Quality Control for Electronic Products: Implementation of a Burn-In Test for Printed Circuit Boards

Luã Malco da Conceição Souza[1]*, Alan Gramacho dos Santos[1], Breno Prazeres Barbosa[1]
[1]SENAI CIMATEC University Center; Salvador, Bahia, Brazil

The production process of Printed Circuit Boards (PCBs) for projects that require high quality standards demands a robust Quality Control System. A product may undergo several qualification levels, with rigorous testing and high certification, and still present failures in the field, compromising customer satisfaction and, consequently, brand reputation. Considering that electronic components tend to exhibit a high probability of failure in the early stages of their useful life, this work aims to implement a Thermal Stress Screening Test Plan (Burn-in) for PCBs, anticipating the manifestation of latent defects before the product is deployed in the field, selecting those with greater durability without compromising their useful life. This test plan, necessary for implementation, must define test conditions, techniques, infrastructure, acceptance criteria, data collection procedures, and data analysis methods to ensure test standardization and reproducibility.
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This work aims to propose a burn-in test plan applied to a real manufacturing process, as a strategy to improve the quality and reliability of printed circuit boards produced under the responsibility of SENAI CIMATEC. The test will be one of the manufacturing qualification processes that will compose the Quality Control System (QCS) of electronic component production within the same program. The use of environmental tests such as these is of crucial importance to increasing the quality level of electronic products.

A test plan is a document that must function as a "recipe", a specific methodological procedure for a given product, so that results can be achieved under the same experimental framework. Relevant information such as test conditions, environment, test duration, initial conditions, and boundary conditions must be well defined. This document must include the applied techniques, methods, approval criteria, test parameters, analysis strategies, scope, and other relevant information necessary for test implementation.

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Address for correspondence: Luã Malco da Conceição Souza. Av. Eng. Gentil Tavares, 1166 - Getúlio Vargas, Aracaju - SE, Zipcode: 49055-260. E-mail: luamalco1@gmail.com.
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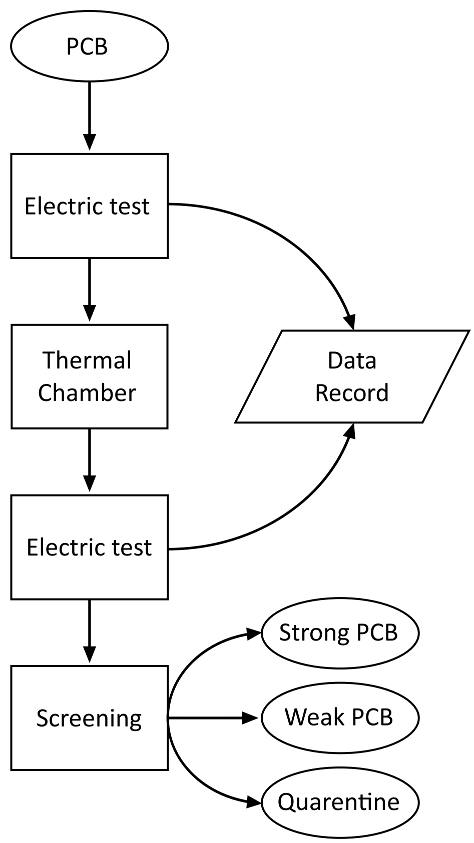
This work is still in its initial phase and will include a future implementation stage, in which experimental results will be obtained. One of the main challenges to be overcome is the lack of Life Test data and other more comprehensive Environmental Tests from preliminary stages of product development, which hinders the development of a statistical approach. Given the difficulty in acquiring references to Burn-in test plans for PCBs in the literature that could serve as models—due to confidentiality and industrial secrecy—it is necessary to develop a proprietary approach capable of being improved and adapted to product needs.

Materials and Methods

This work is an ongoing, highly confidential research project that will soon unfold into experimental work. At present, it consists of planning the execution of the Burn-in method for the Printed Circuit Board (PCB) manufacturing process through a product-linked test plan. The Burn-in process is described by the Figure 1.

The Burn-in test plans were developed considering two main aspects in the selection of test parameters:
i) the test temperature must encompass the maximum temperature to which the Device Under

Figure 1. Burn-in procedure.



Test (DUT) will be subjected in the field, including transportation, storage, and installation stages; **ii)** the test temperature must not exceed the minimum maximum temperature rating of all individual electronic components on each PCB.

Regarding exposure time, the 96-hour parameter specified in MIL-STD-750 [1] was used as a reference. It should be noted that exposure time parameters may be modified during the execution of other tests, once trends, data patterns, or even process optimizations are identified. The key aspect is to ensure that all developed tests are properly recorded and traceable.

Standardizing test conditions is essential to ensure reproducibility and, consequently, more reliable data [2]. The tests must be carried out under the following conditions according to Table 1.

Data acquisition will be performed using test devices integrated into the Quality Control System. The DUT must undergo electrical testing before

Table 1. Test conditions.

Ambient temperature	25°C ± 3°C
Relative humidity	50% ± 5%
Temperature profile	70°C ± 2°C
Exposure time	96 h
DUT's condition	De-energized

being subjected to the thermal chamber. After completion of the test, the DUT must undergo a 24-hour stabilization period so that possible physicochemical reactions resulting from heating can stabilize. After this period, the DUT must again undergo electrical testing. The acceptance criteria for unit electrical tests are the same as those used by the Quality Control System.

The standard acceptance criterion will be Go/No-Go. That is, products presenting nonconformities must be removed from the population. Depending on the criticality of the changes resulting from the test, rejected products may or may not undergo remanufacturing.

The test scope must be total, meaning all products must be subjected to the Burn-in test. In the initial periods, especially during the first tests, smaller sample sizes should be used to allow adjustments and mitigation of potential losses.

All tests must be recorded, considering the test batch and the serial number of each DUT. Records must include test parameterization, test conditions, and any objections or anomalies observed. Data recording must be performed through the Quality Control System infrastructure itself.

A thermal chamber with precise temperature control must be used to ensure greater process reproducibility.

Tests must not be interrupted under any circumstances [2]. There must be no contamination, power outages, or failures in the temperature control system. Test conditions must be reproducible and inexorable [3].

The tests will result in the creation of a database to be used for future optimizations, improvements, and analyses.

Theoretical Background

A Printed Circuit Board (PCB) has a considerable probability of failing immediately after completing the assembly process or during the early stage of its life cycle [4]. This may occur due to chemical reactions in its materials that are not yet fully stabilized, divergences in the assembly process detected by quality control mechanisms, or the presence of random effects. This behavior is described in the literature as the “bathtub curve” (Figure 2).

The use of testing methods that apply Environmental Stress Screening loads is a viable strategy to ensure the delivery of higher-quality products, mitigating the occurrence of premature failures and undesirable effects that harm brand credibility, increase customer dissatisfaction, and substantially impact product quality [5].

Burn-in is a type of thermal stress test widely used in the electronics industry [4]. Basically, a climatic chamber is used, into which a population of DUTs (Devices Under Test) is inserted and subjected to a specific stress load or combination of stresses for a defined exposure time. It is a type of non-destructive accelerated life test that moves the product from an “infant mortality” stage—where weaknesses are more frequent—to a more mature stage, where the failure rate is lower and constant.

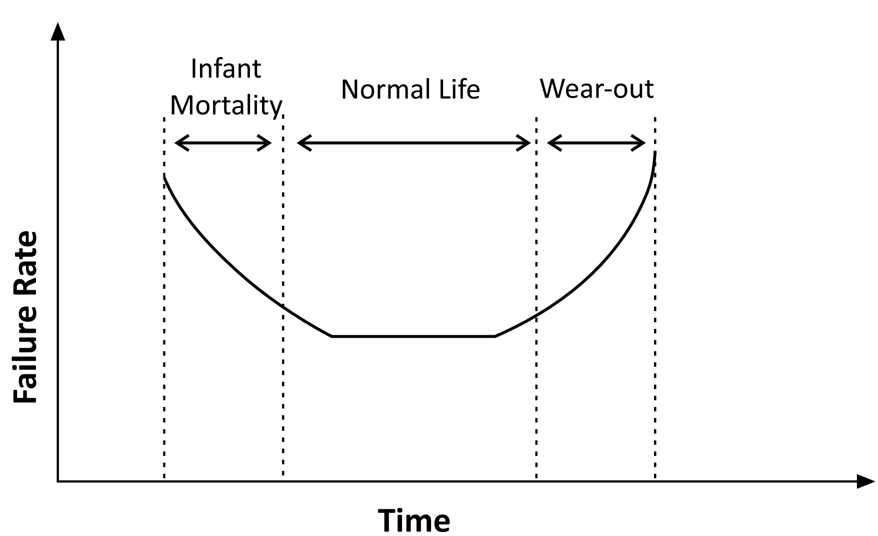
This approach is primarily used for screening purposes, separating weak products from the population that will be deployed in the field. The test is usually planned to simulate the environmental operating conditions that the DUT will face, without exceeding stress levels, in order to avoid unnecessary product aging [5]. It is typically conducted at a reasonable and constant temperature, below design operational limits, with a longer duration compared to other accelerated life tests found in the literature.

It must be considered that each product has individual characteristics in terms of design, materials, and manufacturing processes. Therefore, Burn-in is applicable only to a specific type of product. Each PCB series produced must undergo a specific Burn-in test, with its own parameters and test conditions—an exclusive “recipe.” Although widely used in the electronics industry, Burn-in test plans are kept confidential as industrial secrets and are rarely disclosed, representing a strategic advantage [6].

Conclusion

The test plan must enable the implementation and execution of the Burn-in test in such a way that it can be reproduced, replicated, and even improved. The implementation of this test should primarily

Figure 2. Bathtube curve.



result in the generation of useful data, both for detecting product weaknesses and for screening stronger products.

The test plan must undergo fine-tuning of parameters such as temperature and exposure time to adapt to production needs as improvements and optimizations become necessary based on experimental results. Some losses are expected during the process, such as PCB populations that may fail due to excessive test aggressiveness rather than product weaknesses, requiring adjustments to test parameters.

The implementation of Burn-in is expected to solve the lack of product life test data, enable the detection of weaknesses, and consequently deliver products with high quality and durability.

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