Importance of Third-Party Verification of a Quality Management System for a PV Module Manufacturer

How to ensure consistency in PV Modules performance and design life

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Amonix
Third-Party Verification of PV QMS

Types of Audits

Customer

First-Party
Audit your own organization

Internal Audit

Organization

Second-Party
You audit your supplier

Supplier

Third-Party
Independent audit organization
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**Types of Audits**

- **Customer** — *purchaser or an agent of the purchaser audits the organization to insure proper procedures are maintained for the product*

- **Internal** — *organization self-audits against declared procedures*

- **Third Party** — *an entity not associated with the customer or the organization performs an audit*

- **Questionnaire** — *type of an audit that allows organization to self address a list of questions*
# Third Party Verification of PV QMS

<table>
<thead>
<tr>
<th>Audit Type</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer</strong></td>
<td>• Provides specific information to customer</td>
<td>• Customer needs to be an expert in all supplier businesses</td>
</tr>
<tr>
<td><strong>Internal</strong></td>
<td>• Organization ensures internal procedures are followed</td>
<td>• Typically not shared externally</td>
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<tr>
<td></td>
<td></td>
<td>• If procedures are inadequate, does not provide improvement</td>
</tr>
<tr>
<td><strong>Third Party</strong></td>
<td>• Audit against a specific standard</td>
<td>• Multiply third party audits may become expensive for an organization</td>
</tr>
<tr>
<td><strong>Questionnaire</strong></td>
<td>• Quick and low cost</td>
<td>• Inability to distinguish reality or just answering correctly</td>
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Many audits and auditors each requiring something a little different – inefficient for Company and Customers of the Company
Third Party Verification of PV QMS

ISO 9001 is Born

• The birth of ISO 9001 – standardized QMS auditing and allowed companies to provide certificates of compliance to customers reducing the need for customer audits

• Third party auditors for ISO 9001 must be certified by IAF national certification body and must comply to ISO 19011
## Third Party Audits of PV QMS

### Key Principles of auditing – ISO 19011:2001

<table>
<thead>
<tr>
<th>Principle</th>
<th>Explanation</th>
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<tbody>
<tr>
<td>independence</td>
<td>the basis for the understanding and reliability of the audit conclusion</td>
</tr>
<tr>
<td>ethical conduct</td>
<td>the foundation of integrity and professional status</td>
</tr>
<tr>
<td>fair presentation</td>
<td>the foundation of integrity and professional status</td>
</tr>
<tr>
<td>evidence</td>
<td>the rational basis for reaching audit conclusions based on the application of defined criteria</td>
</tr>
<tr>
<td>due audit care</td>
<td>reasonable care in all matters and completeness in the presentation of the audit report</td>
</tr>
</tbody>
</table>
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Number of Companies making PV Modules by year

Source: PV News, May 2013 issue & Cleantechnica.com
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Current State of Affairs

• Several companies are offering to audit module producers
  – Are they consistent?
  – Now module manufactures may have to comply to several audits (a motivator to universalize for ISO 9001)
  – Who is “qualifying” the companies to do the audit?
Many audits and auditors each requiring something a little different – inefficient for Company and Customers of the Company
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ISO 9001 by itself is inadequate for PV

- ISO 9001 is a one size fits all – companies are responsible to identify the critical aspects of their business to ensure proper quality
- Companies with little to no field experience with PV may have a poor foundation to establish a proper QMS for module lifetime control
- ISO 9001 is not specific to requiring certification of products to published standards
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ISO 9001 by itself is inadequate for PV

- ISO 9001 is general and up to interpretation company by company

DO YOU SEE TWO FACES, OR A VASE?
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What have other industries done?

• **Automotive => ISO/TS 16949**
  – Created to *harmonize* quality standards throughout the automotive vast supply chain and to promote *continuous improvement, defect prevention, variation and waste reduction*.

• **Medical Device => ISO 13485**
  – Due to the *regulatory nature* of medical devices, an industry specific standard was desired. National standards, such as 21 CFR Part 11 in the US, existed. Companies desired an international standard for easier compliance for their multi-national businesses. This standard emphasizes that device design must be controlled by a quality management system that ensures the manufacture of safe products as established by the design.
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What have other industries done?

- **Aerospace => AS9100**
  - Due to the *unique* “high risk” nature of aerospace, it was felt that ISO 9001 did not adequately prescribe process and systems required in the Aerospace industry to maintain acceptable design and manufacturing performance to minimize the risks.

- **Telecommunications => TL9000**
  - With the globalization of telecommunications, overlapping standards created unnecessary complications. A lack of a consistent industry-specific standard was deemed to reduce the complications and reduced the *cost impact of poor quality* in the Telecommunications industry.
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What have other industries done?

- Harmonization, Uniqueness
- Simplification, Continuous Improvement,
- Defect Prevention
- Regulatory Nature
- Cost Impact of poor Quality,
- Variation and Waste Reduction

Justifications for an Industry Specific QMS PV Industry?
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Driver for PV Industry

Project

BANKABILITY
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What initial qualification may detect

Almost no infant mortality detected due to small initial sample size & perhaps an end of life mechanism is determined

Bankability looks good.
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What may happen in manufacturing

Infant mortality may increase and become variable. During production a new failure mechanism may be introduced due to uncontrolled changes.

Bankability looks bad.
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Requiring reliability in the manufacturing Process

• Kent Whitfield, a member of Task Group 4 – Diodes, shading and reversed bias, presented a paper at NREL’s Photovoltaic Module Reliability Workshop 2013 on the potential affects of Electrostatic Discharge (ESD) on diodes and their potential to be a hidden defect only exposed after use in the field.

PV QMS

“The organization shall maintain an Electrostatic Discharge (ESD) safe environment at the raw material storage, processing, assembly areas, as appropriate”

Plus five other references to incorporate into design, components, manufacturing, validation and audits
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**Field Failures related to Manufacturing Control**

- Poor Solder Joint => Hot Spot
- Cracked Cells
- Uncontrolled change of material or processes
- Supplier changes material without notifying the manufacturer
- Poor installation manual leads to improper installation
- Improper installation of junction box leads to a loss of electrical connection
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More Power = More Heat – 2 types of Hot Spots

Hot Spot caused by crack in the cell

Hot Spot caused by poor solder joint

Source: “Hot Spot Evaluation of Photovoltaic Modules”, Govindasamy (Mani) Tamizhmani and Samir Sharma, Photovoltaic Testing Laboratory (ASU-PTL)

Source: “PV Module Arc Fault Modeling and Analysis”, Jason Strauch, Sandia National Laboratories

Lesson Learned: Control the critical processes or pay for it in the field.
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Manufacturing Change Control

A change in Anti-reflective coating (ARC) caused an interaction between the encapsulant and the ARC which caused delamination in the field.

Source: “TISO 10 kW Array – Born on May 13, 1982”, G. Travaglini\textsuperscript{a}, J. Bishop\textsuperscript{b}, Et al., \textsuperscript{a}LEEE-TISO, Univeristy of Applied Sciences of Southern Switzerland, \textsuperscript{b}ESTI, JRC, Ispra

Source: “Lifetime Performance of Crystalline Silicon PV Modules”, Ewan D. Dunlap, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Renewable Energies Unit
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What is in the proposed standard?

- Provision of resources for the warranty System
- Requires the planning of product certification and design lifetime alignment with warranty
- Establishes requirement for power degradation and its relationship to design lifetime
- Previous failures must be incorporated into design requirements
- Establishes ESD requirements in design, components, manufacturing, validation and auditing
- Improves customer communication requirements
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What is in the proposed standard?

- Requires the use of FMEA, or equivalent, in the design and manufacturing phases
- Design lifetime becomes an explicit requirement for design
- Emphasizes design and validation of manufacturing processes
- More explicit definition on controlling the purchasing process and requires key materials to be traceable
- Requires control plans to be established for manufacturing processes
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What is in the proposed standard?

- Requires identification and traceability of modules through key raw materials and process steps
- Improved control for power measurement test equipment
- Requires process capability studies on all new manufacturing processes
- Implements an on-going reliability test to detect shifts in the process that may affect module lifetime
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Standard so Far

- Task Group 1 lead by Ivan Sinicco has produced a draft document
  - Japan – Eguchi/Yamamichi
  - China – Zhou
  - Europe – Brueggemann
  - America – Mikonowicz/Lokanath/Norum/Kurtz

- NREL report can be found at:

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Future

- IEC Technical Committee 82 Working Group 2 has submitted a New Work Item Proposal as the next step to generating this standard
- There is an effort to generate Conformity Assessment working group specific to Renewable Energy (Declaration approved on 6/10/2013).

Decision 33/21 — IEC RE System - Basic Rules

In agreeing with the proposal to establish the Renewable Energy Conformity Assessment System, given in CAB Decision 33/20, CAB applauds the establishment of a working group to work on a draft set of Basic Rules and encourages CAB WT CAC to collaborate closely with WG 15 and experts from TC 82 in light of preliminary work by WG 15, while continuing to feed the WT industry voice into this pursuit and report back at the next CAB meeting in New Delhi.
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IEC Structure

COUNCIL (C)  
(Full Member National Committees)

COUNCIL BOARD (CB)

EXECUTIVE COMMITTEE (EXCO)  
(IEC Officers)

CENTRAL OFFICE  
(The Executive)

STANDARDIZATION MANAGEMENT BOARD (SMB)  
Management of International Standards work

MARKET STRATEGY BOARD (MSB)  
Technology watch / market priorities

CONFORMITY ASSESSMENT BOARD (CAB)  
Management of conformity assessment policies, activities and systems

Technical Committees

Technical Advisory Committees

Strategic Groups

Systems Work

Special Working Groups

CAB Working Groups

IECEE

IECEx

IECQ
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IEC RE

Conformity Assessment Offerings

CAB - Conformity Assessment Board

IECEE
System for Conformity Testing and Certification of Electrotechnical Equipment and Components

IECEx
System for Certification to Standards Relating to Equipment for use in Explosive Atmospheres

IECQ
Quality Assessment System for Electronic Components

IEC RE
IEC Systems Approach for Certification to Standards relating to plant, equipment and services associated with Renewable Energy Systems

IEC SOLAR
Scheme

IEC WIND
Scheme

IEC ME
Scheme
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IEC RE System Common Elements

IEC WT-CAC
Wind System

Type
1) Turbine Design
2) Turbine Testing
3) Mfg. Quality

Factory

IEC ME Marine
Energy Scheme

Type
1) ME Design?
2) ME Test?
3) Mfg. Quality?

IEC Solar
Energy Scheme

Type
1) Panel + Converter Design
2) Panel + Converter Test
3) Mfg. Quality

Type
1) Project
2) Commissioning?
3) Operation

Field

Project
1) Installation
2) Commissioning
3) Operation

Project

1) Installation?
2) Commissioning?
3) Operation?
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*Thank You for your Attention*