Opportunities for HALT/HASS in designing robust electronics

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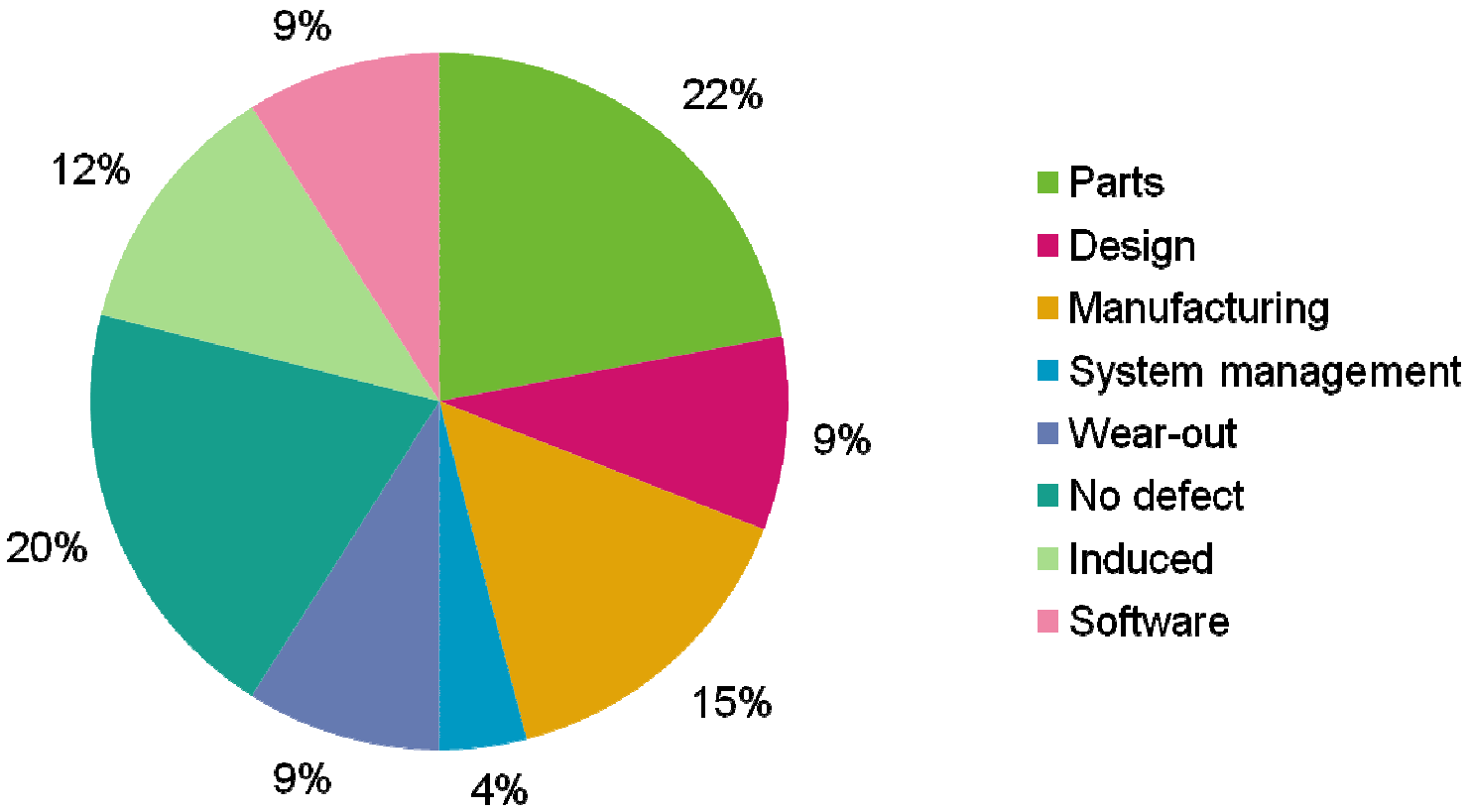
Outline

- Introduction
- HALT
- HASS/HASA

Predominant failure causes



Opportunities for HALT?

Environmental Stress Screening

- Goal: remove the “weak” ones out of the whole population

- Method:
  - Start with an identical population
  - Increase the temperature and vibration stress
- Other method:
  - HASS

Objective of HALT

- Highly Accelerated Life Testing
- **Objective:**
  find weak links in design and fabrication processes of a product during design phase

- DVT: Design Verification Testing
  - Tests done before product release

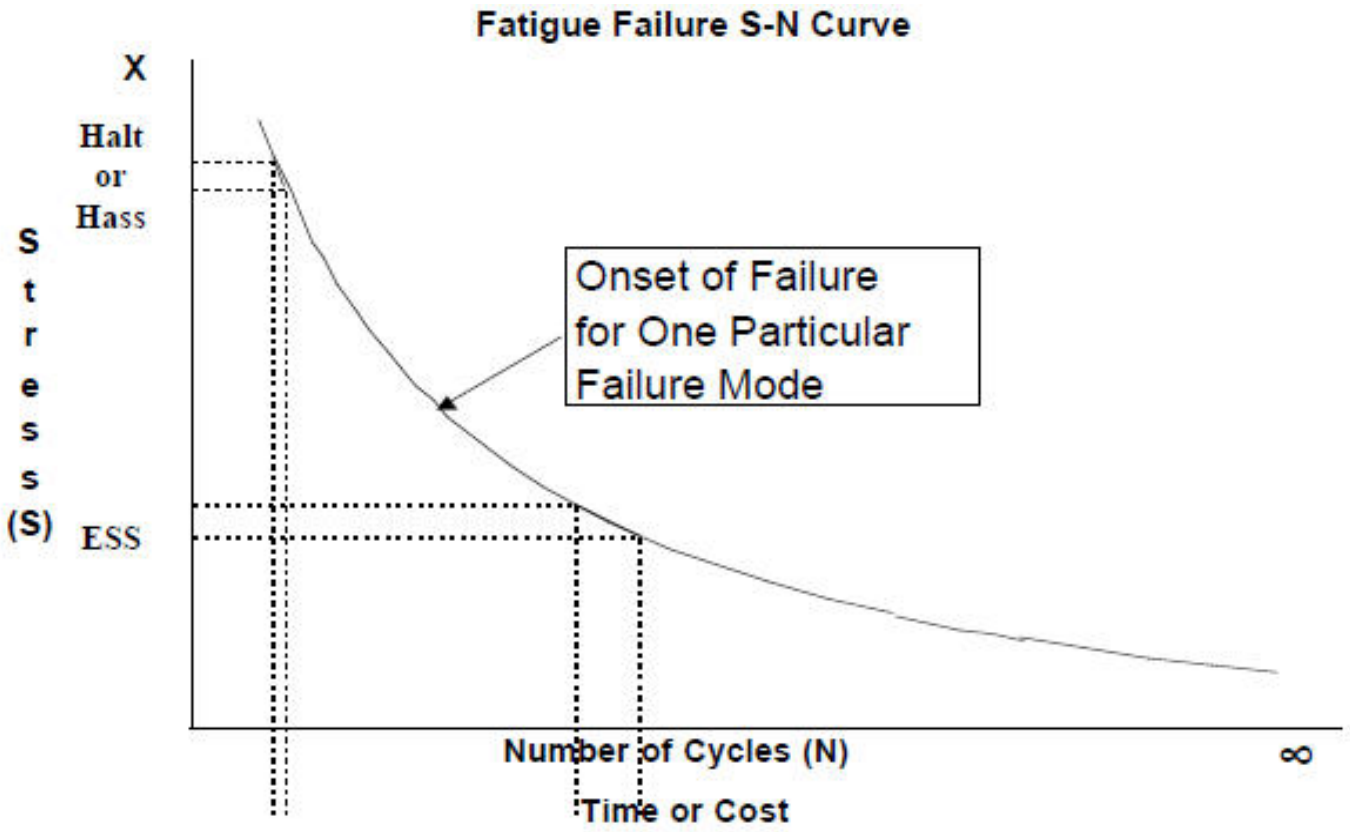
HALT: what is it?

- Process of discovery and optimization
  - Operating limits and destruct limits: points where the system ceases to work as specified but will return to operation if the stress is removed (operating limit) and ceases to operate even if the stress is removed (destruct limit)
  - Try to maximize the operating and destruct margins of the product
- **Not** a pass/fail test

HALT: what is it?

- Product is stressed well outside operating specifications
  - Stress until “fundamental limits of technology”
- Stimulate failures (not simulate the environment)
- Find failures - fix “on the fly” and continue testing

Why do HALT?



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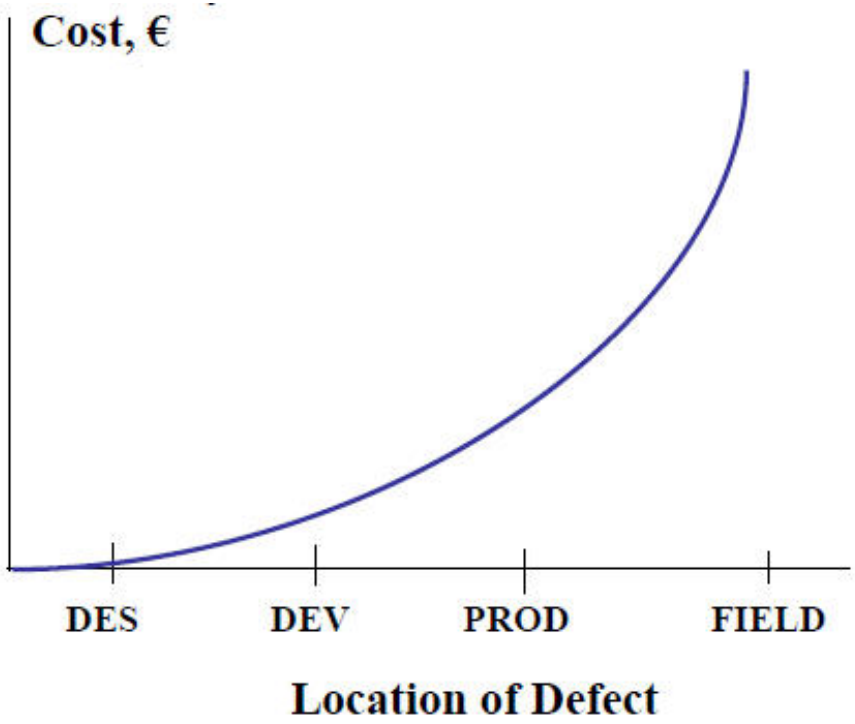


Rule of 4:
Every new step in product design costs 4 times more than the previous step

Example:
Cost design change: 100 €
Cost change in the field:
100 € x 4 x 4 x 4 = 6400 €

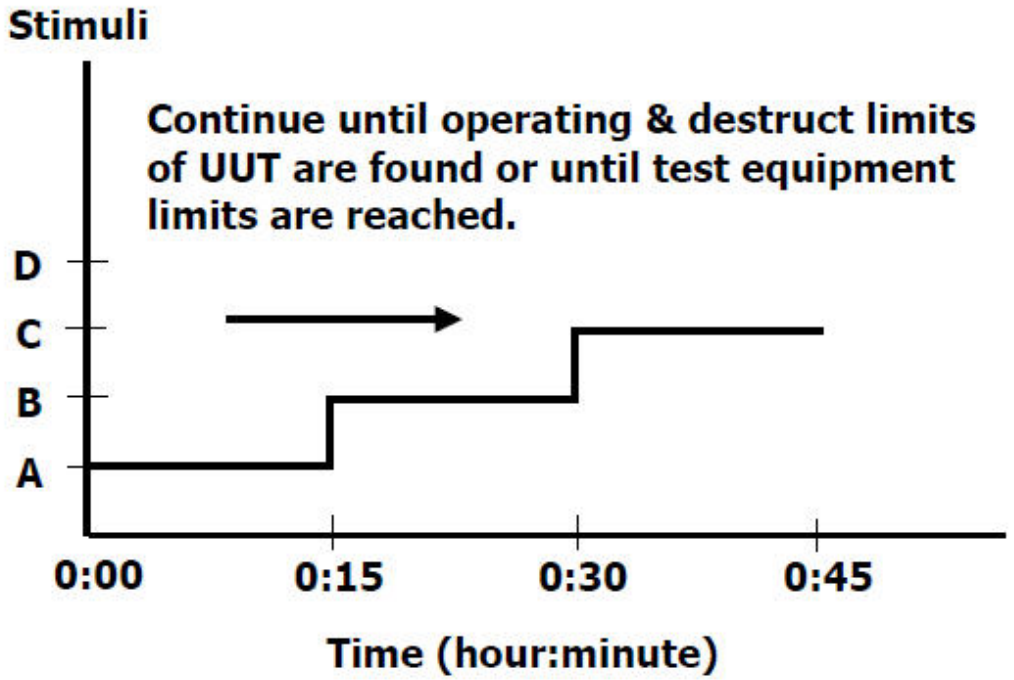
THE FASTER, THE CHEAPER

HALT tests

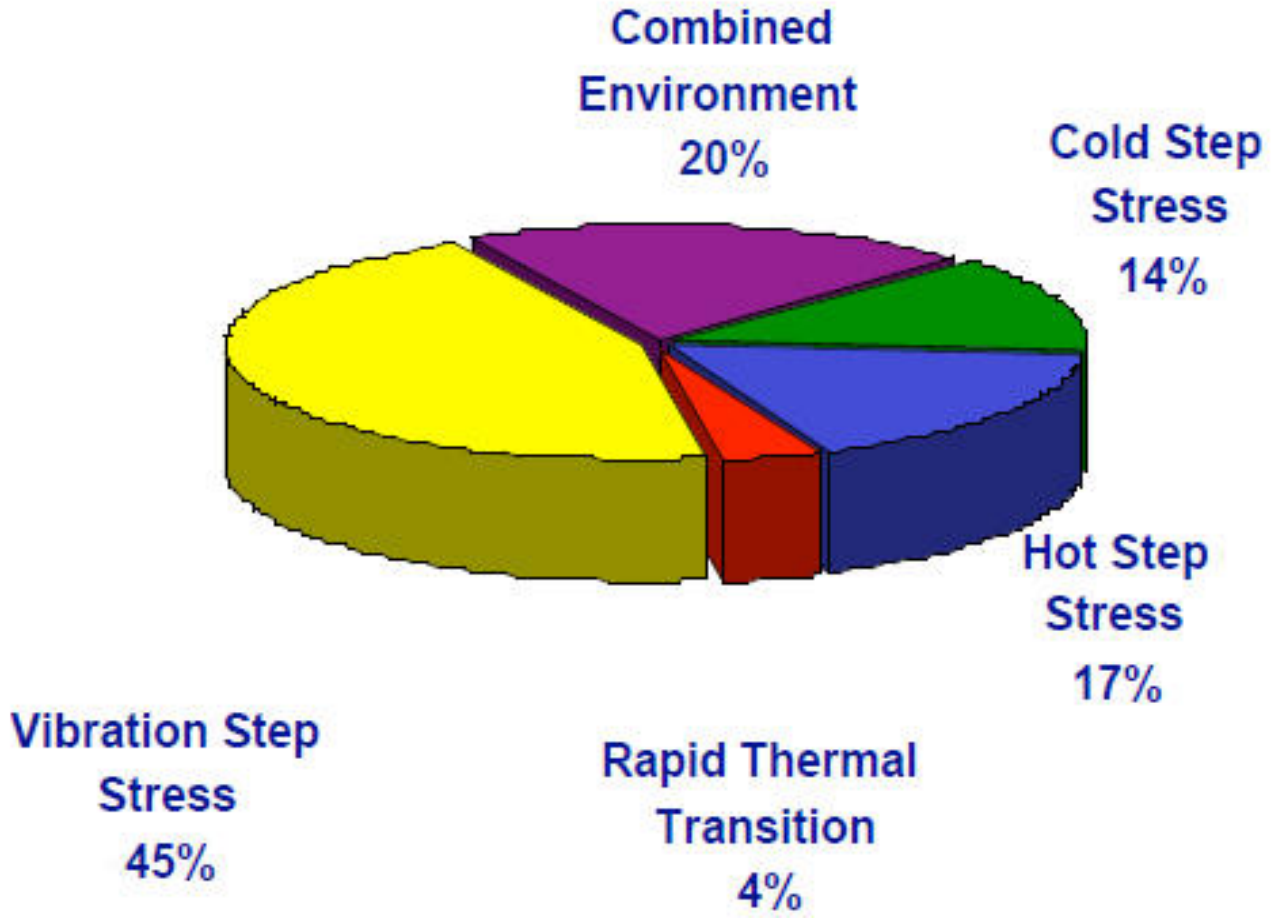
- HALT= always a series of tests
- Single & combined environments
  - Cold testing
  - Heat testing
  - Vibration testing
  - Heat and vibration testing
  - Cold and vibration testing
  - Thermal swings

HALT process

Using Step Stress Approach . . .



HALT test results



HALT versus traditional testing

HALT	Traditional testing
• Stresses product beyond specification	• Verifies that a product meets specification
• Gathers information on product limitations	• Simulates a “lifetime” of use
• Focus on design weakness & failures	• Focus on finding failures
• 6 DoF Vibration	• Single axis vibration
• High thermal rate of change	• Moderate thermal rate of change
• Loosely defined – Modified “on the fly”	• Narrowly defined – Rigidly followed
• Not a “Pass/Fail” Test	• “Pass/Fail” Test

HALT benefits

- Quickly discover design & process limitations
- Evaluate & improve design margins
- Characterize statistical information on margins
- Faster time to market
- Increased reliability more robust products
- Greater customer satisfaction
- Lowered warranty cost through higher MTBF
- Minimized chance of product recalls

When is HALT not indicated?

- HALT is not recommended or *cost effective* for *extremely low production rates* products
- HALT is not recommended for *one of a kind or very expensive* products
- HALT does not replace *qualification testing* such as that performed for *space* applications

HASS/HASA

- Highly accelerated stress screen/audit
- Less extreme version of HALT-test on sub-assembly or final assembly level
- Performed on all production units or on a statistical relevant amount of units
- Precipitate latent defects/workmanship defects and correct

Benefits of HASS/HASA

- Detect & correct design & process changes
- Reduce production time and cost
- Increase out-of-box quality and field reliability
- Decrease field service and warranty costs
- Reduce infant mortality rate at product introduction

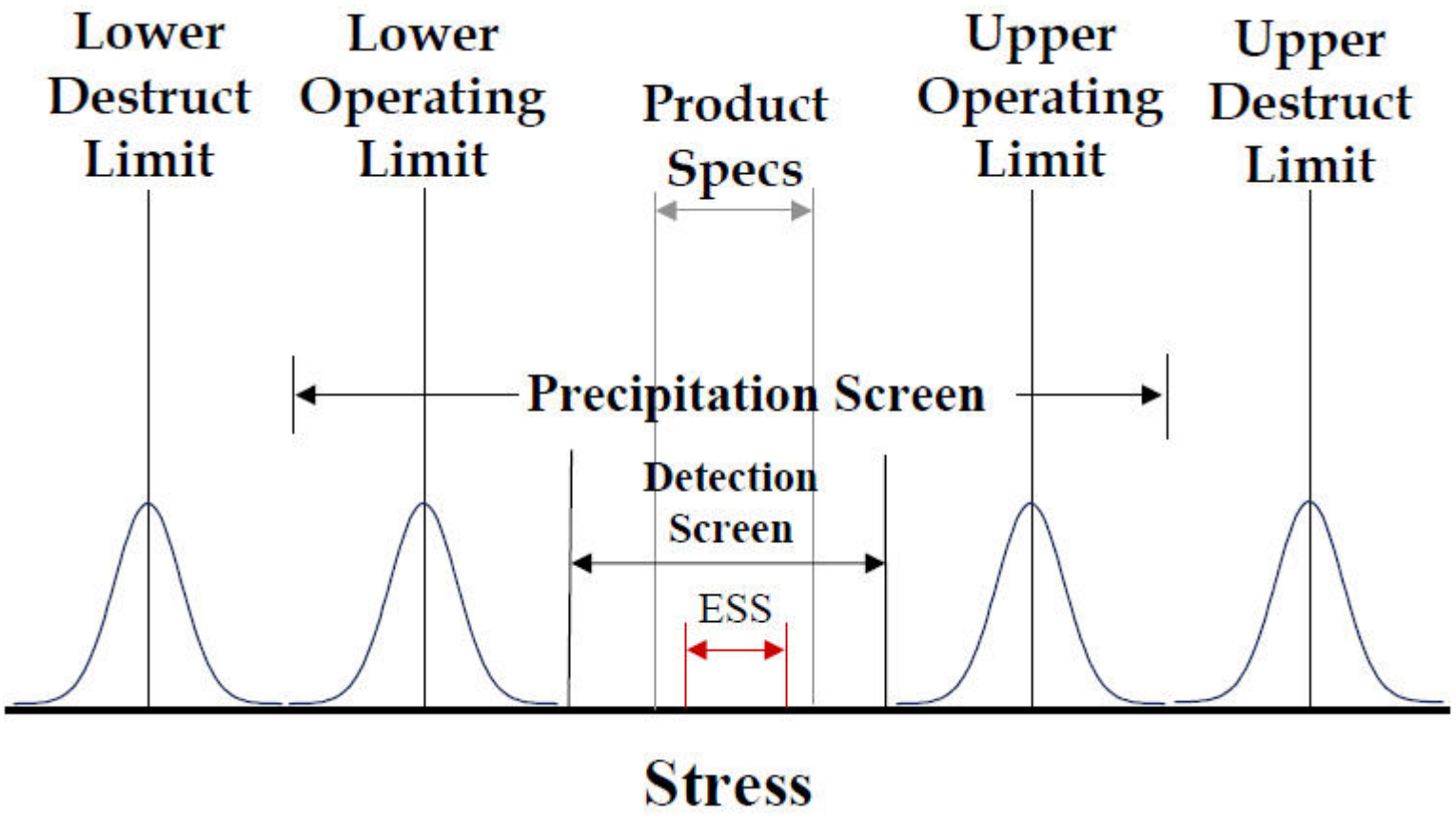
HASS is not a test, it's a process

Each product has its own process

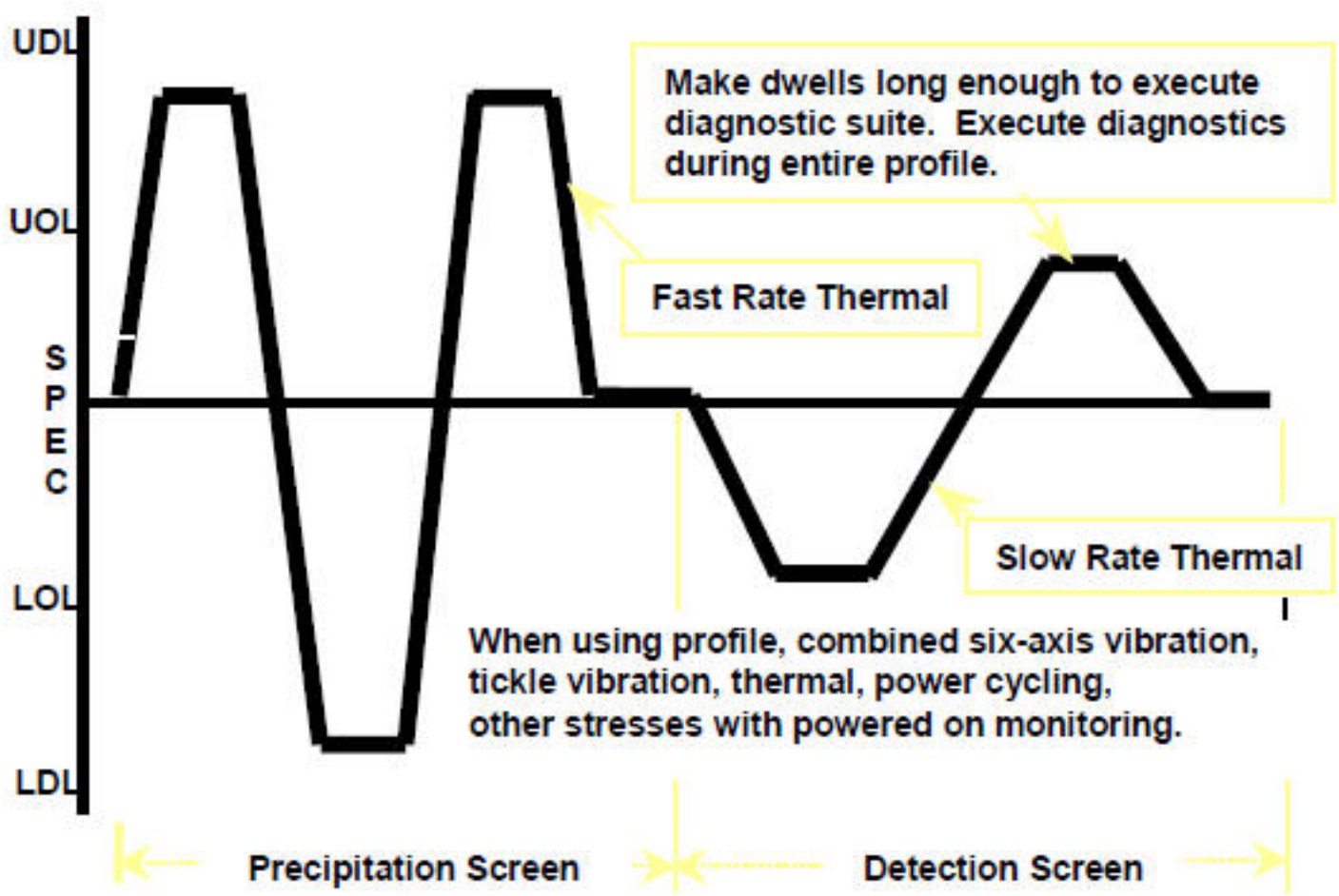
HASS ≠ burn-in

Burn-in	HASS
– Weed out infant mortality	– Verify that HALT limits haven't changed
– Verify function at elevated temperature	– No new "weak links" due to process or component changes

HASS screen diagram



Typical HASS profile



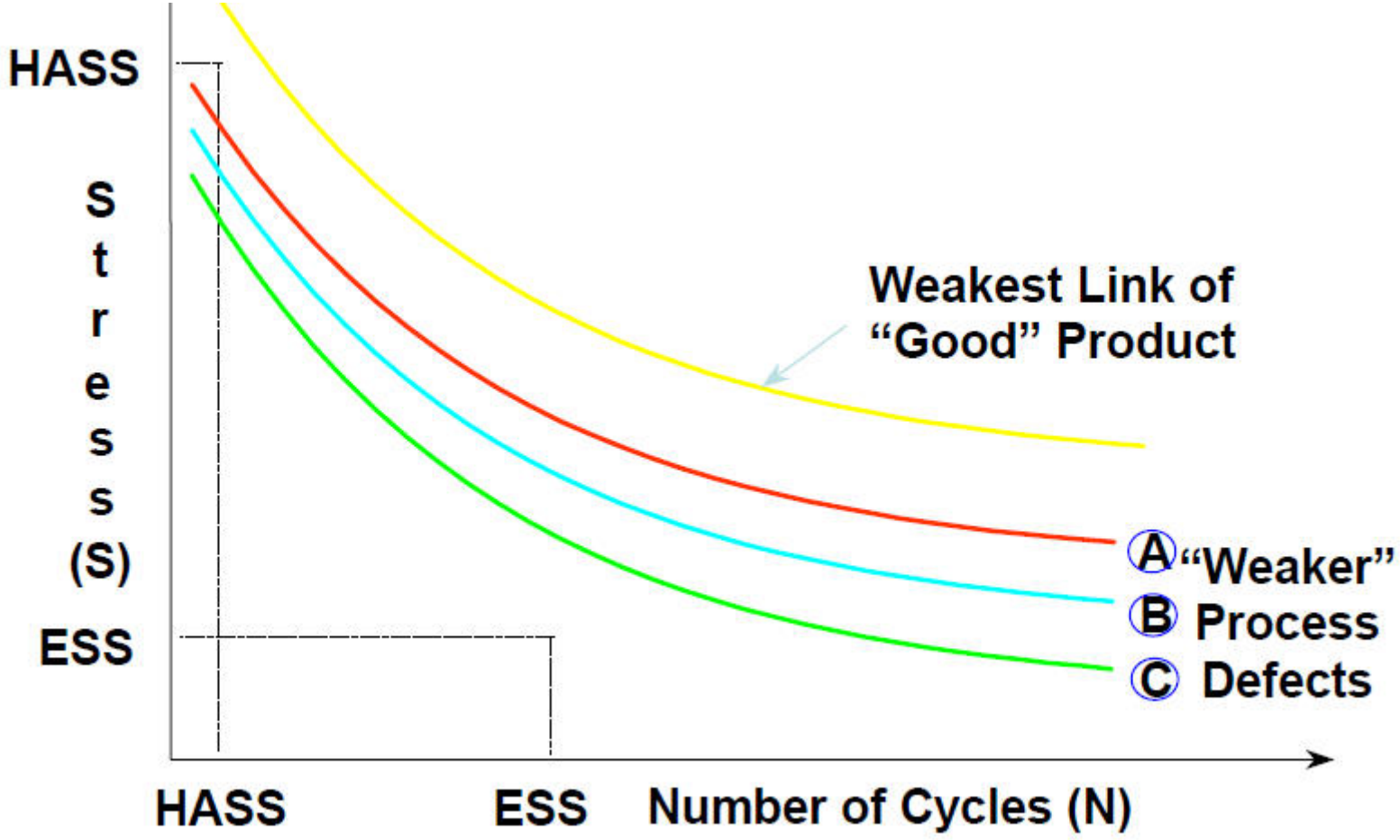
Proof-of-screen

- Serves two key purposes:

  – Verify that the screen is not taking excessive life out of the product

  – Verify that the screen is effectively finding defective units

Robustness and screenability



Typical defects detected in HASS

- IC process changes
- Solder issues
- Electrical tolerance
- Component placement
- Mechanical tolerance
- IC process problems
- Timing problems
- Raw board problems

When is HASS not indicated?

- HASS is not needed if a product is mature and the vendors and manufacturing process cannot be changed

- HASA can be used for high production products to provide nearly the same protection as 100% HASS screening

HASS versus ESS

	Current Stress Screening	HASS
Screening coverage	100% (on every unit)	100% (on every unit)
Screening time/unit	36h	**4h**
Lifetime reduction	Unknown	**Less than 3%**
Stress nature	Temperature and vibration separated Low thermal transition rates	Temperature and multi-axis vibration combined **High thermal transition rates**
Fixture (mounting)	Only for vibration	Dedicated to have uniform temperature and vibration stress
When to use	For all quantities	Not for very low quantities

HASS vs ESS

	Burn-in and shaker	HASS
Temp. Load	Extreme temperatures	Thermal shock
Vibr. Load	1 DOF per test run 10 minutes Low freq. (2-3gRMS) = workmanship	6 DOF +100 minutes High freq. (15-40gRMS) = workmanship & solder & components
Load	Sequential	Combined
Life reduction	Unknown	Known & <3%
Wall clock time	36h	4h
Investment cost	- 1 vibration fixture - “x” test setups to facilitate 36h testing	-“y” HASS fixtures - “y” test setups - minimal 1 unit for screen-validation
Recurring cost	Electricity	Electricity and LN_2