THERMAL AND VIBRATION ISOLATION TECHNIQUES FOR HARD DRIVES AND PCI CARDS

Mike Silverman, C.R.E.
Managing Partner, Ops A La Carte, LLC

BIOGRAPHY

Mike is an experienced leader in reliability improvement through analysis and testing. He has also led numerous quality system development programs. He has 20 years of reliability and quality experience, the majority in start-up companies. Mike is also an expert in accelerated reliability techniques, including HALT and HASS. He set up and ran an accelerated reliability test lab for 5 years, testing over 300 products for 100 companies in 40 different industries. Mike is founder and managing partner at Ops A La Carte, a Professional Business Operations Company that offers a broad array of expert services in support of new product development and production initiatives. Through Ops A La Carte, Mike has had extensive experience as a consultant to high-tech companies, and has consulted for over 100 companies including Cisco, Ciena, Siemens, Intuitive Surgical, Abbott Labs, and Applied Materials. He has consulted in a variety of different industries including telecommunications, networking, medical, semiconductor, semiconductor equipment, consumer electronics, and defense electronics. Mike has authored and published 7 papers on reliability techniques and has presented these around the world including China, Germany, and Canada. He has also developed and currently teaches 8 courses on reliability techniques. Mike has a BS degree in Electrical and Computer Engineering from the University of Colorado at Boulder, and is both a Certified Reliability Engineer and a course instructor through the American Society for Quality (ASQ), IEEE, Effective Training Associates, and Hobbs Engineering. Mike is a member of ASQ, IEEE, SME, ASME, PATCA, and IEEE Consulting Society.

ABSTRACT

Highly Accelerated Life Testing (HALT) is one of the fastest growing segments of the testing industry because it shortens the time it takes to evaluate the reliability of a product. This enables the user to make design changes earlier in the design cycle. HALT is a powerful tool that can help manufacturers achieve high reliability quickly. HALT is performed at the design phase of a project to quickly expose the weak points of a design so that the product can be re-designed to remove these weak points, thereby expanding the margins of the design.

When performing HALT, different assemblies within a product are likely to fail at different levels. Therefore, to receive maximum benefit from a test, it is recommended to separate a product to isolate the weaker assemblies and remove them from the stress testing as they fail. One specific type of fixturing technique allows this type of separation while the product is still connected. This technique has been proven to work on many different types of products, including computers, controllers, and robotics. In each of these cases, the assembly being isolated is typically removed from the stress by making the extension cable long enough to remove the entire assembly from the chamber. However, in some cases, the extension cables

have a maximum allowable length prohibiting the assembly from being removed from the chamber. In these cases, the assembly being isolated must remain in the chamber inside a special box isolated from thermal and vibration energy. This paper shall focus on two such products – Hard Drives and PCI Cards.

KEY WORDS

HALT Acronym for Highly Accelerated Life Test. In HALT, stresses such as six degree-of freedom repeated shock vibration, rapid temperature transitions, voltage margining, frequency margining, and any other stresses that are appropriate are used to find the weak links in the design and fabrication processes of a product. HALT is performed during the design phase.

INTRODUCTION

When performing HALT on the hard drive, the two assemblies being separated were the head assembly and the controller board. The head assembly was weaker than the controller board. Therefore, when the limit of the head assembly was reached, the head assembly was isolated to allow testing to continue on the controller board.

When performing HALT on the PCI Card, the PCI card was required to be connected to a motherboard for its functional test. Therefore, the two assemblies being separated were the PCI Card and the motherboard. The motherboard was weaker than the PCI Card. Also, the PCI Card was the product under test. Therefore, when the limit of the motherboard was reached, the motherboard was isolated from the PCI Card. Limits for the motherboard were obtained for comparison purposes only.

USING EXTENSION CABLES FOR TESTING HARD DRIVES AND PCI CARDS

For the hard drive and PCI Card products, an extension cable was used to separate the two assemblies. Based on the hard drive tested at the lab, a separation of 12 to 18 inches did not affect the performance of the product. Based on the PCI card tested at the lab, a separation of 3 to 6 inches did not affect the performance of the product. The weaker assembly was placed in a box made of a thermal insulating material with a hole cut out for the extension cable. The extension cable was passed through the lid of the box and connected to the isolated board that resided in the box. To help assure that the assembly within the box remained as close to ambient temperature as possible, gaseous nitrogen at room temperature was directed into the box through a ¼" PVC line.

The entire box was then placed upside down on a vibration isolation stand directly over the top of the assembly under stress. The height of the stand depended on the length of the cable.

The legs of the stand rested off the vibration table so that the stand experienced no direct vibration from the table.

The box was built out of ceiling tiles, using RTV to seal the pieces together. For the vibration isolation stand, aluminum channels were used for the PCI Card fixture and welded aluminum bars were used for the hard drive fixture.

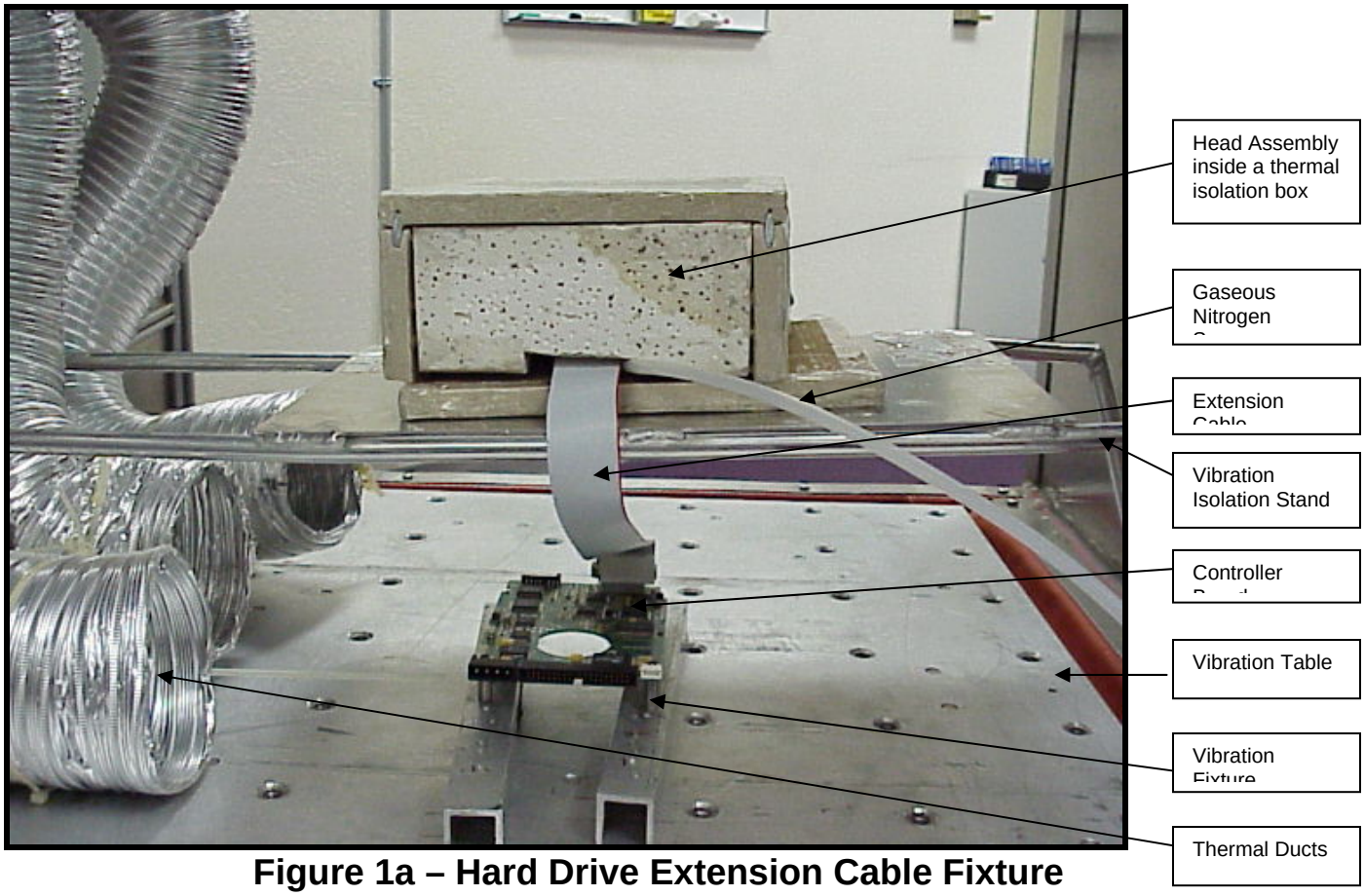

Figure 1a – Hard Drive Extension Cable Fixture

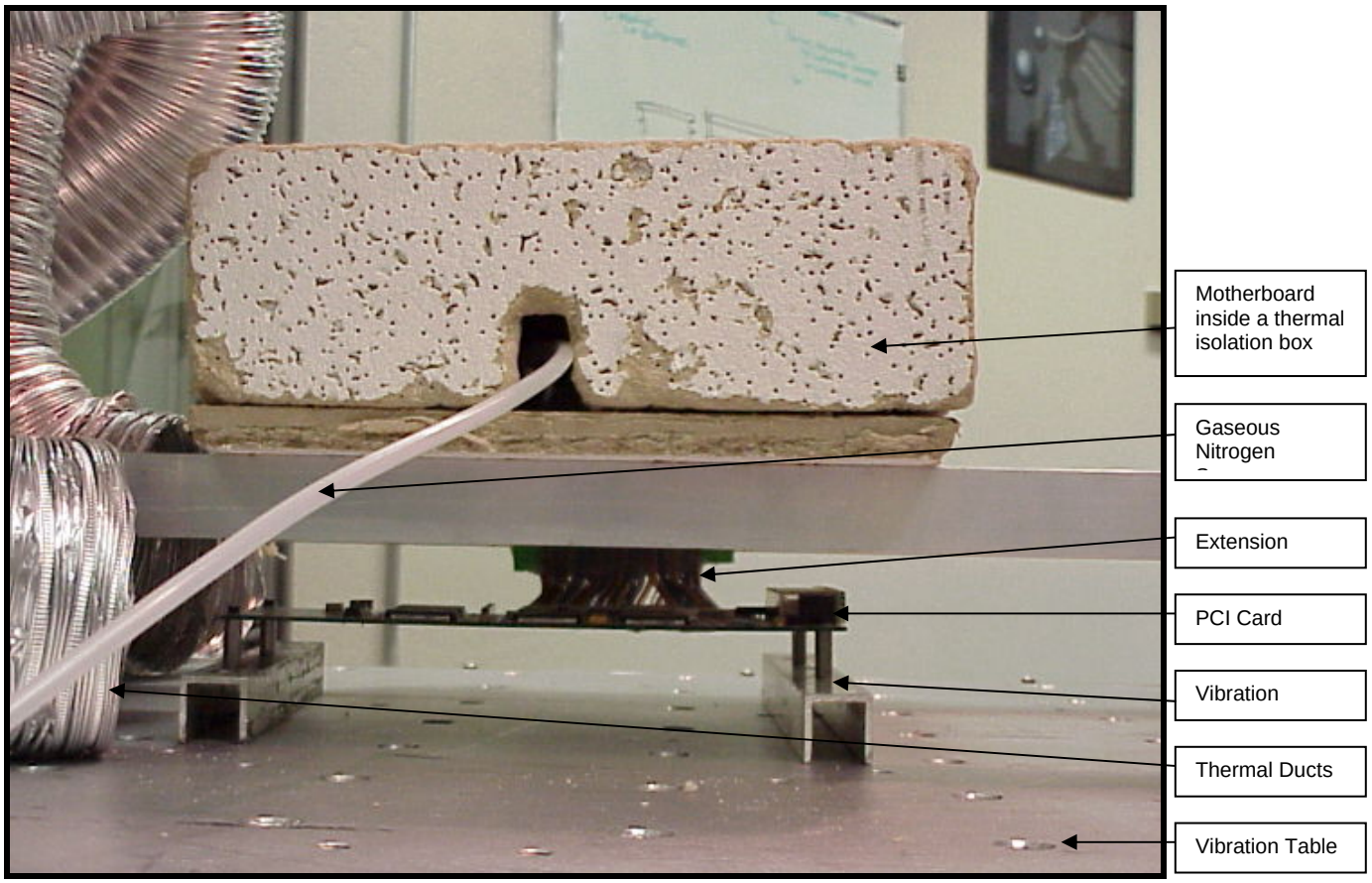

Figure 1b – PCI Card Extension Cable Fixture

DESCRIPTION OF EXTENSION CABLES

For the hard drive extension cable, a 10 pin 18" ribbon cable was used with a female connector on one end and a male connector on the other end.

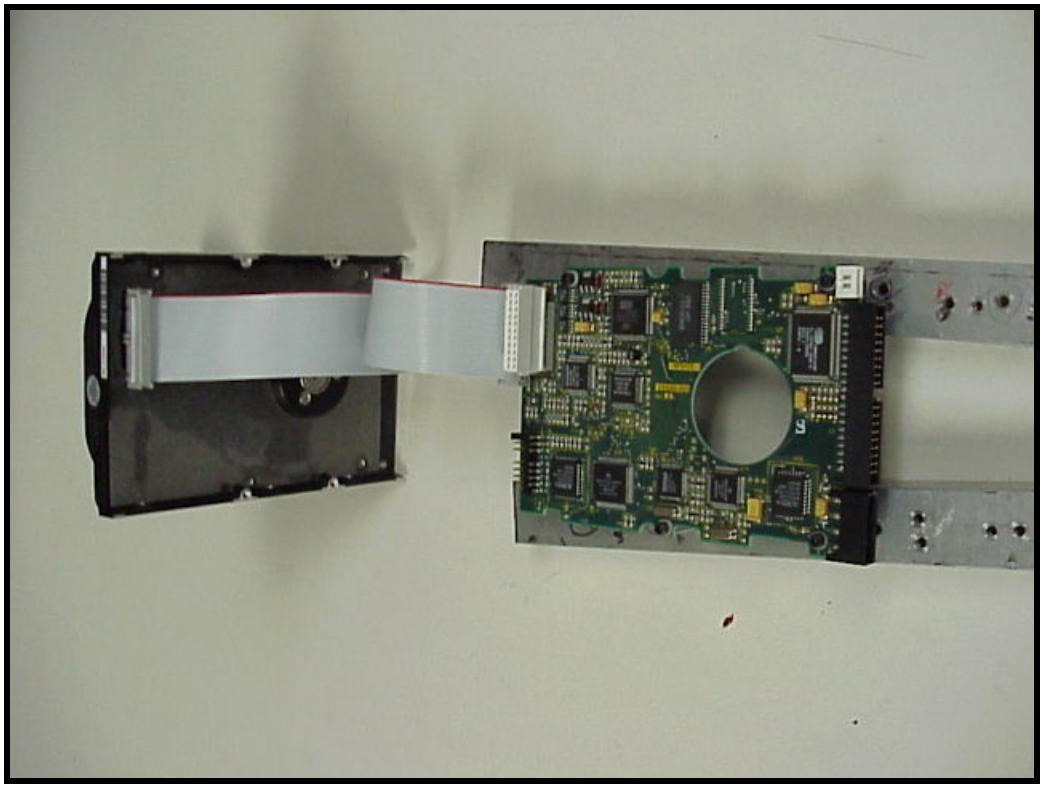

Figure 2 – Hard Drive Extension Cable

For the PCI Card extension cable, the finger portion of a mini extension cable was used on one side and a female connector from a motherboard was used on the opposite end. Then 30 AWG wire was run between the two connectors, and RTV was placed across all of the solder connections for durability.

RESULTS

Below are the results we experienced for the two products. Note that the limits shown below for the Controller Board and for the PCI Card were achieved after isolating their respective assembly pairs.

Table 1a – Hard Drive Results

Stress Type	Controller Board	Head Assembly
LOL	Beyond -100°C	-50°C
LDL	Beyond -100°C	-50°C
UOL	Beyond +120°C	+85°C
UDL	Beyond +120°C	+90°C
VOL	Better than 50 Grms	0.5 Grms
VDL	Better than 50 Grms	20 Grms

Table 1b – PCI Card Results

Stress Type	PCI Card	Motherboard
LOL	Beyond -100°C	-50°C
LDL	Beyond -100°C	-70°C
UOL	+110°C	+75°C
UDL	Beyond +100°C	+90°C
VOL	Better than 50 Grms	20 Grms
VDL	Better than 50 Grms	20 Grms

The improvement in limits for each assembly type within each product type was a good rationale for using this type of fixturing technique. Without it, testing would have had to stop after reaching the limit of the weaker assembly. This would have contradicted one of the primary goals of HALT – to push each individual assembly to its technological limit. This is because the assembly that failed first during HALT may not be the assembly that will fail first in the field. For the hard drive test, the failure mechanisms were much different for the mechanical head assembly than that of the electronic controller board. For the PCI Card test, the failure mechanisms were much different for the PCI Card than that of the motherboard because the PCI Card consisted mostly of ASICs and PALs whereas the motherboard was predominantly processors and memory. Even if the assembly that failed first in HALT did fail first in the field, the remaining assembly was still tested to its limit because it could eventually fail in the field if enough products were to be fielded. Therefore, we pushed each assembly to its technological limit.

CONCLUSIONS

When performing HALT on the hard drive and on the PCI Card, the difference in limits for each of the assembly types for each product type was a good rationale for using extension cables and isolating the weaker assembly from thermal and vibration energy. Without it, testing would have had to stop after reaching the limit of the weaker assembly, and would have contradicted one of the primary goals of HALT – to push each individual assembly to its technological limit.

Developing these types of fixtures was necessary in order to discover and expand the limits of each assembly of the products tested.

Mike Silverman is Managing Partner of Ops A La Carte LLC, a Professional Consulting Company founded by him in 1999. Ops A La Carte provides a complete range of Reliability Engineering Services employing both Conventional and Accelerated Reliability (HALT) techniques. Mike has pioneered the concept of "Reliability Integration" using multiple Reliability Tools in conjunction with each other to greatly increase the power of Reliability Programs. Please visit www.opsalacarte.com for copies of this paper and other useful resources.