Photovoltaic Solutions

DuPont global PV reliability

2019 Field analysis

Executive summary

The DuPont Global Field Reliability Program is a highly developed field inspection and analysis program that tracks material degradation and its effect on module performance.

This program is one of the most thorough of its kind, guided by a multistep inspection protocol at sites in North America, Europe, Asia, and the Middle East. Resulting data are analyzed using a variety of criteria – including component, material, mounting, time in service, and climate.

For nearly a decade, DuPont has collaborated with field partners, customers, downstream developers, universities, and national labs to perform these field inspections. Our mission is simple yet critical: to inspect, assess, and understand the state of degradation of fielded PV modules.

This 2019 field analysis was compiled from inspection and analysis by DuPont teams of nearly 2 GW of PV installations around the globe. It is offered as a current and reliable source to help buyers understand the breadth of component degradation issues and module failures that occur in the field.

6.5 M
Modules

355
Installations

1.8 GW
Total power

While our field analysis looks at all component materials, we focus special attention on backsheet durability, which plays a critical role in ensuring modules will last long enough to reach the financial objectives of their owners.

2019 Study

With 1.8 GW of fields inspected, the following observations were made:

- Total module defects: 34%
- Total backsheet defects: 14%
- Backsheet defects increased 47% from 2018
- Cracking comprises 66% of all backsheet defects

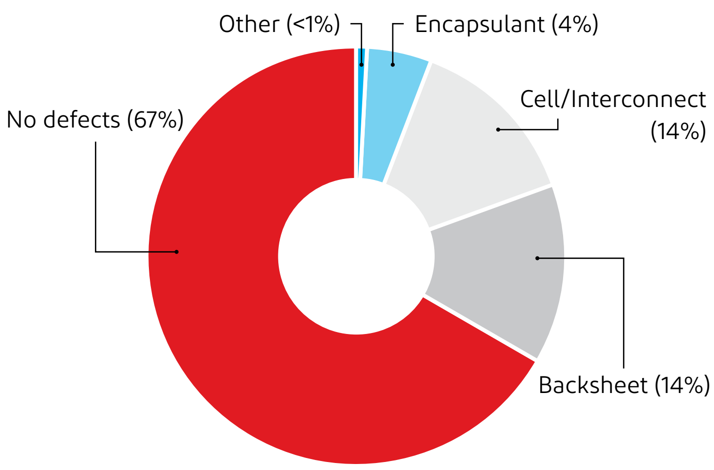
Compared to the analysis from 2018:

- The number of fields grew from 275 to 355.
- The number of panels increased from 4.2 million to over 6.5 million (1.04 GW to 1.8 GW).
- Overall module defect rates increased since 2018.
- Year-over-year backsheet defects increased 47%.

Module defect trends

While there were no defects in the majority of module materials, the following defects were observed at certain levels:

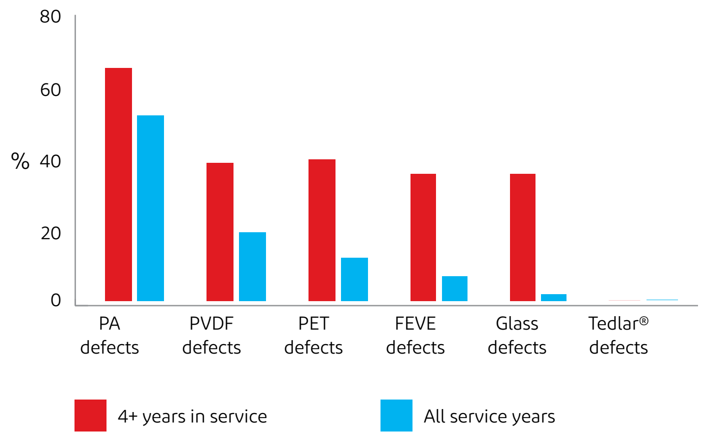
- Cell/Interconnect – corrosion, hot spot, snail trails, broken interconnect, cracks, burn marks
- Backsheet – outer-layer (air side) and inner-layer (cell side) cracking, delamination, yellowing
- Encapsulant – discoloration, browning, delamination
- Other – glass defects, loss of AR coating, junction box



Backsheet defects by panel age

There was a sharp increase in backsheet defects after 4 years for competing module materials, yet Tedlar® defects stayed at a low 0.04%.

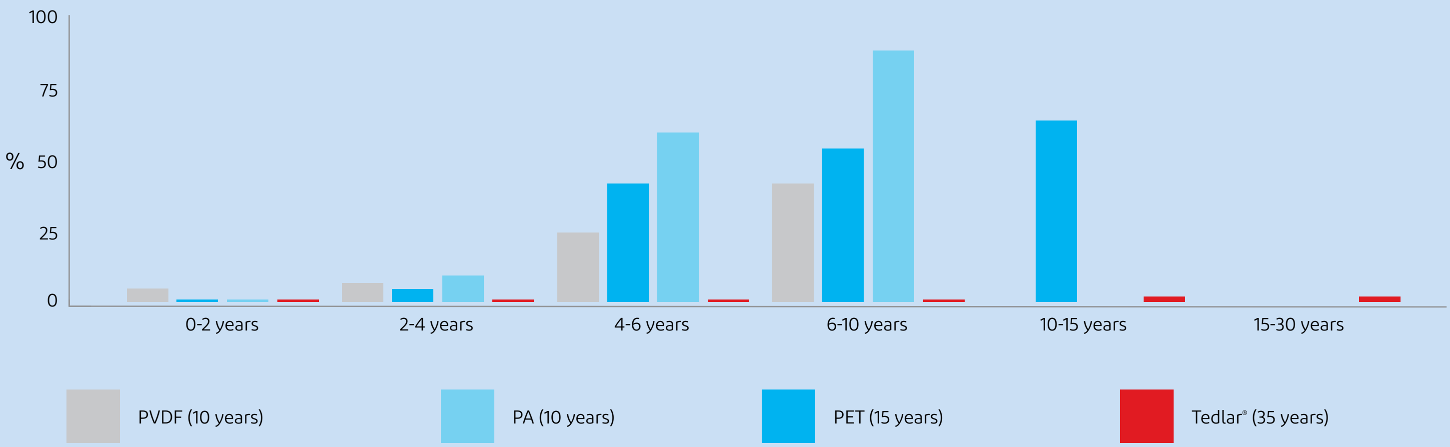
Sharp increase in backsheet defects after 4 years



PA= Polyamide
PET = Polyethylene Terephthalate
PVDF = Polyvinylidene Fluoride
FEVE = Fluroethylene Vinyl Ether

In fact, Tedlar® PVF film-based backsheet maintains the lowest defect rates – even after 35 years in the field.

Only Tedlar® PVF maintains lowest defect rates after 30+ years



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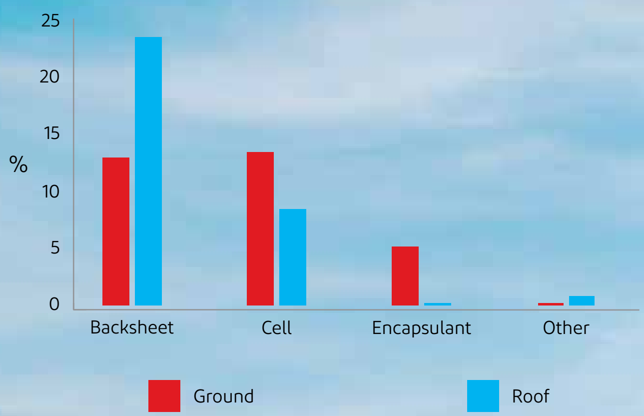
Backsheet defects by temperature

Higher temperatures cause backsheet defects to accelerate. These rates are 75% greater for roof installations than ground, as roof-mounted systems typically run 15 °C higher than ground-mounted.[1]

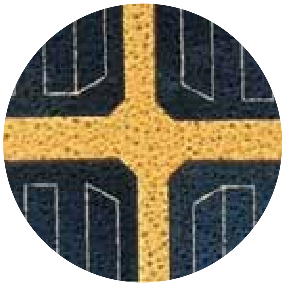
Higher temperatures accelerate backsheet defects



1 David C. Miller, Michael Kempe, "Creep in Photovoltaic Modules: Examining the Stability of Polymeric Materials and Components," 35th IEEE Photovoltaic Specialists Conference (PVSC '10), Honolulu (2010)

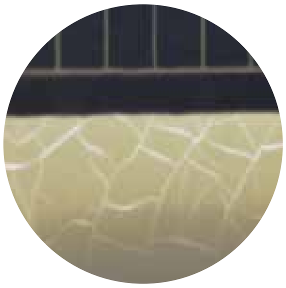
Backsheet defects by degradation mode

Cracking and delamination can compromise the electrical insulation of the module. Yellowing can lead to mechanical degradation and embrittlement of many backsheet polymers.

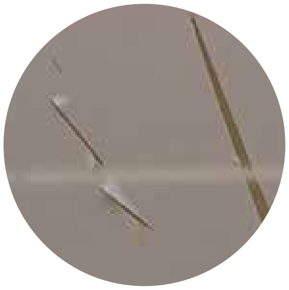


31%
Cell-side yellowing

4%
Air-side yellowing



22%
Cell-side cracking



41%
Air-side cracking

3%
Delamination

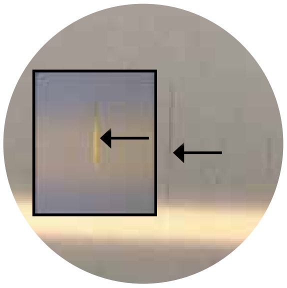
PVDF backsheet failures

Outer-layer cracking

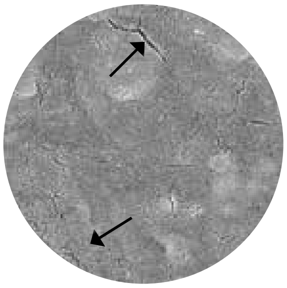
• Widespread cracks allow for delamination, directly exposing the core layer to the environment

Inner-layer yellowing

• Yellowing can be an early sign of material degradation and embrittlement

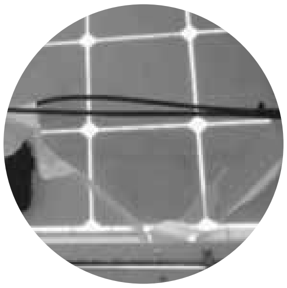


Outer-layer cracks
6 years, NW China

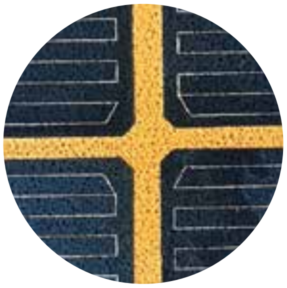


Outer-layer microcracks
2.5 years, Northern China

Outer-layer cracks
7 years, SW USA

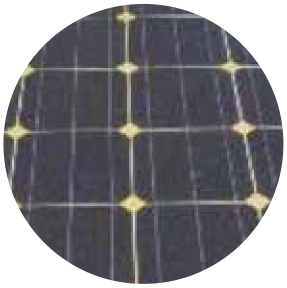


Outer-layer cracks and delamination
6 years, Canada

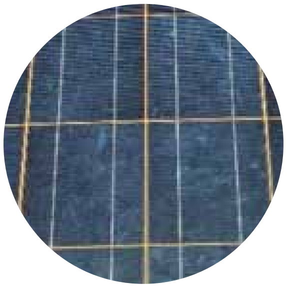


Inner-layer yellowing
6 years, SW USA

Inner-layer yellowing
6 years, NW China



Inner-layer yellowing
7.5 years, Italy



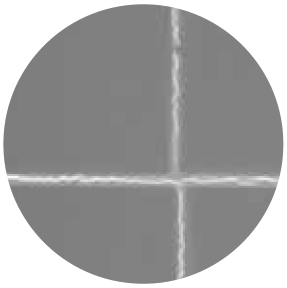
Inner-layer yellowing
5 years, NW India

Polyamide backsheet failures

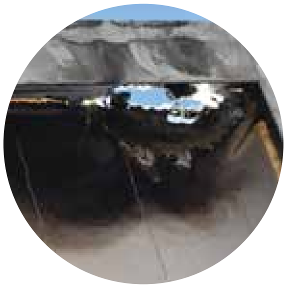
Widespread backsheet through-cracks

- These failures are prevalent along busbar ribbons, but with continued weathering can extend to cell gaps and other regions
- Arcing and shorts often lead to localized burn-through and sometimes full module fires
- Reported inverter tripping and ground faults
- Over 12 GW of field failures to date

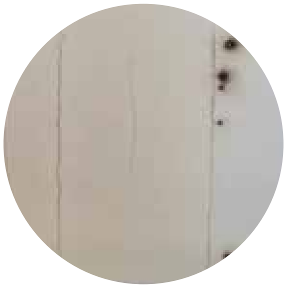
Outer-layer cracks
6 years, NW China



Inner-layer cracks
6 years,
Sonoran Desert, USA



Burn-through
7 years,
Sonoran Desert, USA

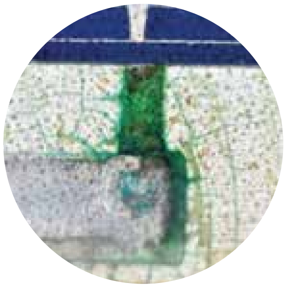


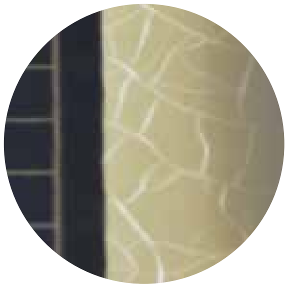
Burn-through
6 years, High Desert,
Nevada, USA

PET backsheet failures

Inner- and outer-layer cracking

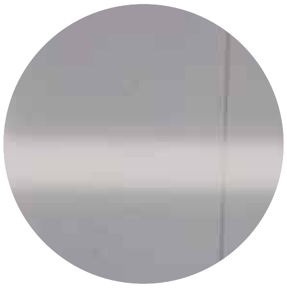
- Inner-layer cracks enable moisture to enter, often leading to busbar corrosion
- Outer-layer cracking exposes PET core to environmental degradation, also allowing moisture to enter
- Exposing module interiors to moisture can lead to shorting, inverter trips, power loss, and multiple module fires





Inner-layer cracking
7 years, Sonoran Desert, Arizona, USA

Outer -layer cracking
8 years, Arizona, USA

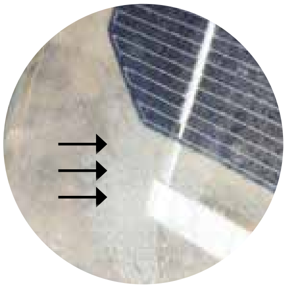


Outer-layer cracking
6 years, NW China

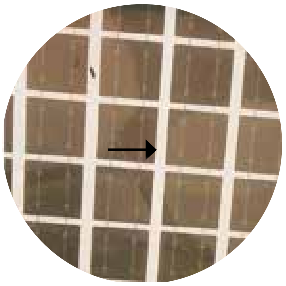
Glass – glass module failures

Delamination and cracking

- Delamination appears to originate near edges of a module or at individual cells
- Cracks likely originate at scratches or chips on the glass surfaces and edges or at stress risers introduced by the racking system



Glass/encapsulant delamination
1.5 years, Northern China



Encapsulant delamination
10 years, Arizona, USA

Delamination and corrosion
15 years, Southern China

Delamination
20+ years, Italy

Materials Matter™ when it comes to backsheets

A large independent power producer (IPP) in Arizona discovered one of their sites was producing less energy than predicted. Upon reviewing the system for failures, they found certain backsheets had started to crack and delaminate – leading to high leakage currents tripping inverters and causing partial shutdowns and late starts.

DuPont inspected the 7-year-old site through its Fielded Module Inspection Program and discovered widespread backsheet cracking and delamination on many of the modules. While the site was composed of modules from a single manufacturer and model, as many as three different backsheet types were identified, suggesting the module manufacturer used multiple bills of materials (BoMs) for the same project.

- **100% of PA backsheets exhibited cracking along busbar ribbons**
- **100% of PET backsheets exhibited inner-layer cracking**
- **100% of PVDF backsheets exhibited outer-layer cracking**
- **0 defects in Tedlar® PVF backsheets**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