Which Vibration/Shock System is best for HALT/HASS?

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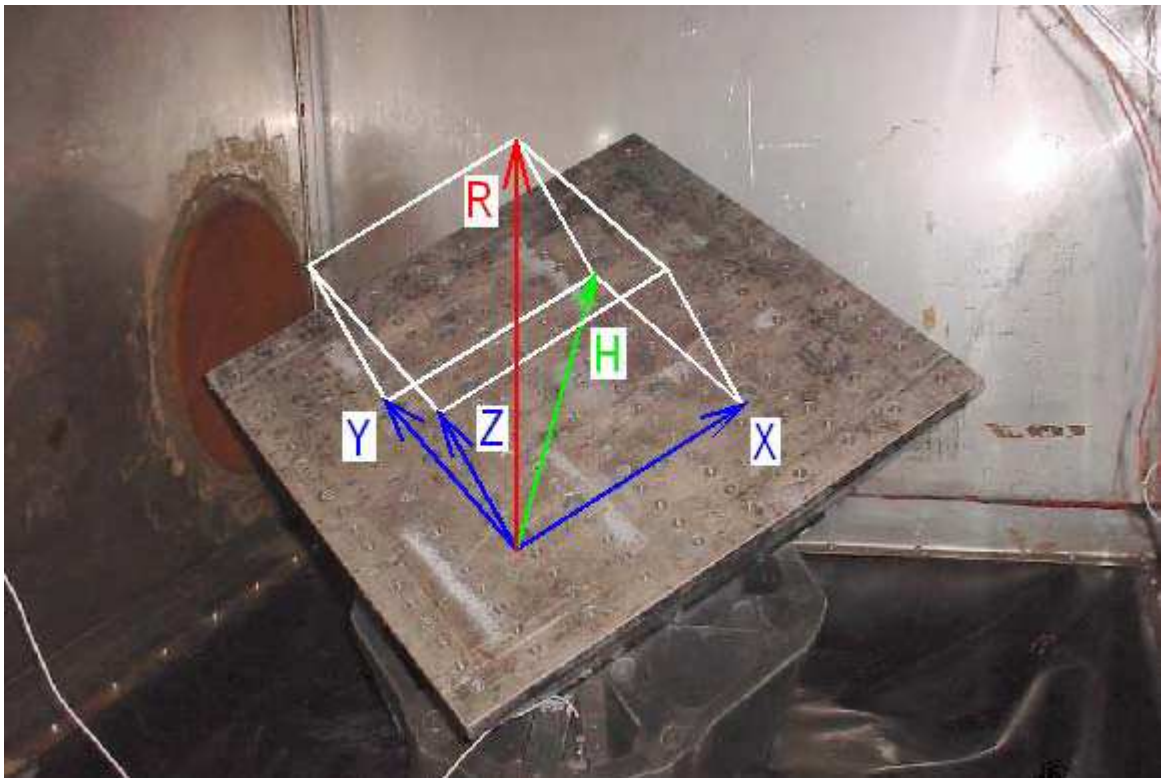
In order to quickly find the weaknesses of a product, a combined test of temperature cycling and vibration is currently the most popular choice. However, for vibration, there are several different types of equipment that can vary in cost and complexity of set up; namely, single axis shaker, skewed fixture with electro-dynamic shaker, pneumatic hammer table and 3axes shaker systems. Which type of system is the best for finding product weaknesses is of interest to all of us.

Several papers [1, 2] have compared the effectiveness of some of the equipment above, but until now, no paper has included a comparison of the effectiveness of a 3 axis shaker system in finding product weaknesses with other vibration systems. This investigation was designed to address this issue.

In order to have an accurate comparison, the three axis acceleration values were measured on the surface of the skewed fixture, mounted on a single axis electro-dynamic shaker while vibrating vertically at 2.5, 5.0 and 7.5 grms. The spectrum of this random vibration was flat from 5 to 500 Hz. Thus, acceleration values used; number of units tested and total time tested for this comparison test on each of the systems were as follows:

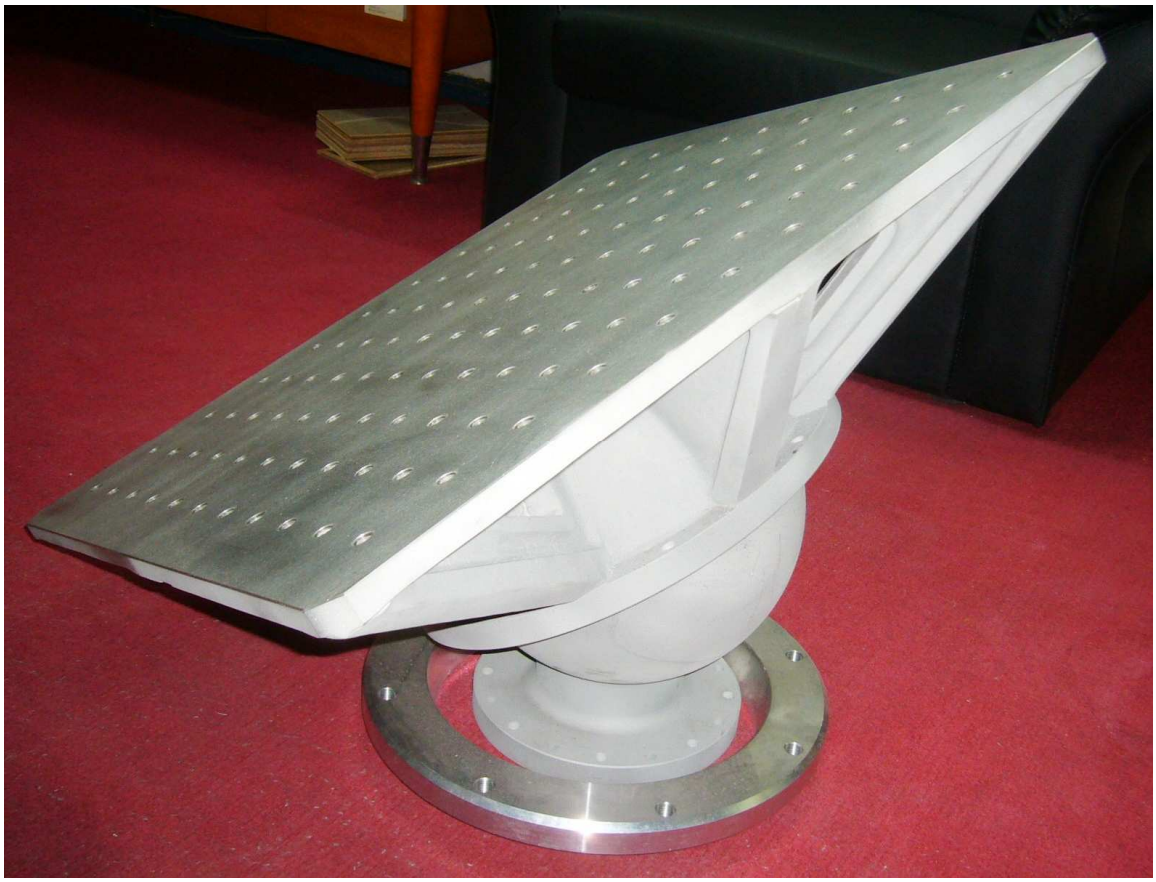


Quanta Laboratories' Skewed Fixture with Electro-Dynamic Shaker System

Vibration System	Vibration Spectrum	No. of Units Tested	Total Time Tested
Pneumatic Hammer	5 to 500 Hz; 10/20/30/40 Grms; 10min./each grms level	3	40 min.
Skewed Fixture with ED Shaker	5 to 500 Hz; 2.5/5/7.5 Grms; 10min./each grms level	3	30 min.
3-axes Shaker	5 to 500 Hz; 10min./each grms level 2.5Grms X: 1.05 Grms ; Y: 1.07 Grms ; Z: 1.90 Grms 5.0Grms X：2.07 Grms ; Y： 2.11 Grms ; Z：3.76 rms 7.0Grms X：3.11 Grms ; Y：3.17 GrmsZ：5.64 Grms	3	30 min.
Single Axis Shaker	5 to 500 Hz; 10 min./axis/each grms level (30 min./each grms level) 2.5Grms X: 1.05 Grms ; Y: 1.07 Grms ; Z: 1.90 Grms 5.0Grms X：2.07 Grms ; Y： 2.11 Grms ; Z：3.76 Grms 7.0Grms X：3.11 Grms ; Y：3.17 GrmsZ：5.64 Grms	1	90 min.

Side Note:

- The acceleration ratios of the three axes do not have to be fixed; it can be varied to match the required ratios by a ball connection between the skewed fixture and the shaker. (See below)



Courtesy of King Design, Taiwan

Single axis shaker

One unit of the product was vibrated on a single axis shaker using the acceleration values measured on the skewed fixture in all axes one at a time. The duration of this random vibration is 10 min. on each axis and at each grms level, for a total of 30 minutes at each grms level. The total accumulated vibration time was 90 minutes.

Single Axis ED Shaker at Huawei

The problems found on the single axis shakers are tabulated in the following table.

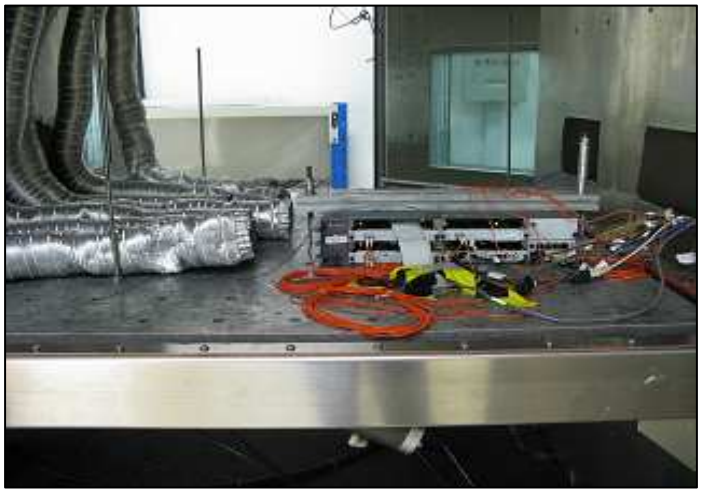
Vibration on Single Axis ED Shaker					
Vibration Level & Axis	Problem Discovered	Cause of Problem	No. of Samples Tested	No. of Samples with This Problem	Is this Problem Found in the Field
5 grms, X axis	Base Band Board intermittent communication problem	LAN switch IC failure	1	1	NO
5 grms, X & Y axis	Intermittent failure of Power Board	Transient connection failure between Power Board & Main Board	1	1	NO

No problems were found at 2.5 grms and no new problems were found at 7.0 grms

Pneumatic Hammer

Since a pneumatic hammer system cannot precipitate product defects at low grms levels, much higher levels were chosen at 10, 20, 30 and 40 grms. Vibration was performed for 10 minutes at each grms level. The total vibration time was 40 minutes.

The problems indentified by the pneumatic hammer were as follows:



Pneumatic Hammer Table at Huawei

Vibration on Pneumatic Hammer					
Vibration Level & Axis	Problem Discovered	Cause of Problem	No. of Sample Tested	No. of Sample with This Problem	Does this Problem Found in the Field
10 grms	FE interface communication failed	Intermittent connection of FE interface with?	3	1	NO
30 grms	Serial port hang up	Transient cable connection failure between what & what	3	1	NO

No additional problems were found at 20 and 40 grms.

Skewed Fixture with ED Shaker

The product was then vibrated on a skewed fixture on an electro-dynamic shaker at 2.5, 5 and 7.5 Grms.

Skewed Fixture with ED Shaker at SMQ

The problems found are tabulated in the table below.

Vibration on Skewed Fixture with ED Shaker					
Vibration Level & Axis	Problem Discovered	Cause of Problem	No. of Sample Tested	No. of Sample with This Problem	Does this Problem Found in the Field
2.5 grms	System hang up	BGA & IC crack	3	1	YES
7.5 grms	Power Board no output	Capacitor fell off	3	1	YES
7.5 grms	Main control board reset	Transient connection failure between Power Board & Main Board	3	2	NO

No problems were found at 5.0 grms.

3-axis shaker

Finally, the product was mounted on a 3-axis electro dynamic shaker system, using the acceleration values as measured on the skewed fixture for the inputs in the x, y & z axes for 10 minutes at each of the grms levels. The total vibration time was 30 minutes. The problems discovered are listed in the table below.

Tri-axial Shaker at Suzhou Testing Instrument Factory

Vibration on tri-axial ED Shaker					
Vibration Level	Problems Discovered	Cause of problem	No. of Sample Tested	No. of Samples with This Problem	Does this Problem Found in the Field
5.0 grms	Main control board reset	DDR IC BGA crack	3	1	No
5.0 grms	Main crystal oscillator failed to work during vibration	Recovered & failure can not replicated	3	1	No
5.0 grms	Intermittent failure of the power board	Transient connection failure between Power Board & Main Board	3	3	No
5.0 grms	Base band board showed abnormal	Connection with the back plan is lost	3	3	No
7.5 grms	Power board no output	Power board solder pad crack	3	1	Yes

No problems were found at 2.5 grms.

Observations:

From these results the following observations can be made:

•The 3-axis shaker system uncovered the most problems, followed by the skewed fixture with ED shaker system. The pneumatic hammer and single axis shaker systems found the least number of problems, despite the fact that these last two systems were vibrated for a longer period of time.

•Skewed fixture with ED shaker system uncovered product problems at lower grms levels as compared with all other systems. And it also discovered more of the field problems as compared with all other systems, including the 3-axis shaker system.

•Problems found by the single axis vibration system and pneumatic hammer system did not match with any of the field problems.

•The Pneumatic hammer system requires very high vibration levels to precipitate product defects. Too much product life is spent during product screen with this equipment.

Conclusions:

For the particular product tested, the skewed fixture with ED shaker was able to find more relevant field failures than all the other systems. The cost of a 3 axes ED shaker system is many times more than the cost of the skewed fixture ED system. We believe that for its simplicity, the skewed fixture with ED shaker is a much more cost effect approach and the most time saving way to find the product weaknesses. However, testing of more products is needed to determine whether this is true for other products as well.

References:

[1] New approach for production line environmental stress screening by Dr. Hong-sun Liu, Test Engineering and Management, August/September 2005

[2] Comparison testing of shock versus vibration ESS systems by Dr. Hong-sun Liu-Quanta Laboratories; Mingwei Lu, Zhigang Gao, Yong Bian and Mingyuan Zhao Huawei Technologies Company, Test Engineering and Management, October/November 2007