks or chips** in the glass.
- **Discoloration, delamination, or bubbles** in the panel.
- **Hotspots or burn marks** indicating overheating.
- **Loose, corroded, or rusted connections** in the junction box and wiring.
- **Frame integrity**—look for bent, loose, or damaged frames.

2. Electrical Inspection

- Measure **open circuit voltage (Voc)** and **short circuit current (Isc)** with a multimeter to compare with specifications.
- Check **string voltage and current** to ensure they match expected values.
- Inspect **connectors and cables** for loose connections, corrosion, or damage.
- Verify **proper grounding** to prevent electrical hazards.

3. Performance Testing

- Use an **IV curve tracer** to measure panel efficiency and compare it to rated performance.
- Conduct an **insulation resistance test** to check for leakage currents.
- Perform **thermal imaging** with an infrared camera to identify **hotspots** or faulty cells.
- Check **shading effects** that may reduce efficiency.

4. Structural & Mechanical Inspection

- Inspect **mounting structures** for rust, cracks, or loose bolts.
- Ensure **proper tilt and orientation** for maximum sunlight exposure.
- Check for **accumulated dust, bird droppings, or debris** that might affect performance.

5. Environmental & Safety Checks

- Inspect the **surrounding area** for tree branches, dirt accumulation, or objects causing shading.
- Check **weather seals and waterproofing** to prevent moisture ingress.
- Ensure **safety labeling and signage** are intact and visible.

6. Cleaning & Maintenance

- If dust, dirt, or bird droppings are present, clean the modules with **soft water and a microfiber cloth** (avoid harsh chemicals).
- Remove any obstructions or foreign objects near the panels.

7. Documentation & Reporting

- Record **findings, measurements, and defects** in an inspection report.

- Take **photos of damages or concerns** for future reference.
- Recommend necessary repairs or replacements.