IEC PAS 62257-10

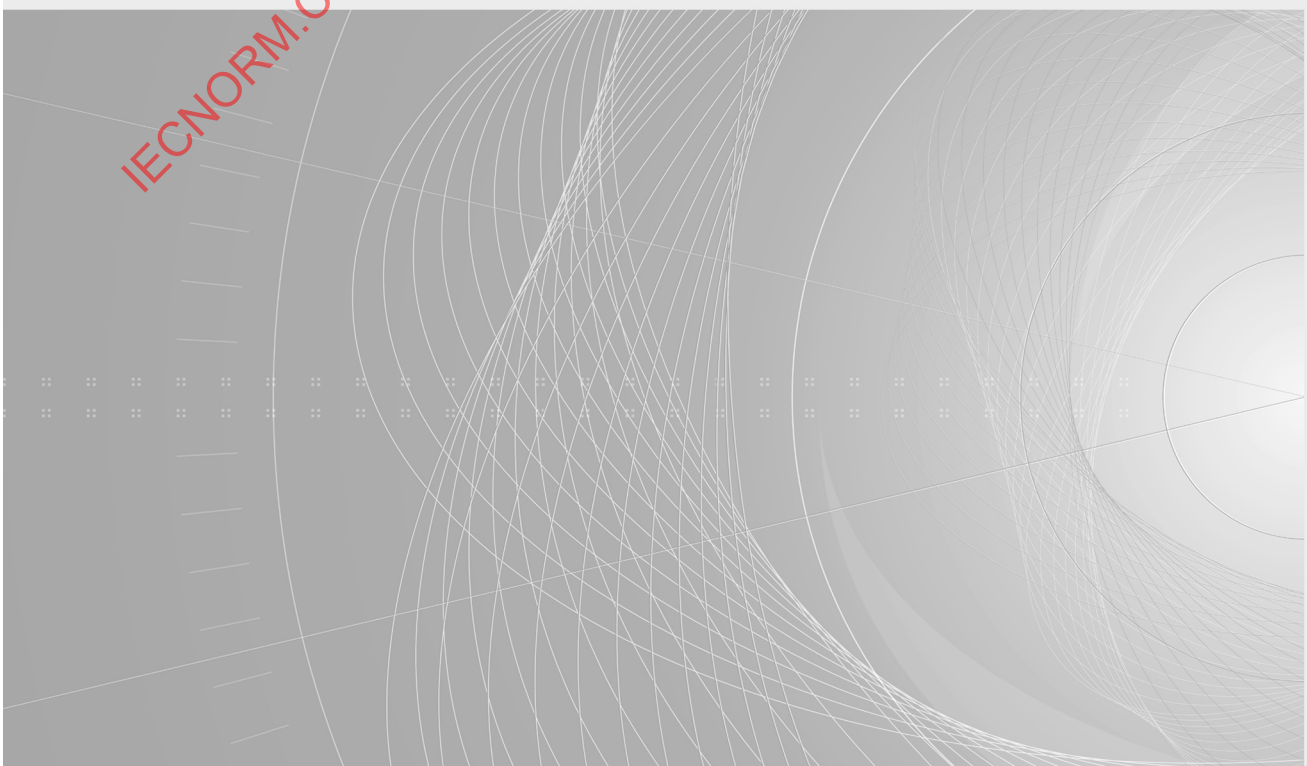
Edition 1.0 2017-08

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

colour inside

Recommendations for renewable energy and hybrid systems for rural electrification –
Part 10: Silicon solar module visual inspection guide



IEC PAS 62257-10:2017-08(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

IEC PAS 62257-10

Edition 1.0 2017-08

PUBLICLY AVAILABLE SPECIFICATION

PRE-STANDARD

colour inside

Recommendations for renewable energy and hybrid systems for rural electrification –
Part 10: Silicon solar module visual inspection guide

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 27.160

ISBN 978-2-8322-4643-6

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 10: Silicon solar module visual inspection guide

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public.

This PAS is based on the document by Zayed Energy and Ecology Centre, Version 1.8, 2016-12-01, K. Sinclair and M. Sinclair.

IEC PAS 62257-10 has been processed by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
82/1274/DPAS	82/1312/RVDPAS

Following publication of this PAS, the technical committee or subcommittee concerned may transform it into an International Standard.

This PAS shall remain valid for an initial maximum period of 2 years starting from the publication date. The validity may be extended for a single period up to a maximum of 2 years, at the end of which it shall be published as another type of normative document, or shall be withdrawn.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This document is organized into a terminology section and a checklist, followed by a table cataloguing and describing the defects to be visually inspected. The schematics in the terminology section describe where each component is found on a common solar PV module. A severity rating is also defined to give users guidelines on how concerning a particular defect may be. In the checklist and the catalogue of defects, defects have been organized by the component of the module on which they appear, followed by severity rating. The order in which components are inspected goes from the back to the front of the module, following a procedure developed elsewhere [3][1]. The catalogue of defects is subdivided into two sections: the first referring to defects that might be found on new modules, and the second describing defects that might appear over time. This document is principally focused on defects that are observable at the beginning of product life. Selected significant defects that may appear over time are also included for completeness and to address the second-hand market.

This document was developed as a response to observations of sub-standard quality and counterfeit solar products present in developing world markets. Many consumers and retailers are not aware of the presence of significant visually observable defects that may limit performance and/or lead to premature product failure. Nor are they aware that good quality PV modules should last 25 years or more. Note that no amount of visual inspection or electrical product testing can guarantee that a module will perform reliably for 25 years.

Although visual inspection cannot catch all possible defects, it can be used as a screening method to identify poor performing products and potential early failure modes. This document was designed with the intention of being a quick tool that is inexpensive to implement, as it does not require any test equipment. Although helpful, no prior knowledge of solar photovoltaics is required to benefit from this guide, and an inspector should be able to be trained in its use in two days or less.

[1] Numbers in square brackets refer to the Bibliography.

RECOMMENDATIONS FOR RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 10: Silicon solar module visual inspection guide

1 Scope

This document is designed to be used as a guide to visually inspect front-contact poly-crystalline and mono-crystalline silicon solar photovoltaic (PV) modules for major defects (less common types of PV modules such as back-contact silicon cells or thin film technologies are not covered herein). The modules under consideration may be of any size or rated power, however some specific use-cases for solar modules may have different requirements and therefore adaption of this document is application and institution dependent (ex. labelling may not be present for a solar module sold as part of a small off-grid lighting kit). This document is meant to supplement and support rather than replace international testing standards (for example IEC 61215 or UL 1703 [1], [2]). A lack of visually observable defects is necessary but not sufficient to determine if a module would pass IEC 61215 testing.

Several applications could be envisioned for this document, including use by:

- border agents to inspect product shipments at ports of entry to a country. Standardized rejection criteria could be used as grounds for barring defective products for import in conjunction with an adopted IEC standard such as IEC 61215;
- standards agencies or regulatory authorities in search and seizure efforts. A tool that can be used onsite to determine if defective or fraudulent products are found for sale in markets;
- retailers/distributors to ensure they are receiving acceptable quality products from manufacturers;
- installers/technicians when selecting product from retailers or distributors for customers;
- educators as a teaching tool for students of solar energy, for example when training technicians;
- inspectors of already installed solar products to catalogue defects and attempt to trouble-shoot failures.

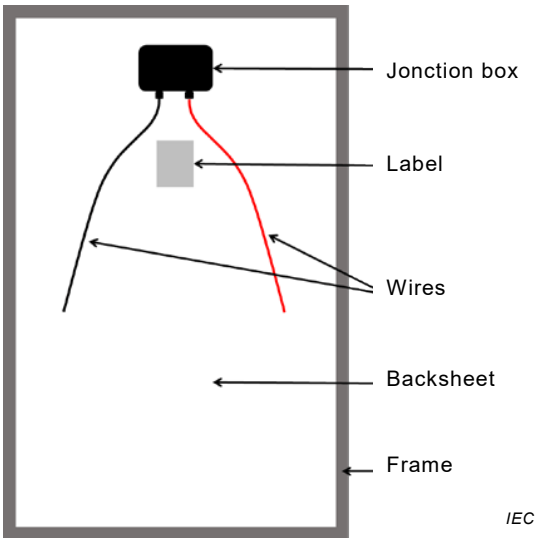
However, as this guide deals primarily with new modules, alternative tools are recommended for this task (see for example [3]).

2 Normative references

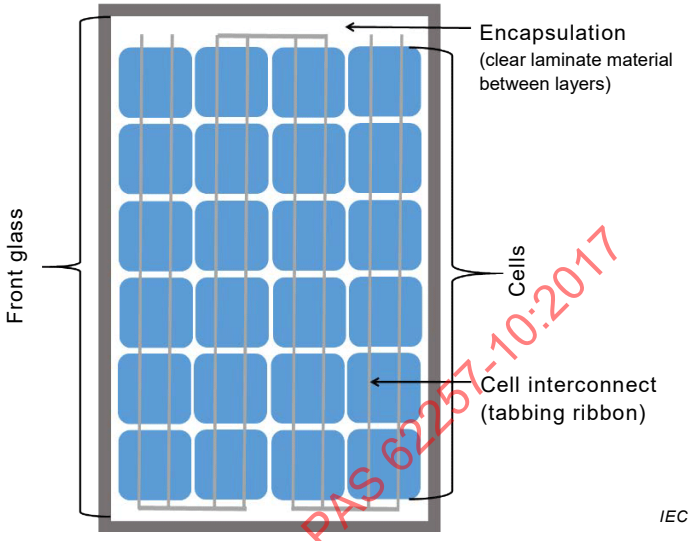
There are no normative references in this document.

3 Terms, definitions, symbols and abbreviated terms

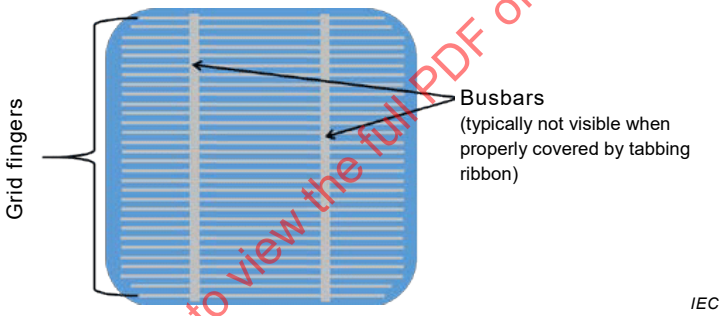
3.1 Clarification of terminology



Rear side of silicon module



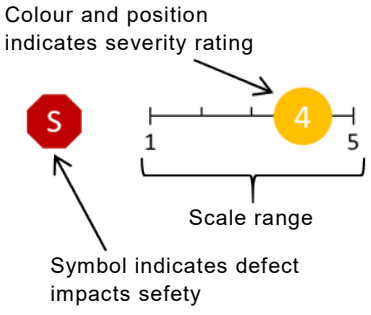
Front side of silicon module



Individual silicon solar cell

3.2 Clarification of severity rating

Efforts were made by the authors to provide a comparative rating of the severity of the defects. The range of the scale indicates influence to performance and/or reliability, and is given is from 1 (low severity) to 5 (high severity). A range is provided when the severity of a defect can vary, for example with the size of the affected area. An additional icon is given if the defect poses a potential safety risk to the installer or the end user. The authors assume no liability for actions taken as a result of this document.



Key

S Symbol indicating a safety risk, separate from quantitative scale

1 The defect is an indicator of poor quality with no direct effect on performance or reliability

2 The defect has a minor impact on performance and/or reliability

3 The defect has a moderate impact on performance and/or reliability

4 The defect has a high impact on performance and/or reliability

5 The defect is indicative of a major quality issue, a critical failure, or a counterfeit panel

4 Recommendations

4.1 General

The following subclauses provide recommended guidelines for the use of this document. This includes recommendations on an inspection procedure and accept/reject criteria.

Institutions may choose to adapt the checklist into a format unique to the needs of the given application. A cover page could be used to accomplish this. For example, different institutions/application might require specific administrative details to be recorded beyond the fields of module ID, inspector and date that are currently included (ex. location, reason for inspection, shipment, company, actions taken, comments, etc.).

4.2 Inspection procedure

The following procedure should be followed for each product lot to be inspected (ex. shipment, retail location, installation, etc.).

a) Identify and differentiate the different product types/sizes to be inspected within the lot.

b) Select a minimum of 8 samples of each size/type randomly for inspection (see IEC 61215 for sampling recommendations). Care should be taken to select samples from different locations (boxes, containers, etc.) within a lot (for example do not simply select the first 8 samples that are seen). Depending on the application this may not be sufficient: for example, if inspecting existing modules at a solar installation, it would likely be desirable to inspect 100 % of samples.

c) The inspector should complete one checklist per sample, proceeding through the list of defects in the order in which they are presented in order to ensure completeness.

   1) For each defect in sequence complete the checklist with an indication of defect presence, severity and whether or not the defect represents a potential safety risk.

   2) Depending on the requirements and the resources of the institution, it may be of interest to take photos of defects for inclusion in an inspection report, along with overview photos of the front, back, and label of a module.

   3) If further information or clarification is needed, refer to the detailed catalogue of defects which includes a description of the affected component, defect photos, a description of the defect, why it is important and guidelines on assessing defect severity.

   4) For used samples, both “new” and “used” checklists should be completed in this order.

Inspectors should be sufficiently familiar with defects unique to used modules such they can be identified during the inspection of ostensibly new products.

d) Once the inspection checklist is complete the inspector can review the results to determine whether the inspected module is acceptable for the intended application. The accept/reject criteria for a single module and an entire lot may be based on the recommendations below, or as per a standardized procedure determined by a given institution.

4.3 Accept / reject criteria

Acceptance and rejection criteria may be application and end user dependent. For example; small modules for off-grid applications may have slightly different quality requirements than full sized modules for utility scale applications. The market for small off-grid module may tolerate minor defects whereas the utility-scale market may not allow any visual defects which might pose even a small risk to the reliability and therefore the long term economic viability of the project.

Users of this document should make final accept/reject decisions based on a consistent, standardized and documented process which is justified by the needs of the market being served. The following provides a recommended set of guidelines for deciding on the acceptability of modules under visual inspection.

A solar PV module sample will be considered to be rejected due to its observable quality defects if any one of the following conditions are met:

a) If any single observed defect has been evaluated as a severity of 5. A severity of 5 indicates a major quality issue; a critical failure or a fraudulent module. This evaluation alone is sufficient justification for the rejection of a sample.

b) If any single observed defect has been evaluated to pose a safety risk. Under no conditions should a module that risks the safety of an installer or end user be considered acceptable.

c) If any combination of observed defects that have a summed severity score greater than or equal to 5 (acceptable summed value could be raised or lowered at the discretion of a given institution). This condition allows for the possibility to accept modules with minor defects that do not critically affect performance or reliability. This is done with the intent of not putting prohibitively stringent demands on developing markets that can tolerate minor deficiencies.

d) If any module that is expected to be new shows any of the used module defects. The defects listed under the used module checklist should be exclusively visible on used modules. At the discretion of the institution, the inspector might be directed to also always complete the used module checklist in order to rule out these defects, or alternatively simply complete the last row of the new module checklist to indicate the module does not appear to have been used previously.

If one or more samples are rejected for any of the above conditions then further action is required. Dependent on the application to which this process is applied and the goals of the inspection, several options are possible at the discretion of the responsible institution:

e) Reject the entire lot under inspection.

f) If only one of initial 8 samples is defective, reselect at minimum 8 random samples from the lot and repeat the above inspection procedure. If rejects are again found then reject the entire lot.

g) Require 100 % inspection on all samples within the lot and reject all non-conforming samples.

h) Instigate a more in-depth secondary inspection to further investigate the quality of the lot under question, likely to include electrical testing. The procedure for this testing is beyond the scope of this document.

Annex A
(normative)

Checklists

Module ID: Inspector: Date:

CHECKLIST: New module

COMPONENT	DEFECT		Defect present? No	Yes	If yes, score	Safety issue?
1. Label	1.1	Missing				
	1.2	Poorly attached				
	1.3	Information is missing				
	1.4	Incorrect spelling				
2. Backsheet	2.1	Delamination				
3. Junction box	3.1	Faulty electrical connection				
	3.2	Cracks/breaks/gaps in housing				
	3.3	Sealant failure				
	3.4	Electrical polarity not indicated				
4. Wiring	4.1	Wire(s) missing or poorly attached				
	4.2	Too short and/or too thin				
5. Frame	5.1	Damaged				
	5.2	Adhesive/sealant failure				
6. Front glass	6.1	Cracking				
	6.2	Scratches				
7. Encapsulation	7.1	Delamination				
8. Cells	8.1	Fake				
	8.2	Dummy pieces disguising missing material				
	8.3	Cracks				
	8.4	Partially covered				
	8.5	Scratches				
	8.6	Differently sized				
	8.7	Edge chips				
	8.8	All cells very shiny				
9. Cell metallization	9.1	Fingers not connected to busbar				
	9.2	Not the same pattern on all cells				
	9.3	Fingers off of edge of corner of cells				

COMPONENT	DEFECT		No	Yes	If yes, score	Safety issue?
10. Cell interconnection	10.1	Interconnection is discontinuous				
	10.2	Cells connected in parallel (counterfeit)				
	10.3	Poorly aligned and/or soldered				
	10.4	Cells connected in parallel (real cells)				
Defects are present suggesting module is used rather than new						
SUMMARY Indicate if any defects and safety issues are present and sum score						

ACCEPT: ☐ **REJECT:** ☐

CHECKLIST: Used module

COMPONENT	DEFECT		Defect present?			
			No	Yes	If yes, score	Safety issue?
1. Label	See new module checklist					
2. Backsheet	2.2	Burn marks				
	2.3	Discolouration				
3. Junction box	See new module checklist					
4. Wiring	4.3	Cracks or exposed metal				
5. Frame	See new module checklist					
6. Front glass	See new module checklist					
7. Encapsulation	7.2	Discolouration				
8. Cells	8.9	"Snail trails"				
	8.10	Shiny locally/inconsistent colour				
9. Cell metallization	See new module checklist					
10. Cell interconnection	See new module checklist					
SUMMARY Indicate if any defects and safety issues are present and sum score						

Annex B
(normative)

Catalogue of defects: new modules

B.1 LABEL

Provides important product information. Adhered to the rear of a module by the module manufacturer.

B.1.1 Missing

IEC

Description: A label shall be present. This may be unlikely if the panel is small (<5 W).

Why it is important: Lack of label implies sub-standard manufacture. Lack of this information is a potential safety issue. Label information is needed to properly install and operate the panel.

Severity:

B.1.2 Poorly attached

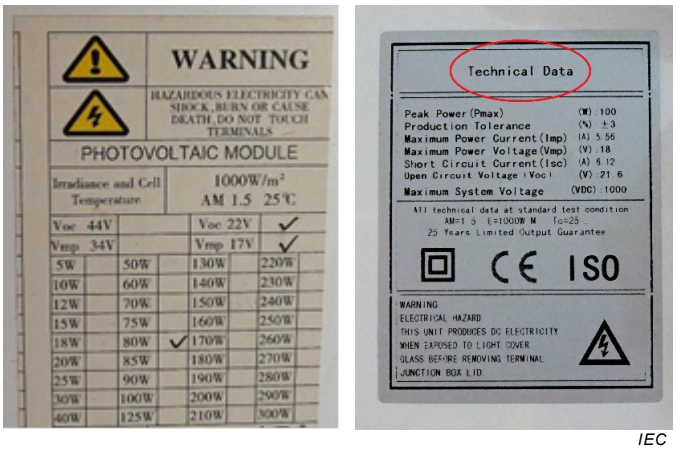
IEC

Description: Label should be made of material that resists water or light damage. Label should not be peeling or bubbling. Label should be permanently adhered (example at right uses clear tape overtop of a poorly affixed label).

Why it is important: Label needs to provide panel information for the duration of the panel lifetime. Lack of this information is a potential safety issue as described above.

Severity:

B.1.3 Information is missing



IEC

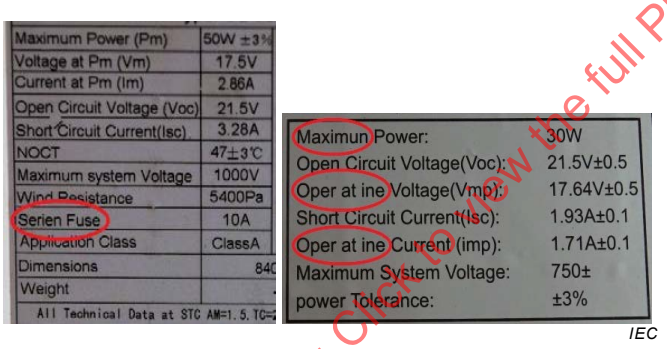
Label on left gives no current data. Label on right gives no manufacturer data. Neither gives model or serial #.

Description: Label should give the following: maximum power, current and voltage at maximum power, short-circuit current, open-circuit voltage, maximum system voltage, manufacturer name, model #, serial # (sometimes on a small label on the front of the module, can be a barcode). High quality products will have marking symbols from UL, IEC or TUV.

Why it is important: Data is needed to properly install, operate and maintain equipment. Lack of this information is a potential safety issue.

Severity:

B.1.4 Incorrect spelling

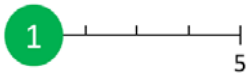


IEC

Description: Words should be spelt correctly in whatever language is used.

Why it is important: Does not affect performance, reliability or safety, but is an indicator of the lack of professionalism of the manufacturer.

Severity:



B.2 BACKSHEET

Back substrate of module. Protects module interior from the elements

B.2.1 Delamination

IEC [3]

Description: Backsheet not well laminated to module. Surface is bubbled or peeling.

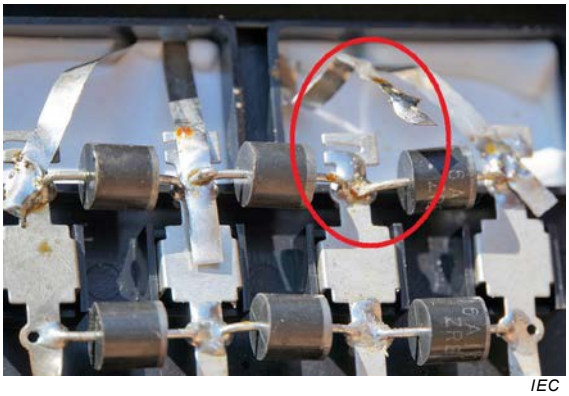
Why it is important: Bubbles are space for moisture to accumulate. Moisture in the module will decrease performance and affect long term reliability.

Severity:

B.3 JUNCTION BOX

Electrical enclosure on the rear of the module where external wires connect to the internal tabbing ribbon. The junction box also contains the diode(s).

B.3.1 Faulty electrical connection



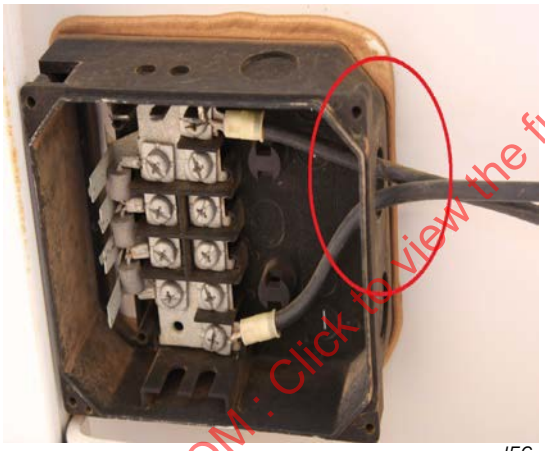
IEC

Description: Broken solder joints, broken wire or tabbing ribbon.

Why it is important: Broken electrical contacts can cause module failure.

Severity:

B.3.2 Cracks/breaks/gaps in housing

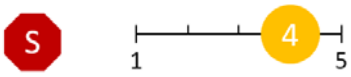


IEC

Description: Cracks in the housing, missing a continuous seal for the lid or around the wires. Possibility of water ingress.

Why it is important: Accumulated moisture can cause short circuits or corrosion of the metal contacts, increasing the risk of melting or fire. The junction boxes on high quality modules will be permanently sealed to mitigate this risk.

Severity:

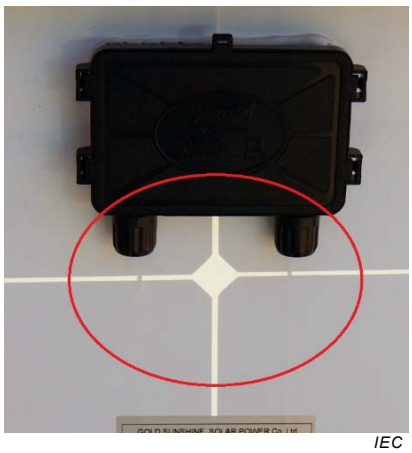


B.3.3 Sealant failure  IEC	**Description:** Holes in the seal, brittle material (should feel rubbery with fingernail) or adhesion failure. Possibility of water ingress. **Why it is important:** Accumulated moisture in the junction box can cause short circuits or corrosion of the metal contacts. Corrosion can increase the risk of melting or fire. **Severity:** If the sealant is brittle but not yet failed then the severity should be 3. If means of water ingress is visible, the severity should be 4. 
B.3.4 Electrical polarity not indicated Photo not available.	**Description:** Does not include a clear indication of the positive (+ or red) and negative (- or black) terminal of the module. Can be done with colour-coded wires instead of marked on junction box. **Why it is important:** Improper wiring of the module could cause a safety risk or lead to equipment failure. **Severity:** 

B.4 WIRING

The wires carry electricity from the module to the charge controller or inverter.

B.4.1 Wire(s) missing or insecurely attached



IEC

Description: One or both wires are missing or loosely connected to the module.

Why it is important: Two wires are necessary to make a circuit. All new modules come with wires securely soldered to the tabbing ribbon and diodes inside the junction box.

Severity: If the product is intended to be sold directly to the consumer, then wires are required for module function and severity is a 5. If further assembly is intended, no defect is present.

B.4.2 Too short and/or too thin

IEC

Description: Wires are not long enough to make a robust (waterproof, electrically sound) connection to the rest of the system. Wires too short to reach past the frame of the module are likely a concern. Thickness requirements depend on module current. Examples of max ratings include: 2,9 A for 17 AWG (1,04 mm^2), 7,4 A for 13 AWG (2,63 mm^2), 15 A for 10 AWG (5,26 mm^2), 30 A for 7 AWG (10,55 mm^2)[4]

Why it is important: If wires are too thin they could melt or burn. For safety, all electrical connections shall take place inside a sealed enclosure, ex. junction box.

Severity:

B.5 FRAME

The frame provides structure, rigidity, and mounting features. Sometimes non-metal for small modules (for example <10 W). Metal is needed for rigidity for large modules. If metal is used, electrical grounding is required.

B.5.1 Damaged

Photo not available

Description: Bent or cracked frame or the corners are not well aligned.

Why it is important: Loss of mechanical integrity, to the extent that the installation and/or operation of the module would be impaired. For example, may not be rigid enough to withstand handling during installation and/or high winds.

Severity: Low severity and no safety risk if dents/cracks in the frame are unlikely to affect mechanical integrity. High severity and safety risk if damage could lead to safety issues from cracked glass, poor electrical grounding, or if installation and/or operation are likely to be impaired.

B.5.2 Adhesive/Sealant failure

IEC

Description: Discontinuous perimeter seal or loose attachment to module.

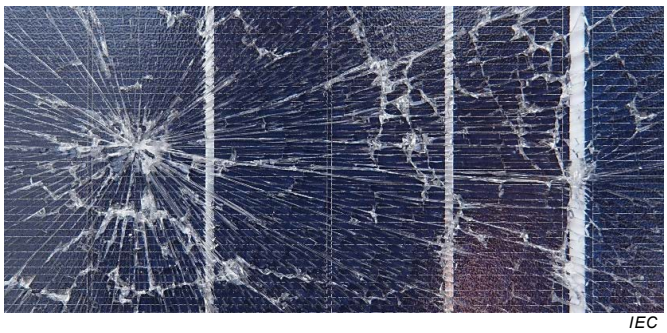
Why it is important: The adhesive is also a sealant that prevents water ingress into the module. Water in the module layers will decrease performance and affects long term reliability. Severity depends on atmospheric humidity.

Severity:

B.6 FRONT GLASS

Provides structure to the module and protects the cells. Allows transmission of light to the cells.

B.6.1 Cracking

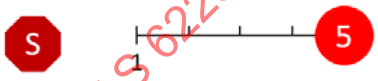


IEC

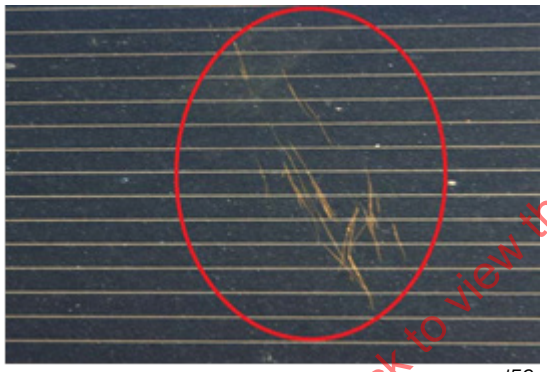
Description: Front glass is cracked locally or over the full area.

Why it is important: Module mechanical integrity is compromised. Possible path for water ingress. Mechanical and electrical safety issue.

Severity:



B.6.2 Scratches



IEC [3]

Description: Permanent scratches on the surface of the front glass. Cannot be removed with cleaning.

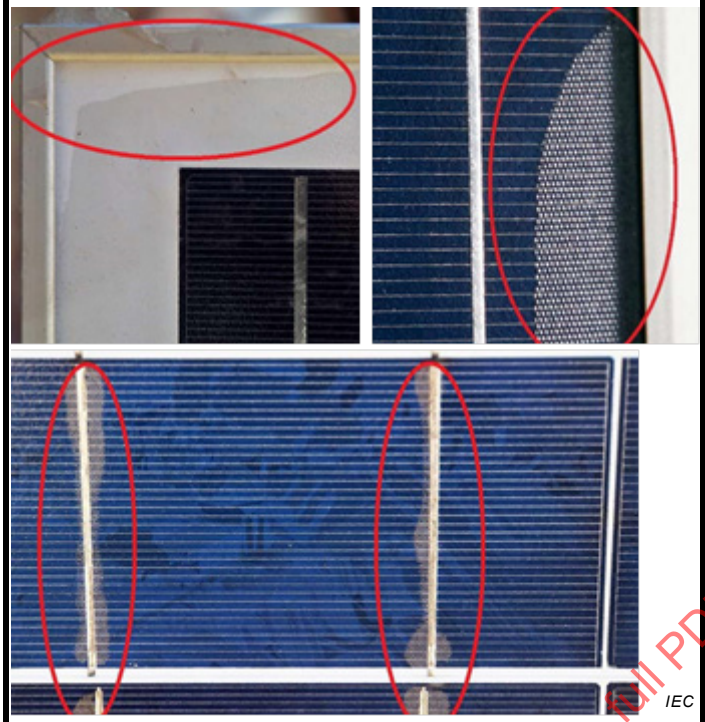
Why it is important: Transmission of light to the underlying cells, and therefore module power, is reduced.

Severity: Severity increases with affected area. A score of 5 should be given if 10 % or greater area is affected above any individual cell.

B.7 ENCAPSULATION

Used to laminate module layers together. Transparent to allow light to reach cells.

B.7.1 Delamination



Description: Any local separation of the layers between the front glass and the cells or the front glass and the backsheet. May appear continuous (top left) or spotted (right and bottom, due to texture of glass). Also could be bubbles. Most commonly appears around busbars or at the edge of the panel.

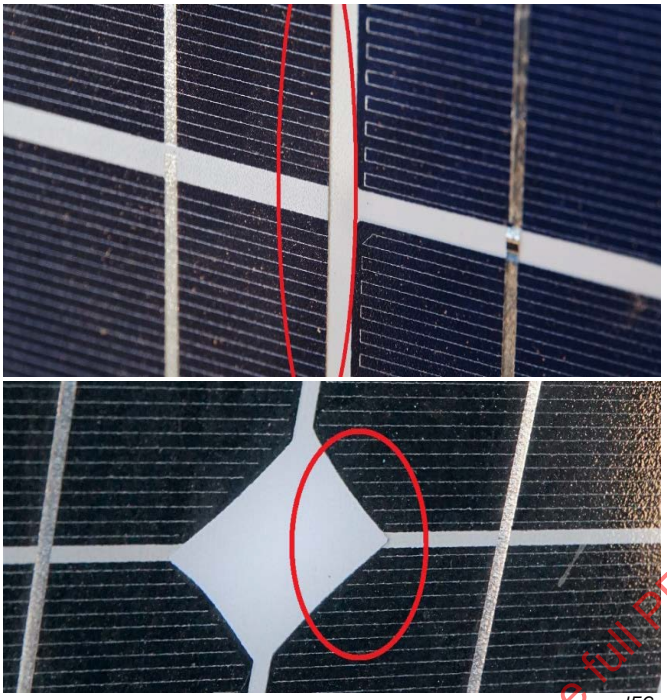
Why it is important: Can reduce structural integrity of the module. Transmission of light to the underlying cells and therefore module current is reduced.

Severity: Bubbles of delamination forming a continuous path between any part of the electrical circuit and the edge of the module is a safety risk due to possible water ingress. If delamination does not form such a path no safety risk exists. Influence on performance increases with affected area. A score of 5 is given if 10 % or greater of any individual cell's area is affected. A barely visible bubble would correspond to a score of 2.

B.8 CELLS

Active component of the solar module. Electricity producing material converts sunlight to electricity.

B.8.1 Fake

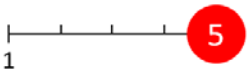


IEC

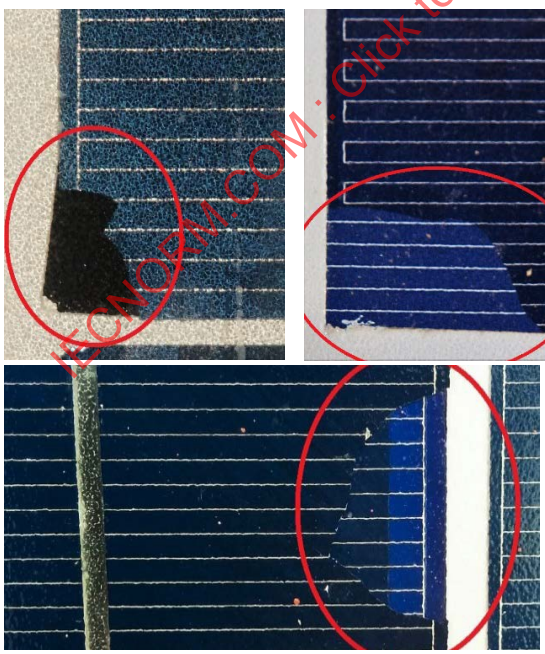
Description: Cells not made of active material, are instead printed paper images. Likely only a portion of the cells in a given module may be fake. May be evident in the white space between fake cells, where the edge of the paper can be seen. Examples of fake poly and mono-crystalline cells in top and bottom images respectively. If counterfeiters instead cut around each paper cell individually it will be harder to spot, and instead might be caught when inspecting the cell interconnection.

Why it is important: Purposely deceitful behaviour of manufacturer. The customer pays for fraudulent material that will not produce power.

Severity:



B.8.2 Dummy pieces disguising missing material



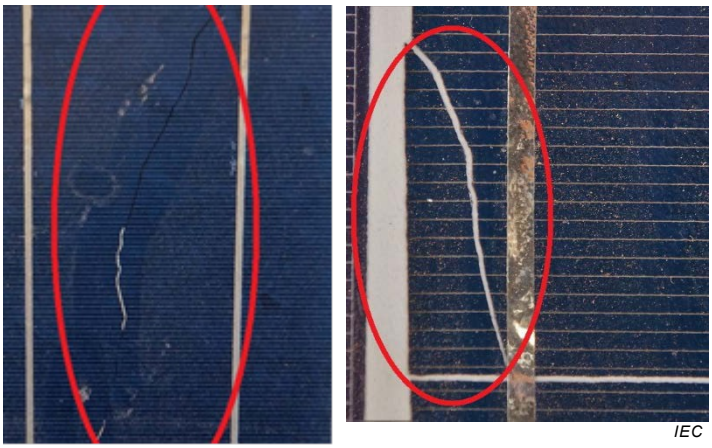
IEC

Description: Inactive material (dummy cell fragment or dark paper) has been placed behind an active cell in order to hide the fact that the cell has broken and has a piece missing.

Why it is important: Power output of the module limited by the missing material area. Purposely deceitful behaviour by the manufacturer. Indication of sub-standard cells and practices.

Severity: Power loss depends on size; a score of 5 should be given if 10 % or greater of any individual cell's area is missing. If the piece that is missing extends up to the edge of the metallization, a score of 3 is given. If the piece does not contain any metallization, this defect is instead an edge chip (see B.8.7).

B.8.3 Cracks



IEC

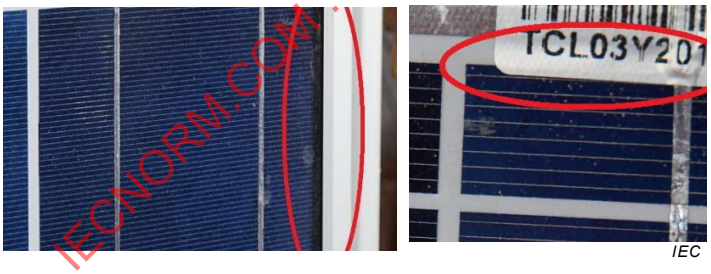
Left: large crack across the cell, but both halves are still connected to busbars. Right: smaller crack is actually more severe: a portion of the cell is no longer electrically connected.

Description: Cell is cracked. Crack may be partially or all the way across a cell. Partial cracks are likely to propagate over time. Depending on size cracks may be hard or impossible to spot. The white backsheet may be visible through large cracks.

Why it is important: Power output of the module limited if portions are removed from the electrical circuit. Visible cracks indicate poor mechanical handling by manufacturer; likely more cracks exist that are not currently visible.

Severity: Severity depends on affected area. A crack is considered a major defect (score of 5) when its propagation could remove more than 10 % of that cell's area from the electrical circuit [1]. The presence of a crack of any size that does not, or likely will not through its propagation, isolate any portion of the cell from the electrical circuit is a score of 2.

B.8.4 Partially covered



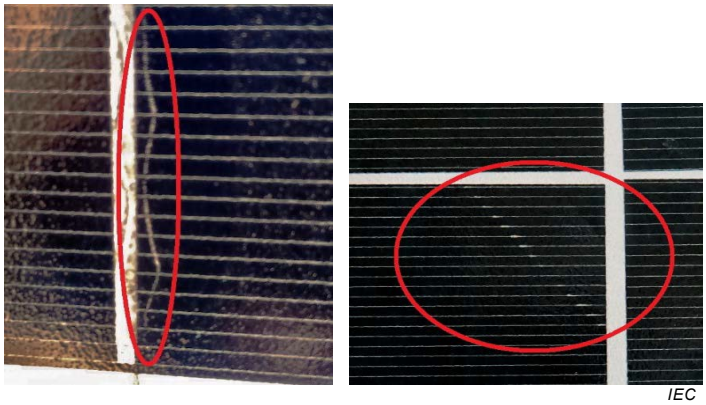
IEC

Description: A cell is partially and permanently covered, for example by the frame, a label, or by another cell.

Why it is important: Reduces active cell area. Current will be limited by the smallest cell area. An indicator of sub-standard manufacturer design and fabrication.

Severity: Influence on performance increases with affected area. A score of 5 is given if 10 % or greater of any individual cell's area is covered.

B.8.5 Scratches



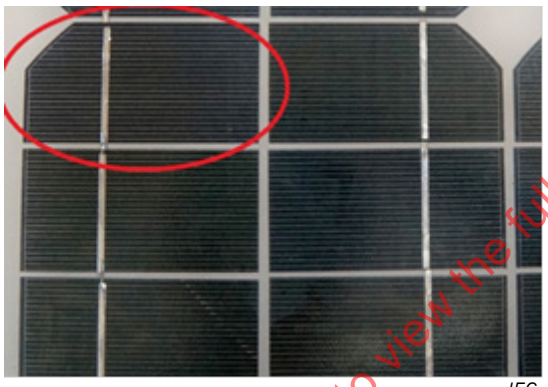
IEC

Description: Scratches in the surface of the cell from poor handling during module assembly. Often next to tabbing ribbon and caused by operator scraping the cell during soldering.

Why it is important: Deep scratches risk shorting the cell, but shallow scratches may have minimal impact.

Severity: Severity hard to evaluate visually.

B.8.6 Differently sized



IEC

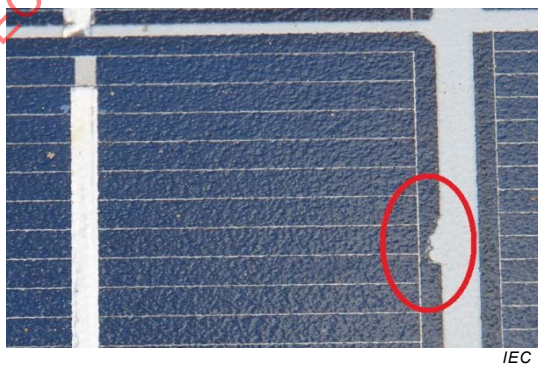
The circled cell is a different shape and size than the other cells having full corners.

Description: Cell fragments of different sizes connected in series within a module.

Why it is important: Current will be limited by the smallest cell area. Larger cells will operate at a higher temperature as they burn off excess current, potentially decreasing product lifetime. Indication of a poor module design. Can be compensated for by increasing height, which can be roughly checked by comparing the number of metal fingers on differently sized cells.

Severity:

B.8.7 Edge chips

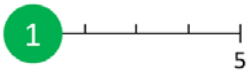


IEC

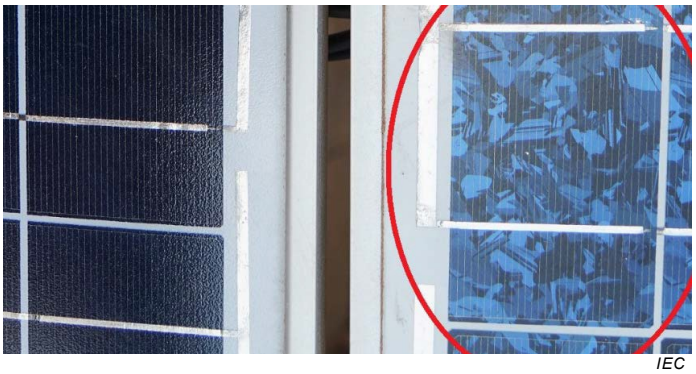
Description: A small region is missing from the edge of the cell. Does not enter metallized region.

Why it is important: Edge region is generally low power producing, so defect has minimal impact. It is a concern if many cells in a module have this defect; it indicates poor mechanical handling.

Severity:



B.8.8 All cells very shiny



IEC

Description: Cells are very shiny, reflecting instead of absorbing light.

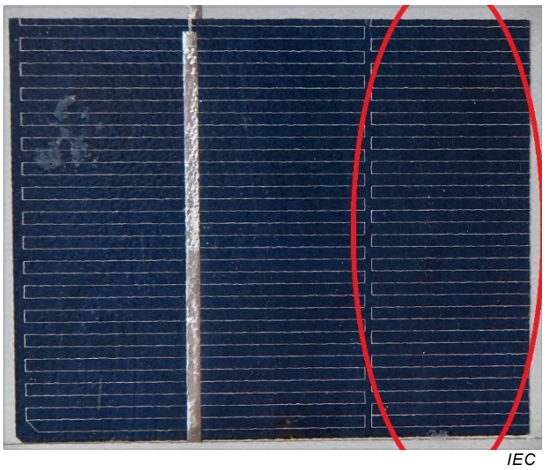
Why it is important: May be less efficient than darker cells, which is not inherently a problem if a module is sold based on rated power. Retailers selling such modules at a higher price to uninformed consumers who associate “shiny” with “new” or better is deceitful practice.

Severity:

B.9 CELL METALLIZATION

Metal fingers collect and conduct current from the cell to the busbars (covered by tabbing ribbon)

B.9.1 Fingers not connected to busbar



IEC

Description: Metal fingers are not connected to the busbars of a cell.

Why it is important: Current of unconnected region cannot be used. Severity depends on effected region. In the example here 1/3 of the cell area is effectively unused. Indicates a poor design and a sub-standard manufacturer.

Severity: Severity depends on affected area. Considered a major defect when 10 % or greater of a cell's area is excluded from the electrical circuit [1].

B.9.2 Not the same pattern on all cells

IEC

Description: Different metallization patterns apparent on different cells in the same module.

Why it is important: Not inherently an issue if cells have the same performance characteristics. However if mis-matched cells are combined in a module, higher performing cells will be limited by lower performers. Potential indicator of poor manufacturing practices.

Severity: