

# SEMI PV38-0912 (Reapproved 0818)

## TEST METHOD FOR MECHANICAL VIBRATION OF c-SI PV CELLS IN SHIPPING ENVIRONMENT

This Standard was technically approved by the Photovoltaic Global Technical Committee. This edition was approved for publication by the global Audits and Reviews Subcommittee on March 19, 2018. Available at [www.semiviews.org](http://www.semiviews.org) and [www.semi.org](http://www.semi.org) in August 2018; originally published September 2012.

### 1 Purpose

1.1 For c-Si technology, one of the problems is to identify and eliminate the sources of mechanical defects such as thermo-elastic stress and cracks leading to the loss of wafer integrity and ultimate breakage of as-grown and processed Si cells. A significant challenge in using thinner crystalline silicon wafers for solar cell manufacture is the reduced yield due to increased cell breakage. Cell breakage mostly depends on the stresses induced in the processing, handling and transportation, and also depends on the presence of defects such as micro-cracks. Shipping damage is always one of the top problems of the PV failures in the field.

1.2 This Standard presents a test method for mechanical vibration of c-Si PV cells in transportation environment, which might be carried by truck, train, aircraft and shipboard, etc. This Standard aims to provide a common test method to evaluate the micro-cracks or defects on the PV cells due to stress during transportation. The cell makers and buyers, or any other party interested, can thus have a common testing standard to refer to when desired.

1.3 The test result also can evaluate cell package performance during transportation.

### 2 Scope

2.1 *Basic Test System Requirements* — This Standard states the basic vibration test system requirements.

2.2 This Test Method covers the random vibration test of filled transportation unit, will be used to assess the performance of package design for mono/multicrystalline cells during shipping by different transportation vehicles.

2.3 *Testing Procedure* — The general testing procedures are provided with a flowchart, including the vibration test, pre-test and post-test examination of the PV cells performance, according to current IEC standards. These specifications for the vibration, including the frequency range and power spectral density, etc., corresponding to particular means of transportation are chosen by the user according to existing standards (e.g., ASTM, MIL-STD).

2.4 *Sampling Method* — Usually multiple PV cells are stacked as a block; multiple blocks are stacked as a box and shipped boxes together in a test specimen. It is unnecessary, time-consuming and cost-intensive to carry out full performance tests on all blocks in the same test specimen. Therefore, select suitable test blocks of cells that undergo the pre-test and post-test examinations shall be helpful.

2.5 *Sample Report and Data Formats* — Results and relevant information are stated in the final test report to the customer, and in recommended report and data formats in the Appendix.

**NOTICE:** SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

### 3 Limitations

3.1 This Document does not specify any kind of package for shipping unit.

3.2 This test and measurement method does not provide the specifications of the vibration. The allocation and number of measurement points, PSD, intensity and the test time should be considered.

### 4 Referenced Standards and Documents

#### 4.1 SEMI Standards and Safety Guidelines

SEMI PV23 — Test Method for Mechanical Vibration of Crystalline Silicon Photovoltaic (PV) Modules in Shipping Environment

#### 4.2 ASTM Standards<sup>1</sup>

ASTM D999 — Standard Test Methods for Vibration Testing of Shipping Containers

ASTM D4169 — Standard Practice for Performance Testing of Shipping Containers and Systems

ASTM D4332 — Standard Practice for Conditioning Containers, Packages, or Packaging Components for Testing

ASTM D4728 — Standard Test Method for Random Vibration Testing for Shipping Containers

#### 4.3 ISO Standard<sup>2</sup>

ISO 2233 — Packaging – Complete, Filled Transport Packages and Unit Loads – Conditioning for Testing

#### 4.4 IEC Standards<sup>3</sup>

IEC 60068-2-64 — Environmental Testing – Part 2-64: Tests – Test Fh: Vibration, Broadband Random and Guidance

IEC 60904-1 — Photovoltaic Devices – Part 1: Measurement of Photovoltaic Current-Voltage Characteristics

IEC 61215 — Crystalline Silicon Terrestrial Photovoltaic (PV) Modules – Design Qualification and Type Approval

IEC 61730-2 — Photovoltaic (PV) Module Safety Qualification – Part 2: Requirements for Testing

#### 4.5 United States Military Standard<sup>4</sup>

MIL-STD-810 F — Environmental Engineering Considerations and Laboratory Tests

**NOTICE:** Unless otherwise indicated, all documents cited shall be the latest published versions.

## 5 Terminology

### 5.1 Abbreviations and Acronyms

5.1.1 *c-Si* — crystalline silicon

5.1.2 *EL* — electro-luminescence

5.1.3 *Grms* — root-mean-square acceleration

5.1.4 *Pmpp* — maximum power

5.1.5 *PSD* — power spectral density

5.1.6 *PV* — photovoltaic

5.1.7 *STC* — standard test conditions

### 5.2 Definitions

5.2.1 *block* — stacked sample cells for the purposes of vibration testing. (See Figure 1.)

5.2.2 *customer* — an individual or a company who uses this Standard.

5.2.3 *defects* — imperfection of *c-Si* like broken cell, crack or micro-cracks, cell with chips, holes in cells, etc.

5.2.4 *sample cell* — a real cell that undergoes the pre-test and post-test examinations for the evaluation of damages induced by vibration.

5.2.5 *test block* — a block of sample cells to check vibration response with vibration test, and electric performance with both pre-test and post-test examinations.

---

<sup>1</sup> ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA; Telephone: +1.610.832.9585, Fax: +1.610.832.9555, <http://www.astm.org>

<sup>2</sup> International Organization for Standardization, ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland; Telephone: +41.22.749.01.11, <http://www.iso.org>

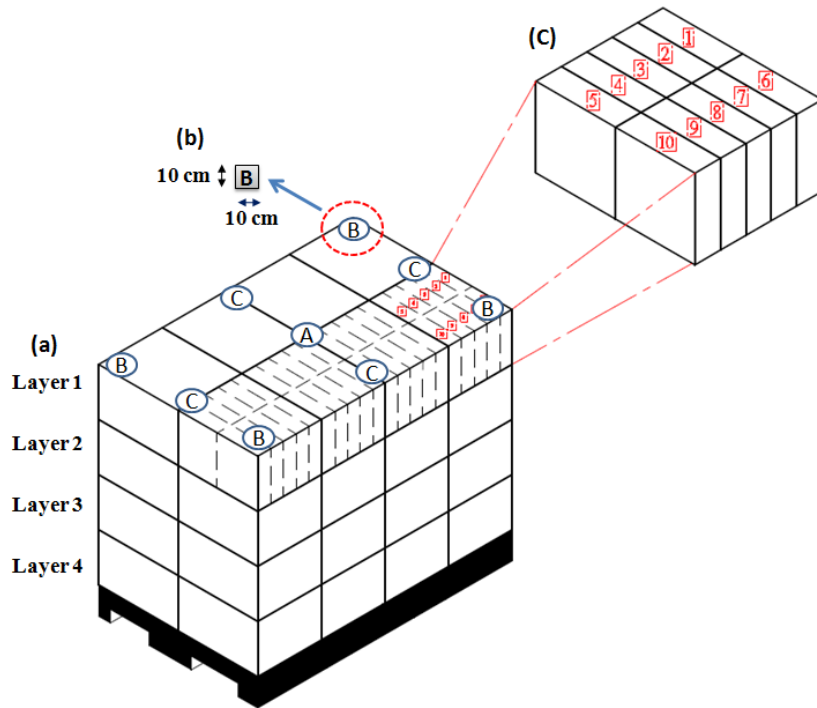
<sup>3</sup> International Electrotechnical Commission, 3 rue de Varembe, Case Postale 131, CH-1211 Geneva 20, Switzerland; Telephone: +41.22.919.02.11, Fax: +41.22.919.03.00, <http://www.iec.ch>

<sup>4</sup> Available from EverySpec; <http://www.everyspec.com>

5.2.6 *test block locations* — the location of the test block inside the test specimen to be placed during the vibration test.

5.2.7 *test specimen* — a complete, filled transport package or unit load during the actual transportation or shipping. (See Figure 1.)

5.2.8 *vibration test specification* — data required to perform a vibration test using the apparatus in § 6, including PSD - Grms and test time, etc.



(a) Test specimen with 32 boxes in 4 layers ( $2 \times 4 \times 4$ ) and 8 boxes ( $2 \times 4$ ) in one layer.

(b) 9 measurement points include one center point (A), 4 corner (B) and 4 middle points (C) of both long and short edges, each measurement point is within an area of  $10 \text{ cm} \times 10 \text{ cm}$ .

(c) 10 blocks ( $2 \times 5$ ) in one box.

**Figure 1**  
**Example for Test Specimen, Block and Measurement Points**

## 6 Apparatus

### 6.1 Vibration Table (Shaker)

6.1.1 The vibration table must be sufficiently large to contain the whole test specimen. It shall be sufficiently strong and rigid in order to deliver the vibration specification, in terms of rated force, displacement and frequency range. In cases where the test specimen might fall off the table during testing, low fences should be used to restrict sideways movements.

### 6.2 Instrumentation

6.2.1 Apparatuses including the accelerometers, signal conditioners, analyzers, data display, storage devices and electronic controls are required to measure and control the vibration table. In addition, the instrumentation is required for measuring the response of the tested item. Accelerometers should be miniature type and light weight enough as to not influence the results of the test or measurement.