

## Air Conditioner Production Failure Analysis Techniques

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### Abstract

*This paper aims to apply the use of quality tools for fault analysis techniques and internal circuit board defect reduction in an air conditioner company. We currently have millions of air conditioners installed and produced annually on all continents and consecutively there is increasing consumer complaints that internal circuit boards are one of the most critical components of an appliance and it is it that controls its functions as a for example: receive the temperature signal chosen on the remote control so that it works to increase or decrease the temperature as per customer requirement. According to vendor defect, data our top one defects are related to evaporator EEPROM non-write defect circuit board problems and with that 3.12% defect work, we achieved a 0% reduction of defects after Work completed with 2 weeks of follow-up.*

**Keywords:** Indoor unit; Outdoor unit; EEPROM;

### 1. INTRODUCTION

The present work was conducted in an air conditioner industry where failure analysis techniques were applied, being a company of Japanese origin, which uses the “QC STORY” methodology which is also used by other multinationals around the world. like Toyota in its TPS which is the Toyota production system, Nissan, Honda and QC STORY is best known to us Brazilians for problem solving method with its acronym MASP in which it aims to produce an improved product or service. cheap, easier to maintain, safer with faster delivery and the following tools have been used and still second [1] is crucial for the control to be

exercised. The problem analyzed is based on internal and external facts and data and is justified by increasing climate change and consecutively higher sales demand. The objective of this work is to apply the failure techniques meeting the expectations of customers to buy products with required quality, also enabling greater competitiveness in the market with high quality and value added products, better quality indices, lower costs with poor quality, better organizational knowledge of the teams involved in continuous improvement using the “QC STORY” quality tools.

## **2 THEORETICAL FOUNDATION**

### **2.1 PCDA**

According to [2], the first activities developed with the PDCA cycle methodology took place in the 1920s by [3] and according to the book Quality Management of [4] says that the concept of the cycle consists in establishing improvements to the standards set in the organization. , which serve as a reference for its management. Thus it was used so that all work had a direction in the following aspects of the tool in which P is (Plan) which is the planning of the work in which the methods and goals are defined, the (Do) where it should be performed, educate and train, the (Check) where we should verify the results and the (A) action action where we should act correctly.

### **2.2 Pareto Chart**

[5] points out that the Pareto chart helps determine priorities in an order of solving each problem. [6] cites 5 steps for a pareto analysis, 1) problem identification, 2) problem stratification, 3) maximum related data collection, 4) through the prioritization chart, and 5 assigning responsibility for solving the problems. problems. And according to [7] his concept is that 80% of problems originate from only 20% of causes.

### **2.3 Cause and Effect Diagram**

Cause-and-Effect Diagram [4] is one of the 7 original quality tools proposed by Japanese professor Kaoru Ishikawa in 1968, she clearly investigates the relationship between the causes and effect of the problem, in which each effect has various causes and if uses the 6M's, such components are: 1) labor, 2) method, 3) materials, 4) measurements and 6) environment (business or environment).

### **2.4 Flowchart**

[9] points out that the flowchart is an excellent tool for analyzing the process and is used to map the steps of each activity. Processes through a series of sequential activities that should be taken into consideration in problem analysis, making it clear which process sequences the product or part is produced best visualize who is responsible and what types of processes are involved.

### **2.5 Check Sheet**

Compliance check sheet [10] is a means of facilitating, standardizing and organizing the collection of records and data for later compilation and analysis to be optimized. To check a given situation or sample quantity or defect in an inspection amount over a period of time to quantify process testing, process change,

process deviation or even validation of a change to collect data for analyzes used the check sheet.

**2.6 5W2H**

As [10] mentions that 5W2H is a tool that assists in planning the proposed actions that will be developed, this tool is made up of a spreadsheet by columns and each of the letters means: Why, What, Who, When, Where, How, How Much. It is used to secure and also inform a set of action plans, diagnosing problems by planning their respective actions. In the spreadsheet or table used in this tool it is possible to visualize the appropriate solution of a problem, with possibilities of monitoring the execution of an action. Seeking to facilitate understanding through the definition of deadlines, responsibilities and methods, resources and also the objectives. For [10], the technique used is equivalent to describing the problem, defining how it affects the process analyzed, the people and circumstances arising from these situations and can be monitored the details of who should do what, when will do how.

**3 Methodology**

A case study was done in an air conditioner company to reduce internal circuit board failure where it was done according to the following steps as shown in Figure 1. Steps are: 1) Process Overview, 2) Choice of Theme 3) Current problem situation, 4) Goal definition, 5) Factor factorial analysis, 6) Countermeasures application, 7) Results and effects assessment, 8) Defined non-recurrence methods and 9) Choice of next theme challenge.

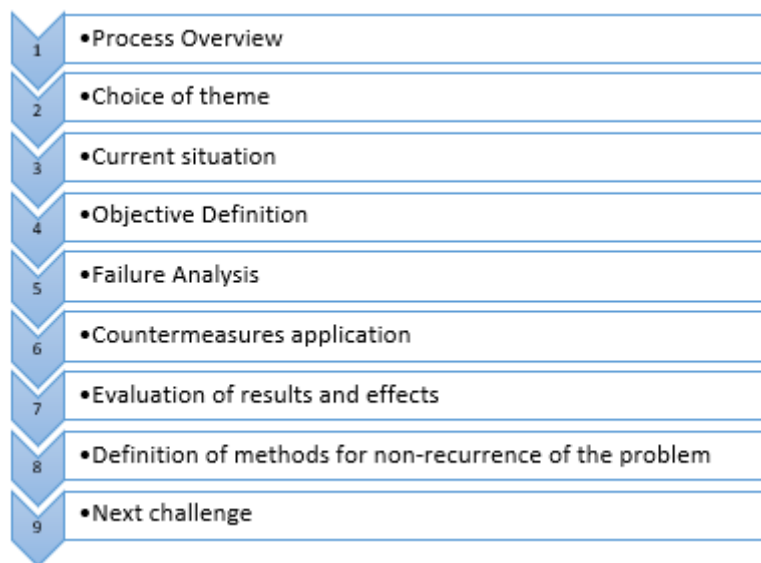


Figure 1 (Failure Analysis Flow)

**4 Study Application**

**4.1 Process Overview**

The internal problem-solving analysis method proved to be very effective compared to previous work because it is a standardized and guided defect resolution methodology based on data and facts in a logical sequence. In the process vision step, it was necessary to make 3 layouts because we had the internal factory

process and we also had 2 plate assembly processes in our supplier which resulted in the layout we call factory layout (figure 2) which is the process of AC factory, SMD layout (figure 3) automatic plate processing and DIP layout which is the manual and plate testing process (figure 4).

The layout factory process flow (figure 2) has the following process the product as soon as it leaves the supplier comes to the factory and is entered in the inbound inspection sector that checks some quality items according to the technical, dimensional and visual specification of the parts. and soon after they are released for storage and when requested by the productive sector that works as demand are delivered to the production where the electrical assembly is assembled passes the microprocessor functional test and is then assembled the other components of the conditioner together with the assembly. electric air conditioner and undergoes functional testing where the entire product is thoroughly tested to certify its operation.

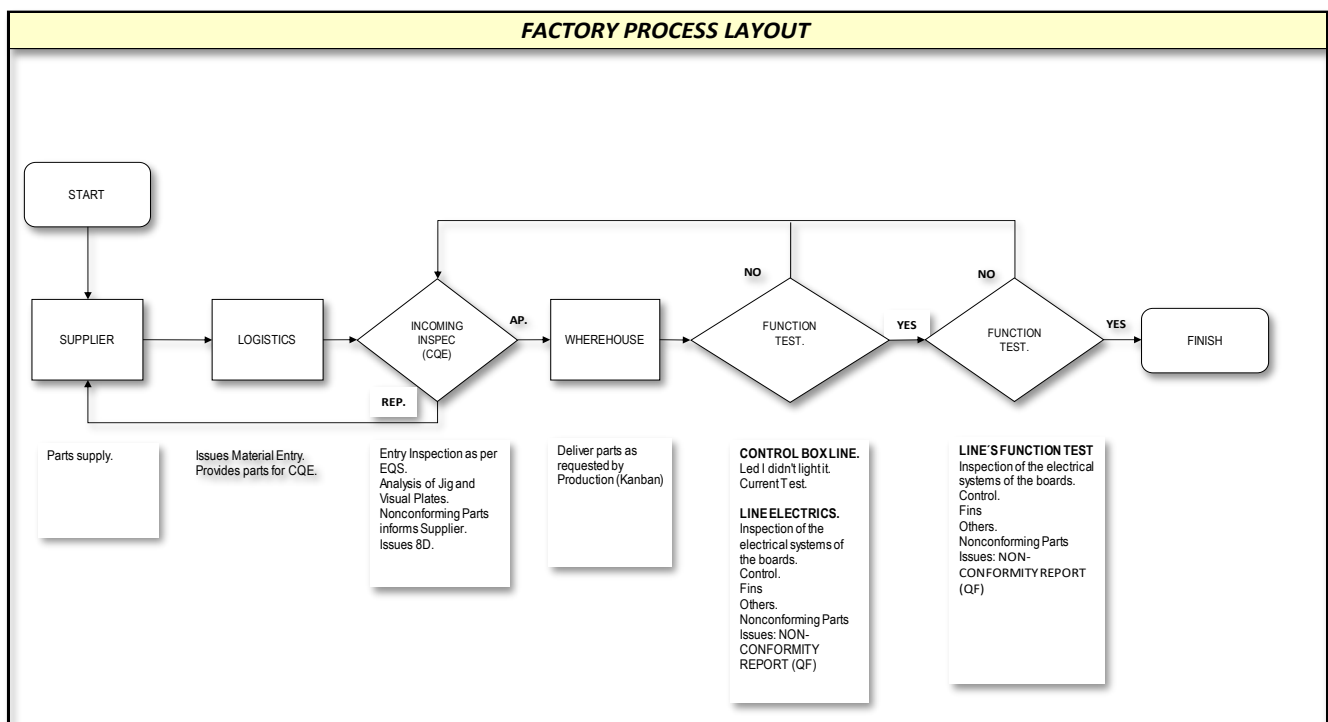


Figure 2 (FACTORY LAYOUT)

The flow of SMD processes (figure 3) goes through the stock with controlled humidity and temperature, goes through the printer a machine where the components are automatically placed in the unmounted pcb, when the components are inserted it must be added with a glue so that If the board on which we call the printer is stuck after this process the board goes through a machine called SPI that checks the volume of the glue and then the assembly of the chip then goes through the 1st inspection, the oven, the inspection 2 ° AOI a camera that checks the position of the components, if approved position will go through the visual inspection finalizing the process the top side of the board we call TOP, the bottom side process or bottom side some components that cannot be inserted by the top side are made to insertion by the machine called axial and radial passed by visual inspection so that it can go to the next process step (DIP).

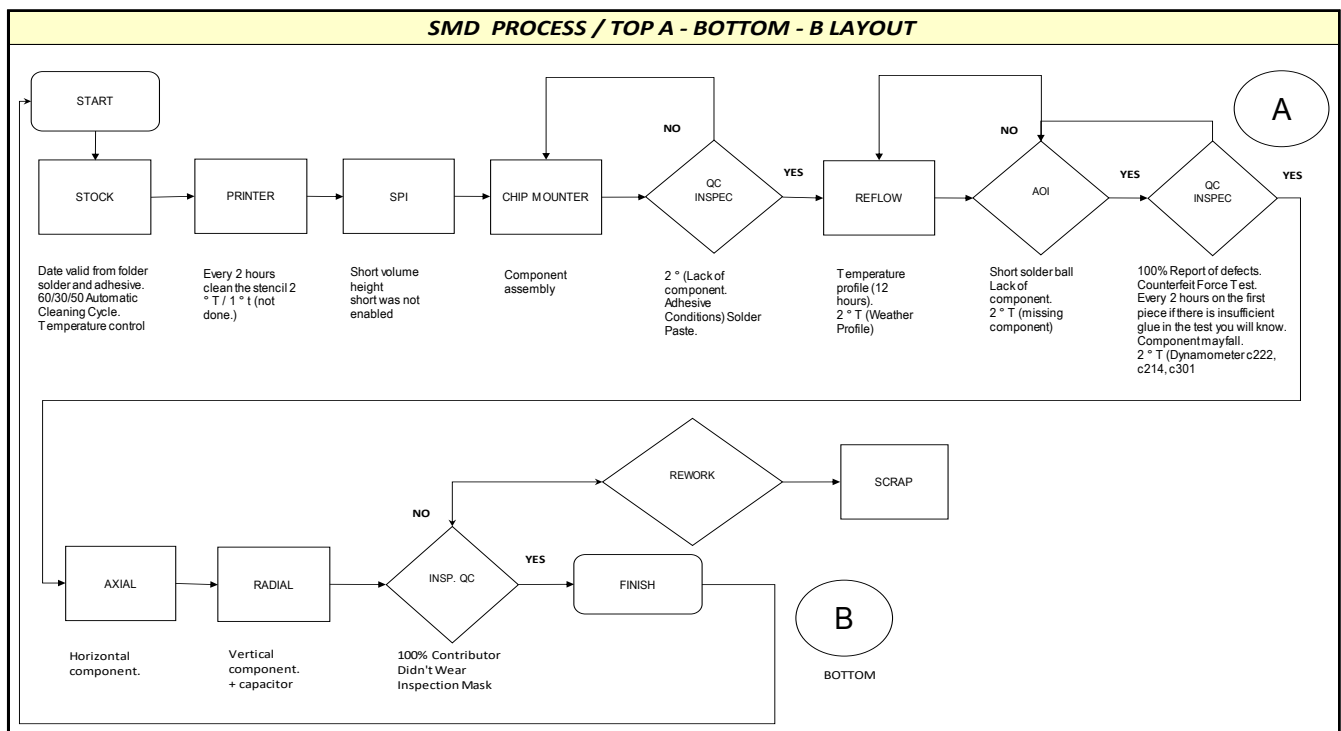


Figure 3 (SMD LAYOUT)

The DIP line flow process (Figure 4) is where the plate components that have been assembled on the SMD, axial and radial machines are finished, in this process step parts that cannot be inserted by machines are made manually by passing then by an oven that has melted solder paste welding the components, that glue that is passed on the printer serves to prevent the components from falling into the wave, the rectifier bridges are also soldered manually, presence testing of the components is done and then ICT The FCT undergoes functionality testing and its last step is that of protective coating which is handmade with a brush so that components and parts that cannot be sealed are protected using JIG for such activity.

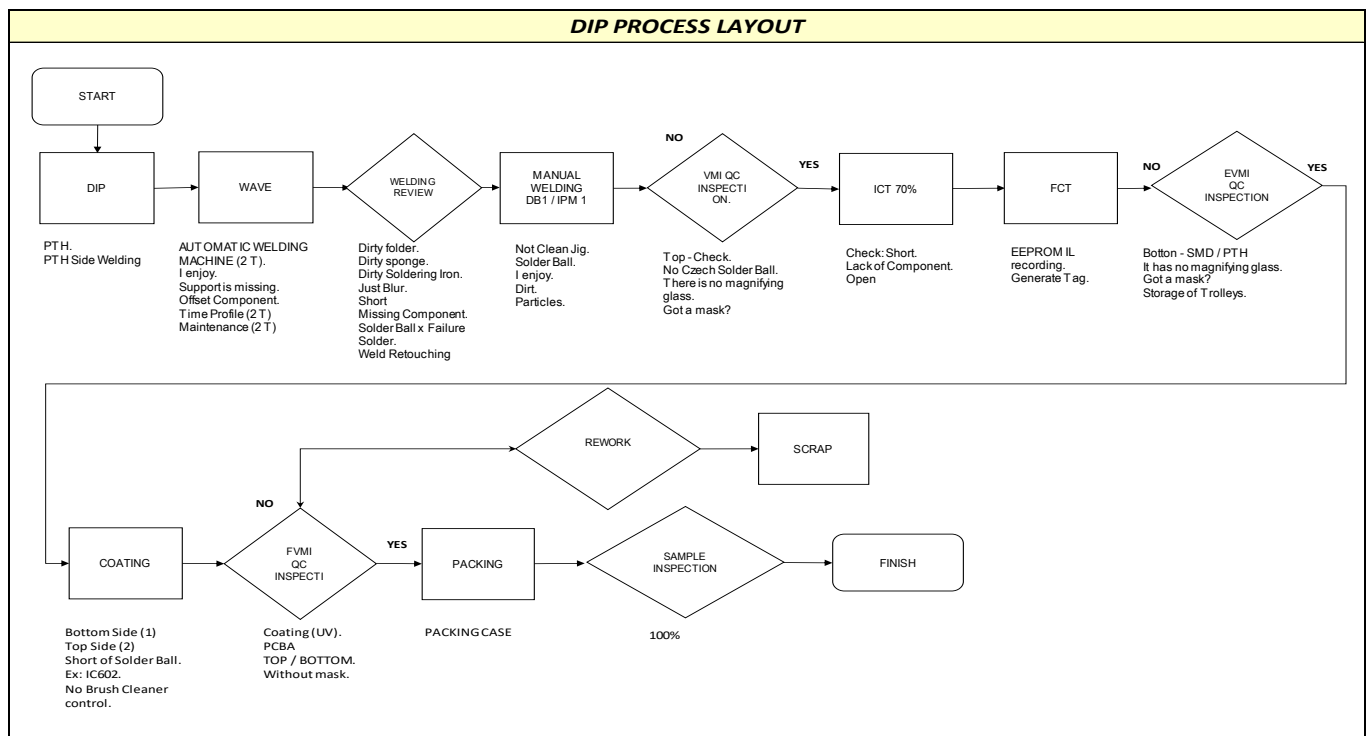


Figure 4 (DIP LAYOUT)

**4.2 Choice of theme**

As shown in figure 5 (Choice of theme) we can see were raised index data from suppliers A, B, C, D, E, F and G and from 2017 and 2018 and we can see that supplier A in 2017 represented 3, 1% of the defects in Pareto chart already in 2018 he had a very high nonconformity high going to 63% with 839 defect units and supplier B had zero defects in 2017 and 267 defects in 2018, in this first analysis we can see that supplier “A” had the highest defect rate in% and per unit of defects in 2018, so supplier A with the most nonconformities was the supplier chosen for problem analysis.

As we know that supplier “A” was the lowest performing and highest number of non-conforming suppliers in 2018 with 839 defects representing 64% of the chart, among these 839 defects there were 4 types of products that we will call Plate A with 679 nonconforming items representing 96.9% on the chart, Plate B with 65 defect items representing 99.9% on the Pareto chart, Propeller A with 95 defect items representing 99.7% of defects and Propeller B representing 100% of the chart.

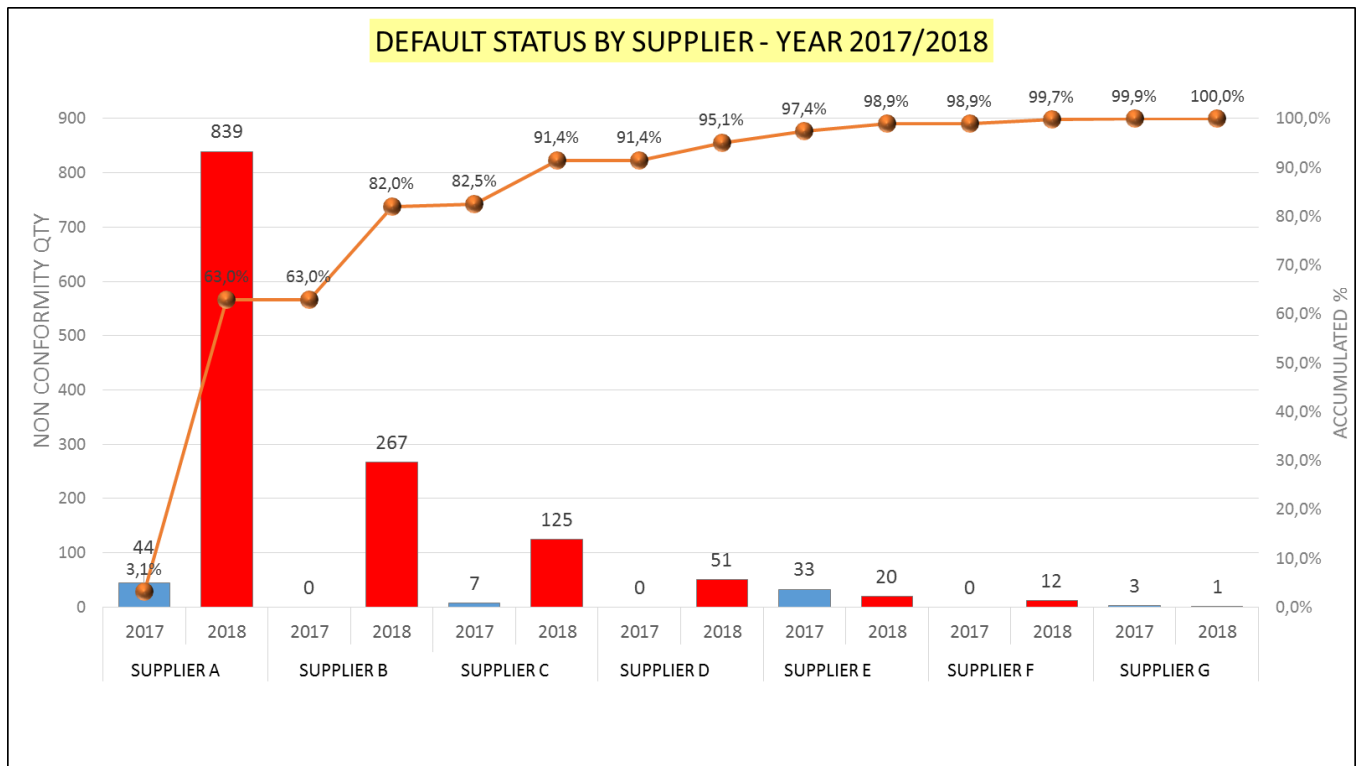
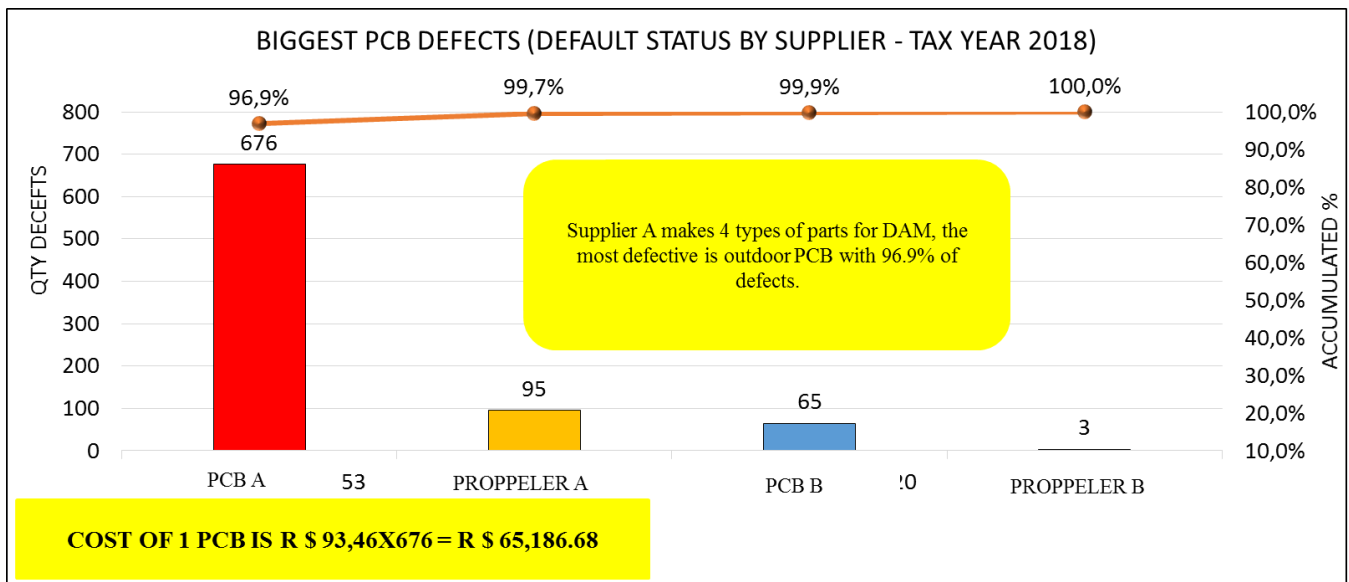


Figure 5 (Choice of theme)

### 4.3 Current Situation

As in the current situation stage we must use graphs so that we can illustrate the scenario of the problem, was made the survey of defects by suppliers from 2017,2018 and 2019 until the month of February, so that we could know which was the supplier. underperforming, after knowing which supplier (A) had the worst result with 63% of supplier defects. We did a survey to see how many items he provided and we identified that were 4 items as (Figure 6) (Biggest PCB defects) May, of these 4 items we found that the PCB of the air conditioner outdoor unit had a higher rate than 96, 9% and after that we made a survey and made a Pareto chart to know what types of defects existed and further deepening the data identified that the defect that had the highest index was the non-compliance of the LED board did not light in the test. micon ID recording which had a higher Pareto chart index with 30.4% with 156 defect units following the IC out of specified with 55.6 %%% with 129 defect units and 62.2% exposed copper and 65 units of nonconformities, the analysis and application of the defect analysis tools will be used on the largest defect Led Does not light.



ITEM	SUPPLIER A			
	PCBA	PROPELLER A	PCB B	PROPELLER B
QUANTITY PRODUCED	21658	29061	44850	22089
AMOUNT OF DEFECTS	676	95	65	3
PERCENT	3,12%	0,33%	0,14%	0,01%
ACUM %	96,9%	99,7%	99,9%	100,0%

Figure 6 (Biggest PCB defects)

#### 4.4 Definition objectives

The objective of the analysis of the data collected and defined by the quality team was that of the three largest defects would be reduced to zero defect thus leaving 156 LED defects does not light to zero defect as shown in figure 7 below.

DEFECT TYPE	Defects QTY	GOAL
LED does not light	156	ZERO DEFECT

Figure 7 (Goal Setting)

In the factor analysis of the problem proposed for improvement was the part that we use the most problem analysis tools, in this step we use the brainstorm to raise all possible causes and effects after that we use the cause and effect diagram allocating all possible causes in its “M”, after drawing up the cause-and-effect diagram that was worked out together with the kaizen team of the quality industry factory with a group of 3 people from the supplier where we had quality, process and process engineering people, was Also defined in meeting which responsibilities of each member and dates for checking each cause raised during the survey we noticed that some problems were detected such as the lack of grounding in the functional testing equipment of the components of the board called FCT, was also evidenced. that in the factory process there was an ungrounded screwdriver, the red items While in the cause and effect diagram according to Figure 8, items with non-standard deviation, non-specific or undetermined, items in blue and green are items that conform with no anomaly found.



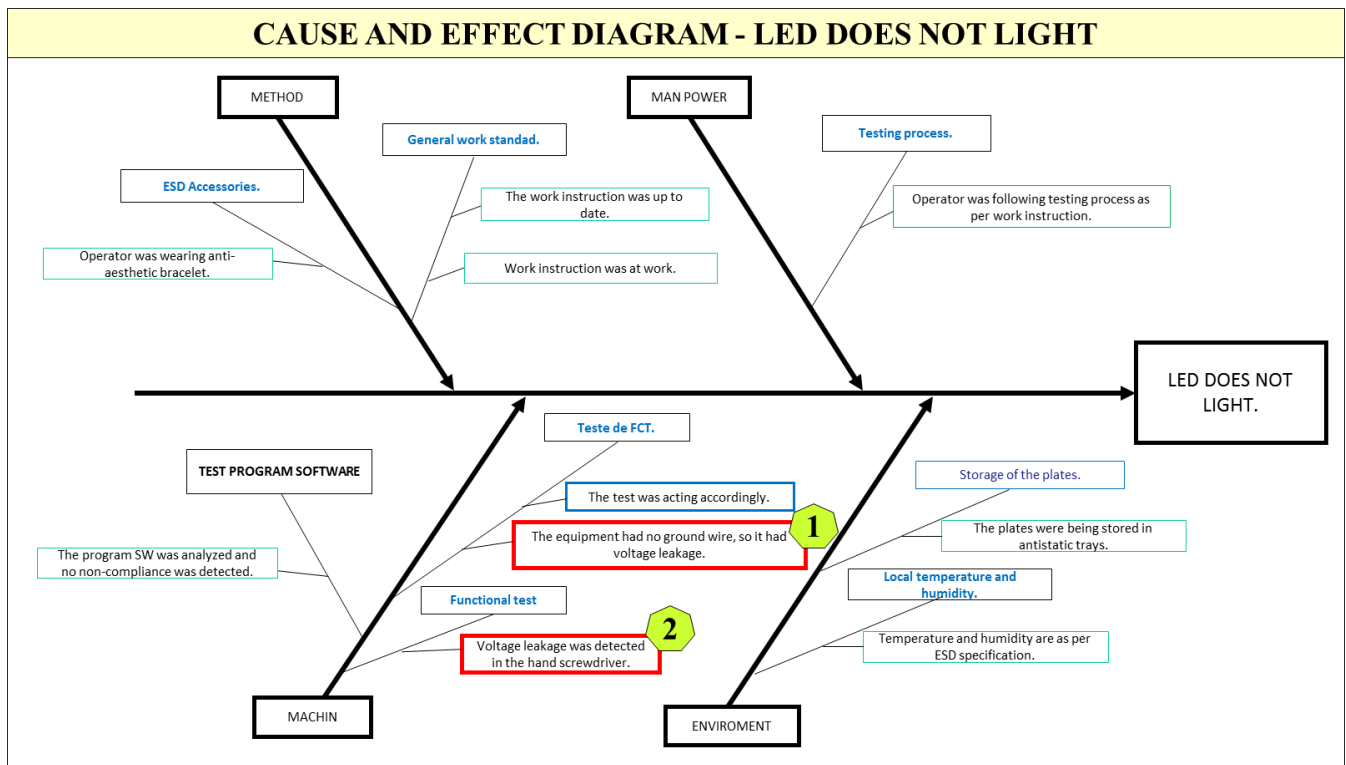


Figure 8 (Cause and Effect Diagram, Author: Fernanda Yakushijin)

The nonconformities found were analyzed and dealt with as shown in Figure 9 below two nonconforming items and one item verified nonconformity are in the image, the functional test grounding and the ungrounded screwdriver both processes were installed grounding and subsequently met to specification and The recording confirmation of the functional test program was confirmed by daily checklist with quantity produced vs. quantity of recording records checked on the equipment computer if the tested quantities were the same as those recorded on the test computer.

ACTIONS OF NONCONFORMITY ITEMS- LED DOES NOT LIGHT							
No	4M	WORKSTATION	TYPE OF ACTIVITY	DESCRIPTION	POSITION SPECIFIED	EVIDENCE	STATUS
1	MACHIN	FCT SMD/DIP	FUNCTION TEST	EQUIPMENT NEEDS GROUNDING TO AVOID CURRENT LEAKAGE.	FCT MACHIN.		NG ↓ OK
2	MACHIN	FUNCTION TEST	FUNCTION TEST	ELECTRIC SCREW REQUIRES GROUNDING TO AVOID CURRENT LEAKAGE.	FUNCTION TEST.		NG ↓ OK
3	MACHIN	FCT SMD/DIP	SW RECORDING ON FCT TEST.	MAKE SURE RECORD TEST ACCORDS DAY PRODUCTION.	FCT MACHIN.		OK

Figure 9 - Actions of Nonconformity Items-Led does not Light.

### 5 Results and discussions

Our results obtained as shown in (figure 10) were where we had a reduction of 156 LED defects does not light up to zero defects equivalent to 100% after the improvement, in December we had 92 nonconformities in March nine and the first two weeks of. April after improvement we had zero defects during the post-implementation effectiveness check period.

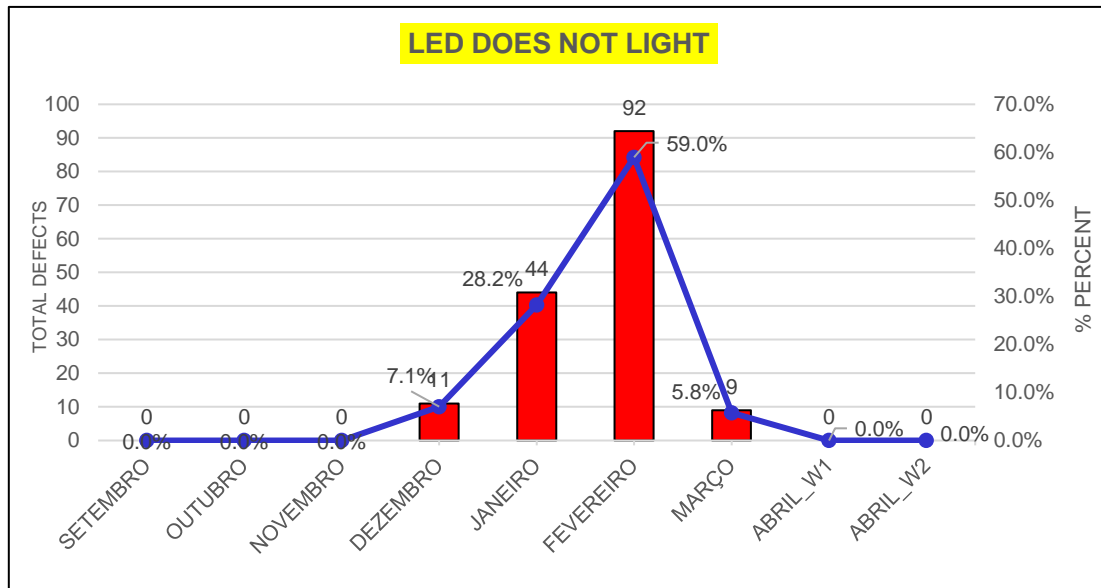


Figure 10 Results Led does not Light

In order to be sure that the problems did not recur, some rules, procedures, standards and specifications were created for everything that was found out of place and also what was pointed out as a cause or potential point avoiding a possible future problem for these definitions. a plan using 5W to define the responsibilities of each item pointed out until status verification.

ACTION PLAN 5W							
IT.	WHAT?	WHO?	WHEN ?	WHERE ?	HOW ?	STATUS	EVIDENCE
1	STRATEGIC MEETING FOR PLATE DEFECT REDUCTION (BRAINSTORM).	RICARDO	30/01/2019	FORNECEDOR'A	Assemble defect reduction strategy using quality tools.	CONCLUÍDO	
2	DEFECT INDEX CREATION FOR NON-CONFORMITY CONTROL.	FELICIA	30/01/2019	EMPRESA AC	CHECK STATUS OF DEFECTS DETECTED ON AC.	CONCLUÍDO	
3	PREVENTIVE MAINTENANCE OF WAVE CHAIN, WELDING MACHINE.	RICARDO	05/02/2019	FORNECEDOR'A	MAINTENANCE PLAN.	CONCLUÍDO	
4	WELD DENSITY FLOW.	WANDER	05/02/2019	FORNECEDOR'A	LEAD FREE WELDING DENSITY STATUS.	CONCLUÍDO	
5	WELDING BAR WITH VALIDITY TIME.	ERIKA	05/02/2019	FORNECEDOR'A	ANALYSIS OF PRODUCT EXPIRY DATE WITHIN.	CONCLUÍDO	
6	APPROVAL PROCEDURE (PROFILE).	WANDER	20/02/2019	FORNECEDOR'A	SEND EVIDENCE TO TEAM AC COMPANY - EQUIPMENT SPECIFICATION.	CONCLUÍDO	
7	(ESD) ANALYSIS, GROUNDING.	ERIKA	06/02/2019	FORNECEDOR'A	PROCESS AUDIT (MAKE SURE THE PROCESS IS IN ACCORDANCE WITH ESD / EOS AND GROUNDING SPECIFICATIONS.	CONCLUÍDO	
8	CUSTOMER PROCESS LAYOUT VS SUPPLIER.	ANDREA	08/02/2019	EMPRESA AC	COMPLETED BY SUPPLIER 'A' AND AC COMPANY.	CONCLUÍDO	
9	TEMPERATURE MEASUREMENT STATUS AND LOCAL HUMIDITY.	ERIKA	01/02/2019	FORNECEDOR'A	MAKE SURE TEMPERATURE IS ACCORDING TO SPECIFICATION. 18 - 28 ° C; 40 - 60%.	CONCLUÍDO	

Figure 11 Action Plan 5W

### 6 Final Considerations

When the work began it was found that the defects of Led does not light was a defect that could not be identified by visual inspection and its high rate of nonconformity was the main reason for choosing this theme so we use Failure Analysis Techniques In a production line of air conditioners, because of this the general objective of the work was to discover the causes of the problem using the analysis techniques tools and consequently it was demonstrated that with the use of the proposed tools and their logical sequence the The conduction of the work was more agile due to its format that helped in the elaboration of the work without having to return to the previous topic thus reducing the time and better results. The initial goal of zero defects was achieved with the discovery of the source of the problem that was not grounding the machinery causing a current leakage damaging the equipment and after the adjustment of the groundings no more LED defects does not light up and the hypothesis that we did not have an electronic component defect was confirmed after analyzing the proposed problem and discovering the source of the failure. As the work was conducted using analysis tools such as first place verification, current factual situation, defect data by supplier type, defect type, survey of possible probable causes, tests to prove the problem beyond the methods used we noticed a certain It is difficult to find FCT testing content and issues involved with FCT testing, so we needed the help of FCT software engineer from headquarters to help us with questions about the design and operation of this test.

## 7 References

- [1] FALCONI, Vicente. TQC: Controle da Qualidade Total (no estilo Japonês). Rio de Janeiro: Bloch, 1992. 229 p.
- [2] AGOSTINETTO, J. S. Sistematização do processo de desenvolvimento de produtos, melhoria contínua e desempenho: o caso de uma empresa de autopeças. Dissertação (Mestrado em Engenharia de Produção) - Escola de Engenharia de São Carlos, Universidade de São Paulo, São Carlos, 2006.
- [3] SHEWHART, W. Economic control of quality of manufactured product. New York: D. Van Nostrand Company, 1931. 501 p.
- [4] ABRANTES, José. Gestão da Qualidade. 1ª. ed. Rio de Janeiro: Interciência, 2009.
- [5] GIOCONDO, Francisco I. César; FRANCISCO, I. Ferramentas Básicas da Qualidade. **Instrumentos para gerenciamento de processo e melhoria contínua. São Paulo: Biblioteca24horas**, 2011.
- [6] CHIAVENATO, Idalberto. Administração nos novos tempos. Rio de Janeiro: Ed. **Campos**, 1999.
- [7] JURAN, J.M. Planejando para a qualidade. São Paulo: Pioneira, 1990.
- [8] LUCINDA, Marco Antônio. Qualidade: Fundamentos e práticas para cursos de graduação. Rio de Janeiro: Brasport, 2010.
- [9] LUCINDA, Marco Antônio. Qualidade: Fundamentos e práticas para cursos de graduação. Rio de Janeiro: Brasport, 2010.
- [10] WERKEMA, M. C. C. Ferramentas Estatísticas Básicas para o Gerenciamento de Processos. 1. ed. Belo Horizonte: WERKEMA, 2006.