



2026 PV Module Reliability Scorecard

Why Module Testing is More Important Than Ever

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Kiwa PVEL

kiwa

*creating trust, **driving progress***

Kiwa PVEL is the Independent Lab of the Downstream Solar Market

15

Years of
experience

700+

Bills of materials
tested in the lab

30+

Premium
partners

Our mission is to support the worldwide solar and energy storage buyer community by generating data that accelerates adoption of solar technology.

Services at a glance:

- Extended reliability and performance testing for PV modules
- Batch testing of PV modules
- Outdoor testing of PV modules
- Data services for PV buyers and investors

See more details at kiwa.com/pvel

Kiwa Solar – Services for the Entire Supply Chain



Market Intelligence

Industry leading reports, from analysis of key solar and energy storage components pricing, technology trends, policy updates, as well as custom data and reporting.



Technical Advisory

We support investors, developers, EPC contractors, asset managers to procure high quality equipment, optimize system performance and conduct technical due diligence.



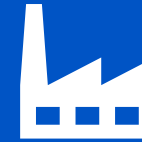
Engineering

Owner's engineering services for PV and BESS plants in order to support investors in the development and construction of reliable assets.



Product Testing

Independent, industry-leading performance testing of PV modules, inverters, battery energy storage, and other key solar equipment.



Factory Inspection

Factory audits and inspections benchmarking manufacturing quality based on our expertise in processes, materials, and technologies to ensure the long-term performance, reliability, and safety of key equipment.



Field Services

Expert assessments of PV and BESS power plants during construction and operation to ensure high quality installations and long-term optimal performance.

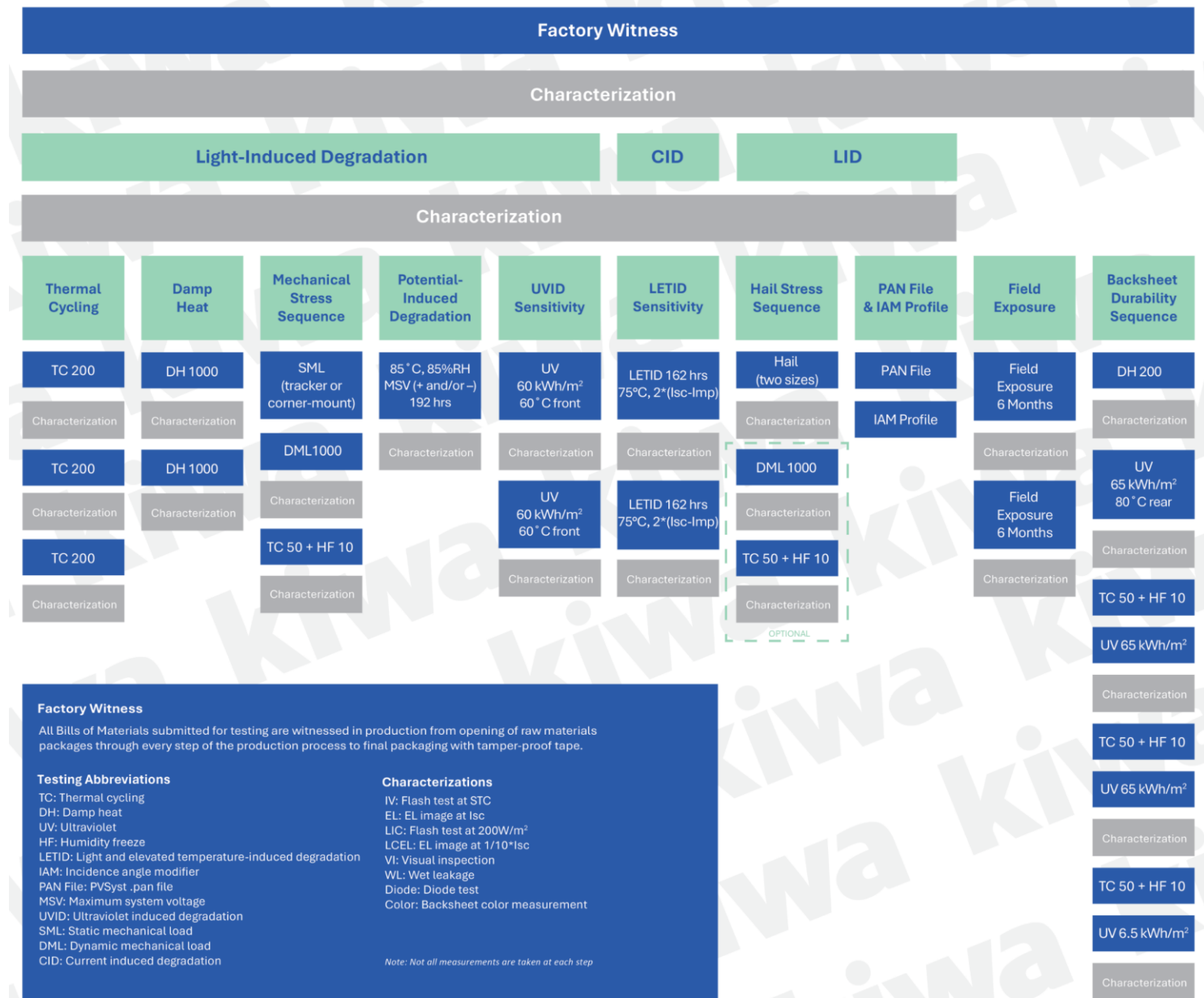
See more at kiwa.com/solar

PQP Test Sequence

The PQP evolves every 2-3 years based on feedback from Kiwa PVEL's downstream partners, module manufacturers, and the industry's collective understanding of module failure modes and test mechanisms.

The previous update, shown here, introduced the UVID test.

The latest update, introduced in April 2026, includes a new test to failure approach for module durability. Learn more about the new version of the PQP test plan at kiwa.com/pvel/pqp12.



PV Module Reliability Scorecard Overview



The annual PV Module Reliability Scorecards lists top performing modules and insights from Kiwa PVEL's PQP. Each year the Scorecard is accessed by **tens of thousands unique visitors from over 150 countries.**



- To be eligible for the Scorecard, manufacturers must have:
 - Completed the PQP sample production factory witness within 18 months of the Scorecard publication and have new Top Performer results.
 - Submitted at least two factory-witnessed PV module samples to all PQP reliability tests, as per Kiwa PVEL's BOM test requirements.
- Top Performer criteria:
 - TC, DH, MSS, PID, UVID must have < 2% power degradation.
 - LID+LETID must have < 1% combined power degradation.
 - HSS must not experience glass breakage with ≥ 40 mm hail.
 - PAN must place in the top quartile for energy yield.
 - Top Performers must not have experienced a wet leakage failure, 'major' defect during visual inspection, or a diode failure for that particular test.

Key highlights from the 2026 PV Module Scorecard

- **43 manufacturers are named Top Performers**, including 13 first time Top Performers.
- **UVID is a new Top Performer test category.**
- **No ‘all-stars’:** No single model/BOM excelled across all tests – a first for the Scorecard.
- **Power loss is decreasing for some tests, but failure risk is rising:** most notably, degradation due to PID and UVID improved, yet **failures reached record highs** (87% of manufacturers and 61% of BOMs experienced at least one failure).
- **Failure mix is shifting: Module breakage remains the #1 source of failures**, but delamination surged sharply **with 45% of manufacturers having at least one major delamination defect.**
- **Higher powered modules result in higher energy:** Energy yields continue to improve due to better temperature coefficients and bifacialities.

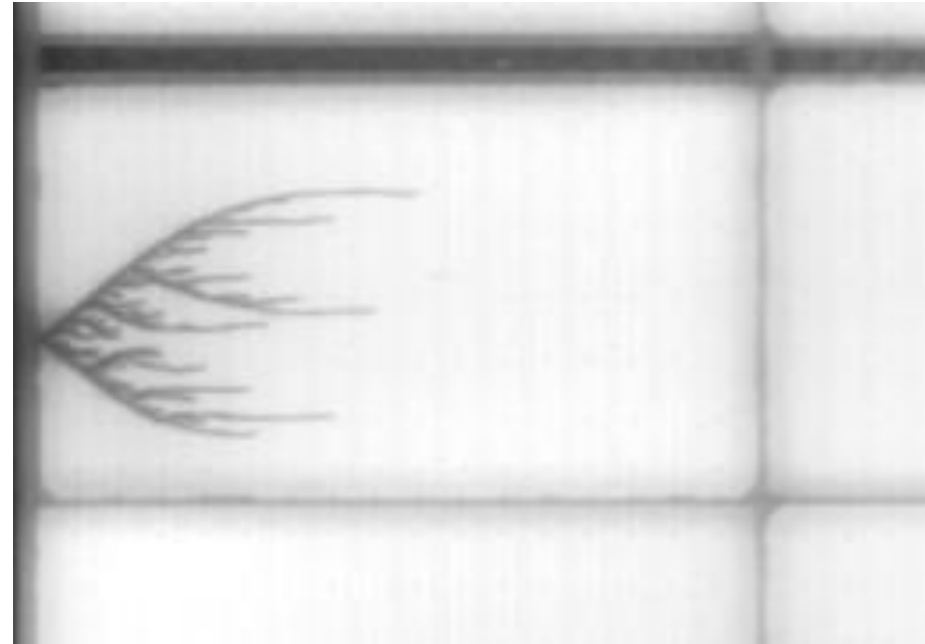
Module Breakage

26% of BOMs undergoing MSS testing had at least one (of two) broken modules.

62% of broken modules in MSS showed evidence of pinched glass via front glass breakage. Example:



Module-1 broke during testing, showing a clear point of breakage due to edge pinch.



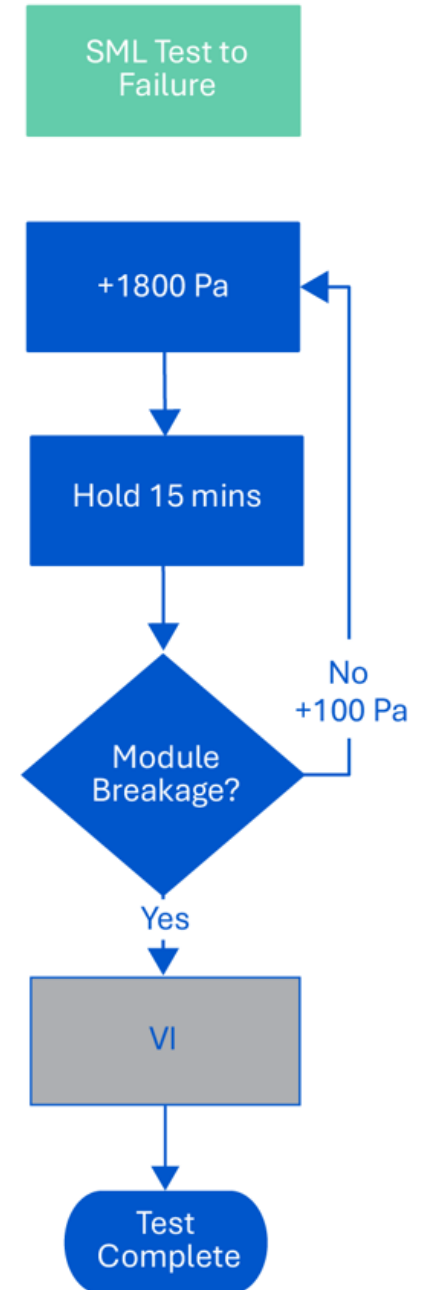
Module-2 did not break, but edge pinching on one cell can be seen in the EL image.

Mitigating Module Breakage

Load testing on only one or two modules, then buying 100 MW (or more) is asking for trouble!

The updated PQP includes a new SML Test to Failure approach to better target module durability concerns.

Batch Testing: **Kiwa recommends performing SML+DML on 2 modules per 10 MW of production, using the site's mounting method and pressure.**

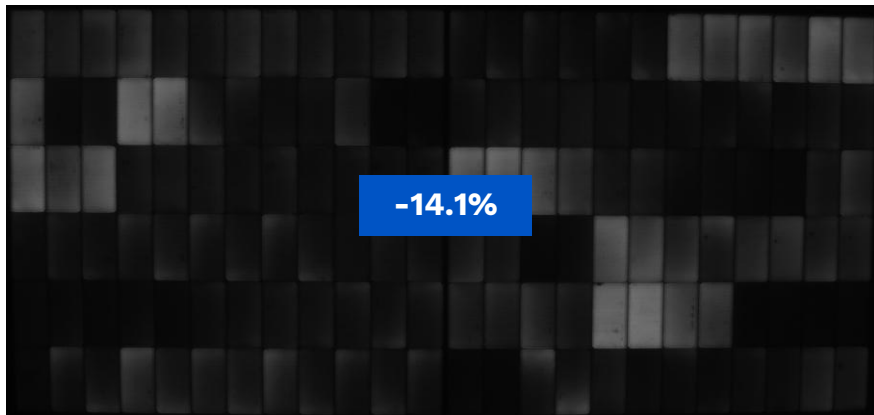


UVID – Getting Better But Not Solved

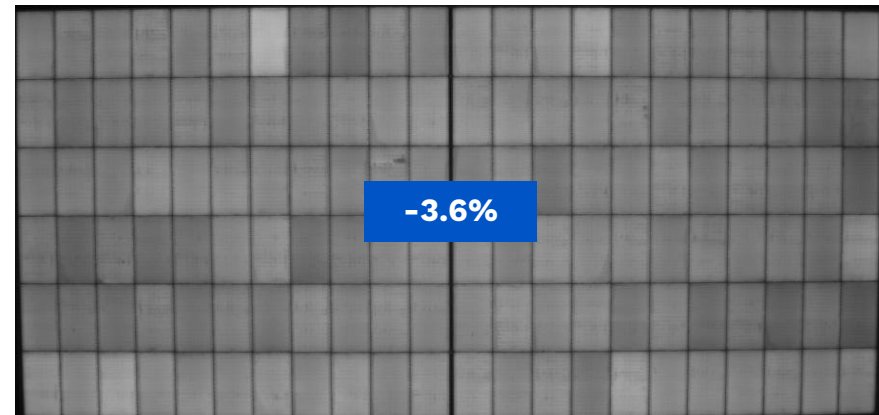
19 manufacturers named 2026 Top Performers for UVID with <2% UVID.

Median UVID power loss for 2025 TOPCon BOMs was 3.0%, up from 4.3% for 2024 BOMs.

UVID is still not solved for some. Example of same module and cell manufacturer, different UVID results:



BOM-1 (M10 cells)



BOM-2 (G12R cells)

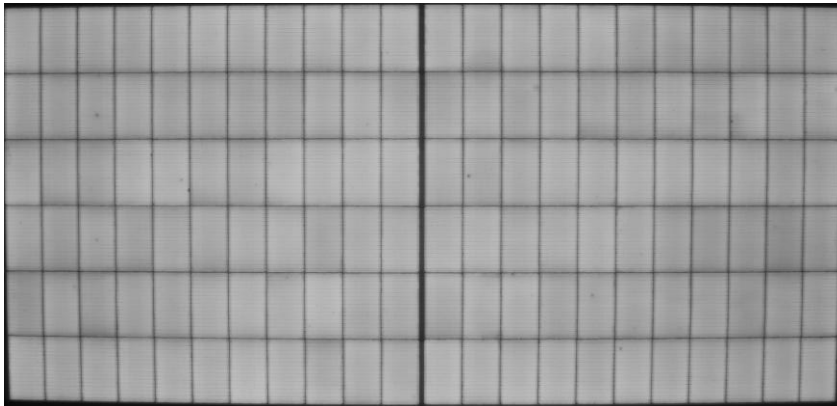
Batch Testing: **Kiwa recommends UV60 on 2 modules per 50 MW of production.**

PID – Getting Better But Not Solved

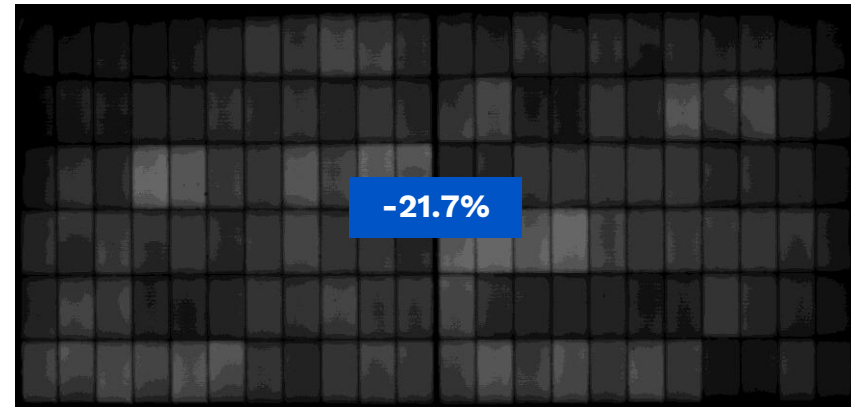
83% of 2025 BOMs had <2% PID(-) power loss.

But PID outliers still appear – 2000V modules/system will not help with this failure mode.

This was the worst case over the past year:



Initial: nothing to see here



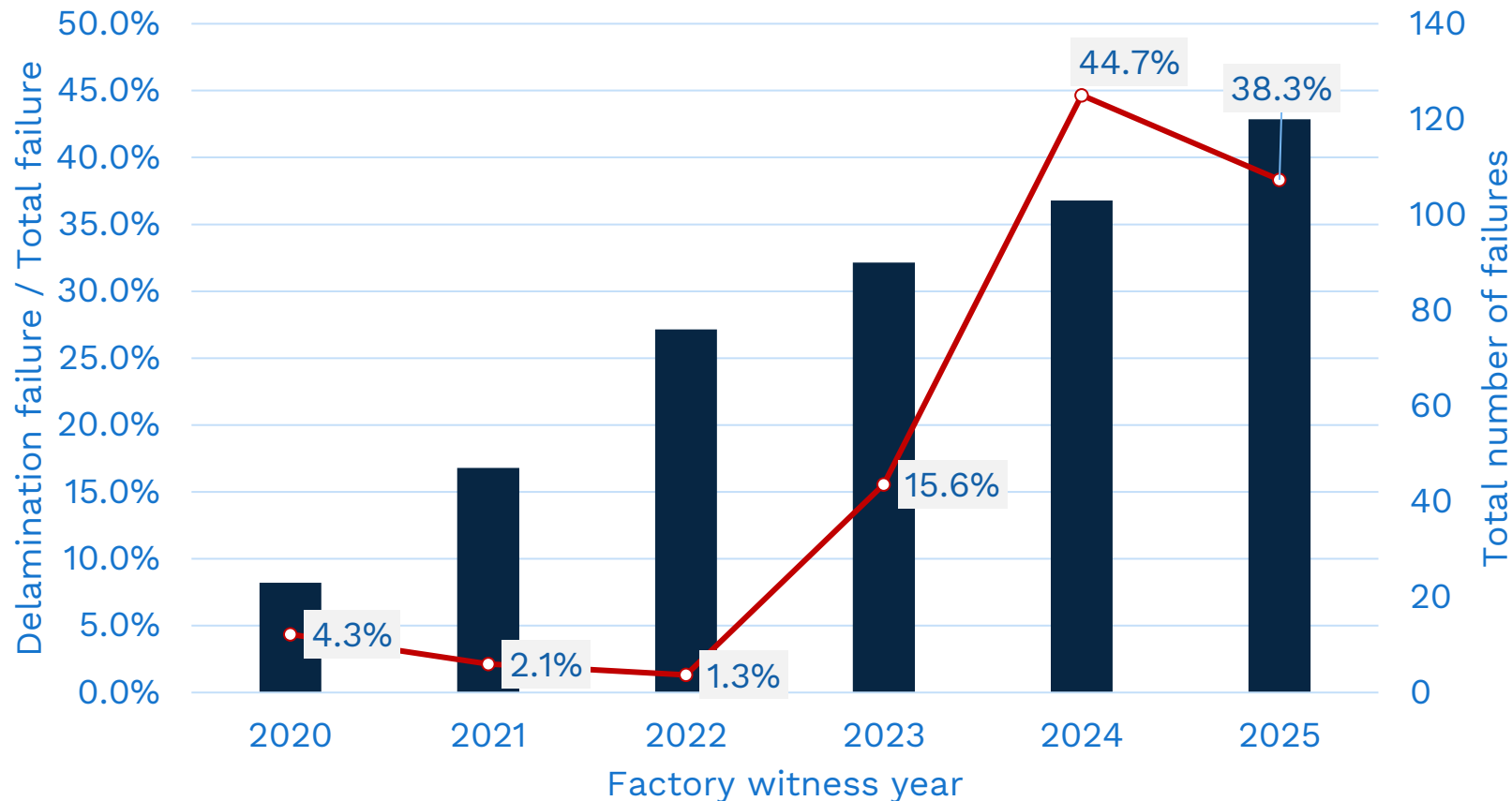
Post-PID192(-): whaaa' happened??

Batch Testing: **Kiwa recommends PID96 on 2 modules per 10 MW of production.**

Delamination – On The Rise

45% of manufacturers had at least one major delamination defect.

1/3 of these defects came after DH testing (DH1000 or DH2000), but also observed during initial characterizations and after TC, MSS, PID and UVID.



Delamination – Examples and Consequences



Delamination, corner



Bubbles, edge



Delamination, label

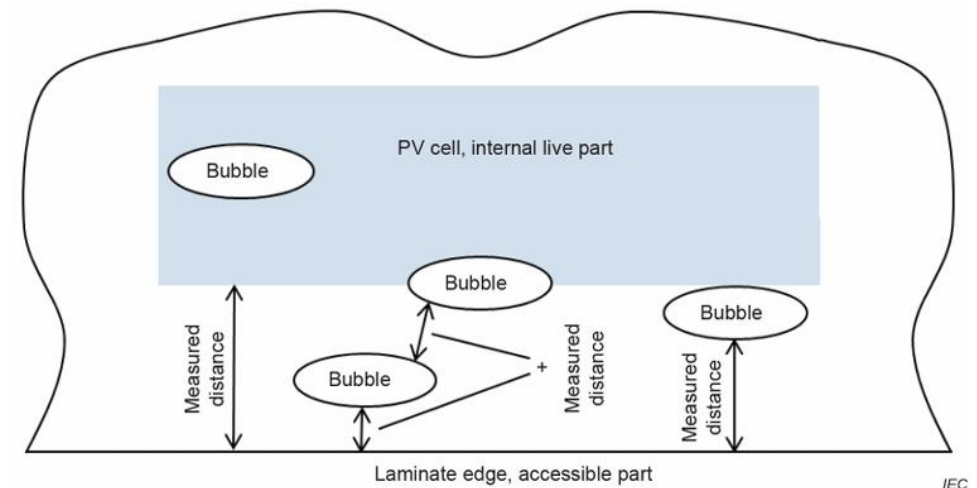


Delamination, edge



Bubbles, j-box

Per IEC61730, bubbles are assumed to be conductive. **Considered a Major Defect when creepage distance is below IEC 61730-1 requirements.**



IEC

a) Example for delamination assessment when measuring creepage distances and clearances, or distance through insulation

Delamination – Field Failure



45% of manufacturers had at least one major delamination defect.

Batch Testing: Kiwa recommends DH1000, TC200 and HF10 each on 2 modules per 50 MW of production and PID96 on 2 modules per 10 MW of production.

Delamination Risk Factors – Preliminary Conclusions

Factor	Importance level	Note
Module design	★	No obvious differences between G//B and G//G modules.
Module size	★	No obvious differences for big floppy modules.
Encapsulant type	★★★	EPE as front and rear encapsulant seems to trigger the greatest number of major defects.
Encapsulant thickness	★★	A thinner encapsulant does not show a higher risk of delamination in DH (<i>unexpectedly</i>).
Edge pinch	★★★	Failure rate increases as encapsulant size decreases in width.
Lamination method	★★★	Locking frame appears least susceptible to delamination.
Lamination process	★★	Lamination temperature and time are not the main failure drivers (<i>also unexpectedly</i>).
Gel content	★	Does not seem to be a direct predictor.
Peel force	★	Does not seem to be a direct predictor.
Solder flux	★★★	Improper flux recipe can lead to delamination extending from string busbars.

Kiwa PVEL's Premium Partner Program

Module purchasing/investing companies can subscribe to the Premium Partner Program to receive a quarterly dashboard of Kiwa PVEL's Product Qualification Program (PQP) test results.

PQP results from over 45 module manufacturers are included in the Dashboard, with at least 35 manufacturers sharing their non-anonymized results. Over 300 BOMs are included, with almost 200 BOMs non-anonymized.

A selection of the current Premium Partners attending ModuleTech:





See more of the 2026 Scorecard including all Top Performers at www.scorecard.pvel.com

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