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Pitfalls to Avoid in HALT and HASS

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Much has been written on what to do in HALT and HASS. What not to do should also be discussed in order to enforce the positive. Some of the most commonly occurring mistakes will be discussed and it will be pointed out why each is a mistake. The mistake is first stated in bold type and then is discussed very briefly. All of these are covered in more detail in my textbook, *HALT and HASS, Accelerated Reliability Engineering*, which is sold through Hobbs Engineering.

Not performing Safety of HASS.

This is one of the worst possible mistakes that can be made and is somewhat equivalent to playing Russian Roulette with several cylinders loaded. Highly Accelerated Stress Screens are quite capable of reducing the usable field life of good hardware if the stresses are chosen to be too high for the design and processes under which it is built. If HALT has been properly done, then this rarely occurs. If HALT has not been done at all or if the margins attained are not high enough, then field life reduction may occur. The only way to reasonably prove that the screens are safe to use in production is to run Safety of HASS. If this is not done, then the field failures will determine if the HASS has been proper or not. Clearly, this wait and see approach is not a good way to find out if the screens are too intense as, by the time it is recognized that the screens are too intense, substantial numbers of reduced life units will have been shipped. <u>Safety of HASS is mandatory for proper technique.</u>

Not monitoring with high coverage during stimulation.

This is also one of the worst possible mistakes that can be made and usually leads to a substantial financial loss. What will usually happen in this situation is that flaws will be precipitated but not detected and then the customer will have failures due to precipitated defects soon after delivery leading to a very unhappy customer and many field returns. It is suggested that if one cannot monitor the product to at least a modest extent during stimulation with the various stresses, the whole idea of HALT and HASS should just be abandoned. HALT and HASS (as well as classical screening and testing) without good coverage are less than worthless! Coverage can be determined and improved significantly by performing Software HALT™.

Not using accelerated stress conditions.

If accelerated stress conditions are not used, there will be no time compression. If only singular stresses are used, then the acceleration factor will be less than 1, that is, slower than in the real world conditions which are almost always combined stresses. Without using accelerated stresses, it will take years to mature a product. This has been the result of classical validation testing as used by the auto companies in the past and of qualification testing as used by the military contractors in the past, and to a large degree, today. Compliance testing is not suitable in today's accelerated product development scenario as there will be little discovered in the time available. Test to fail techniques such as HALT, which are discovery testing, have replaced the success-run techniques as the prevailing paradigm among the reliability leaders of the world. Unfortunately, most of the leaders do not publish because of their advantage which they desire to keep to themselves.

Selecting a screen using seeded samples.

This can be a major blunder which seems to be somewhat popular. The flaw in this approach is one of skill on the part of the experimenters who may not be able to place flaws at highly stressed areas of the product. Knowing where to place the seeds requires knowledge of stress distributions due to vibration, thermal cycling and electrically induced stresses. Most investigators do not posses such skills and so place flaws (seeds) in some areas of relatively low stress. When the overall stress levels are increased until the seeds fail, the overall stress level may be way too high. If Safety of HASS is performed, then this situation will become apparent. However, if Safety of HASS is not performed, then some areas in the product will have entirely too high stress levels and severe life reduction will take place.

Using a heritage screen.

In this approach, one uses the screen that was used successfully before. Even if a screen were used successfully before, there is no guarantee that it will work on the current products unless Safety of Screen and Screen Tuning are correctly done and demonstrate that the chosen stress levels are appropriate for the product. In general, screens are very product unique and must be individually developed using the techniques in my textbook.

Not improving the product to the fundamental limit of the technology.

When a weakness is found in HALT, the situation presents an opportunity for improvement. If advantage is not taken of the opportunity, then progress toward a failure free product will have been lost. It is generally found that almost everything found in HALT will show up in the field sooner or later. During HALT is a perfect time to improve the product as much as possible while it is cheap to do so. Later the fixes will be very expensive and the HALT investigator will appear to be very incompetent when the same failure modes are discovered in fielded hardware. Usually, anything that shows up in HALT will eventually show up in the field. One does not design to the expected HALT environments. HALT only identifies the weaknesses very quickly. It is generally very easy to improve the product to the point where it is more robust than it needs to be without spending undue funds in doing so. Since this is usually the case, it is foolish not to gain the very large margins that lead directly to high reliability and cost little or nothing to obtain. Everything found does not have to be improved, it just needs to be considered and those improvements that will improve field reliability or reduce cost are the ones that need to be done. It is better to err on the conservative side than to miss an opportunity. Hewlett-Packard found in the 1990’s that an average cost of missing an opportunity in STRIFE usually resulted in $10,000,000 in field failures before a fix could be implemented.

Not using HALT and HASS unless your competition is openly admitting to or advertising doing so.

Many companies that are successfully using the methods will not admit to doing so as they have a technical and financial advantage with the use of the methods and it is to their benefit to remain quiet. Do not assume that a particular company is not using the techniques just because they will not admit to doing so. The author has worked with numerous companies that will not admit to using HALT and HASS. Many of these companies are among the world leaders in product quality and reliability.

Needing to verify that HALT and HASS will work on one's own products before starting a program.

This seems to be human nature and occurs very frequently, many times because some of the results that have been reported seem far too good to be true. The methods are extremely versatile and have been used on hundreds of types of products. If one can figure out what failure mode is sought and how to stimulate the mode to occur and then detect the fact that a precipitated defect is present, then one can perform HALT and HASS very effectively. If one cannot figure out what failure mode is sought and therefore what stress(es) to use to activate it, one can just use the whole gamut of stresses and find out what shows up and fix those modes that seem to be relevant. Focus on the failure mode and not on the stress type or level which exposes the flaws. To focus on the stress type or level will lead to the conclusion that one should not fix many relevant flaws that should, in reality, be fixed. Many an amateur at HALT has discovered this after it is too late to fix the problem at a reasonable cost.

Requiring uniformity of stresses on various units.

The tables designed for HALT and HASS generally have large observed variations in spectrum and overall level as one moves accelerometers around the table surface. This is not intentional by the designers but just comes out that way. It has been shown that uniformity is not necessarily required for excellent screens if HALT has been properly done as well as Safety of Screen and HASS Optimization. Buying one of the six degree of freedom tables specifically designed for HALT and HASS and then mapping it out and trying to obtain uniformity will probably slow the introduction of use of the table by a large time factor during which time one could have been making progress in HALT or HASS. Safety of HASS and HASS Optimization will determine if the uniformity is good enough, whatever it happens to be. I wrote an extensive paper on this in 1981. A copy is available upon request.

Missing the fact that the lowest and highest frequency modes of your product must be stimulated in order to perform a good HALT or HASS.

In general, all significant modes in all six directions must be excited to a reasonable level in order to obtain the desired effect. In addition, one must be able to monitor the product under test and to be able to detect any anomaly that may occur. This means that a broad-band all-axis excitation system that has little or no emitted magnetic field should be used. In specific cases such as simulating a vehicle passing over speed bumps or some other narrow band event in principally one direction, this comment does not apply and single axis hydraulic shakers may be the optimum choice.

Using fixturing that does not transmit the stress to the product under test.

This is a lost cause because sufficient levels of the stress never reach the product. Three examples are:

1. Using a vibration fixture that will not transmit the frequencies associated with critical modes of vibration of the product under test or isolates the mid-and high-ranges.
2. Using a thermal fixture that does not transmit the conditioned air to the product such that the product can be rapidly changed in temperature over a broad range.
3. Using electrical overstress and having some circuitry such as the lightning arrestor circuitry bleed off the high voltage before it gets to the internal circuits.

If the stress does not get to the product, then nothing has been accomplished. The author has seen all three above examples and more in the field over the years.

Using inappropriate vibration and thermal equipment.

Companies frequently find themselves becoming interested in the methods after acquisition of the equipment to do the old "MIL-Spec" type of tests (compliance testing) which are conceptually totally different than the accelerated philosophy. The HALT and HASS methods are intended to break the product under test if it has a weakness where the old MIL-Spec tests were intended to accurately simulate the environment one stress at a time with the goal being to demonstrate sufficiency--not to find and fix problems. Further, the tests were often tailored for passing by clipping all stress levels above 3 sigma vibration levels and maybe even notching out troublesome frequencies. Most classical test equipment cannot even get close to simulating the real environments much less stimulating to time compression levels. The obsolete equipment can still be used for a low stress HALT and HASS program to the point of demonstrating that the techniques work on the products produced by the company before the purchase of the equipment specifically designed for HALT and HASS.

Not using simultaneous excitations of appropriate stresses.

This mistake is not only technically much less effective than combined excitations, but is also much more expensive as it requires more test equipment to monitor the product under test. In some comparisons, specifically in the author's seminar workshops, 100% of the defects detected using Modulated Excitations could not be detected at all with single or combined excitations. Combined excitation is a quantum leap ahead of single excitations in effectiveness and is several times more effective in terms of cost due to reduced instrumentation and floor space required. Modulated Excitation is a quantum leap better than simple combined excitations in many cases. Several discoveries of precipitated flaws were only observable at very low GRMS levels, below 1 GRMS. Only some HALT systems will start and run at these levels without mass loading of the shaker which reduces the dynamic range.

Not using Modulated Excitation during detection.

Experience has shown that modulated six-axis vibration combined with slow temperature changes have exposed many flaws that could not be found any other way. Modern HALT and HASS equipment will easily do the modulation and it increases detection efficiency by at least a factor of ten or more in many cases. It has been repeatedly demonstrated that patent defects could not be found until the Modulated Excitation was done. Many times, 100% of the patent defects cannot be found without it. This is especially true for cracked plated through-hole solder joints and cracked surface mount solder joints. Very low vibration levels are important if not essential.

Not performing Re-HALT.

The strength distributions will be pushed as far as possible from the in-use environments during HALT. Screens will then be selected, proven to be safe and optimized done. If the strength distributions subsequently move toward the center, as one is assured that they will by the Second Law of Thermodynamics, then Safety of HASS and HASS Optimization will both be nullified. In this case, HASS can take an unacceptable amount of life from the products leaving them unable to make it through a normal lifetime without failing in a wear out mode. The author has seen several companies make the mistake of assuming that everything would remain the same when it did not and never will. The results were screens of intensities that were too high for the product with its reduced margins resulting in many early field failures. In two of these cases, essentially the entire population failed during the warranty period. It does not get much worse than this! Keep those margins up with Re-HALT.

Performing Proof of Concept on a mature product.

The point of Proof of Concept is to demonstrate that the methods work on your products. If a mature product is subjected to HALT, nothing should be found. This defeats the test goal and will lead to the incorrect conclusion that HALT does not work. It is suggested that one take a known problem product to the Proof of Concept demonstration so that there is something to find and the process can be proven to work. This will convince all concerned that the methods very quickly expose weaknesses in the product.

Concentrating on short-term costs.

This has been the classical failing of American management over the last few decades. One must get beyond thinking in terms of shipments this quarter regardless of reliability resulting from the necessary shortcuts taken to obtain the "numbers" and focusing on short-term outputs at the expense of long term attainment of goals. In many instances shareholders and owners are interested in the long term profits and stability of the company. Management attitudes should reflect this interest. HALT costs money up front in the design phase, the returns come later in design, production and field service. The emphasis should be on long-term profitability that can be gained with a comprehensive HALT and HASS program, not on short-term gains to meet this quarter's projections.

Not optimizing the HASS.

The task of optimizing HASS is relatively simple and straightforward. It usually takes a few weeks to accomplish in high production programs. Cost savings have amounted to 50-80% of the pre-optimization costs in many cases. Considering the costs of HASS during a high volume production program, it only makes sense to reduce the cost as much as possible while also proving that the HASS regimen exposes all flaws that are present. If the initially chosen HASS regimen is not quite enough to precipitate all latent defects, then those remaining will occur in early field life, perhaps during the warranty period.

Outsourcing without closed loop corrective action.

Many companies outsource anticipating economy of scale. Precipitation, Detection, Failure Analysis, Corrective Action and Corrective Action Verification should all be done at one location in order to be effective. The manufacture's plant is the correct place to do them. There is a section in my seminar on disasters created by outsourcing and how to prevent them.

Terminating HALT and HASS activities after initial successes.

Some companies have terminated HALT and HASS activities after attaining the position of world leader in their field using them (and other techniques as well). The Second Law of Thermodynamics states that this position cannot be retained without utilizing a vigorous HALT and HASS program, perhaps using HASA (Highly Accelerated Stress Audit). Designers will go back to their old ways if the product does not face HALT before production. Regression from HALT has been observed several times by the author. It is a real shame to attain the lead and then to regress to the back of the pack.

Attempting HALT and HASS without education on the technology.

Education is fundamental to success in many scientific fields including this one. Without a basic understanding of the principles and techniques, the person attempting HALT and HASS can be expected to make all of the mistakes listed herein and maybe more. People call wanting to obtain the "spec" for HALT or the "spec" for HASS or the source of the "software to test the product during screening". All of these demonstrate a lack of knowledge in the principles of HALT and HASS. Many attempts at HALT and/or HASS have been made using knowledge gleaned from published papers. Since many of the published papers display one or more of the mistakes covered herein, the success of such attempts can be readily seen to be sub-optimum.

Using MIL-Handbook 217 or its Derivatives.

Some well-known documents such as MIL-HANDBOOK 217 and derivatives of it treat all flaws as all being precipitated by temperature alone, which is completely erroneous. Some component problems can be found by burn-in and that is why the component manufacturers use burn-in so successfully. Many companies that are assembling above the component level are discontinuing burn-in as it has not been found to be cost effective. In order to test this thesis, it is suggested that HASS be performed and then, on the same products, burn-in performed. It generally is found that very little is discovered in the burn-in. When the cost of performing burn-in is considered, the usual decision is to terminate the burn-in. Most of what can be found by burn-in can be found in a proper HASS thermal cycle. As a matter of general interest, the Arrhenius equation has been incorrectly used to describe any number of failure modes which do not follow the equation at all. MIL-HANDBOOK 217 was a prime example of the rampant misuse of the equation. In my opinion, MIL-HANDBOOK 217 should be immediately placed in the shredder. MIL-HANDBOOK 217 will go down in history as one of the biggest impediments to progress ever promulgated on the technical community. The ISO 9000 series may be in the same league, but may have some value for companies with little quality organization. Only recently has corrective action been included.

Conclusions

Properly performed HALT and HASS have been shown to be extremely effective in terms of cost and reliability obtained. Commonly made mistakes can be prevented by education on the correct principles and applications of the methods.