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Elimination of the No Defect Found Problem

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Introduction

A problem that has existed for many years is that of the No Defect Found, Can Not Duplicate or Retest OK as it is called by various people. These all relate to field failures that can not be duplicated in the rework area and therefore can not be fixed. Usually these units are returned to the field as suitable for service only to fail again, frequently on the next usage. I have experienced this myself in aircraft avionics which failed many times and were "fixed" or "retested OK" many times. This continuing problem results in many field failures, some critical to safety, and to many retest actions. Some military repair stations have a vast supply of NDFs hanging around, all of which have been replaced by new units at great expense. Over the years, I discovered clues to the solution of the problem and finally put all of the clues together to come up with a solution.

The Solution

A solution to the problem of No Defects Found, Retest OK, No Fault Found or Can Not Duplicate has been developed. These unfound and therefore unfixed problems can run over 90% for many high tech products such as avionics, automotive electronics, commercial electronics, medical, etc. It is generally agreed that there are many "bad pulls", that is, a box that was taken out when there was indeed nothing wrong with it. Bad pulls are frequently committed due to time constraints (such as to get an airliner into the air). Everything that could be causing the problem is changed out and sent to the repair station where the technician faces numerous boxes with no defects at all. This paper does not address the bad pulls, but just notes their existence for completeness. The methods presented will, however, prove that the bad pull returned item is really OK.

Also for completeness I will detail the steps in the process. First we need to precipitate a flaw from latent to patent; for example, crack a defective solder joint. Next, we need to detect the cracked joint which requires that the flaw is put into a detectable state (what this paper is all about) and then we need coverage in order to detect the flaw, frequently as an intermittent or something that will only show up under "over spec" conditions. Resolution will help with trouble shooting as it will accurately locate the flaw. Since the conclusions of this paper are not intuitively obvious, I will relate my experiences that led me to these methods that expose the defects in an estimated 95% of what would otherwise be a No Defect Found situation.

In the late 70's and early 80's, I was working on military and NASA hardware. I discovered that many failures precipitated during screens would not later show up on the test bench. We had a small thermal chamber with hand ports available and we also had a miniature vibrator (about 1"x4" in size) and could "buzz" on the product while temperature cycling it during continuous monitoring. Some 40% of the total defects were found this way.

In an attempt to find the rest of the defects, we used a single axis electrodynamic shaker within a thermal chamber and performed "vector" excitation. We had an adjustable fixture that could shake in any one direction with broadband random. We found absolutely nothing in this manner after spending weeks trying. Finally, we put the unit back into our all axis vibration plus thermal chamber and lowered the temperature 20 or 30 degrees C and applied "tickle" vibration, that is, very low levels of all axis impact random and found the last 10%. An interesting fact is that the conditions under which discovery was made were exactly those of the in-use environment! This is an example of why the techniques being discussed herein were developed.

After learning from this experience, I started using "tickle" vibration after HALT (then known as Design Ruggedization) and found substantial issues that had not been detected during HALT. It seems that some precipitated defects only show up under very low stress levels. Some of the defects in question were plated through-hole cracked solder joints. Later equipments tested included surface mounts, so the conclusions seem to be universal and not unique to plated through-hole solder joints or even to electronics only.

In 1995, I was involved in tests on some 16 units where intermittents were found in many combinations of temperature and vibration. I naturally asked myself "Well, where should I look in the two-space of temperature and vibration?" The answer was "everywhere!" This thought led to Modulated Excitation[TM,1] which is a search of the two space of temperature and vibration to find the combination wherein an intermittent is found. An example is shown below in two different presentations.

In this test, one sweeps vibration up and down while slowly varying the temperature, that is, we are searching the two-space for the combination that will put the system into a detectable state. One could sweep vertically but that would cost substantially more due to the repeated thermal cycling, so horizontally is the economical way to accomplish this search which has been named Modulated Excitation[TM].

There is another way to portray the sweep in the time domain and that is shown below. Both portrayals result in exactly the same search pattern.

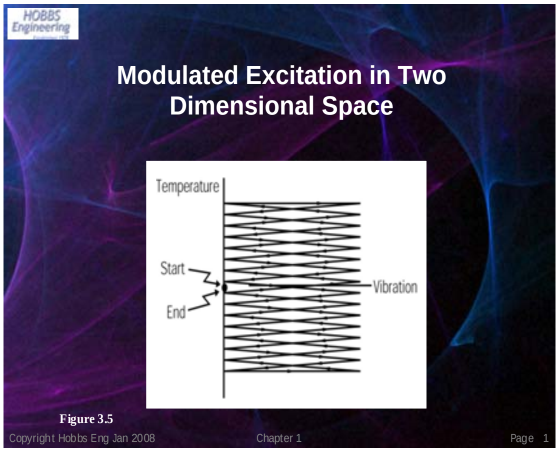

Figure 3.5

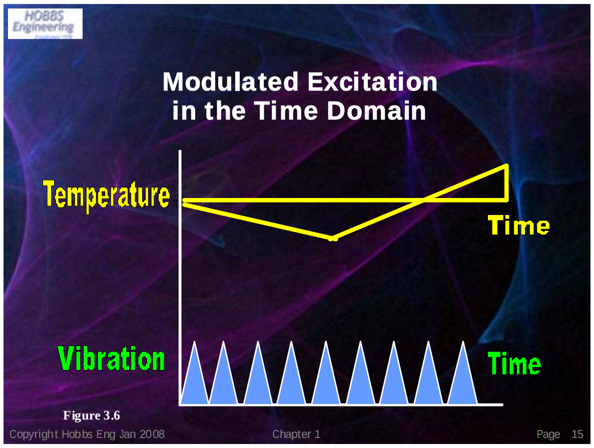

Figure 3.6

When this search pattern was first developed, the lowest vibration available with existing shakers was about 5 GRMS. If I attempted to start below 5 GRMS the shakers would not start and the integral in the control loop would wrap up and the shakers would drastically overshoot, perhaps damaging a product. With the advent of the newer HALT chamber, the shakers could start and run down to 0.1 GRMS as well as to run up to over 150 GRMS! This improvement in the dynamic range of the shakers brought an increase in discovery of about 73% more than had been previously observed as well as to allow larger loads on the shaker or allow higher time compression factors due to the higher vibration levels now available.

Please note that the high levels of vibration are used in precipitation in HALT and HASS and the low levels are used in detection screens in HALT and HASS. This is an interesting application as a technique which was developed for HASS is now used in HALT as well. The invention of precipitation and detection screens had added a factor of about 10x to time compression (that is, shorter by 90%) and now Modulated Excitation which added a 10x gain in detection (that is, 1,000% more discoveries) has gained another 73% (or 1.73 times as many) in detection by using lower GRMS levels for a total of a 1,730% gain in detection! It is therefore quite apparent that huge improvements in the techniques and equipment have been obtained in the last few years.

Let us now consider a few comments about HASS in passing. In my experience of late, about 90% of the intermittents can not be observed without Modulated Excitation. When the shaker is turned off with the temperature held at the point where an intermittent was observed, almost without exceptions the intermittents are not present. When the shaker is turned back on, the intermittents almost always reoccur. This is one of the many reasons that I said in 1981 that the IES Guidelines on ESS were completely in error when they stated that thermal cycling was the most effective screen. Clearly a combined excitation is much more effective.

Another point to be made is that it is almost impossible to drive an intermittent to a hard failure, that is, a failure that shows under bench top conditions. Usually the attempt to stimulate a soft failure into a hard failure will cause something else to fail as well as to do substantial fatigue damage to the product under test. Once the now hard failure is fixed, the intermittent will still be there!

Screening without Modulated Excitation may cause precipitation without detection. This is a terrible situation as most real world environments include modulated stresses and so the precipitated defect will be exposed in early service life in the field, just what we are trying to avoid in using HALT and HASS.

Modulated Excitation with the most capable equipment will increase discovery and allow trouble shooting under stress in the chamber leading to a completed failure analysis and to a proven corrective action. Most of the No Defect Founds can truly be eliminated as many users of this techniques have discovered.

Conclusions

A solution to the No Defect Found problem has been outlined. It has been found to work very well on many different kinds of products over the years since its first inception and has increased the number of defects actually detected by some 1,000% due to the Modulated Excitation. Recent equipment developments have improved the methods by some 73% more. Those rooms full of No Defect Found products that reside at repair stations can now be repaired and returned to reliable service saving huge amounts of money. The No Defect Found problem has been eliminated to a very large degree and the bad pulls can be verified as suitable for return to service with confidence.

1. *HALT and HASS, the Accepted Quality & Reliability Paradigm* by Gregg K. Hobbs, published by Hobbs Engineering Corporation.