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HIGHLY ACCELERATED LIFE TESTING (HALT), HIGHLY ACCELERATED STRESS SCREENING (HASS) AND METHODOLOGY FOR USAGE OF COTS COMPONENTS

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HIGHLY ACCELERATED LIFE TESTING (HALT), HIGHLY ACCELERATED STRESS SCREENING (HASS) AND METHODOLOGY FOR USAGE OF COTS COMPONENTS

1.0 INTRODUCTION

Highly Accelerated Life Testing (HALT) and Highly Accelerated Stress Screening (HASS) are two accelerated methods used to reveal the design and process weaknesses of a product very quickly during the development and production phases. Both rely on time compression concept and use much higher stresses than experienced in the field environments to force failures to occur in significantly less time.

1.1 The purpose of the HALT is to expose deficiencies in the design leading to improvements which may be required to be incorporated into the design **prior to qualification testing.** In HALT, every stimulus of potential value is used under accelerated test conditions to find the weak links in the design and fabrication processes of a product. The HALT process may include all axis impact vibration, broad range thermal cycling, burn-in, over voltage, voltage cycling, humidity and whatever else exposes relevant defects in the product. The stresses are stepped up to levels well beyond the expected field environments until the fundamental limits of the technology are reached. Reaching the fundamental limit generally requires fixing every failure found, even if it is uncovered above the qualification levels. Although it would cost much, the cost of failures if HALT is not adopted would be much more.

1.2 HASS screens use the highest possible stresses, frequently well beyond the qualification level, to attain the time compression in the screens. Many stimuli applied simultaneously results in an exponential acceleration of flaw precipitation. A drastic reduction in time of screening equipment and manpower can be achieved if we use the correct stress. The screens must be of acceptable fatigue damage accumulation or life-time degradation. Using Proof - Of - Screen techniques one or more products are screened repeatedly to show that enough product life is left after performing HASS. Generally HASS is not possible unless a comprehensive HALT has been performed.

1.3 The goal of environmental stress screening is to make the defective / weak areas of the structure fail. With the proper application of HALT, the design will have several of the required life times built into it and only an inconsequential portion of its life would be removed in a HASS. This will be verified in Proof – Of - Screen. The relevant question is "How much life is left after HASS?" and not "How much did we remove in HASS?" It is a fact that all screens remove life from the product. However properly executed HALT and HASS programs will leave enough life left in the product at delivery and will do so at a much reduced total program cost compared to the classical methods.

1.4 Defects of different types have different relationship between stress and the damage accumulation, but all seem to have a very large time compression factor resulting from the slight increase of stress. This is precisely why the HALT and HASS techniques work and are preferred.

1.5 Commercial Off The Shelf (COTS) components are being increasingly used in almost all the avionic equipment. There has been a phenomenal growth in COTS technology and most COTS products show total reliability when used within the limits. There has been an increasing tendency, of late, to use such COTS components outside the manufacturer's specification limits. Whether used within or outside specification limits, HALT and HASS programs provide a means to regulate usage of such COTS components. If found unsuitable during HALT, the COTS components have to be replaced. Both HALT and HASS are carried out at the equipment level and not component level and would uncover any latent failures in the components. If HALT & HASS do not reveal any failures of these components, then use of such COTS components is justified.

1.6 HALT has provided substantial MTBF gains even when used without production screening and has reduced product time to market, warranty expenses, design and sustaining engineering, and total development costs. HALT still is an emerging technology and continues to be improving at an amazing rate. HALT and HASS have application on an ever-increasing number of commercial and military programs. Many of the leading commercial companies use HALT and HASS techniques with all-axis impact vibration and moderate to ultra-rate thermal systems successfully. However, most are being relatively quiet about it because of the phenomenal improvements in quality and reliability and vast cost savings.

2.0 EQUIPMENT REQUIRED

The application of HALT and HASS is generally enhanced by the use of environmental equipment of the latest design. Basically this equipment consists of an all - axis impact shaker and very high rate - of – change thermal chambers (60° C/min or more).

3.0 DEFINITIONS

3.1 HIGHLY ACCELERATED LIFE TESTING (HALT)

Involves the use of environmental stimuli (temperature, vibration, voltage and power cycling) to expose product(s) to high levels of stress in order to precipitate failures that may result from design weaknesses, limited margins and latent defects. The upper and lower operating and destructive limits of the product are to be identified. These limits are required to define product design margins and also to develop screening levels for production ESS / HASS.

The objective of HALT testing is to run a selected number of tests in sequence at test levels in excess of the qualification test levels. The test sequence will then be repeated at progressively higher test levels until a failure occurs. The failure mode will be analyzed with emphasis on improving the design to prevent recurrence of the failure. The UUT will then be repaired and testing will continue until test levels are too high to yield useful information.

3.2 RE-HALT

The verification of the upper and lower operating and destructive limits of a product after the product has been modified. Modifications which change the product's physical layout or change the type of components used whether resulting from the findings during a previous HALT or not, require a Re-HALT of the product.

3.3 HIGHLY ACCELERATED STRESS SCREENING (HASS) FOR PRODUCTION

HASS is a process that utilizes enhanced product testing techniques to detect more rapidly and more thoroughly the process flaws and parts defects. Using highly accelerated techniques like HASS can reduce standard end-product examination methods which often lasting several days down to under 60 minutes. The process is used in manufacturing and allows the discovery of production changes and prevents product with latent defects from reaching the customer.

3.4 PROOF OF SCREEN (POS)

POS process shows that the HASS does not damage / take away much life from products and is effective in finding all the defects present in the production. The POS usually consist of 10 to 20 HASS cycles and detection of failures during the first cycle.

3.5 UPPER OPERATING LIMIT(UOL)

The high temperature or vibration limits below which the product will operate within specifications. At and above this limit the product may still be operating, however, it will not be operating within specification(s). The UOL should be well above the expected normal field operational environment to ensure that the whole population will perform as intended to.

3.6 UPPER DESTRUCTIVE LIMIT (UDL)

The high temperature or vibration limit above which the product will fail permanently. This limit is where hard failures occur. The UDL should be well above expected storage and transportation limits in order to ensure that the entire population will survive. This information will also be used to set the maximum hot temperature limit and the maximum vibration limit of the production HASS to ensure that the life removed from the product due to screening is insignificant

3.7 LOWER OPERATING LIMIT (LOL)

The low temperature limit above which the product will operate within specifications. At and below this temperature the product may still be operating, however, it will not be operating within specification(s). The LOL should be below the expected normal field operational environment to ensure that the whole population will perform as intended to.

3.8 LDL - LOWER DESTRUCTIVE LIMIT

The low temperature limit at and below which the product will fail permanently. This limit is where hard failures occur. The LDL should be well below expected storage and transportation limits in order to ensure that the entire population will survive. This information will also be used to set the maximum cold temperature limit of the production HASS to ensure that the life removed from the product due to screening is insignificant.

3.9 FUNDAMENTAL TECHNOLOGY LIMITS

The fundamental limits of a technology are the levels at which a small increase of a particular stress will cause many simultaneous failures to occur in the product. A fundamental limit is reached when the multiple failures are the result of product over-stress and not caused by weak component design, poor component mounting, weak product design, or manufacturing process flaws. The product's fundamental technology limits must be well above its UDL and well below its LDL so that when exposed to an aggressive production HASS, it will experience little decrease in service life.

3.10 HARD FAILURE

A product failure that is permanent and the product is no longer operational.

3.11 SOFT FAILURE

A product failure which interrupts operation, but that can be reset. The product is still operational at reduced stress.

3.12 INTERMITTENT FAILURE

A product anomaly or failure that is randomly, periodically, or continuously present during the application of a stress and is not present when the stress is removed.

NOTES

3.a. DESIGN MARGIN ENHANCEMENT PRIOR TO HALT

It is recommended that the design margin enhancement techniques such as Voltage margining be completed prior to application of vibration and temperature HALT.

3.b. HALT AND DESIGN IMPROVEMENT

In HALT, the product will be "step stressed" in vibration and temperature until failure occurs. In this way, any failure mode can be compared to operational units to help determine the root cause of each failure. At the completion of the HALT, address all failure modes as per paragraph 4.7 and re-HALT the improved product.

3.c. ENVIRONMENTAL LIMITING DEVICES

Disable devices and circuits that would normally act to restrict the functioning of the product in harsh environments, such as power supply, high temperature thermostats and vibration level sensors.

3.d. FUNCTIONAL TESTS

Before starting the HALT, check the product for functionality using applicable functional test hardware and software. Designer or Reliability Engineer or any other initiator of this test may request additional specific tests. It is important to continuously perform the functional testing whenever the HALT is in progress in order to expose the effects of the HALT on the product's functionality. If the product fails and is repaired, re-apply the functional tests to verify proper operation before resuming the HALT. Follow the standard test procedures in the applicable engineering documentation.

3.e. TESTING SEQUENCE

This test procedure outlines the sequence in which to apply the stresses. However, depending on the product's response to a particular stress condition, it may be necessary to alter or deviate from the procedure. Any deviations from the procedure must be recorded.

3.f. DETERMINATION OF PRODUCT LIMITS AND FAILURE MODES

The visual presentation of the limits and flowchart for executing the HALT procedure are given below at Fig 1 & 2 respectively. Determine the product's upper operational and destructive limits for vibration and temperature as well as its lower operational and destructive limits for temperature. It is also important to determine what kinds of failure modes are being precipitated. It is possible that observed operational or destructive limits are not design problems specific to the product, but are rather the fundamental limits of the product's technology.

3.g. PHYSICS OF FAILURE

In this approach, an attempt is made to determine the underlying mechanism which describes the failure modes with mathematical equations so that the effect of various variables can be studied and the product designed thus to be more robust. There are two types of failure; short-term overload and fatigue failure. If load is rapidly increased, an overstress condition can cause a failure. Similarly if a lower intensity stress is cycled over long time, fatigue will eventually occur and will cause failure. In HALT and HASS programs, the processes expose the weak links in a product and then the Physics Of Failure approach can be followed to analyse the product and look for ways to improve the weak link.

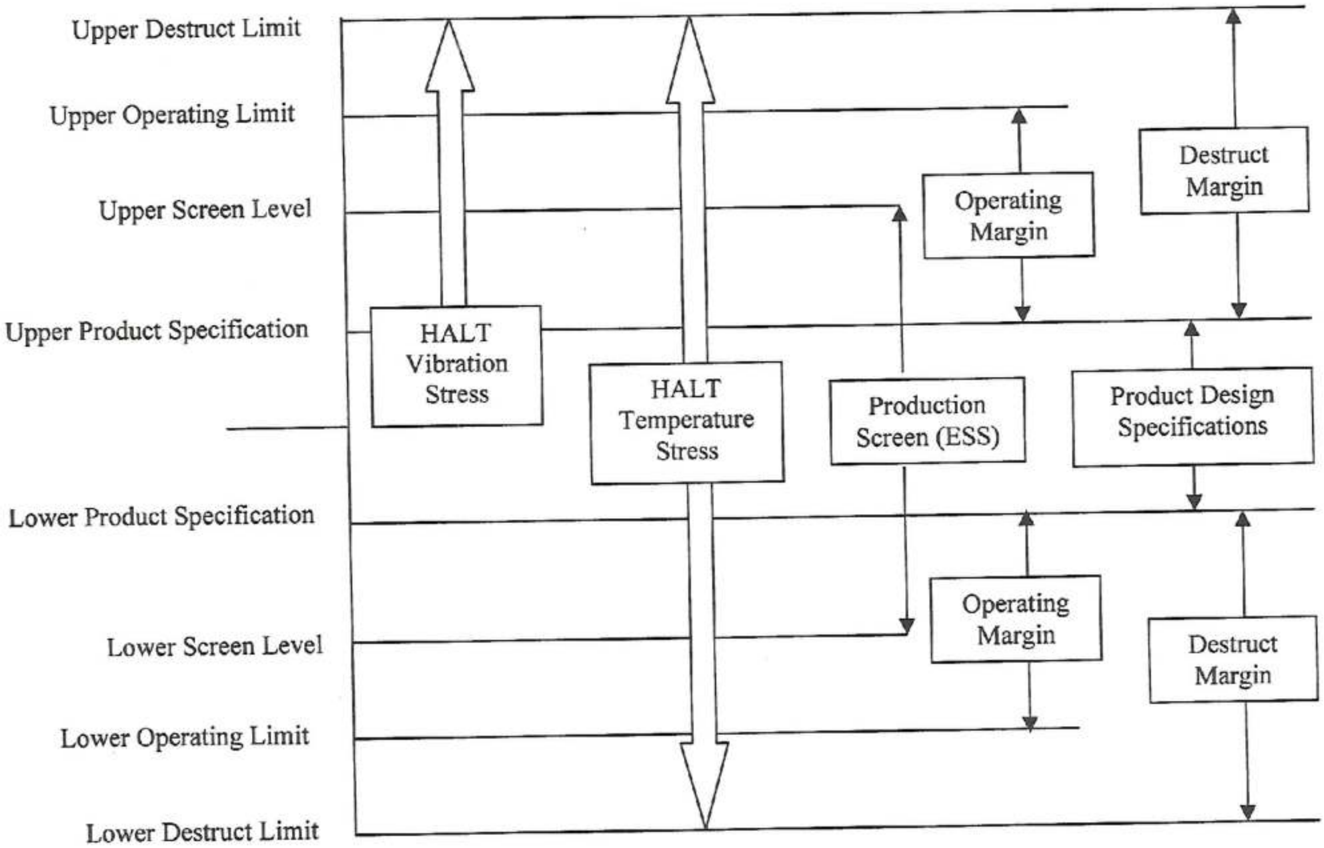


Fig – 1 Upper & Lower Operating and Destructive Limits

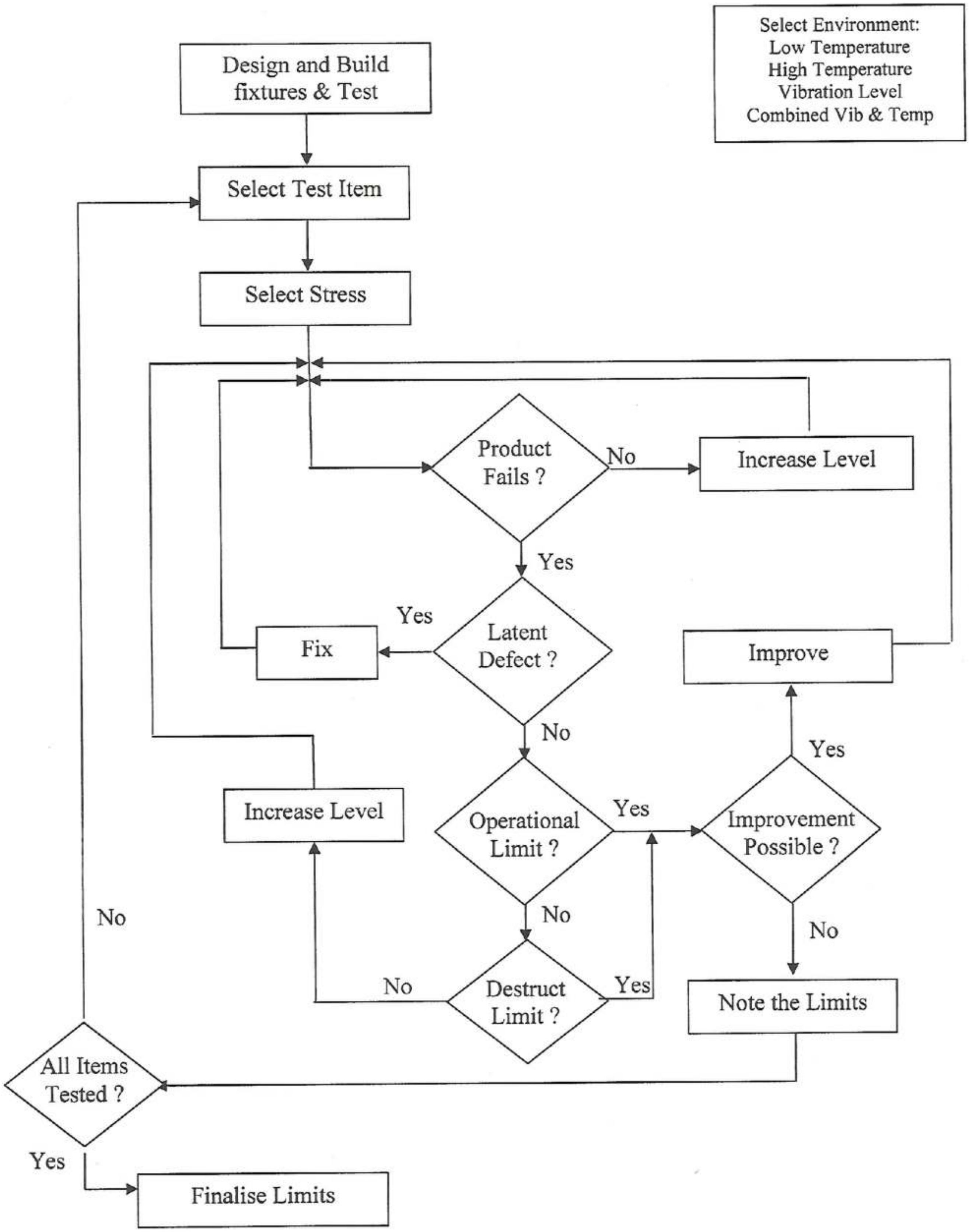


Fig – 2 HALT Process flow chart

4.0 HALT TEST PROCEDURE

4.1 PURPOSE

The purpose of the design verification testing is to make sure that the design meets the requirements of the technical specifications. The purpose of the HALT testing is to expose deficiencies in the design leading to improvements which may be required to be incorporated into the design prior to qualification testing.

4.2 HALT TEST OBJECTIVES

1. To determine the upper and lower operating and destructive limits of the product.

2. To find and fix weak component and product design, poor component mounting practices, and manufacturing process problems that can restrict the production ESS environment.

4.3 HALT TEST FACILITIES

The facilities required for HALT/HASS testing and analysis shall consist of the following:

a. HALT/HASS chamber
   Temperature spec range: -60°C to 150°C
   6 axis / Tri-axial random vibration specification range: 0 upto 50 gRMS

b. Type- T Thermocouples

c. Product clamping test fixtures

d. Product power supply, test harnesses and test equipment.

e. 10 mV/G miniature single axis accelerometers.

4.4 PRE-AND POST HALT TESTS

4.4.1 INTERNAL VISUAL INSPECTION

The unit shall be visually inspected prior to and on completion of the HALT test.

Means for this test shall include optical equipment having a capability of magnification required by the test specification, and other equipment (gauges, drawings, illustrations, etc.).

These means are necessary for conducting an efficient examination, and to enable the person conducting the test to objectively determine the acceptability of the unit being tested.

Necessary care should be taken if the unit is sensitive to ESD.

4.4.2 FULL FUNCTIONAL TEST

A functional electrical test shall be conducted according to the appropriate ATP prior to and on completion of the HALT test and the test results shall be documented.

4.5 TEST DESCRIPTION

4.5.1 GENERAL

The LRU shall undergo design verification testing, including Highly Accelerated Life Testing (HALT). Increasing test levels progressively until failure occurs is the main issue of this testing. It provides a determination of the safety margin built into the design, possible failure modes and areas where design improvements may be made prior to commencement of the design verification testing.

The testing is designed to increase confidence in the ability of the LRU to withstand the storage and operating environments of the specification requirements and to allow incorporation of design improvements in the event of test anomalies.

4.5.2 UUT

The tests detailed in this procedure will be performed on the UUT (Unit Under Test) During test the LRU shall pass the electrical tests as defined and the results shall be recorded.

4.6 TEST PROCEDURES

4.6.1 PRELIMINARY HALT (OPERATIONAL LIMIT)

4.6.1.1 Temperature Test, Cold

<u>Step 1</u>

Adjust the test chamber conditioned air ducting to allow rapid stability of product temperatures.

<u>Step 2</u>

Place the product response thermocouple inside the product underneath a circuit board or any other location specified to determine the temperature response time. In addition, place other thermocouples, if available, in places inside the product that will provide meaningful temperature response data. Cover all thermocouples with high temperature tape to isolate them from direct conditioned airflow.

<u>Step 3</u>

Carryout the product's functional test or self-diagnostics, if applicable, for the duration of the test. The product should be monitored closely during testing for failure modes not normally detected by its self-diagnostics, e.g. mechanical parts loosening, electronic parts breakage, etc.

<u>Step 4</u>

Decrease the test chamber temperature to 0°C at a rate of 40°C/min. When the product's internal temperatures reach within 5°C of the target temperature, dwell for 20 minutes. It may be necessary to set the chamber set point temperature 3° to 5°C lower than the desired temperature to ensure that the product's temperatures are correct, as heat dissipation by the product's hardware may cause the internal temperatures to raise by a few degrees.

<u>Step 5</u>

If no failures occur, continue to decrease the temperature level according to the predetermined levels as per temperature test profile at fig 3 with 20 minute dwells as defined in step 4 at each step until a failure is obtained.

Step 6

When the LOL is determined, proceed to testing as set out in paragraph 4.6.1.2 Temperature Test Hot.

Step 7

Whenever an anomaly or failure is detected, perform the procedures defined in paragraph 4.7 Failure analysis.

NOTES

When a failure occurs below O°C, it is best to raise the chamber temperature to 20°C or warmer before opening the chamber doors to address the failure. Opening the doors at much below room temperature will cause condensation on the product and chamber surfaces that may influence the test results.

After addressing the failure, close the chamber doors and lower the temperature back to the desired level. If the time to address the failure was less than one hour, dwell for at least 10 minutes before proceeding with the test. If the product has been at room temperature for more than one hour, follow the standard 20-minute dwell as called for in step 4.

4.6.1.2 Temperature Test, Hot

Step 1

Upon completion of the low temperature steps, raise the test chamber temperature to 30°C at a ramp rate of 40°C/min. When the product's internal temperatures reach within 5°C of the target temperature, dwell for 20 minutes. It may be necessary to set the chamber set point temperature 3°C to 5°C lower than the desired temperature to ensure that the product's temperatures are correct, as heat dissipation by the product's hardware may cause the internal temperature to raise by a few degrees.

Step 2

If no failures occur, continue to increase the temperature level according to the pre-determined levels as per temperature test profile at fig 3 with 20 minute dwells as defined in step 1 at each step, until a failure is obtained.

Step 3

When the UOL is found proceed to testing as set out in paragraph 4.6.1.3 Vibration Test.

Step 4

Whenever an anomaly or failure is detected, perform the procedures defined in paragraph 4.7 Failure Analysis.

NOTES

When a failure occurs above 50°C, it is best to lower the test chamber temperature to between 25°C and 50°C before opening the chamber doors to address the failure. Opening the chamber doors at 50°C or hotter temperatures may cause personal discomfort or injury.

After addressing the failure, close the chamber doors and raise the temperature back to the desired level. If the time to address the failure was less than one hour, dwell for at least 10 minutes before proceeding with the test. If the product has been at room temperature for more than one hour, follow the standard 20 minute dwell as called for in step 1.

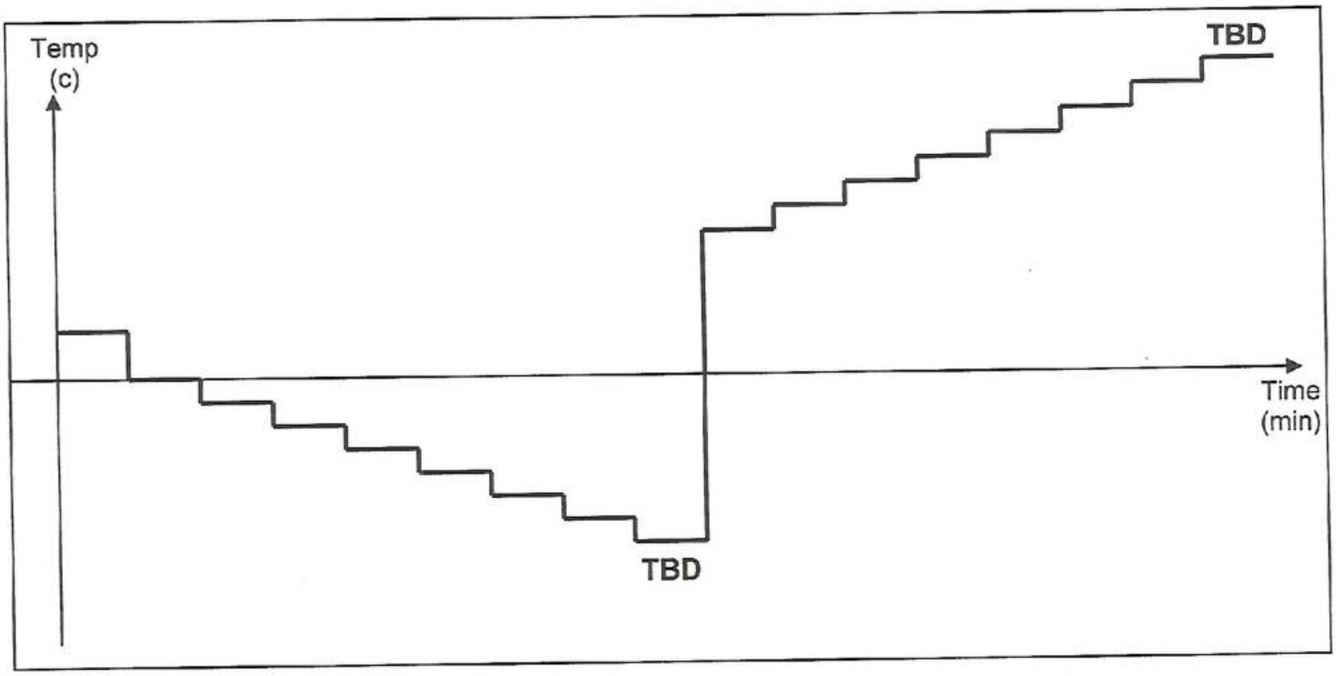


Fig – 3 HALT Temperature Test Profile (Cold / Hot)

4.6.1.3 Vibration Test

Step 1

Prepare a vibration text fixture to hold the product securely on the vibration table. Check for secure attachment several times during the test.

Step 2

Mount the system feedback accelerometers on the table surface or on the fixture at locations that afford protection from damage during product handling.

Step 3

Attach an auxiliary accelerometer to the product to measure its vibration responses. It is best to orient three accelerometers along the x, y and z axes and mount them on circuit boards and/or rigid mechanical assemblies.

Step 4

Carryout the product's functional test or self-diagnostics, if applicable, for the duration of the test. The product should be monitored closely during testing for failure modes not normally detected by its self-diagnostics, e.g., mechanical parts loosening, electronic parts breakage, etc.

Step 5

Begin vibration at 10 gRMS performed over a frequency bandwidth from 2Hz to 5 KHz on the product for 10 minutes. Maintain the test chamber at room temperature (about 23°C).

Step 6

Step the stress (increase the gRMS level on the product) as per vibration test profile at fig 4 and dwell for 10 minutes at each gRMS level.

Step 7

Perform a continuous functional test to verify proper operation of the product during each level of vibration testing and perform a complete functional test before going on to a new level. Inspect the product for fatigue damage or for possible failures not detected by the product's diagnostics. If no fatigue damage or failures are found, proceed to the next level until the UOL is determined.

Step 8

When the UOL is determined or if no failures have occurred up to the maximum vibration capability of the system, proceed to the test in paragraph 4.6.1.4 Simultaneous Temperature and Vibration Test.

Step 9

Whenever an anomaly or failure is detected, perform the procedures defined in paragraph 4.7 Failure Analysis.

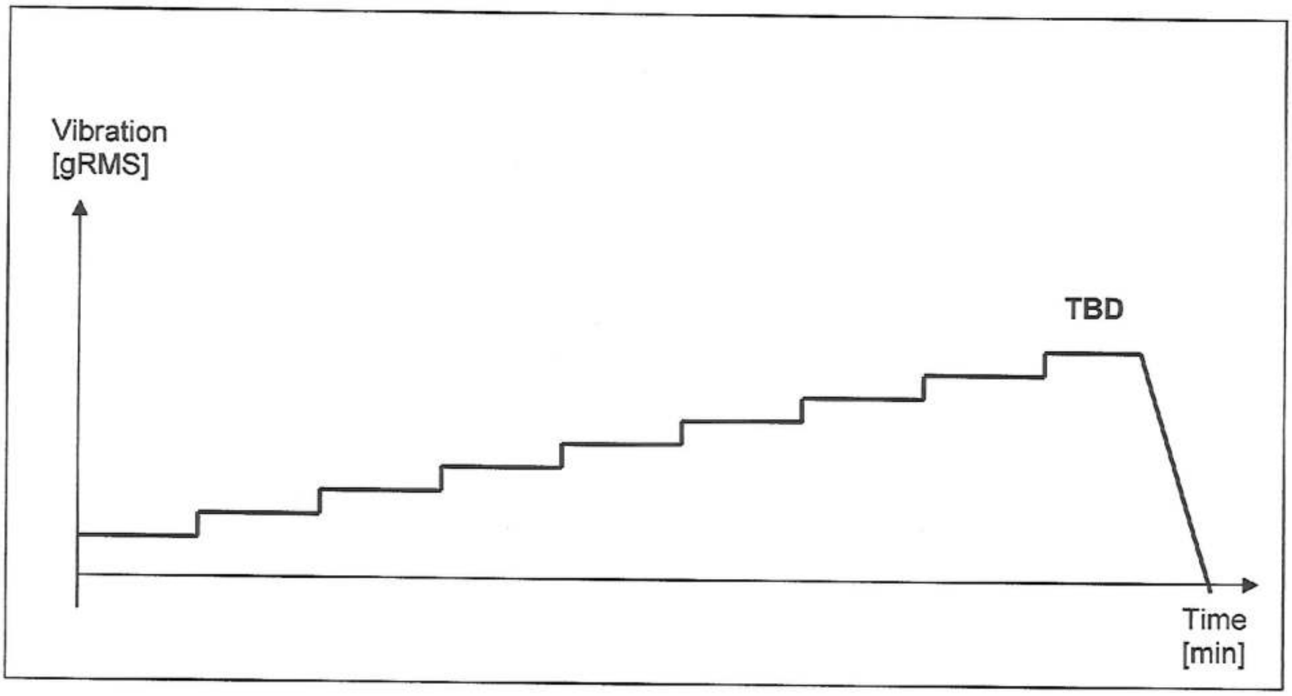


Fig – 4 HALT Vibration Test Profile

4.6.1.4 Simultaneous Temperature and Vibration Test

On completion of Temperature, Cold and Hot and Vibration tests, proceed to the following Combined Temperature and Vibration test according to Fig 5.

The purpose of this test is to verify that the combined temperature and vibration environments do not raise the temperature LOL, lower the temperature UOL or decrease the vibration level UOL.

<u>Step 1</u>

Place the product response thermocouple inside the product underneath a circuit board or any other location specified to determine the temperature response time. In addition, place other thermocouples, if available, in places inside the product that will provide meaningful temperature response data. Cover all thermocouples with high temperature tape to isolate them from direct conditioned airflow.

Step 2

Attach the auxiliary accelerometer(s) on the product to measure the vibration response of the product.

Step 3

Carryout the product's functional test or self-diagnostics, if applicable, for the duration of the test. The product should be monitored closely during testing for failure modes not normally detected by its self-diagnostics, e.g. mechanical parts loosening, electronic parts breakage, etc.

Step 4

Set the test chamber temperature set point to the temperature LDL at a ramp rate of 40°C/min. When the product's internal temperatures reach within 5°C of the target temperature, dwell for 15 minutes. It may be necessary to set the chamber set point temperature 3° to 5°C lower than the desired temperature to ensure that the product's temperatures are correct, as heat dissipation by the product's hardware may cause the internal temperatures to raise by a few degrees.

Step 5

If no failure occurs, decrease the temperature to the temperature LDL at a ramp rate of 40°C/min. When the product's internal temperatures reach within 5°C of the target temperature, dwell for 15 minutes as defined in Step 4.

Step 6

If no failure occurs, repeat steps 4 & 5 for four more cycles as per Fig 5. The last cycle is defined in step 7.

Step 7

After 10 minutes of dwell at cold temperature, set the vibration set point to 2 steps below the vibration UOL and apply for 5 minutes. Then proceed according to step 5.

Step 8

After 10 minutes of dwell at hot temperature, set the vibration set point again to 2 steps below the vibration UOL and apply for 5 minutes as per Fig 5. Then proceed according to step 6.

Step 9

Stabilize the LRU at 25 °c and conduct the product's performance test.

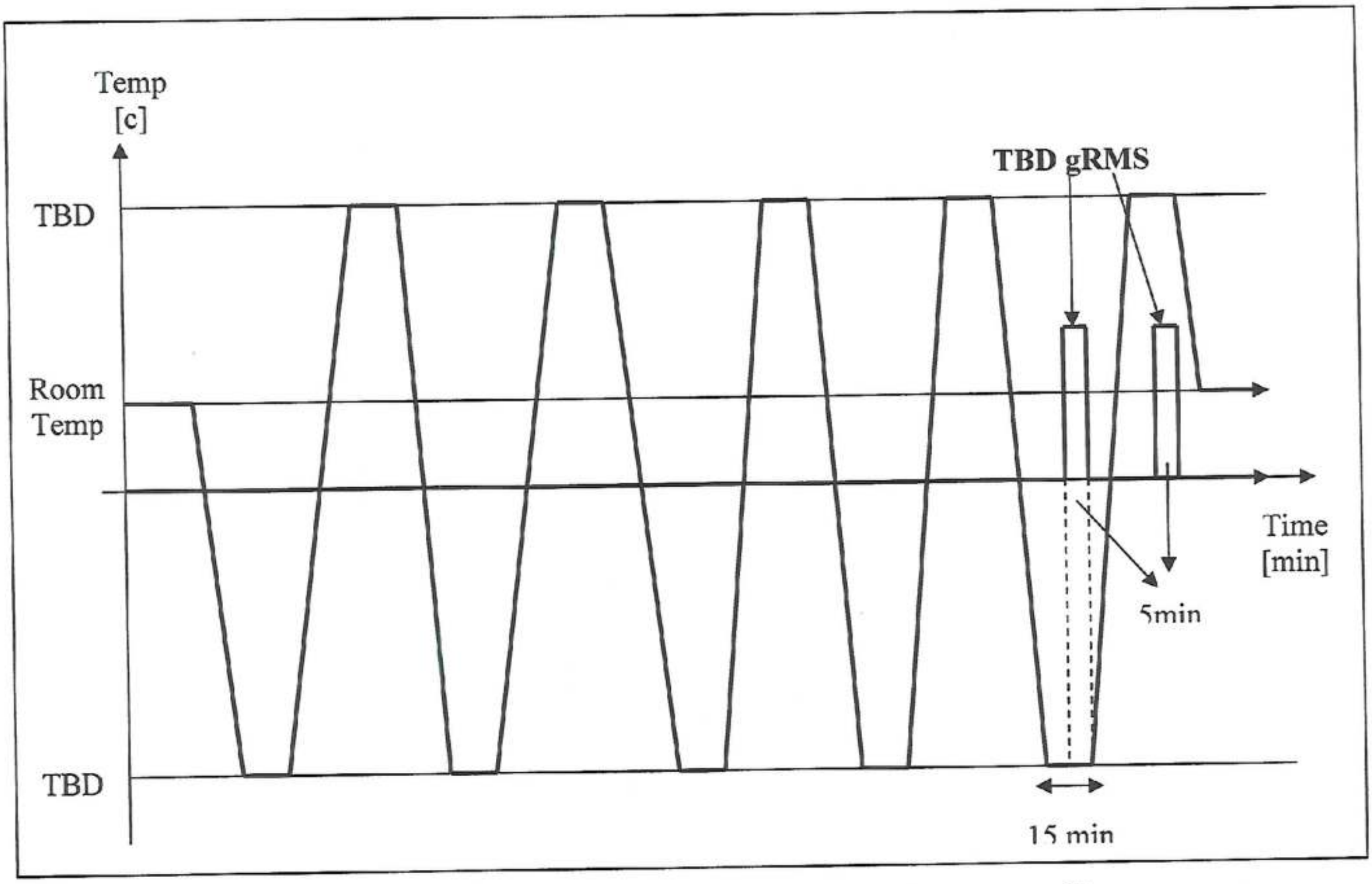


Fig – 5 Simultaneous Temperature and Vibration test profile

4.6.2 PROOF OF SCREENING(POS)

This process demonstrate that the chosen screen does not take out much life out of the equipment and sufficient life is left in them to survive the normal lifetime of field use. Also it shows that the chosen screen is effective in finding out the latent defects in the product.

After completion of the environmental qualification tests as per approved test plan, the POS shall be carried out on new production standard equipment as defined in the following steps: -

Step 1

Perform a test according to paragraph 4.6.1.4 Simultaneous Temperature and Vibration Test, step 7 (the last cycle of combined temperature and vibration test) and record the results.

Verify that the test results are similar to test results recorded in paragraph 4.6.1.4 Simultaneous Temperature and Vibration Test.

Step 2

According to the test results define the HASS test levels as specified below.

Temperature : 15% higher / lower the temperature LOL / UOL.

Vibration : 50% of the vibration UOL.

No of Cycles: Three (3) with 10-minute dwell at cold and hot, last 5 minutes of cold/hot dwell of last cycle with vibration.

Step 3

Perform POS procedure: 20 HASS cycles. Record the results.

Note: If HASS contains 3 cycles then the POS shall be 60 cycles.

Failure during POS

If a failure occurs during POS, perform the following:

When a failure is indicated a Unsatisfactory Condition Report (UCR) shall be filled. The failure shall be investigated and corrective action shall be performed. Resume the POS to the same test step, which was interrupted with the failure. If repetitive failure is found, a new test limits shall be tailored and the unit shall be retested.

4.6.3 FINAL HALT (DESTRUCTIVE LIMIT)

Step 1

Continue the HALT test until the destructive limits are reached by repeating the tests described in paragraphs 4.6.1.1 to 4.6.1.4 of the Preliminary HALT, but starting from the maximum levels obtained during the Preliminary HALT, and record the results.

If the Operational levels and the Destructive levels are similar, define these levels as the HALT levels and the HASS levels that were defined in paragraph 4.6.2 POS shall not change.

But, if there are differences between the Operational and the Destructive levels, updating the HASS levels shall be taken into consideration.

4.7 FAILURE ANALYSIS

4.7.1 GENERAL

Analyzing product failures to the root cause is the only way to make the HALT effective. All failures should be recorded in the order in which they occur. This includes noting of failure symptoms, stress levels (temperature and vibration), other test conditions such as the product's set parameters, and any corrective action taken, temporary or permanent. Write a brief note in the HALT test results matrix. Multiple failures with the same symptoms should be recorded on the same sheet. This observation report sheet follows the symptom(s) of a possible failure through analysis .If a symptom is determined to be a relevant failure, it should be analyzed to find its root cause and addressed through corrective action.

4.7.2 CLASSIFICATION

Failures are classified in two groups - soft failures which can be reset and therefore allow continued operation of the product and hard failures which cannot be reset. Procedures for dealing with each type of failure are outlined below.

4.7.2.1 Soft Failures

If a failure occurs and the root cause cannot be easily determined, reset the product and continue with the test. If the failure occurs every time the product is subjected to a certain stress level, initiate an Unsatisfactory Condition Report (UCR). Temporarily suspend testing at this point and perform root cause analysis.

4.7.2.2 Hard Failures

If the product cannot be reset (is no longer operational), stop testing at this point in order to determine the root cause of the failure. Issue an UCR. It may be necessary to implement a temporary correction rather than a permanent solution in the HALT unit only, in order to continue testing without excessive delay.

5.0 HASS TEST PROCEDURE

5.1 PURPOSE

The purpose of HASS is to screen the product using the highest possible stresses, frequently well beyond the qualification level, to attain the time compression in the screens. This process is used in production to prevent product with latent defects from reaching the customer.

5.2 OBJECTIVES OF HASS TESTING

To find and fix weak component, poor component mounting practices and manufacturing process problems.

5.3 HASS TEST FACILITIES

The facilities required for HASS testing and analysis shall consist of the following:

a. HALT / HASS test chamber.

Temperature spec range: -60°C to 150°C

Trial-axial random vibration spec range: 0 to 50 gRMS

b. Type - T thermocouples

c. Product clamping test fixtures

d. 10 mV/G miniature single axis accelerometers.

e. Product powers supply, test harnesses, and test equipment.

5.4 TEST DESCRIPTION

5.4.1 GENERAL

LRU shall undergo Highly Accelerated Stress Screening (HASS).

The testing is designed to increase confidence in the ability of LRU to withstand the storage and operating environments of the specifications and to allow incorporation of design improvements in the event of test anomalies.

During the test LRU shall pass the electrical test as defined in the test schedule and the results shall be recorded in the HASS test report.

5.4.2 FUNCTIONAL TESTS

Before starting the HASS, check the product for functionality using applicable functional test hardware and software. It is important to continuously perform the functional testing whenever the HASS is in progress in order to expose the effects of the HASS on the product's functionality. If the product fails and is repaired, re-apply the functional tests to verify proper operation before resuming the HASS.

5.4.3 TESTING SEQUENCE

This test procedure outlines the sequence in which to apply the stresses.

However, depending on the product's response to a particular stress condition, it may be necessary to alter or deviate from the procedure. Any deviations from the procedure must be recorded.

5.4.4 HASS TEST RESULTS

Results of the HASS test shall be documented in the HASS test report.

5.5 TEST PROCEDURE

The results from the completed HALT process are used to determine and set up the HASS screening process.

Step I

Mount the LRU in the fixture and apply the screening procedure. Adjust the test chamber conditioned air ducting to allow rapid stability of product temperatures.

Step 2

At room temperature carryout the product's functional test or self-diagnostics, if applicable, for the duration of the test. The product should be monitored closely during testing for failure modes not normally detected by its self-diagnostics, e.g. mechanical parts loosening, electronic parts breakage, etc.

Step 3

Perform the test according to Fig - 6.

Step 4

Place the thermocouple on the middle of the upper cover of the unit.

Step 5

The temperature rate of change (often equal to the maximum capability of the screening system unless the rate-of-change step stress test or HASS test indicates that a slower rate is appropriate). is 40 °C/min.

Step 6

Record the data for each product screened according to the HASS test report.

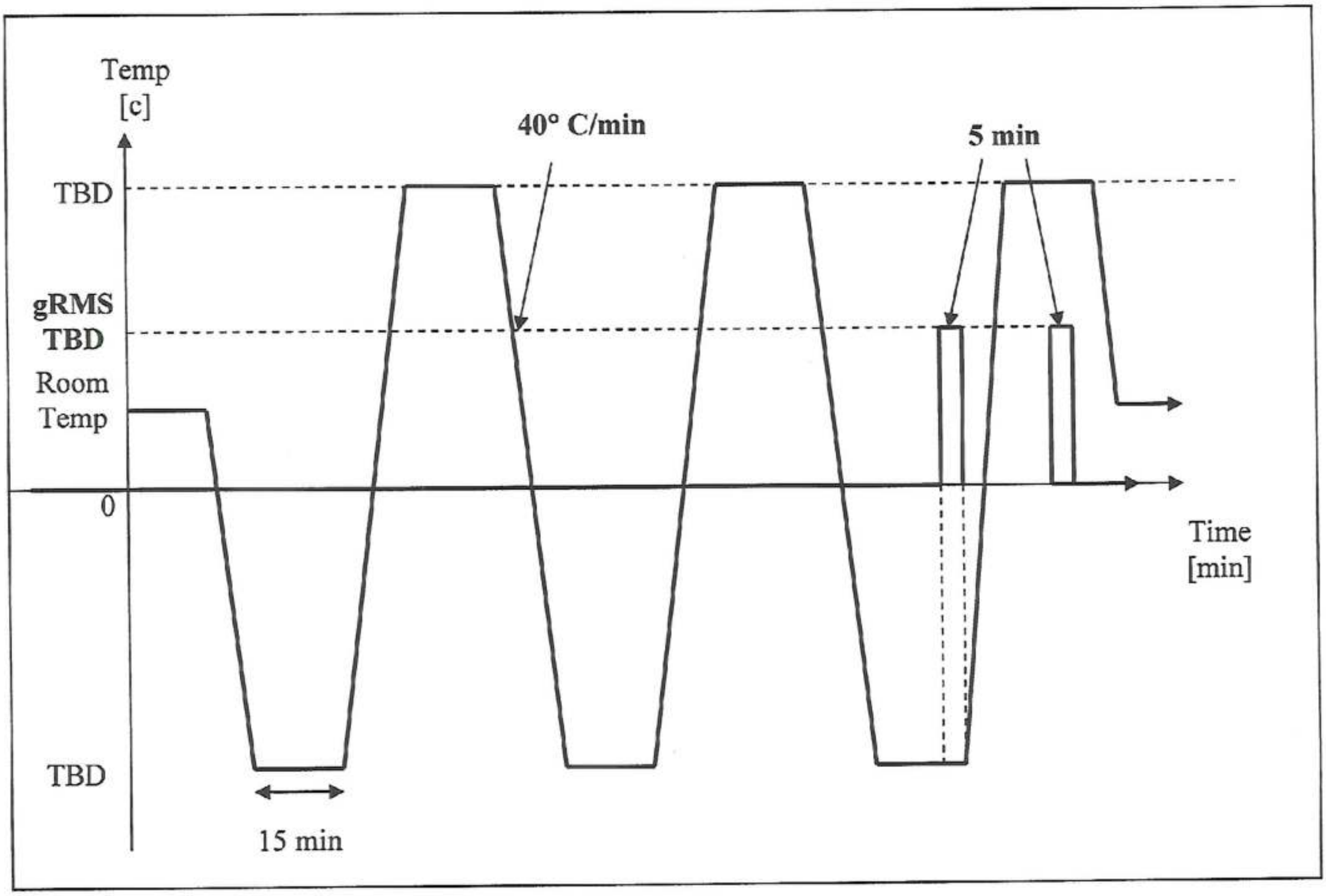


Fig – 6 HASS Test Profile

5.6 ELECTRICAL TESTS

The electrical tests shall be performed according to the approved performance test schedule.

5.7 FAILURE ANALYSIS

5.7.1 General

Analyzing product failures to the root cause is the only way to make the HASS effective. All failures should be recorded in the order in which they occur. This includes noting of failure symptom(s), stress levels (temperature and vibration), other test conditions such as the product's set parameters, and any corrective action taken, temporary or permanent, Along with a brief note in the HASS test results. If a symptom is determined to be a relevant failure, it should be analyzed to find its root cause and addressed through corrective action.

5.7.2 Classification

Failures are classified in two groups - soft failures which can be reset and therefore allow continued operation of the product, and hard failures which cannot be reset. Procedures for dealing with each *type* of failure are outlined below.

5.7.2.1 Soft Failures

If a failure occurs and the root cause cannot be easily determined, reset the product and continue with the test. If the failure occurs every time the product is subjected to a certain stress level, document the result in the HASS test report. Temporarily suspend testing at this point and perform root cause analysis.

5.7.2.2 Hard Failures

If the product cannot be reset (is no longer operational), stop testing at this point in order to determine the root cause of the failure. Document the result in the HASS test report. After repairing the unit, repeat at least two cycles of the HASS procedure. This failure shall be documented in a UCR.

6.0 DOs and DONTs

What not to do in HALT & HASS also is important in order to enforce the positive outcome of HALT/HASS. Some of the most common mistakes are listed below.

6.1 Attempting HALT and HASS without education on the Technology

Without basic understanding of the principles and techniques, attempting HALT and HASS on equipments may lead to many mistakes.

6.2 Not performing safety of HASS/Proof of screen

HASS is quite capable of reducing the usable field life of good hardware if the stresses chosen are too high for the design. By doing the proof of screen procedure one can optimize the HASS stresses so that only minimum useful life is taken out of the equipment.

6.3 Not monitoring with full coverage during stimulation

If the product is not monitored closely during HALT/HASS, the flaws precipitated during the process may not be seen by the producer and the customer will have failures due to these precipitated flaws soon after delivery of the equipment.

6.4 Outsourcing without closed loop corrective action

Precipitation, detection, failure analysis corrective action and corrective action verification should be done with the involvement of everybody associated.

6.5 Not improving the product to the fundamental limit of technology

When a weakness is found in HALT, the situation presents an opportunity for improvement. If the advantage of this opportunity is not taken then the progress towards a failure free product will be lost. HALT is the perfect time to improve the product and any effort to fix a problem at later stage will become costlier.

6.6 Using fixtures that do not transmit the stress to the products under test.

It should be ensured that sufficient levels of stress are reached up to the product in order to ensure proper selection of stresses.

6.7 Using inappropriate thermal and vibration equipments

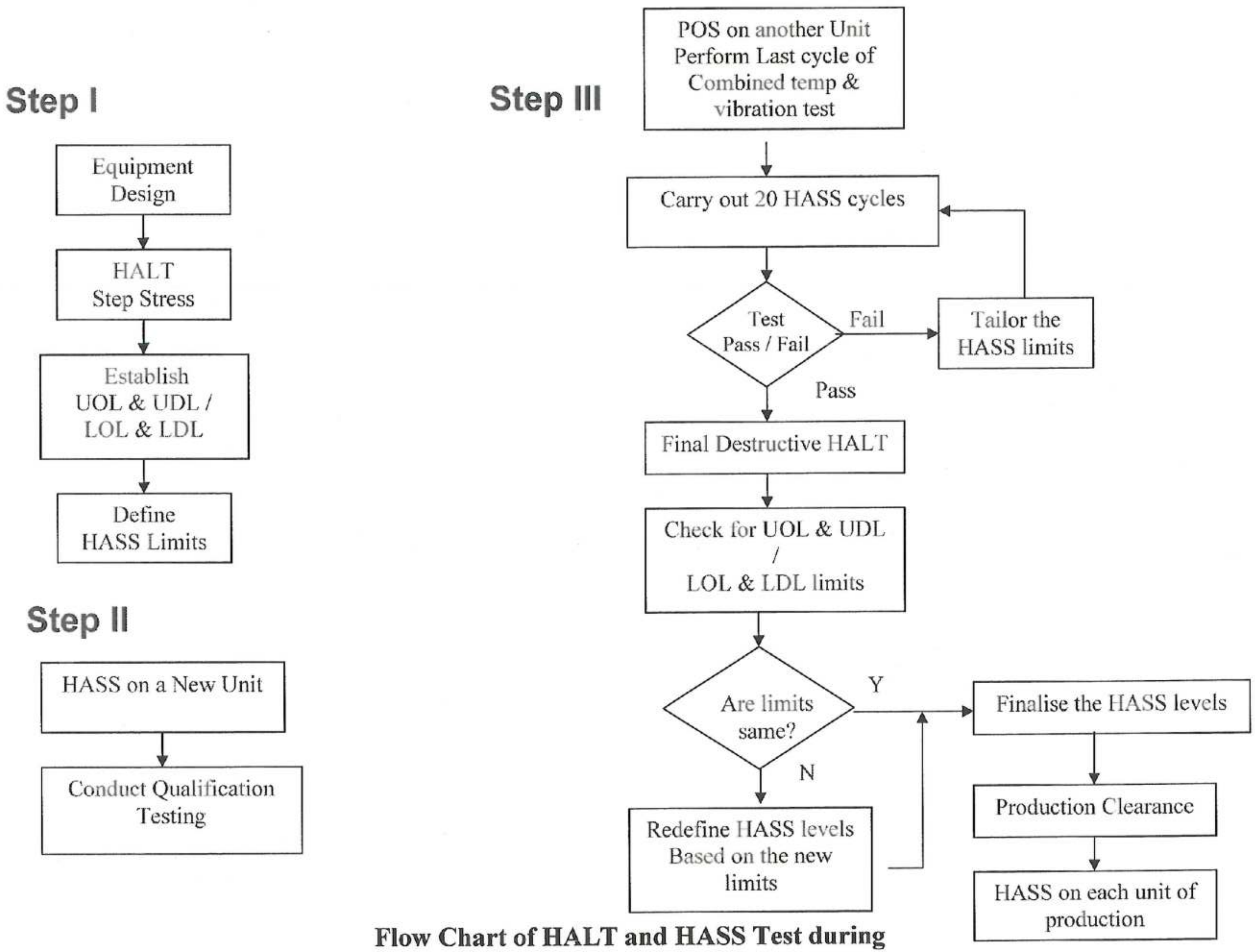
HALT and HASS are intended to precipitate the flaws in the product under test and the equipment used for the test should be able to stimulate the environment as close to the real environment.

6.8 Not using modulated excitation during detection

Modern HALT and HASS equipment will easily generate modulated six axis vibrations combined with fast temperature changes. Use of this simultaneous excitation is necessary in bringing out flaws in the system easily and effectively.

6.9 Not performing Re-HALT

Any modifications arising at any stage of the product life cycle calls for a Re-HALT so as to ensure the safe margin is built into the product. It is also necessary to select / finalise the production HASS limits.



Flow Chart of HALT and HASS Test during Development and Certification phase