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Junction Box and Wiring Issues in Reliability*

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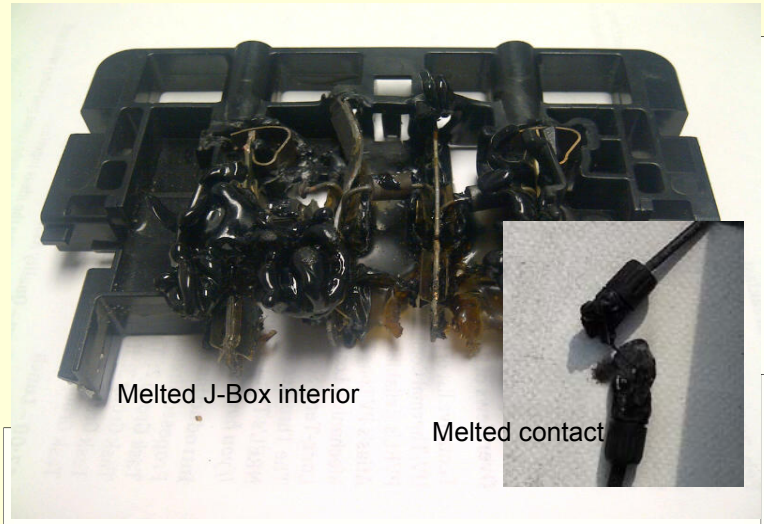
Abstract: Junction box design sometimes may be part art as well as part engineering, but it is always cost driven. Cost cutting has the potential to drive J-box configurations in directions compromising safety and durability. J-box and wiring deficiencies are being reported in our PV field installations after relatively short outdoor exposure of a few years. Some failures are traceable to lack of quality control in manufacturing or installation, but a commonality in failures appears to be designs allowing the onset of arcing. Standards in place (at IEC) or being written now (at UL) may not be adequate to identify the observed field J-Box and wiring failures. We examine what kind of testing beyond these certifications could be useful in anticipating the infant mortality field failures being observed and for guiding development of O&M programs.

Example of J-Box and wiring failures from overheating within 2-3 years in the field



Statement of Problem:

IEC and UL certification play central roles in eliminating deficient materials, validating mechanical and electrical designs, and establishing manufacturing guidelines/standards

IEC and UL certification cannot protect the customer against:

- **Manufacturing or installation errors**
- **Deficiencies in module material properties**
- **Failures caused by field conditions which combine extreme variable excursions:**
  - **mechanical, temperature and applied voltage stresses**

Certification is not sufficient to provide guidance for structuring of O&M

Studies are needed to evaluate what testing beyond certification can identify deleterious impacts of observed short term component failures on long term PV plant performance

Standards applicable to J-Boxes and wiring

- European Standard EN 50548:
  (Reviewed by Guido Volberg of TUV Rheinland, in *Photovoltaics International,* November, 2011, pp. 114-121)
  - Nine tests (A-I) specified
  - Only one "I" (Reverse current test) relates to electrical performance
  - Corrosion tests subject metal parts to ammonium chloride solution
  - Mechanical test protocols are very precise on stress application limits
  - Protocols leave a lot to subjectivity for training of installers
  - Soldered and non-soldered not called out in standards
- UL 1703 and 2703 - J-Box standards currently under development

Experience in early mortality (2-4 years) field failures

- Melting of J-Boxes with non-soldered wiring contacts
- Plastic cracking of interconnect wiring sleeves in products made with materials which have passed UL certification testing
- Melted connectors likely due to poor installation practices

Field failures have not been studied systematically for a number of reasons: proprietary designs, inadequate post-mortem examinations, multiple failure mode possibilities

Cannot expect tests can be devised to identify all factors, particularly manufacturing errors, BUT:

- What systematic studies on early field failure modes are needed to cull out bad designs in J-Boxes and wiring?
- What new tests are needed to address quality control in manufacturing and installation?

Case studies, extended testing are needed. Example:

Suspect arcing may be common fault in wiring and J-Box press fit contacts which may be less robust than soldered ones. Tests can be performed while under electrical load to determine rate of corrosion, deterioration during:

- Mechanical tests (shifting of contacts, fatigue)
- Electrical tests (corrosive effects, impact of humidity)
- Use of different pottant compounds (flammability)
- Elevated temperatures (simulating overheated diode)

* Contains no confidential information