Learning How to Read Between the Lines of Accelerated Testing Chamber Specifications

Determining which HALT or HASS chamber can best meet your reliability program requirements takes more than a quick glance of spec' sheets.

For those engineers who are not accelerated testing experts, but yet surveying the market for the best value in HALT and HASS chambers, the industry is full of bewildering and confusing "specmanship" claims. A larger value of itself does not guarantee better performance in actual use, and sole reliance on the data supplied from most specification sheets is a recipe for disaster. The subtleties of accelerated testing chambers cannot always be easily boiled down to readily quantifiable attributes. Instead, it takes an educated eye to see beyond the printed figures to understand the true performance factors of any given chamber.

New specs for new testing procedures

HALT (Highly Accelerated Life Testing) and HASS (Highly Accelerated Stress Screening) have been recognized as one of the fastest and most effective new disciplines for design verification testing and production screening—allowing a broad range of industries like consumer electronics, medical, automotive, military and aerospace to bring products to market quickly with reduced design and warranty costs.

But modern accelerated chambers come with their own set of parameters which go beyond those of traditional electro-dynamic (ED) shakers that are designed to test *to* a design spec'. Therefore, consider data such as "thermal ramp rates" and "vibration frequency and energy" as merely the starting points for comparing the new repetitive stress (RS) chambers utilized for HALT and HASS that incorporate stresses *in excess* of that found in the field.

Ideally, the best way to choose a chamber is to take a design under test (DUT), seed it with known failures, and have each of the manufacturers under consideration subject the product through an abbreviated HALT test. The most effective chamber will be the one that finds most or all of the failure modes. Secondly, a visit to each manufacture allows an engineer to observe

how each chamber is designed and built, and to discover what support resources are available to help initiate and optimize a HALT/HASS program.

Since neither of these approaches is seldom practical, the next-best way to begin evaluation is to obtain as much detailed technical information as possible. Digest it with the following considerations in mind.

Temperature ramp rate and air velocity

"Almost by definition, a HALT chamber must have very rapid thermal transition rates that border on being classified as thermal shock," says Tom Peters, Senior Application Engineer for QualMark. "This is important because the faster the rate, the greater the stress you're going to apply to the product. As an example, some of our tables can go from –100° C to +200° C, at 60° C per minute."

Denver, Colorado-based QualMark Corporation is a leader in designing, marketing, and manufacturing accelerated testing systems. By virtue of conducting more than 4,000 tests within in its own lab facilities, and installing and maintaining over 700 chambers in 30 countries, QualMark has earned the position as the Knowledge Leader in accelerated testing methods.

With five of years of accelerated testing experience behind him, Peters points out that engineers should delve beyond the temperature ramp rate, as this figure may reflect only the temperature of the *air* within the chamber, as opposed to the temperature of the *product* within the chamber.

"Some manufacturers specify a ramp rate based upon a thermocouple hanging in midair within the empty chamber, but for the application of HALT and HASS, you must be able to move the *product* temperature at a very high rate of change in order to detect weaknesses in a compressed time environment," Peters reiterates.

When considering airflow, the typical velocity in a standard thermal humidity chamber is around 400 to 700ft/min., whereas the air velocity in high performance, purpose-built HALT chambers

approaches 4,000ft/min (see Graph 2). This difference in air velocity is crucial to the thermal ramp rate performance of the chamber, but still does not tell the whole story.

"The air management system is the critical element affecting the thermal performance of a chamber," stresses Peters. "The air boundary layer on the components and assemblies must be overcome in order to rapidly change *product* temperatures, as required in HALT/HASS processes."

Here, an evaluation of the construction of the chamber helps determine effectiveness. For example, the carefully engineered use of a plenum and ducting helps maximize air volume over the product by creating a turbulent—as opposed to laminar—airflow. Turbulent airflow extracts the greatest BTU change rate on a product (see Graph 1).

Air management also plays a significant part in the thermal efficiency of a chamber. If more BTUs are more quickly transferred to the DUT, then less energy is required to run the chamber. For example, QualMark makes a HALT chamber that achieves a rated ramp rate of 70º/min with 100AMP service. If another comparable chamber requires 160AMPs to achieve the same ramp rate, then it will incur greater utility costs.

"One way to compare thermal efficiency is to develop a standard HALT test profile and then ask each manufacture to calculate the energy consumption for the standardized test," adds Peters.

Vibration frequency and consistency

Random vibration specifications are often the most confusing of any data published for accelerated testing chambers.

The maximum vibration of a HALT/HASS system is usually expressed in units of gRMS. This value represents the root mean square value of the acceleration (measured in Gs) of the vibration system at maximum control set-point over some defined frequency band. This specification is usually based on an unloaded table, but as Peters points out: gRMS data on an empty table is useful only for an empty table.

What is needed to properly evaluate a *loaded* vibration system is information about the energy distribution within the specified frequency range, as this can vary wildly for the same level of acceleration (see Graphs 3A and 3B, which represent 30 gRMS, but at different energy distributions).

"If plotted—with frequency along the x axis, and gRMS along the y—the ideal wave form would be a horizontal straight-line; i.e. all energy is equal across the entire frequency range," explains Peters. "While it will never be perfectly straight, you want that line to be as flat as possible. A frequency distribution of +/- 6 db from 200-2000 Hz would indicate a well-designed repetitive stress table."

On the other hand, the worst scenario is to have major gaps (often referred to as "picket fencing") in energy across the frequency spectrum (see Graph 5). This can happen on poorly designed systems and can also occur on systems that are dependent on pneumatic modulation in an attempt to get good frequency distribution when they are run near maximum vibration levels.

"The whole idea of vibration is to excite all the resonant frequencies of a product, but if you have energy missing in big gaps, then you're going to miss problems," says Peters.

Typically, electronic and electro-mechanical products have resonances from below 1,000Hz for discrete components such as transformers, heat sinks, torroids etc., to above 4,000Hz for SMT (surface mount technology) components. In order for a vibration system to be effective across a wide range of applications, it must produce energy across a broad spectrum of frequencies—ideally from 10Hz to 5,000Hz.

"One way of addressing this issue is by having several different types of hammers underneath the RS table, each with different repetition rates to ensure thorough fill," observes Peters. "A very low rep' rate, say 10Hz intervals, ensures energy at 10, 20, 30, 40, 50, 60Hz, etc. In this manner you get a complete spectrum with very little, if any, gaps."

When addressing the issue of vibration consistency across the X, Y, and Z axis: ideally, a table will have fairly equal energy in each of the three axis vectors. This would be represented by a ratio between any two of the axes approaching 1:1. However, as for other specifications, this data may not prove useful if it is expressed using an empty, flat table. In reality, the ratio of X and Y to Z will vary with the load, and with the height that the DUT is fixed above the table.

"If you think of the RS table as the hull of a sailboat, and the mast the distance above the table that your product is fixtured to, you can easily visualize that the higher above the table, the greater will be the X and Y motion relative to the table surface," illustrates Peters. "So if the X, Y and Z ratios are expressed at a *set* distance above the table surface, then this gives you a better picture of the actual energy in each axis that your product will experience."

Adding it all up

Since the majority of failures in the field are caused by thermal and vibration stresses, getting behind the numbers on these particular specifications can provide the greatest return on HALT/HASS program dollars. Ultimately, the most useful specifications to make valid chamber comparisons would be those that are based on a mass that closely represents your product. At least with technically definitive manufacturer's data, an engineer can make an informed decision as to which chamber will best help the organization attain its reliability goals.

For further information, contact QualMark via Jeffrey Hale, Vice President of Sales and Marketing at 303-876-0614 or by email: jhale@qualmark.com.

By Dave Rizzo

Dave Rizzo is a freelance writer based in Fullerton, California

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