

# *Environmental Screening*

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## *Why ?*

Environmental screening is intended to determine whether a particular device or batch of devices can survive in a given environment, for a known period of time.

Additionally, this type of screening is used to remove devices that have imperfections during design and/or manufacture, that would lead to premature failure in its intended working environment.

## *Tests discussed*

- Temperature related tests
  - Dynamic Burn-in
  - High Temperature Operating Life (HTOL)
  - Stabilisation bake
  - Data retention bake
  - Temperature cycle assessment and test
  - Thermal shock
  - Highly Accelerated Stress Test (HAST)
  - Autoclave and 85/85 tests
- Mechanically related tests
  - Particle Impact Noise Detection (PIND)
  - Gross and Fine leak
  - Centrifuge
  - Mechanical vibration
- Electrically related tests
  - Solderability
  - Latch-up assessment
  - ESD assessment and test
  - Thermal testing

## *Dynamic Burn In*

- How
  - Device is dynamically operated at elevated temperature, generally 125°C, for 168 hours or 1000 hours.
- Why
  - Accelerates the majority of real-life failure mechanisms
  - 168 hours operation at 125°C equates to over 7 years normal operation at 25°C.

# *HTOL*

## *High Temperature Operating Life*

- How
  - Device is dynamically operated at elevated temperature, generally 125 °C, for an extended period, often upto 8000 hours.
- Why
  - Accelerates the majority of real-life failure mechanisms
  - To predict the reliability of the product type.

## *Stabilisation Bake*

- How
  - Device is stored, unbiased, at elevated temperature, generally 125 °C or 150 °C, for typically between 24 and 48 hours.
- Why
  - Performs final “annealing” of device, enhancing any contamination during final manufacturing process.
- Note
  - Generally not performed on “regular” logic or analog parts nowadays.

## *Data retention bake*

- How
  - Unbiased storage for upto 1000 hours at 125°C or 150°C, as stabilisation bake.
- Why
  - Accelerates failures in Flash or EEPROM type technologies, generally associated with charge leakage from the storage element, equating to data loss of the device.
- Note
  - Applies mainly to memory storage devices that claim data retention.

## *Temperature Cycle Screen*

- How
  - Devices are cycled, in air or inert gas, from cold to hot, generally from  $-65^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ , for a small number of cycles, generally between 5 and 10, with a specific rate of change of temperature.
- Why
  - Eliminate manufacturing defects prone to failure due to thermal expansion.

## *Temperature Cycle Assessment*

- How
  - Devices are cycled, in air or inert gas, from cold to hot, generally from  $-65^{\circ}\text{C}$  to  $150^{\circ}\text{C}$ , for a large number of cycles, upto 1000 cycles, with a specific rate of change of temperature
- Why
  - Determine the reliability of the product when exposed to regular temperature cycles.
  - Exaggerates the stresses that can occur from power-cycling, revealing any weaknesses caused by mismatch of thermal expansion between die and package.

## *Thermal Shock Assessment*

- How
  - Devices are mechanically transferred from one temperature extreme to the other extreme in as fast a time as practical
- Why
  - Thermal shock highlights thermo-mechanical incompatibility from mechanical expansion/contraction, often caused by the selection of incorrect materials or processing.

# *HAST*

## *Highly Accelerated Stress Test*

- How
  - Devices are subjected to both high temperature (~130 °C) and humidity (~85% RH) in a pressurised environment, with or without electrical bias.
- Why
  - Accelerates ionic contamination and corrosion within die/package interface and device leads. Tests for ingress of moisture in plastic packages
- Note
  - Only applicable to plastic packages.

## *Autoclave*

- How
  - Devices are subjected to high temperature (121 °C) and saturated humidity (100% RH) under no bias conditions
- Why
  - Accelerates ionic contamination and corrosion within die/package interface and device leads.  
Tests for ingress of moisture in plastic packages
- Note
  - Only applicable to plastic packages.

# *Temperature Humidity Test*

## *85/85 Test*

- How
  - Devices are subjected to high temperature (~85 °C) and humidity (~85% RH) with or without electrical bias.
- Why
  - Accelerates ionic contamination and corrosion within die/package interface and device leads.  
Tests for ingress of moisture in plastic packages
- Note
  - Only applicable to plastic packages.

# *PIND*

## *Particle Impact Noise Detection*

- How
  - Device is subjected to both mechanical vibration and shock in alternating cycles, with a sensitive microphone attached listening to sounds from within internal hermetic cavity
- Why
  - To detect extraneous particles within a hermetic cavity, which may impact and embed upon the active die surface, thereby interfering with the device operation.

## *Gross Leak*

- How
  - Cavity packages are subjected to a high-pressure gas, such as air or a fluorocarbon, and then placed in a high-temperature inert liquid and monitored for emerging bubbles indicating gas egress from the package.
- Why
  - To ensure hermeticity of a cavity package.

## *Fine Leak*

- How
  - Cavity packages are subjected to a high-pressure inert gas, such as Helium, and then placed in a mass-spectrometer to detect minute traces of the gas. Helium is often used due to its small molecule size.
- Why
  - To ensure hermeticity of a cavity package.

## *Centrifuge*

- How
  - Devices are placed in a centrifuge and subjected to angular acceleration, typically upto 30,000 G's.
- Why
  - Tests the mechanical stability and survivability of the final assembly, including die attach and bond-wires, especially to extremely high perpendicular acceleration forces.

# *Shake, rattle 'n roll Assessment*

- How
  - Devices are placed on a mechanical vibration jig, that subjects the device to a number of vibration cycles, ranging from 1-, 2- and 3-axis shock, and frequency swept vibrations.
- Why
  - Tests the mechanical stability and survivability of the final assembly, including die attach and bond-wires, including susceptibility to resonant vibrations.

## *Solderability Assessment*

- How
  - Devices are solder-dipped under worst case conditions, and then visually examined.
  - Various techniques, including the measurement of surface tension, are often employed.
- Why
  - Ensures the ability of the device to be used in a normal manufacturing environment.
- Note
  - This will become more prevalent as various Pb-free solder mixtures are used with differing fluxes.

## *Latch-Up Assessment*

- How
  - High voltage pulses are sent to each I/O pin on a device, and the supply current is monitored to detect latch-up, in accordance with JEDEC 57.
- Why
  - Modern CMOS technologies inherently have a self-regenerative NPNP structure which, under certain circumstances, can cause destructive supply currents to flow, known as “latch-up”. This test assess the protection mechanisms emplaced to prevent the occurrence of “latch-up”

## *ESD Testing and Assessment*

- How
  - A purpose-built ESD tester is used, forcing a human or machine body-model discharge to each device pin in turn for a number of cycles, then analysing each pin with a V-I curve trace to detect ESD damage.
- Why
  - Devices, especially employing CMOS technology, are susceptible to I/O pin damage caused by electro-static discharge. This test assesses the ESD protection.

# *Temperature Screening*

- How
  - Devices are electrically tested at both temperature extremes.
- Why
  - To ensure compliance to the data-sheet specification, and to ensure correct operation in application.
- Note
  - Different failure mechanisms or device marginality can be observed and highlighted during these tests.