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Photovoltaic systems – Guidelines for effective quality assurance of power conversion equipment

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

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

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PHOTOVOLTAIC SYSTEMS – GUIDELINES FOR EFFECTIVE QUALITY ASSURANCE OF POWER CONVERSION EQUIPMENT

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.
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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 63157, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/1595/DTS	82/1625A/RVDTS

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

INTRODUCTION

The fundamentals of maintaining a quality assurance system are described in ISO 9001. The IEC Technical Committee 82 has supplemented ISO 9001 with additional technical details for guiding creation of quality assurance systems for the manufacture of photovoltaic (PV) modules (IEC TS 62941) and for installation of photovoltaic systems (IEC TS 63049).

Failures of PV systems are often reported to be caused by failures of the power conversion equipment, such as inverters and DC-DC converters. This document was developed to help the industry reduce those failures in a standardized and cost-effective way. It builds on ISO 9001 by adding technical details to be included in a quality assurance system. To facilitate the understanding of how ISO 9001 complements this document, the related ISO 9001 clause/subclause numbers are noted in square brackets as part of each heading as well as being tabulated in Annex A. A few references are also made to the IATF (International Automotive Task Force) 16949 *Quality Management Systems.*

PHOTOVOLTAIC SYSTEMS – GUIDELINES FOR EFFECTIVE QUALITY ASSURANCE OF POWER CONVERSION EQUIPMENT

1 Scope

This document lays out recommendations for best practices for product realization, safety, customer satisfaction, and stakeholders' relationship used in the manufacture of power conversion equipment (PCE).

This document captures key requirements customers would like to see completed to ensure high-quality products, specifically, that the products have the documented properties, including properties needed to give customer satisfaction with regard to the warranty.

The object of this document is to provide more confidence in the ongoing consistency of performance and reliability of certified power conversion equipment. The requirements of this document are defined with the assumption that the quality management system of the organization has already fulfilled the requirements of ISO 9001 or equivalent quality management system. These guidelines also form the basis for factory audit criteria of such sites by various certifying and auditory bodies.

This document covers manufacture of electronic power conversion equipment intended for use in terrestrial PV applications. The term PCE refers to equipment and components for electronic power conversion of electric power into another kind of electric power with respect to voltage, current and frequency. This document applies to PCE in both indoor and outdoor open-air climates as defined in IEC 60721-2-1 and IEC 60721-3-3. Such equipment may include, but is not limited to, DC-to-AC inverters, DC-to-DC converters and battery charge converters.

This document covers PCE that is used with PV arrays. The equipment may also be connected to other DC source or load circuits such as batteries. All parts of the PCE are included (*e.g.* connectors and software). This document may be used for accessories for use with PCE, except where more appropriate standards exist.

The object of this document is to define steps for providing assurance that:

- The customers' expectations are identified and the product is designed to meet those expectations,
- The performance characteristics and method of meeting the customers' expectations (*e.g.* efficiency) are identified,
- The specifications are either in conformance with the related standards or mentioned by the manufacturer on the data sheet or other product literature,
- The product has each of the properties described on the data sheet or other product literature, and
- The product has been designed and manufactured to retain those same properties after normal and reasonable environmental stresses experienced in the field (including worst-case typical temperatures, thermal cycling, corrosive conditions, over voltages/currents on DC and AC lines, transportation and installation, etc.) as well as survive stresses coming from the grid within the promise of the warranty.

To achieve these goals, this document requires:

- Analysis to identify potential failure modes and creation of a plan to prevent these during the time of the design lifetime,
- A documented change management control process to address raw material or manufacturing changes arising both internal and external to the organization,

- A documented supplier quality management process with integrated performance standards that uses continuous improvement to enhance overall product quality,
- A documented manufacturing process with workmanship standards that uses continuous improvement to enhance product quality,
- A documented manufacturing process that includes steps that identify when the process has gone out of control and high-level measures to follow to bring the process back in control as specified by an out-of-control action plan (OCAP). This includes measurements that ensure that the products have the defined properties including test results expected for certification, standards and warranty, and
- Testing of software to ensure that it works in the anticipated situations.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 61000-6-1:2016, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61000-6-3:2006, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-3:2006/AMD1:2010

IEC 61000-6-4:2018, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 61850-7-420:2009, *Communication networks and systems for power utility automation – Part 7-420: Basic communication structure – Distributed energy resources logical node*

IEC 62093, *Balance-of-system components for photovoltaic systems – Design qualification natural environments*

IEC 62109-1, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

IEC 62109-2, *Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters*

IEC 62443 (all parts), *Industrial communication networks – Network and system security*

IEC 62894:2014, *Photovoltaic inverters – Data sheet and name plate*

IEC 62920:2017, *Photovoltaic power generating systems – EMC requirements and test methods for power conversion equipment*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement*

ISO 4180, *Packaging – Complete, filled transport packages – General rules for the compilation of performance test schedules*

ISO 9000:2015, *Quality management systems – Fundamentals and vocabulary'*

ISO 9001:2015, *Quality management systems – Requirements*

ISO 19011:2018, *Guidelines for auditing management systems*

IEEE 1547, *IEEE Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces*

FCC Title 47 CFR Part 15, *Federal Communications Commission rules and regulations, Code of Federal Regulations, Title 47, Part 15*

IPC-9592B:2012, *Requirements for Power Conversion Devices for the Computer and Telecommunications Industries*

ANSI/ASQ Z1.4:2013, *Sampling procedures and tables for inspection by attributes*

ANSI/ASQ Z1.9:2013, *Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming*

ANSI/ESD S20.20-2014, *Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)*

IATF 16949:2016, *Quality Management Systems*

3 Terms, definitions and acronyms

For the purposes of this document, the terms and definitions given in ISO 9000, IEC TS 61836, and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
balance of system
BOS
parts of a PV system other than the PV array field, including switches, controls, meters, power conditioning equipment, PV array support structure, and electricity storage components, if any

3.2
containment
action taken to protect the customer from the effect of a situation. Containment may include correcting an existing situation or adding additional screening or retesting

Note 1 to entry: Containment may include correcting an existing situation or adding additional screening or retesting.

3.3
control plan
documented description of the systems and processes required for controlling the product and process quality by addressing the key characteristics and engineering requirements

3.4
cost of quality
cost of not creating a quality product or service, including the cost of reworking of product that is found to be outside of tolerance

Note 1 to entry: The cost of quality may include the cost of reworking of product that is found to be outside of tolerance.

3.5
critical item list
list of materials, components and software that have relatively high impact in determining product reliability

3.6
customer
all of the stakeholders and decision makers involved in the various stages of the system delivery process, and including the end user

3.7
design for assembly, manufacturing and testing
design technique for manufacturing ease of an assortment of parts to be assembled into the final product, focusing on minimizing the complexity of the manufacturing and assembly processes

3.8
design lifetime
design target period during which balance-of-system (BOS) components are expected to safely satisfy the specified performance under the specified conditions

Note 1 to entry: Specified conditions include application of use, installation environment configurations and operation conditions of the BOS components in use. The design target period is set considering changes in performance of BOS components due to aging degradation of parts and materials used in the stated environment.

3.9
define, measure, analyze, improve, and control
DMAIC
data-driven quality strategy for improving processes and an integral part of a Six Sigma quality initiative

3.10
electrostatic discharge
ESD
sudden flow of electricity between two electrically charged objects caused by contact, an electrical short, or dielectric breakdown

Note 1 to entry: Electrostatic discharge events are known to damage semiconductor devices such as diodes.

3.11
Failure Modes and Effects Analysis
FMEA
document that defines the design, process, or solution with requirements and includes potential modes, causes and severity of effects of failure, along with an evaluation of the likelihood of their occurrence and ease of detection.

Note 1 to entry: The FMEA provides a mechanism to prioritize the risks and take appropriate mitigation steps.