PVEL
MAKE DATA MATTER.

PV Module Product Qualification Program (PQP): Backsheet Durability Sequence

When the backsheets of PV modules are made with substandard materials or poor-quality construction methods, they are likely to degrade – and ultimately cause solar asset underperformance. PV Evolution Labs (PVEL) provides buyers with the data they need to evaluate this critical component with the backsheet durability sequence. This new backsheet test is now included with PVEL's updated PV Module Product Qualification Program.

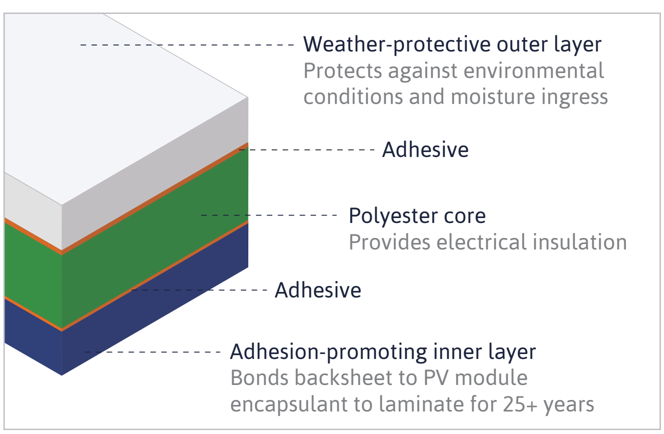
Why Test Backsheets

Backsheets are essential to PV module reliability because they protect internal components from environmental exposure and moisture ingress. When PV module backsheets are not constructed from durable materials, the consequences can be severe and widespread, for example:

- A 2017 study of PV failure modes classified "compromised backsheet insulation" as the most severe failure category due to its "major effect on power and safety."[1]
- A 2019 study of 489 systems and subsystems across 45 countries identified backsheets as a top failure mode in four out of five climates zones analyzed. [2]

Inside a PV Module Backsheet

Backsheets are typically made of a polyester core laminated between a layer of weather protective film and a layer of adhesion-promoting film. Each layer of the backsheet plays a role in PV module reliability.



Independent testing and field data show that certain materials and construction methods are more likely to result in failure than others.

The Consequences of Backsheet Failure

Backsheet cracks that allow moisture to enter a PV module can severely impact field performance. Other signs of backsheet aging, such as yellowing and chalking (this refers to powder accumulation on the backsheet as the material breaks down), are often signs of accelerating backsheet degradation.

Backsheet failure in the field

Ultimately, cracked backsheets can lead to:

- Ground faults: When water enters the PV module through a backsheet crack, it may create a path to ground. In many climates, morning dew will create these high leakage currents on a daily basis. Inverters will then partially shut down or start up late, driving energy losses over time and creating safety issues.
- Delamination: As moisture accumulates in PV modules due to backsheet cracks, delamination may eventually occur. Over time, this moisture will separate the layers of the PV module and cause corrosion of electrical circuit. Results can include extreme loss of power. Safety issues are also a concern.

Since degrading backsheets may not cause power loss right away, it is important to pursue warranty claims before the manufacturer's product construction warranty expires. Terms are typically ten years.

[1] Photovoltaic failure and degradation modes, D. C. Jordan, T. J. Silverman, J. H. Wohlgemuth, S. R. Kurtz, K. T. VanSant,, Prog Photovolt Res Appl, vol. 25, pp. 318-326, April 2017.
[2] Statistical evaluation of PV system performance and failure data among different climate zones, M. Halwachs, L. Neumaier, N. Vollert, L. Maul, D. Dimitriadis, Y. Voronko, G. C. Eder, A. Omazic, W. Mühleisen, Ch. Hirschl, M. Schwark, K. A. Berger, R. Ebner, Renewable Energy, vol.139, pp. 1040-1060, 2019.

PVEL's Backsheet Durability Sequence (BDS)

- Factory Witness
- Characterization
- DH 1000
- Characterization
- **BACK** UVA 65 kWh/m^2
- Characterization
- TC 50 + HF 10
- Characterization
- **BACK** UVA 65 kWh/m^2
- Characterization
- TC 50 + HF 10
- Characterization
- **BACK** UVA 65 kWh/m^2
- Characterization
- TC 50 + HF 10
- **BACK** UVA 6.5 kWh/m^2
- Characterization

Step 1: Factory Witness and Intake

As with every test in PVEL's PQP, our backsheet durability sequence (BDS) begins with a factory witness to record the bill of materials (BOM) used in module production. A coupon of the backsheet is saved in PVEL's sample repository. The coupon can be used to verify the materials used in fielded PV modules if necessary. The module receives baseline characterization as part of PVEL's intake process.

Step 2: Damp Heat

The module is placed in an environmental chamber at 85°C and 85% humidity for 1,000 hours. This step stresses the backsheet in order to break down the bonds in degradation-prone materials.

Step 3: Characterization

- Wet leakage to determine if path to ground will occur.
- Visual inspection for cracking and chalking.
- Color measurement for yellowing using a high-precision colorimeter.

Step 4: UV Light

The rear side of the module is exposed to UV light at 65 kWh/m^2 to simulate sunlight and cause UV degradation. The total amount of UV light for the full duration of the BDS is equivalent to about 15 to 20 years in the field, depending on irradiance, albedo and other environmental conditions.

Step 5: Thermal Cycling and Humidity Freeze

For thermal cycling, the module is placed in an environmental chamber and the temperature is cycled between -40°C and 85°C to a total of 50 three-hour cycles. These temperature changes result in the expansion and contraction of backsheet materials, which creates mechanical stress.

For humidity freeze, the chamber is raised to 85°C and 85% humidity for twenty hours followed by a rapid temperature drop to -40°C. This process is repeated for a total of ten cycles. Humidity freeze creates mechanical stress while also driving moisture into the module.

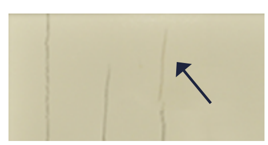
Step 6: Repeat and Measure

Steps 3 through 5 are then repeated twice. The ultimate steps are a final UV light exposure of 6.5 kWh/m^2 for photobleaching, which eliminates any minor color changes that may be captured by the colorimeter but would not occur in the field, then a final characterization.

Test Results: Replicating Field Failures in the Lab

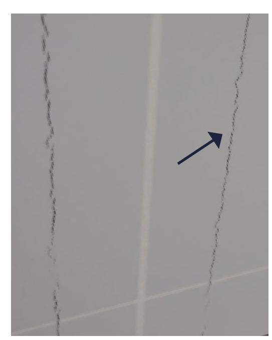
PVEL's BDS replicates the backsheet yellowing, chalking and cracking that have been observed in the field. The goal is to recreate failure modes observed in the field inside of a controlled laboratory environment. Both backsheet construction methods and material selection impact performance.

PVEL's research shows a range of results in backsheet durability and reliability, proving that both high and low quality backsheets are in the market today. As shown in the images on the right, one low-cost polyamide (PA) backsheet formulation introduced in 2009 that is known to degrade rapidly in the field also performed poorly in the lab. However, PVEL has also tested modules with co-extruded polyamide backsheet formulations that achieved strong results.



Cracks formed in PA backsheet after one round of lab testing

PA backsheet without cracks after three rounds of lab testing



Cracks formed in PA backsheet after four years of field exposure

Advantages of PVEL's Backsheet Durability Sequence

PVEL's backsheet durability sequence (BDS) is performed on full PV modules that have the bill of materials (BOM) factory witnessed. This process ensures representative test results and material traceability for downstream buyers. The rear-side UV included in the BDS is more similar to backsheet behavior in the field than tests with lower UV doses.

Our BDS helps PV module buyers and investors avoid the financial consequences of backsheet underperformance. With the data in our Product Qualification Program reports, downstream project stakeholders can mitigate the risk of procuring modules with faulty backsheets. Manufacturers can leverage independent data from the PVEL BDS to demonstrate the long-term reliability of their PV modules to our network of 300+ partners worldwide.

For more information about PVEL's backsheet durability test, please contact:

Tristan Erion-Lorico
Head of PV Module Business
PV Evolution Labs (PVEL)
info@pvel.com

PVEL
MAKE DATA MATTER.