



Short-Term Reliability Tests - Standards Development

Jianzhong Jiao, Ph.D.
September 29, 2016

JZJ Consulting, j_jiao@hotmail.com

Outline



- Reliability test standards overview
- Light source component tests
 - Tests for semiconductors and LEDs
 - Tests for lighting electronics
- Lighting product level tests
 - Learning from other lighting sectors

Overview



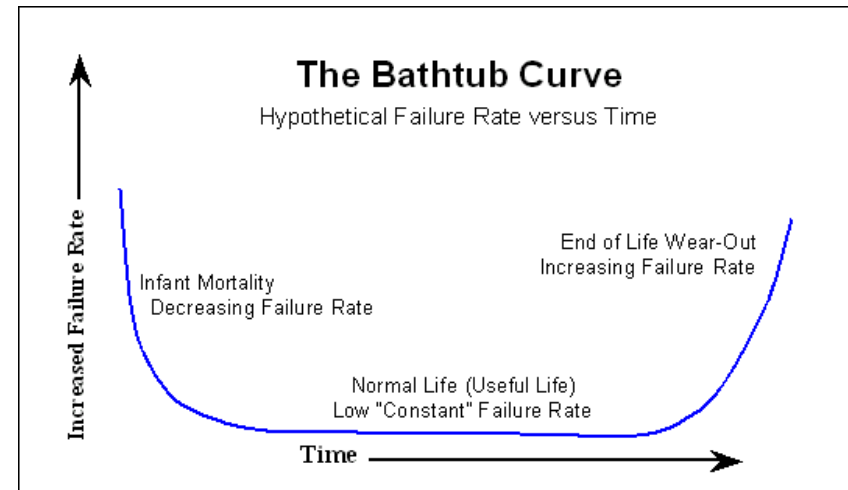
Background

● What's product reliability

- The probability that a device will perform its required function, subjected to stated conditions, for a specific period of time.
- Product reliability is quantified as MTBF (Mean Time Between Failures) for repairable product and MTTF (Mean Time To Failure) for non-repairable product.

● What's product robustness

- A product is strong and effective in all or most situations and conditions.



Overview



What should be tested for reliability?

● Accelerating failures – stressors

● Stressors for LEDs

● Temperature

● Humidity

● Voltage

● Stressors for LEDs drivers & electronics

● Electrical, EMI, EMC

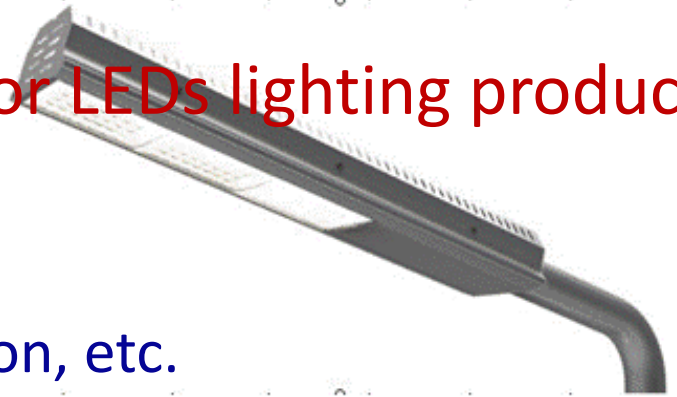
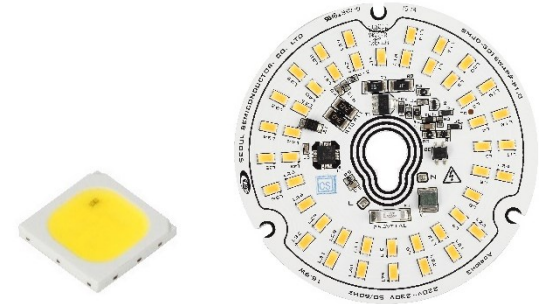
● On-off cycle

● Reliability or robustness stressors for LEDs lighting products

● All the above, plus:

● Mechanical: vibration, impact, etc.

● Environmental: dust, chemical corrosion, etc.



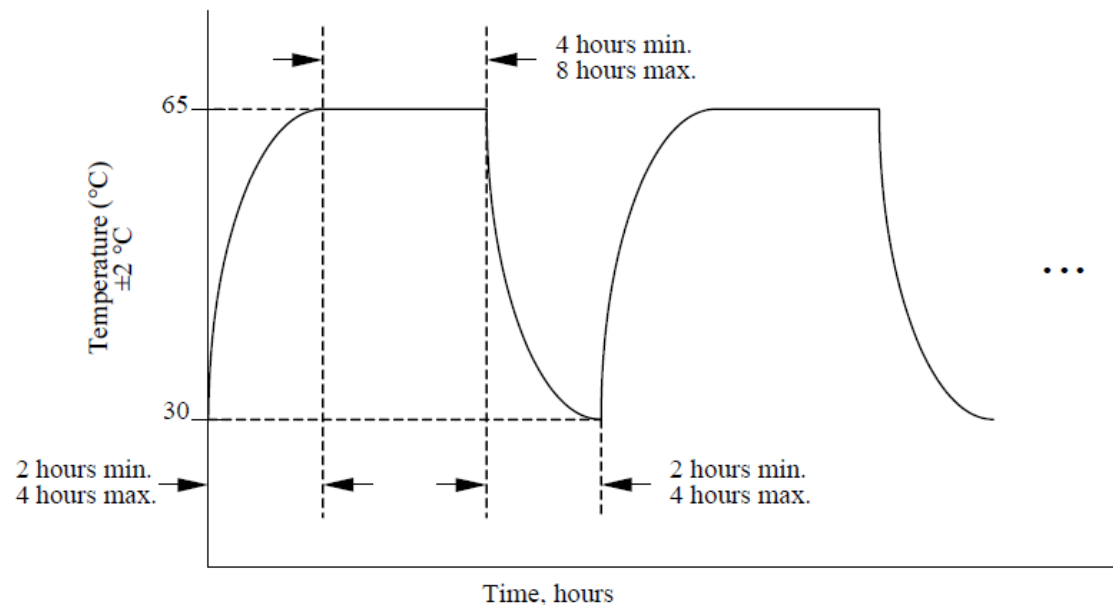
Component Level Tests



JEDEC Standard: JESD 22-A100

● Cycled Temperature-Humidity-Bias Life Test

- For the purpose of evaluating the reliability of non-hermetic, packaged solid state devices in humidity environments when surface condensation is likely. It employs conditions of bias, temperature cycling and high humidity that will cause condensation to occur on the device surface. It is useful to determine device surface susceptibility to corrosion and/or dendritic growth.



Component Level Tests



JEDEC Standard: JESD 22-A101

● Steady State Temperature Humidity Bias Life Test

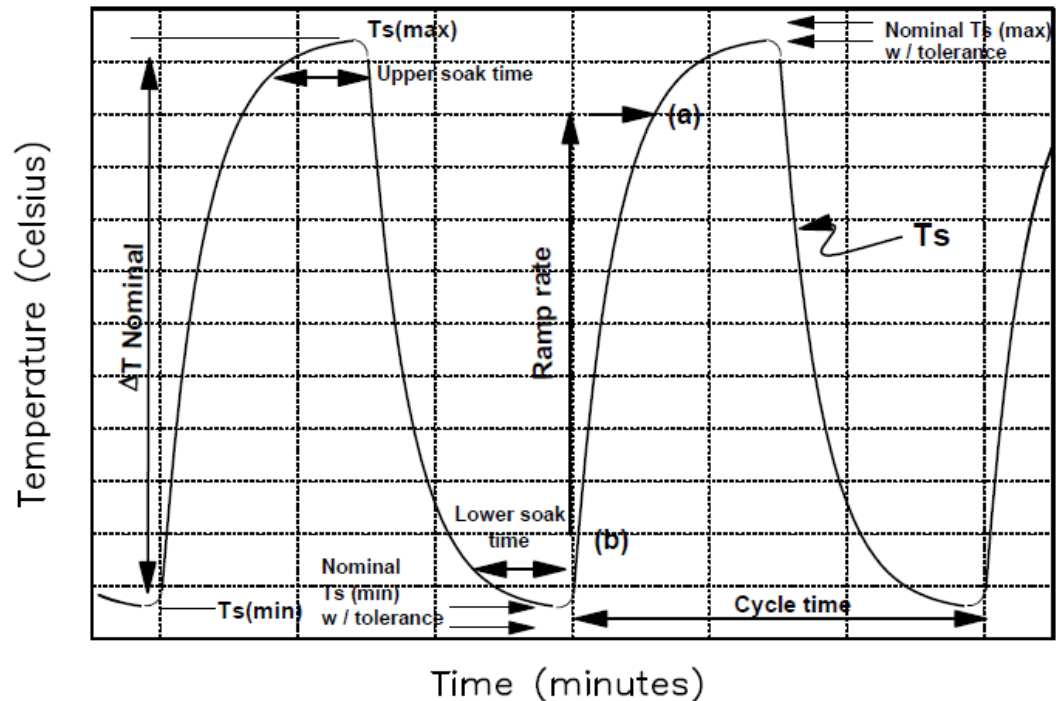
- To evaluate the reliability of nonhermetic packaged IC devices in humid environments. Temperature, humidity, and bias conditions are applied to accelerate the penetration of moisture through the external protective material (encapsulate or seal) or along the interface between the external protective material and the metallic conductors which pass through it.
- Rum up, rum down, continuous bias or cycled bias

Component Level Tests

JEDEC Standard: JESD 22-A104

● Temperature Cycling

- To determine the ability of components and solder interconnects to withstand mechanical stresses induced by alternating high- and low-temperature extremes. Permanent changes in electrical and/or physical characteristics can result from these mechanical stresses.



Component Level Tests



JEDEC Standard: JESD 22-A108

● Temperature, Bias, and Operating Life

- To determine the effects of bias conditions and temperature on solid state devices over time. It simulates the devices' operating condition in an accelerated way, and is primarily for device qualification and reliability monitoring. A form of high temperature bias life using a short duration, popularly known as burn-in, may be used to screen for infant mortality related failures. The detailed use and application of burn-in is outside the scope of this document.
- High: 125 °C, low: -10 °C

Component Level Tests



JEDEC Standard: JESD 22-A113

- **Preconditioning of Nonhermetic Surface Mount Devices Prior to Reliability Testing**
 - For nonhermetic solid state SMDs that is representative of a typical industry multiple solder reflow operation. These SMDs should be subjected to the appropriate preconditioning sequence of this document by the semiconductor manufacturer prior to being submitted to specific in-house reliability testing (qualification and reliability monitoring) to evaluate long term reliability.
 - Typical preconditioning sequence flow

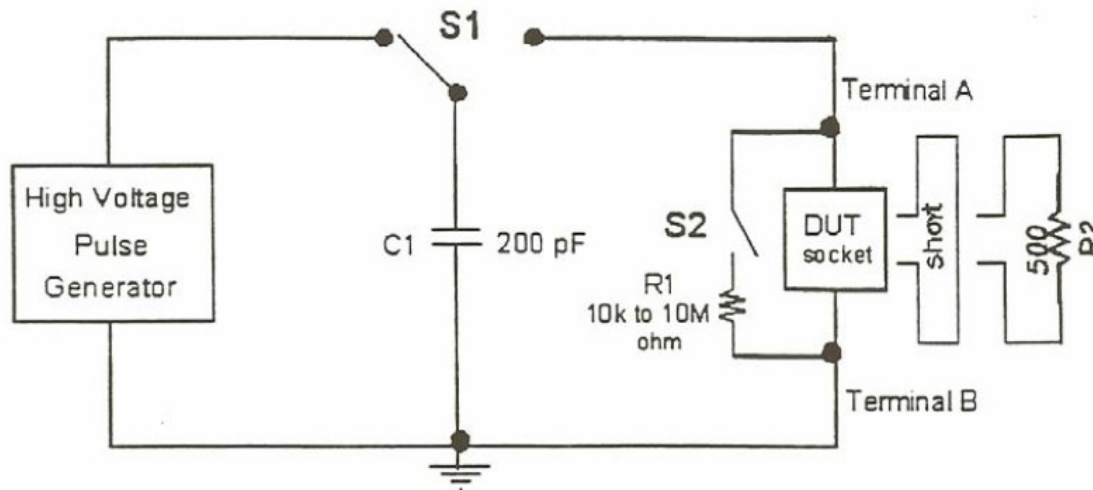
Component Level Tests



JEDEC Standard: JESD 22-A115

● Electrostatic Discharge Sensitivity Testing, Machine Model

- The objective is to provide reliable, repeatable MM ESD test results. The model is useful for producing human-body model (HBM)-like ESD effects at lower voltages and for failure mode determination. The method produces results with are closely related to HBM and produces similar failure modes.



Component Level Tests



JEDEC Standard: JESD 22-B101

● External Visual

- Examination of the external surfaces, construction, marking, and workmanship of a finished packaged device. External visual is a noninvasive and nondestructive test. It is functional for qualification, quality monitoring, and lot acceptance.
- This test method is applicable to: 1) finished packaged devices only; 2) all solid-state device package types/styles; 3) devices having attachments as shipped (see clause 3 for definition).
- This test method is not applicable to: 1) customer-processed devices; 2) piece parts incoming to a device assembly operation, or to sub-assemblies in a manufacturing line (WIP); 3) the carrier, dry bag, packing, or container used to ship devices; 4) the orientation or loading aspects of devices in carriers; 5) the internal, non-viewable features of a device.

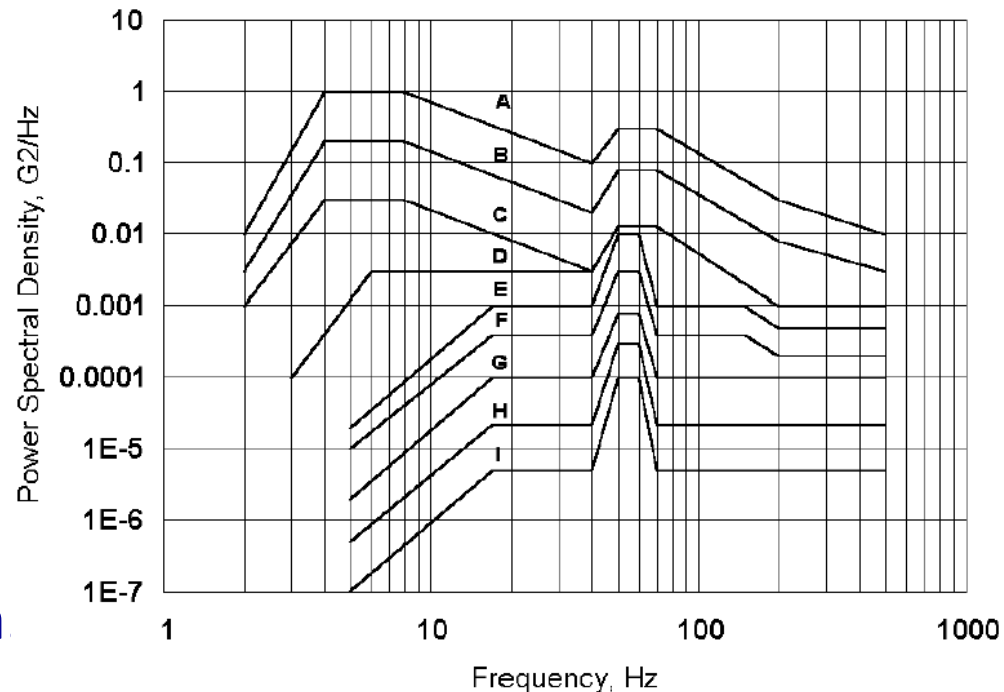
Component Level Tests



JEDEC Standard: JESD 22-B103

● Vibration, Variable Frequency

- To evaluate component(s) for use in electrical equipment. It is intended to determine the ability of the component(s) to withstand moderate to severe vibration as a result of motion produced by transportation or field operation. Vibration of this type may disturb operating characteristics, particularly if the repetitive stress causes fatigue. This is a destructive test intended for component qualification.



Component Level Tests



ANSI Standard: C82.15 (Draft)

● LED Driver Robustness

- To evaluate LED drivers robustness or their ability to withstand the specific stress described. The scope includes LED drivers that operate from supply sources up to 600V and 50/60 Hz or DC applications.
- Hardware based driver
- Microprocessor based driver

Component Level Tests



ANSI Standard: C82.15 (cont.)

- **Hardware Based Drivers – Stresses**
 - Electrical
 - Temperature
 - Vibration
 - Humidity

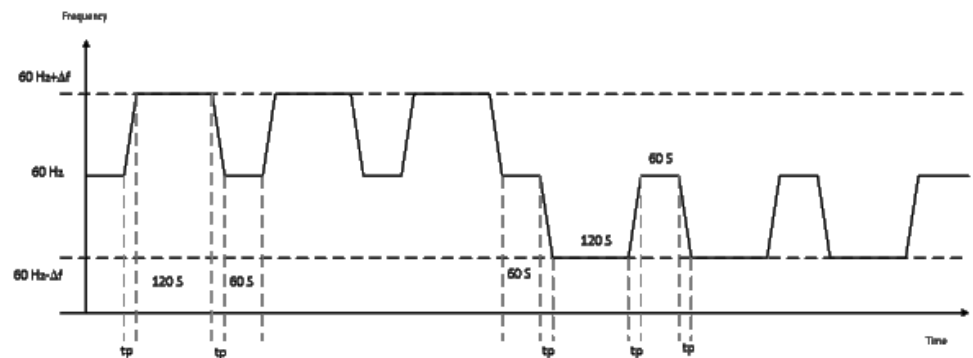
Component Level Tests



ANSI Standard: C82.15 (cont.)

● Microprocessor Based Driver

- Power-up and power-down
- Voltage dips and interruptions
- Ring wave test, and combination wave test
- Electrostatic discharge (ESD)
- Radio frequency electromagnetic fields (EMI)
- Abnormal operation
- Mains frequency change
- Thermal cycling
- Humidity stress
- Vibration stress



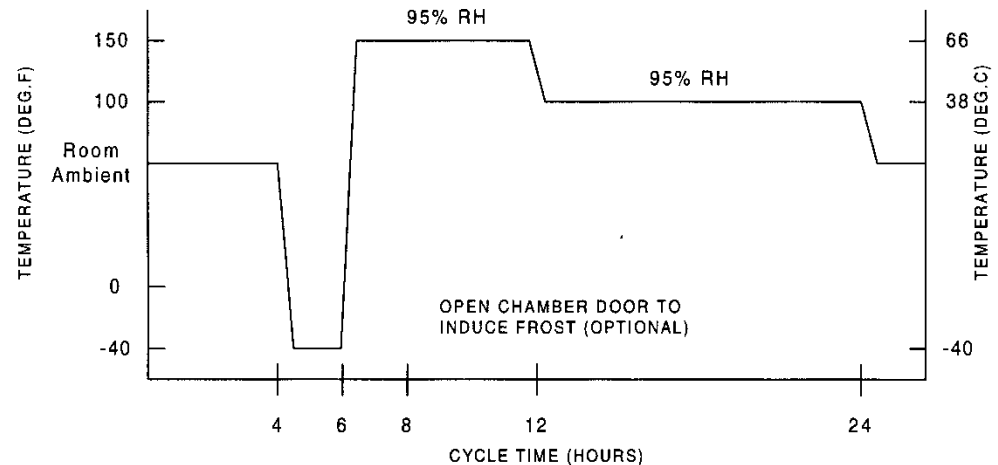
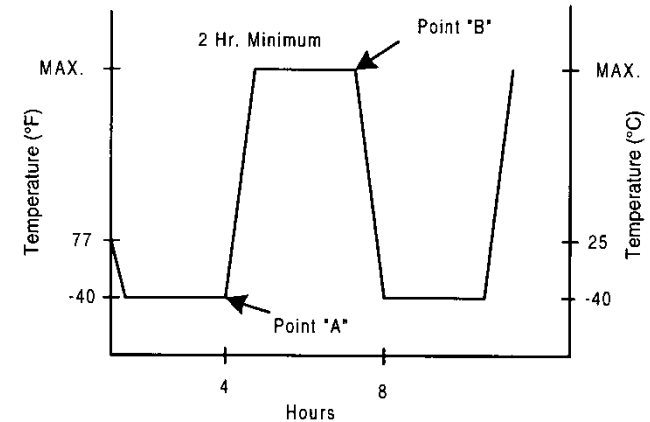
Component Level Tests



SAE Standard: J2357

● Electronically Driven and/or Controlled Exterior Automotive Lighting

- Thermal cycle
- Thermal shock
- Humidity
- Chemical resistance
- Vibration
- Electrical stress



Component Level Tests



IES Standard: LM-87 (draft, will change to TM-xx)

● Robustness Tests for LEDs

- To provides recommendations for robustness tests for LED packages. The test methods are provided in the JEDEC standards listed in the Normative Reference Section. This approved method does not make any recommendation regarding predictive estimations or extrapolations.

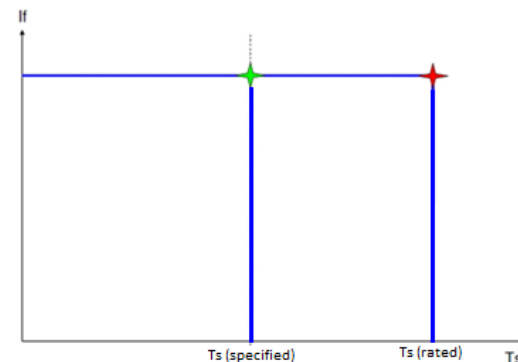
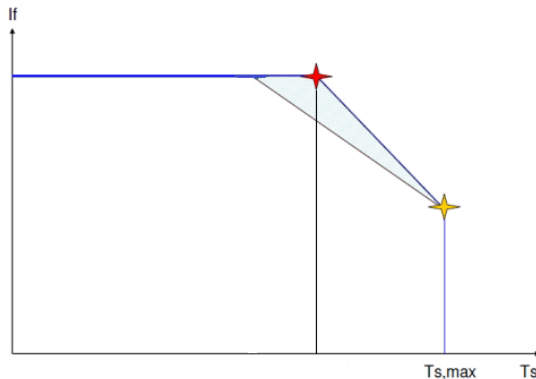
Component Level Tests



IES Standard: LM-87 (cont.)

● Robustness Tests for LEDs (cont.)

- High temperature operating Life (HTOL) test: derating and non-derating cases
- Temperature cycling (TMCL) test
- Resistance to soldering heat (RSH) test
- Wet high temperature operating Life (WHTOL) test
- Electrostatic discharge (ESD)
- Continues switching cycles until failure



Component Level Tests



IES Standard: TM-26

● Methodologies for Projecting Failure Rate of LED Packages

- Methodologies for projecting catastrophic failure rate of LED packages. This document applies to the LED packages that are defined in ANSI/IES RP-16-10.
- Results of failure rate in table format
- Imperial data model for catastrophic failure rate
- “Textbook” model for catastrophic failure rate

	-10 °C	25 °C	55 °C	85 °C	T _{i,max} °C
I _{F, DC maximum}	100	200	400	800	1000
I _{F, DC nominal 2}	40	100	200	400	800
I _{F, DC nominal 1}	20	40	80	200	600
I _{F, DC minimum}	10	20	40	100	400

$$\lambda = \lambda_{ref} \times \pi_I \times \pi_T$$

$$FIT = \frac{\chi_\alpha^2(2r+2)}{2T} \times 10^9$$

Component Level Tests



IEC Standard: IEC/TS 62861 (Draft)

- **Guide to Principal Component Reliability Testing for LED Light Sources and LED Luminaires**
 - LED package and interconnects
 - Optical materials
 - Electronic assembly

Component Level Tests



IEC Standard: IEC/TS 62861 (cont.)

● Initial qualification tests for LEDs

- Low temperature operating life (LTOL)
- High temperature operating life (HTOL)
- Pulsed operating life (PLT)
- Temperature Cycling (TMCL)
- Vibrations variable frequency (VVF)
- Wet high temperature operating life (WHTOL)
- Damp heat cycling (DHC)
- Electrostatic discharge, human body model (ESD-HBM)
- Electrostatic discharge, machine model (ESD-MM)
- Environmental stress: hydrogen sulphide (H₂S), flowing mixed gas corrosion (FMGC), sulfur dioxide (SO₂)

Component Level Tests



IEC Standard: IEC/TS 62861 (cont.)

- **Initial qualification tests for optical materials**
 - Relative humidity (RH)
 - Boiling water (BW)
 - Oven water (OW)
 - High temperature exposure (HTE)

Component Level Tests



IEC Standard: IEC/TS 62861 (cont.)

- **Initial qualification tests for electronic assembly**
 - Temperature and operation stress (PTC)
 - Humidity and operation stress (HOT)

Lighting Product Level Tests

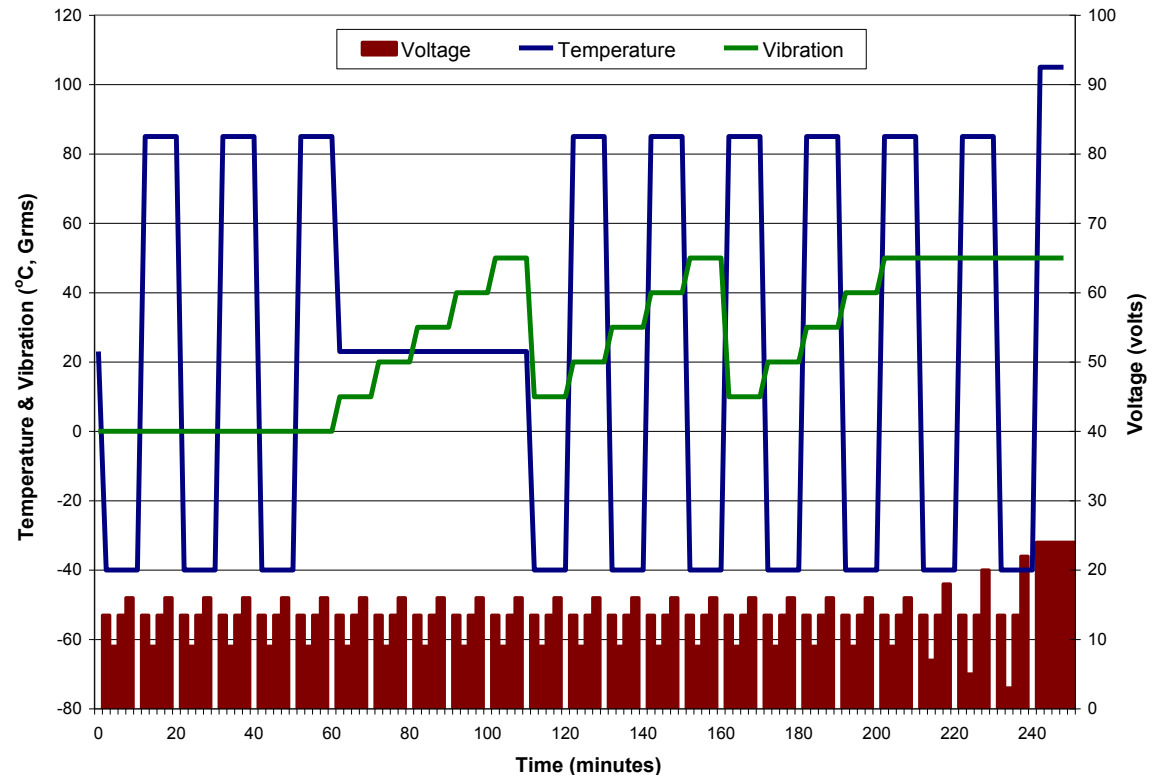
SAE Standard: J3014

- **Highly Accelerated Failure Test (HAFT) for LED Lamps**
 - To provides test procedures, requirements, and equipment recommendations for the methods of the measurement that characterizes potential design failures by utilizing a step stress approach to subject a device under test to thermal, vibration, and electrical stresses of types and levels beyond what it may see in actual use, but which will rapidly induce failure modes, allowing them to be detected and corrected.
 - Stressors: temperature, vibration, and voltage

Lighting Product Level Tests

SAE Standard: J3014 (cont.)

- **Equipment, procedure and evaluation**
 - Thermal chamber with a vibration machine
 - Voltage variation
 - Temperature cycle
 - Vibration
 - Test to fail

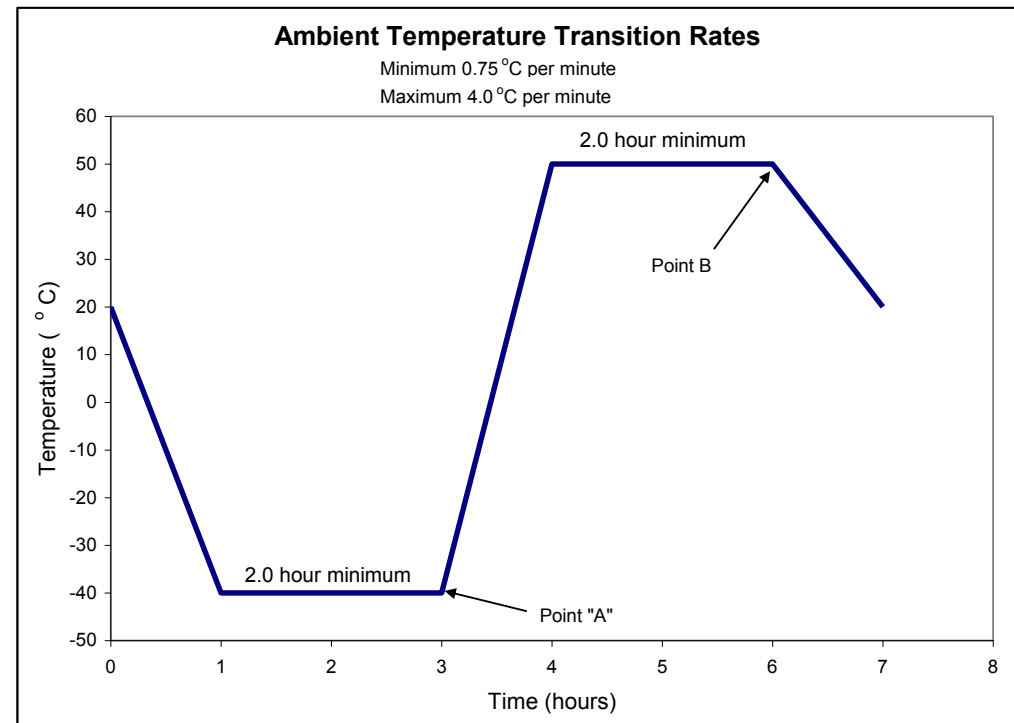


Lighting Product Level Tests

SAE Standard: J575

● Test Methods and Equipment for Vehicle Lighting

- It is intended for lighting devices used on vehicles.
- Vibration
- Impact
- Thermal cycle
- Moisture
- Humidity
- Dust exposure
- Corrosion
- Chemical resistance



Lighting Product Level Tests

IES Standard: LM-89 (proposal, will change to TM-xx)

● LED Lamp/Luminaire Robustness Testing

- To provide a formal definition of LED lamp/luminaire robustness, recommendations for robustness testing protocols for LED lamp/luminaire. These tests are performed using the over-stress tests conditions. LED lamp/luminaire specific test conditions are provided focusing on system-level test conditions, procedures, and methodologies. This approved method does not make any recommendation regarding predictive estimations or extrapolations.

Summary



Goal: Short-Term Tests for Long-Term Projection

- **Industry standards are based on:**
 - Understanding of stressors for each product or product levels
 - Establishing stressors for the products based on applications
- **Currently established or developing standards**
 - Test methods to accelerate stresses on the devices
 - Qualitative measures
- **Standard work continues**
 - Developing projection models



Than You!

For further information, contact:

j_jiao@hotmail.com

+14156063322