

HALT

HIGHLY ACCELERATED LIFE TEST
October 2010



WHEN YOU NEED TO BE SURE

SGS

■ HALT

- At a Glance: What is HALT?
 - The Basic Steps of a HALT Test
 - What next? After the HALT Test
 - What is it good for anyway?

■ HASS

■ Summary, Questions

AT A GLANCE: WHAT IS HALT?

- HALT = Highly Accelerated Life Test

Method/Tool to quickly uncover design weaknesses

- Mistakable, it is not about “life” and more than a “test”

 - ⇒ “Highly Accelerated Aging Method” would be clearer

- Mainly Thermal and Vibration Stress is used to accelerate aging

- Stress levels far exceeding expected environmental conditions

 - ⇒ Trigger failures, Find limits

 - ⇒ To “stimulate” failures, not to “simulate” failures

AT A GLANCE: WHAT IS HALT?

- There are no specified limits. The limit is determined by the product.
 - ⇒ “Stress the sample until it breaks”
- There is no international standard for HALT.
- There are a number of company specifications for HALT with largely identical procedures (e.g. from Airbus, GM, Case New Holland)

HALT is not a “pass/fail” test – you can not “pass” a HALT test. Failures are what you’re looking for!

AT A GLANCE: WHAT IS HALT?

- Who is doing HALT?
 - Mainly in aviation industry
 - Increasingly in the automotive industry
 - But also in telecommunication or medical technology ... and others
 - In Germany e.g. BMW, Opel, Siemens, Liebherr, Diehl, Balluff
 - To some extent HALT seems to become fashionable in some industries
 - HALT is more widespread in the USA than it is Europe

AT A GLANCE: WHAT IS HALT?

- Who is doing HALT?

The advertisement features three columns of text, with the middle column circled in orange. At the top, a green circular logo partially shows the text '& Reparieren'. At the bottom right, the Toshiba logo and slogan 'Leading Innovation >>>' are displayed. A small vertical disclaimer is on the far right edge.

> SICHER
Zuerst entwickelten wir mit der Tecra A9 ein sicheres Business-notebook.

> SICHERER
Dann machten wir es durch den HALT Test noch sicherer, z.B.: Simulierter 3-jähriger Dauereinsatz, Schocktest, Vibrationstest, etc.

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www.toshiba.at/doppelgarantie
www.toshiba.de/doppelgarantie

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Toshiba Advert for Laptop, German news magazine Focus (Nr. 8, 18. Feb. 2008)



QualMark Typhoon 3.0

HALT Chamber

- Cooling with liquid nitrogen
- Heating with hot air
- Temperature range: -100 to 200 °C
- Rate of temperature change
 - Realistic (small sample): 60 °C/min
 - Max. cooling (air stream): 135 °C/min
 - Max. heating (air stream): 90 °C/min
- Vibration with pneumatic hammers
- Broad band (5 to 10,000 Hz), repetitive shock, quasi-random vibration
- 6 degrees of freedom (3 axis + 3 rotations)
- 5 to 50 grms

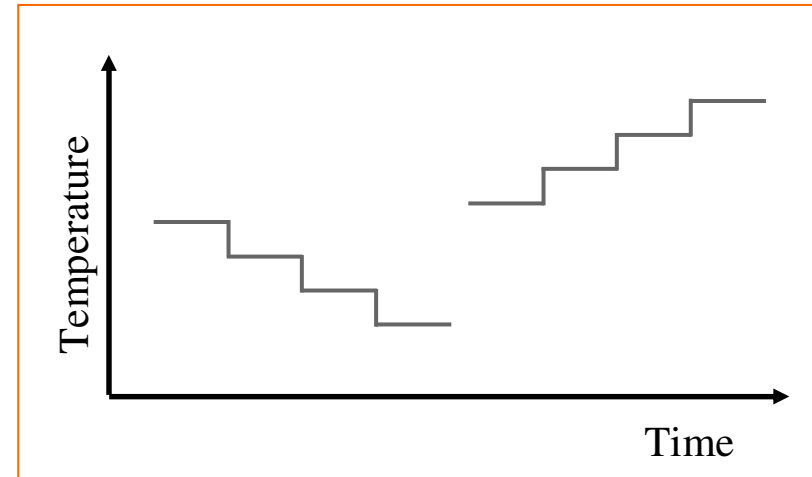
THE BASIC STEPS OF A HALT TEST

A HALT Test mainly consists of five steps

- Temperature Steps Cold and Heat
- Thermal Cycles
- Vibration Steps
- Combined Environmental Stress (Vibration, Thermal Cycles)
- Two types of limits are encountered
- Operation Limit (reversible)
- Destruction Limit (non-reversible)

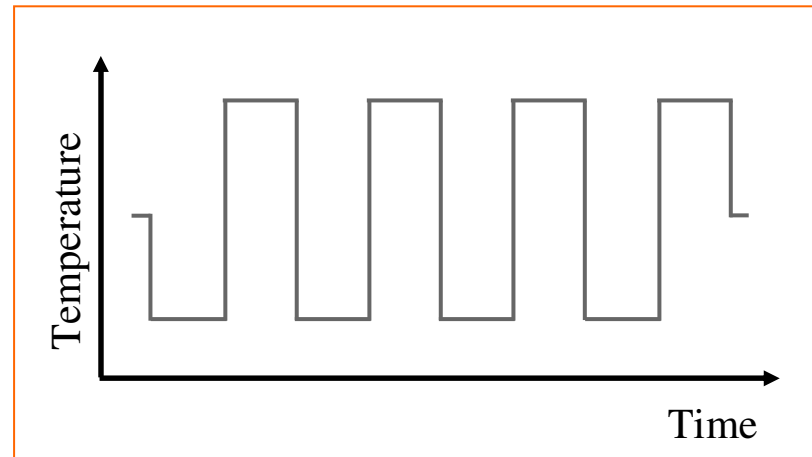
Temperature Steps Cold and Heat

- Main stress:
absolute temperature



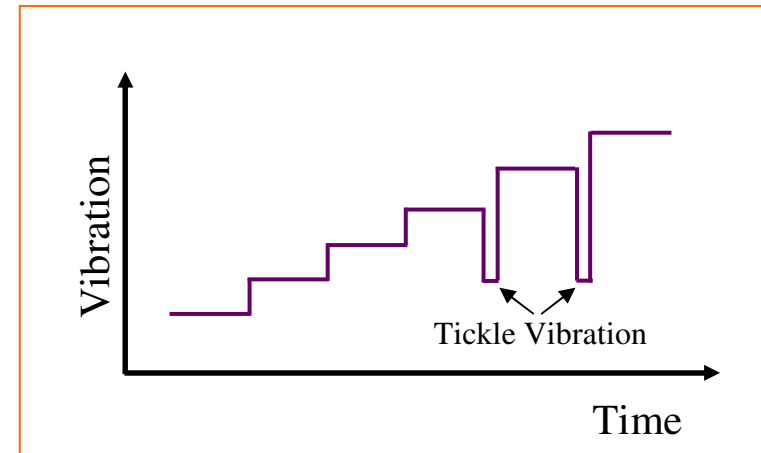
Thermal Cycles

- Main stress:
change of temperature
(not so much absolute
temperature)



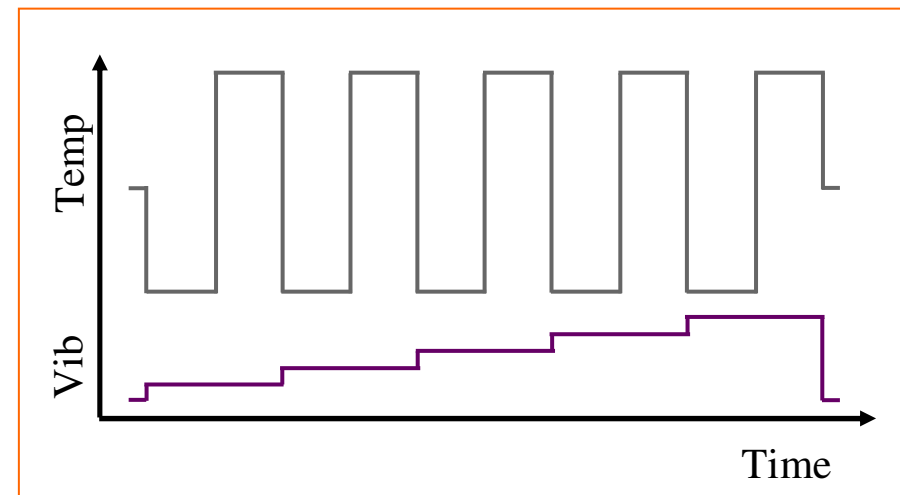
Vibration Steps

- Main stress: vibration



Combined Environmental Stress

- Main stress: combination of test stresses



THE BASIC STEPS OF A HALT TEST

Further product specific test stresses are possible

- Input Voltage, Load, Reference Frequency, ...

HALT does not include Humidity

- Humidity can not be increased much except under pressure (⇒ HAST)

One HALT run usually takes 2 to 5 days

Number of necessary samples

- 2 ⇒ the absolute minimum (search for operating limits only)
- 5 ⇒ for the 5 test stresses (usually about 3 will die)
- 15 ⇒ for some statistics

THE BASIC STEPS OF A HALT TEST

The typical procedure for a HALT test is a sequence of the five basic steps

... but actually it never happens like that ...

At least one person, who knows the sample very well, should be on site.

Try to analyze a failure and to track down the reason for a failure as far as possible on the spot.

- ⇒ This eases the later thorough root cause analysis
- ⇒ Continue to search for additional failures if a temporary fix is possible

THE BASIC STEPS OF A HALT TEST

When to start HALT?

- The earlier failures are known, the cheaper it is to fix them and the more time you have to do this
⇒ **The earlier, the better**
- The more complex a sample is, the more difficult the failure analysis
⇒ **Start on board level or with subunits**

The costs for fixing a failure are:

| | |
|-----------|--------------------|
| \$35 | Design phase |
| \$175 | Before procurement |
| \$368 | Before production |
| \$17,000 | Before shipment |
| \$690,000 | At customer site |

Hiroshi Hamada, President of Ricoh
at EuroPace Quality Forum,

October 1991

However ...

- Operation of single boards or subunits may be difficult
- During design phase the number of available samples may be even more limited
- Results from a prototype in HALT may not be representative for a sample from bulk production (due to different components and manufacturing process used)
⇒ **Trying to start too early isn't advisable either**

WHAT NEXT? AFTER THE HALT TEST

Root Cause Analysis

The most important step of a HALT test is the subsequent Root Cause Analysis.

- To be performed by someone very knowledgeable of the samples a test lab can only support
- Find and thoroughly analyze reasons for the failures

WHAT NEXT? AFTER THE HALT TEST

Shall I fix that failure?

Unfortunately there is no straight answer for that ☹️

High stress causes two types of failures, due to ...



Accelerated Aging

e.g. fatigue



Uniquely caused by
high stress level

e.g. melting

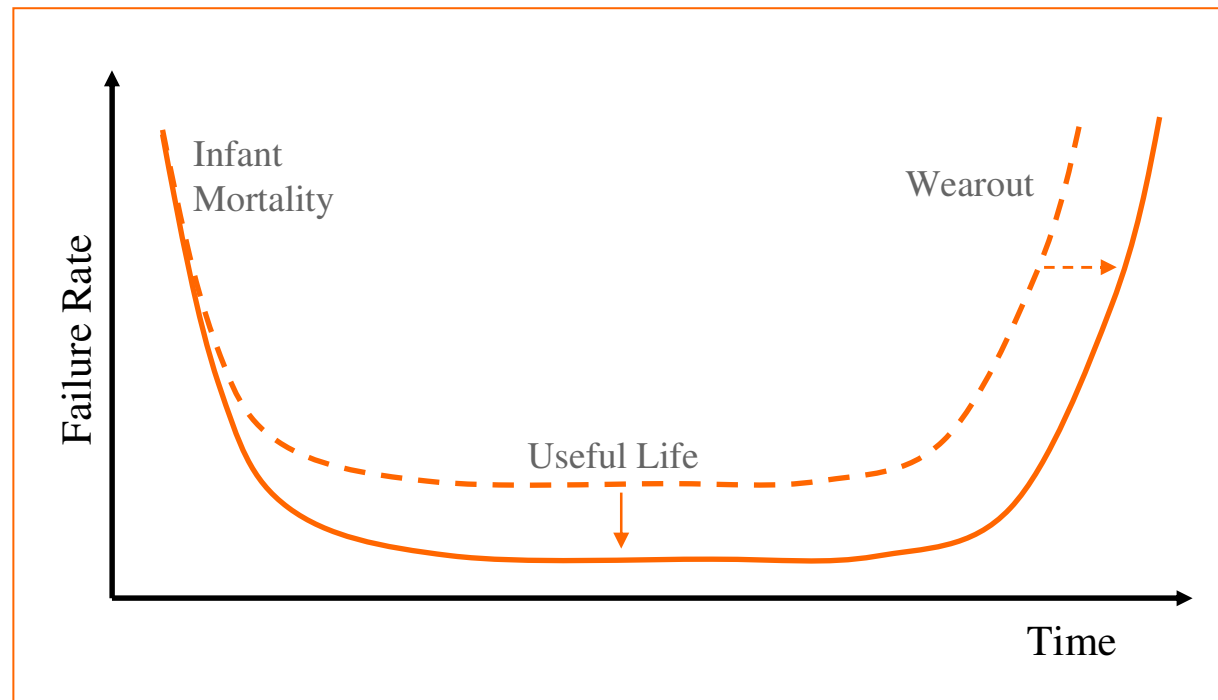
WHAT NEXT? AFTER THE HALT TEST

Shall I fix that failure?

- Could the failure mode appear in the field due to aging?
How much would it cost if the failure appeared in the field?
 - ⇒ Fix failures that could appear in the field and would cause unacceptable costs.
(regardless at which stress level they appear during HALT)
- Is the failure uniquely due to the high stress applied?
How big are the margins already?
 - ⇒ Fix unique high stress failures if anywhere close to spec.
- How much does it cost to fix the failure?
 - ⇒ If it's cheap then fix it anyway! Many failures are low cost fixes.

WHAT IS IT GOOD FOR ANYWAY?

The **main goal** of HALT is to find and eliminate the first failure modes.



WHAT IS IT GOOD FOR ANYWAY?

The **secondary goal** of HALT is:

- To increase the product margins

HALT **can also be used** as:

- Rigorous comparison test of a 2nd source product (or redesign) with an established 1st source, where both pass the regular product qualification tests.

HALT **should not be misused** as (but sometimes is):

- Pass/Fail test to verify customer specified limits

Design Verification Testing vs. HALT

DVT

- Verifies that the product meets the specification
- Tests tailored to specific product
- Is successful when product shows no failures
- DVT is a „Pass/Fail“ test

HALT

- Stresses product beyond specification
- Stresses product until weak points fail
- Determines operating and destruction limits
- General test
- Is successful when failure modes are found and eliminated
- HALT is not a „Pass/Fail“ test

Different purpose, different method, different test equipment.
HALT doesn't replace "classical" environmental and qualification testing.
The results are not always comparable.

WHAT IS IT GOOD FOR ANYWAY?

Advantages

- Quickly find design weaknesses
- Faster than classical aging (one HALT run takes 2 to 5 days)
- Cheaper than classical aging
 - ⇒ Reduced time to market
- Cheaper than classical aging
 - ⇒ Reduced development costs
- More reliable product
- Greater product margins
 - ⇒ Decrease field service & warranty costs

WHAT IS IT GOOD FOR ANYWAY?

Limitations

- HALT as such is not suitable as basis for a MTBF or lifetime calculation.
You would have to “calibrate” an acceleration factor without changing the dominant failure mechanism (by testing to failure at different stress levels) and extrapolating the time to failure down to a “normal” stress level (CALT).
- Limited reproducibility of temperature and vibration results due to the way the chamber works. But ...
 - The stress under which the failures occur is not significant – the significant thing is that they are the first ones to appear.
- One has to “have confidence” in HALT to some extent.

Obstacle

- The samples don't work yet (at all)
Only about 20 % of the HALT tests in our lab are performed as originally planned.

HASS = Highly Accelerated Stress Screen

Method to monitor quality of production (detect faulty samples)

- Stimulate latent failures before products are shipped
- Same goal as Environmental Stress Screening (ESS)
- Based on margins found during HALT
- Mainly Thermal and Vibration Stress is used
- Stress levels strong enough to detect failures of week samples ... but without taking too much of the shipped product's life time

Unlike HALT, HASS is a “pass/fail” test

“The basic nature of the HALT process is one of discovery that requires flexibility in thought and method as it progresses. [...]

Accept the ambiguity that is intrinsic to an explorative development test.”

from GMW8287, 03-2004

SGS



THANK YOU!

- HALT: Highly Accelerated Life Test
- HASS: Highly Accelerated Stress Screen
- HASA: Highly Accelerated Stress Audit
- HAST: Highly Accelerated Temperature/Humidity Stress Test

- OL: Operation Limit
- DL: Destruction Limit
- EUT: Equipment Under Test
- MTBF: Mean Time Between Failure
- CALT: Calibrated Accelerated Life Test (see e.g. GMW8758)

FURTHER READING & CONTACTS

- HALT Guideline
QualMark, www.qualmark.com/PDF/HALT_guideline.pdf
- HASS Guideline
QualMark, www.qualmark.com/PDF/HASS_guideline.pdf
- Accelerated Reliability Engineering – HALT and HASS
Gregg Hobbs, John Wiley & Sons Ltd
- Why HALT is not HALT
Craig Hillman, www.dfrsolutions.com/pdfs/Why_HALT_Is_Not_HALT.pdf
- Fundamentals of Accelerated Stress Testing Thermotron
- Various company specifications
(e.g. Airbus, General Motors, Case New Holland)
- Manufacturers of HALT Chambers:
www.qualmark.com, www.thermotron.com, www.haltandhass.com,
www.wut.com, www.tira-gmbh.de
- Center for Quality Engineering: www.sgs-cqe.de
- Local SGS Contact: www.ee.sgs.com/worldwide-contacts.htm