

# **Reproduction of 2009 Presentation**

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# **Recommended Protocol for Accelerated Aging Testing**

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## Accelerated aging tests of PV modules

	Accelerated Qualification Testing	Accelerated Comparative Testing	Accelerated Lifetime Testing
<b>Design Quality Confidence</b>	Minimum *	Medium **	High ***
<b>Objective</b>	Minimum testing for reliability / durability of <b>specific module design</b>	Extended qualification testing to compare relative reliability / durability of <b>multiple designs</b>	Site (and configuration) specific testing or worst case site(s) testing of any <b>specific module design</b>
<b>Cost and time</b>	Low	Medium	High
<b>Goal</b>	<b>Introduce</b> the specific design in the market	<b>Compare</b> (to improve / purchase / invest) multiple designs	<b>Predict</b> lifetime and/or protect warranty
<b>Testing protocol</b>	Test <b>standards exist</b>	Tester defined protocols exist but a <b>uniform protocol is needed</b>	None publicly exists, if any. <b>Needs a comprehensive understanding on failure mechanisms, failure modes and mathematical models to develop an appropriate testing protocol</b>
<b>Test requirement</b>	<b>Pass / Fail</b> (>5% Pmax drop = Fail)	<b>Relative</b> power loss for a specific stress time or relative stress time for a specific power loss	Identify ultimate failure mode and/or <b>to determine / substantiate warranty period</b>
<b>User</b>	Manufacturers / Consumers / Investors	Manufacturers / Consumers / Investors	Manufacturers



## Current Study

<b>Literature search and review on failure mechanisms</b>	<b>Literature search on failure modes</b>	<b>Literature search and review on mathematical models</b>	<b>Literature search and review on potential accelerated testing protocols to simulate the failure mechanisms and ultimate failure modes</b>
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## Future Work Needed

<b>Develop an appropriate accelerated lifetime testing protocol</b>
<b>Design and execution of preliminary experiments</b>
<b>Develop initial mathematical models</b>
<b>Validate and improve the mathematical models through detailed experiments</b>
<b>Develop “Recommended Protocol for Accelerated Lifetime Testing”</b>



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# Details on the presentation



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Accelerated aging tests of PV modules may be classified as:

- Accelerated qualification testing (minimum design quality confidence)
- Accelerated comparative testing (medium design quality confidence)
- Accelerated lifetime testing (high design quality confidence)

### **Accelerated qualification testing:**

- Objective: Define **minimum testing** requirements to **substantiate minimum** durability and reliability of a **specific module design**.
- Cost and time: **Minimum** so that the time-to-market can be reduced
- Goal: It is a test-to-pass testing to **introduce** module in the market
- Testing protocol: **Standardized** protocols defined by the test standards (Examples: IEC 61215 and IEC 61646).
- Test requirement: It is a pass / fail test with a maximum allowed limit of **5% drop** in power after accelerated stresses.
- User: Used by **most manufacturers** and it is a **market driven requirement** in Europe but it is not a requirement in the United States, except in the State of Florida.



## Accelerated comparative testing:

- Objective: Define **extended / repetitive qualification testing** requirements to **compare** the durability and reliability of **different module designs**.
- Cost and time: **Medium** – falls between qualification testing and lifetime testing
- Goal: It is a relative testing to **compare** different module designs
- Testing protocol: Currently, **tester defined relative / comparative testing** is used by the industry (Examples: BP Solar, NREL and ESTI protocols). A uniform protocol could be developed and adopted by Solar ABCs and recommended to a standard committee.
- Test requirement: It is a relative testing with a maximum allowed **limit** (limit the time and identify relative power loss OR limit the power loss and identify relative time, former is preferred) **defined by the tester**.
- User: It could be used by the **manufacturers** (or consumers / investors) to **improve** their module designs and/or to **compare** with competitors' module designs.



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## Accelerated lifetime testing:

- Objective:

Define **site (and configuration) specific testing** requirements to **predict site specific lifetime of any module design.**

OR

Define **worst case sites (and configuration) testing** requirements to predict the **worst case lifetime of any module design.**

- Cost and time: **Maximum** so that the warranty period can be substantiated or determined
- Goal: It is an ultimate failure testing to **predict lifetime** and/or to protect warranty.
- Testing protocol: Currently, **none is publicly available [if any]**. Based on the field failure mechanisms, failure modes and physical / statistical models, a unique consensus testing protocol needs to be developed. It may be developed by Solar ABCs and recommended to a standard committee. As a first step, a **comprehensive literature search will be conducted** on the field failure mechanisms, life-limiting failure modes, potential accelerated testing methods and mathematical models.
- Test requirement: It is a testing to determine **ultimate failure mode** or to a maximum allowed power loss **limit dictated by the manufacturer warranty (20% or 25%)**. A consensus definition for the term “ultimate failure” needs to be developed
- User: It could be used by the individual manufacturers to **determine / substantiate their warranty.**

