



STATISTICAL ANALYSIS OF PV MODULE QUALITY IN MASS PRODUCTION

2013: 1 PANEL OUT OF 4 IS DEFECTIVE



November 2013

ABOUT STS

STS-Certified is a leading provider of quality assurance services, mass-production scale testing and inspection solutions.

STS-Certified owns a 3,000m² PV module testing facility strategically located in China, closer to PV makers and main ports of shipment. In 2012, 200,000 solar panels have been tested by STS-Certified, which makes STS testing center the largest of its kind in the PV industry.

Like no other company, STS-Certified is able to run tests on every module (as opposed to tests by sampling), in order to guarantee that all the modules approved are free of defects.

More than testing, inspecting and certifying products, STS helps the PV industry stakeholders from manufacturers to authorities and regulation agencies make certain that the projects they are taking part to will perform properly on the long course.

ABOUT THE TESTS

Place of tests:

STS Testing Center - Kunshan, China

Standards applied:

STS-QUA-REG-11013:2.1 and client's standards

Period of test:

January to September 2013

Number of manufacturers tested:

13

Manufacturers' origin / Production location:

China

PURPOSE OF THE TESTS

By performing tests at a module level in mass-production scale, STS reveals the actual quality level of PV module manufacturers in the most representative and comprehensive way.

Through the in-depth analysis of tens of thousands of PV modules, this document offers a detailed perspective on which quality defects are the most present in PV modules, and at which rate, so that PV module buyers and PV projects stakeholders can better anticipate the required actions to prevent risks in PV modules.

Going beyond the mere assessment of solar panels for PV buyers, STS also aims at providing PV module manufacturers with a different approach to the various defects that can be found after large-scale production.

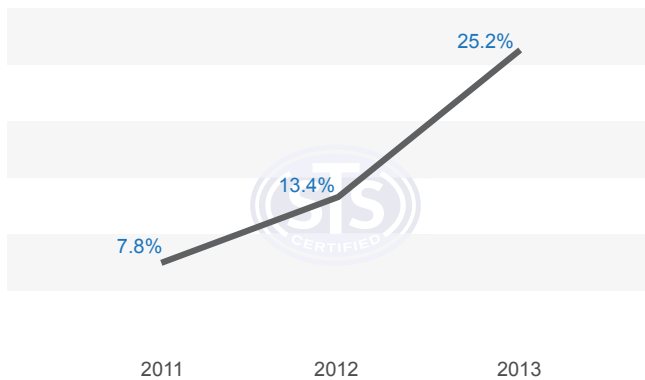
For more information about this document, contact us at technical.support@sts-certified.com

OVERALL RESULTS

Defective panels rate:	25,2%
Average quantity of defects per panel:	0.316

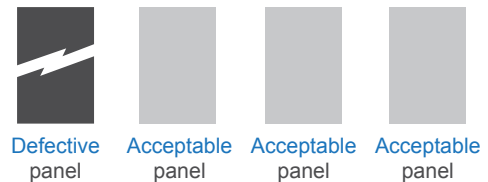
More than 25% of the products tested between January and September 2013 were found defective by STS. Some products showed multiple types of defects, and statistics demonstrate that a product will have in average 0.316 defects. Tests were conducted based on STS proprietary Quality Standards as well as clients' required standards, the latter tending to be less comprehensive, or enforced by their PV module supplier and therefore not as strict as STS standards. Should STS standards have been applied to all the products, the defect rate would have been higher than 25.2%.

HISTORICAL EVOLUTION OF DEFECTIVE PANELS RATES

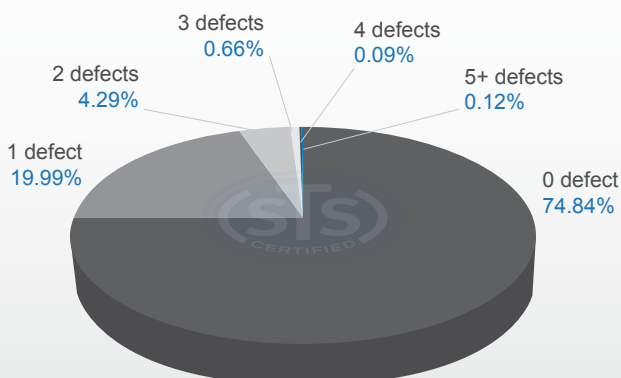


Defect rates have been steadily increasing year-over-year. While in 2011 one PV module out of 13 was defective, in 2013 one PV module out of 4 is defective. Since STS started to collect statistics on defects, the defect rate has increased by 72% in 2012, and by 88% in 2013, the sharpest increase yet. While the methodology of testing did not differ during the observation period, the standards used between the different periods have been less strict year-after-year—results in 2011 and 2012 were only based on STS quality standards—which does not affect the statistics hereby. This growth indicates that solar panels are increasingly defective, that improvements in production are not being made, and quality as a whole is being neglected.

Representation of defect rate in 2013:
1 panel out of 4 is defective →



DISTRIBUTION OF QUANTITY OF DEFECTS PER MODULE



Tests reveal that 25% of the products had one or more defect types. The majority of defective PV modules had one or two defect types, while less than 1% of them had 3 or more defect types.

TOP 10 MOST RECURRING DEFECTS

DESCRIPTION	CLASS	COMPONENT	TYPE	DEFECT RATE
Micro-cracks	Major	Cell	Reliability	15.577%
Frame with sharp edge	Critical	Frame	Safety	2.676%
Scratched frame	Minor	Frame	Cosmetic	1.943%
No barcode	Major	Label	Function	1.482%
Wrong size of installing holes	Major	Frame	Function	1.363%
Low power	Major	Unclassified	Performance	1.265%
Wrong manufacturer label	Major	Label	Function	1.017%
Length of cable out of spec	Major	Junction Box	Function	0.859%
Grid defects	Major	Cell	Performance	0.788%
Processing marks	Minor	Cell	Performance	0.694%

Micro-cracks are by far the largest cause of defects seen in PV modules. Micro-cracks are breakages in solar cells observed by electro-luminescence, which may directly reduce the power generation of each solar cell and impact the performance of the product. STS has observed that this defect has steadily increased year after year and is now a major concern for clients. While most manufacturers do perform the required tests, they still do not segregate defective products for multiple reasons such as poor internal quality standards, ineffective testing equipment, unqualified operators, lack of concern for micro-cracks, performance of sample testing instead of 100%, etc.

DEFINITIONS OF CLASSES

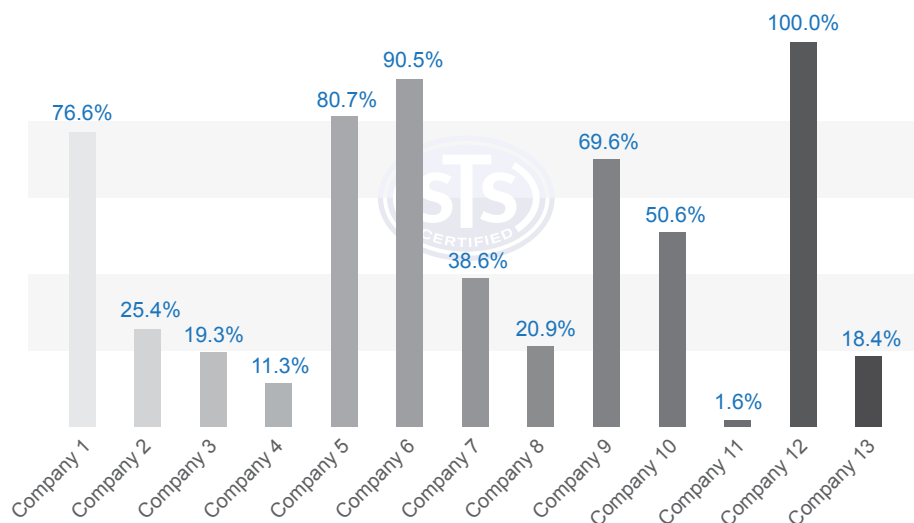
Critical: A defect that is likely to result in hazardous or unsafe conditions for the individual using the product, likely to cause damages to other products or property, or that is generally contravening mandatory regulations.

Major: A defect that is likely to reduce the usability or resulting in failure of the product to fulfill its function. Obvious appearance defects that are likely to reduce the sale ability of the product.

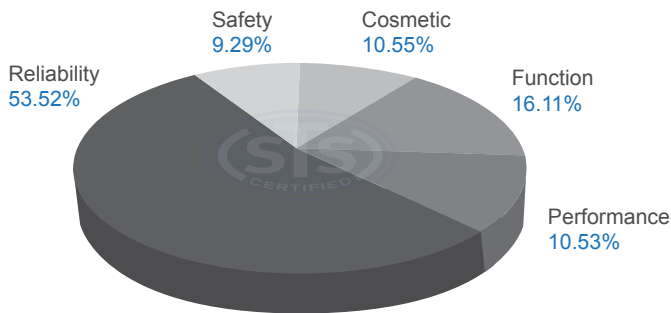
Minor: A defect that does not reduce the usability of the product, but is nevertheless a workmanship defect beyond the acceptable quality standard.

DEFECT RATES BY MANUFACTURERS

The defect rate varies considerably according to the manufacturer itself. While many consider that large factories produce better quality, STS results do not reflect this statement. STS has recorded both high and low defect rates at Tier 1, Tier 2 and Tier 3 manufacturers. STS has observed however a learning curve at manufacturers who are prepared to have their products tested by third parties. In addition, we observe on this chart a defect rate of 1.6% for Company 11, for which the manufacturer's standards were applied; should STS quality standards had been applied, the defect rate would have been higher.

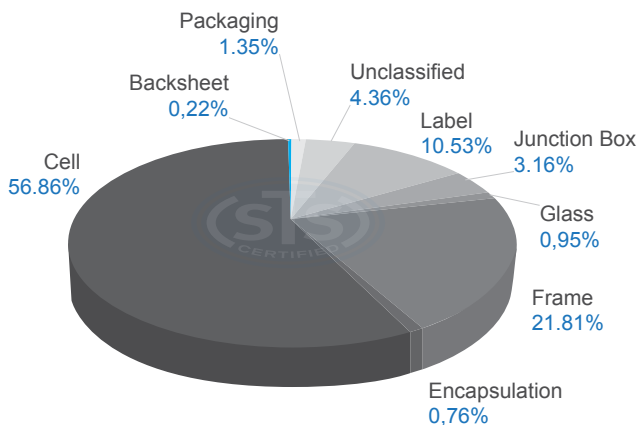


DISTRIBUTION OF DEFECTS BY CATEGORY



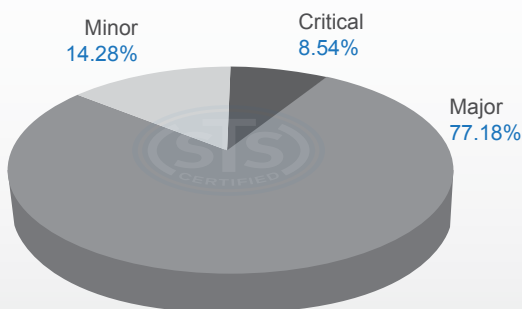
Reliability and Performance defects are often seen by STS clients as the most important defects to avoid, as they lead sooner or later to an underperformance of the PV module in the field and to economic loss for the end-user. Combined, those defects account for almost 65% of the defects recorded. Typical defects in these two categories are micro-cracks, low power and defects related to the solar cell construction. Safety risks, while often detected, are too often neglected; they indicate a non-compliance with standards such as IEC or UL and may affect the safety of the installers or users. Cosmetic defects such as scratches on the front glass or on the frame may lead to a degradation of the PV modules in the long run, while Function defects may result in installation or traceability issues.

DISTRIBUTION OF DEFECTS BY COMPONENTS



The component most affected by defects is the solar cell (56.86%), a primary component of PV modules. These defects directly impact the performance of the PV module. Frame defects account for 21.81%, and may lead in some cases to risks of injury for installers. Defects in other components are less recurrent.

DISTRIBUTION OF DEFECTS BY CLASS



Most defects (77.18%) are classified as Major Defects: they may affect the performance of the PV module, but may not harm or injure the user. Critical defects however present a safety risk that must be prevented. Minor defects may not influence the actual performance of the PV module nor cause any risk of injury, but are still inconsistent with a stable manufacturing practice.

APPENDIX

DEFECT RATES BY TYPE

DEFECT RATES BY TYPE

DESCRIPTION	CLASS	COMPONENT	TYPE	DEFECT RATE
Micro crack	Major	Cell	Reliability	15,577%
Frame with sharp edge	Critical	Frame	Safety	2,676%
Scratched frame	Minor	Frame	Cosmetic	1,943%
No barcode	Major	Label	Function	1,482%
Wrong size of installing holes	Major	Frame	Function	1,363%
Low power	Major	Unclassified	Performance	1,265%
Wrong manufacturer label	Major	Label	Function	1,017%
Length of cable out of spec	Major	Junction Box	Function	0,859%
Grid defect	Major	Cell	Performance	0,788%
Processing mark	Minor	Cell	Performance	0,694%
Frame misalignment	Major	Frame	Reliability	0,686%
Cells class difference	Minor	Cell	Performance	0,552%
Unclear barcode	Minor	Label	Cosmetic	0,343%
Wrinkled manufacturer label	Minor	Label	Cosmetic	0,236%
Dirt on glass	Minor	Glass	Cosmetic	0,177%
Wrong direction of barcode	Minor	Label	Cosmetic	0,126%
Scratched glass	Major	Glass	Reliability	0,122%
Wrong printing of package	Minor	Packaging	Cosmetic	0,118%
Soldering defect	Major	Cell	Reliability	0,118%
Missing sealant	Major	Encapsulation	Reliability	0,114%
Wrong product	Major	Unclassified	Function	0,099%
Scratched cell	Major	Cell	Reliability	0,095%
Inclusion in active area	Major	Encapsulation	Reliability	0,091%
Damaged connector	Major	Junction Box	Function	0,075%
Dirt on frame	Minor	Frame	Cosmetic	0,063%
Wrong position of grounding hole	Major	Frame	Function	0,051%
String offset	Major	Cell	Cosmetic	0,039%
Damaged pallet	Major	Packaging	Safety	0,035%
Wrong packing method	Major	Packaging	Function	0,035%
Duplicated barcode	Major	Label	Function	0,035%
Inconsistent barcode	Minor	Label	Function	0,032%
Frame dents	Minor	Frame	Cosmetic	0,032%
Dirt on backsheet	Minor	Backsheet	Cosmetic	0,032%
Dent on backsheet	Minor	Backsheet	Cosmetic	0,032%
Printing smudge	Minor	Packaging	Cosmetic	0,024%
Burr on frame	Major	Frame	Cosmetic	0,024%
Overflowing of sealant	Minor	Encapsulation	Cosmetic	0,024%
Poor cover sealing	Major	Junction Box	Reliability	0,020%
C notch	Major	Cell	Reliability	0,020%
Frame deformation	Major	Frame	Cosmetic	0,016%
Dirt on package	Minor	Packaging	Cosmetic	0,012%
Dirt on barcode	Minor	Label	Cosmetic	0,012%
Wrinkled barcode	Minor	Label	Cosmetic	0,012%
No manufacturer label	Major	Label	Function	0,012%

DEFECT RATES BY TYPE

DESCRIPTION	CLASS	COMPONENT	TYPE	DEFECT RATE
Damaged frame edge	Major	Frame	Cosmetic	0,012%
Polarity mark defect on cable	Major	Junction Box	Cosmetic	0,012%
Cell distance out of spec	Critical	Cell	Safety	0,012%
Damaged cells surface	Major	Cell	Reliability	0,012%
No EL image	Major	Cell	Performance	0,012%
Wrong direction of manufacturer label	Minor	Label	Cosmetic	0,008%
Scratched backsheet	Major	Backsheet	Reliability	0,008%
No polarity sign	Critical	Junction Box	Safety	0,008%
Closing function defect	Major	Junction Box	Function	0,008%
Sealant is not well distributed	Major	Encapsulation	Reliability	0,008%
Cell color difference	Minor	Cell	Cosmetic	0,008%
Cell broken	Major	Cell	Reliability	0,008%
High power	Major	Unclassified	Performance	0,008%
Package out of spec	Minor	Packaging	Function	0,004%
Peel off barcode	Minor	Label	Cosmetic	0,004%
Unclear "QC" seal	Minor	Label	Cosmetic	0,004%
Dimension of frame out of spec	Major	Frame	Function	0,004%
Position of mounting hole out of spec	Major	Frame	Function	0,004%
No mounting hole	Major	Frame	Function	0,004%
Frame blister	Minor	Frame	Cosmetic	0,004%
Inclusion in inactive area	Minor	Encapsulation	Cosmetic	0,004%
Damaged junction box	Major	Junction Box	Reliability	0,004%
Dirt on junction box	Minor	Junction Box	Cosmetic	0,004%
Scratched cable	Major	Junction Box	Safety	0,004%
Dirt on cable	Minor	Junction Box	Cosmetic	0,004%
Cells connector misalignment	Major	Cell	Cosmetic	0,004%
V notch	Major	Cell	Reliability	0,004%
Short circuit	Major	Unclassified	Performance	0,004%



WWW.STS-CERTIFIED.COM