What Solar Module Test Failures Reveal in 2026:

Key Takeaways from Kiwa PVEL's PV Module Reliability Scorecard

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INTRODUCTION

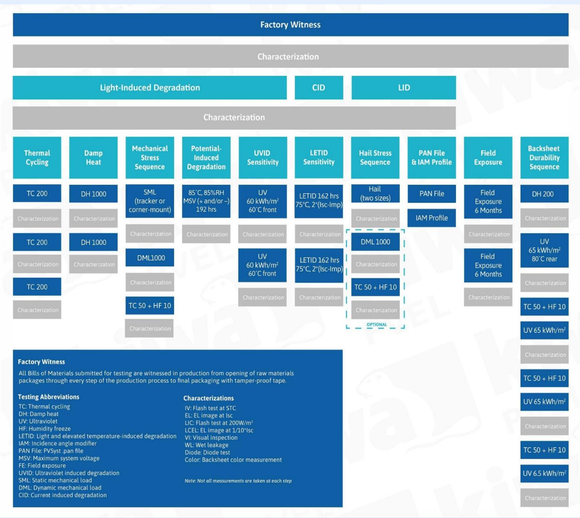
- **Kiwa PVEL's *2026 PV Module Reliability Scorecard*** highlights the latest testing insights from Kiwa PVEL's flagship Product Qualification Program (PQP).
- It's the solar industry's trusted resource for module reliability and performance data.
- Showcasing a broad range of Top Performer manufacturers and module model types.
- To earn Top Performer status, model types made from unique sets of bills of materials (BOMs) need to meet or exceed the stated criteria for that particular PQP test.

Failure Highlights:

- In 2026, the PQP failure rate continued to increase at manufacturer level and BOM level.
- 87% manufacturers had at least one PQP failure.
- 61% BOMs had at least one PQP failure.
- 45% manufacturers had at least one delamination failure.

METHODOLOGY

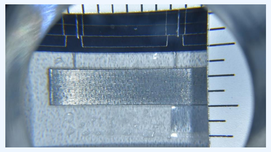
- **Eligibility for the 2026 Scorecard:** Manufacturers must have:
  - Completed PQP sample production factory witness after Nov. 1, 2024, and have at least one new Top Performer-achieving result not included in the 2025 Scorecard.
  - Submitted at least two factory-witnessed PV module samples to all PQP reliability tests, as per Kiwa PVEL's BOM Test Requirements.



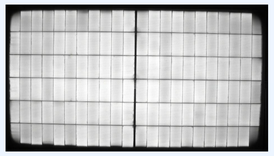
Visit kiwa.com/pvel/pqpv12 for updated PQP test plan.

PQP FAILURE TYPES

Safety Failure
Modules with safety failures may be hazardous to operate in field.



Visual Inspection
Helps identify issues that cause premature field failure.



Power Degradation
Modules with power loss failures may underperform in the field.

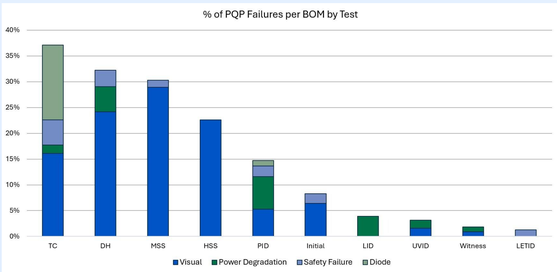
Diode Failure
Failed bypass diode can no longer protect modules from hot spots.

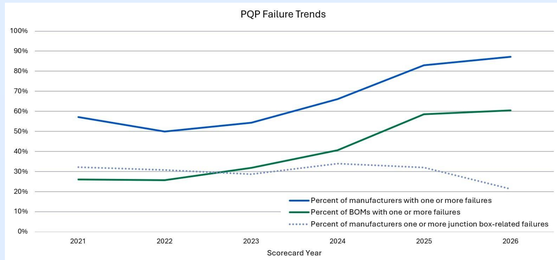
Power loss is minimal across many tests; the PQP focus is now mainly on failures.

Most common failure type is a visual inspection major defect → accounted for 73% of all failures.

Visual inspection failures mainly constitute module breakage (50%) and delamination (46%).

- Module breakage: 60% of manufacturers had at least one module breakage failure. Main occurrence in MSS and HSS tests.
- Delamination: 45% of manufacturers had at least one delamination failure. Main occurrence in DH, TC, MSS, PID and UVID tests.
- Junction box failures: 21% of manufacturers had at least one JB-related failure. It includes bypass diode failures (17%), safety failure linked to JB (9%) and JB covers falling off (4%).
- Power loss failures: 26% of manufacturers had at least one power loss failure. Main occurrence in PID, UVID, TC, and DH tests.



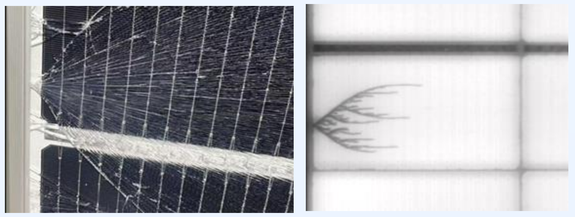


MODULE BREAKAGE

Mechanical Stress Sequence (MSS) Results

- Failures remain high: 30% of BOMs experienced at least one MSS failure.
- Frame design impact: >2x increase in breakage rate observed when frame thickness is reduced.
- Glass pinch issues: 62% of broken modules showed evidence of pinched glass via front glass breakage.

Module 1: Post-SML | Module 2: Post-SML+ DML

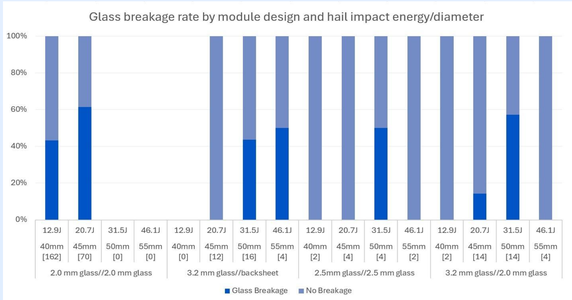


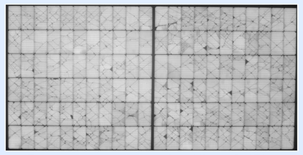
Edge pinching causes breakage of module (1) and cell (2).

26% of MSS BOMs experienced at least one broken module, indicating the industry has not yet solved this issue, and reports of fielded module breakage will likely continue.

Hail Stress Sequence (HSS) Results

- Increased failures: 23% of BOMs experienced an HSS failure (module breakage when tested at both hail sizes, 35 and 40 mm, or when a retest occurs).
- Standard modules breakage: 61% of 2.0 mm/2.0 mm G/G modules experience glass breakage from 45 mm hail impacts, while 43% of these modules break from 40 mm hail impacts.
- Hail-hardened modules: 7% of thicker glass modules break from 45 mm hail. Thicker glass modules are significantly less susceptible to glass breakage than standard modules.





Example module with Kiwa PVEL-induced cell cracks from a cell cracking power loss study.

Branching cell cracks can be observed on G/B modules following hail testing, but suffer relatively little hail-induced power loss due to the use of half-cut, multi-busbar cells.

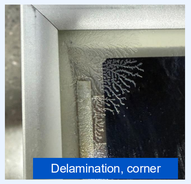
DELAMINATION

45% of manufacturers had at least one delamination failure (3X compared to the previous year).

Group	Maximum temperature	Share
DH/PID/MSS (HF)	High temperature (85°C) & High humidity (85%RH)	52.2%
TC/LETID	High temperature (75~85°C)	26.1%
LID/UVID/FE	Medium temperature (40~65°C)	17.4%
Intake	/	4.3%

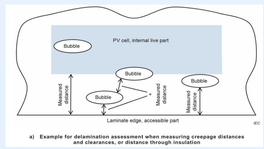
Damp Heat (DH) Results

- DH failure: 23% of DH BOMs experiencing a delamination failure.
- Encapsulant influence: Delamination is more correlated to encapsulant type than thickness.
- Process influence: lamination process is likely the key contributor to delamination.



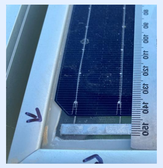
- **Field failure**: Insufficient creepage distance resulted in electrical arcing and subsequent fire failure.

Creepage distance measurement as per IEC 61730-1



Module maximum system voltage	Creepage distance requirements
1000V	>6.4mm
1500V	>10.4mm

Measured creepage distance <0.3 mm (string to string gap)



Bubbles at glass edge compromised the creepage safety distance

Ref: Kiwa PI Berlin Report, kiwa.com/2026pvmfrreport

SUMMARY

- **Solving module breakage and delamination would address high failure rates**, as Kiwa PVEL consistently identifies related failures as primary contributors to power loss and warranty claims.
- **Enhancing glass strength, encapsulant selection, and lamination process control would mitigate these issues**, thereby improving long-term reliability.

Visit scorecard.pvel.com for more.