Existing Codes and Standards

Utility-Scale Grid-Tied PV Inverter Workshop

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BEW - ENGINEERING AND CONSULTING ACTIVITIES

- Project feasibility studies
- **Technical due diligence**
- Independent Bank's Engineering
- Owner's Engineering
- PV system design engineering
- **"Bankability" reviews – including utility scale inverters**
- Energy and performance modeling
- Utility grid interconnection studies, model and data preparation
- **Component design and prototyping**
- Intellectual property development
- **Standards development and compliance assessment**
- **Co-convenor for TC82 Working Group 6, Balance of System**

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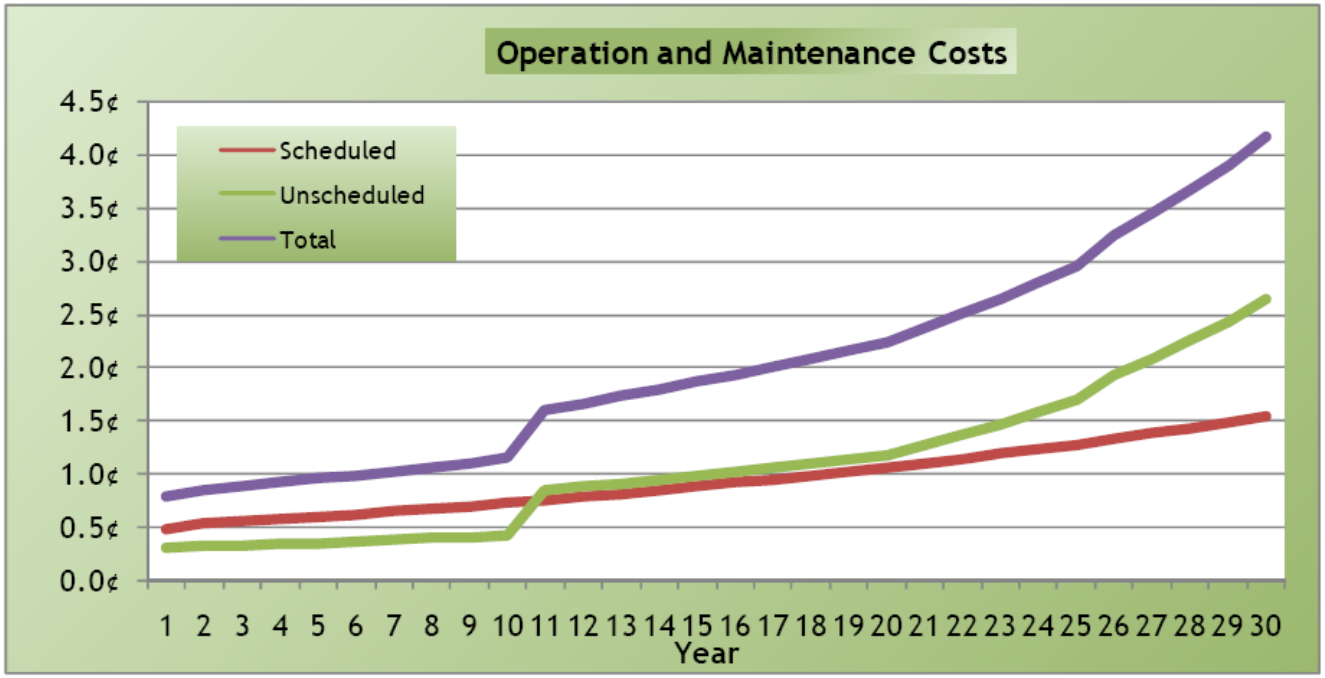
BEW RELIABILITY EVALUATION

- Field history
- Traditional reliability standards
  - MIL STD 217
  - Telcordia SS
- Halt Testing
- FMEA
- PV plant O&M modeling assumes parts, not unit replacement
  - Instead of replacing inverter after 5, 10, 12 years
  - Partial, component and sub-assemblies, after 10 years
  - Full unit after 20 years

OPERATIONS AND MAINTENANCE MODEL

- Developed by BEW
  - Detailed operations and maintenance cost model ($/kWhr)
  - Bottoms-up method with component and activity details
  - Time to fail and availability assumptions included



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EXISTING PV INVERTER RELIABILITY STANDARDS

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STANDARDS WITH SOME RELEVANCE

- ISO 3741
- ISO 3744
- ISO 7779
- ISO 9001
- ISO 9296
- ISO 10302
- IEC 60028-2-27
- IEC 60068-2-31
- IEC 60068-2-32
- IEC 60068-2-64
- IEC 60529
- IEC 60950-1
- IEC 61000
- IEC 61000-3-2
- IEC 61000-4-2
- IEC 61000-4-3
- IEC 61000-4-4
- IEC 61000-4-5
- IEC 61000-4-6
- IEC 61000-4-11
- IEC 61000-4-12
- IEC 62040-1-1
- IEC 61209
- IEC 61215
- IEC 62093
- EN 50116
- EN 55022
- EN 55024
- TELCORDIA
- GR-1274-CO
- SR332
- EIA/JESD22-A101
- JESD22-A108
- JESD22-A114
- JESD47
- UL 1741
- IPC J-STD-001
- IPC/ECA J-STD-002
- IPC/JEDEC J-STD-020
- IPC/JEDEC J-STD-033
- IPC-T-50
- IPC-A-610
- IPC-9591
- IPC-9592A
- IPC-9701
- CAN/CSA C22.2 No. 60950-1
- Others……

WHAT EXISTS FOR INVERTERS?

- UL 1741 and IEC 62109 – Safety Standards
  - Not reliability standards - BUT - some qualification and reliability addressed through safety requirements
  - Addresses failure vs. degradation over time for protective elements
  - If something is going to fail, fail safely – translates to some redundant elements
  - There is the option to add some level of reliability or qualification testing to these documents (per Tim Z)
- IEC 62093, MIL-Specs for components, JDEC Standards, Telcordia, IPC 9592A

What can we learn from module standards?

IEC 61215

- *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval. 2nd edition, 2005.*
- Equivalent standards for other PV:
  - IEC 61646 – Thin film
  - IEC 62109 – CPV
- IEC 61730 – Safety Standard, references the qualification standards
- Scope: Design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in general open air climates
- Objective: Determine electrical/thermal characteristics and demonstrate that the module is capable of withstanding prolonged exposure in climates

IEC 62093 – SCOPE

- *Balance of system components for photovoltaic systems – Design qualification natural environments. 1st edition, 2005*
- *BOS components for PV systems, suitable for indoor our 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

- *Test sequence to determine performance characteristics*
- *Demonstrate components capable of maintaining performance after exposure to expected environmental conditions*
  - *Within reasonable constraints of cost and time*
- *"The actual life expectancy of components so qualified will depend on their design, their environment and the system conditions under which they are operated."*
- *No claims on reliability (lifetime)*

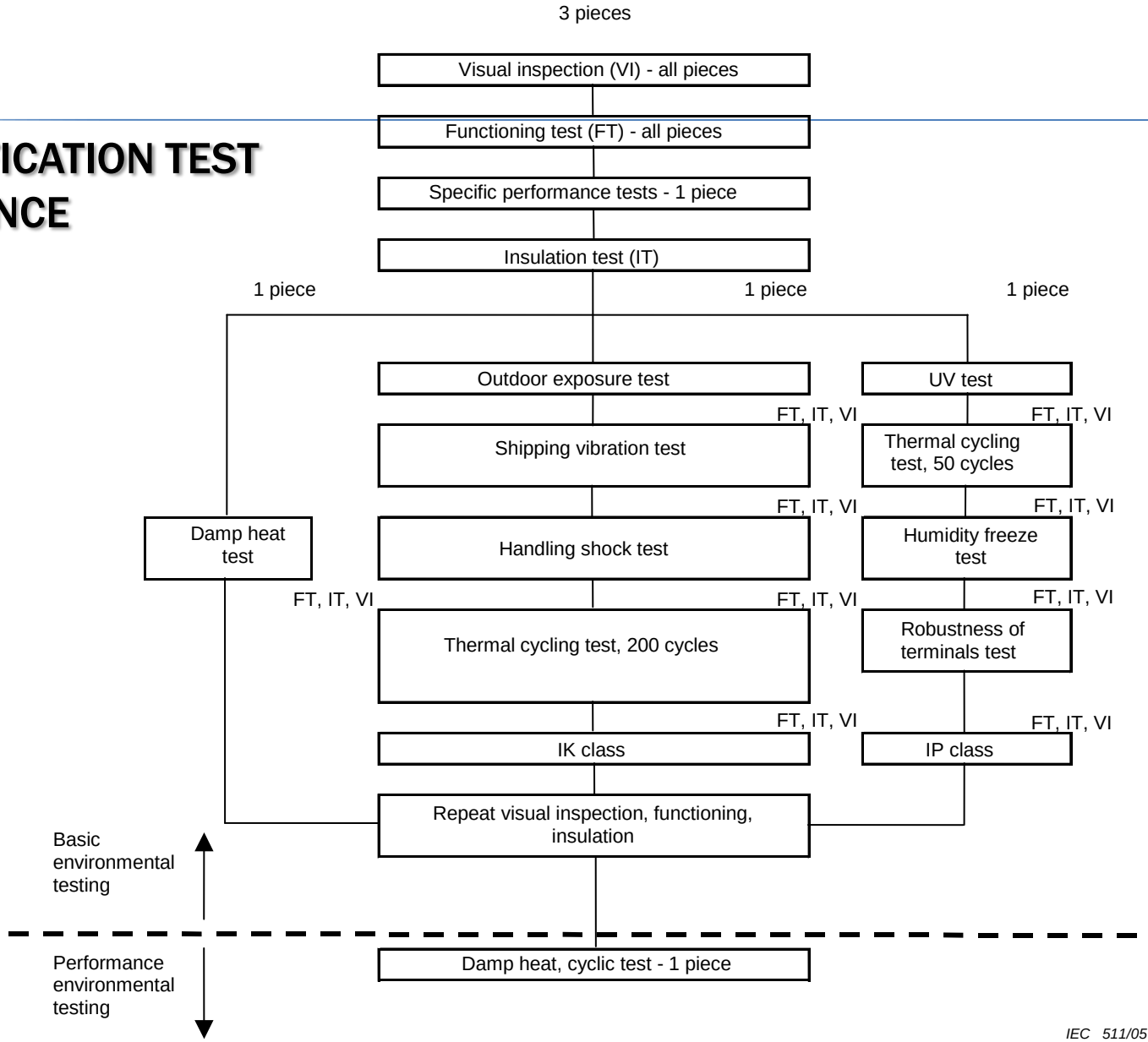
IEC 62093 – REFERENCES

- 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*

IEC 62093 – TEST PROCEDURES

- Visual inspection
- Functioning tests
- Specific performance tests for components
- Insulation test
- Outdoor exposure test
- Protection against mechanical impacts (IK-code)
- Protection against dust, water and foreign bodies (IP-code)
- Shipping vibration test
- Shock test
- UV test
- Thermal cycling test
- Humidity-freeze test
- Damp heat test
- Robustness of terminals test
- Damp heat, cyclic test

QUALIFICATION TEST SEQUENCE



IEC 511/05

WHAT NEXT?

- What are the gaps in codes and standards specific to inverters and power electronics, or, what should inverter companies be doing outside of existing standards?

- IPC 9592A – Power conversion industry example

IPC 9592A

- *Requirements for Power Conversion Devices for the Computer and Telecommunications Industries, 2010*
- Scope: ac to dc and dc to dc modules, converters and power supplies
  - Specific requirement and methods to meet the performance parameters
    - Design for Reliability,
    - Design Qualification Testing,
    - Manufacturing Conformance Testing, and
    - Quality Processes.
- Purpose - create a set of consistent specifications and methods to assure suitability, quality, safety and reliability of PCDs for the electronics industry

IPC 9592A – WHAT'S IN IT?

- Extensive list of qualification tests – list reads like a combination of 62109 (electrical disturbance) and 62093 (environmental) tests
- Halt Testing
- Design for Reliability
  - FIT reliability prediction calculated using Telcordia Technologies SR-332
  - Component selection
  - Corrosion testing
  - Derating guidelines

IPC 9592A – WHAT'S IN IT?

- Design Failure Modes and Effects Analysis (DFMEA)
  - Recognize and evaluate the potential failure modes of each component in a product and its effects on the product.
  - Identify actions that could eliminate or reduce the chance of the potential failure occurring.
  - Document the process for improvement of future designs.
- Quality Processes
  - Statistical process control
  - Corrective action process
  - Calibration
  - Continuous improvement
- Manufacturing Conformance Testing

NEXT STEPS?

- Codes and standards can be viewed as cost constraints and a source for reliability improvement. How can these opposing elements be better synchronized?
- Qualification testing of some level should be applied. Module manufacturers didn't like it at first but the value is clear
- Create a standard with basic minimal qualification/reliability requirements with criteria of
  - improving performance and customer confidence, but
  - limiting imposed cost constraints
  - allowing innovation in internal approaches for companies to improve, stand out

IEC 62093 REVISION

- Standard is in “maintenance” cycle, for revision in TC82 Working Group 6
- Not a best seller
  - Sales from 2005 to 1st Q 2010 = 30 copies
- Suffers from poor name – Design Qualification Natural Environments???
- Spread too thin to encompass charge controllers, batteries, etc.
- Written with small inverter mindset.
- Ad hoc committee formed to review and make recommendations
  - Increase it’s value, acceptance, usage using 61215 model
  - Side by side review with IPC 9592A for more meat
  - Careful attention to small vs. large inverter protocols

THANK YOU!

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