

AIAA S-111A-2014  
(Revision of S-111-2005)

# Standard

## Qualification and Quality Requirements for Space Solar Cells

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(Revision of AIAA S-111-2005)

## **Standard**

# **Qualification and Quality Requirements for Space Solar Cells**

### **Sponsored by**

American Institute of Aeronautics and Astronautics

### **Approved**

June 2014

### **Abstract**

This standard establishes qualification, characterization, and quality requirements for all solar cells intended for operations in space. It defines terminology and establishes standard tests, environmental conditions, procedures, and systematic methods for verifying the capability of a photovoltaic solar cell device to operate in the environment of space. This standard is intended to be used to establish the minimum level of testing required to demonstrate that a solar cell type will operate in a predictable and understood manner. Success and failure criteria are defined for each qualification test. For the characterization tests, sufficient data is collected to predict electrical performance and behavior as a function of pertinent operational and environmental parameters.

Published by  
**American Institute of Aeronautics and Astronautics**  
**1801 Alexander Bell Drive, Reston, VA 20191**

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Printed in the United States of America

ISBN 978-1-62410-280-6

## Contents

Foreword.....	v
Introduction .....	vii
1 Scope .....	1
2 Tailoring.....	1
3 Applicable Documents.....	1
4 Vocabulary .....	2
5 Summary of Qualification and Characterization Tests.....	4
6 Test Requirements .....	5
6.1 Sample Selection .....	5
6.2 Solar Simulation .....	5
6.3 Electrical Test.....	5
7 Qualification Tests.....	5
7.1 Solar Cell Weld or Solder Test .....	5
7.2 Solar Cell Integration Test.....	7
7.3 Cell-Level Humidity Test.....	10
8 Characterization Tests .....	12
8.1 Electron Radiation Effects .....	12
8.2 Proton Radiation Effects.....	13
8.3 Bend Test.....	15
8.4 Breaking Load Determination.....	16
8.5 Light I-V Characterization for Multiple Temperatures .....	17
8.6 Quantum Efficiency .....	18
8.7 Dark I-V Characterization .....	18
8.8 Capacitance Effects .....	19
8.9 Solar Cell Electrostatic Discharge Sensitivity (ESDS) Test.....	19
8.10 Accelerated Life Test.....	20
9 Quality Requirements .....	20
9.1 Performance.....	20
9.2 Solar Cell Reliability .....	20
9.3 Certification of Conformance .....	21
9.4 Lot Identification and Traceability .....	21
9.5 Test Equipment Maintenance and Calibration System.....	21
9.6 Incoming, In-process, and Outgoing Inventory Control .....	21
9.7 Process Control.....	21

AIAA S-111A-2014

9.8	Environmental Controls .....	22
9.9	Conformance of Production Solar Cells to Qualified Product .....	22
9.10	Electrostatic Discharge Sensitivity Program .....	22
9.11	Reworked Solar Cells.....	22
9.12	Design Construction and Process Change Control Procedures .....	23
10	Critical Materials.....	23
10.1	Scope .....	23
10.2	Requirements.....	23
11	Reporting Requirements.....	23
11.1	Reports to be Produced.....	23
11.2	Qualification Report.....	23
11.3	Characterization Report.....	24
11.4	Quality Report .....	24
11.5	Delta Qualification Report.....	25
12	Bibliography.....	25

**Tables**

Table 1	— Summary of qualification and characterization tests.....	4
Table 2	— Electron energies and fluences .....	13
Table 3	— Suggested proton energies.....	15

## Foreword

AIAA Standard S-111-2005, *Qualification and Quality Requirements for Space Solar Panels*, was originally developed to provide a “gold standard” for space solar cell qualification, with provisions included to supplement industry standards for quality.

In this revised version of the standard, effort and care has been taken to update, clarify and resolve controversial provisions that were present in the original. The result is a new standard that the Solar Cells and Solar Panels Committee on Standards has developed and reached consensus that defines the best practices for space solar cell qualification.

At the time of the 2014 revision, the members of the AIAA Solar Cells and Solar Panels CoS were:

Henry Brandhorst (Chair)	Carbon-Free Energy, LLC
Robert W. Francis (Co-Chair)	Aerospace Corporation
Edward Gaddy (Co-Chair)	Johns Hopkins University Applied Physics Laboratory
Amalia Aviles	The Boeing Company
Scott Billets	Lockheed Martin Space Systems Company
Robert Bornino	National Technical Systems
Marc Breen	The Boeing Company
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The above consensus body approved this document for publication in June 2014. The AIAA Standards Executive Council (VP-Standards, Laura McGill, Chairperson) accepted this document for publication in June 2014.

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## Introduction

The purpose for this document is to provide a high level of confidence to the community that a solar cell type is qualified for space applications, and that it is ready for qualification under AIAA-S-112A-2013 *Qualification and Quality Requirements for Electrical Components on Space Solar Panels*.

Bypass diodes, interconnects, covers, and adhesive are not completely qualified by this Standard. Nonetheless, any failure of these components exposed by tests required by this Standard must be reported. In addition, the qualifier must investigate the component failure, determine its cause and take corrective action. The qualifier must also evaluate the component failure with respect to its effect on the cell qualification.

The goal of this document is to standardize testing protocols within the industry that uses, builds, and performs research on space solar cells. The tests included are perceptive to problems seen both in ground testing and on-orbit, and are the first step in including a “test like you fly” protocol in the space solar cell industry. As ground rules for inclusion in this standard, tests had to have been previously documented; experimental tests were disallowed and test equipment had to be available in at least one facility. The order of test execution in this standard was set up to be as close to the sequence of solar cell and panel build, storage, integration and flight as possible.

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## 1 Scope

This document establishes qualification and quality requirements for crystalline silicon and gallium arsenide-based single and multiple junction solar cell types for space applications. This includes requirements for solar cell manufacturer quality systems and for characterization of solar cells. Requirements for acceptance testing of lots are not defined in the current version of this document.

Qualification is required when introducing a new solar cell design. Delta qualification is required when making modifications to the materials and processes used to manufacture a qualified cell. If the materials and process changes are limited, these may be considered and evaluated for the scope of a delta qualification. The delta qualification must be based on how the changes might affect the performance and reliability of the cell. The justification for the delta qualification and a detailed description of the changes must be documented per section 11.5, Delta Qualification Report. A change to the lateral dimensions of a qualified cell type does not require delta qualification or re-qualification.

## 2 Tailoring

Unless otherwise specified, this document may not be tailored.

## 3 Applicable Documents

The following documents contain provisions, which, through reference in this text, constitute provisions of this standard. Amendments to, or revisions of, any of these documents do not apply. This standard takes precedence in the event of a conflict between it, the documents cited below, and other documents.

ANSI/NCSL Z540.1-1994	Calibration Laboratories and Measuring and Test Equipment— General Requirements
ASTM C1161	Standard Test Methods for Flexural Strength of Advanced Ceramics at Ambient Temperature
ASTM C1239-07	Standard Practice for Reporting Uniaxial Strength Data and Estimating Weibull Distribution Parameters for Advanced Ceramics
ASTM C1683-10	Standard Practice for Size Scaling of Tensile Strengths Using Weibull Statistics for Advanced Ceramics
ASTM E490	Solar Constant and Zero Air Mass Solar Spectral Irradiance [Notwithstanding the above, the latest version of this document applies.]
ASTM E595-93(2003)e2	Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment
ASTM E927-10	Standard Specification for Solar Simulation for Photovoltaic Testing
EIA 557 (1995)	Statistical Process Control Systems
EIA 625	Requirements for Handling Electrostatic Discharge Sensitive Devices
Jet Propulsion Laboratory Publication 82-69	Solar Cell Radiation Handbook, Third edition