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ZERO DEFECTS METHODS USED IN AN AUTOMOTIVE COMPANY

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Abstract: Contemporary manufacturing must prioritize the sustainability of its manufacturing processes and systems. Zero Defect philosophy focuses on minimizing waste of any kind using data-driven technology, hence enhancing the quality of all manufacturing aspects (product, process, service, etc.). The present article wants to show how a company in the field of automotive manufacturing has integrated the Zero Defect methods in a strategy of zero defects. In the second part of the research, are presented five examples of the mentioned methods in the strategy.

Keywords: zero defects, automotive, quality, improvement

1 INTRODUCTION

This article is presenting general information about Zero Defects and how they are integrated in an automotive company.

This short introduction has the role of presenting the idea of the zero-defect philosophy without delving into the subject, which has been studied quite a lot lately by researchers.

The phrase "Zero Defects" appears for the first time in 1979 in the book by Philip Crosby (businessman and author) entitled "Quality is Free". This author launched for the first time in the industry the idea of "the right thing done the first time", which led to the improvement of quality and the increase of competitiveness in the field of enterprises.

The Zero-Defect Theory ensures the absence of waste in a project. Waste referring to all processes, equipment, utensils, employees, etc. non-productive, meaning that they do not add value to a project. Eliminating this waste creates a process of improvement and corresponds to lower costs. (Simplilearn, 2022)

Crosby did not define some rules to be followed by companies to achieve a standard of quality, but instead left fourteen improvement steps that can be implemented by anyone with the goal of achieving Zero Defects: (Manawis, 2022).

The implementation of the Zero Defects strategy in a production system can have beneficial effects on production, but it is not a simple procedure due to the implications that the strategy creates. However, for a successful implementation of the strategy, it is recommended to support the four strategies: Detection, Prediction, Repair and Prevention and for the company to understand why it is necessary to approach the strategy, before implementation.

2 COMPANY PRESENTATION

The study of the research work was carried out within the global company in the automotive field: Hirschmann Automotive SRL. The company has been active in the field for over 60 years, having 12 locations worldwide. The headquarter is in Austria, and 6 other production plants distributed on all continents: Romania, Czech Republic, Germany, Morocco, Mexico and China and several sales offices, where they work on the progress of the automotive industry with more than 7000 people.

One of the company's main strategies is to be a global player and offer customized products to its customers. The company successfully meets the most difficult challenges in connectors, cable assemblies and sensor systems. In addition, is an expert in high voltage applications for electric vehicles.

Standard products such as contacts and connector systems, sensors and cable assemblies alongside over-injection technologies together with products customized to customer needs ensure efficiency and endurance under the most extreme conditions and areas of a vehicle.

3 ZERO DEFECTS STRATEGY IN AUTOMOTIVE COMPANY

"Zero Defects", as was described in more detail in the first chapter, is not a program or a number of steps that must be followed in order for a company to ensure its implementation, but refers to a philosophy, a mentality that should to understand that the company's profit can increase by eliminating the costs of mistakes and increasing customer satisfaction. Because the philosophy does not come with step-by-step instructions, companies are free to structure their own methods to ensure and improve their systems and processes in order to achieve the concept of zero defects in production. The same is the case of the company we are talking about, taking into account aspects from the design concept to customer satisfaction after the delivery of the products, including monitoring and continuous improvement.

The Zero Defects strategy in Hirschmann Automotive is part of the company's global quality strategy, representing the very basic pillar of this strategy. The summary of the Zero Defects strategy within the company is made in the form of a figure where the area of application is briefly described (suppliers, in the product development phase and during manufacturing), the activities through which it is applied, the application methods and the available procedures any employee describing that activity in detail. Below is this mentioned in Figure 1.

In the following, some of the methods integrated in the strategy will be deepened and the way in which they are used will be presented.

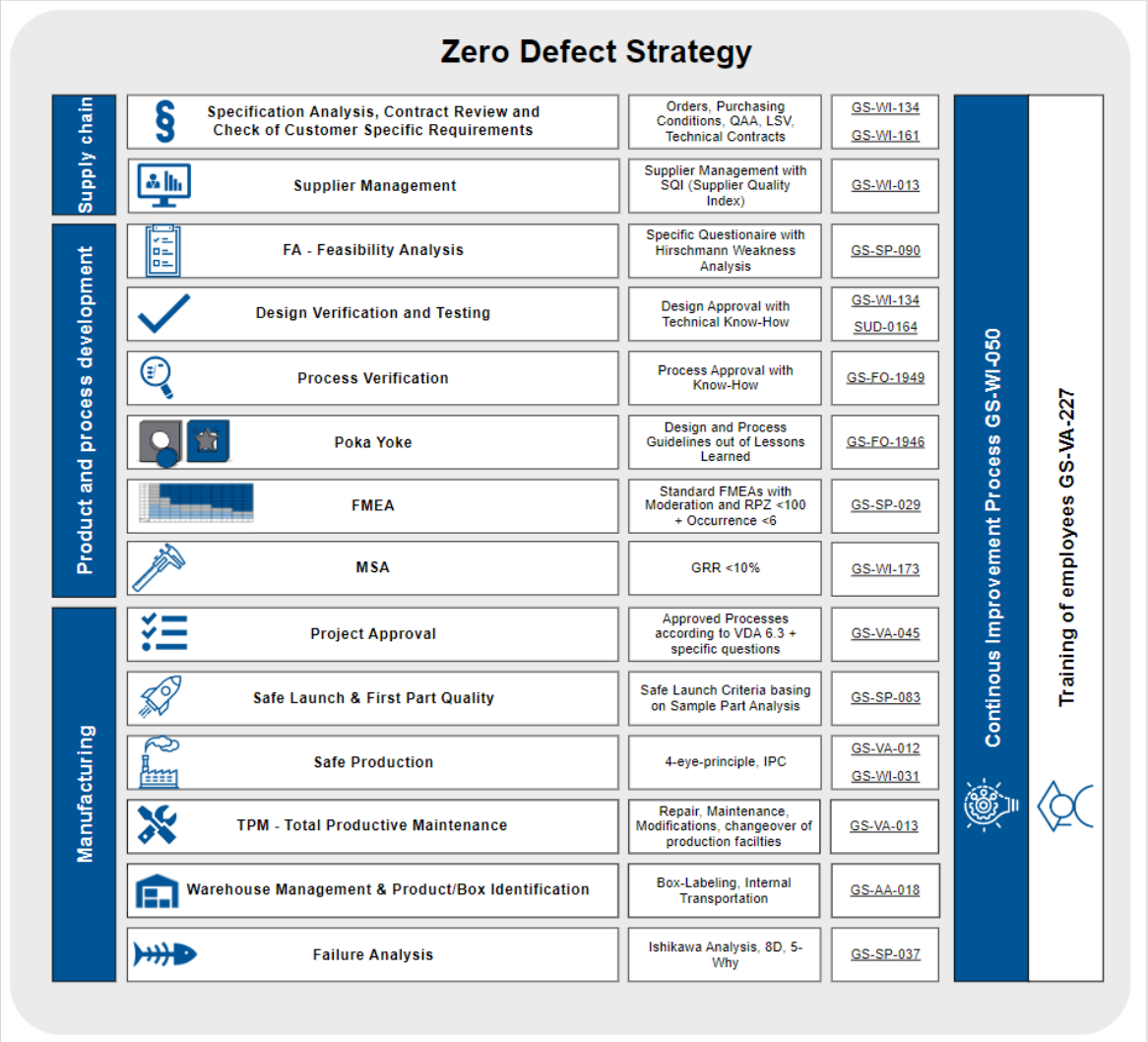

Figure 1. Zero Defects company strategy

3.1 4-eyes Checking

The "4 eyes" check has the role of ensuring the quality of the production, in some specialized documents it is found in the form: the "4 eyes" principle or the rule of 2 two people.

This method is a risk check mechanism, where an action/activity needs to be evaluated by two people before a decision is made. The risk of two people making the same mistake is low, or even zero. For this reason, some activities are provided by this concept.

Is this implementation value or non-value added within a process? - Ideally, it would be without added value. Regardless, there are cases where clients are willing to pay for multiple people to verify certain aspects. In such scenarios, 4 or 6, even 8 inspection eyes bring added value. Except in these cases, the 4-eye principle is a non-value-added activity implemented to ensure the activity performed.

At Hirschmann Automotive, the 4-eye check is an activity included in every step of the production process. This is described globally in

a global procedure and is included in the training of all company employees.

At the start of each process, the workers are required to produce 4 parts and then be validated by a more experienced person, such as: quality inspector or technicians. Depending on the process, the 4 parts are tested and checked based on the technical documentation and then documented on the 4-eye sheet, present at each workstation.

One by one, in each column they must note: Date, Product ID, Number of the equipment they are working on, Number of the workbench, Reason for checking, order number, Brand number, Signature and Time.

English

Process start-up control (4-eyes principle)

Visually check according order map (drawing, Control Plan, failure catalog)
An entry must be performed after each new start of a Production Order, each set-up, each disturbance and each interruption.

Date	Product number	Tool number	Machine number Work station number	Process step	Reason	Order Number	Position	Staff number	Time	Comments
					Start/set-up		Operator 1			
					After disturbance		Operator 2			
					After interruption					

Figure 2. 4-eyes check form

Although it may seem like an activity with no added value, within Hirschmann Automotive, most processes are manual, because of this automatic checks are difficult to implement, and the 4-eye check significantly reduces the risk of producing defects in series, precisely for this reason being considered an important activity towards achieving the goal of Zero Defects.

3.2 Kaizen Morning-Market method

The term "Morning Market" first appeared in the book written by Masaaki Imai, entitled "Gemba Kaizen". Although not described in detail, the idea conveyed is that the first activity of the day should be to review defects while they are "fresh", making an analogy to the morning market when all the food is fresh. The concept involves displaying all defects, classified by knowledge level:

A – when the cause is known and corrective actions can be implemented immediately,

B – when the cause is known, but the necessary corrective actions are not known

C – when the cause is not known, thus preventing the repair and reduction of defects produced immediately, it being necessary to analyze the process and define corrective actions

In Hirschmann Automotive, this Morning-Market activity is present in all factories and is executed under the following activity session:

Each production area has its own organized collection area for defective products. This is divided for 3 shifts and for the existing processes in that area, where the workers at the end of each shift or activity are responsible for taking their defective products to the collection area to be evaluated and recorded by the quality department managers.

The first two images below show us the existing types of waste boxes in Hirschmann Automotive, the third image represents the worker who takes the non-conforming products and takes them to the collection area (fourth image):

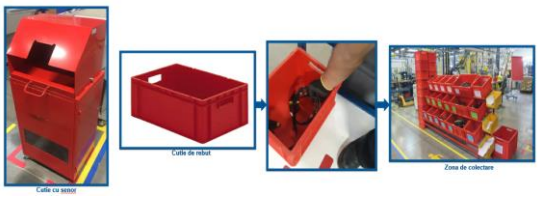

Figure 3. Collecting failures area

Every morning, at 8:30, the multidisciplinary team of each production area composed of: area manager, technical engineers and quality engineers meet and evaluate the defects made the previous day, analyze the processes if applicable and define corrective actions.

This method is appreciated within the company because it allows the entire team to be informed and involved in order to constantly improve manufacturing processes and ensure quality in the process.

3.3 Ishikawa and 5-Why methods

Although these two basic methods of quality analysis are usually discussed individually, in this paper they are presented together, because at Hirschmann Automotive both are used in the case of a quality analysis.

The Ishikawa method, also called a fishbone or cause-effect diagram is a diagram showing the potential causes of an effect. Each cause for deviations is a source of variation in a process, usually causes are grouped into broad categories to identify and classify sources of variation. These categories, in the manufacturing industry, are known as 5M: Worker, Machine, Environment, Material and Method, but the number is not limited to 5, variants with more categories are also accepted, including management, measures or others.

This technique is easy to learn and apply, being a visual one, the main problem is represented by the head of the "fish", and the potential causes being represented as bones, making it easier to finally visualize the causes of the problem.

Attached below is an example from within the company where the "Clip open" problem was analyzed as described by the customer following a complaint (due to this the product is not fixed in the car). The product consists of a clip with which the customer ensures the assembly of the product in the car assembly.

And the following is Ishikawa's analysis for this problem. For the 5 M's: machine, worker, method, environment and material, potential causes that could have caused this defect were defined by the multidisciplinary team (complaint manager, technical engineer, quality engineer, production leader and test engineer) in the area of production. At the end of this stage of collecting potential causes, the team votes on the cause of the defect - marked in orange:

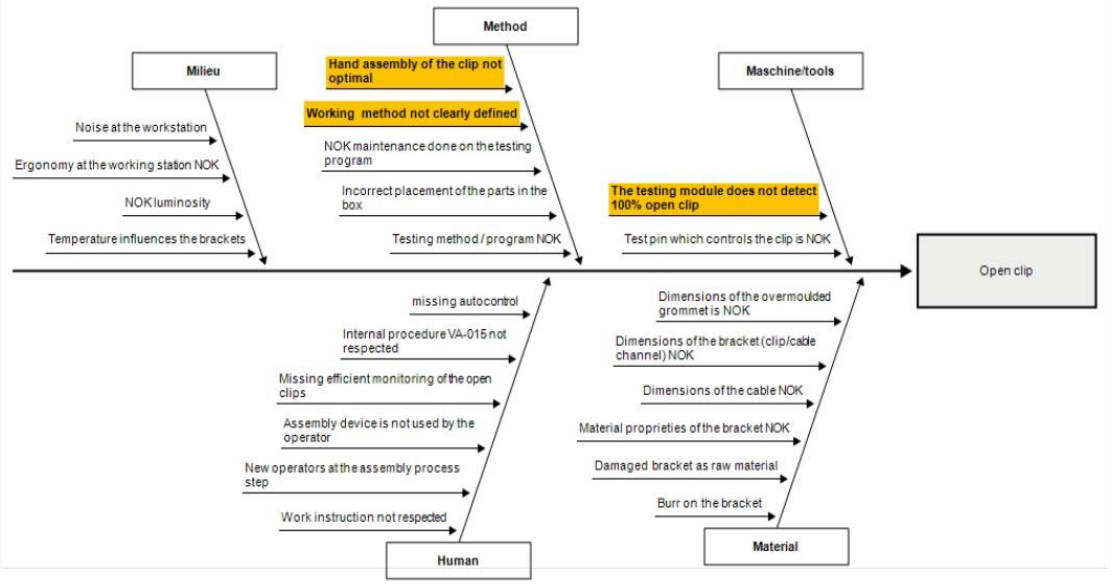

Figure 4. Ishikawa diagram example

Method 5 Why, complements the Ishikawa diagram through the interrogative technique of the cause-effect relationship. Aiming to determine the root cause by repeating the question "why?" a maximum of 5 times on the 2 main causes: the cause of appearance and non-identification.

Cause of Occurance / Ursache des Auftreten		
The part that was complained on 30.07.2020 was reworked by the operator, so the analysis of the complained part was not possible. The part that was complained on 20.08.2020 and the part that was complained on 03.09.2020 were sent back for the internal process analysis. It was concluded that failure occured during the holder assembly process step, where the bracket is assembled on the cable. This process step is realized using a dedicated guiding device. The operator places the holders in the dedicated place of the device and following is fixing the cable. Since at this step it is necessary to push the clips of the bracket to fix itself on the cable, it has come to the situation that the responsible worker at the line did not push it sufficiently as to it enter in its designed location, with this creating the risk of the clips to open. In our case the clips were not introduced suficiently so during the manipulation and transportation they opened.	1. Why?	The clip was closed partially or was completely left open
	2. Why?	The clip has to be closed manually by the operator
	3. Why?	The assembly process is operator dependent
	4. Why?	The assembly process is performed based on a clear work instruction
	5. Why?	Working method is not clearly defined
Cause of Non Detection / Ursache des nicht Entdeckens		
End of line testing equipment did not detect the complained failure resulting in the customer complain. The worker checked partially the product so therefore the failure was not detected at the assembly line neither at the end of line process step.	1. Why?	Failure was not detected by EOL test
	2. Why?	EOL test is detecting as OK the partially closed clip
	3. Why?	EOL testing pins design

Figure 5. 5-Why analyze example

The last answer to each of the two causes, is the starting point for defining corrective actions, so that the risk of recurrence of the problem is eliminated. In the example above: "the working method is correctly defined" and "the design of the equipment is not developed to verify the closure of the clip".

At Hirschmann Automotive, in the case of a situation that requires a product or process analysis and the identification of the cause is necessary, the methods are applied: Ishikawa and 5 Why? in the order previously described. These two methods have had effective results whenever they have been applied, regardless of the applied situation, even though they are simple techniques.

3.4 MSA – Measurement Systems Analyze

Every day, our lives are affected by more and more data, regardless of whether we are aware of it. Especially in industry, data is used in various ways, especially in measurements and inspections. When measurable data is used to make a process-related decision, it must be accurate. If there are some errors in the measurement system, decision making is based on incorrect data. An effectively planned and executed measurement systems analysis is a foundation for any decision-making process.

In the manufacturing industry, the English abbreviation MSA (Measurement System Analysis) is used because it is easier and because the entire production chain: suppliers – customers, use the same acronyms.

An MSA is an experimental or mathematical method by which the existing variation of a measurement process is determined, with the aim of evaluating the accuracy, precision and stability of an equipment. Accuracy is the average of the measurements against the reference value and includes: stability, linearity, resolution and bias – the difference between

Analyzing measurement systems in Hirschmann Automotive is an essential step towards quantifying the effectiveness of all measurement systems used. In each factory of the company there are these equipment's:

caliper, dial gauge, digital ruler, microscope and various electrical continuity checking equipment. MSA studies are also performed in some cases for workers, especially those responsible for the sorting process to assess precision, attention, accuracy, repeatability and reproducibility. The variation of gauges being defined by accuracy and precision. Accuracy being represented by the average of measurements close to the reference value and includes: stability, linearity, resolution and bias (the difference between the observed value and the reference value). Accuracy is a constant measure every time and includes: repeatability and reproducibility.

Although there are several types of MSA, the most common within the company are type 1 and type 2, according to the internal classification.

Type 1 MSA study: accuracy study, applied with the role of identifying deficiencies in the measurement system. An operator measures a reference product several times, minimum 20 repetitive measurements. This type of MSA is carried out in case of new measuring equipment, in case of location changes and in case of different measured tolerances.

How is this verification carried out? – the product and the equipment are ready for the operator, who is responsible for entering the measured values in the table. The recorded values are then generated with the help of a software in the MSA report.

MSA type 2 study: repeatability and reproducibility. This study is the combination of variations caused by repeatability and reproducibility errors and determines the following two aspects: how much variation is due to the equipment and how much variation is due to the operator making the measurements. For this study, it is necessary for at least 2 operators to participate and there to be 10 measurers on the numbered products. The first set of measurements is taken by one operator, they are recorded, then they are taken by another operator, and the expected results should not be influenced by the first set of measurements.

3.5 SPC – Statistical Process Control

Statistical process control is a statistical method of monitoring and controlling the quality of production processes. This ensures that the processes performed are efficient, with higher productivity and fewer defective products. This control can be applied to any process where product conformity can be measured.

The SPC is carried out in two big phases: the initial phase, being the establishment of the process - which process is monitored?, then its stabilization. In the second phase, a period decision must be examined, depending on the 5 big factors described in the previous sub-chapter to method 5 Why? (method, worker, material, environment and machine). This control method has an important role and is also considered an inspection method, during which problems are detected and prevented, in some cases corrected before they reoccur.

Considering that no two products or features are ever the same because there are always variations in the process. Variations in the process are classified into 2 types: common causes, which are normal to occur, and special causes, which are not expected to occur and which can destabilize the process, affecting the quality of the executed products.

All these variations are documented and analyzed based on control charts.

Below is an example of the Hirschmann Automotive product documentation, where the values entered based on the control limits can be seen in Figure 6.

Within the company, the statistical process control system is applicable to all products that have at least one measurable special characteristic. The program used for data recording and product statistics is: SAP, it provides all the necessary charts based on

measurements entered by qualified personnel (SPC quality inspectors).

In Hirschmann Automotive, SPC documentation is carried out together with the 4-eye check, i.e. at each shift start or after each intervention during the process. This inspection provides quality assurance, long-term capability recording, and the ability to analyze if process deviations occur over time.

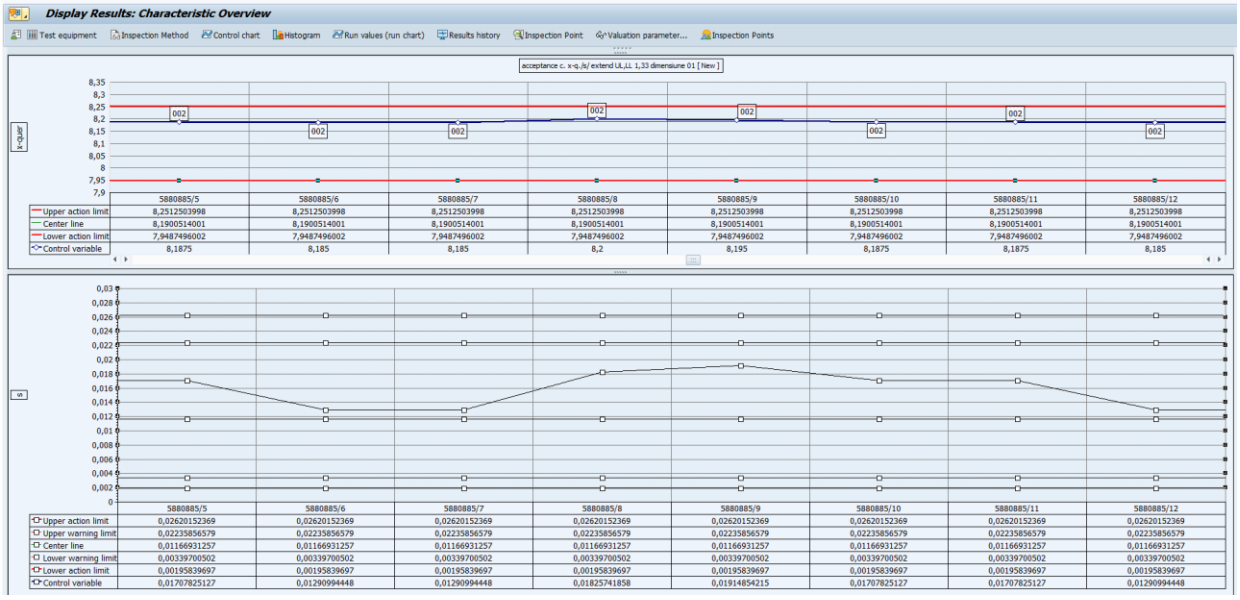

Figure 6. Process Variation example

4 CONCLUSIONS

This article provides some examples by which Zero Defect methods are applied within a company. Using a real industrial example, we performed a first validation of our approach with a simple use case from the automotive domain. The results of the validation example revealed that the ranking of tasks based on the applicability is a multi-criteria and complex procedure, and the results are not obvious, which is the reason behind the current research paper.

The proposed method can be used either at new manufacturing systems and existing ones. The key differences is that existing manufacturing systems already have inspection, data collection and analysis equipment, which sometimes this might be limiting and increasing the cost of Zero Defects implementation. When a new manufacturing system is designed for a specific product then the most efficient equipment for the specific case can be acquired and achieve higher levels of performance. Furthermore, the proposed methodology can be used of any type of discrete manufacturing systems. The higher the quality requirements the higher the need of Zero Defect methods and the higher the benefits from the proposed approach.

The application of the proposed method is generalizable and open to enrichments in different contexts limitation of this research is related to the complexity and difficulty of testing the proposed method and practical implementation guide in real industrial scenarios since it is challenging to engage industrial companies for collecting the required data for achieving results.

Future research should focus on applying the proposed method to several cases in redesigning existing and/or designing new manufacturing systems for achieving zero-defects. Another area of investigation could be to improve this method for multi-objective optimization of various performance target measures beyond quality.

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