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Statistical Guidance For Setting Product Specification Limits

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Background

Nuclear weapon (high-reliability) components must meet requirements across a range of use-settings.

- Inputs (e.g., electrical and acceleration).
- Environments (e.g., thermal and mechanical).

Components undergo 100% functional testing at nominal settings.

PS limits are delegated from DA to PA.

- Violations of limits result in delays to testing and production.
- Key to identifying quality issues.

Approach

The 3-step process outlined here is a margin-based approach for setting PS limits.

The methods proposed emphasize the question: 'What will provide sufficient margin to the requirement?' while still considering, 'What is producible?'.

The approach is not novel or prescriptive; rather, it is a logical conceptual framework.

Prerequisite

Identify the performance characteristics most critical to component function, on which to collect data.

Step 1 Predict component performance in the acceptance testing and worst-case settings.

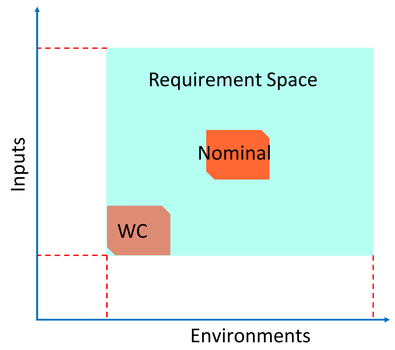
Understanding range of component performance across inputs and conditions is key.

Requirement space is high-dimensional in practice.

Green box depicts acceptance testing settings.

Orange box depicts worst-case use setting.

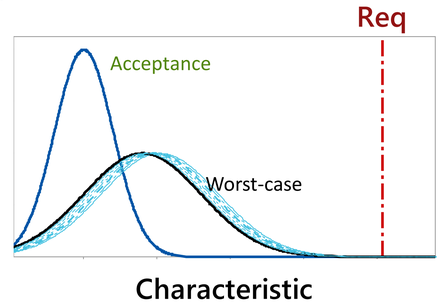
- Occurs here at lowest input and environmental condition. (This will vary.)



Enumerating and considering aleatory and epistemic uncertainties is key.

Aleatory uncertainty is encompassed within the performance distributions.

PS limits truncate both distributions in order to ideally prevent failures of the requirement in the presence of these uncertainties.



The light blue lines depict epistemic uncertainty in the worst-case setting

Specify the acceptance testing distribution, and then a mapping to the worst-case distribution.

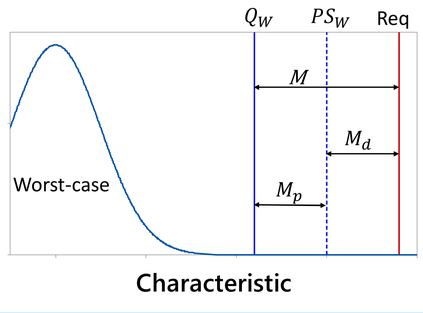
Step 2 Determine the worst-case PS limit by considering margin in the worst-case setting.

Q_W is an extreme percentile on the WC distribution.

M is overall margin to the requirement.

M_d is designer margin.

M_p is producer margin.

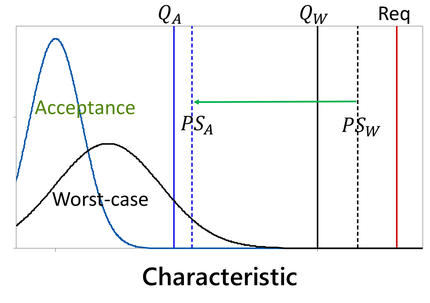


Balance designer and producer margin by placing PS_W between Q_W and the requirement, to ensure productivity while protecting against requirement failure.

Step 3 Transform the PS limit from the worst-case setting to the acceptance testing setting.

PS_W is transformed to the acceptance testing PS limit, PS_A, using the previously defined mapping.

Note: PS_W and PS_A correspond to distribution percentiles. With a deterministic model there is a 1-1 mapping between percentiles.



The DA and PA should work together to ensure that both M_d and M_p are sufficient.

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