Determination of Early Failure Rates for Card Assembly by Surface Mount Technology (SMT) from Production Yield Data

Peter Lubomir Polak, Alex de Macedo, Edson Yuichi Suzuki, Victor Sonnenberg, and Mauricio Massazumi Oka

Abstract—**Assembled card burn-in is used to be carried out in Celestica, however the process is not optimized. A card was selected and its production yield data, available in a database in Celestica, was analyzed. As a result, an experiment was designed for determining the burn-in parameters. The percentage of failures was determined. It is proposed that the percentage of defects evidenced by burn-is a subgroup of the total defects, being 10.6 % of the defects.**

Index Terms—**Burn-in, Weibull plot, SMT, early failure.**

I. Introduction

IN many industrialized products, including electronics, part of the production is used to fail prematurely, before reaching its lifetime. These early failures are attributed to the variations in production processes and miss handling of the components, which introduces weaknesses in some of the components. The purpose of the burn-in is to force the occurrence of all early failures, preventing fragile products to be shipped to the consumer. For this purpose, the product is submitted to an effort of convenient extent and duration. The task is to define the effort (for example, increase of the temperature) and how long the burn-in should continue, balancing the requirements of reliability and total cost. Designing the burn-in is used to be very difficult, because a huge amount of data must be collected. Usually it is not possible to determine the optimum burn-in conditions, and the actually used conditions are result of guesswork. How well suited are the guessed conditions, is function of the knowledge of the own process. Thus, it is of vital importance to know the optimum burn-in condition for as many cards as possible. In this work a database in Celestica was analyzed, regarding to the assembly yield of a selected card, and an experiment that would allow determining the parameters of burn-in was designed.

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Peter Lubomir Polak is undergraduate student of the Faculdade de Tecnologia de São Paulo, Pça. Cel. Fernando Prestes, 30, CEP 01124-060, São Paulo, SP, Brazil, (e-mail: peterpolak@uol.com.br).

.Alex de Macedo, is undergraduate student of the Faculdade de Tecnologia de São Paulo, Pça. Cel. Fernando Prestes, 30, CEP 01124-060, São Paulo, SP, Brazil; (e-mail: anderlexm@ig.com.br).

Edson Yuichi Suzuki is with Celestica, Rodovia Presidente Dutra, km 214 P2, CEP 07210-902, Cumbica, Guarulhos, SP, Brazil, (e-mail: eysuzuki@celestica.com).

Victor Sonnenberg is with the Faculdade de Tecnologia de São Paulo, Pça. Cel. Fernando Prestes, 30, CEP 01124-060, São Paulo, SP, Brazil; (e-mail: sonnen@lsi.usp.br).

Mauricio Massazumi Oka is with the Electrionics System Department, of the Escola Politécnica da Universidade de São Paulo, Av. Professor Luciano Gualberto, trav. 3, nº 158, CEP: 05508-900, São Paulo, SP, Brazil, (e-mail: oka@lsi.usp.br).

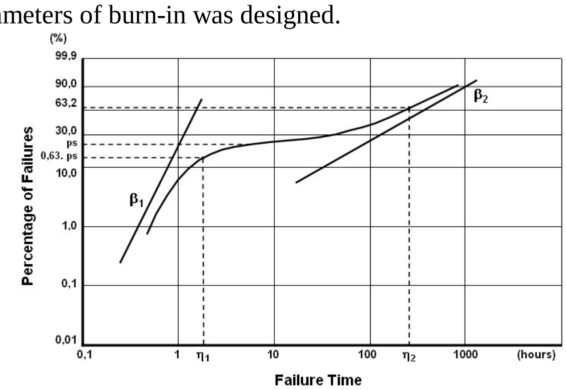

Fig. 1. Weibull curve, from cumulative percentage of failures shows the parameters β, η.

II. Summary of the Theory [1]

In the burn-in study, the cumulative failures distribution function for a product ($F(t)$) may be written as:

$$F(t) = p_s.F_1(t) + (1-p_s).F_2(t) \quad (1)$$

$$F_i(t) = 1 - e^{-\left(\frac{t-t_i}{\eta_i - t_{0i}}\right)^{\beta_i}} \quad (2)$$

p_s is the proportion of the products that present early failures, $F_1(t)$ is the cumulative failures distribution function for the weak subpopulation (presenting early failure) and $F_2(t)$ for the main subpopulation (not presenting early failure). $F_1(t)$ and $F_2(t)$ are the Weibull distribution (Eq. 2). β_i is the Weibull shape parameter, η_i is the characteristic lifetime, and t_{0i} is the location parameter. Index i denotes the weak subpopulation (1) or the main subpopulation (2). It is usual to adopt $t_{0i} = 0$ and $\beta_i = 1$, remaining to determine p_s and η_i. In Fig. 1, a typical Weibull curve is shown.

III. Experimental Procedure

For the burn-in study, a multilayer card, with three metal layers, with approximate dimension of 7 cm x 7 cm, with SMD (Surface Mount Device) components assembled in just one of the faces was chosen. Each card has a 32 pins connector, an ejector, about 50 SMD components, and two analog IC's. There are two card versions, differing basically by the two IC's (Integrated Circuits). One of these versions has two IC's with 48 pins SOP (Small Outline Package) package with 0.65 mm pitch. The other version has two IC's with 32 pins PLCC (Plastic Leaded Chip Carrier) package with 1.27 mm pitch.

The cards are assembled using standard SMT (Surface Mount Technology) process, passes by the burn-in that uses a set of parameters that is typical for electronics assembly (45 ± 5 °C for 30 h), and, finally, they are tested. During the testing, two "Quality Process Reports" are filled: the Report-A and the Report-B. In the Report-A it is filled the number of cards produced and the number of cards that failed. Report-B details the type (identified by codes) and localization of the failure. The two versions of the card are not distinct in the database and they were arbitrarily assumed to be identical.

IV. Results and Discussion

Fig. 2 shows the fault rate calculated from the data available in Report-A, in arbitrary unit (a.u.). It is observed a large dispersion of data. Inconsistencies were found in the data, possibly caused by error in typing or error in the fulfilling the reports. It was opted to perform a filtering of the data. In the Report-A the following cases were discarded: cases in which no failures are reported, cases in which the failure rate is one order of magnitude larger than the average, and cases with less than one thousand cards assembled in a day. Fig. 2 shows also the failure rates after the data filtering. After filtering, excepting the period of July/1999 to December/1999, the data dispersion is lower and the average failure rates is the value of p_s. In Fig. 2, p_s corresponds to 1 a.u. It is believed that the increase of the failure rate is related to a transient caused by an unexpected production growth that occurred close to this period.

The Report-B data was analyzed considering the types of failure and the identification of the defective component. Data filtration was also carried out. Data that indicated detection of more than ten defects in a single card, or those where a non-existing code of defect was typed, were eliminated. Given the nature of burn-in, it was assumed that the only type of failure evidenced by the burn-in is the electrical characteristic variation. 10.6 % of the defects were related to variation in electrical characteristics of a component, and 96.5 % of them were defect in IC's, showing that IC is the critical component for the selected card. Therefore, the percentage of defects that could be evidenced by the burn-in was approximately 10.6 %.

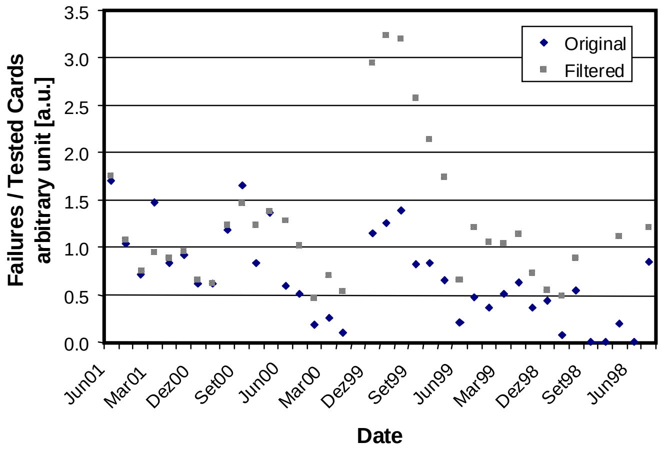

Fig. 2. Histogram of the failure rates calculated from the production yield data available in Celestica's database, without the filtering of data and after filtering.

Roughly speaking, 100 failures must be detected in order to assure a variance of 10 failures. If p_s is known, the amount of cards that must be analyzed is given by $100/(0.106 \times p_s)$. For the selected card it was found that more than 100,000 cards must be analyzed. In order to trace a curve similar to the one shown in Fig. 1 it would be necessary to multiply this number of cards for the number of points required to plot. Therefore, it is foreseen that a long time will be demanded to determine the parameters of the burn-in for the selected card. The validity of the assumptions made in this work is analyzed elsewhere [2].

V. Conclusions

It was shown that the value of p_s, that is one information necessary to design a burn-in process, can be determined from reports of failure rate for a process that passes for the burn-in. For the selected card, it was shown that only 10.6 % of the observed defects are probably evidenced by the burn-in. From these results, it is foreseen that it would be necessary to analyze a huge amount of cards in order to plot the Weibull curve.

Acknowledgment

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