CHAPTER 16

HIGHLY ACCELERATED STRESS TESTING (HAST)

CONTENTS

1. INTRODUCTION

1.1 Accelerated testing is an approach for obtaining more information from a given test time than would normally be possible. It does this by using a test environment that is more severe than that experienced during normal equipment use. Highly Accelerated Stress Testing (HAST) is one method of accelerated testing.

1.2 Highly Accelerated Stress Testing (HAST) was developed by Nihal Sinnadurai while working as a Research Engineer at British Telecommunications Research Laboratories in 1968 in order to perform highly accelerated reliability testing of electronics components that are likely to encounter humid environments during normal (ambient) operation. The test is sometimes referred to as the Pressure Cooker Test (PCT). (See Part C Chapter 45 Environmental Stress Screening for the application and benefits of ESS). HAST has gained in popularity as it can deliver results in typically 100 test hours. Temperature Humidity Bias (THB) is a similar humidity and temperature testing process. THB is used to accelerate corrosion activities in metal and typically requires a test time of 1000 hours.

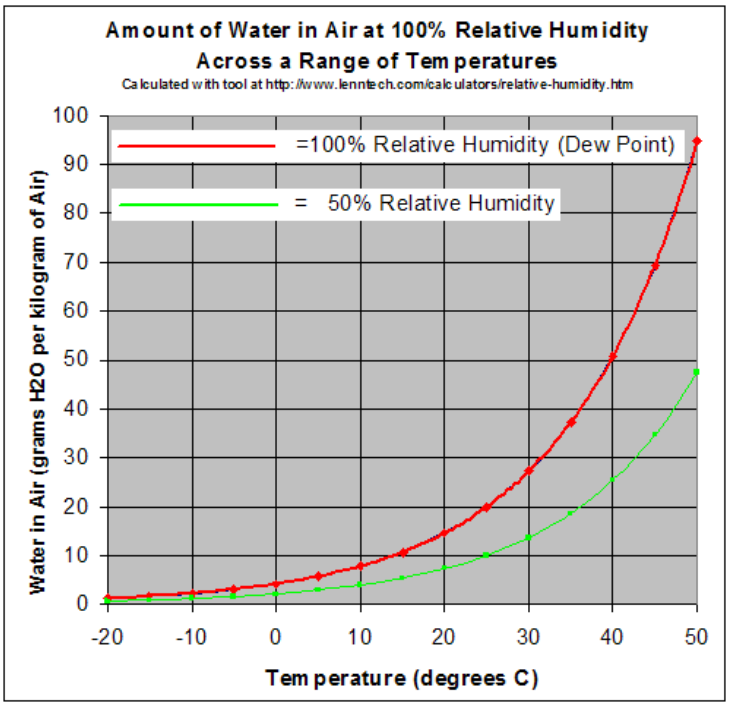
1.3 Within the discipline of Reliability, HAST can be used to reduce the time required to complete humidity and temperature testing of semiconductor and other electronic devices.

Critical assumption – the same failure mechanisms will be present at the higher stress levels and will act in the same manner as at normal stress levels.

2. PRINCIPLES OF HAST

2.1 Unless fully protected - Hermetically Sealed, semiconductor devices and other components will be subjected to the effects of moisture in the air, Humidity. The use of desiccants and other moisture extraction systems can reduce the humidity that the devices are subjected to.

2.2 Relative humidity is the term used to describe the amount of moisture in the air relative to the maximum amount of moisture that the air can hold at a given temperature and pressure. Therefore for a relative humidity of 50% the moisture in the air is half the amount of moisture that the air could hold. The chart below illustrates relative humidity for 100% and 50%. From the chart it can be seen that the amount of moisture that air can hold rises rapidly with temperature.



The relative humidity (ϕ) of an air water mixture is defined as the ratio of the partial pressure of water vapour (H_2O) (e_w) in the mixture to the saturated vapour pressure of water (e^*_w) at a prescribed temperature. Relative humidity is normally expressed as a percentage and is calculated by using the following equation:

$$\phi = \frac{e_w}{e^*_w} \times 100\%$$

2.3 The processes used in HAST are intended to accelerate moisture penetration into the internal parts of the item under test by raising the water vapour pressure using a test chamber. The level of penetration and the effects are then evaluated to determine the test item's resistance to humidity.

2.4 Simplistically, the test chamber is a pressure vessel able to withstand the planned temperatures and pressures required for the test. The chamber contains water and a heater in order to produce the required humidity and gauges to measure the conditions within the chamber. More complex test systems consist of two chambers that allows for the creation of saturated or unsaturated levels of humidity. The use of vapour circulation fans, vapour heaters and condensation shields will improve test reproducibility. As condensation will form on the walls and ceiling of the chamber if a shield is not provide it can drip onto the test item affecting the test results.

3. EXAMPLE HAST TEST

3.1 Test samples at room temperature are placed in the test chamber, any electrical connections being made. Humidifying water is also added. After the chamber has reached 100C air from within the chamber is released so that the atmosphere remaining in the chamber is water vapour. The vapour pressure inside the chamber is then raised to the test value where it is maintained for the designed test time. Test item functionality tests and parameter measurements can be performed within the test environment. At the end of the vapour pressure test the chamber and test item are cooled or allowed to cool naturally. Final examination and test of the item should be performed within twenty fours hours of cooling.

4. CONSTRAINTS AND LIMITATIONS OF HAST

4.1 Testing will only inform on the performance of products subjected to test parameters. When these results are used in a model to extrapolate performance at different levels of stimulus (moisture and pressure) or time interval the results will only be as good as the model employed. As with all models, they are only a model and not reality itself and therefore the limitations of the model must be understood if the modelling results are to usefully contribute to a product design or development.

5. FURTHER STUDY

5.1 Publications

Yamamoto T. Humidity Measurement and Control in the HAST. Report No 1. ESPEC Technology Report No 5.

5.2 Standards

IEC 60068-2-66: Environmental Testing Part 2: Test Methods – Test Cx; Damp heat, Steady state (unsaturated pressurised vapour)

IEC 60749 Semiconductor devices Mechanical climatic test methods. 5C Damp heat, steady state highly accelerated.