



# Update on IEC Inverter Standards Activity

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Sandia Inverter Reliability Workshop  
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# IEC Technical Committee (TC) 82

## Solar photovoltaic energy systems

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- IEC = International Electrotechnical Commission, founded 1906
- Prepares and publishes International Standards for all electrical, electronic and related technologies. These are known collectively as “electrotechnology”.
- ~174 TCs and SCs (Subcommittees), and ~700 Project Teams (PT) / Maintenance Teams (MT) carry out the standards work of the IEC

### TC 82 Working Groups

|                             |                              |
|-----------------------------|------------------------------|
| <a href="#"><u>WG 1</u></a> | Glossary                     |
| <a href="#"><u>WG 2</u></a> | Modules, non-concentrating   |
| <a href="#"><u>WG 3</u></a> | Systems                      |
| <a href="#"><u>WG 6</u></a> | Balance-of-system components |
| <a href="#"><u>WG 7</u></a> | Concentrator modules         |

### Joint Working Groups

|                               |  |
|-------------------------------|--|
| <a href="#"><u>JWG 1</u></a>  | Small renewable/hybrid systems for rural electrification |
| <a href="#"><u>JWG 32</u></a> | Electrical safety of PV system installations             |

# Working Group 6

## Balance of System Components

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- Scope: Develop BOS standards in the general areas of performance, safety, environmental durability (reliability), quality assurance and quality assessment criteria.

- Co-convenors
  - Greg Ball (US)
  - Vicente Salas (Spain)
- Number of members: 74
  - 66 one year ago
  - Meet twice per year with WG3
  - Typical attendance ~45-50
  - Some house cleaning needed

|    |             |   |              |
|----|-------------|---|--------------|
| 10 | US          | 2 | Italy        |
| 10 | Korea       | 1 | Czech        |
| 9  | Germany     | 1 | Finland      |
| 7  | Spain       | 1 | UK           |
| 4  | Canada      | 1 | Israel       |
| 4  | Japan       | 1 | India        |
| 3  | Australia   | 1 | Kenya        |
| 3  | Austria     | 1 | Malaysia     |
| 3  | Switzerland | 1 | Norway       |
| 3  | China       | 1 | Thailand     |
| 3  | Denmark     | 1 | South Africa |
| 3  | France      |   |              |

# TC82 Working Group 6 Inverter Standards Activity

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- Safety
  - 62109 - Safety of power converters for use in photovoltaic power systems
    - Part 1. General requirements (Published)
    - Part 2. Particular requirements for inverters (Published)
    - Part 3. Particular requirements for PV modules with integrated electronic devices (Drafting)
  
- Anti-Islanding
  - 62116 - Test procedure of islanding prevention measures for utility-interconnected PV inverters (Published/Maintenance)
  
- Efficiency
  - 61683 - Photovoltaic system power conditioners - Procedure for measuring efficiency (Published/Maintenance)
  
- Nameplate ratings
  - Data sheet and name plate for photovoltaic inverters (Drafting based on existing EN standard)
  
- Emissions Testing (kicking off)
  
- BOS Component Qualification:
  - 62093 - BOS components for PV systems – Design qualification and natural environments (Published/Maintenance)

# IEC 62093 -- Scope

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- Balance of system components for photovoltaic systems – Design qualification natural environments. 1<sup>st</sup> edition, 2005
- BOS components for PV systems, suitable for indoor or outdoor environments, protected or unprotected
  - Based on module standards IEC 61215 and 61646
  - Modified to reflect features of BOS components
  - Added dust, fungus, insects, shipping vibration, shock, and protection class (mechanical and environmental)
  - **Covers a wide variety of equipment in addition to inverters, including batteries and charge controllers**

# IEC 62093 – Objectives and Tests

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- Demonstrate components capable of maintaining performance after exposure to expected environmental conditions
  - Within reasonable constraints of cost and time
- No claims on reliability (lifetime)

|       |   |    |
|-------|---|----|
| 11    | Test procedures .....   | 35 |
| 11.1  | Visual inspection.....  | 35 |
| 11.2  | Functioning tests .....   | 37 |
| 11.3  | Specific performance tests for components.....                    | 45 |
| 11.4  | Insulation test .....   | 49 |
| 11.5  | Outdoor exposure test.....  | 51 |
| 11.6  | Protection against mechanical impacts (IK-code) .....             | 53 |
| 11.7  | Protection against dust, water and foreign bodies (IP-code) ..... | 53 |
| 11.8  | Shipping vibration test.....                                      | 55 |
| 11.9  | Shock test .....  | 55 |
| 11.10 | UV test .....   | 57 |
| 11.11 | Thermal cycling test.....   | 59 |
| 11.12 | Humidity-freeze test.....   | 63 |
| 11.13 | Damp heat test .....  | 67 |
| 11.14 | Robustness of terminals test .....                                | 69 |

# IEC 62093 Revision

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- Standard is in “maintenance” cycle
- Revision gives us the opportunity to respond to market needs for basic/improved qualification and reliability requirements
  - Address large influx of new manufacturers from all over
  - Name overhaul to “Inverter and BOS Qualification Testing Requirements” (e.g.)
  - Remove batteries
    - being handled by another TC
  - Expand context (written with small system perspective)
  - **Greatly expand inverter qualification and testing requirements**
  - Be conscious of but not overly bound by cost constraints
    - Module manufacturers didn’t like it at first either but the value is clear
  - Don’t hamper innovation of reliability approaches practiced by experienced players

# Environmental Test Subcommittee

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- Paul Parker – SolarBridge, Test subcommittee chair
  - Peter Hacke – NREL
  - Chris Deline - NREL
  - Jon Kalfus – Independent Consultant
  - Harry McLean – Enecsyst
  - Mike Fife – AEI
  - Mike Silverman – Ops A La Carte
  - Sig Gonzalez – Sandia
  - Greg Ball – IEC 62093 committee chair
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- Team first assembled Feb '12
  - Draft inverter test document completed Feb '13



# Highlights of Subcommittee Draft of Expanded Testing

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- **Four categories of PV inverters**

- Category 1: Inverter assemblies (e.g. < 700W AC)
- Category 2: Wall mounted assemblies, e.g. string inverters and small 3-phase inverters
- Category 3: Free-standing single bay assemblies (e.g. 100 kW)
- Category 4: Free-standing multi-bay assemblies (e.g. 500 kW)

- **Two Levels of test requirements, level chosen by manufacturer dependent on target lifetime and business priority**

- Level 1: minimum set of requirements, typically used for shorter lifetime products, e.g., 10 year target design life
- Level 2: more aggressive requirement for longer lifetimes, e.g., >20 years design life
- Or... maybe Level 1 and Level 2 becomes size based

# Environmental Tests

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- **Highly Accelerated Stress Test (HALT)**

- Test beyond spec, step stress to failure (identify design margin)
  - Cold Step Stressing
  - Hot Step Stressing
  - Rapid Thermal Cycling
  - Vibration Step Stressing
  - Combined Environments

- **Damp Heat (DH)**

- 85°C / 85% RH -- Identifies corrosion related mechanisms

- **Humidity Freeze (HF)**

- 85°C / 85% RH followed by -40°C -- Identifies weaknesses in environmental protection design

- **High Temperature Operating Bias (HTOB)**

- 85°C / 85% RH -- identifies thermally activated mechanisms

- **Thermal Cycle (TC)**

- -40°C to 85°C -- Identifies mechanisms related to thermo mechanical cyclic fatigue

# Unique aspects of proposed testing

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- **Powering and real time monitoring critical**

- Many failure mechanisms require voltage / power to activate
- Frequent functional monitoring ( $\leq 1$  minute intervals)
- AC and DC power cycling required

- **Test beyond specification**

- Required to accelerate failure mechanisms
- Level 1: + 10°C beyond spec
- Level 2: + 20°C above spec

- **Prioritizing failure modes**

- Class 1: Catastrophic hardware failure. Unit under test fails to produce power under all test conditions
- Class 2: Failure requiring an AC and / or DC power cycle to return to normal operation
- Class 3: Soft failure under a specific test condition
- Class 4: Error in data reporting accuracy

# Issues and Status

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- Draft received numerous comments from WG6 and was discussed at length at Sydney meeting in April
- Considerable pushback from large inverter representatives in WG6
  - Concerns with testing beyond spec
  - Concerns with cost
    - Cost of performing tests
    - Cost and availability of test samples, especially for large systems
  - Concerns that HALT tests aren't representative of field failure mechanisms
    - nor are they better than tests developed from specific field experience
- So... need additional large power inverter participants
  - Passage of new revision depends on consensus
  - Make-up of some voting national committees is manufacturer heavy
  - Also need large customers and users for support
- How to enforce use of standard
  - IEC standard has to be adopted by countries
  - May be market driven rather than imposed

# Next Steps

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- Revise current draft addressing WG comments
  - Hopefully improve large inverter approach with additional participants
- Develop Design Verification Testing section
- Clean up and edit remainder of main document
- Submit as a Committee Draft (CD) by end of year for review / comment by all national committees
- Address comments and submit for vote

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# Thank You!

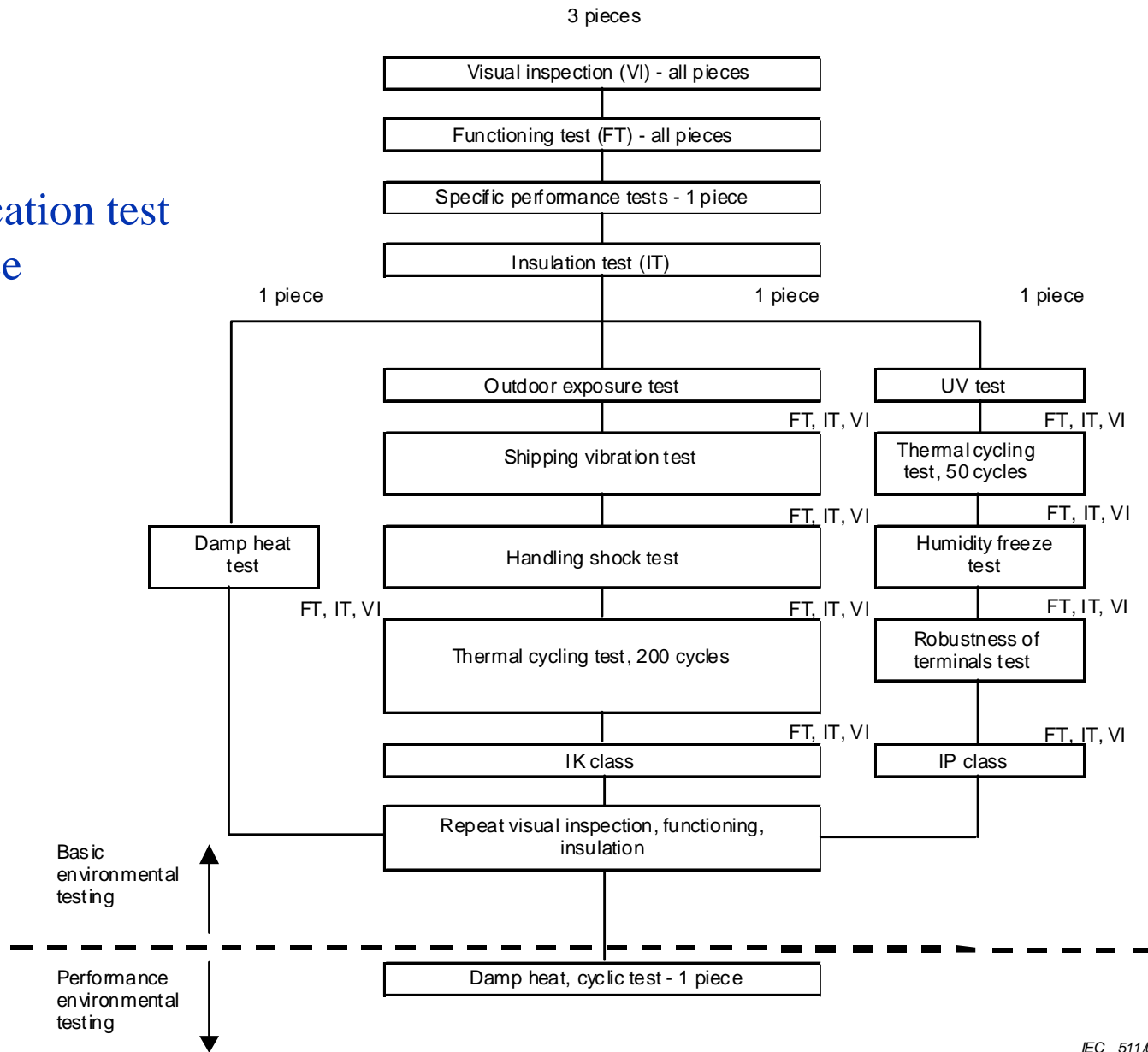
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[www.dnvkema.com](http://www.dnvkema.com)



# Qualification test sequence



IEC 511/05



# IEC 62093 -- References

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- References numerous IEC standards for general environmental testing, i.e. cross industry
  - IEC 60068 Series covering:
    - Vibrations, robustness of terminations, shock, damp heat (steady state and cyclic, hammer, temperature/humidity chambers.
  - 60721 Classification of environmental conditions
  - 62262 – Enclosure protection from external mechanical impacts (IK code)
  - 60529 - Enclosure protection from environment (IP code) -- similar to NEMA rating
- Report per requirements of ISO/IEC 17025
  - *General requirements for the competence of testing and calibration laboratories*