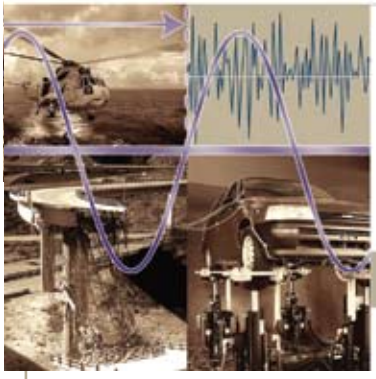

ERI News

your reliability newsletter

August 2007 | Equipment Reliability Institute | Volume 28

In this issue...

New MIL-STD-810G Test Method Offers Multiaxis Shaking

by Wayne Tustin

The long-standing procedure of three vibration tests, shaking a product first in the product's X axis, then in the product's Y axis and finally in the product's X axis, is not realistic. In spite of that, the 1962-issued MIL-STD-810, revised six times since 1962, most recently as the "F" revision in 2000, has only offered the single-axis-at-a-time method. SESA stands for single exciter single axis. About May 2008 the "G" revision will offer a new Multiexciter Test Method 527, MEMA (multi exciter multiaxis).

Figure 1 - Three-axis electrodynamic shaking. courtesy IMV, Visteon and Spectrum Technologies.

(continued on page 2)

Proactive Reliability is a lot like Pro Football

by Ted Kalal and Mark Levin

The shortsighted view of commitment to reliability is to redouble efforts toward correcting product failures by focusing on field failure analysis and corrective actions. Certainly this is part of the reliability effort, but the main effort must be to reinvent the process. The commitment must be to change the process so that failures are caught and corrected before the product is ever shipped. Management must commit to developing the know-how to change the process. At first this know-how will come from reliability engineers, specialists and consultants. These few individuals will impart their knowledge to the rest of the workforce. After a time the processes will be well established, understood, and in place as part of the day-to-day ongoing activities of the company.

Reinventing the process will be a team effort. A football team has top management, a head coach, assistant coaches, many support individuals, a wide array of

(continued on page 4)

Wayne Tustin

Voice of the President

ERI's new "Vibration and Shock Video Training"

Have you wished you could bring Wayne Tustin or another ERI instructor into your facility to teach the fundamentals of vibration and shock testing, measurement, analysis and calibration? Teach about the vibration aspects of ESS, HALT and HASS? Here is a new way to do just that!

When considering "live" training, have you been restrained by

- ► too few people to train, so the "per person" cost was high?
- ► can't spare your people for say three full days?

Have you therefore considered sending individuals to one of ERI's "open" courses?

Have you been restrained by

- ► high work load, so you can't spare them?
- ► high "per person" course fee?

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Electrohydraulic Shaking of Automobiles

It is commonly known that real-world vibrations exist simultaneously in multiple axes. We are all aware, for instance, that our automobiles receive six inputs from the road: vertical, fore-and-aft, left-and-right linear inputs in addition to pitch, roll and yaw angular inputs.

Automotive testing long ago graduated from vertical-only mechanical SESA shaking to multiple exciter single axis (MESA) shaking to today's multiple exciter multi-axis (MEMA) shaking. Most automobile manufacturer use multiple long-stroke electrohydraulic EH (sometimes called servohydraulic) shakers to accomplish such tests. Multiple EH shakers drive each of the four wheels of complete vehicles.

Major automotive assemblies needing vibration tests instead are mounted on a MEMA vibrating platform.

Multiple Electrodynamic Shakers?

EH Shakers take automotive hardware to 200, perhaps to 500 Hz, but many workers need to shake to 2,000 Hz for airborne applications, using electrodynamic (ED) shakers.

The U.S. Army Research Lab at Adelphi, Maryland pioneered the use of three mutually perpendicular ED shakers to solve a problem: a land-vehicle assembly frequently failed in the field. SESA shaking could not replicate the failure. Army researchers hoped that MEMA shaking *would* replicate the failure. MEMA did the job and several similar instances have occurred over the years. This system can shake vertical only or north-south only or east-west only or any combination of axes including all three simultaneously.

A second system was installed at White Sands Proving Ground, New Mexico. Partly because 810F is SESA oriented, this system is little used.

The U.S. Navy recently acquired its first MEMA system at Keyport, Washington.

The U.S. Air Force owns and Boeing operates an eight-shaker MEMA system that goes further. Their system can in addition vibrate roll-only or pitch only or yaw-only or all six axes (6DoF) simultaneously.

Commercial Multiaxis ED Shaking

Can commercial enterprises afford three ED shakers, each with its own power amplifier and control channel? In 2008 they'll moan that they can't afford multiaxis shaking, but by 2018 such systems will be common.

I remember my pre-teaching days, selling electrodynamic (ED) shakers. Some potential customers balked at buying even one ED shaker, citing the considerable expense. Within a few years, many of those customers owned several shakers. Why? Because the first was so heavily used. Chamber sales engineers have told me similar stories.

Commercial test lab staffs may be interested to learn that shaker systems similar to Figure 1 are said to be quite common among Japanese automobile manufacturers. Figure 1 came to me from Spectrum Technologies at Redford, Michigan www.spectrum-technologies.com, said to be the only US commercial

When the controls for a triaxial shaker array are set for pure up-down motion, unwanted lateral motion of the up-down shaker is actively controlled by the north-south and the east-west shaker systems.

►travel expense and living costs?

ERI's "distance learning" program is one alternative. The participant receives a CD with perhaps 1,000 PowerPoint slides, some of which are animations; others are video clips. At the end of each lesson (33 lessons) he/she opens a quiz, answers questions, works problems, etc. and e-mails his/her work to Wayne for grading. This approach is much work for each participant and for Wayne, and so is quite expensive. But it has worked for ten years!

NEW! NEW! NEW!

ERI's new "Vibration and Shock Video Training" solves many of the difficulties listed above. It will be shot over the heads of participants at Wayne's August 20-22, 2007 class at the Santa Barbara Harbormaster's Office. Participant questions, comments and arguments will add variety.

To see a prototype of Lecture 20 on random vibration, visit this link, shot in a small studio, where Wayne couldn't move around. A hand-held camera shot closeups. The August class will provide classroom flavor.

We expect to deliver the new Video Training Program in Streaming Video and DVD formats. Inquiries are invited.

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environmental test lab having 3-axis ED shaking capabilities. Mike Pickel at 313-387-3000 offers details.

Less Expensive Approach #1 to Multiaxis Vibration

The Tilt" fixture of Figure 2 skews the test article relative to shaker vibratory motion. In my opinion this is not multiaxis vibration. True, there is a component of motion in the specimen's X, Y and Z axes, but the correlation is 100%. Don't think

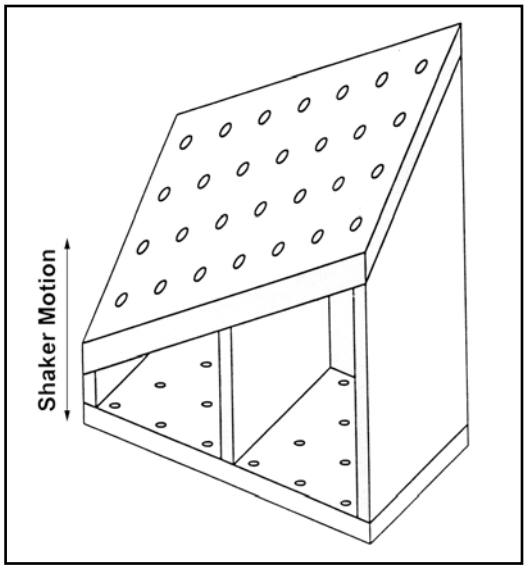

Figure 2 - 'Tilt' fixture skews the test article relative to single-axis shaker vibratory motion.

you are simulating the "real world," where a specimen's X, Y and Z inputs are often much different.

Less Expensive Approach #2

The idea of Figure 3 is several non-synchronized pneumatic hammers tilting upward into the bottom of a softly-sprung "6DoF" horizontal multiaxis platform, on different (but adjustable) compass headings.

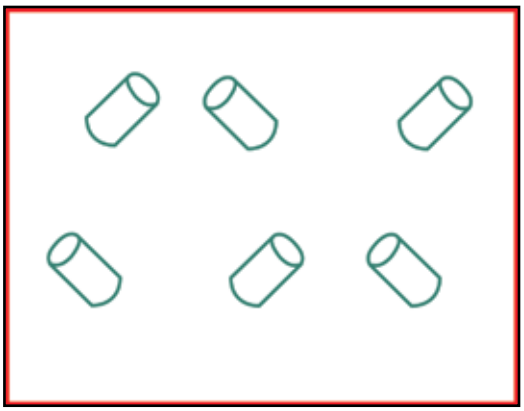

Figure 3 - Non-synchronized pneumatic hammers on bottom of multiaxis platform excite test articles on top.

Their non-synchronized programmed repetition rate hammering results in translational and rotational (six axes) motion. The platform serves as the bottom of a varying-temperature chamber. Test articles atop the platform receive thermal cycling + multiaxis vibration. Several manufacturers offer these HALT (highly accelerated life testing) and HASS (highly accelerated stress screening) chambers. They effectively **stimulate** failures; but there is no attempt to **simulate** the "real world." There is little control over

Without question, variable-repetition rate hammering induces failures by simultaneously exciting all test article resonances. Such units are being used widely to find design and production weaknesses in electronic assemblies. But many reliability engineers question the use of a tool whose vibration is poorly controlled in both the time and frequency domains. Repeatability is questionable.

From Wayne: "I'm willing to share some of my PowerPoint slides (including these figures) showing some of the military multi-shaker systems mentioned herein. Ask for my paper entitled "MIL-STD-810G will better define Dynamic Tests" at the 2007 Spacecraft & Launch Vehicle Dynamic Environments Workshop June 26, 2007 at El Segundo, California.

Wayne Tustin, ERI's president, can be reached by e-mail or phone (805) 564-1260. Read more about Wayne online.

Have you visited FindaLab.net yet?

FindaLab helps test engineering personnel quickly locate qualified environmental labs to perform testing operations. At www.findalab.net, you can perform searches by location or test capabilities and get a list of capable local environmental testing, HALT/HASS or Package Testing laboratories in a few seconds. And it's free for Labseekers!

Lab Marketers still have a chance to take advantage of FindaLab's free trial period, which will end on November 1st, 2007. It's easy and simple to enroll. Just visit http://www.findalab.net/join.php to learn more.

http://www.findalab.net

Training in Engineering Judgement

Many decisions are to be "based upon engineering judgement."

ERI may offer a short course on Engineering Judgement - if we can find an instructor who thinks he/she is qualified. Please call Wayne Tustin at 805/564-1260 or e-mail.

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resources, and of course, the players. The players are the ones who have to implement top management's and the coach's plays to be successful. The players must believe in the game plan (process). To be a winner the coaches know that they have to have a strong running game, a deceptive passing game, and a versatile kicking game.

If the line coach sees weaknesses in the right side of the defensive line he will study the plays and the players to learn their weaknesses. If the offensive coach has a quarterback who can throw the ball into an opening that was created by a deceptive running back and hits his receiver perfectly, and yet the ball falls incomplete to the ground, he knows he has to improve performance. Through observations the coach may find that the receiver is taking his eyes off the ball. As a result, the player's hands aren't ready to clasp the ball at the precise moment. One last detail, one seemingly trivial task needs to be controlled for completion of the pass. Follow-through by everyone who is part of the process is absolutely required to be successful to win the game.

The FMEA process is not unlike the pass play in a football game. It is completed by a group of people who gather to identify weaknesses in a design. In a typical FMEA the team may identify a small resistor, that if it were to open, would cause power supply voltage to double, thus destroying surrounding componentry. As part of the FMEA process the group readily determines that because resistors are extremely reliable this failure is an unlikely outcome. Upon further investigation one member of the team points out that the resistor is to be located near a corner mounting hole. He points out that when printed circuit boards are installed and removed there is good deal of flexure of the circuit board at and near the mounting holes. Resistors placed in close proximity to significant board flexing will cause the solder connections at the resistor to flex, possibly enough to cause a crack. This failure may occur at the first time of flexure or over time. An open resistor or open connection to the resistor will, in this case, cause power supply overvoltage and much damage. A probable outcome of this observation will be to make a recommendation to ensure that the resistor is mounted where little flexure will take place. This means that one of the team members will be assigned that task with a date for completion. The person assigned this task must be certain that the information is accurately given to the printed circuit board designers and that they understand where acceptable resistor locations might be. Then, after the printed circuit board is fabricated, this FMEA team member must verify that the resistor is in an acceptable location. This is closure. This is follow-through. This is reliability.

In football, a lack of follow-through may range from an incomplete pass, to a missed block, to running in the wrong direction. Too many of these mistakes will lead to a lost game and a lost season. Knowing what you are supposed to do and executing every detail leads to success. Follow-through to closure, when done in football or in business, will ensure reliability of the outcome.

Follow-through in HALT is no different. In the FMEA process the findings are theoretical and probabilistic. In HALT the findings are real. Remember that the failures discovered in HALT will bear a strong correlation to the failures that may be found in the field. Correcting them before shipment is the intent of the process. After the failure is encountered during HALT, the first step is to find the actual failure. Then you must investigate still further to determine the root cause, and the actual physics that led to the failure. At this point in the process you are half done. You must still identify what action is needed to prevent this failure from re-

2007 Vibration and Shock courses coming up

Wayne and several ERI specialists will teach short courses on vibration testing, shock testing, measurement, analysis, calibration, HALT, ESS and HASS at the following locations:

August 20-22, 2007, Santa Barbara, California

October 3-5, 2007, Albuquerque, New Mexico

October 9-11, 2007, San Juan Capistrano, California *(presented by Steve Brenner)*

November 12-14, 2007, Boxborough, Massachusetts

November 13-15, Suzhou, China *(presented by Deepak Jariwala)*

December 4-6, 2007, Detroit, Michigan

Reader Feedback

"I always enjoy reading the "ERI reliability newsletter." In your "Voice of the President" article (May 2007), I noted with interest the quote by Joseph Sullivan, Vibration & Simulation Technical Specialist at Visteon Corp. He commented about more 3-axis shakers being sold in Japan than in the entire United States, relating it as a factor in the "..Japanese gaining automotive market share." This reminded me of our experience in the early stages of the modal testing era in the 1980's when Japan was ordering

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occurring. It will very likely require a design change. So one of the outcomes of the HALT process is a list of recommendations driven from failure and root cause analysis that need to be implemented. And still you're not done. You must be certain that the recommended changes have been implemented and retested to ensure that the changes perform correctly. Again it is follow-through to closure. Without complete closure the HALT process will not yield any improvement in reliability.

No matter how many items you find that need to be corrected in a product your reliability efforts will fail if you disregard follow-through to closure. Finding the problems is only part of the task.

Ted Kalal is a practicing reliability engineer who has gained much of his understanding of reliability from hands-on experience and from many great mentors. He is a graduate of the University of Wisconsin (1981) in Business Administration after completing much preliminary study in mathematics, physics, and electronics. He has held many positions as a contract engineer and as a consultant, where he was able to focus on design, quality, and reliability tasks. He has authored several papers on electronic circuitry and holds a patent in the field of power electronics. With two partners, he started a small manufacturing company that makes hi-tech power supplies and other scientific apparatus for the bioresearch community. Ted is currently consulting in the field of reliability focusing on HALT/HASS, Design & Process FMEA, and Reliability Assessments. (www.reliabilityhelp.com).

Mark Levin is a Reliability Engineering Manager at Teradyne, Inc. in Agoura Hills, California. He received his Bachelor of Science degree in Electrical Engineering (1982) from the University of Arizona and a Masters degree in Technology Management (1999) from Pepperdine University. He has more than 23 years of electronics experience spanning the aerospace, defense, consumer, and medical electronics industries. He has held several management and research positions at Hughes Aircraft's Missiles Systems Group and Microwave Products Division, General Medical Company and Medical Data Electronics. His experience is diverse, having worked in manufacturing, design, and research and development. He has developed manufacturing and reliability design guidelines, reliability training, workmanship standards, quality programs, JIT manufacturing, and ESD safe work environments. He has also installed surface mount production capability and design guidelines. Mark is doing post graduate studies at the University of Maryland in Reliability Engineering. (Markalevin@aol.com)

more PCB Modal Excitation Hammers for structural testing than were ordered by any other country. Clearly, they identified "test,test, test,test,test" as a key to their marketing thrust."

Jim Lally, Chairman
PCB Group

Fixture, Acoustics and Shock Isolation courses coming up

Steve Brenner, who has been working in the field of environmental simulation and reliability testing for over 30 years, will teach "Vibration and Shock Test Fixture Design

- October 22-24, 2007, Easton, PA
- November 13-15, 2007, Roy (near Salt Lake City), Utah

Ravi Beniwal, Senior Diagnostician at SenSound, a relatively new Detroit firm, will teach:

- "Where is that Sound Coming From? October 22-23, 2007, in Detroit

Herb Lekuch, with extensive background in mechanical design, analysis and test, developed over 30 years of aerospace, military and industrial experience, will teach:

- "Enclosed and Shock Isolated Shipboard Electronics", October 16-17, 2007, at College Point, NY

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Test Lab Musings (part 17)

by Robert L. Renz

Speaking of cleaning accelerometer connectors – does your shaker slip table have an open oil trough? If it does, perhaps you've seen for yourself how any dropped cable connector leaps into the oil every chance it can. Some new shakers have a slot milled along the sides of the slip table, plus a shield that partly slides into the slot. In addition to keeping miscellaneous nuts and bolts out of the oil, it also keeps your cables high and dry. It might be worth adding to your shaker as a retrofit.

How do you mount a control accelerometer on your head expander? In the past, I've used various 10-32 adapters that bolt into an existing expander bolt threaded hole (drawback: Simple, but requires space), I've drilled and tapped 10-32 holes in the expander shoulder (drawback: Murphy's Law always requires that your fixture covers the existing 10-32 holes), and I've used adhesives to anchor an accelerometer mounting base to the expander (drawback: cleaning the adhesive residue from the head expander). One idea to consider is a short section of hex stock, threaded male on one end to screw into an existing head expander mounting hole, with the other end faced off, drilled and tapped 10-32 for your control accelerometer.

Speaking of holes in a head expander / slip table, a few months ago, I got rid of an old slip table from a long-gone shaker. When that shaker was in use, the operators drilled mounting holes directly into the slip table instead of using a fixture. Why is anyone's guess. By the time I got rid of that table, I didn't know if it was magnesium scrap or stainless steel scrap from all the holes that had been drilled and all the inserts that had been installed…..

I recently moved all my signal conditioners to a rack cabinet with a hinged center section. Now I can access the signal conditioners without disconnecting them. The serial number of each conditioner is duplicated on a permanent label on its front. Calibration tags at the end of each row of conditioners. That way, I don't have to disconnect and remove the conditioners to see the serial number and the calibration stickers.

Robert L. Renz of General Dynamics - Advanced Information Systems at Bloomington, Minnesota.

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Conference on Acoustic Emission

The Fifth International Conference on Acoustic Emission, the 50th meeting of the Acoustic Emission Working Group and its 40th anniversary. Harvey's Resort and Casino, South Lake Tahoe, NV. October 29 - November 2, 2007. Contact: Allen Green, GreenA4@asme.org Phone: 916 483-1311. Fax -2124, or at www.aewg.org.

Selecting Your First Shaker?

Every year, a few companies or agencies invest in their first shaker: electrodynamic (ED) or electrohydraulic (EH) - sometimes called servohydraulic.

Often the individual who is assigned to make that selection lacks an appropriate background. Are you that individual?

ERI has several specialists who can help you make that selection. I'll be happy to introduce you via e-mail and phone to several of our specialists.

Is Anyone "Unwired"?

Does any reader happen to know someone who doesn't use computers but who is somehow involved in environmental or transportation testing or in stress screening?

Please tell him/her to communicate with ERI (contact info below).

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