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Qualmark ASK THE EXPERTS

HALT and HASS in IPC-9592A

ARL
Austin Reliability Labs

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Presentation Summary

- IPC and 9592A
  - History, IPC Standards
  - HALT in 9592A
    - Changes from 9592
    - HALT Process
    - Functional Test Requirements
  - HASS and HASA
    - Profile Development
    - Implementation
    - Fixturing
  - Summary, Questions

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History, IPC and 9592

History, IPC and Standards

- 1957: Institute for Printed Circuits
- 1977: Institute for Interconnecting and Packaging Electronic Circuits
- 1999: IPC
- Mission:
  - Represent all facets of the industry, including design, printed circuit board manufacturing and electronics assembly
  - Member-driven organization and leading source for industry standards, training, market research and public policy advocacy

History, IPC Standards

- In 1995, IPC adopted “Principles of Standardization” as a guiding principle
- IPC Standards and Publications are designed to serve the public interest through **eliminating misunderstandings between manufacturers and purchasers**, facilitating interchangeability and improvement of products, and **assisting the purchaser in selecting** and obtaining with minimum delay the proper product for his particular need.
- Existence of such Standards and Publications **shall not in any respect preclude** any member or nonmember of IPC from **manufacturing or selling products not conforming** to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally

History, IPC and Standards

- Problem:
  - Users of Sub-Tier Critical Components can not assure consistency of:
    - Design
    - Quality / Reliability
- No Industry Standards
  - Design Specifications
  - Materials Specifications
  - Product Specifications
  - By Class of Use

Critical Components:

- **Air Movement Devices (IPC-9591)**
- **Power Conversion (IPC-9592A)**
- **Passive Components**
- **Li Batteries**

IPC 9592 (original) and 9592A (new release)

IPC 9592

- 2010: Subcommittee initiates Revision A of IPC-9592
  - Subcommittee determined that some sections of the current standard needed improvement or additions
    - Reduction of the use of AABUS (As Agreed Between User and Supplier)
    - More definitive preconditioning tests
    - Moisture sensitivity levels (MSLs)
    - Better defined corrosion practices and tests
    - HALT Procedure Guidance

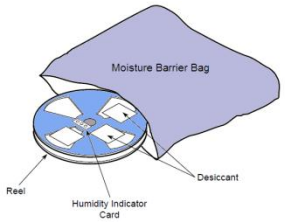
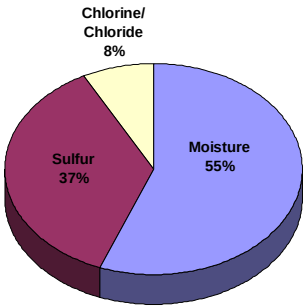


Image from: Intel 2000 Packaging Databook



Distribution of Corrosion Related Field Failures

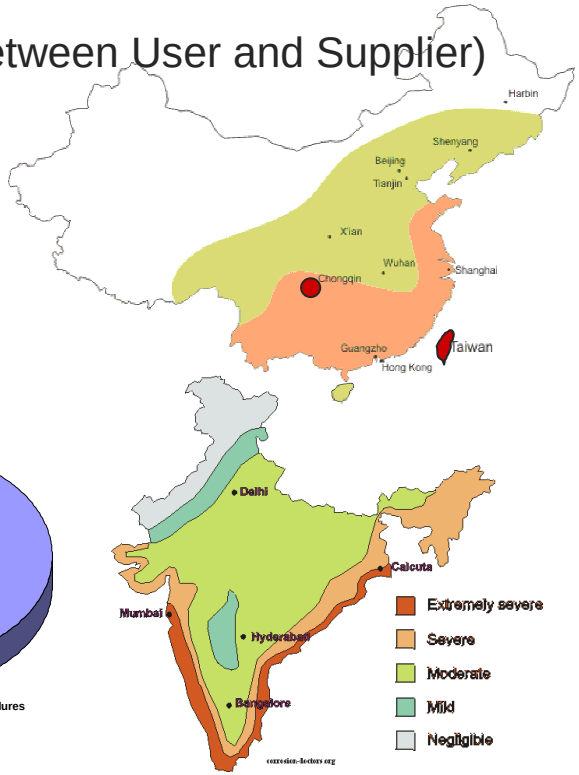


Image from APEC 2011 Presentation

IPC 9592

- Harmonized the supplier's requirements for design, qualification, and production test practices
  - Design for Reliability
    - Best practices to specify, design and document performance and reliability, (MTBF, Derating, Corrosion, FMEA, Voltage Spacing, MSL)
  - Design and Qualification Testing
    - 2 purposes: provide assurance product performs to specification & it will perform in the intended environment w/o failure, (DVT, EST: HALT, THB, HTOB, TC, PTC, S&V, Drop, Corrosion, Dust, Solderability, EMS: EFT, ESD, Immunity, Emissions, Acoustic Noise, Product Safety)
  - Quality Processes
    - Defines quality process supplier & sub-tier requirements, (QMS, Sub-Tier, Materials Traceability, Change Authorization & Qualification
  - Manufacturing Conformance Testing
    - Manufacturing requirements, (HASS, HASA, BI, ORT, Safety, OBA)

IPC 9592

- Power Conversion Devices (PCD):
  - AC to DC and DC to DC modules, converters and printed circuit board assemblies
  - Categories:
    1. Internal DC output power supplies (AC or DC input)
    2. Board mounted DC to DC converter
    3. External AC to DC power supplies (adapters & chargers)
  - Classifications
    1. General or Standard – controlled environment, 5 yr. life
    2. Enhanced or Dedicated Service – carrier grade/high performance, 15 yr. life

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HALT in 9592A

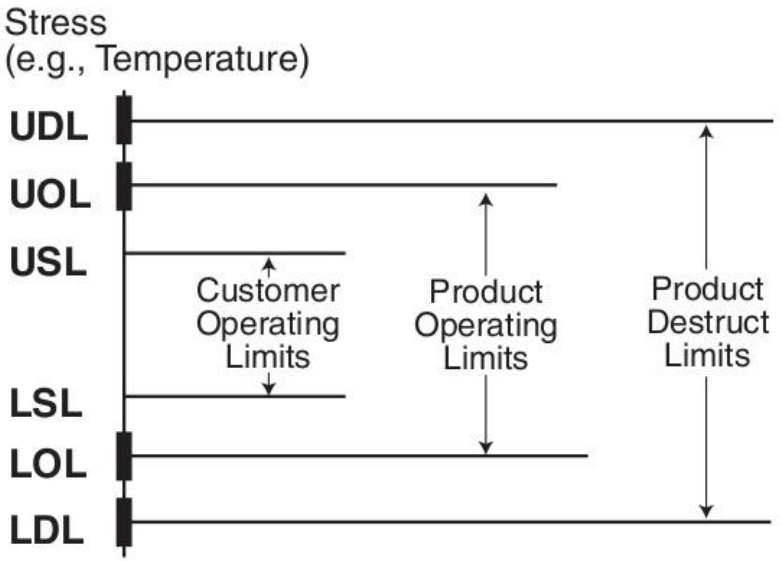
HALT in 9592A

- HALT was included in the original standard (Section 5.4 Stress Testing)
- Rev A provides much greater detail on the purpose and the process
- Changes came from a desire to clarify and specify a process that was not well defined in the industry
- Included requirement for HALT, recommendation for HASS
- Defined the HALT and HASS processes

HALT in 9592A: Section 5.2.3 Definition

- "…HALT is a series of tests performed on a product as part of the design process to aid in improving product robustness. The principal idea of HALT is to find design weaknesses as quickly as possible and then fix them. After improving one weakness, the next design weakness is found and improved and so on until no design weaknesses remain that could result in field failures. During HALT, a product is stressed beyond the product specifications… to quickly accelerate and identify design weaknesses. … HALT is not a pass/fail test."

HALT in 9592A

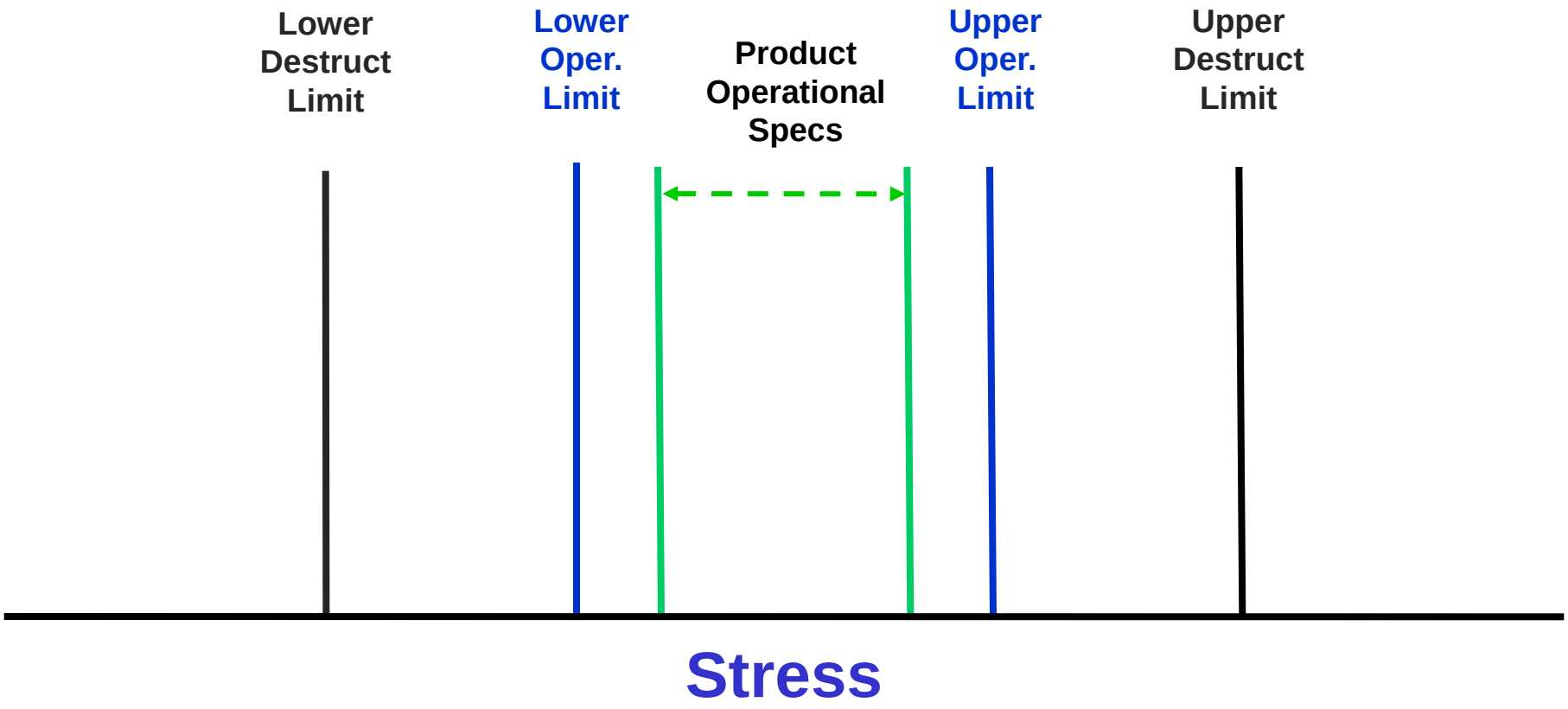


- USL/LSL — Upper/Lower Specification Limits. Limits to which you guarantee operation of your product.
- UOL/LOL — Upper/Lower Operating Limits. Limits to which product ceases to function, however can be returned to USL/LSL and begin working again.
- UDL/LDL — Upper/Lower Destruct Limits. Limits at which product fails catastrophically.

IPC-9592-d-1

IPC-9592A, Figure D-1

HALT in 9592A - Margin Improvement



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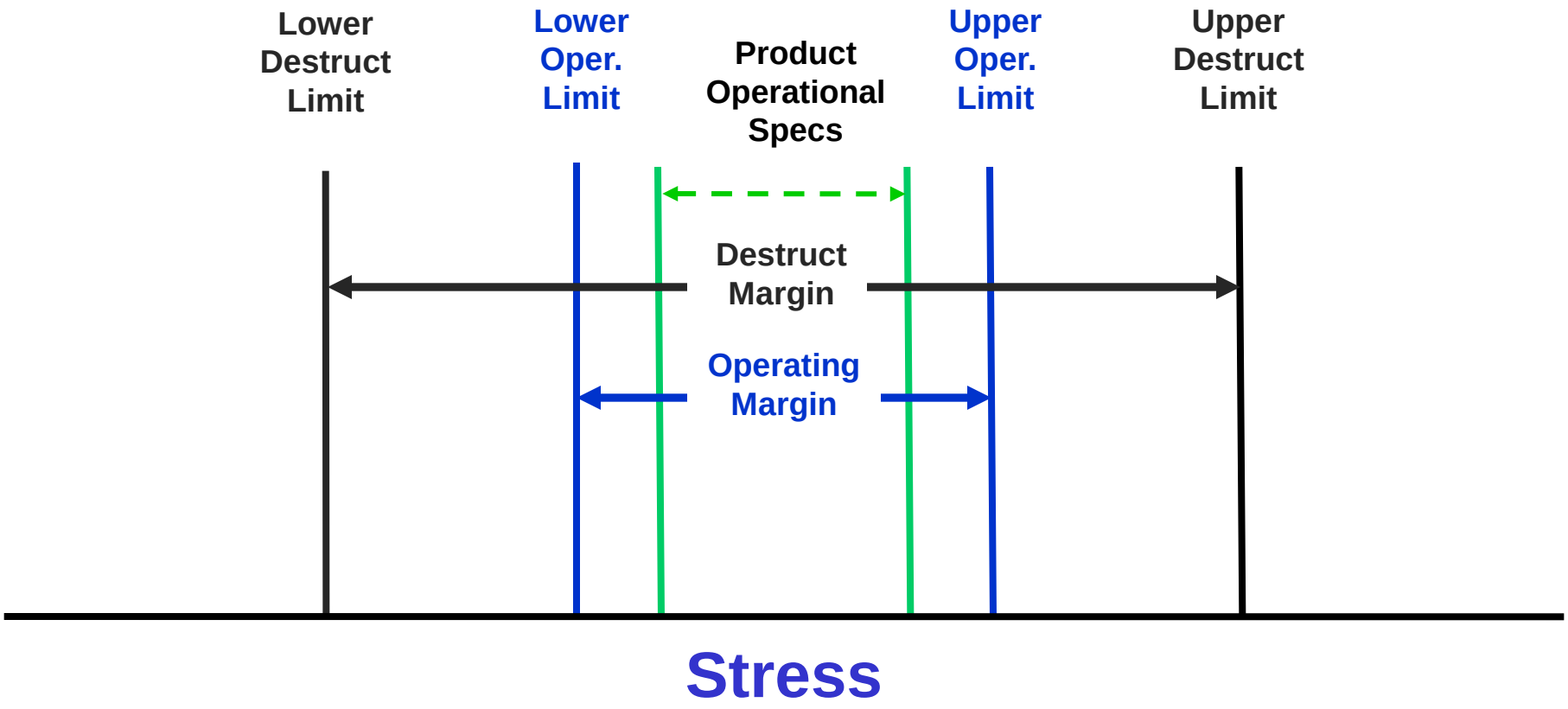
HALT in 9592A - Margin Improvement



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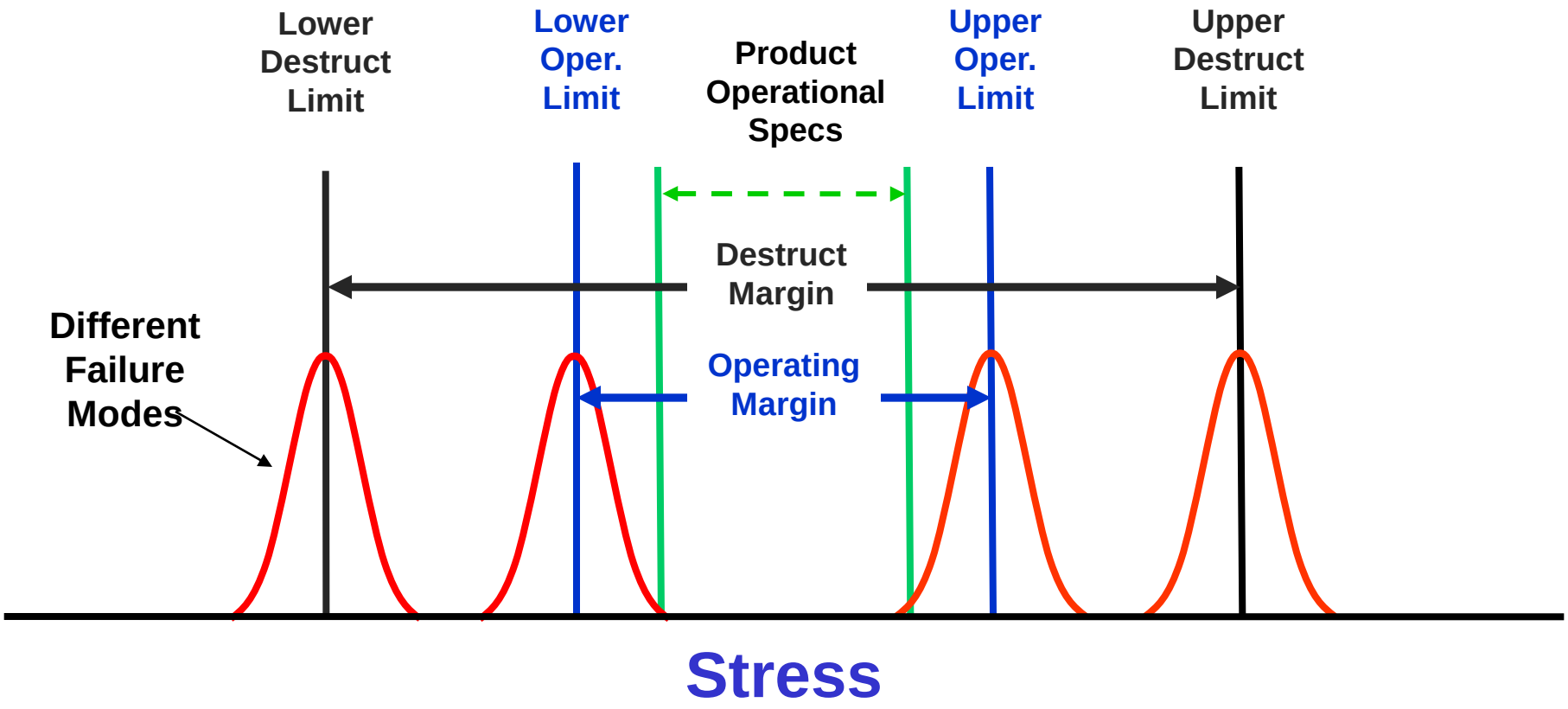
HALT in 9592A - Margin Improvement



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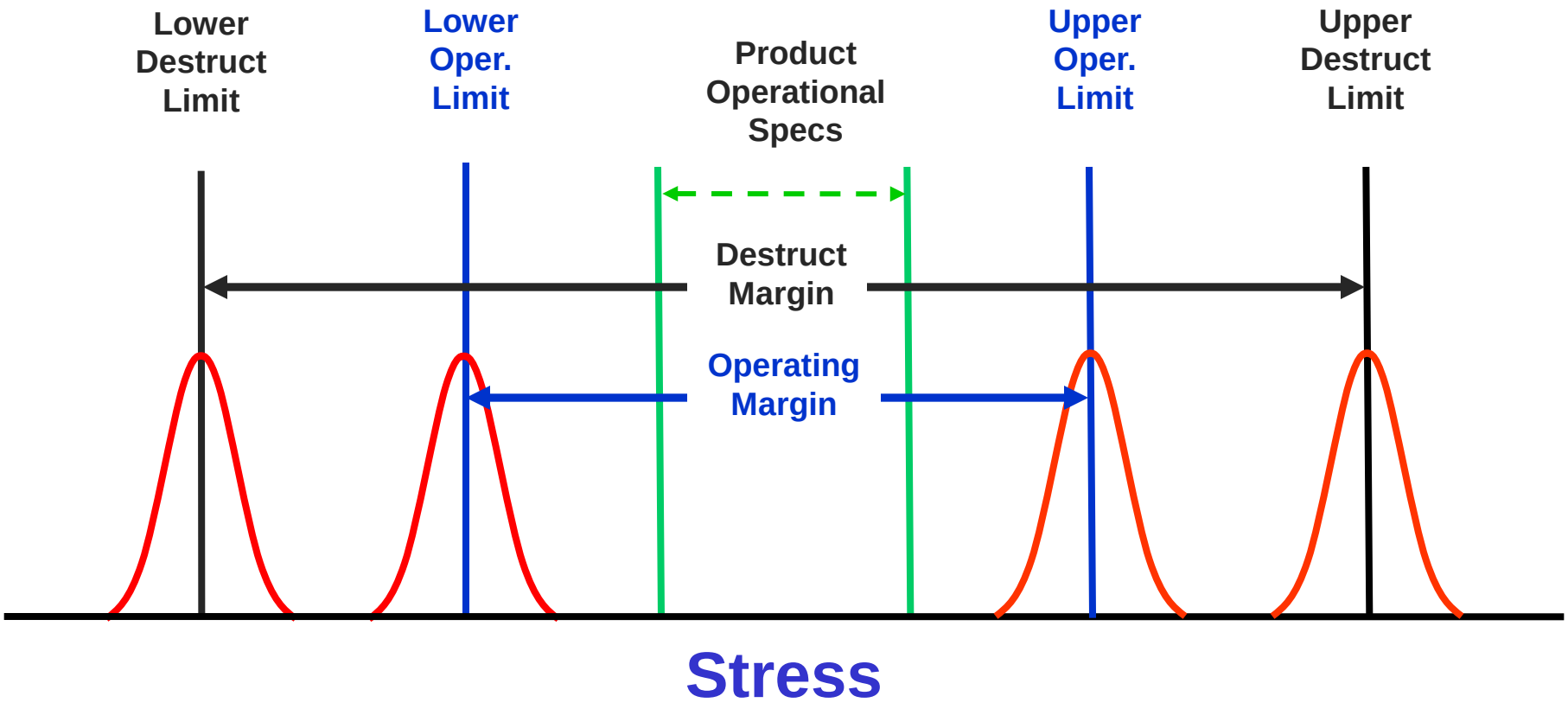
HALT in 9592A - Margin Improvement



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Equipment Needed for HALT

- Equipment defined is typical for HALT use:
  - 5.2.3.2.1 Defines chamber requirements
  - Combined thermal and vibe environment
    - RS, 6dof vibration, 50 Grms minimum
    - Wide thermal range, -80°C to +170°C
    - Rapid (45°C/minute minimum) ramps, LN2 cooling
- Extreme stresses are necessary to achieve desired results

Equipment Needed For HALT Lab

- 9592A goes on to define ancillary lab equipment for HALT
  - DUT Performance
    - Programmable voltage source
    - Programmable electronic load
  - Stress monitoring
    - Temperature: thermocouples, data-logger
    - Vibration: accelerometers, SA
  - Extensive data recording and reporting capabilities are specified

HALT Functional Testing Requirements

- 9592A also defines basic requirements for functional testing and sample size
  - Functional test: input voltage and output load variations
  - Sample size:

Table 5-1 Minimum Sample Size for HALT Tests

	Low Temperature Step Test	High Temperature Step Test	Rapid Thermal Cycling Test	6-DOF Random Vibration Test	Input Voltage Test	Output Load Test	Combined Stresses Test
All Classes and Categories[1]	3	3	3	3	3	3	3

Note 1: For Categories 1 and 3 (Power Supplies /Adapters), users have the option of starting with less than 21 samples and re-using samples which survive a given sequence of testing. Users are cautioned that some HALT failures require extensive repairs after failures during early testing and may not be suited for subsequent testing. Category 2 (BMPM) must begin with 3 new units for each test sequence, except for units which have not failed a HALT test when the equipment capability limits have been reached. These units may be used in the next test rather than replacing them with new units.

IPC-9592A, Table 5..1

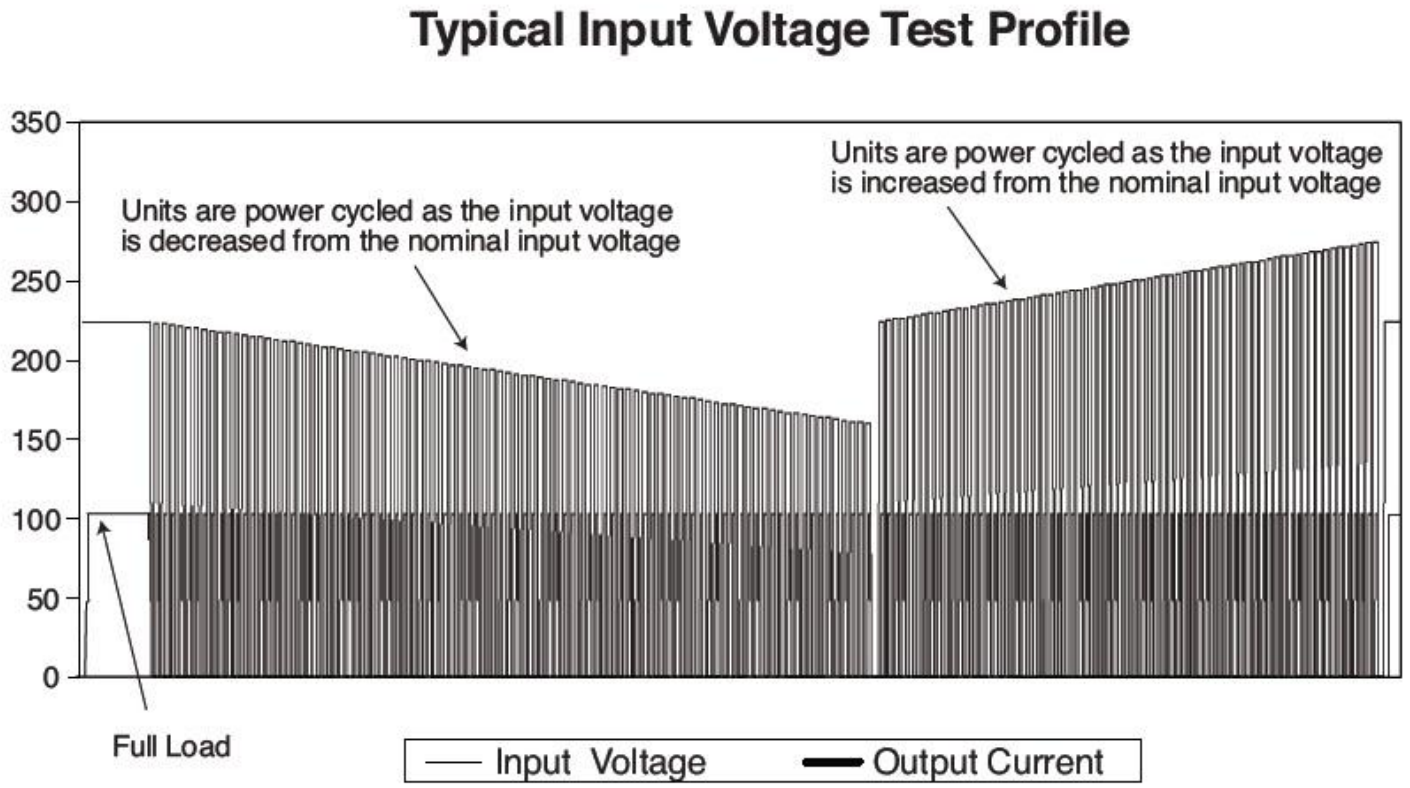
HALT Process

- HALT environmental stresses
  1. Cold Step
  2. Hot Step
  3. Vibration Step
  4. Rapid Thermal
     - 30 Cycles minimum
     - Dwell: 30 minutes for Pb Free, 5 minutes for Leaded
  5. Input Voltage Step
     - Power cycling w/ stepped low and high input voltage, UOTL & LOTL
  6. Output Load Step
     - Load current, 22 minute dwells, UOTL
  7. Combined

HALT Process

- 9592A also defines product specific stresses
  - D1.1.5 and D1.1.6 define product specific stresses to be used in HALT
  - Applies concept of HALT to input and output stresses on PCU
  - Upper and lower input voltage, upper output current limits are determined
    - As in HALT, specifications are not considered in stress levels
  - Step stressing is applied to these stresses as well

HALT Process: Product Specific Stresses

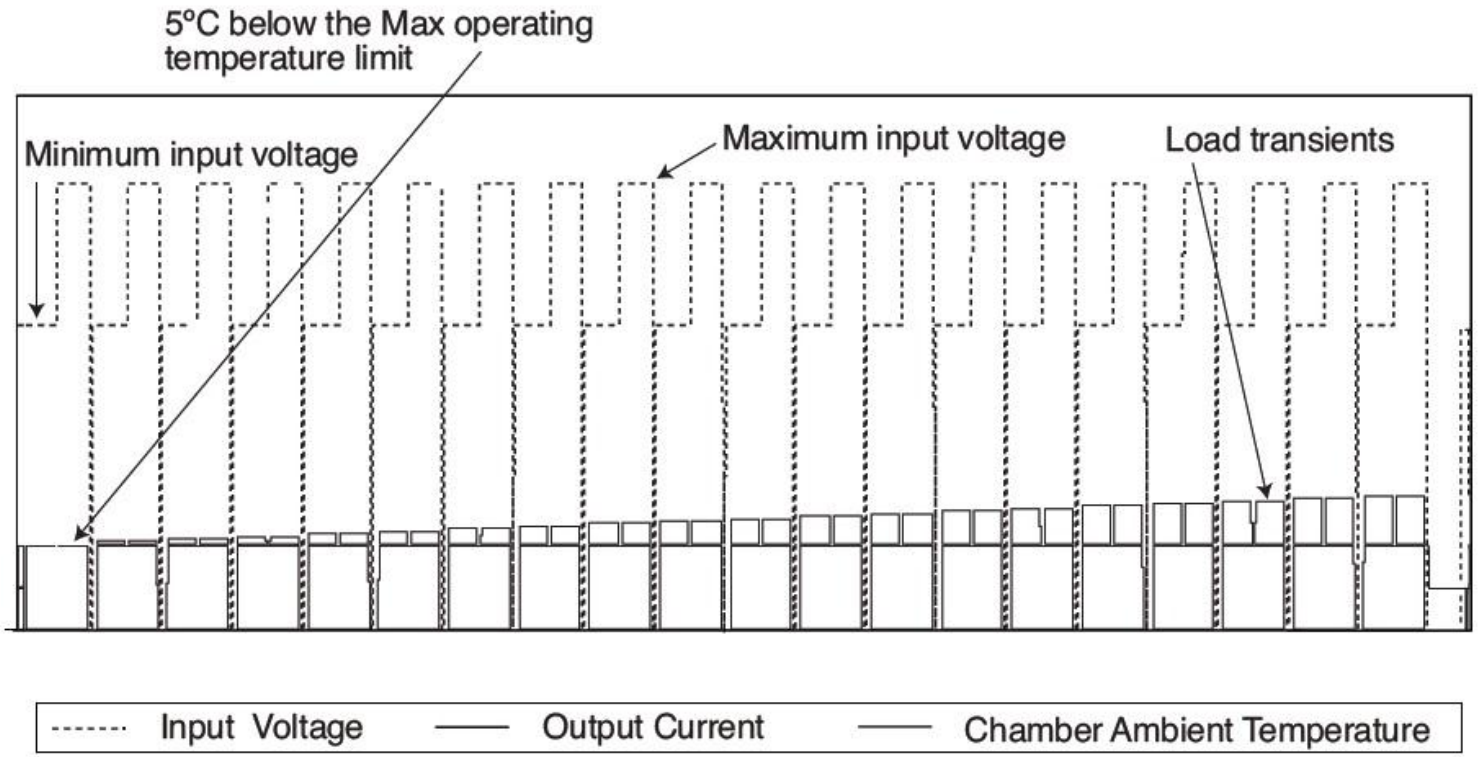


IPC-9592A, Figure D-7

IPC-9592a-d-7

HALT Process: Product Specific Stresses

Typical Output Load Test Profile



IPC-9592A, Figure D-9

IPC-9592a-d-9

HALT Reporting

- 9592A defines minimum reporting and documentation requirements
  - Because HALT is not pass/fail and has many components that are unspecified and variable, complete and detailed reports are critical
    - Can provide end user with evidence and details of HALT execution by supplier
    - Also provides information for repeating test if necessary
    - Documentation of failure modes

HALT Reporting

- Documentation on units tested and test equipment also defined
- HALT is done early, while board and system revisions are still changing
  - Status of tested units can make a significant difference in test results

Root Cause Analysis & Corrective Action

- 5.2.3.8: “All failures found during HALT tests shall be analyzed to their root causes.”
  - Critical to HALT success
  - Corrective actions must be thoroughly documented
  - Any decision not to implement corrective action on a failure must also be described clearly in documentation

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HASS and HASA in 9592A

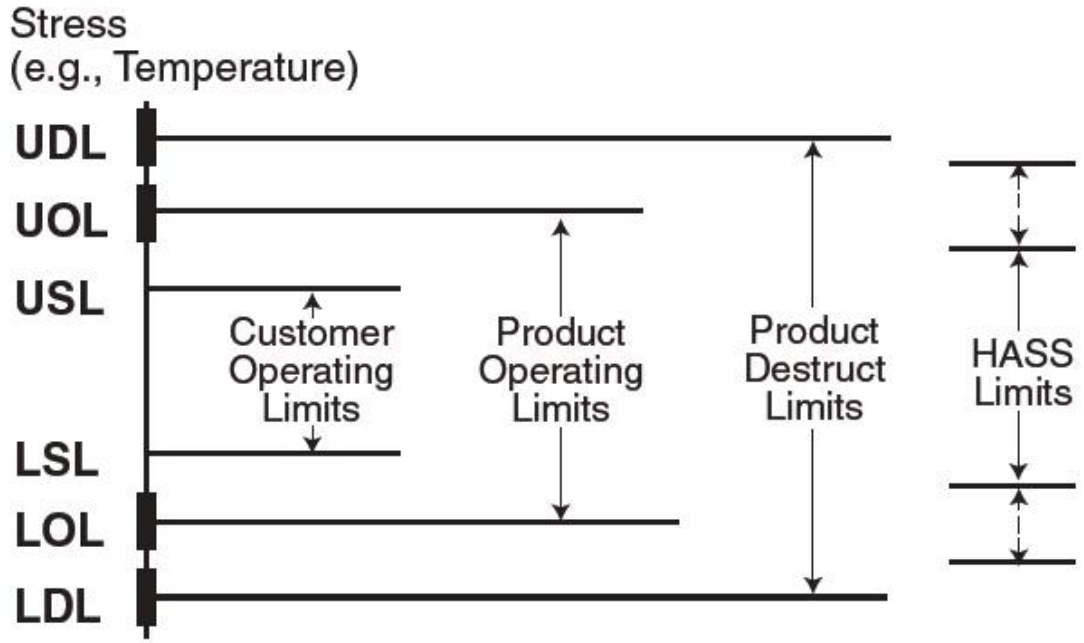
HASS and HASA in 9592A

- First version of 9592 described HASS and HASA
  - HASS – Highly Accelerated Stress Screen
  - HASA – Highly Accelerated Stress Audit
  - Desired by OEMs
  - Stated as an alternative to Burn-In
- 9592A expanded descriptions and recommendations for usage
  - Product Supplier can choose between HASS or Burn-in
  - HASS strongly recommended as more effective than Burn-In
- Defined in 7.3.2, detailed description in Appendix D

HASS Notes

- HASS is customized for each product line
  - Unique fixtures
  - Unique stress levels
  - Unique screen durations
- Customization makes it impossible to define limits

HASS Limits Compared To HALT Limits



- USL/LSL — Upper/Lower Specification Limits. Limits to which you guarantee operation of your product.
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- UDL/LDL — Upper/Lower Destruct Limits. Limits at which product fails catastrophically.

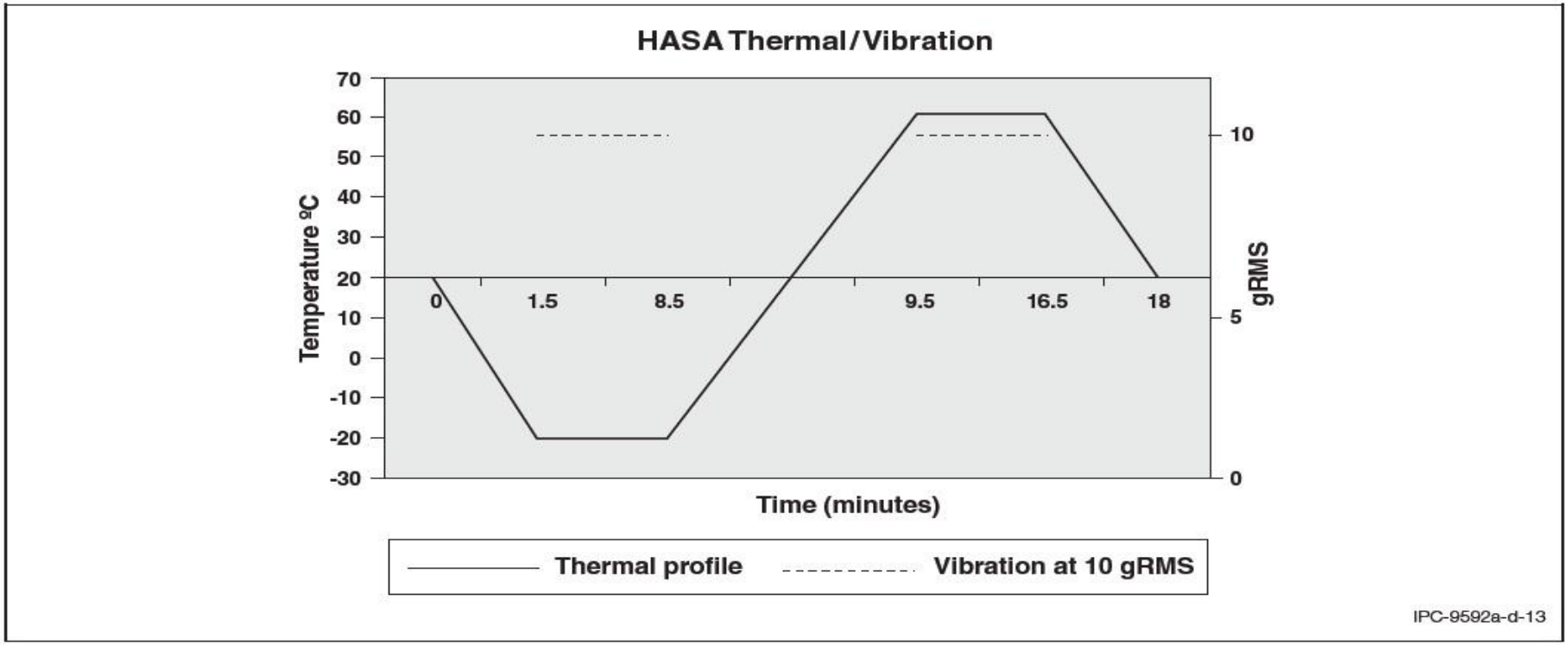
IPC-9592-d-1

IPC-9592A, Figure D-1

HASS Development

- Unchanged from original 9592
- Based on HALT limits
- Requires proof of screen before implementation
  - Demonstrate both safety and efficacy of screen

Typical HASS screen



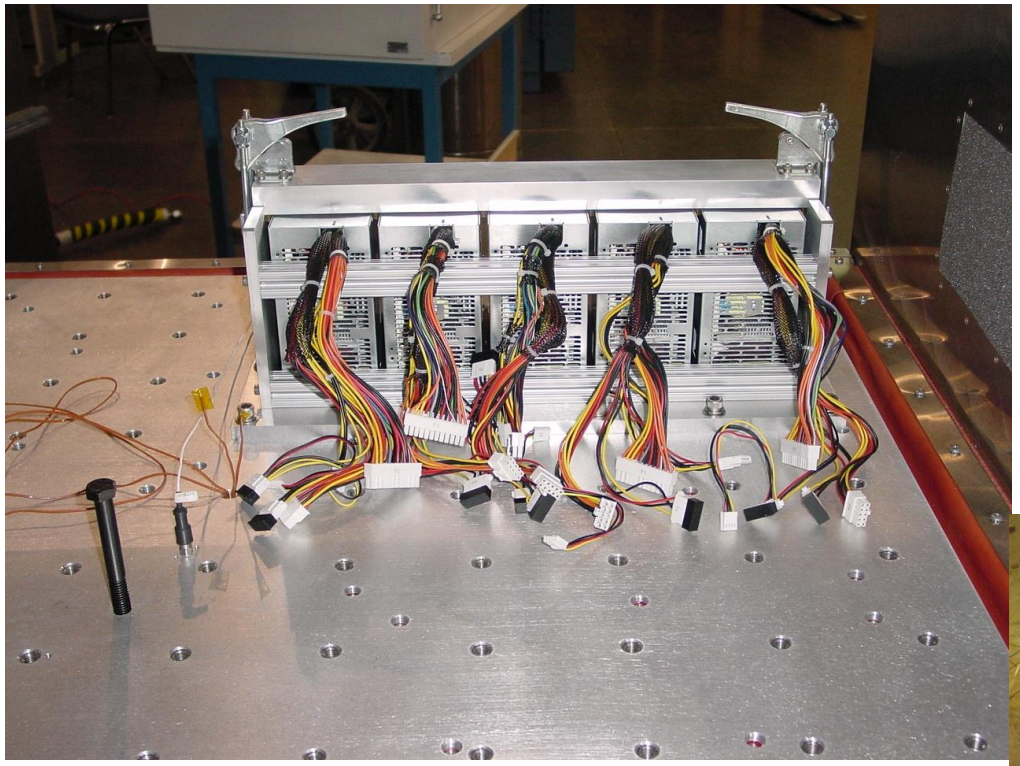
HASS Equipment

- As in HALT, 9592A defines test chamber requirements for HASS
  - Similar to HALT chamber requirements
  - Reduced stresses of HASS reduce requirements on chamber
    - RS random vibe, 6 DoF
    - 30°C/min minimum change rates defined
- Functional test support equipment
  - Programmable voltage source
  - Programmable electronic load

HASS Fixture Design and Validation

- Critical that HASS fixture is designed correctly
  - Uniform vibration and thermal stresses
    - +/- 20% across fixture is typical tolerance
  - Consistent stresses from test to test
  - Low cycle time
  - Human factors
- Fixture Validation confirms desired uniformity

HASS Fixture Examples



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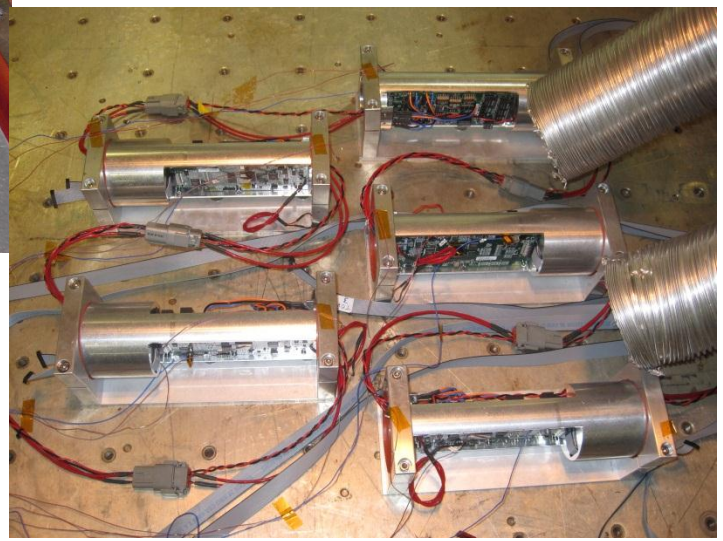

HASS Requirements

- 100% screen on initial production
- Strong emphasis on failure analysis, especially during HASA
  - E.2.2.3: “Failures that occur in a sample population require immediate Root Cause FA/CA …”
- Cycle reduction
  - Begin with 5 minimum
  - Reduce to 2
  - Reduce to 1
  - Transition to HASA

HASA (Highly Accelerated Stress Audit)

- 100% screen on initial production
- As before, 9592A clearly defines when it safe to go to an audit, based on failure rates and production maturity (Table E-1)
- A sampling of production units sent through HASS screen
- Initial 5% of production
- Can be eliminated

Summary: HALT and HASS in 9592A

- 9592A includes requirements for HALT by product suppliers
- HASS offered as a recommended alternative to Burn-In
- Processes for these tests are included in the standard
- In all cases, Root Cause Failure Analysis and Corrective Action are critical
- Process definition improvements helps suppliers to correctly perform procedures and achieve the maximum gains in reliability

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