

IEEE Recommended Practice for Qualification of Concentrator Photovoltaic (PV) Receiver Sections and Modules

Sponsor

IEEE Standards Coordinating Committee 21 on Photovoltaics

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Abstract: The minimum tests and inspections required to evaluate photovoltaic concentrating modules, and a common approach (e.g., between producer and purchaser) in conducting qualification tests are provided.

Keywords: concentrators, modules, photovoltaic (PV), qualification tests, receivers, recommended practices

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Introduction

[This introduction is not part of IEEE Std 1513-2001, IEEE Recommended Practice for Qualification of Concentrator Photovoltaic (PV) Receiver Sections and Modules.]

This recommended practice provides qualification tests and procedures to evaluate terrestrial photovoltaic concentrating modules intended for power generation applications. It builds on a Sandia publication (SAND92-0958, "Evaluation Tests for Photovoltaic Concentrator Receiver Sections and Modules," 1992), and follows the format of the recently completed IEEE Std 1262-1995 for flat plate PV modules.

The intent of this recommended practice is to provide the minimum tests and inspections required to evaluate photovoltaic concentrating modules and to provide a common approach (e.g., between producer and purchaser) in conducting qualification tests. The tests and procedures provided in this recommended practice may be supplemented by additional tests and procedures established between the producer and purchaser.

Concentrator module designs are under development, and new concepts continue to appear. This situation requires that qualification tests be flexible enough to allow a reasonable assessment of new designs, yet complete enough to identify weaknesses that would lead to problems in the field. Ideally, modules that experience early failures in field operation should fail qualification tests. Therefore, it is important to note that the design of this recommended practice and the tests specified were developed to eventually serve as a uniform standard for the photovoltaic concentrator industry.

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IEEE Recommended Practice for Qualification of Concentrator Photovoltaic (PV) Receiver Sections and Modules

1. Overview

1.1 Scope

This recommended practice establishes recommended procedures and specifications for qualification tests that are structured to evaluate concentrator photovoltaic receiver sections and modules intended for power generation applications.

1.2 Purpose

The qualification tests provided in this document should assist in evaluating the design performance, reliability, safety, and susceptibility to known failure mechanisms of concentrator photovoltaic (PV) receiver sections and modules.

Emphasis is placed on testing for potential degradation of receiver sections and module performance resulting from environmental weathering, mechanical loading, shadowing, or corrosion.

The procedures given in this recommended practice provide a common approach for conducting module qualification tests. Although acceptable results from these tests should provide reasonable assurance that the modules produced by the same processes as those that pass these tests will perform reliably in the field after installation, this recommended practice does not address design, safety, or performance of PV systems.

1.3 Limitations

These qualification tests are applicable to concentrator photovoltaic receivers and modules.

This document will be revised as required to incorporate the latest information on failure mechanisms and the relationships between accelerated tests and field reliability.

2. References

This recommended practice should be used in conjunction with the following publications. If the following publications are superseded by an approved revision, the revision shall apply.

ASTM E892-87 (1992), Standard Tables for Terrestrial Solar Spectral Irradiance at Air Mass 1.5 for a 37° Tilted Surface.¹

ASTM E927-97, Standard Specification for Solar Simulation for Terrestrial Photovoltaic Testing.²

ASTM E973M-96, Standard Test Method for Determination of the Spectral Mismatch Parameter Between a Photovoltaic Device and a Photovoltaic Reference Cell.

ASTM E1036-96, Standard Test Methods for Electrical Performance of Nonconcentrator Terrestrial Photovoltaic Modules and Arrays Using Reference Cells.

ASTM E1038-98, Standard Test Method for Determining Resistance of Photovoltaic Modules to Hail by Impact with Propelled Ice Balls.

ASTM E1171-99, Standard Test Method for Photovoltaic Modules in Cyclic Temperature and Humidity Environments.

ASTM E1462-00, Standard Test Methods for Insulation Integrity and Ground Path Continuity of Photovoltaic Modules.

ASTM E1802-96, Standard Test Methods for Wet Insulation Integrity Testing of Photovoltaic Modules.

ASTM E1830M-96, Standard Test Methods for Determining Mechanical Integrity of Photovoltaic Modules.

IEC 61215 (1993-04), Crystalline silicon terrestrial photovoltaic (PV) module—Design qualification and type approval.³

IECQ PQC 12, Provisional blank detail specification: Crystalline silicon terrestrial Photovoltaic (PV) modules.

IEEE Std 928-1986 (Reaff 1991), IEEE Recommended Criteria for Terrestrial Photovoltaic Power Systems.⁴

IEEE Std 1262-1995, IEEE Recommended Practice for Qualification of Photovoltaic (PV) Modules.

UL 1703-2000, Standard for Safety for Flat-Plate Photovoltaic Modules and Panels.⁵

¹This standard was discontinued in 1999 and replaced by ASTM G159-98, Tables for References Solar Spectral Irradiance at Air Mass 1.5: Direct Normal and Hemispherical for a 37° Tilted Surface.

²ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

³IEC publications are available from the Sales Department of the International Electrotechnical Commission, Case Postale 131, 3, rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iec.ch/>). IEC publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA.

⁴IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁵UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>).

3. Background and overview of qualification test program

3.1 Background

In developing this qualification test document, several sources of information were referenced and used in designing and formulating the majority of the tests given. Primary sources included: SAND92-0958 [B5]⁶ document for evaluation tests for PV concentrator receiver sections and modules; IEEE Std 1262-1995 for flat plate modules;⁷ IEC 61215 (1993-04) for crystalline silicon modules; UL 1703-2000 for flat plate modules; and Technical Specifications for the Photovoltaics for Utility Scale Applications (PVUSA) Project, as referred to in Hester, et al [B6].

Since the publication of these documents, photovoltaic materials technology and concentrator module development have advanced. Efforts in module reliability research have produced a better understanding of known and potential failure mechanisms associated with photovoltaic concentrator modules, especially with regard to the effects of moisture ingress. The results of these efforts and experience gained have been used in formulating new tests and modifying earlier tests for inclusion in this recommended practice.

3.2 Overview of qualification test program

The qualification test sequence is illustrated in Figure 1. Module qualification test program requirements, which provide detailed guidance and minimum requirements for the overall qualification test, are given in Clause 4. Requirements and evaluation of test results necessary for passing the qualification test are provided in 4.4, and they include the following:

- a) Initial tests and inspections.
- b) Sequence “A,” “B,” “C,” “D,” and “E” tests, which subject the modules to a specified sequence of environments and stresses. All intermediate electrical performance tests are optional and they may help identify which test caused a failure, but they are not required.
- c) Final tests and inspections.

Descriptions of the required test and inspection procedures are provided in Clause 5.

Initial tests and inspections (see 4.2) establish selection and acceptance of as received modules as test module specimens. They also establish “baseline” visual inspection information and electrical performance measurement data for comparison and determination of the effects on module physical characteristics and electrical performance following all subsequent tests.

A minimum of five test modules and seven receiver sections are required to complete all the specified tests. If the intrusive bypass diode thermal test (sequence E) is to be performed, an additional specially fabricated receiver is required. A module is the smallest, complete, environmentally protected assembly of receivers and optics, and related components such as interconnects and mounting, that accepts unconcentrated sunlight. A receiver is an assembly of one or more PV cells that accepts concentrated sunlight and incorporates the means for thermal and electric energy removal. Figure 2 is a schematic of cells, receivers, and modules. In the case of a large PV concentrator module and receiver, a receiver section is a portion suitable for specific tests.

Test sequences A through E subject the receivers or modules to a specified sequence of environments and typical or accelerated stresses similar to those which final, deployed modules should survive. The final tests and inspections (see 4.3) provide data for comparison with initial test and inspection results. The criteria for passing the qualification tests are provided in 4.4.

⁶The numbers in brackets correspond to those of the bibliography in Annex A.

⁷Information on references can be found in Clause 2.

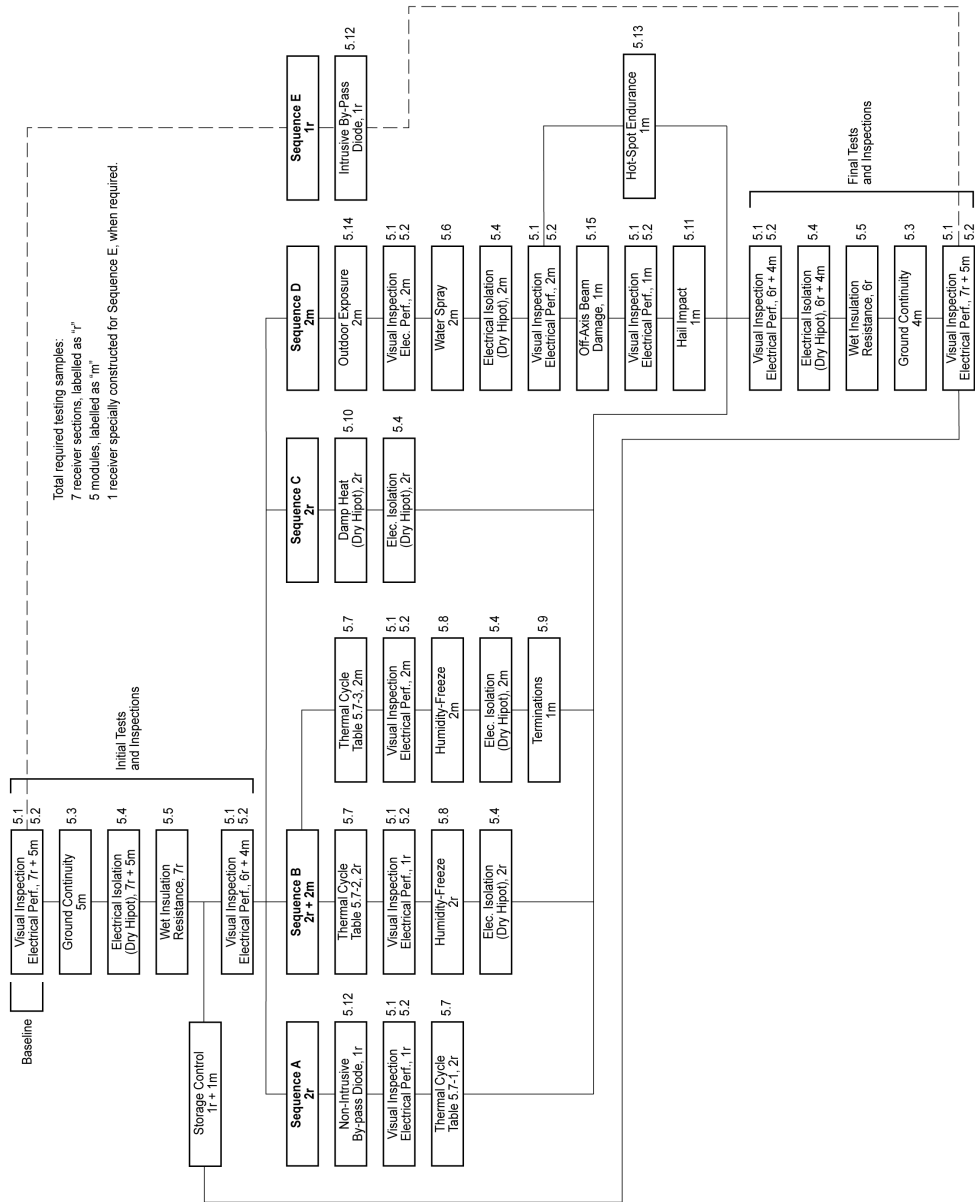


Figure 1 — Concentrator PV receiver sections and modules qualification test program