EVALUATION OF CURRENT STANDARDS AND PRACTICES FOR THE SIMULATION OF WIND-BLOWN SANDS AND THEIR APPLICABILITY AS ACCELERATED AGEING TESTS FOR PV MODULES

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Sand movement is categorized in saltation, surface creep and suspension. For the simulation of stresses caused by sand movement, suspension and saltation are of particular importance. As a basis for a simulation the annual amount of sand affecting a single photovoltaic (PV) module in a particular location is estimated. Basing on these estimations, this work discusses three test methods which are applied to electronic products or military equipment as potential technical test procedures for PV modules. The test methods within MIL STD 810G, IEC 60068-2-68 and IEC 60529 vary in terms of wind velocity, particle density, particle dimension and distribution of sand grains. The relevance of a wind-blown sand or a dust test is very crucial in arid regions. However, each individual location of a PV system has other basic conditions (e.g. grain characteristics, wind velocities, ...). The expected service life of PV systems requires a reproducible test procedure representing long-term ageing and exposure effects. The main question is the reliability and the electrical safety of PV modules and other system components. Critical effects like abrasion on backsheets, cables, connectors or junction boxes could cause a loss of isolation. For the local energy yield it is furthermore relevant if shading effects caused by dust and sand are quantifiable to define cleaning cycles. Abrasion of glass can further influence the long-term power output of a PV system. Within this work furthermore alternatives to quartz dust as test medium are discussed, since quartz dust used for abrasion tests is known to pose great danger to test personnel by causing silicosis. The test methods discussed are open test systems with a single impact or closed circuit systems. The aim is to define an applicable test sequence which enables a confirmation of a resistance against weather phenomena with wind-blown sand. Consequently, this work derives input for future standardization progress and the finding of an applicable test method.

COMMON SAND GRAIN PROPERTIES

According to Bagnold [1] there are three different type mechanisms for sand transport:
• Suspension → particles smaller than 80µm float with the wind current
• Saltation → uplift of sand grains between 100 µm and 300 µm and acceleration through wind with later down force hitting other grains (splash)
• Reptation → grains are forced to move forward on the ground impulsed by saltation effect by other grains when splashed (300 µm and greater)

PROPOSED TEST FLOW FOR RESISTIVITY DETERMINATION

Deriving values for sand grains and velocities are based on calculation and analyzed weather data. Individual parameters have to be adjusted from local measurements. Dust blown effects and UV conditions from the field give evidence of distinctive brittleness from single components.

SPECFICATION OF CURRENT TEST STANDARDS AND DERIVATION OF ULTIMATE TEST PARAMETERS

Quartz has a hardness degree of 7 Mohs. The introduction of standardized test methods needs to regard such grain properties, as well as a realistic weighting of different grain sizes. Since SiO2 can cause silicosis hazards to test personnel. An important aspect is to determine alternative test materials as substitutes with similar hardness degrees (e.g. glass). The test methods of MIL STD 810G, IEC 60068-2-68 and IEC 60529 contain a wide variety of grain dimensions, wind velocities, weighting of grain, but also test durations vary. All tests are defined for specific products, such electronics or military equipment for potential exposure to areas with wind-blown sand. General applicable test specifications are hard to determine. For further discussions an overview of the most relevant characteristics from these standards are given:

- Test material (grains):
  • Minimum hardness = 7 Mohs
  • Alternative to SiO2
  • Standard test materials (sand and dust)
  • One-way / multiple-way blasting materials
- Different maximum grain classes:
  • ≤ 75 µm
  • ≤ 150 µm
  • ≤ 300 µm
- Grain densities:
  • < 6.18 g/cm³
  • 6.18 g/cm³ – 8.0 g/cm³
  • 8.0 g/cm³ – 9.55 g/cm³
  • 9.55 g/cm³ – 10 g/cm³
- Wind velocities (profiles):
  • ≤ 1.5 m/s → 100x/hrs
  • Laminar wind bow, avoidance of turbulence

CONCLUSIONS AND INPUT FOR STANDARDIZATION WORK

- Standard proposed wind velocities need to be validated and adjusted by field data.
- Due to the great diversity of particle characteristics from individual areas, it is impossible to define a globally valid test method.
- A combination of sand and dust tests with UV pre-conditioned test samples is recommended to determine the resistance of PV components against abrasion effects from wind-blown sand.
- Current and later standards and reports need to clearly identify what grains (and properties), wind velocities, UV dosis and test duration was applied to achieve a transparent evaluation of the products sand storm resistivity.
- Sand storms are one phenomenon in deserts. Resistivity tests to such do not determine the suitability of products for arid areas alone (increased ambient temperatures are of most importance).