METHODOLOGY FOR DESIGN AND IMPLEMENTATION OF THE TQM (TOTAL QUALITY MANAGEMENT) SYSTEM IN AUTOMOTIVE INDUSTRY COMPANIES IN MACEDONIA

МЕТОДОЛОГИЈА ЗА ПРОЈЕКТОВАЊЕ И ПРИМЕНИ TQM СИСТЕМА У АУТОМОБИЛСКЕ ИНДУСТРИЈЕ У МАКЕДОНИЈИ

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Abstract: *The present paper analyzes the performances of the company's logistics sectors in the automotive industry in Macedonia, producing circuit boards as an intermediate product for car dashboards. The research was conducted as an attempt to perceive the current situation in this company in the field of design and implementation of a quality system, analyzed through the four pillars of the house of quality on the top of which is the top management, and the basis of which is measuring, evaluating, analyzing and comparing quality/poor quality.*
The data obtained from the research and the application of the integrated methodology for design and implementation of the TQM (Total Quality Management) system shall be useful guidelines for all other Macedonian companies tending to become "world class" organizations.
The results of the application of this methodology showed that the realization of the company's vision and its main objectives is viable in terms of meeting the needs of the internal and external customers, in a timely manner, eliminating or improving processes that do not add value.

Key words: *TQM system, automotive industry, logistics sector, customer satisfaction*

Sadržaj: *Овај рад анализира перформансе Сектора логистике у компаније аутомобилској индустрији у Македонији, која производи електронске плоче које представљају полуфабрикат у командној табли аутомобила. Истраживање је урађено као покушај сагледавања тренутног стања у овој компанији у области пројектовања и имплементације система квалитета, преко анализа четири стуба куће квалитета на чии врх је топ менаџмент, и у основи је мерење, вредновање, анализирајући и упоређујући квалитета / неквалитета. Подаци добијени из студије и примене интегралне методологије за пројектовање и спровођење система по TQM -а треба да буду корисне смјернице за све остале македонске компаније које имају тенденцију да постану организације "светске класе".*

Ključne reči: *TQM систем, аутомобилска индустрија, логистички сектор, задовољство купаца.*

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1. INTRODUCTION

Each organization needs to develop quality system activities which can be represented as a "house of quality" [1]. The pillars of the house of quality are as follows: internal standardization, methods and techniques for faultless operation, education and motivation and costs of quality. The top management is the most responsible segment in the "house of quality" and it is "holding" itself upon the four pillars that are subsystems of the system. At the base of the house of quality lies the measuring of the defined, collected data on business processes in order to understand and control them, as well as to collect important information regarding products and services, to improve their quality and optimize business processes. Monitoring does not go only into quality of products/services, but also the adequacy of the entire TQM (Total Quality Management) system in the implementation of quality functions [2]. The measuring is necessary for the following:

- understanding processes, products, resources. It can serve as a basis for future comparison;
- control of processes, products, resources, which includes corrective and preventive actions, that means, analyzing the measurements to identify opportunities for improvement and defect of processes, products, resources;
- improvement of processes and products. Measurements can be used to predict the future behavior of processes, products.

Monitoring covers all subsystems of the house of quality, and using documented procedures, assessment under the EFQM (European Foundation for Quality Management) criteria is performed, being used to assess companies' progress in achieving business excellence [3]. The checking of the TQM system must be part of the daily strategic management activities. It should be in function of taking timely corrective measures. The assessment refers to the following [4]:

- analysis of the external environment (business trends, legislation, sales, competition, customer/user satisfaction, supplier satisfaction, impact on the company);
- analysis of the internal environment (effectiveness, efficiency, structure and employee satisfaction, business results);
- analysis of the company's situation in regard to environment (benchmarking).

Measurement results shall show: what the company has achieved, while the opportunities show how these results have been achieved [5].

2. RESEARCH METHODS AND RESULTS ANALYSIS

The activities taking place in the company's logistics sectors in the automotive industry in Macedonia are as follows: receipt of orders from customers; planning of production; orders of raw materials; monitoring the suppliers' performance; warehouse operations; planning the physical inventory; monitoring of supply chain processes; management of material operations software; organization of transport; and organization of customs procedures.

The application of the integrated methodology for design and implementation of the TQM system in this sector means application of more methodologies [4]: Methodology on subsystem - internal standardization; Methodology on subsystem - statistical process control (SPC); Methodology for analysis of the total cost of a process; Methodology on subsystem - education; Methodology on assessment the success of the designed and implemented TQM system (Audit).

The present paper analyzes the application of these methodologies in the logistics sectors through the application of the Pareto analysis to detect the places where most defects occur,

the Ishikawa access to discover the causes of errors, such as 8D (8 Disciplines) methodologies; the Six Sigma approach, CI Trac tool for monitoring projects, as well as the PFMEA method applied to ensure first trial operation, without errors, claims and losses.
The design and implementation of the TQM system in the automotive industry is based on several pillars, one of which is internal standardization. All processes throughout the company are documented and organized in a so-called Business Operational System (BOS). Besides the use of general documents, local ones are created as well for the purposes of more detailed explanation of the process and the allocation of responsibilities, as well as for as a result of the need to adjust the process to the local national laws. The business documents can be work instructions, forms, databases, standards, list of instructions and specifications. Work instructions consist of six parts: purpose (which process is defined in such instruction), competence (the organization it is applied in), responsibility (working position task matrix), description of the process in a block diagram and a textual description, records (list of documents used in the process) and references (list of work instructions and standards related to specific work instructions). Figure 1 shows a standard operating procedure for the business process - organizing transport for an outgoing consignment, in which the documents used in the process, the employees who participate, and the possibility to comment with additional explanation or indication of instructions which define the sub-processes are provided.

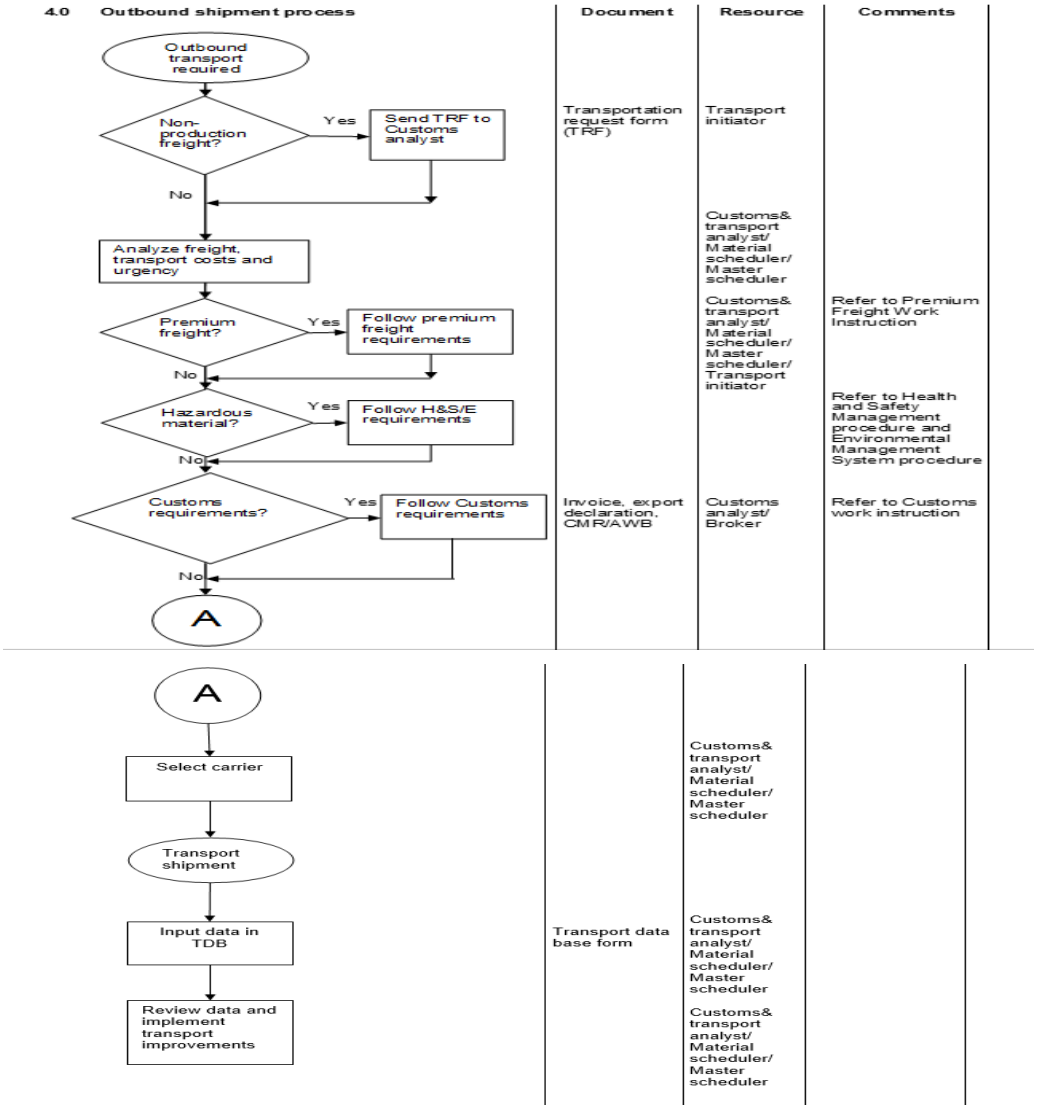
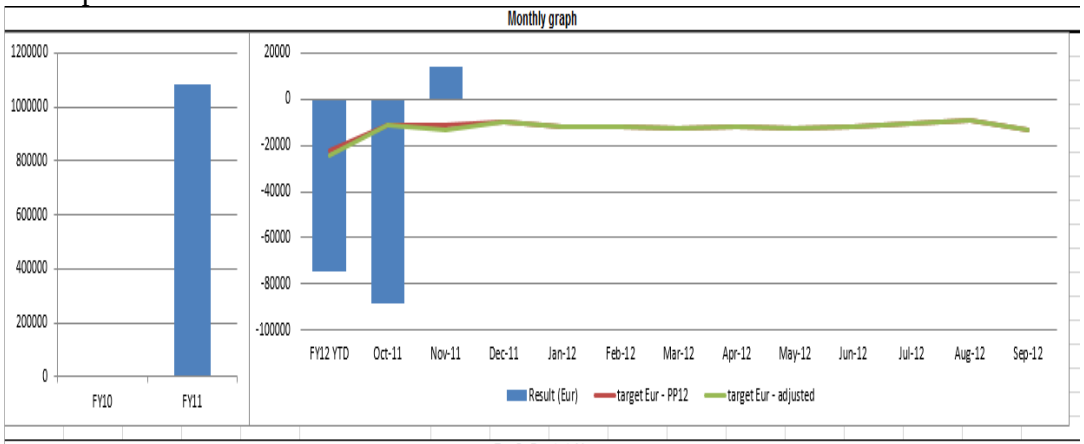


Figure 1: Standard Operating Procedure for the business process - organizing transport for outgoing consignment

The application of internal standardization improves personnel's responsibility in the implementation of the business processes. The company's operations management, showing its good will and persistence shall include its own human resources by forming teams of all profiles, integrating their knowledge in the direction of reducing logistics costs and achieving the required level of inventory, as well as proactive internal and external communication in the supply chain in order to meet customer requirements.

2.1. Monthly Key Performance Indicator (KPI) on loss of inventory in the logistics sector

The application of the TQM system methodology means designing a good documented quality system that covers all business processes of the company and is the necessary basis for successful application of SPC (statistical process control) and efficient teamwork, which otherwise could not be put in place in case of a bad quality system.
The performance results in the logistics sector are analyzed on monthly basis and are defined in a document on key indicators which are measured (Key Performance Indicator) and for which records are kept by fiscal year, Fig. 2. Based on the conducted analysis, steps are undertaken to address the disadvantages and the document is used for further reporting and establishing the needs for the next fiscal year.
The indicators which are measured are as follows: rate of customer service expressed in percentage (percentage of observed orders); backlog of deliveries, in pieces (backlog); transport costs for delivery of finished products (including analysis of contingency transports - premium freights); level of stocks, transport costs for delivery of raw materials (including analysis of contingency transports - premium freights); quantity of obsolete raw materials; shortage of raw materials for production; loss of stock; customs duties; transport costs for indirect material; traceability of raw materials and measuring scrap of raw materials due to warehouse problems.



Top 5 - Pareto table

ID	Description of the issue / Root cause	Value	%	% Cum.
1	2125623 relabeling pos cyc rcnt of 1321005 for the same qty, total ammount is in positive 1k eur	-4000	22%	22%
2	1949433 BOM mistakes: 1. 2 speakers put on the bom on same date - it was consumed only one 1949433 2. production consumed the 1949433, in the system was 2266290 pos cyc rcnt of 2266290 for the same qty	-2095	12%	33%
3	2340858 During the October inventory it was counted 2340858 instead 1708871 pos cyc rcnt of 1708871 for the same qty	-1902	10%	44%
4	1301128 Two coils counted twice during October Inv.	-749	4%	48%
5	178058248 relabeling pos cyc rcnt of for the same qty, total amount change -3 eur	-617	3%	51%
		-18199		

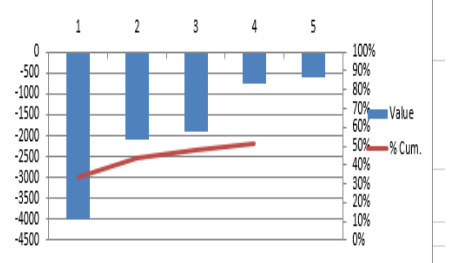


Figure 2: Monthly Key Performance Indicator (KPI) on loss of inventory in the logistics sector

Figure 2 shows the first part of the monthly analysis on loss of inventory. The cumulative loss in the previous fiscal year is shown and the cumulative loss in the current fiscal year to the month when the analysis was conducted is also shown, as well as the level of losses in months with the given target under the forecast and the adjusted target to conform with changes in the plans, are also shown. The Pareto analysis shows the five most influential reasons for the deviations. In order to detect the causes of the problems Five (5) Why analysis have been used, as shown in Figure 3.

	Why 1	Why 2	Why 3	Why 4	Why 5	Inventory Analyze Actions	Responsible	Date
2	Start and end eff date not done ona a correct way.	Phisical change not correspodent with system change	Information for the physical change was not provided on a change managmement meeting. Persons affected for the change were not informed (Procurement and Logistic) by Method	Method is not aware about consequnces of not well provided information		Not use cyc rcnt to correct process In check list to be informed process	1. SCM 2. Method	1. 01/11/2011 2. 14/11/2011

Figure 3: Five (5) Why analysis to detect the root of the problem

Upon establishing the causes of the problem, the actions to be taken are defined, as well as the person responsible for implementation of such actions and the deadlines for the implementation of corrective measures.

Solving problems is not a complicated method, but requires a new way of thinking and using simple tools in order to find the true cause of the problem and prevent the its recurrence.

The basic approach to solving problems requires application of integral methodology related to preventive operation or focusing on the origin of the problem by finding the original cause.

The 8D (8 Disciplines) methodology is applied to solve a problem with a LED diode which does not perform its function in the circuit board. The steps of the implementation of this methodology are shown in Figure 4:

8D Problem Analysis Report

Customer:	DAG Spanien/Remchingen	**Date Issue Occurred:**	21-October-2011	☐ Advanced Development
Program:	LP. SMD-BEST. NCV2 PTS/F DC	**4D Due Date:**	when PCB arrived in Skopje	☐ Concept Development
Product:	Reference:104127326	**8D Due Date:**		☐ Product Definition
Issue #:	PB15552 PB15553 PB15554	**Date Issue Closed:**		

1. Team Members	**Champion Name**	**Champion Title**	**Champion Phone Number**	**Champion E-mail Address**
	Brankica Kuzmanoska	Customer Quality Engineer	+389 2 3202 289	brankica.kuzmanoska@jci.com
	Additional Team Member Name(s)	**Title(s)**	**Phone Number(s)**	**E-mail Address(es)**
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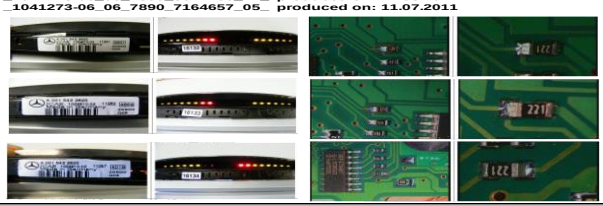
	Svetislav Smilkov	Quality Menager	+3892 202 232	Svetislav.Smilkov@jci.com
	Petar Kojcevski	Method Engineer	+3892 202 249	Petar.Kojcevski@jci.com

2. Problem Description

Description (Describe issue in terms of what, where, when and how many)

What: Part with both left red LED´s failed. Analyze in Remchingen showed that component resistor RL20 is not soldered (Report N0 1554). and both right red LED´s failed due to resistor RL28 not soldered (Report N0 1552, 1553,).
Where: SAS Spain
When: Defect reported from Renchingen on 21.10.2011, parts not yet received in Skopje
How many: Three
Serial numbers: _1041273-06_06_7890_8566738_07_ produced on: 09.08.2011
_1041273-06_06_7890_8624483_11_ produced on: 12.08.2011
_1041273-06_06_7890_7164657_05_ produced on: 11.07.2011



Impact on Customer (Identify the potential for shut down, line interruptions, yard recalls, warranty, etc..)

KM0

Facilities Involved (Customer, JCI and any Suppliers)

SAS Spain
Johnson Controls Remchingen
Johnson Controls Macedonia

3. Interim Containment

What actions were taken to immediately protect the customer and contain any suspect inventory?

1. Make notification for operator awareness.

2. Daily monitoring of quality reject rate of all references from ASJ.

3. Skopje has conducted team and discused the corrective actions. This is repeating issue - Tombstoning effect (lifted components) on ASJ resistors. Since problem appeared, Skopje is has made actions to adapt production process and reduce PPM for this issue.

4. Adjust reflow profile:
- longer soaking and cooling zone with higher temperature ;
- switch pick zones1 and 2 => decreased internal reject rate
- decrease temperature picks between zones in reflow

5. Continous improvement and adjustment of placement placement parameters in P&P machine

6. Increase oxygen level in reflow when there is quality alert on the line=> decreased internal reject rate

Other Product/Platform at Risk ?	Identification of certified material ?

Sorting Results (Time, Date, Total Number Sorted and Quantity Rejected)

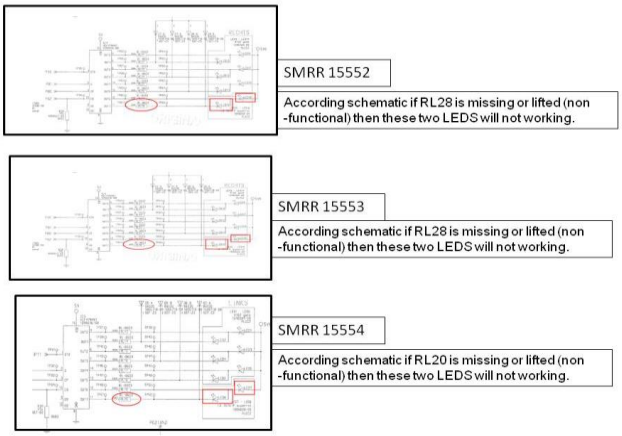
Sorted #	Defect #	Interim Containment Start Date

4. Root Cause

ROOT CAUSE

Why Made & How Verified

1. Expertise analyze made and defect confirmed on all 3 defective pcbs. Internally Tombstoning effect (lifted components) on ASJ resistors is present in Skopje.
Root cause of the lifted resistor with position RL28 and RL20 is solderabilty and not equal metal parts on ASJ resistors.
Please see expertise reports



Why Shipped & How Verified

AOI inspection can not detect this kind of failure. No angal inspection possible in AOI.
Component had contact when tested on In circuit and Functional tester in Skopje.

6. Verification of Corrective Actions

Verification of Corrective Action: Has the issue been turned on and off? How? Verification through statical evidence / hypothesis testing. Verification of corrective action for each why made and why shipped is required.

Change of stencil openings for ASJ resistors is validated for other references of PTS.
Validation of new stenicl with modified openings for reistors is palned for end of 2011.
Production with other suppliers without defects is validated. There is lead time to spent all stock of ASJ resitors.

Corrective Action Owner Name	C.A. Owner Phone Number	C.A. Owner E-mail Address	Target Completion Date
Petar Kojcevski			1-Dec-11

Build Date for Certified Material	How Will New Parts Be Identified?

7. Prevention

How will this issue be avoided in the future?
Defect included in PFMEA, Customer Roadmap.

Other Facilities or Platforms At Risk

Name	Part Number	C.A. Owner for Follow Up	Due Date

Has the necessary documentation been updated?	Affected Document	Owner for Update	Date

8. Closure

Closure Statement

Thanks to all participant who take actions to help this issue to be closed

Figure 4: Application of the 8D tool to solve a problem with a LED diode which does not perform its function in the circuit board

2.2. The Application of the Six Sigma method in the logistics sector

The Application of the Six Sigma method in the logistics sector is focused on finding and dealing with the causes of variation in processes in order to produce and deliver the perfect product to customers. The term comes from the concept that if there are six standard deviations between the mean value of the process and the nearest specified limit, virtually no process output will exceed the expectations. Figure 5 is an example of the application of the

Six Sigma methodology as a project in the automotive industry company for the purposes of reducing the defects of excessive flux of test points on circuit boards.

Process Owner: I. Belovski
Black Belt: A. Akova
Master Black Belt: J.R. Pointe

Project Schedule

	Started	Revised Completion	Actual Completion
Definition:	11/01/12		11/05/12
Measure:	11/06/12		11/13/12
Analyze:	11/14/12		11/25/12
Improve:	11/26/12		11/30/12
Control:	11/31/12		12/03/12
Validation:	12/04/12		

Define

1 Identify what's important to the customer. Define the scope.

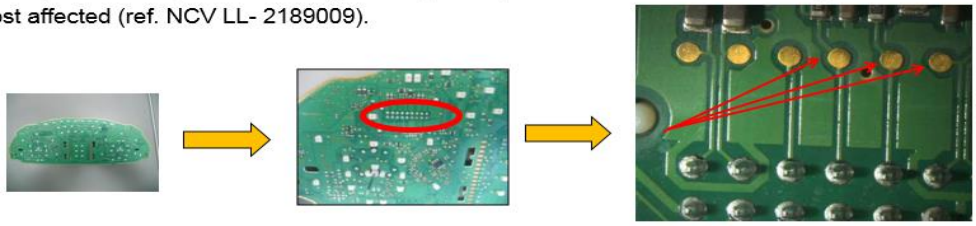
- **Problem Statement:**

Excessive flux on test points around the connector of NCV product. Due to this issue all affected pcb's fail on Functional Tester with "Wrong Pin Check" defect.

Flux on the test points comes from Wave soldering machine - (Before FCT testing all pcb's pass wave soldering process - soldering of connector/stepper motors/relays).

Total rejected 8741 pcb's in FY 12 (Oct - Sep FY12) - different references of NCV product.

Most affected (ref. NCV LL- 2189009).



Measure

2 Determine what to measure (Y) and validate the measurement system.

- **Measure the defect/ problem:**

Y_C: **Affected pcb's fail on PM1 station - CAN BUS check in JC Namestovo. Total RPPM = 54. Improvement Target is to reduce customer rejects for 100%.**

Y_B: **Waste of time for cleaning the surface of the test points near connector from flux. Total rejected = 8741 pcb's. Total PPM = 28316. Target is to reduce internal defects for 80%.**

3 • **Define and measure the process Y:**

Y_P: **Excessive amount of flux applied during wave soldering process. Total allowed amount of flux to affect is 5 mm from connector pin. In our case this limit is exceeded.**

	Description (with unit of measure)	Before	Project Target	After	% Improve
Y_C	RPPM = 54		RPPM =0		
Y_B	IPPM = 28316		IPPM = 5663		
Y_P		Avg: 5.449	Avg: 4.55	Avg:	
		St.Dev: 1389	St.Dev: 0.655	St.Dev:	
		Cpk or Ppk: -0.15	Cpk or Ppk: 100	Cpk or Ppk:	

Analyze

4 Identify causes (Xs) of variation and defects.

- **Potential critical Xs that affect the Ys**

5 Provide statistical evidence that causes are real.

- **Verified Xs that affect Y_p:**

Improve

6 Determine solutions (ways to counteract causes) including operating levels and tolerances.

- **For each verified cause, what is the counteraction** *(What creative, breakthrough, benchmark solutions have your team identified?)*
- **For each process factor, what is the nominal and tolerance**

7 Install solutions and provide statistical evidence that the solutions work.

- **Verified Counteractions for Causes:**
  For each cause, how was it counteracted? (insert decision matrix)
- **Quantify overall improvement in Y_P, Y_B, and Y_C**

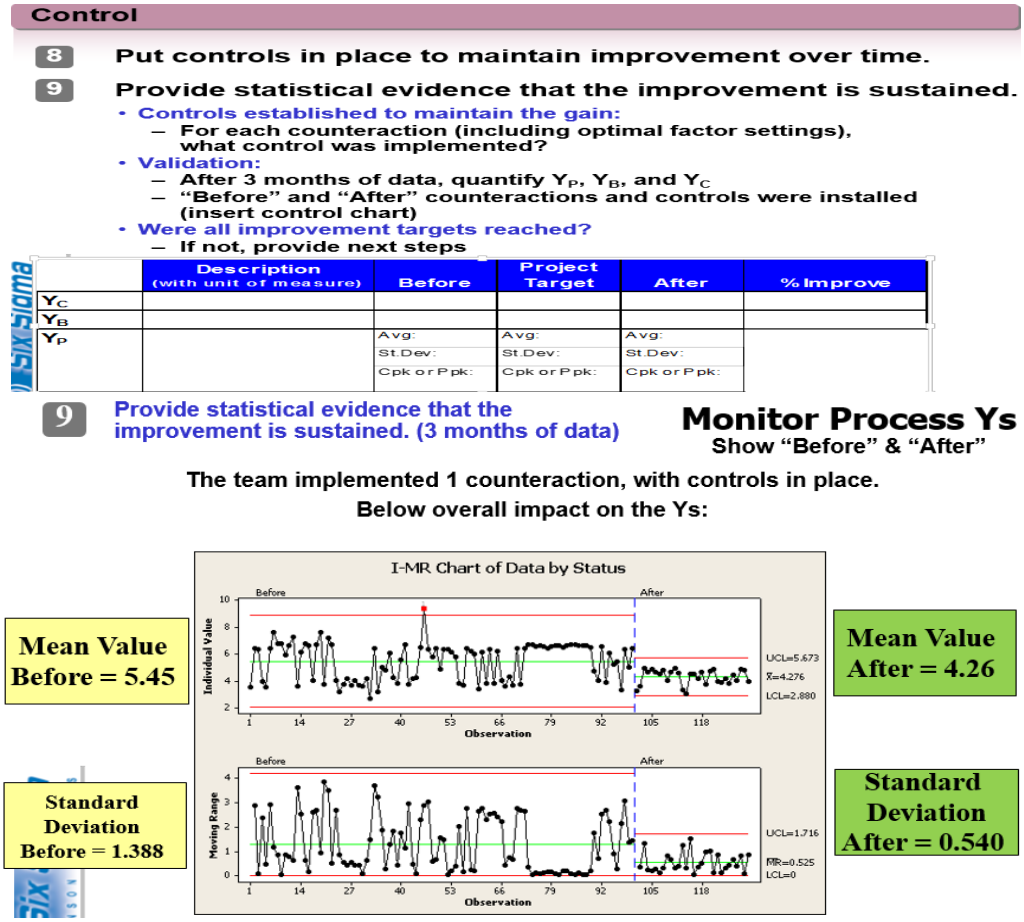


Figure 6: Effects of application of Six (6) Sigma methodology to reduce the defects of excessive flux test points on circuit boards

The application of this method led to improvement of the business processes, i.e. improvements of the mean values from 5, 45 to 4, 26 and improvement of the standard deviation from 1, 38 to 0, 54.

CONCLUSION

The automotive industry company in Macedonia sees the benefits from the application of the TQM system design and implementation methodology in the following:

- the application of internal standardization improves the staff's responsibility for realization of business processes;
- the application of statistical methods and techniques shrinks the defects in operation and it is a significant benefit, especially when looking for defined quality at lowest costs of operation;
- the application of software packages increases efficiency in the application of statistical methods and techniques;
- with quality costs analysis, the losses can be controlled as well and they can be reduced to their minimum in terms of consumption of materials and energy.

Besides these, other significant effects are achieved as well, such as:

- involvement of all employees in achieving quality;
- commitment of employees to improve quality;
- full commitment of top management to the TQM system and its continuous improvement;

- ability to solve problems at all levels;
- small, but significant improvements in processes and products;
- optimization of business processes;
- setting responsibility for decision-making at a lower level.

Without the top management's commitment to the established quality goals and the consistency in their implementation, all these efforts will only mean waste of time and money, at the same time reducing the possibility of success for any such initiative in the future.

This methodology is an integral and universal one, meaning that it is applicable to all companies regardless of the industry they belong to, and the success of its implementation will depend on the achievement of integration of information technology with: internal standardization, methods and techniques for faultless production, cost analysis system and continuous education and motivation of employees to provide competitive advantage. The TQM system design and implementation integral methodology has a back-link as a result of the necessity of business processes ongoing improvement. By way of repetition or spiral repetition of such cycles, the benefits of the application will be felt, thus changing the organizational culture towards welcoming such initiatives as an incentive to higher goals of excellence.

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