HALT / HASS Testing

Vinodh M V

22nd August 2019

Simulation or Stimulation?

Environmental Conditions

Environmental Simulation

Transportation

Storage

Use

- Natural
- Induced
- Tailored

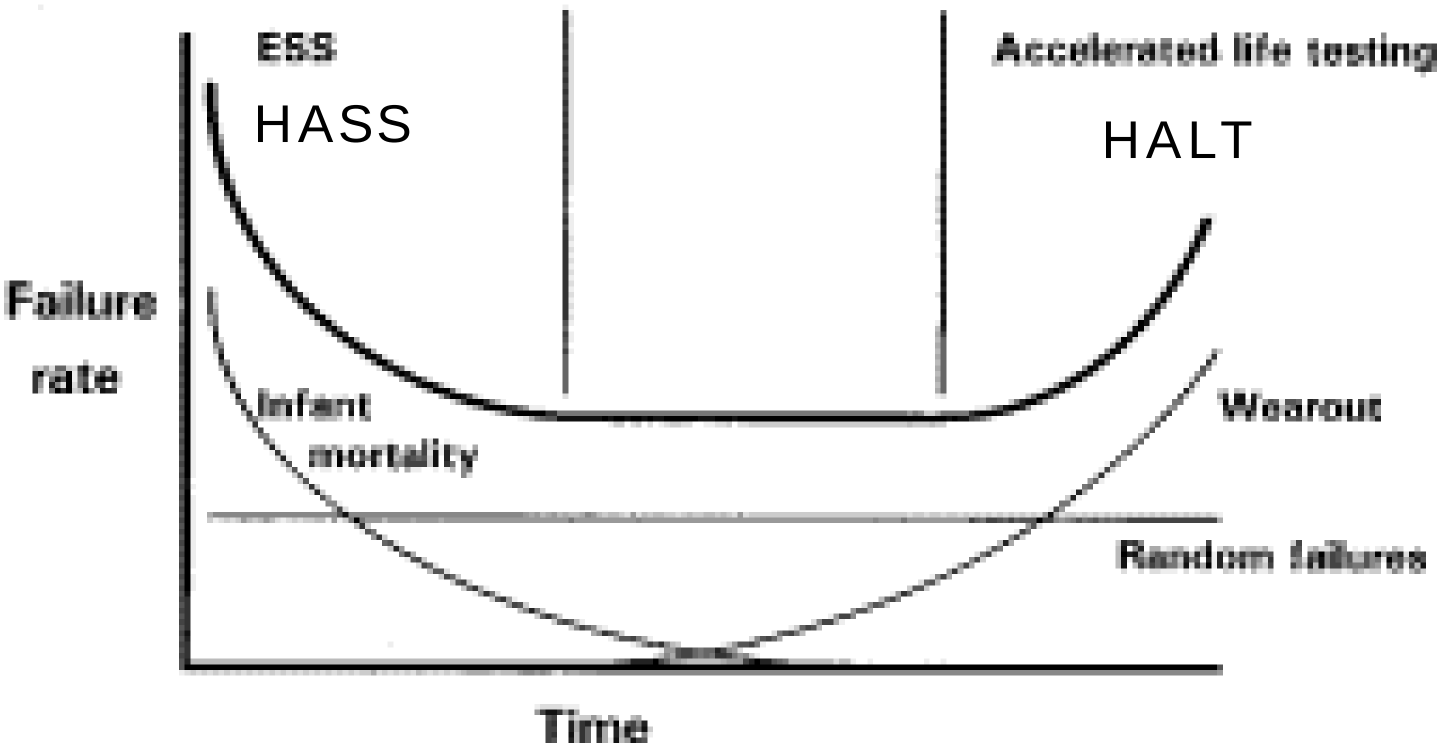
Product *S*timulation

Burn In

ESS

- HALT (Development}
- HASS (Production}

BATH TUB Curve



Product Failures

$$F_T = F_{DEV} + F_{MFG} + F_{INH}$$

F_T = Total product failures

F_{DEV} = Poor design, part selection, lack of ET/HALT

F_{MFG} = Part, workmanship, process, lack of HASS

F_{INH} = Inherent random failures not minimized by robust design.

Failure Types

- **Hard Failure**
  - Once the failure occurs, the failure is exhibited continuously, no matter what the environment.
  - A failure that does not change in any way when the system is reset or power cycled.
    - Example: A damaged part that stops DUT functionality
- **Soft Failure**
  - A failure that "heals" when the environment changes.
    - Example: Temperature sensitive components that work properly when cooled.
    - Example: Processor reset or power cycling "fixes" the failure.

HALT

Highly Accelerated Life Testing

HALT is a technique that utilizes a step stress approach in subjecting products to varied high levels of accelerated stresses with the intention of precipitating failures at weak points. This can include additional stresses on the equipment like power cycling and Voltage/Frequency Marging. HALT enables doing root cause analysis of failures facilitating implementation of necessary design improvements to make the equipment most robust and improve reliability.

HALT

- **Accelerated Life Test**
- **A development test.**
- **Environmentally Stimulates Products**
- **Quickly discover design flaws**
- **Evaluate & Improve design margins**
- **Increase Product Quality/Reliability**
- **Eliminate design problems before release**
- **Reduce development time & cost**
- **Lower Warranty Costs**

HASS

Highly Accelerated Stress Screening

HASS is a high level ESS (Environmental Stress Screening) used to precipitate and find manufacturing process problems, latent defects, margins and infant mortality fall out. Whereas ESS typically stresses the product with in design specifications, HASS exceeds its specifications by some amount as determined by the HALT testing.

HASS

Highly Accelerated Stress Screening

- Accelerated Stress Screening
- A Production Screen
- Not a Pass - Fail Test
- Stress Product Well Outside Operating Spec
- Precipitate Early Life Failures
- Part, Workmanship, Process Problems
- 100% or Sampling

HALT/HASS CONCEPTS

While Designing the tests it should be kept in mind that primary goal of HALT is to push the stresses higher and higher to precipitate as many failure as possible.

HALT/HASS CONCEPTS

Designers have to frame the test specifications to meet their reliability objectives. Steps that can be followed in evolving test specifications are as follows.

a. Identify critical components / modules in the equipment.
b. List specifications with respect to temperature and vibration.
c. Use the following chart for identifying the test limits.
d. Precipitation limits in the chart are the charts used for HALT testing.

Limits of the Product

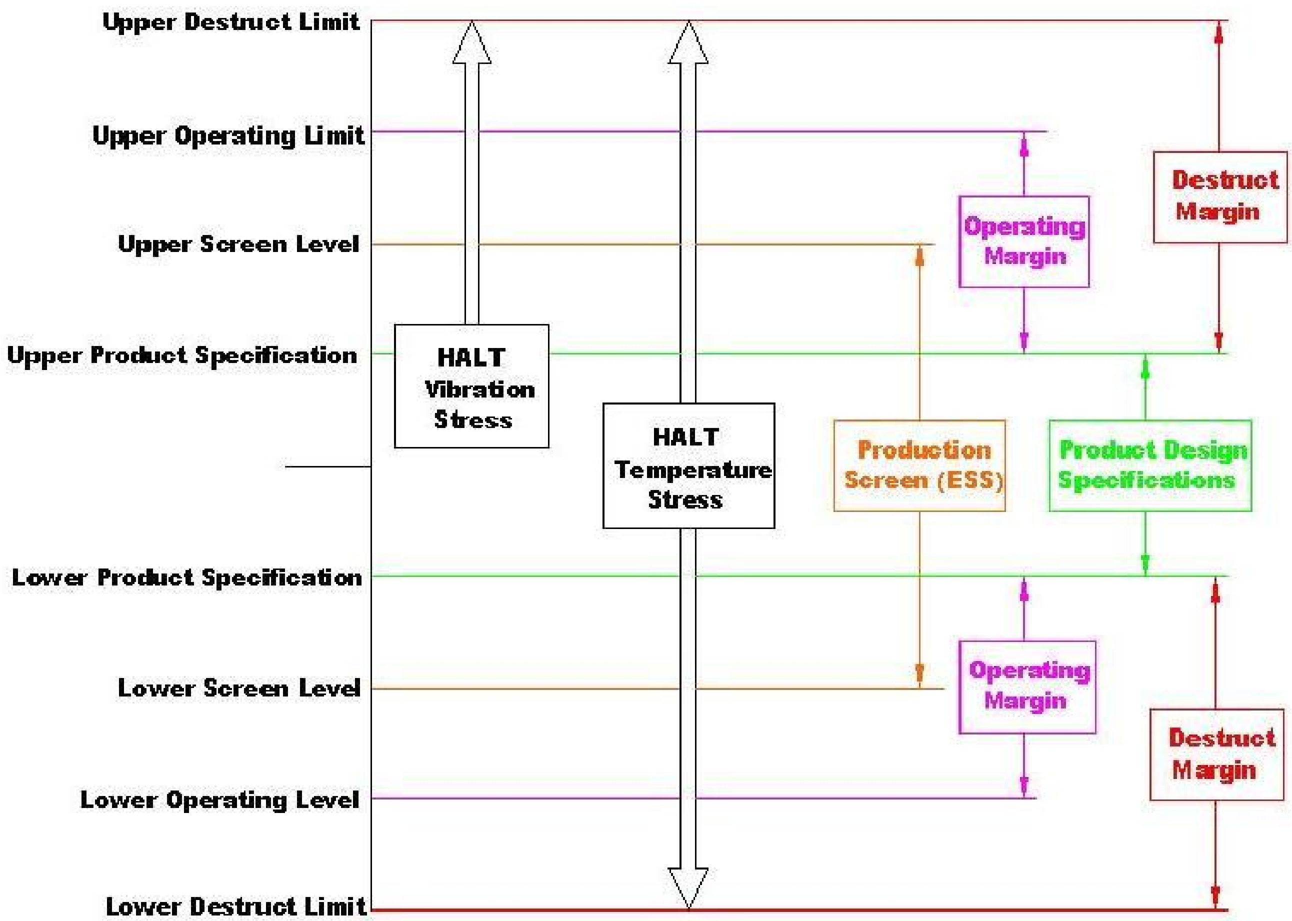


FIG - 1 Upper & Lower Operating & Destruct Limits

HALT/HASS CONCEPTS

HALT is especially suited for indigenously designed and developed subsystems where freedom is there for making design improvements.

Though it is essential for high volume products to go through HALT, it can be beneficially applied for small volume products as well.

There are no specific standards available for arriving at the test profiles.

HALT/HASS CONCEPTS

Design of Functional test is an important component of HALT.

Failure mode that goes undetected due to insufficient Functional testing defeats the purpose of the test.

Transient failures that occur only under stress., but are not detectable at ambient conditions will be identified during functional test.

HALT/HASS CONCEPTS

Before beginning the HALT test process, equipment should be subjected to one or more cycles of functional testing to verify the integrity of test setup and obtain base line performance information of the equipment.

Test Documentation should be adequate to help failure analysis and to reproduce the test if required.

HALT/HASS CONCEPTS

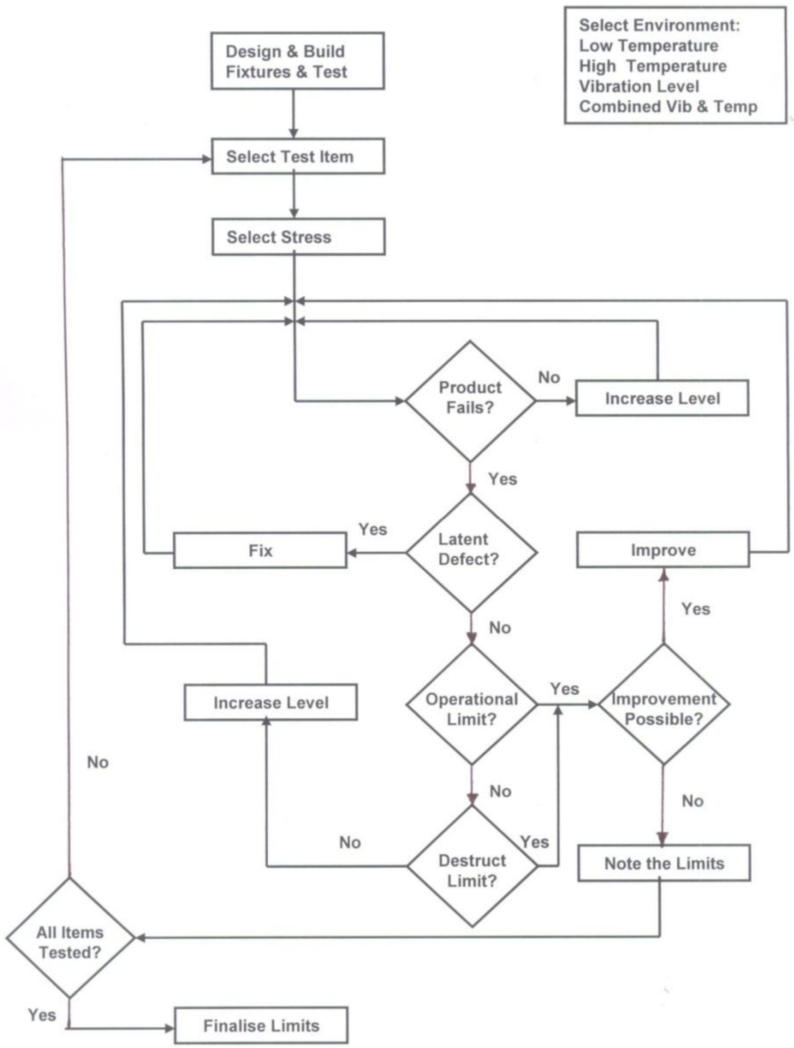
Direct Combined stressing is not recommended because of three reasons. They are

a. Difficulty in exactly assigning the causes for failure in combined stressing.

b. Decrease in accumulated vibration stress.

c. Limits of combined environmental are not known without doing thermal and vibration step stress.

HALT Process Flow Chart



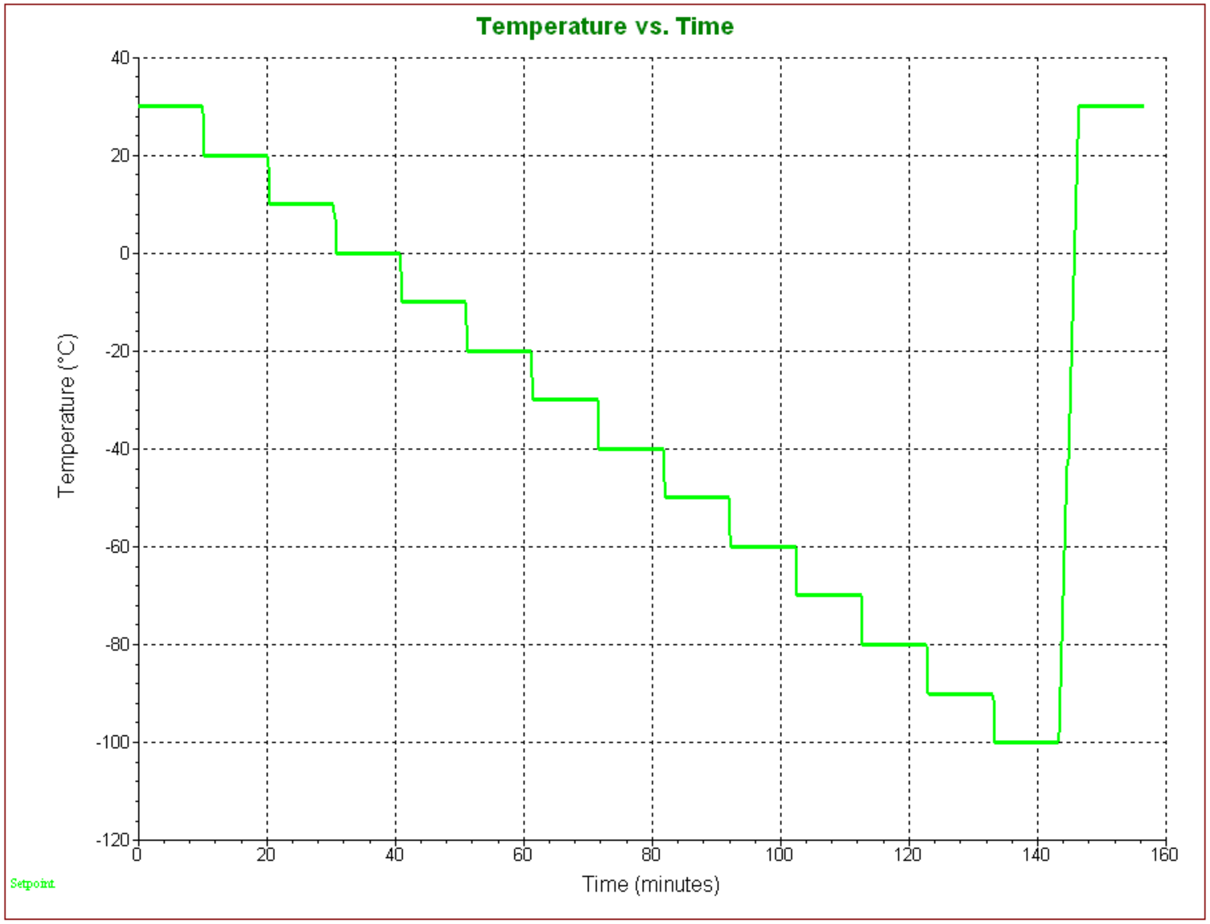
Check list prior to the start of the HALT / HASS test

Sl. No.	Parameter	Observation / Remarks
1	Initial measurements	
2	Ramp rate for temperature	
3	Ramp rate for Vibration	
4	Applicable test conditions & Test Sequence	
5	Unit Under Test Mounting	
6	The control points monitoring points to be used	
7	Details of operation and performance check	
8	Final measurements	
9	Any deviation from the Normal Test Procedure	
10	Number of cycles (For Simultaneous Temperature and Vibration stress test)	

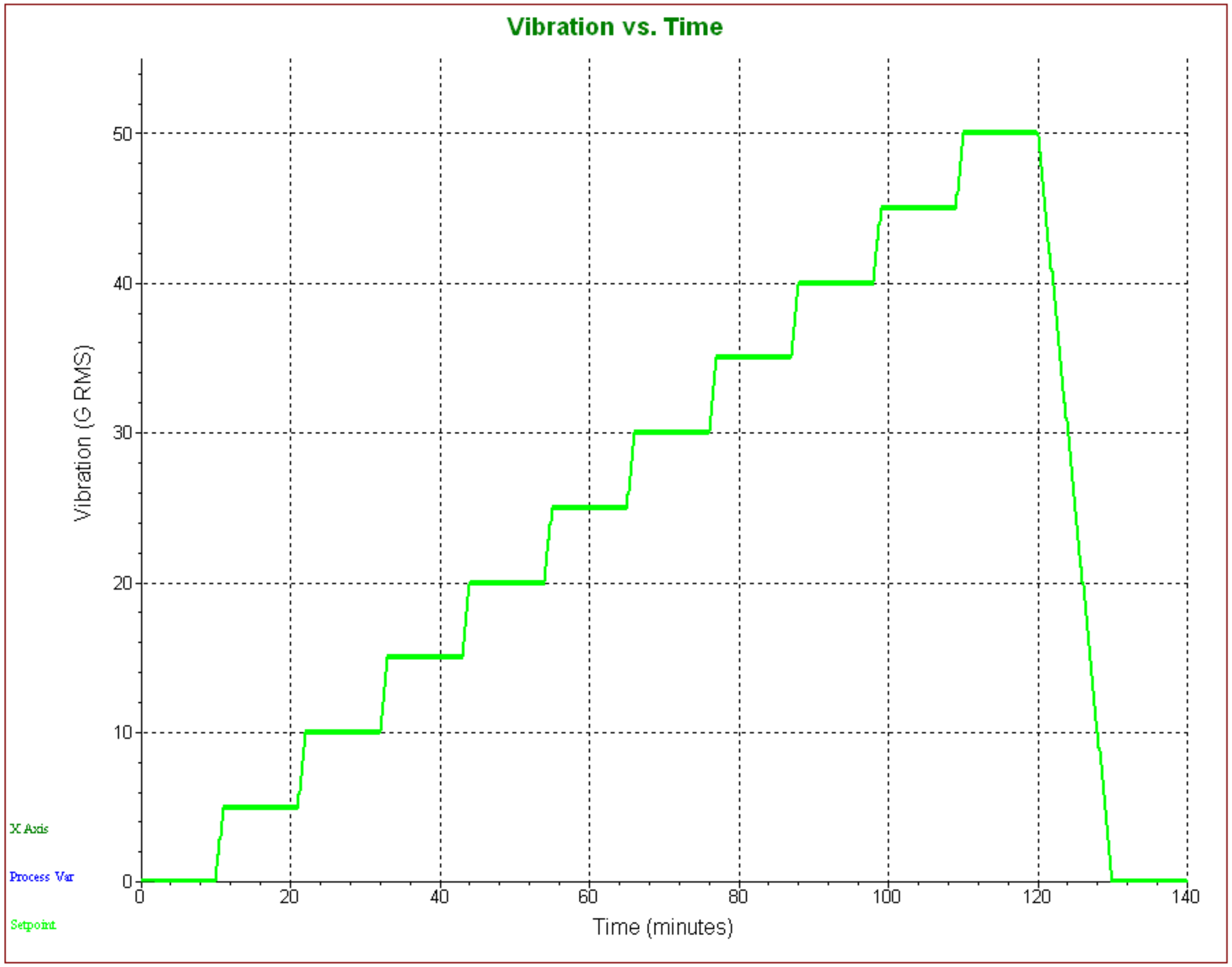
HALT Test Procedure

1. Cold Temperature Step Stress
2. High Temperature Step Stress
3. Vibration Step Stress
4. Rapid Thermal Transition
5. Simultaneous Temperature & Vibration Stress

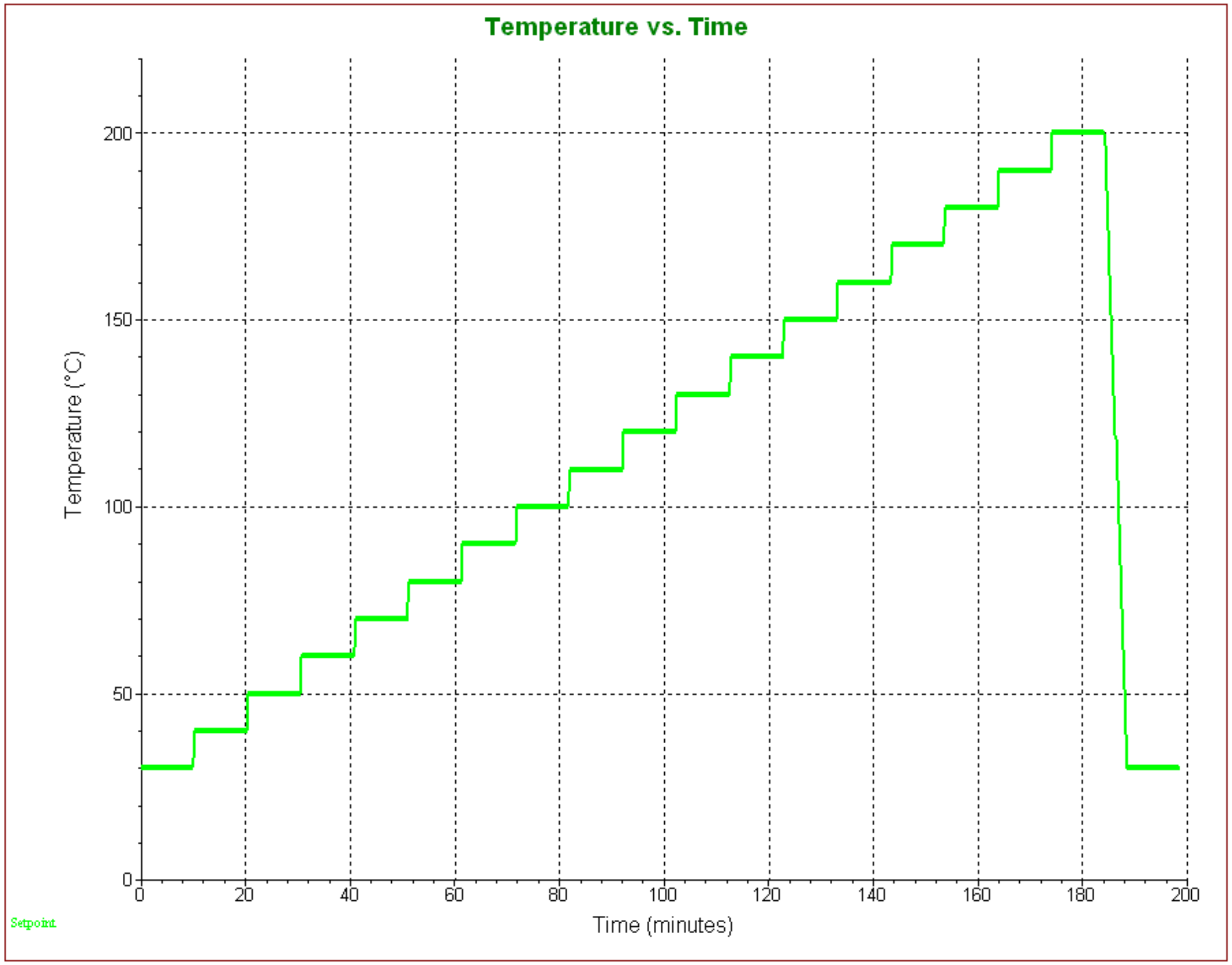
Cold Temperature Step Stress



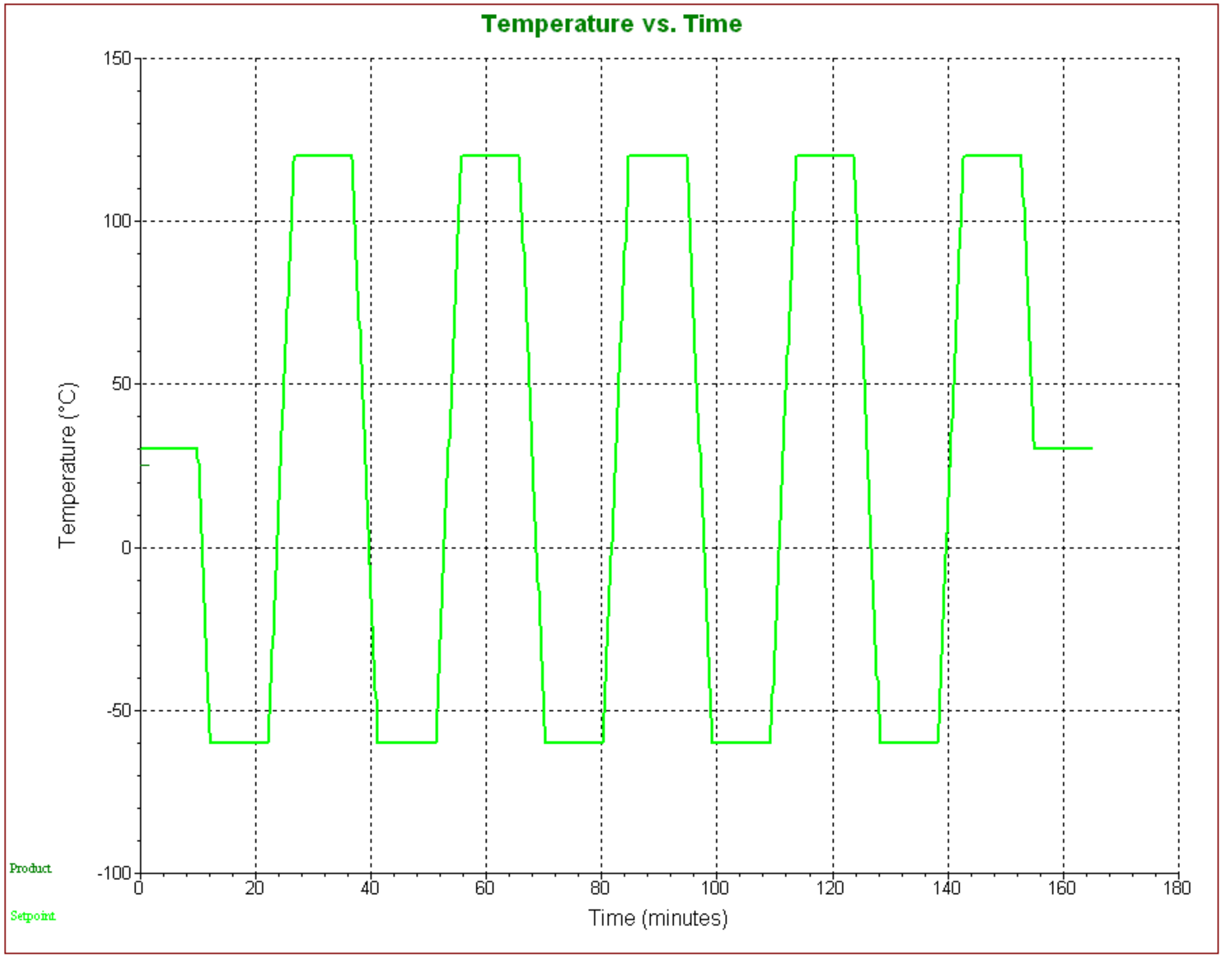
Vibration Step Stress



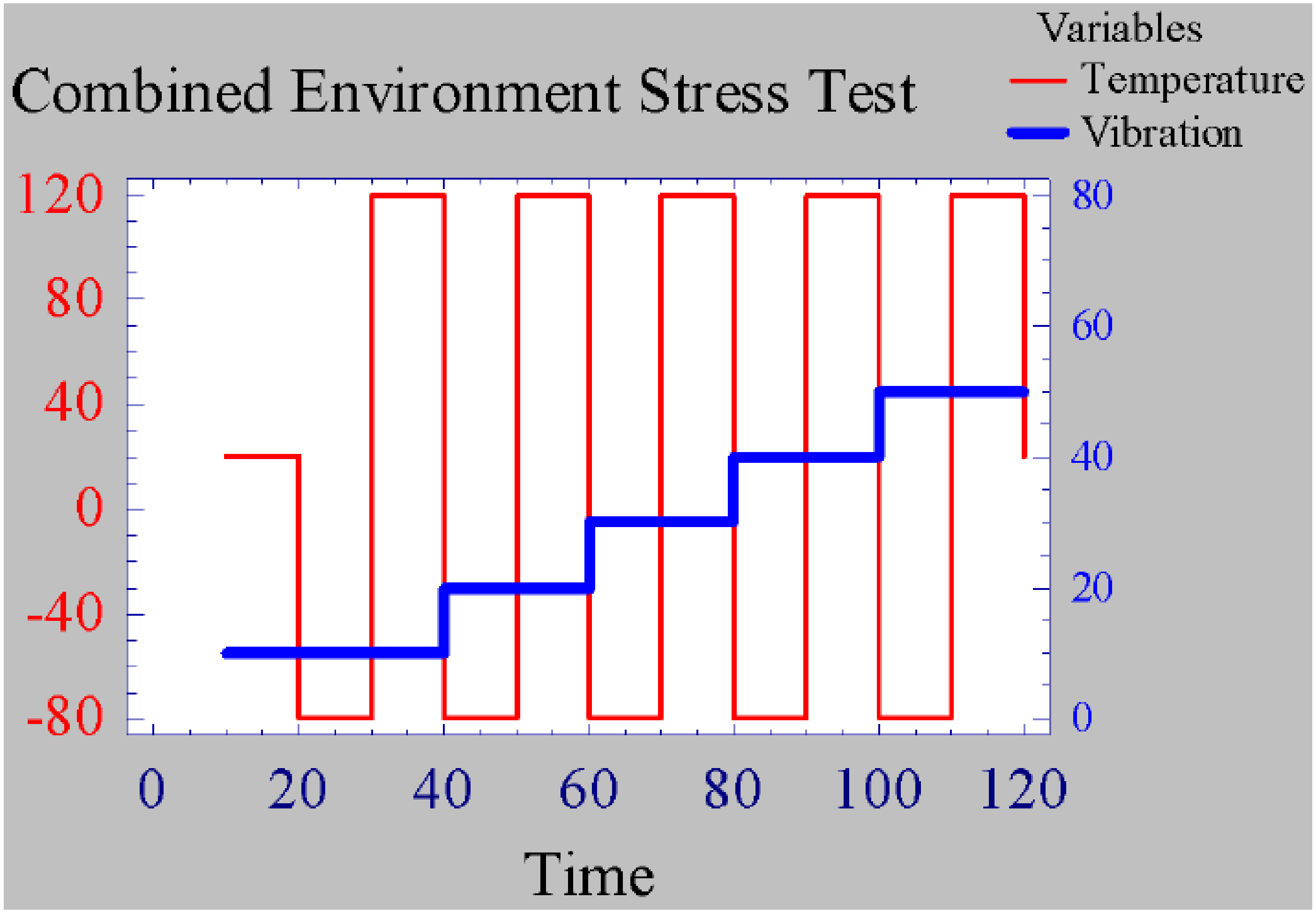
High Temperature Step Stress



Rapid Thermal Transition



Combined Temperature & Vibration



Handling Failures In HALT

When a failure mode is detected, all available details about the failure and the associated stresses to be recorded in the test report.

a. Root cause analysis

b. Corrective action

c. Verification HALT testing

Replacing of components, implementing thermal or vibration isolation measures may also done to continue the test past the first failure

HALT vs. Traditional Testing

HALT	Traditional Testing
- "Stress, Repair, & Test"	- "Test, Analyze, & Fix"
- Gathers info. on Product Limitations	- Simulates a "Lifetime" of use
- Focus on Design Weakness	- 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
- Test Time in Days	- Test Time in Months
- Results used for ESS (HASS)	- Results typically not used in ESS

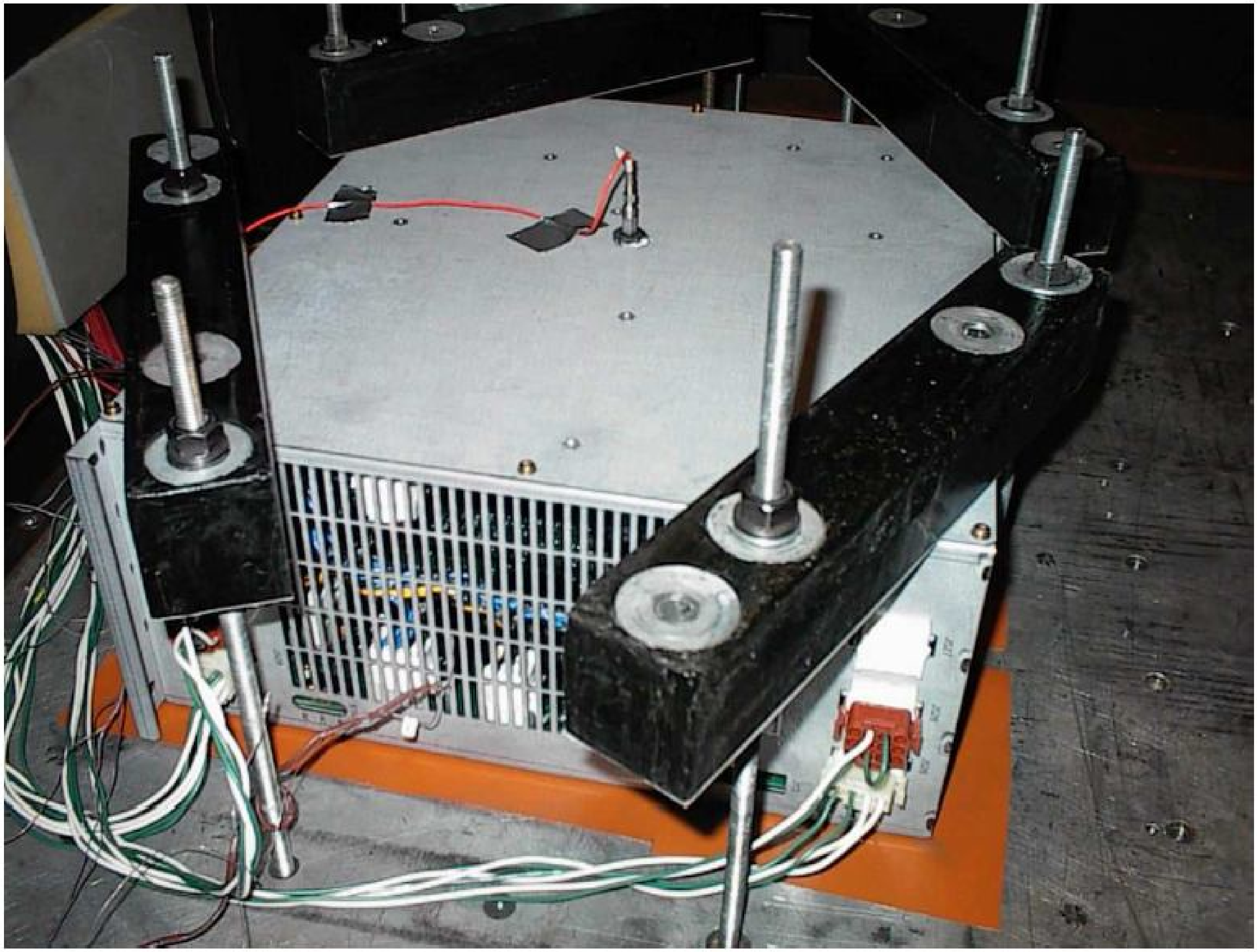
HALT is…	**HALT isn't …**
An excellent tool for learning about what types of failures you can expect to see during the lifetime of a product	The only tool in the toolbox
A way of finding the absolute limits of a product	A pass/fail test – you are expecting it to fail. That is the reason for the test.
Similar to classical ESS tests, taking it through to the failure stage (suggested as the first test with ESS, though many chose to skip that)	As slow as ESS, and is purposely testing the product hard
A way of saving money through warranty costs by catching possible failures ahead of time	A guarantee of any given dollar amount saved – it depends upon the product
A process that allows you to understand your product more fully	Magic that fixes everything

Comparison of Vibration (Electrodynamic Shakers vs HALT Chamber)

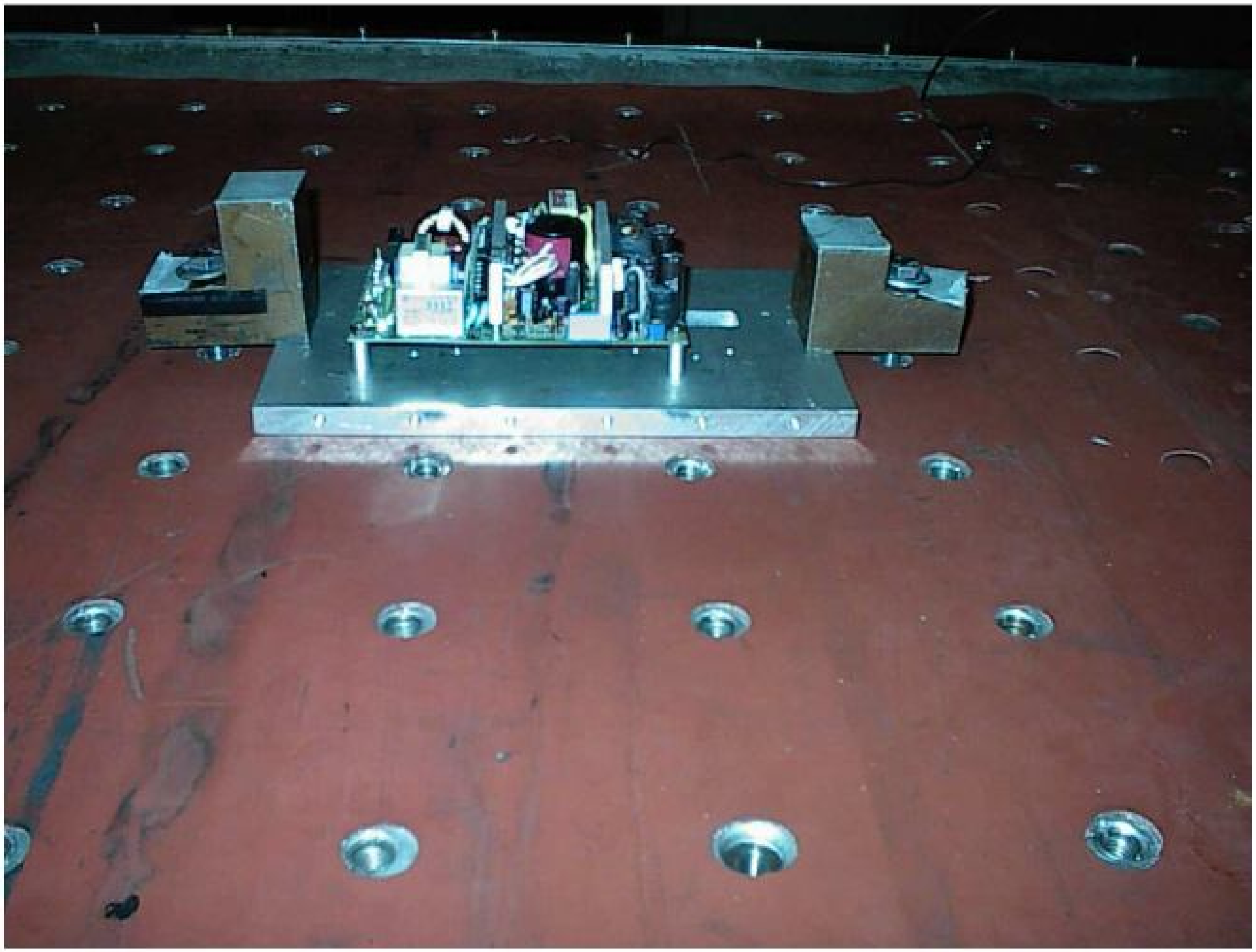
ELECTRO-DYNAMIC & PNEUMATIC VIBRATION SHAKER COMPARISON

CHARACTERISTICS	ELECTRO-DYNAMIC	PNEUMATIC
NUMBER OF AXES	**ONE** PER SHAKER - MULTIPLE SHAKERS CAN BE CONNECTED TOGETHER, BUT DIFFICULT AND EXPENSIVE	**SIX** - X, Y, Z, ROLL, PITCH & YAW THE Z AXIS IS ALMOST ALWAYS HIGHER IN ACCELERATION LEVELS THAN ANY OF THE OTHER AXES
LOAD CAPABILITY	THOUSANDS OF POUNDS DEPENDANT ON SIZE OF SHAKER	UP TO 1000 LBS, TYPICALLY LESS THAN 500 LBS. DEPENDANT ON TABLE SIZE AND NUMBER OF VIBRATORS.
VIBRATION LEVELS LIMITING FACTORS	SIZE OF: ARMATURE (ED), COOLING, POWER SUPPLY AND FIXTURE	VIBRATION TABLE MASS, FIXTURE, SIZE AND NUMBER OF VIBRATORS
VIBRATION SPECTRAL RANGE	APPROXIMATELY 5-2000 HZ	APPROXIMATELY 10-5,000 HZ MOST OF THE ENERGY IS CONCENTRATED BETWEEN 400-2000 HZ
DISPLACEMENT RANGE	TYPICALLY +/- 1/2 INCH ON A MID SIZE ED SHAKER	MICROINCHES TO MILLI-INCHES
SPECTRAL CAPABILITIES	COMPUTER CONTROLLED - SINE, RANDOM, SINE-ON-RANDOM, PULSES, ETC.	UNCONTROLLED SPECTRUM QUASI-RANDOM, FULL OF HARMONICS, HOLES, UNEVEN LEVELS, ETC.
ACOUSTIC NOISE	VARIES WITH SPECTRUM, FIXTURE AND INPUT FORCE LEVELS	VERY LOUD - REQUIRES SOUND DEADENED ENCLOSURE (CHAMBER) VARIES WITH INPUT VIBRATION LEVELS.
ELECTOMAGNETIC FIELDS	SOME- GENERATED BY THE ARMATURE AND FIELD COILS	NONE

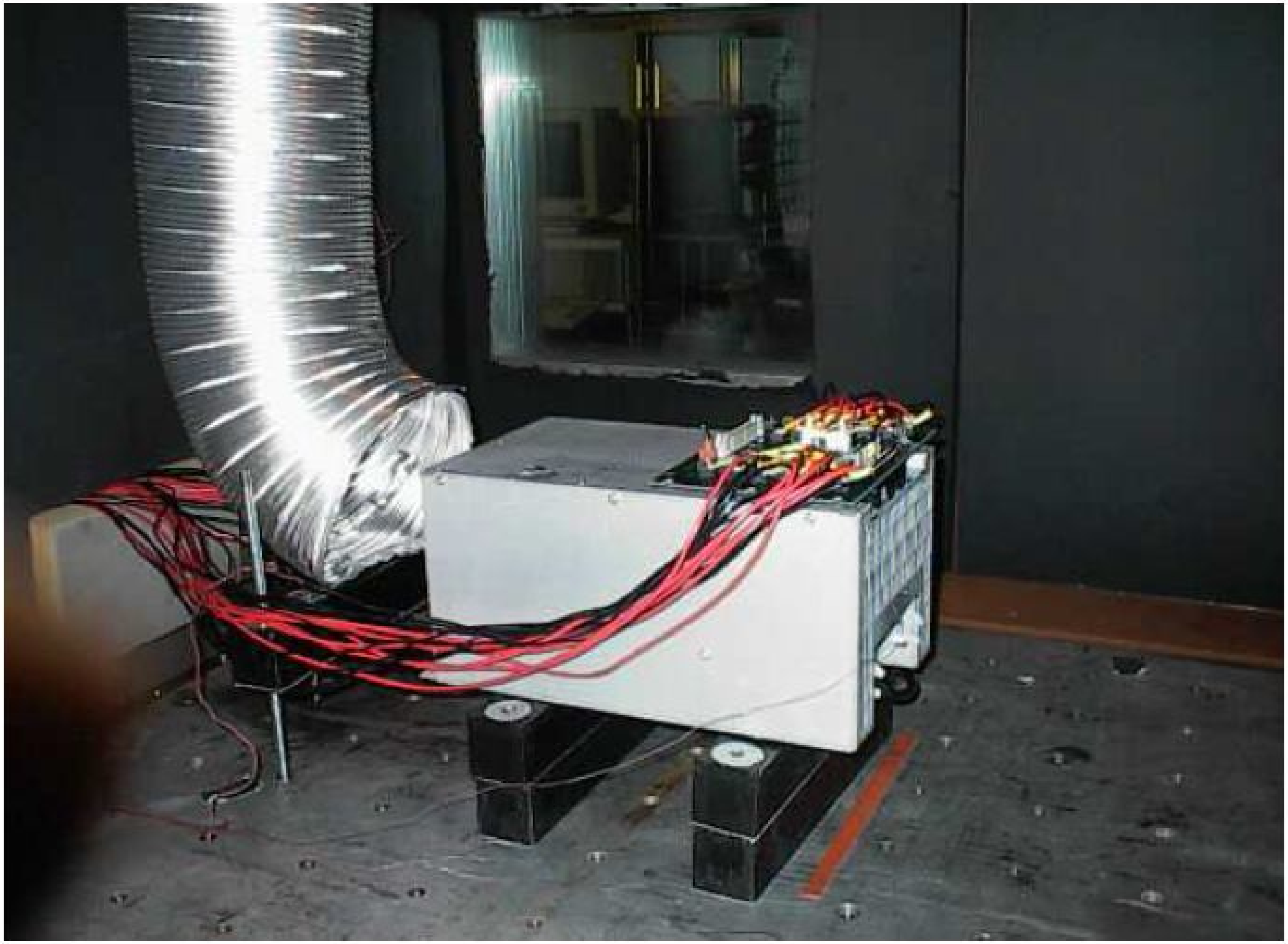
HARD MOUNTING OF UNIT UNDER TEST



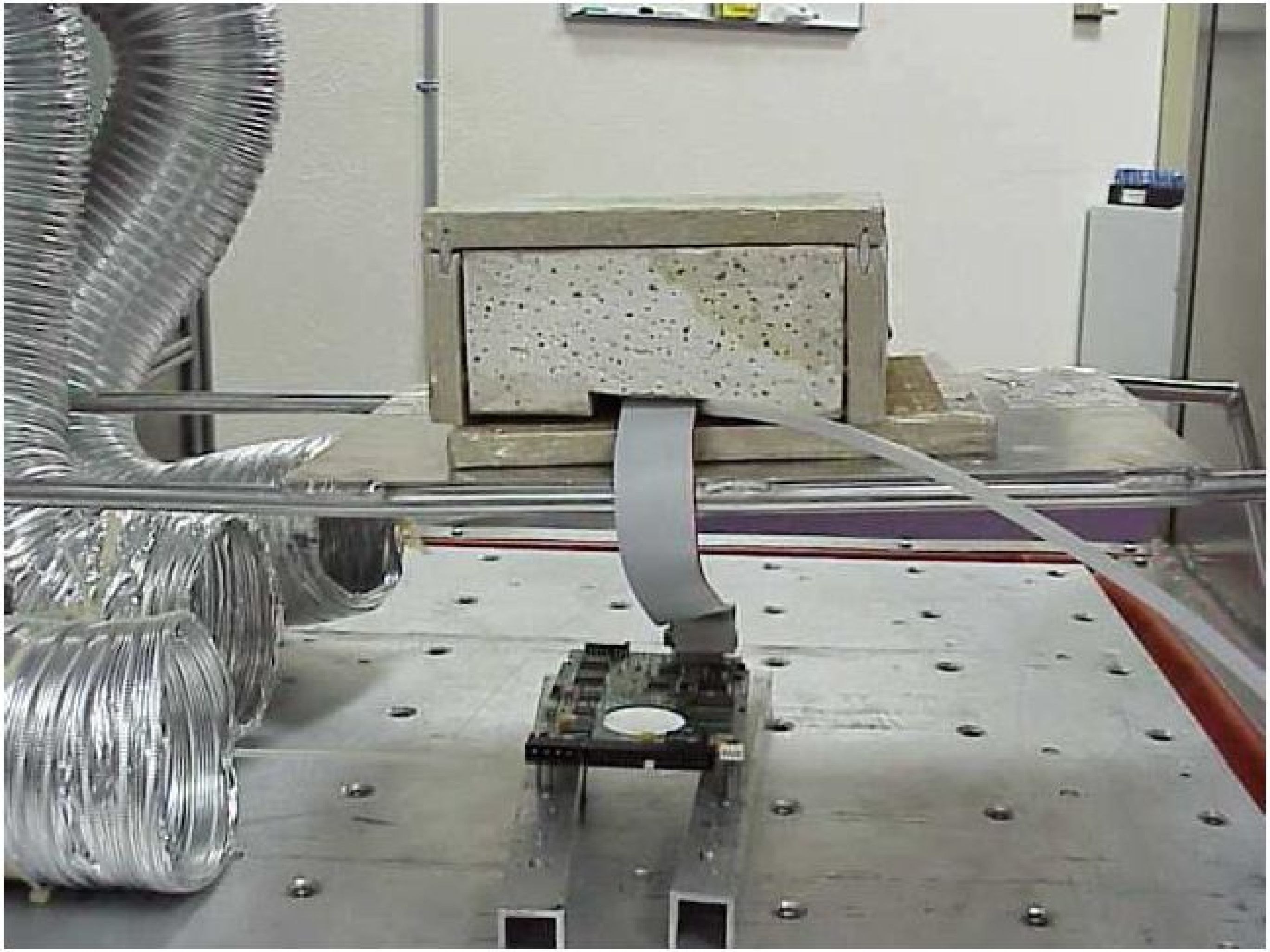
Fixture for PCB



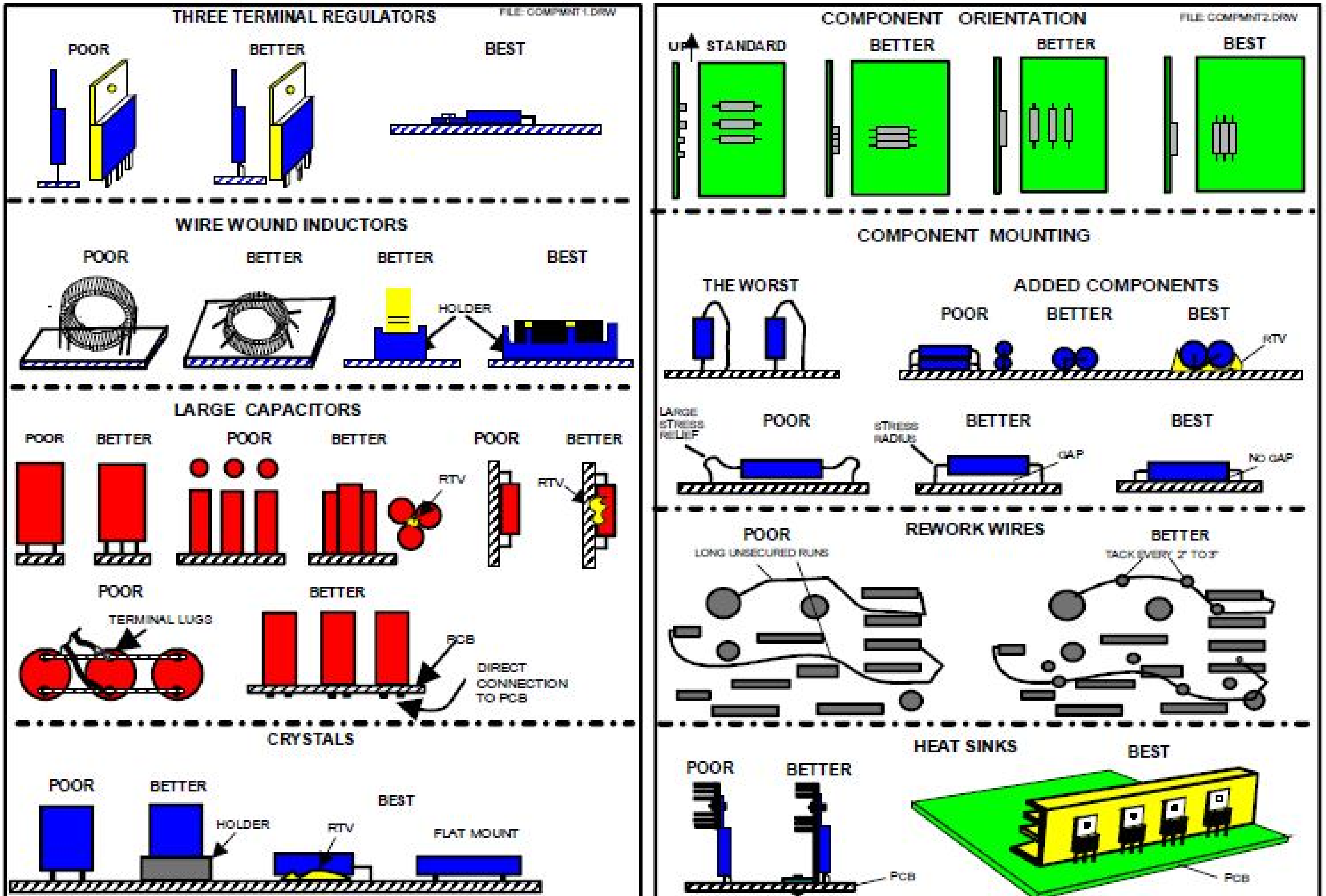
DUCT TO FOCUS CONDITIONED AIR



ISOLATION OF VIBRATION SENSITIVE MODULE



RUGGEDISATION OF COMPONENT MOUNTING



Figures 80A and 80B Examples of component mounting ruggedization

HALT/HASS Applications

• Motorola	wireless electronics
• Eastman Kodak	cameras
• Compaq	PCs
• Raytheon	avionics
• Ericsson	cell phones
• Amway	home humidifiers
• Lockheed Martin	weapons systems
• Solectron	circuit boards
• Medtronic	pacemakers
• GM	automotive electronics

THANK YOU