

# HALT/ HASS TEST CHAMBER

Defence Avionics Research Establishment ,  
Bangalore

# Testing of EW System Modules in HALT/HASS Chamber

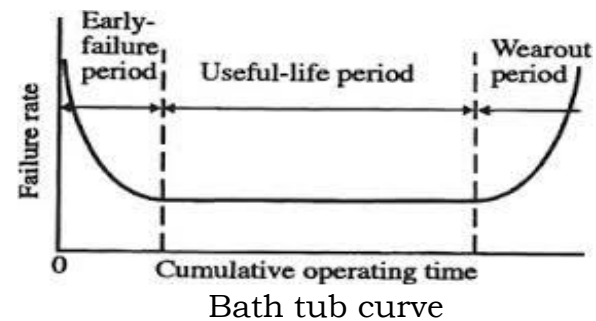
- Introduction.
- The Accelerated Reliability Testing.
- Brief description of HALT/HASS test chamber.
- HALT/HASS Test Profiles
- Dwell Time and Ramp Rate.
- System General Failures & Classification, Operating S/W
- HALT/HASS precautions & Limitations
- EW Modules Temperature and Vibration Limits with Stresses.
- Conclusion.

# Introduction

- Airborne EW systems are designed to fly in **higher altitude** and exposed to severe environmental conditions in air and ground.
- The **accelerated reliability** is one of the fastest growing field which enables the user to determine the **reliability of a product quickly**.
- HALT & HASS processes are special types of accelerated reliability techniques that are **very effective** and are being used **around the world** by **different applications** for providing better systems.
- The **weak point in the link** of a chain is exploited in HALT process



Weak link in chain



- The famous **bathtub curve** is a representation of the reliability performance of components or non-repaired items.

# The Accelerated Reliability Testing

- The concept of accelerated reliability is to **compress time** and **accelerate the failure mechanisms** in a reasonable test period so that product reliability can be assessed.

Arrhenius formula : Speed of reaction causes the degradation processes in materials

$$r_{AE} = c.exp (- A_E/KT)$$

Where

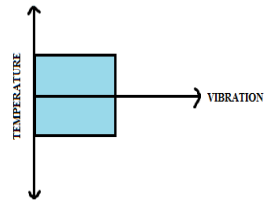
$r_{AE}$ - speed constant of the reaction

$A_E$  = the minimum activation energy to initialize the degradation process, [ev]

C - Constant

K - Boltzman constant,  $k= 1,38.10^{-23}$  [JK<sup>-1</sup>]

T - Absolute temperature at degradation.



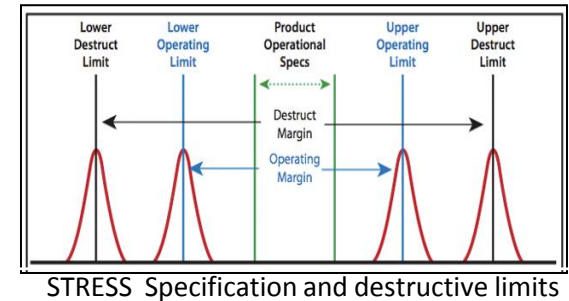
Modulated excitation

- **Stress excitation** : Each axis independently , Combined noise and Modulation excitation of vector [temperature, vibration, pressure etc. ] .
- **Modulated excitation** is considered an excellent method to **diagnose field failure modes** that are difficult to reproduce in a laboratory environment (i.e. 'no fault found' problems).

# HALT/HASS TESTING

- The stresses applied in HALT and HASS are not meant to **simulate the field environments**, but are meant to expose the **weak links in the design and processes** using only a few units and in a very short period of time.
- HALT/HASS is used to determine **robustness of electronic product** and the testing shall be carried out **as per standards**.

- **Highly Accelerated Life Testing (HALT)**: The temperature and vibration stress conditions are used during product development to find weak spots in the product design.



- The HALT process alone will not improve the reliability of the system. The root cause of the failures noted need to be determined and the problems corrected until the fundamental limit of the technology for the system can be reached.
- **Highly Accelerated Stress Screening (HASS)**: This is a production process that identifies product weaknesses through the application of environmental and electrical stresses.
- In production it is difficult to increase the duration of the tests or the volume of the samples, the solution was to increase the stress level at reliability testing. This will reduce the test duration, allowing to obtaining quickly the necessary information about the reliability of the batch of products.

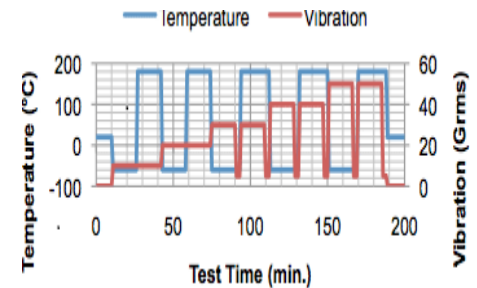
# HALT/HASS Test Profiles

## ➤ Temperature profiles:

- Determine the min and max **product operating temperature limits**.
- **Accelerate the aging process** of the device/module under test by applying **extreme temperatures &** test with various **climatic and pressure conditions**.
- **Burn-in under elevated temperatures at a high duration rate.**

## ➤ Vibration profile:

- Determine the maximum **product operating vibration levels**.
- Find **mechanical defects early in the work-in-process cycle**.
- Simulate **global transportation conditions** on the device/module under test



Temperature and Vibration cycles

## ➤ Humidity Profile:

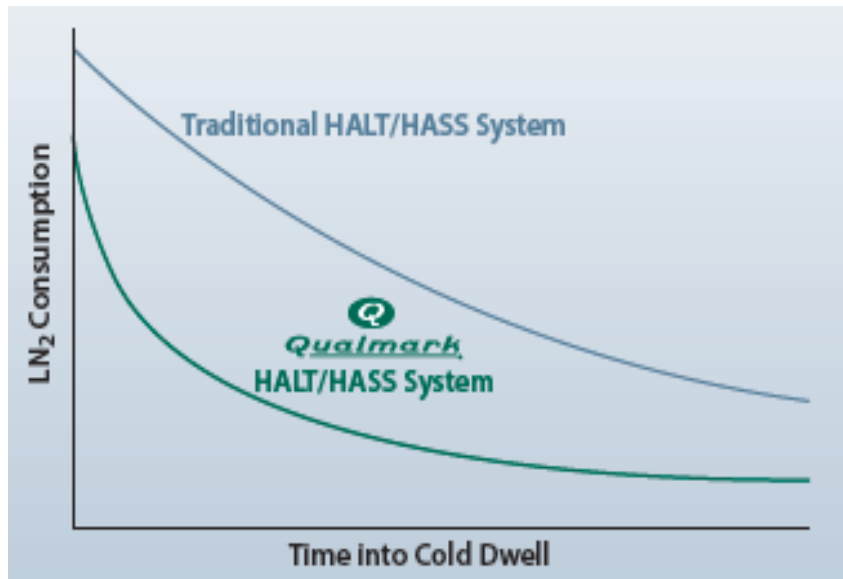
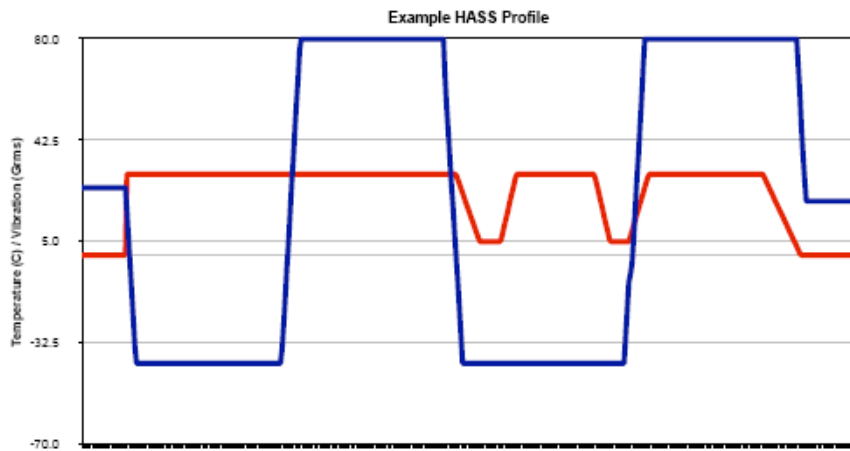
- Determine the effects of **high/low humidity on the modules** (high humidity - corrosion, low humidity - electrostatic discharge ).
- Find **latent shorts on PCBs** related to humidity (typically due to ion migration).
- Accelerate the aging process of the module by applying **extreme humidity conditions**.
- Test the module under global **humidity and pressure** (i.e. altitude) conditions.

## ***Dwell Time and Ramp Rate***

- **Thermal step stress**: Ramp rate & Dwell time  
Mismatch in coefficients of thermal expansion for the constituent materials on a printed circuit board causes stresses to develop.
- **Vibration step stress**: Applied at 5-6g rms & increased in steps of 5g rms increments until the operating and destructive limits were reached. The product is functionally tested during each dwell time.
- **Combined operation**: The product is subjected to combined stresses. The stress levels are applied simultaneously the vibration step stress and the temperature step stress.
- A thermal profile is developed with **upper and lower temperature extremes**, close to the operational limits determined during temperature step stress. At each temperature extreme, **10 minutes dwells** were applied to allow time for temperature stabilisation and to run the test routines using the same test conditions described for thermal stress.
- Stepping vibration during thermal stress found to be important because the **vibration response of many products change as the temperature changes**. Operation and destructive limits were determined for this combined operation of stresses.

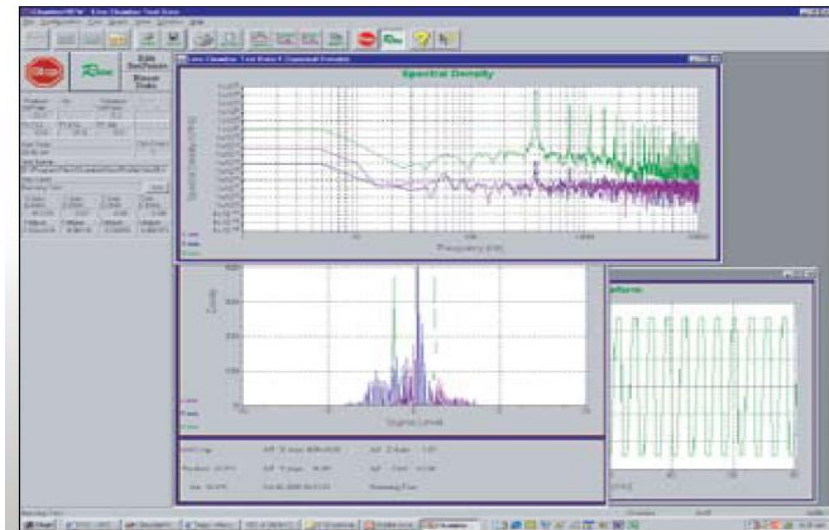


# HALT/HASS CLASSIFICATION OF FAILURES



Large classification	Middle classification	Automobile parts	Control board	Laptop computers
Junction	Connector terminals, FASTON terminals, etc.	○		○
PCB holding part	Solder	○		○
	Screws	○		○
Lead fixing part	Heavy parts: transformer, coil, battery, etc.			○
	Tall parts: aluminum electrolytic capacitor, FET, etc.	○	○	
	Large parts: LCD, etc.			
Electronic parts	Mechanical parts: switches, relays, etc.	○	○	
Others	Lead cable wiring	○		
	Others			○

CLASSIFICATION OF FAILURES DETECTED IN HALT



➤ Star View Software for Temperature and Vibration Control and Analysis



## HALT/HASS LIMITATIONS & SPECIAL PRECUATIONS

- Since LN2 gas is used for conducting the test prior intimation is required. Chamber needs proper ventilation for oxygen to people. Regular maintenance and licenses.
- Compressor pressure to be checked. Through exhaust moisture enter into system. Cumulative Fatigue Damage is key parameter (i.e., Miner's rule)
- The stress levels are higher may go beyond specs advanced input systems are required for conducting the tests. Drive vibration levels are much higher, and correlate to field failure data.
- Cannot support for all tests. For a given failure can be caused by several different stresses. Other than Temperature & Vibration parameter like pressure test is not possible.
- Crossover Effect: One stress may cause a given failure in the field but a different Stress may find the same failure in HALT.
- HALT plans get changed as you conduct the HALT test, depending upon what is found during testing.

## ***HALT/HASS Testing of EW Modules***

- Currently the airborne systems are qualified with **environmental qualification** as per standard **810 F defined QTPs**.
- Production units are cleared with **ESS** to test all manufactured units prior to release to the military application.
- The **frequent field returns** of modules and **customer dissatisfaction** of the system are often the **result of design or process weaknesses** in modules.
- The EW systems or modules need to be verified with the application of **accelerated stress at design level** in HALT /HASS chamber to **improve reliability and to remove weak components** in the design.
- The **modules** like the Antenna, Radome, RF Unit, Front End Amplifiers, Signal Processor unit, display unit, all enclosures and aircraft looms etc., can be subjected to HALT/HASS tests.

# Conclusion

- If the manufacturing facilities are good accelerated stress qualified units will give consistently improved reliability.
- The chamber tests are very useful for producing reliable equipment at low cost.
- The use of new technology & COTS components is increasing the failures and makes airborne modules unreliable.
- The EW & Avionic system design & integration phase qualifying with HALT improves the reliability of equipment and hence long life.
- HALT/HASS test results provide confidence on the system for inspectors and operating users.

# **INTRODUCTION TO HALT/HASS**

**Presented by**

**M.Sreenivasa Rao ,Sc 'F'**

**DARE**

# CONTENTS

- Introduction
- Applicable Standards for Equipment Qualification.
- Environmental Stress Screening.
- Type approval Testing.
- HALT/HASS Testing – Principles, chamber , description , Standard & Stresses , Components ,Gen. failures & profiles , Conclusion.

# INTRODUCTION

- The aim is to bring EW system of **world class quality** to market in **shortest time**, improve **field reliability** , **least expensive** and **lower warranty cost**.
- Current EW digital receivers systems designed are of modular with federated architecture, in wide or narrow band configurations with operating wide frequency coverage range to capture the electromagnetic scenario in real time with high probability of intercept.
- H/W, S/W and system integration is **tested in the laboratory** during development in **injection mode** using **signal simulators**.
- Radiation testing before installing on airborne platform is essential for various **radar signal reception and to verify repeatability**. The evaluation of EW systems like **amplitude comparison** to **phase interferometer** both active and passive can be tested effectively in radiation testing.
- The goal is apply enough stress to find faults – but not enough to remove a significant amount of systems life.

# APPLICABLE STANDARDS FOR EQUIPMENT QUALIFICATION

- ESS process : **Mil Std 2164(EC)**
- JSS on Environmental test methods: **JSS 55555**
- Test method standard and laboratory tests: **Mil Std 810F**
- Requirements for EMI/EMC for subsystems and equipments : **Mil std 461E**
- Military standard for Aircraft Electrical power considerations : **Mil std 704E**
- General requirements and norms of quality of Electrical Energy: **GOST 19705-89**
- Lightning Induced Transient susceptibility: **RTCA DO 160E (Chapter 22)**
- Components used in design of EW & avionics systems: **Mil std 883E.**
- COTs Components used in design of EW & avionics systems: **Industrial grade.**



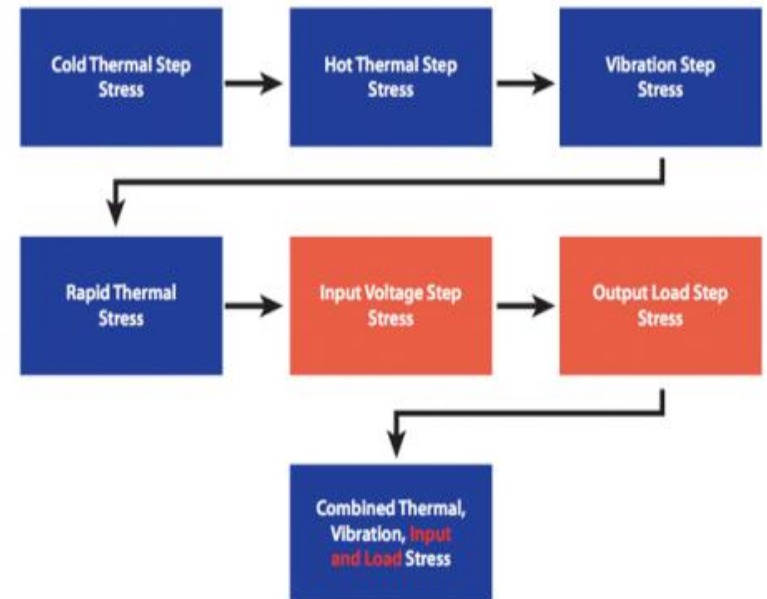
# STANDARDS & STRESSES

- HALT/HASS Technology is invented by Dr. Gregg Hobbs
- HALT/HASS Testing standard IPC 9592A.

IPC-9592 Standards			
Design For Reliability	Design and Qualification Testing	Quality Processes	Manufacturing Conformance Testing
Specifying, designing and documenting performance and reliability	Performance to specification, Performance in intended environment EST, HALT	Quality Management Systems, Supplier and Sub-Tier Quality Requirements	Burn-In, ORT, HASS, HASA

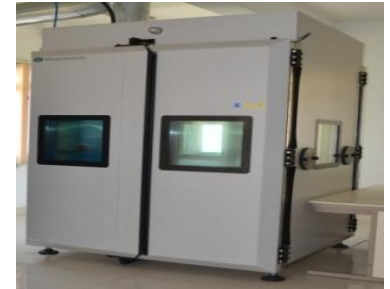
## The Stresses used for HALT

- Extremely high and low temperatures
- Extremely rapid temp stresses (60°C/min)
- 6-axle vibration
- Combined temperature and vibration stresses
- Tension stresses
- Combined heat, moisture and cold
- Other relevant stresses.
- Find faults - fix them - get a better product.



## ***DESCRIPTION OF HALT/HASS CHAMBER***

- HALT / HASS facility comprises of a Chamber, Air compressor and LN2 storage tank. The testing operations range in temperature from -100 deg C to +200 Deg C with the rate of change in temperature max 70 deg C per minute, with 6 degrees of freedom 50g RMS vibration levels.
- The accelerometers were placed on the modules to measure the vibration response of the module.
- This information was then used to tune the fixture in order to maximise the vibration energy from the chamber into the product while maintaining vibration uniformity across the module.
- The thermocouples were attached to the module to measure the actual module temperature verses the chamber set point.
- The ducting was designed for allowing maximum airflow across the module. The module was subjected to a combined environment of vibration and thermal stress.



HALT/HASS Chamber

## ENVIRONMENTAL STRESS SCREENING

- ESS is a process where EW modules or Boards with electronic components are placed in a testing chamber and exposed to thermal stress cycling, vibration stress and other environmental stresses.
- The purpose of ESS is to force the manifestation of latent mechanical defects that result in permanent or catastrophic failure of the component.
- This testing helps ensure the quality, functionality, and reliability of electronic hardware and components during shipping, storage, and use.
- H/W is subjected to conformal coating, Physical Inspection and Burn in.
- Aero dynamically exposed items and more vibration is expected at nose & wings the modules are subjected for vibration  $0.2 \text{ g}^2/\text{HZ}$
- The laboratory testing, Anechoic chamber testing and ESS cleared EW & Avionic modules are sent for aircraft integration.
- ESS testing is less expensive to correct than equipment failures in the field. It is a production systems testing procedure.



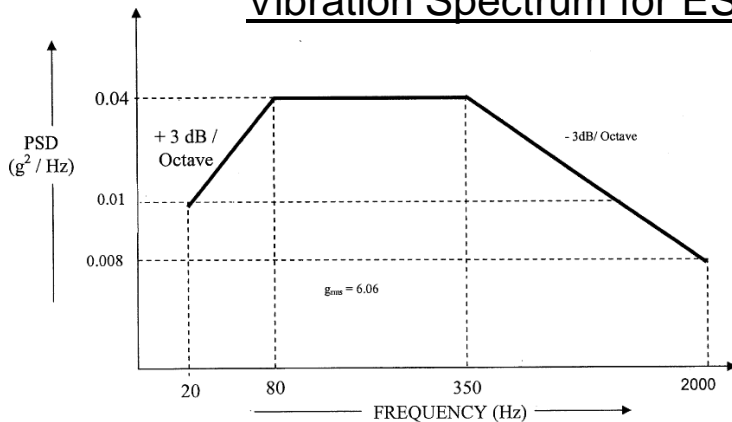
# ESS TEST SPECIFICATIONS

Table-2: Environmental Stress Screening (ESS) Test specifications		
Sl. No	Parameter	Specification
1.	NDT	Physical inspection
2.	Random Vibration (Pre- Thermal cycling )	0.04 g <sup>2</sup> / Hz PSD; 5 minutes/axis 20-2000 Hz
3.	Thermal cycling	-40°C to +71°C (10 cycles) Temperature ramp: Not less than 5°C/ minute
4.	Random Vibration (Post- Thermal cycling )	0.04 g <sup>2</sup> / Hz PSD; 5 minutes/axis. 20-2000 Hz
5.	NDT	Physical inspection

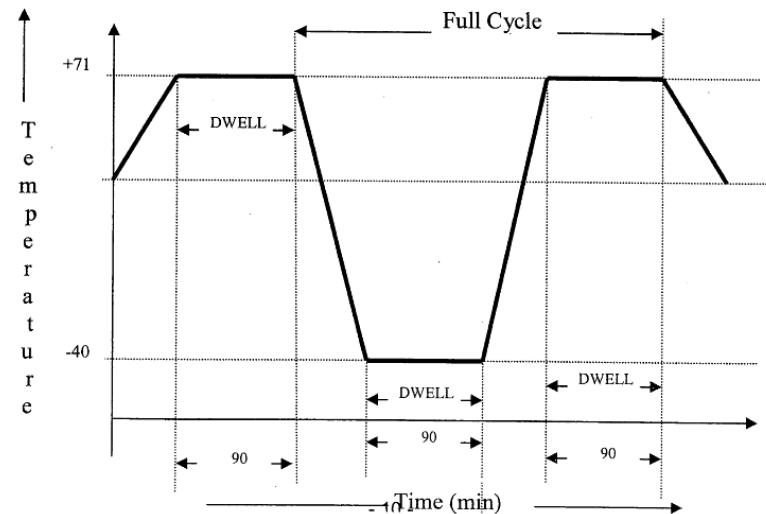
Thermal Cycling test for ESS

Test Spectrum:

## Vibration Spectrum for ESS



Profile 1



Profile 2



# HALT / HASS FAILURES & PROFILES

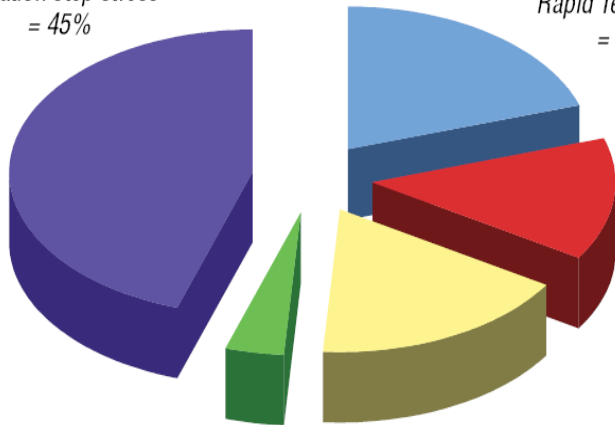


## HALT PRECIPITATED DEFECTS

Vibration step stress  
= 45%

Combination of  
6doF Vibration and  
Rapid Temperature  
= 20%

Hot step stress  
= 17%



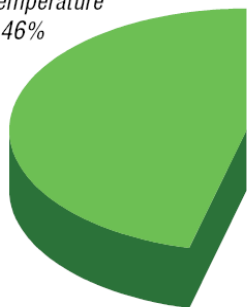
Rapid Temperature  
= 4%

Cold step stress  
= 14%

Combination of  
6doF Vibration and  
Rapid Temperature  
= 46%

Extreme Temperature  
Transitions  
= 12%

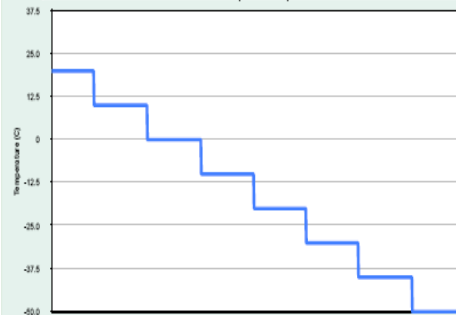
High  
Temperature  
Extreme  
= 12%



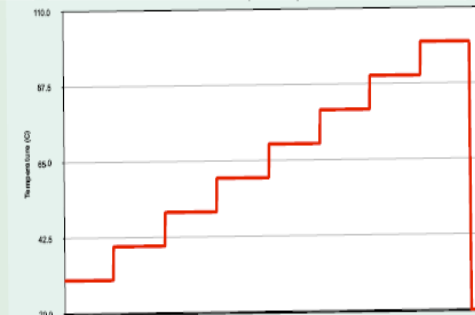
## HASS PRECIPITATED DEFECTS

Low  
Temperature  
Extreme  
= 12%

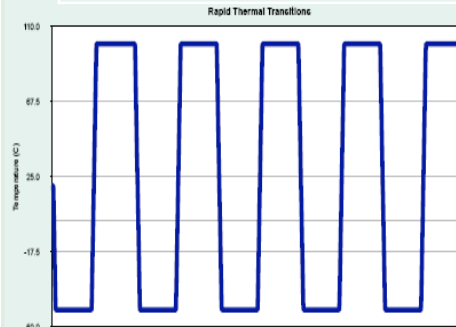
COLD TEMPERATURE STEP STRESS



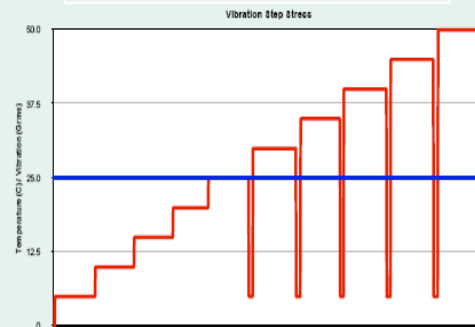
HOT TEMPERATURE STEP STRESS



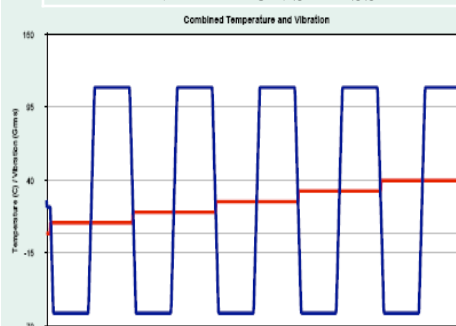
RAPID THERMAL TRANSITIONS



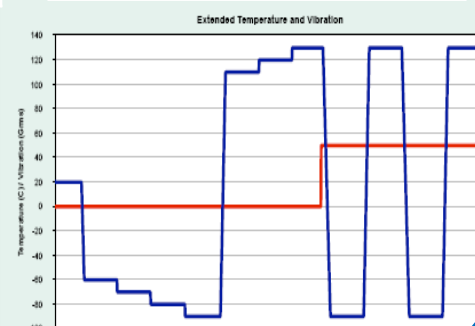
VIBRATION STEP STRESS



COMBINED TEMPERATURE & VIBRATION STRESS

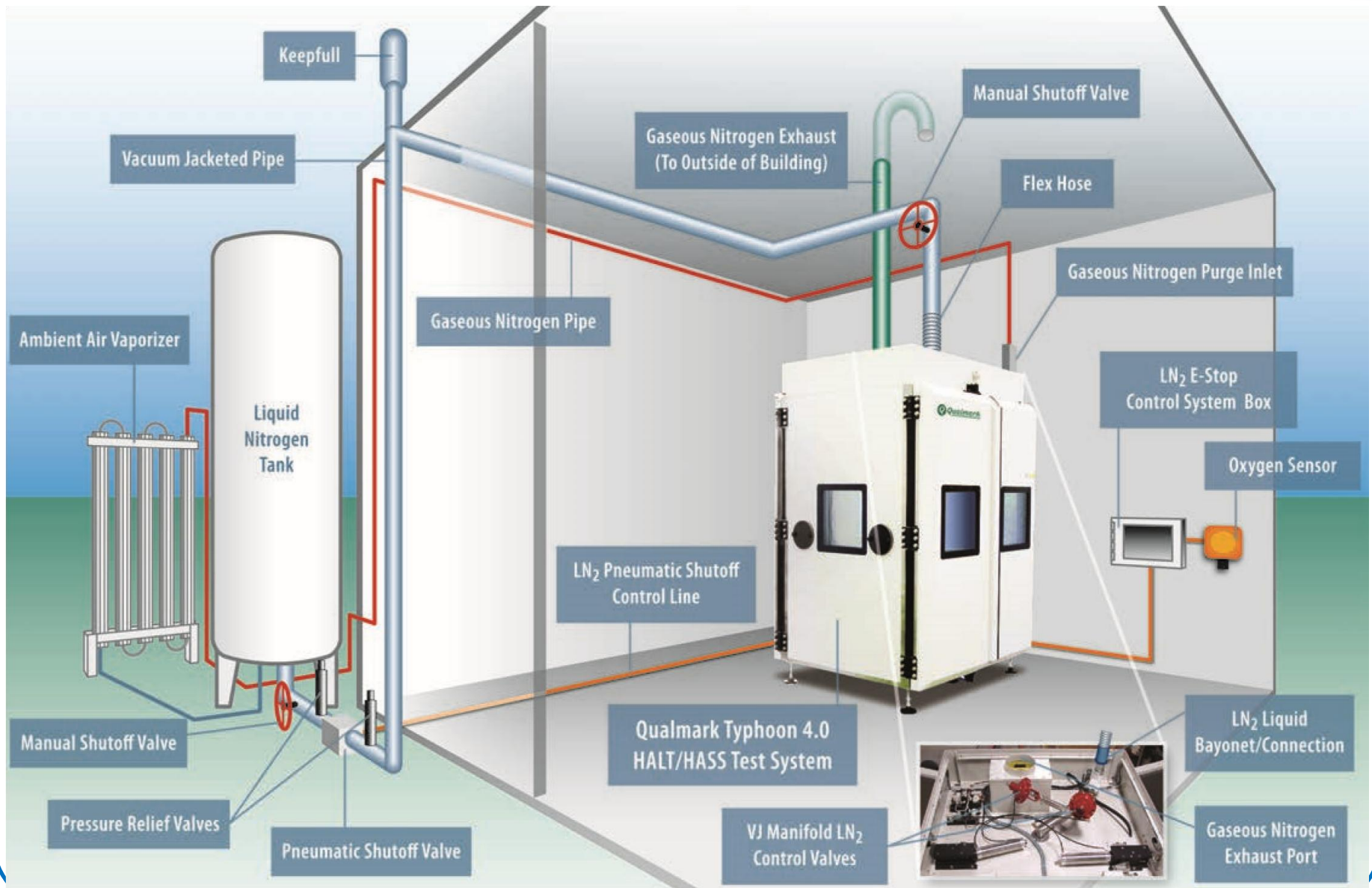


COLD TEMPERATURE & VIBRATION STEP STRESS





# HALT HASS FACILITY COMPONENTS







# CONCLUSION

- *ESS testing is preserving product life and released to aircraft faster .*
- *Type approval testing is required production units meeting the requirement at various manufacturing stages with defined stresses. The product life will be spent and the unit is yellow banded.*
- *The product life will not be reduced and weak components has to be taken out with correct failure by root cause analysis.*
- *HALT testing at design stage is very much required to detect an early stage failure by applying higher stresses and reduce the testing time. Once at design stage HALT is performed and good documentation is necessary & helps during the product life cycle.*
- *HASS testing is done within the destructive limit set by HALT & Iron out the various manufacturing stage defects.*
- *The quality of the developed products will be better and time to delivery will be improved.*