Raising the Bar

Understanding acceptable levels of quality for PV modules

Kiwa PVEL | Kiwa PI Berlin

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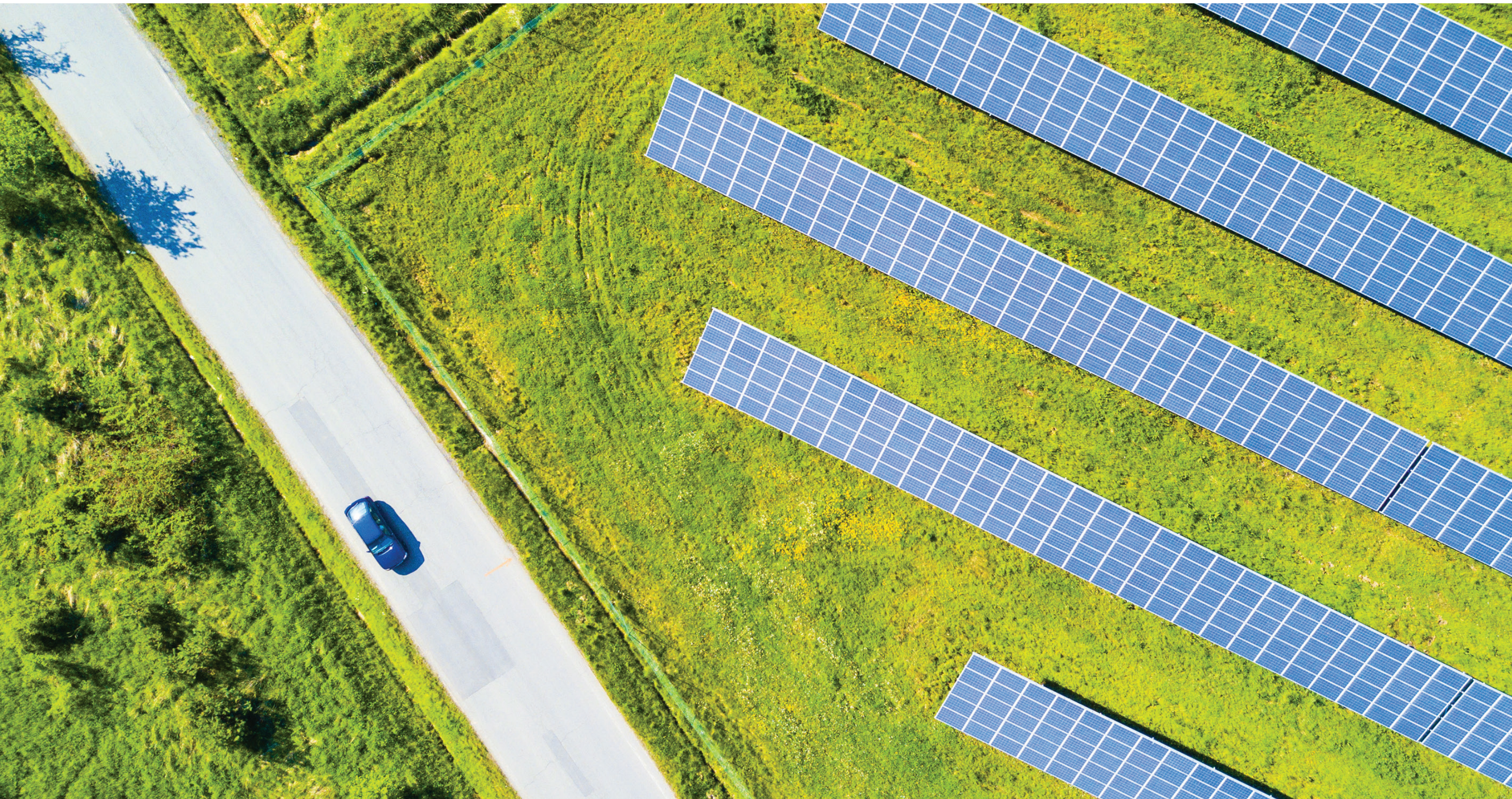
Defining Quality for PV Modules

Photovoltaic (PV) module quality assurance (QA) is a cornerstone of the PV industry, ensuring that modules perform as expected and maintain reliability over their operational lifespan. Effective QA processes help to minimize risks, enhance durability, and ensure that PV systems deliver the expected energy yield. As PV modules are deployed in various environments, often facing extreme weather conditions and long-term exposure to the elements, rigorous and continuous QA is essential to guarantee their performance and safety.

The PV industry is undergoing a significant transformation with the adoption of advanced cell technologies like TOPCon and HJT. With the introduction of new technologies, the role of QA becomes even more critical. These advanced technologies, while offering significant efficiency gains, also present increased risks due to their heightened sensitivity to material choices and manufacturing processes. The complexity of these technologies means that even small deviations in material quality or production consistency can lead to performance degradation or premature failure. Therefore, stringent control and inspection measures are necessary to ensure that modules incorporating these new technologies meet the highest standards of quality and reliability.

With this publication, Kiwa (specifically Kiwa PVEL and Kiwa PI Berlin) aims to provide the industry with guidance on module acceptance across Product Qualification Program (PQP) extended reliability testing, Pre-Shipment Inspection (PSI), Batch Testing and Ongoing Reliability Monitoring (ORM). Kiwa PVEL and Kiwa PI Berlin's review of recent module testing data and module in-factory testing data reviewed in this report shows improvements in the industry which allow buyers to "raise the bar" on quality requirements within their agreements. These key aspects of managing quality are further defined in Kiwa's PV Module Procurement Best Practices.



PQP Test Result Acceptance Guidance

The Product Qualification Program (PQP), shown in Figure 1, is a suite of qualification tests, rather than a "certification" with defined pass/fail criteria. The definition of acceptable PQP test results is therefore typically determined by the module manufacturers and their customers, rather than Kiwa PVEL. For example, a module with higher degradation or other typically less desirable results (such as a visual inspection 'major' defect or wet leakage results that do not meet IEC 61215 requirements) may be acceptable to a module buyer based on other positive aspects of the purchase, such as the modules being higher efficiency or having more favorable pricing, terms and/or delivery schedule.

Similarly, specific site conditions can influence PQP result acceptance. For instance, perhaps a module didn't perform as well in the PQP's PID test, but the site uses microinverters which prevent PID from occurring. Or perhaps a module didn't perform well in the PQP's hail test, but the modules will be installed in a region where extreme hail is a rare occurrence. Perhaps signs of corrosion were seen during the PQP's DH test, but the module is being installed in a desert environment where the risk of moisture ingress is minimized. In all these cases, the selected module might still be appropriate for the specific site and application even with poorer performance in a certain test.

Given all of the above, PQP test reports do not include a defined pass/fail criteria, but that hasn't stopped both module manufacturers and module buyers from regularly asking Kiwa PVEL's opinion on what results are acceptable. Some module buyers have used 5% power degradation as the pass/fail threshold for PQP results. This echoes the acceptance threshold for IEC 61215 certification, but it forgoes looking at what is achievable by current module technology when undergoing PQP testing, nor does it speak to the results of the other PQP module characterizations, including visual inspection, wet leakage electrical insulation test and the bypass diode test.

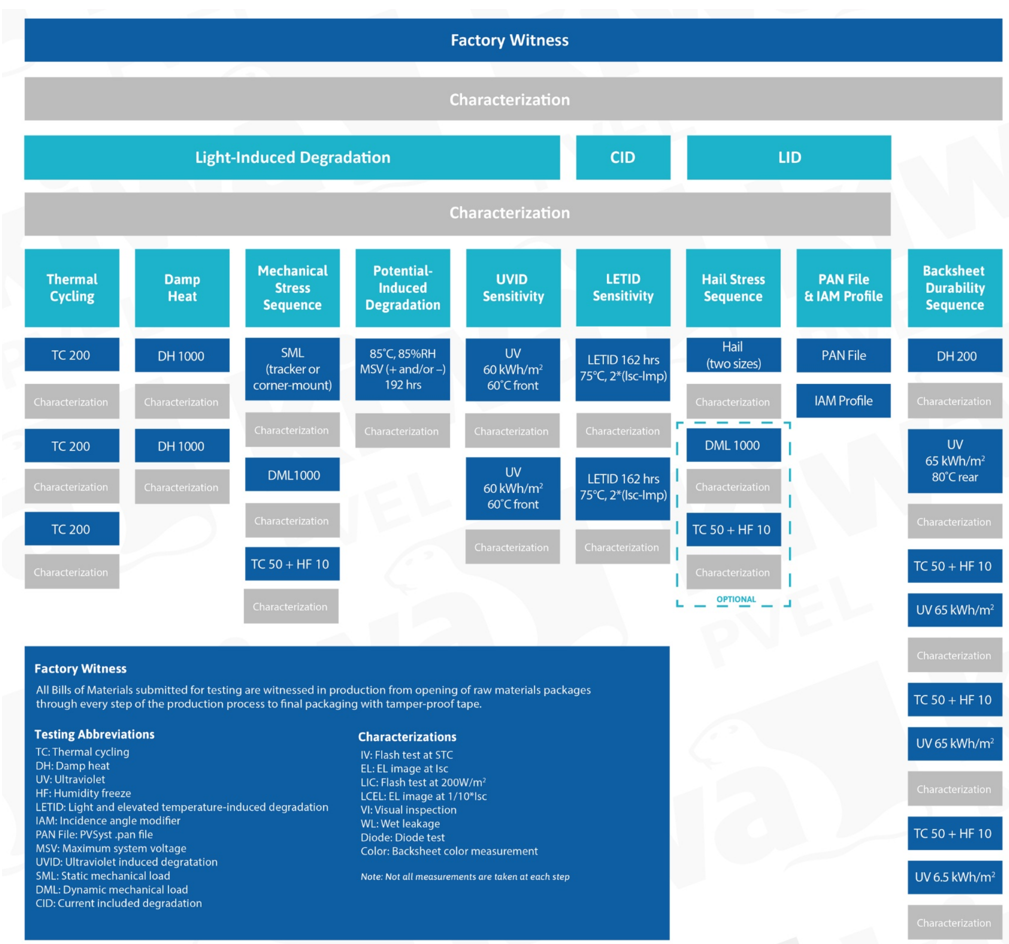


Figure 1. PQP Test Protocol.

PQP Acceptance Thresholds

There is a clear need for more official PQP acceptance guidance, so for the first time, Kiwa PVEL is publicly providing this based on the range of test results seen in PQP testing over the last few years, including those reported in the 2024 PV Module Reliability Scorecard.

This guidance is separated by PQP test based on the test result trends and test type(s). The first grouping is thermal cycling (TC600), damp heat (DH2000), mechanical stress sequence (MSS) and potential induced degradation (PID192). As shown in the individual test pages in the 2024 Scorecard, all of these tests have seen improved year-on-year results (see Figure 2 for an example) to the point where the vast majority of modules experience less than 3% degradation (see Table 1). For these tests, Kiwa PVEL recommends that 3% be considered a pass and 5% or greater degradation be considered a fail, with results landing between 3 and 5% classified as a conditional pass based on the module manufacturer completing a detailed root cause corrective action (RCCA) analysis to the module buyer's satisfaction.

While this works for some PQP tests, using 3% as the acceptance threshold for the average LID combined with the average LETID is too lenient, considering a more achievable LID+LETID acceptance threshold for gallium-doped PERC and n-type modules is 1%, which was achieved by 84% of modules undergoing these tests. The recommend fail threshold is 2% for LID+LETID, with results between 1 and 2% initiating an RCCA analysis. See Table 1 for statistics on how many tested bills of material (BOMs) achieve these different acceptance levels.

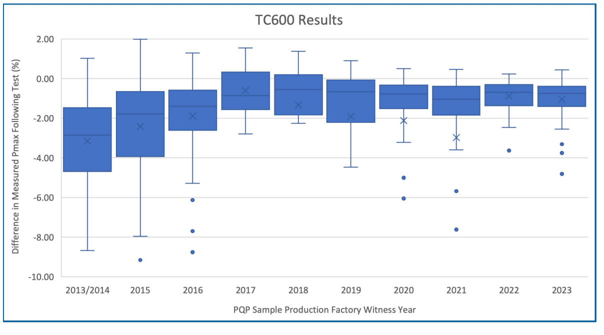


Figure 2. TC results over time.

Power loss stemming from hail testing is relatively minimal, as documented in Kiwa PVEL's contribution to kWh Analytics' 2024 Solar Risk Assessment. Glass breakage is a much more significant concern for this test, and Kiwa PVEL recommends using the site location to determine hail test acceptance thresholds. For example, modules being used in sites within extreme hail regions should not show glass breakage for 50 mm or even 55 mm hail, whereas sites outside of those regions can likely accept modules without glass breakage when tested with 35 mm or 40 mm hail.

Power loss is also of little concern for BDS testing. In fact, Kiwa PVEL does not measure power output over the course of BDS testing, as the test is solely focused on backsheet polymer degradation. What is of great concern is the visual inspection results and ensuring no signs of backsheet cracking are noted in the BDS reports, the presence of which would trigger a failed result as per Kiwa PVEL's recommendation. Other visual inspection 'major defects' during BDS, such as illegible power labels, can likely be considered a conditional pass if a satisfactory RCCA analysis is provided. The change in yellowness seen via colorimeter measurements should also be considered as part of BDS result acceptance. While yellowness is not always a precursor to more catastrophic material failure, based on historical testing, Kiwa PVEL recommends a delta b* value of < 5 be considered a pass, and anything greater than that be considered a conditional pass when coupled with an RCCA analysis.

At the time of publication, Kiwa PVEL does not have sufficient and conclusive data to provide formal guidance on UVID, considering this test is relatively new and research is ongoing to equate UVID test results with fielded module performance. For now, Kiwa PVEL recommends reviewing the UVID section of the PQP reliability reports and comparing the results to others (as published in Kiwa PVEL's recent IEEE PVSC poster and included in Table 1).

Additionally, Kiwa PVEL does not provide official guidance on PAN and IAM result acceptance, although third-party testing from reputable labs should be a firm requirement for these energy model inputs. Benchmarking against different results can be achieved when reviewing trends reported in the Kiwa PVEL Scorecard.

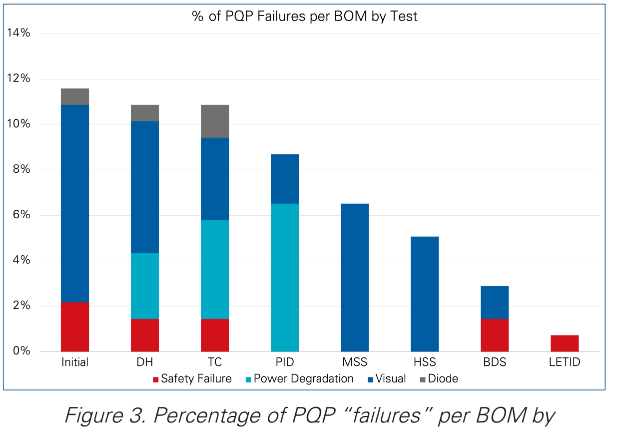


Figure 3. Percentage of PQP "failures" per BOM by test from the 2024 Scorecard.

Other Considerations for PQP

Beyond power loss/degradation thresholds, the number of visual inspection, wet leakage and diode "failures" seen in PQP testing is significant enough that these characterization results must be considered as part of holistic result acceptance. Statistics on reported PQP failures from the 2024 Scorecard are shown in Figure 3, where the percentage of module BOMs experiencing one or more failures per test can be seen. Kiwa PVEL recommends a clear pass for all tests as having no visual inspection major defects, having fully functioning bypass diodes following TC600 and MSS, and having wet leakage test results that meet the IEC 61215 requirements. Should these conditions not be met, Kiwa PVEL recommends classifying the results either as a conditional pass when coupled with an accepted RCCA analysis, or as a failure, depending on the severity. The RCCA analysis should demonstrate that the issue was not caused by a systemic design or process issue (i.e., it was caused by a random quality escape during PQP sample production) and that the manufacturer's quality control plan has been updated to address the issue.

While this guidance is based on recent testing, result interpretation remains nuanced, so official pass/fail criteria will not be included in Kiwa PVEL's PQP test reports. As discussed previously, the site conditions and subsequent relevance of individual PQP tests must be considered. Other test nuances include the type of mounting used during MSS testing (which was recently changed in the PQP from more conservative two-rail mounting to more aggressive tracker or corner mounting), and the field relevance of PID-polarization recovery via UV exposure. Kiwa PVEL also encourages reading the formal PQP test reports to review electroluminescence (EL) images and "minor" visual inspection findings, as these can result in notable findings that may justify requesting an RCCA analysis. And, as always, Kiwa PVEL must stress the importance of ensuring the BOM used for testing matches the BOM being deployed on site.

TEST	<3%	3-5%	≥5%	OTHER FAILURES*
TC	95%	4%	1%	7%
DH	92%	6%	2%	8%
MSS	99%	1%	0%	6%
PID	83%	11%	6%	2%
UVID	25%	35%	22%	17%
TEST	**<1%**	**1-2%**	**≥2%**	**OTHER FAILURES****
LID+LETID	84%	15%	1%	13%

Table 1. PQP Result Summary (BOMs witnessed in 2022 and 2023).

*Other failures (except for UVID) as per the reported PQP failures in the 2024 Scorecard include wet leakage ("safety") failures, visual inspection and diode, but not power degradation. See Failures page for more. Other failures for UVID include BOMs that exceeded 5% degradation after UVID60 and the module manufacturer decided to stop testing at that stage.
**LID and LETID failures include the 'initial' failures plus LETID failures.

TEST	ACCEPTANCE LEVEL	POWER DEGRADATION	OTHER CHARACTERISTICS
TC, DH, MSS, PID	Clear Pass:	<3%	No visual inspection majors, wet leakage failures or diode failures (for TC and MSS).
	Conditional Pass:	3-5%	Visual inspection majors, wet leakage failures and/or diode failures (for TC and MSS) with positive RCCA (e.g. no design/process flaws).
	Clear Fail:	≥5%	Visual inspection majors, wet leakage failures and/or diode failures (for TC and MSS) with no or negative RCCA.
LID plus LETID	Clear Pass:	<1%	No visual inspection majors or wet leakage failures.
	Conditional Pass:	1-2%	Visual inspection majors and/or wet leakage failures with positive RCCA (e.g. no design proces flaws).
	Clear Fail:	≥2%	Visual inspection majors and/or wet leakage failures with no or negative RCCA.
HSS (hail size determined by project site's susceptibility to hail impacts)	Clear Pass:	Less applicable	No glass breakage, no other visual inspection majors or wet leakage failures.
	Conditional Pass:		Visual inspection majors (other than glass breakage) and/or wet leakage failures.
	Clear Fail:		Glass breakage
BDS	Clear Pass:	Not applicable	No visual inspection majors, delta b* ≤5
	Conditional Pass:		Visual inspection majors (other than backsheet cracking) and/or delta b* >5
	Clear Fail:		Backsheet cracks

Table 2. PQP Result Acceptance Recommendations.

Pre-Shipment Inspections Guidance

Pre-Shipment Inspections (PSI) play a vital role in the QA process by providing an independent assessment of the modules before they are dispatched to end-users. These inspections help to verify that the products meet the agreed-upon specifications and quality standards, thereby minimizing the risk of defective products reaching the buyer.

Key Aspects of Pre-Shipment Inspection:

- **Visual Inspection:** Assessing physical defects, including cracks, scratches and discoloration.
- **Flash Testing:** Ensuring electrical performance metrics—such as voltage, current, and power output—align with specified ratings.
- **Bifaciality Measurement:** Evaluating the bifaciality factor to ensure that PV modules meet performance expectations.
- **Dimensional Verification:** Measuring physical dimensions to confirm compliance with design specifications.
- **Electroluminescence (EL) Imaging:** Detecting micro-cracks, hidden defects, or irregularities in PV cells.

Tracking Defects: Results from Solar Panel Inspections in 2022-2023:

Kiwa PI Berlin conducted PSI on 774 batches of solar modules between 2022 and 2023. As seen in Figure 4, ***only 76 batches were found to be defect-free and passed the inspection without any issues.*** Results show numerous shipments from different manufacturers contained defect levels that exceeded the acceptable quality limits (AQL). A significant number of those batches had a high ratio of defective products, raising significant reliability and safety concerns and making it critical to remove defective lots before they were shipped to end-users.

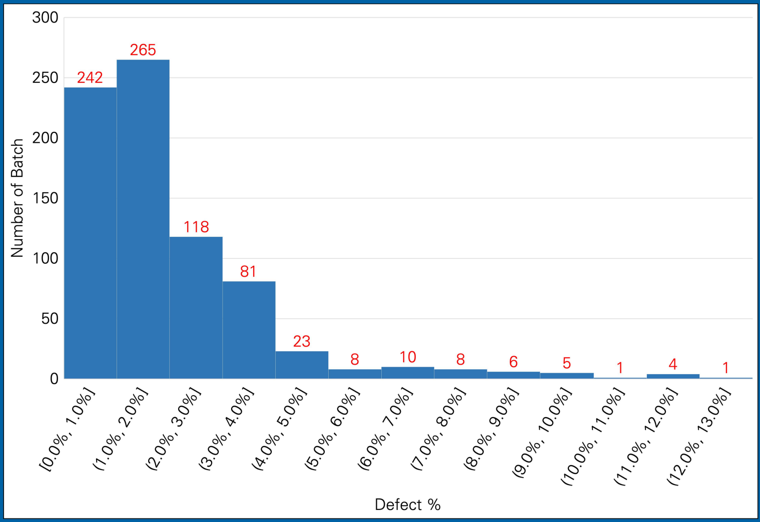


Figure 4. Defect rate across 774 batches of PSI.

In-depth defect data analysis of 2022 and 2023 PSI results reveals that defect rates varied significantly, ranging from 0 to 14% when comparing different manufacturers (see Figure 5). Kiwa PI Berlin's analysis identified several factors contributing to this variation, including module type, cell technology, BOM, equipment and operator training. These factors emphasize the complexity of solar module manufacturing, where even subtle differences can significantly impact defect rates.

Additionally, defect rate variations have been observed within the same manufacturer across different production sites, despite utilizing the same product design and BOM. As shown in Figure 6, the defect ratio shifted considerably for products manufactured by the same company at site B versus site E. This reinforces the importance of closely monitoring and controlling critical production elements such as team training, equipment maintenance and recipe consistency. Ensuring these variables are aligned and optimized is crucial to maintaining product quality across different manufacturing locations.

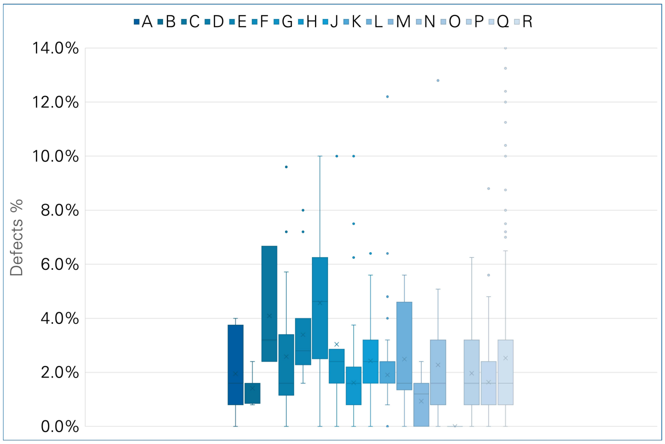


Figure 5. Defect rates across different manufacturers.

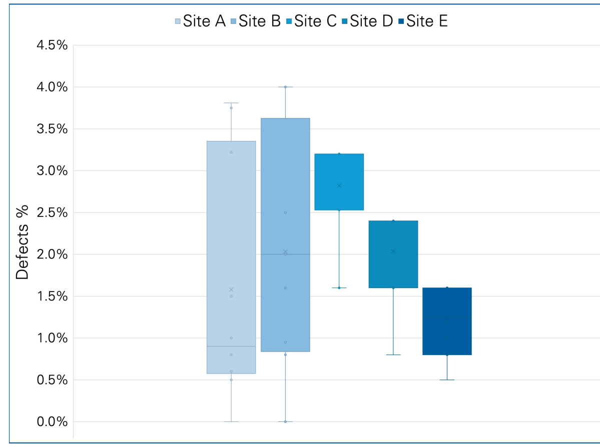


Figure 6. Defect rates across one manufacturer's factory locations.

As shown in Figure 7, the highest proportion of defects was related to EL with issues predominantly stemming from microcracks, weak soldering, cell contamination, finger interruptions, short-circuited cells and more. Microcracks and weak soldering, for example, can lead to critical failures such as hot spots, encapsulation layer damage and eventual power loss. These issues not only compromise the long-term reliability and performance of the modules but can also lead to safety hazards, costly repairs, and decreased energy yield, impacting the overall return on investment for solar projects. Figures 8 and 9 illustrate an example of various defects.

The second most commonly observed defect was related to frame defects, with the most frequently reported issue being corner gaps. Corner gaps can compromise the mechanical performance of the module, potentially leading to structural failures under stress.

In addition to EL and frame defects, several other defects may pose serious safety risks. Issues such as defects in the junction box, cables, connectors and lamination can lead to electrical failures, fire risks and compromised module integrity. Detecting and addressing these defects before the modules are deployed is critical to ensuring safety and reliability.

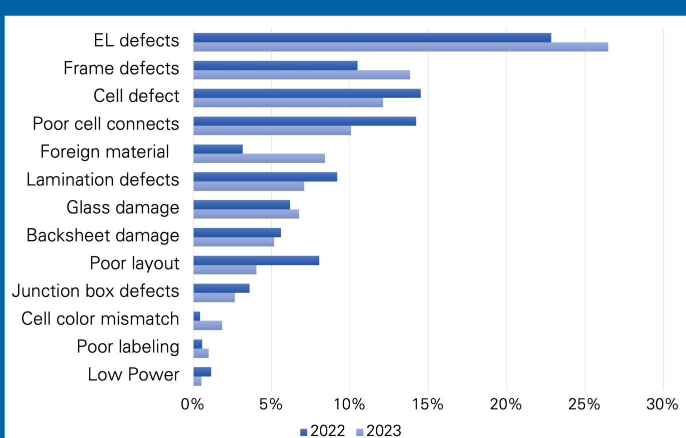


Figure 7. PSI reported defect rates for 2022 and 2023.

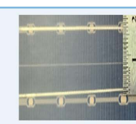
Component	Description	Defect class	Image
Cable	Cable insulation damaged resulting in exposed wires	Critical	
Cell	Misaligned wire	Major	
Frame adhesive	Silicone residue	Minor	

Figure 8. Example of different defects found during PSI.

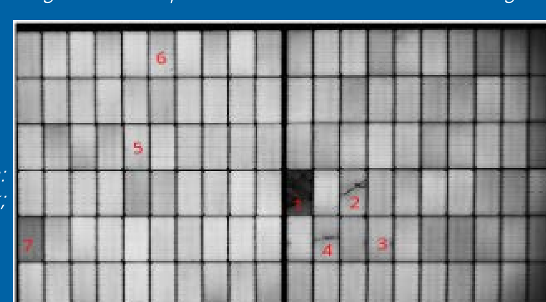


Figure 9. EL image foundduring PSI, showing various defects: (1) branching crack; (2) cross crack; (3) soldering defect; (4) linear crack; (5) finger interruption; (6) cell contamination and (7) cell brightness. >>

Optimizing Inspection Standards

Kiwa PI Berlin recommends conducting PSI based on the ISO 2859-1:1999 standard as a baseline for determining sampling standards, inspection levels and Acceptable Quality Limits (AQL). It is encouraged to set specific AQLs for each defect category based on various factors, including the product technology, BOM, production quality criteria, project size and the number of batches. Adjusting AQLs is one of the primary tools a buyer can use to "raise the bar" of quality when performing PSI. See Figure 10 for defect severity categorization.

Figure 11 illustrates the sampling size and AQL values for each defect category across 59 recent utility-scale projects involving 25 manufacturers. As shown earlier in Figures 5 and 6, defect rates vary significantly between manufacturers and production sites. Therefore, it is essential to provide an appropriate sampling size for PSI based on product and manufacturing conditions, and Kiwa PI Berlin recommends a minimum sampling size based on ISO 2859-1:1999 General Inspection Level II for the applicable lot (batch) size and a maximum lot size of 10 MW or one week of production, whichever is less. Additionally, Figure 11 demonstrates that AQL values differed across projects. An AQL of 0 was applied for critical defects in 100% of the projects, which is aligned with Kiwa PI Berlin's recommendation. Meanwhile, over 80% of the projects used an AQL of 0.65–1.5 for major defects and 2.5–4.0 for minor defects. While the AQL values were determined by various factors, primarily driven by the need to minimize product defect risks and ensure the quality and reliability of the PV modules, Kiwa PI Berlin recommends a maximum AQL of 1.5 for major defects and 4 for minor defects.

Kiwa PI Berlin also aids module buyers in developing detailed technical criteria for flash testing, visual inspection and EL image analysis while assessing the risks associated with different defects in terms of performance and reliability. This is then included in the module procurement contract so that all parties agree to the acceptance criteria before module production.

Kiwa PI Berlin classifies PV module defects into three categories to ensure precise and effective quality control:

Minor: A latent or overt defect that does not impair the usability of the PV module, but is nevertheless considered a workmanship defect beyond normal, acceptable quality standards. This includes obvious visual defects that may cause customer acceptance issues.

Major: A latent or overt defect that could impair the usability or result in under-performance or premature failure of the module. This includes obvious visual defects that are likely to cause customer acceptance issues.

Critical: A latent of overt defect that is likely to result in a hazardous or unsafe condition for the individual using the module, contravenes mandatory regulations and/or may cause damage to other products or property.

Figure 10. Defect severity catagorization.

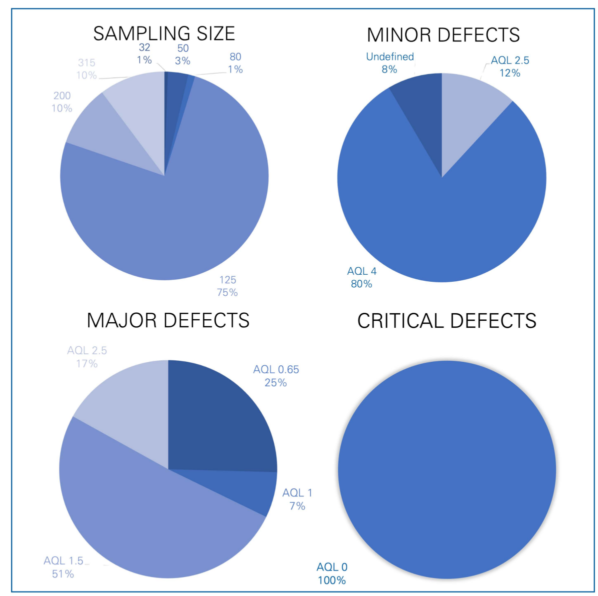


Figure 11. Sampling size and AQL settings for each type of defect category across 59 recent utility-scale projects involving 25 manufacturers.

TEST	MINUMUM SAMPLE SIZE	DEFECT CATEGORY	MAXIMUM AQL
Visual Inspection, Flash Testing, Bifaciality, Dimensional Verification, EL Imaging	ISO 2859.1 General Inspection Level II	Critical	0
		Major	1.5
		Minor	4

Table 3. PSI Acceptance Recommendations

Production Module Testing Guidance

PQP testing and PSI provide valuable insights and safeguards for module buyers, but unseen issues affecting consistent quality and reliability can persist without additional module testing. Therefore, Kiwa PI Berlin and Kiwa PVEL have jointly developed a comprehensive testing and monitoring program that evaluates PV modules at different stages of production and across various batch sizes.

This testing is divided into two main categories:

1. Batch Testing

Batch Testing validates the performance of PV modules across a series of shorter duration tests and is a crucial component to ensure consistent quality. This starts with measuring the power output of the modules offline from the production flash tester to ensure all electrical parameters align with the specifications on the module's power label. Flash testing both sides of bifacial modules ensures the bifaciality meets specifications. These tests are performed on all Batch Testing samples (16 modules in total). Kiwa also recommends flash testing two modules at low irradiance to show consistency of module output at low light conditions.

Following this performance validation, Kiwa recommends conducting shorter duration IEC/UL stress tests that are essential for verifying material and process stability. This includes LID for ≥ 20 kWh/m^2 on two modules, 162 hours of LETID on two modules, 96 hours of PID on two modules for each polarity and static + dynamical mechanical load (SDML) on two modules using the actual mounting to be used at the module buyer's site. Performing wet leakage electrical insulation testing after these stress tests provides confidence in module safety. Performing gel content and peel strength testing on two coupons each helps demonstrate lamination quality. See Figure 12 for the Batch Testing protocol.

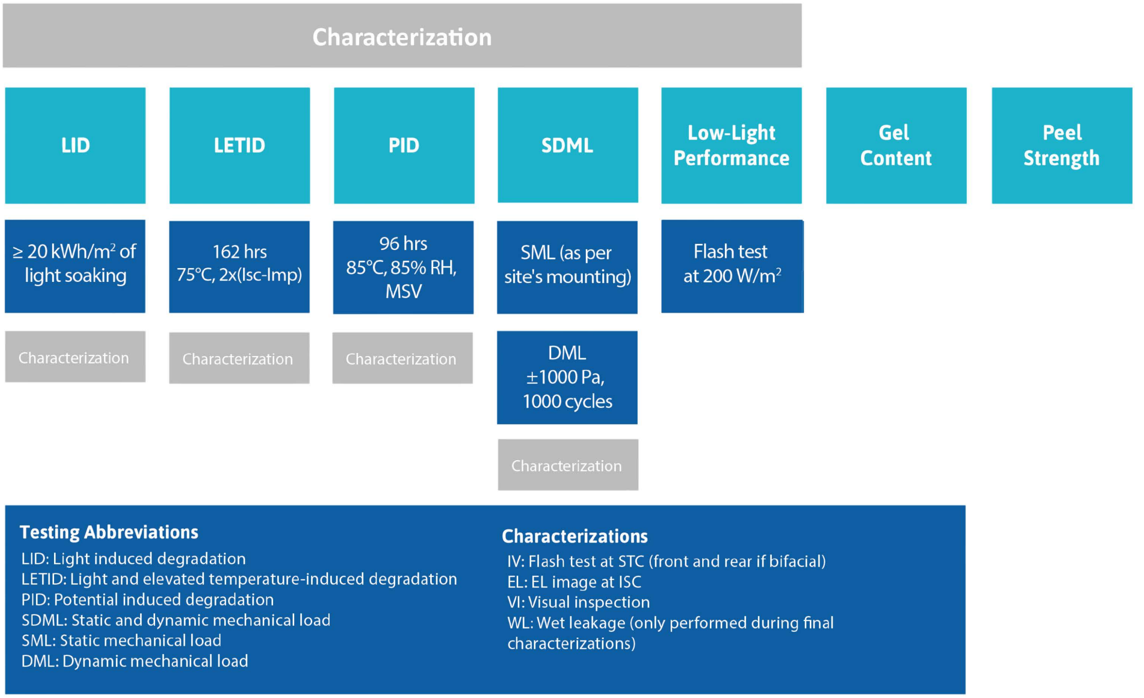


Figure 12. Batch Testing protocol.

2. Ongoing Reliability Monitoring

While Batch Testing helps ensure that each relatively small batch of modules meets quality standards, Ongoing Reliability Monitoring (ORM) is essential for verifying the consistent reliability of the PV modules. The ORM test protocol (as seen in Figure 13) is mainly based on the IEC/UL 61215 standard but is specifically designed to ensure that consistent materials and processes are rigorously monitored over time. It also incorporates tests tailored to the latest cell technologies and module designs including UVID and hail testing. The ORM program involves Kiwa PI Berlin randomly selecting modules from various batches during the project's module production timeline and sending them to one of Kiwa's global laboratories for longer duration testing, with minimum two modules submitted to each ORM test.

The IEC/UL 61215 tests of TC200, DH1000 and HF10 have wide adoption across the industry to validate module reliability consistency and form an essential part of the ORM program. Beyond those, Kiwa also recommends conducting 60 kWh/m^2 of UVID testing, which addresses the high UV susceptibility of PV modules, particularly those with TOPCon and HJT cells. Reports have indicated that these cell technologies may experience permanent and irreversible breakdown under UV exposure, posing a significant reliability risk for industry stakeholders. Therefore, it is crucial to continuously validate the PV modules during production to ensure they meet UV performance expectations.

Hail testing is another crucial addition to the ORM protocol for sites at risk of extreme hail events. This test is particularly important for glass//glass modules which are more sensitive to microscopic glass defects and typically have wider ranges of glass strength. By focusing on glass performance, the hail test allows buyers to regularly assess and ensure that the modules continue to meet their expected durability and reliability.

Finally, performing PAN and IAM testing as part of the ORM program gives module buyers confidence in consistent performance for these important energy model inputs.

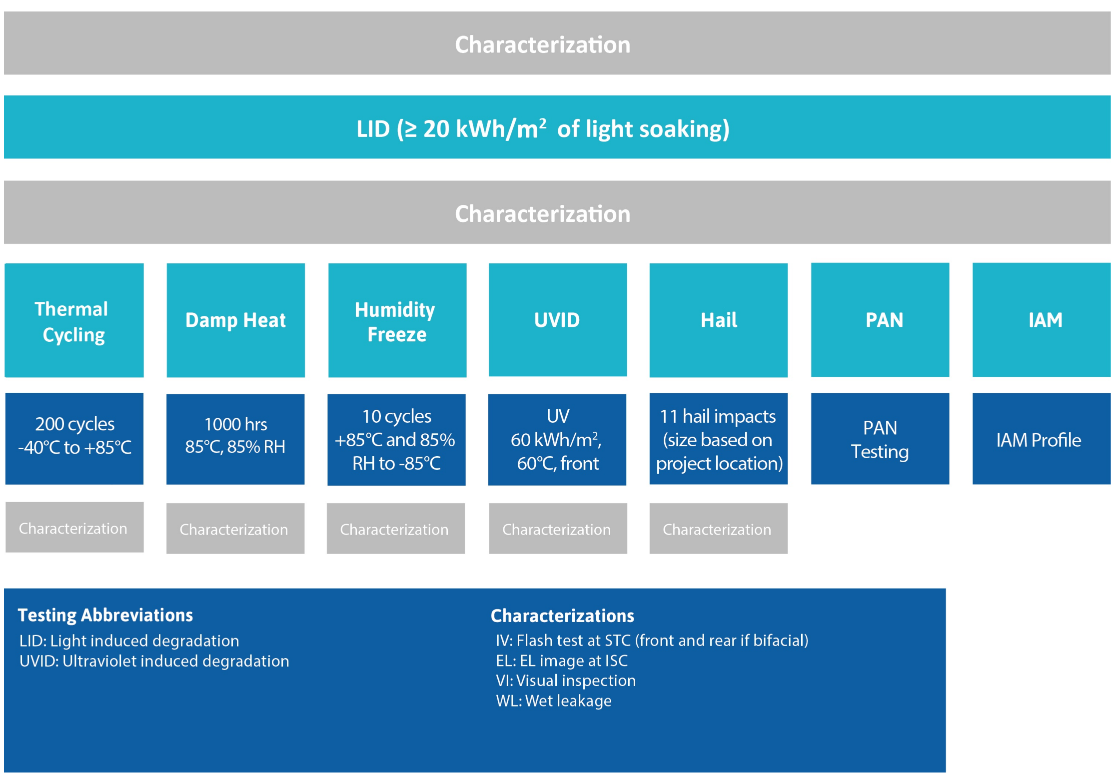


Figure 13. ORM protocol.

Batch Testing Acceptance Thresholds

Kiwa recommends performing Batch Testing on randomly selected samples from each production batch of maximum 10 MW or one week of production, whichever is less. The recommended acceptance thresholds for Batch Testing in Table 4 are based on Kiwa's historic test results across multiple manufacturers and module technologies.

If performed in the module manufacturer's onsite lab facilities with oversight from Kiwa PI Berlin, the Batch Testing results can be used as a prerequisite for shipment release. Alternatively, this testing can be conducted in one of Kiwa's multiple global test labs, the results of which will provide a feedback loop on batch consistency with any failures instigating a RCCA analysis to improve the quality of future batches and production.

TEST	POWER DEGRADATION	OTHER CHARACTERIZATIONS
Flash testing	≥minimum power specified on datasheet and power label	N/A
Bifaciality	≥minimum bifaciality factor specified on datasheet and power label	N/A
LID, LETID	Power degradation ≤ 1%	No major visual defects or wet leakage failures.
PID, SDML	Power degradation ≤ 3%	No major visual defects or wet leakage failures.
Low light performance	Module performance ≥ the initial PAN file	N/A
Peel strength	> 60 N/cm at both interfaces	N/A
Gel content	Gel content > 75% for each measured point	N/A

Table 4. Batch Testing Acceptance Recommendations

ORM Acceptance Thresholds

Kiwa recommends performing ORM on two randomly selected samples per test for every 50 MW or one month of production, whichever is less. Similar to Batch Testing, the recommended acceptance thresholds for ORM in Table 5 are based on Kiwa's historic test results across multiple manufacturers and module technologies. These test durations are typically lower than those used for PQP testing, but with similar acceptance thresholds. This is due to the difference in selecting modules from mass production for ORM testing and the PQP sample production process where the manufacturer is aware that those modules will be shipped for extended reliability testing.

Like Batch Testing, the results from ORM testing provide valuable insights on module reliability and performance consistency with any failures instigating a RCCA analysis to improve the quality of future batches and production.

TEST	POWER DEGRADATION	OTHER CHARACTERIZATIONS
TC200, DH1000, HF10, UVID60	Power degradation ≤ 3%	No major visual defects or wet leakage failures.
Hail test (hail size determined by project site's susceptibility to hail impacts)	Power degradation ≤ 3%	No glass breakage, no other major visual defects or wet leakage failures.
PAN/IAM	Module performance ≥ the initial PAN file	No major visual defects.

Table 5. ORM Acceptance Recommendations.

Conclusion

When used in conjunction with Kiwa's holistic PV module procurement best practices, Product Qualification Program, Pre-Shipment Inspection, Batch Testing and Ongoing Reliability Monitoring provide a comprehensive framework for ensuring that PV modules meet the highest standards of quality and reliability. By continuously evaluating the quality of PV modules from early stage PQP testing to regular inspection and testing during mass production, Kiwa helps module buyers mitigate risks and ensure that their systems will operate reliably throughout their intended lifespan. These tools can also be used for module manufacturers to demonstrate their product quality.

While module testing is a valuable exercise and highly recommended, having contractually specified acceptance levels is critical so that all stakeholders are aligned with expectations. Kiwa is in a unique position to provide guidance to the industry on these acceptance thresholds based on the benchmarking achieved from many years of experience in performing these services. Following Kiwa's guidance will raise the bar on module quality for the industry, resulting in higher performing solar sites for years to come.

About Kiwa PVEL

Kiwa PVEL is the leading reliability and performance testing lab for downstream solar project developers, financiers, and asset owners around the world. As part of the larger Kiwa Group, Kiwa PVEL's integrated services for the solar supply chain offer technical solutions for mitigating risk, optimizing financing and improving solar and energy storage systems performance throughout the project lifecycle.

For over a decade, Kiwa PVEL's Product Qualification Program (PQP) has been globally recognized for replacing assumptions about PV module performance with quantifiable metrics. Related data and consulting services offered by Kiwa PVEL provide vital procurement intelligence to a network of downstream solar buyers.

About Kiwa PI Berlin

Kiwa PI Berlin provides expert technical diligence, procurement, and quality assurance services for a wide range of solar installers, integrators, project developers, utilities and investors. We enable our clients to manage technical risk associated with the investment or procurement of PV equipment. We leverage direct relationships with PV module, inverter and battery manufacturers, apply our expertise to qualified manufacturers and independently verify quality, reliability, and performance.

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Kiwa reserves the right to update this guidance periodically based on the latest test result trends.