Inappropriate Exposure to PV Modules: Description and Effects of Handling Defaults

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Goals and motivation
- During storage, the manual transport but also with an installed generator solar modules are exposed to mechanical stress. By these strains, defects can occur in the cell structure or at soiling joints.
- The impact of defects can frequently not be detected by the human eye, but affect the performance of the modules, and thus an entire string.
- Micro cracks in silicon materials emerge due to a perpendicular acting force during storage, the manual transport but also with an installed generator.

Perpendicular acting force (using the example of default no. 5)

Laboratory conditions:
- defined drop: 0.95 cm (by a body size of 176 cm)
- parallel to the ground
- even, airtight terrain

Real conditions:
- individual drop height of the test persons
- parallel to the ground
- even, airtight terrain

Parallel acting force (using the example of default no. 6)

Laboratory conditions:
- defined drop: 0.75 cm (by a body size of 176 cm)
- vertical to the ground
- even, airtight terrain

Real conditions:
- individual drop height of the test persons
- vertical to the ground
- even, airtight terrain

Overview of handling defaults

<table>
<thead>
<tr>
<th>Classification</th>
<th>No.</th>
<th>Description of the default situation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage</td>
<td>1</td>
<td>Falling over of a poorly secured PV module from vertical stand</td>
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<tr>
<td></td>
<td>2</td>
<td>Falling over of a module pallet</td>
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<tr>
<td></td>
<td>3</td>
<td>Poorly packaged module pallet</td>
</tr>
<tr>
<td>Transport</td>
<td>4</td>
<td>Pulling up of a module over a ladder due to a person on the roof</td>
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<tr>
<td></td>
<td>5</td>
<td>Horizontal carrying of a module by two persons with subsequent drop down</td>
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<tr>
<td></td>
<td>6</td>
<td>Vertical carrying of a module by two persons with subsequent drop down</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Head first carrying of a module</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Crossing the generator field</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Walking along the frame by crossing the generator field</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Tool slipping from hand or tool belt</td>
</tr>
</tbody>
</table>

Summary and outlook
- Due to the simulation of the handling situations it could be established that most of the situations, in which the force acts perpendicular to the surface of the module, cause (in part significant) damages in the cell structure.
- In those situations, in which the force acts parallel to the wafer surface, slight damage to the frame is the result of the test. Small micro cracks can be explained by the different heights respectively the different spread.
- Therefore situations should be avoided, in which the force acts perpendicular to the surface of the module.

The impact of defects can frequently not be detected by the human eye, but affect the performance of the modules, and thus an entire string. Therefore situations should be avoided, in which the force acts perpendicular to the surface of the module.