TECHNICAL UNIVERSITY OF LIBEREC
Faculty of Economics

Quality management in the automotive industry

Master Thesis

Study Study programme: N0413A050030 International Management
Author: Bc. Radoslav Rabina
Thesis Supervisors: Ing. Eva Šírová, Ph.D.
Department of Business Administration and Management

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Master Thesis Assignment Form

Quality management in the automotive industry

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2. Analysis in the selected company with regard to international management.
3. Proposal, measures, recommendations to the company.
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- FOTR, Jiří a Jiří HNILICA, 2014. *Aplikovaná analýza rizika ve finančním managementu a investičním rozhodování*. 2. vyd. Praha: Grada Publishing. ISBN 978-80-247-5104-7.
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Consultant: Eva Laurinová, Plant Quality Manager ve společnosti Monroe Czechia s.r.o.

Thesis Supervisor: Ing. Eva Šírová, Ph.D.
Department of Bussiness Administration and Management

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L.S

doc. Ing. Aleš Kocourek, Ph.D.
Dean

Ing. Eva Štichhauerová, Ph.D.
Head of Department

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Anotace

Diplomová práce se zabývá procesy řízení kvality v automobilovém průmyslu. Jednotlivé skutečnosti jsou ověřovány v mezinárodní společnosti s výrobním závodem v České republice. Práce popisuje nástroje managementu jakosti, které jsou založené na mezinárodních standardech a specifikacích. Práce se zaměřuje na proces schvalování výrobního dílu před uvolněním do sériové výroby. Odpovídá na otázku, zda je tento proces schopen detekovat vadu vyráběného produktu před vstupem do další fáze projektu. Autor se zaměřuje na požadavky zákazníka, mezinárodní normy, globální analýzu osmi disciplín na vzniklém problému v sériové výrobě, včetně jednotlivých kroků směřujících k nalezení kořenové příčiny a k následné implementaci nápravných opatření. V neposlední řadě se autor diplomové práce zaměřuje na finanční návratnost managementu kvality z před sériové fáze.

Klíčová slova

Inženýrství zákaznické kvality, Návratnost nákladů, Osm globálních disciplín, Pokročilé plánování kvality produktu, Proces schvalování výrobních dílů, Řízení kvality.

Annotation

Quality management in the Automotive industry

The diploma thesis deals with quality management processes in the automotive industry. Individual facts are verified in the international company with a production plant in the Czech Republic. The thesis describes various Quality Management tools based on international standards and specifications. The thesis focuses on the Production Part Approval process before a product it is released to the serial production, and answers whether this process is able to detect not ok manufacturing product before entering the next phase of the project. The author focuses on customer requirements, on international standards, on the analysis of global eight discipline on the occurred problem in the serial production. Including individual steps to find the root cause and the subsequent of implementation of corrective actions. The author of diploma thesis focuses on the financial return of quality management from the pre-serial production, after the product is release into the serial production.

Key Words

Advance Product Quality Planning, Costs return, Customer quality engineering, Global Eight Disciplines, Production Part Approval Process, Quality management.

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I would like to express my appreciation and gratitude to Mrs. Ing. Eva Šírová, Ph.D., whose support and guidance has been professional and invaluable throughout the work on this diploma thesis. I would like to express my sincere gratitude for the friendly cooperation and support during the work on the diploma thesis to the professionals from the quality department at Monroe Czechia, especially to Mrs. Eva Laurinová (Plant Quality Manager), to Mr. Jiří Morávek (Customer quality engineer) and for Mr. Stanislav Pokorný (Financial Controller). Finally, I would like to sincerely thank my whole family, for the invaluable support during all my studies at the Technical University of Liberec.

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List of abbreviations

APQP	Advanced Product Quality Planning
ASQC	American Society for Quality Control
BCP	Business Continuity Plan
BOS	Business Operating system
BTAB	Business Transfer Approval Board
CM	Customer Management
DFMEA	Design Failure Mode Effects
FMEA	Failure Mode Effects
G8D	Global Eight Disciplines
OEM	Original Equipment Manufacturer
CRG	Part Return Centre
PSA	Peugeot Société Anonyme
PPAP	Production Part Approval Process
QMS	Quality management system
SM	Supplier Management
TQM	Total Quality Management

Introduction

Today's tough competitive conditions in the international markets require maximum effort to deliver high-quality products, services or systems. Especially in processes where series production takes place at a certain production, quality control is necessary in terms of accepted specifications and standards together with customers' requirements. The selected company for this diploma thesis operates in the international space and in the automotive industry where an analysis of individual quality tools used in serial and pre-serial production was conducted. The diploma thesis deals with quality management in an international company. The target of the analysis was the clarification of the management quality process of the selected product, in relation to its economic return. The literature and materials regarding the theoretical and practical description of the processes is possible to find in a lot of sources for a better understanding of the quality management and quality system. However, there is no singular source material which would describe both phases of pre-serial and serial phases in connection to a focus on the economic return. This diploma thesis can be the material where there is clearly describes common international management quality tools used in the before and after phases of the start of production, together with the economic aspect. The theoretical background has been built on the basis of chosen resources and experience, including information on how the quality costs must be handled. The theoretical background was prepared for the analysis, which begins in the second chapter and which clearly defines the standards of quality management and of individual tools, which are necessary to ensure the quality of the product in terms of quality management. The analysis was built on the base of available data from the manufacturing plant. The core of the diploma thesis is to find answers to these questions:

- What is the cost return of quality management in the international manufacturing company?
- Which international quality tools are being used for the quality management system and affect the final economical results?
- Is the manufacturing plant proceeding according to customer requirements on the selected product?

The analysis includes the production part approval process, advanced product quality planning in the international space. The next are process capability, G8D methods for solving of nonconformities and other tools, which are related to the international quality standards ISO 9001 and IAFT 16949 and customer requirements. The calculation of the financial return is at the end of this diploma thesis.

1. The quality management

Generally, it is possible to say, that the quality expresses the real status of the product, or service, with no occurrence of defects and nonconformities. We should understand, that the requirements on the quality can be different in the individual industrial and business sectors. Expectations for the automotive industry can be reliability, or no occurrence of defects occurrence, but for the health care industry it can be more important for a correct and quick diagnosis, discretion. However, the quality term has some similar common characteristics for all people who are expecting the certain complex property of the service, or of the product, also of the people, or system. The level of the quality can be measurable, can be evaluated, can be improved. The level of the quality, which is expecting for the concrete service, it can bring the feedback. It can be positive, or negative. The quality is complex value for the fulfillment of the requirements, or of the standards. As was mentioned above, customers are expecting in the individual sectors the specific service. The main standards regarding quality are ISO 9001:2916 and IATF 16949 for the automotive industry. Original equipment manufacturer (OEM) expect those standards from their suppliers. The behaviour of producers and suppliers affects the level of the quality. The poor level may affect the next potential businesses or negotiations. Customers dissatisfaction leads to a decrease in sales. The productivity in the manufacturing plan can decrease too. Employee satisfaction and work ethic can be bad. Overhead costs influence our profit. All these facts are the reasons why manufacturers and self-employed people take care of the quality of their products, because all of them want to have the profit. The quality is one of the most important pillars of a successful and long-term business. (Nenadál at al., 2018, p. 15-18)

1.1 Concept

Nenadál at al. (2018, p. 18) wrote about Mr. Masao Umeda who was the president of the company Nishishiba electric Co Ltd in the last century. He said: „quality management is a part of company-wide management, which guarantees the satisfaction and loyalty of customers in the most efficient way.“ This is a key on the basis of the reality of the manufacturing plant. If the quality department is to add value to the company, there has to be close cooperation between all departments. According to this definition we can specify three main quality management functions:

- Maximal satisfaction of customers and all stakeholders.
- Reduction of the overhead costs and prevention of additional costs.
- Constant improvement, lean manufacturing. (Nenadál at al., 2018, p. 18).

The policy of the quality management should be considered with targets of the company, the fulfillment of the specifications and requirements, control and implement standards. Quality goals are in close connection with the police of the quality, which has been created in the company. SMART principles are specific, measurable, achievable, realistic and fulfillable in time. On this basis, quality goals are specified with the requirements of the company and legislation so the final quality requirements can be met. (Prášilová 2017, p. 16-18)

A part of quality management is continuous improvement of manufacturing and of the internal processes, training of the employees, focus on costs, data collecting and then evaluation and eventual implementation of corrective actions. All parts and policies of quality management bring satisfaction to all stakeholders. (Nenadál at al., 2018, p. 21)

The tools[1] which can help achieve satisfaction of all stakeholders can exist through technology, which brings enough financial sources and then the innovation to bring advantages against competitors. The capital, which brings investments to technological development, which supports business performance. Advantage of the technology uses in the production increase the level of the quality control and quality in general. (Poláková, 2014, p. 23)

1.1.1 ISO 9001 and IATF 16949

Total quality management (TQM) is the framework for the management system in the company and on the basis of the requirements it serves as a guide for leading the quality internally and externally. It brings constant review of the quality. We can say, that generally it is a guide for strategy that should lead to better competitiveness. Prášilová (2017, p. 18)

Illés, Szuda and Dunay (2017, p. 100) described principles of the Total quality management:

[1] Example of quality tools. Histogram. Pareto chart. Check sheet. Process capability. Poka-Yoke, Jidoka, G8D method. FMEA. Control plan. PPAP.

- Focusing on the customer and employee involvement.
- Focusing on the process.
- Making the decision on the basis of data.
- Improvement, especially continual improvement.
- Strategic approach to quality management.
- Communication to motivate employees and other involved parts.

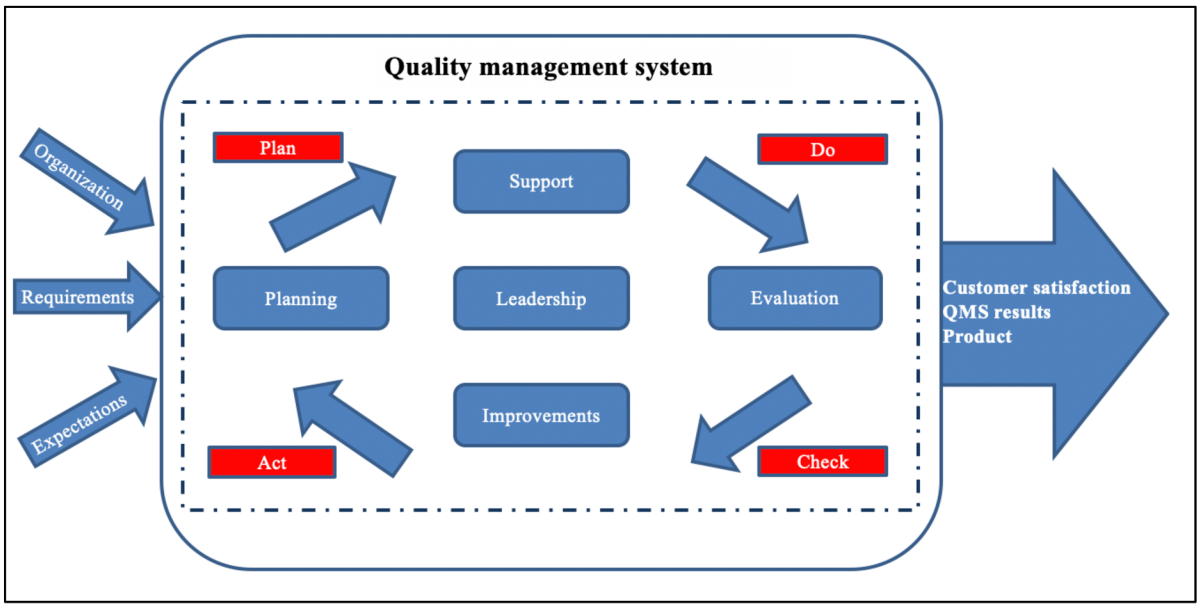
The certification of the ISO 9001 is important to increase the level of the quality and to fulfill customer expectations. It also brings many advantages like the improved level of the product and effective handling of complaints, and then improved corporate image. ISO 9001 describe how the quality management system has to look, then specifies the required documentation. The next part is about the criteria of the responsibility for the company management with delegated responsibilities, mentioned importance of targets and quality controls. Each company has to declare that the manufactured products has been produced according to standards and specifications. Next part of the ISO 9001 defines the importance of the assembly for the production plan. It concerns the requirement for the calibration of the measurement equipment, analysis and on improvement process. Customers have a right to monitor the situation of their suppliers, measure the effectiveness of corrective actions in case that nonconformity happens during the manufacturing. (Johri, Kumar, 2020)

As Reid (2017, p. 56-57) described, the automotive industry sector revised the previous standard IATF 16949 quality management system, (QMS) to align with ISO 9001:2015. This revision considered customer specific requirements (CSR) incorporated with international automotive task force (IATF). IATF 16949 replaced ISO TS 16949. The standard focuses on the preventive actions in the case of nonconformity when problems occur. The next new requirement from the automotive manufacturers was a mandate to use ISO 9001:2015, where certification is provided separately. (Reid. 2017, p. 56-57)

As Nenadál at al. (2018, p. 28-29) wrote about the international automotive task force is an international group of cars manufacturers, where their main task is to increase the quality level in this sector. It includes individual requirements on quality system management and standard IATF 16949:2016. I tis the system, which supports continuous improvements with prevention of nonconformities. It applies for the car manufacturers and their direct, or indirect suppliers. ISO 9001:2015 and IATF 16949:2016 complement the standard ISO 9001:2015.

The organisation TÜV SÜD is the international company providing the certification of the international standards. An individual audit is set up and provides in periodically in the specific time interval. IATF 16949:2016 includes requirements for the system of the quality management. The automotive industry is very specific, and the standards help to achieve customer retirements and supports the effective manufacturing process. (Athena Information solutions, 2017, p.1)

For example, there are specified requirements regarding methods of documentation management for design and development in the standard ISO 9001:2015, but IATF 16049:2016 strictly required the monitored process of the products approval. We can find more similar examples, regarding warranty, risk analysis in supplier supply chain, and anti-corruption policy. Generally we can say, that IATF 16949:2016 goes beyond the scope of ISO 9001:2015 requirements, it is more strict, requires the detailed overview of the quality management, it is more progressive, and both standards together are the main pillars of the quality management system and if the Total quality management. (Nenadál at al., 2018, p. 28-29)



Picture 1: Structure of standard ISO: 9001:2015
Source: Nenadál at al., 2018, s. 18

1.2 Methods and tools of the quality management

Significant group of methods and tools usually used in the automotive industry are for the solution of the nonconformity, in the case of problem, or during the continuous improvement of the system. (Nenadál at al., 2018, p. 53)

Seven basic tools of the quality management are the main and effective conditions for the fulfillment of the quality standards of TQM including Kaizen, G8D methods, PPAP. Six sigma. (Polášková, 2015, p. 23)

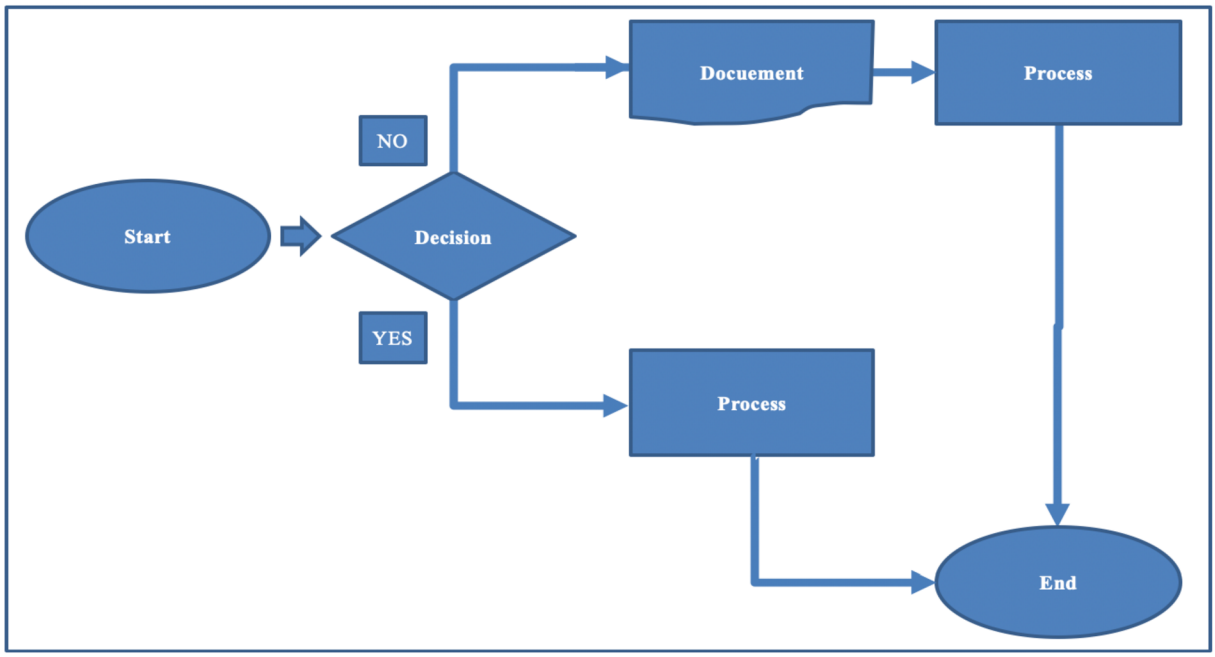
Data collection form

The collection of data has to be provided deeply in the detail and precisely. On the basis of the organised data can the next tools and methods be used. Three stages of the detection can be separate for the record of individual nonconformities, to separate files of the measurement and as the overview of the places, where nonconformities occurred. Filter of the overview can involve the place of nonconformity occurrence, the name of the production line with the supervisor, the name of the product and serial number. However, there is strictly required information, which has to be in the data collection form. They are the source of data, date and time occurrence, identification information about data collector, measurement methods, identification number of the machine. (Polášková, 2015, p. 23)

The data quality framework is a controlled and complex checklist of all basic practices and requirements for the eventual management decision. It provides the information for the evaluation and for the next procedure. Data quality policy refers to the main target and direction of the company. Implementation of the decisions about the next steps is done by the data quality management. The data quality system includes procedures, organizational structure, delegated responsibilities for implementing data quality management. Set up of the activities which are used to fulfill the required quality is called Data quality control. (Patel, 2016, p. 199-200)

1.2.1 Flowchart

Manufacturing process is completed and sometimes hardly readable. Thanks to agreed symbols is possible to create clear overview. Usually it helps to detect some ineffective steps in the process. The main point is to define borders of the process, input and output, connection of all individual processes to one. (Polášková, 2015, p. 24)



Picture 2: Flowchart
Source: Slidemodel [online]

Because of the flowchart is the manufacturing process flow graphically representing of the individual sequence. (Stamatis, 2018 p. 20)

The Flowchart is an ideal tool for the process analysis. It brings identification of individual sectors, where can nonconformity occur. Management defines where control stages can be. To

better understand the process, which is graphically illustrated, it helps also for an explanation of how the process works, especially when a customer asked for the overview of the process and individual quality controls, which are set up during the manufacturing. A better understanding of the flow also helps for the detection of the redundant workstations, that can be removed, and save the overhead costs and increase the profit. The flowchart is created by the team, usually in cooperation between the process engineer and quality engineer. (Nenadál at al., 2018, p. 54)

1.2.2 Failure Mode and Effects Analysis (FMEA)

The risk is the attribute of some activity, in the business, or in the human activity. During the development, or during the implementation of the new project, restriction of the company, can ~~be~~ cause potential risks, where the future result can be different than the planned targets. The management and preparation of the individual steps to achieve results is essential. The quality of the plan affects the success rate. (Fotr, Hnilica, 2014, p.14)

The key target of the project is in the connection with the internal and with the external factors. The company has to calculate ~~with~~ all possible problems, which can affect the final result. The experience and available data are the most essential factors for the risk analysis. The main targets and milestones have to be set up. (Korecký, Trkovský 2011, p. 134)

The main reason for FMEA analysis is to prevent ~~the~~ potential problems in the process, or during the manufacturing of the product. Though the FMEA are evaluated, the customer requirements under the necessary conditions, product and process design proceed to minimize the risks of the potential failure occurrence. The next purpose of the FMEA analysis is to develop and evaluate methods of the design to avoid failures and to take advantage against competitors. The main advantages of the FMEA are the reduction of the costs in the process together with financial return. Effectiveness lies in the time reduction of the project management phase before the product is released on the market, quality improvement of the product and its reliability. (Sharma, Srivastava. 2018, p. 2)

FMEA analysis is created by a team. It is a teamwork. Usually the coordinator is from the quality department. It can be the quality technician who provides the revision in a specified time period. The next departments which cooperate are process engineering, design department, logistic department, or more. It depends on the concrete company. The team is actively working on the reduction of the RPN (Risk Priority Number). This number shows priorities of the risk and helps to set up the corrective actions. (Prášilová, 2017, p. 56)

Process FMEA (PFMEA) is an analysis, prepared by the responsible team, to avoid process failures with associated causes, which have been resolved. All knowledge is linked to the design FMEA flowchart and process capability. There are several expectations like:

- PFMEA has been created always when new procesess or technologies happen.
- Potential of nonconformity can not be avoided through design changes.
- Quality concerns could not be resolve during the production of model year. (Stamatis, 2018 p. 21)

Design FMEA (DFMEA) is an analysis during the verification and validation of the product. Unexpected nonconformities, which occur during this phase always have to be addressed in the DFMEA. (Stamatis, 2018 p. 244)

- DFMEA is about the product design safety concerns.
- Process during the product development phase.
- Set up the priority for design improvement.
- DFMEA info is shared with the PFMEA teams. (Stamatis, 2018 p. 244)

1.2.3 Kaizen

This method leads to a minimization of nonconformities during the manufacturing and to quality management costs. The next important fact is that Kaizen means continuous improvement, which is a concerns employees and managers. (Prášilová, 2017, p. 20)

One of the first automotive company which leads their improvements with Kaizen method was the Toyota Motor Corp. For example, in one of the manufacturing plants, they had the car

construction placed side by side, and it caused a reduction in the production line by about 33 %. (McClatchy, 2011, p.1)

The Kaizen is an effective method of how the top management can ~~to~~ reduce lead time of sales. It can be around 4-5%. It affects cycle time too. According to literature, the value of the reduction is about 3-4%. (Shukla and Ganvir, 2018, p. 14-17)

Prášilová (2017, p. 20-21) mentioned important conditions of Kaizen in her diploma thesis, the Kaizen is effective, only if a company implements the following:

- TQM.
- Just in time system.
- Absolute maintenance.
- Preventive maintenance leads to minimize overhead cost of the machines and equipment.
- Policy implementation => the strategy has to be clear and set up in intervals. (long, medium, annual), so the employees can follow it effectively.
- Improvement system proposals => employees can actively participate in the innovation.

The Kaizen means a small improvement in the processes, which already running, opposite to innovation brings significant improvements through investment. (Prášilová, 2017, p. 21)

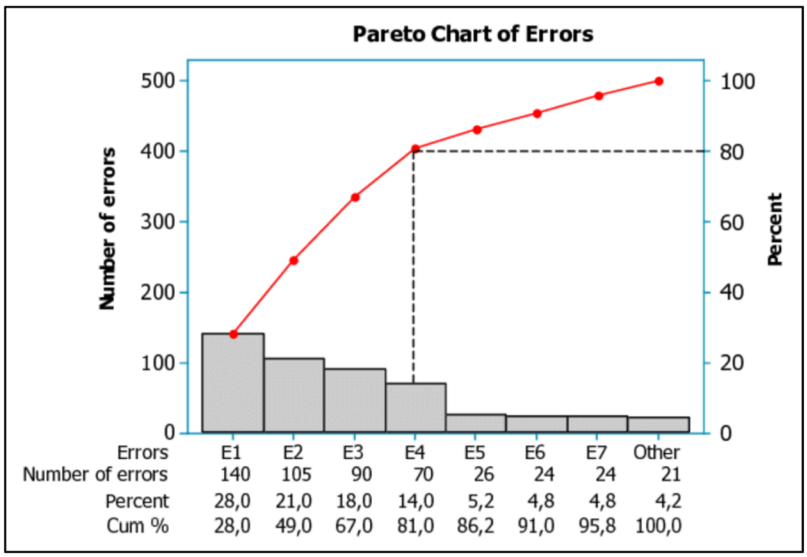
1.2.4 Pareto diagram

Pareto analysis expresses the frequency of nonconformities according to their individual types. It uses, for example to clarify the machine downtime, overhead costs according to occurrence of the nonconformities. The collection of data has to be prepared precisely and they have to be stored. (Prášilová, 2017, p. 25)

Data is divided into minority, which is about the 80 % of the nonconformities, and useful majority, which is represented by the 80 %, but occurs for 20 % of nonconformities. Pareto analysis helps to detect effectively the amount of nonconformities according to root causes, on the basis of the data, which is available, then the responsible quality engineer can proceed to

the next investigation and to corrective action. Also, the analysis brings information regarding additional costs in connection with the root cause. (Prášilová, 2017, p. 25)

The Pareto Diagram is an effective tool on how to solve variations in the process. The variations can be specific and common. The special variations are not possible to predict. An example of common variation can be lighting in the manufacturing assembly hall, when it has not directed influence on the manufacturing production lines, but it can affect human resources. The special variation can be a loss of power during the manufacturing. (Cotter and Galli and Kush, 2016, p. 353-354)



Picture 3: Pareto chart of errors
Source: Serteser at al, 2010 [online]

1.2.5 Process capability

It is a statistical method control to clarify the stability of the process. The ability to manufacture a product within specification. (Stamatis, 2018 p. 244)

As Martin Bažant, an experienced quality engineer described the process capability as an existing process related to the Cpk index, which is related to the position of the mean value. The capable process requirements considered with Cpk is over, or equal to 1,33. The Six Sigma methodology corresponds with 3,4 per part million (PPM). It means that process generates 34 nonconformities on the million produced parts. This value of the six sigma correspond with the Cp = 2, Cpk = 1,5. On the basis of the evaluation of the process capability, the manufacturer is ready to estimate the probability of nonconformities occurrence. The next possible step is to

prepare the plan of the preventive and corrective actions, to evaluate efficiency. Results of the capability are also important for the customers. The results are the proof if the product has been produced in a capable process condition and quality criteria has been fulfilled. Cp is the index of the capability, it is the ratio of the maximal variability of upper and lower tolerances and the actual variability of six sigma value. (Bažant, 2010)

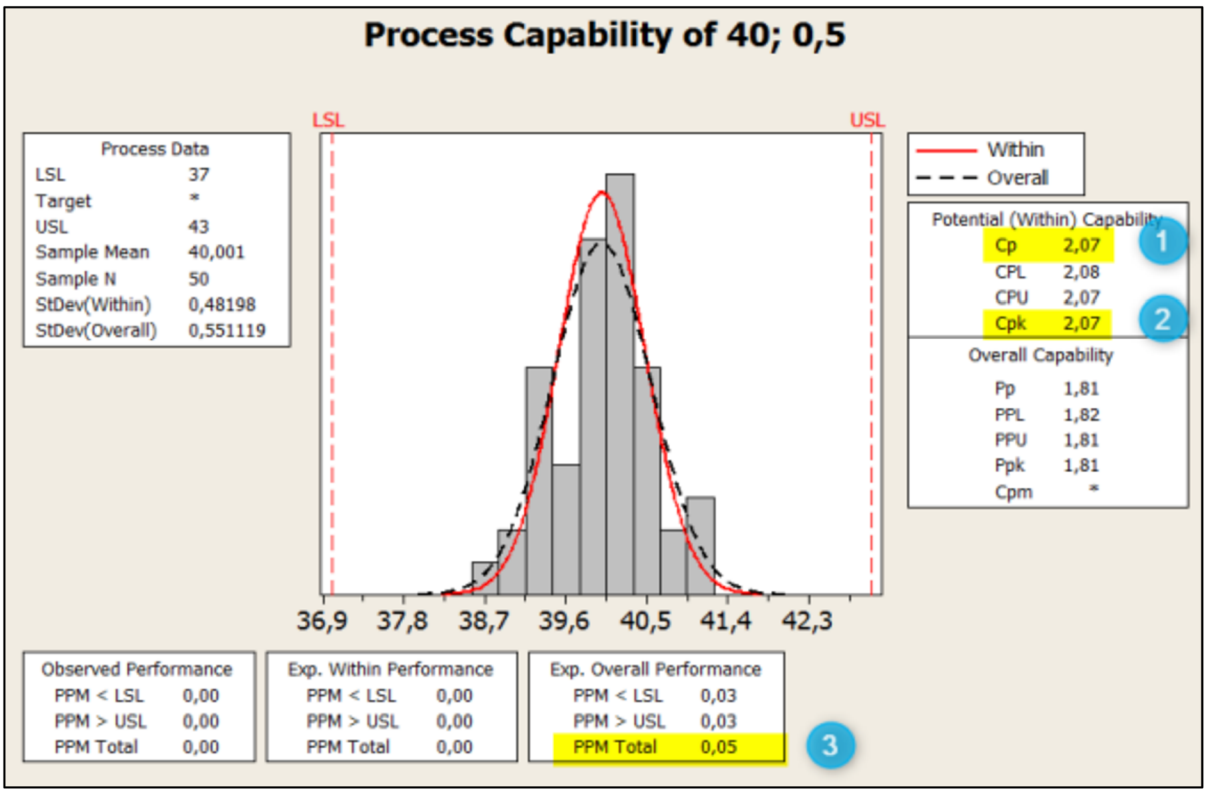
$$Cp = \frac{USL-LSL}{6\sigma}$$ *Equation 1: capability*

$$Cpk = min\left[\frac{USL - \bar{X}}{3\sigma}; \frac{\bar{X} - USL}{3\sigma}\right]$$ *Equation 2: process capability*

- USL means upper specification limit.
- LSL lower specification limit.
- σ is process standard deviation.

Special process characteristics has been created and developed for the monitoring, and if it is necessary for the improvement of the manufacturing process. Variability of the measurement system can change the final results of the capability process and leads to wrong assessment of the process. (Selmi, Amara, Ben Frajd, Kobi, Salah, 2018, 1919-1920)

Cpk expresses there the average value located with respect to the process limits. The Cp process only expresses how well the process fits within the specified limits, but it does not address the position of the process to the limits (if it is in the middle, or at the upper, lower limit). You can see results below (picture 4) with specification limits 40 +/- 3. CP is equal to 2,07, Cpk is equal to 2,07 and that process is capable. The expected PPM is equal to 0,05. It means that during the production of one hundred million parts, there will only be 5 not ok. This kind of process looks ideal. (Bažant, 2010)



Picture 4: Process capability
Source: Bažant, 2010 [online]

1.2.6 G8D method

Some kind of the nonconformity can occur any time. Then it is important how the organisation will handle it. There are two possibilities how to handle problems:

- The first one is to have corrective approach.
- Second one is to have prevention strategy.

The most common method for the solving of nonconformities is the G8D. Stamatis (2018, p.29) described the following criteria, when G8D method is the most beneficial:

- Definition of the symptoms.
- The affect parties have been identified.
- Urgency, growth of the nonconformities, warrants initiation of the process.

G8D report has several steps, through which the analysis is providing. D0 – D8, from the description of the problem to the summary. **D0: Preparation of the G8D process.** During this

first steps, it is necessary to provide emergency actions (if it is necessary). evaluate the needs. Typical tools of D0 step can be the Pareto chart, which shows ranking base on frequency. **D1: The team establishment.** For the successful result of the nonconformity investigation, it is important to specify team roles and memberships, together with operating procedures. Team leader and champion has to be appointed. **D2: Description of the problem.** There has to be the definition of the occurred defect. The problem must be described in a clear and simple way. To identify nonconformity, where the root cause is unknown. It asks questions for the analysis such as what, where, when and how big. A tool which can be used in this step is Process flow diagram. The responsible person can define, where the problem occurred in the process, also identify the possible root causes. **D3: Developing the interim action.** It is necessary to bring proof before implementation, so verification of the way how to id. After the implementation is validating the step, which can confirm the right decision of corrective action. However interim actions are temporarily fixed, and they will be implemented before corrective action will be verified and implemented. **D4: Definition and verification of the root cause. The** problem is defined in this fourth step. The information about location in the process, closest to the root cause, where the problem could be detected, but was not. The defined root cause must be substantiated by the necessary tests and subsequently with substantiated explanation. **D5: Permanent corrective actions.** The main target is to choose the most effective permanent corrective action to remove the root cause. Verification is necessary to show to the customer the effectiveness of the corrective action. It is cross departments cooperation for the investigation and verification. (Stamatis, 2018, p. 30–34)

D6: Implementation of the permanent corrective actions. The team will bring the plan for the implementation, and also the actions will be implemented continuously. After that, it is possible to stop interim corrective actions. The validation of the permanent corrective action will be shared with the customer. The team has to prepare solutions for avoiding similar problems from occurring. **D7: Recurrence prevention implementation.** The quality engineer within cooperation with the process engineer will modify necessary systems. Systemic improvements can run through quality alerts, individual policies, or procedures. The main target is to prevent recurrence of the occurred problem, or similar ones. **D8: Summary.** The last step is about summary of the situation, about the provided work and thanks to the team. (Stamatis, 2018, p. 30–34)

The G8D method has been developed by Ford Motor company for the solving of nonconformities. The main task is to solve the occurred problem, also to repair and to avoid the repetition. It is a standard in the automotive industry, and in the similar industries, where the detailed process of the nonconformity solving is required. (TÜV SÜD, 2022)

1.2.7 5 Why

This analysis technique is detecting the root cause on the basis of effect relationships, which are the basis of the problem occurrence. The target of the 5 Whys is to find the root cause of the detected problem by repeating question. However even if the method is used on the detection of the problem, the results depends on the knowledge of the people involved in the team. For the start, it is necessary to consider who should be in the working group. All people involved have to understand the logic of the cause and effect relationship. Step by step, question by question, precisely continuing to the result, the team have to avoid jumping to conclusions. Root cause can not be human error, worker inattention etc. The system of the process has to avoid human errors. The proper use can bring the result without complicated statistical analysis. (Stamatis, 2018, p. 35-36)

As Myszewski (2013, p. 377) described 5 Whys method as a process going down through details of circumstances. Each step depends with the next question and systematically goes through detection, importance, occurrence. (Sinha, Myszewski, 2013, p. 377)

The 5 Why analysis is a strong tool for the highly experienced workers, this method brings simple, serious flow for solving the nonconformity and for the finding of the root cause. It means that this kind of the analysis is very basic for some analysis of the root causes. It is strongly recommended, that the verification has to be provided before the team will continue with the concrete question, after that it is possible to continue in the investigation process. This can avoid spurious causes. (Stamatis, 2018, p. 35-36)

1.2.8 Ishikawa diagram

It is a typical tool used for the finding of the root cause during the nonconformity investigation. A quality technician, or engineer uses the Ishikawa diagram together with G8D methods. It is

an important tool for step four (Definition and verification of the root cause) from G8D. The structure of the diagram resembles a fish with bones, so it is also called a fishbone diagram. The structure consists of six main points. There are management, material, machine, method, and measurement. The concrete case, when Ishikawa diagram can be used, you can see in the second part of the diploma thesis. (Prášilová, 2017, p. 63–64)

1.3 Advanced product quality planning

The process model of the project management considers follow up processes. The systematic approach during the management is a very important condition for the successful results of the project and for the fulfillment of the requirements and specifications. (Svozilová, 2016, p. 71)

The APQP process has been developed by a commission of experts around the Original Equipment Manufacturers (OEM) from the automotive industry, Ford, General motors and Chrysler. The second partner was the American Society for Quality Control (ASQC). The main target of the cooperation between those two groups was to be develop and specify requirements of the quality for suppliers. Also, to define individual methodologies. The APQP is a common process in the automotive industry today. Individual OEM manufacturers added their requirements into APQP, but the base is the same for each company. APQP is together with international standards ISO 9001, IATF 16949, the most important requirement for the automotive manufacturers. The Target and the main aim of the APQP is the achievement of the task, to develop a product quality plan for products aligned with customer requirements. There are five main activities regarding APQP defined. Planning, product and process development, product and process validation and production. (Stamatis, 2019, p. 17–29)

1.3.1 Product planning

The target of the product planning is to set up the smooth continuation of the communication with all involved parts. The main indicators of the APQP is to implement the team definition, also the definition of the scope, training of the employees, it is necessary to involve the customer and the supplier, next is the implementation of the engineering tools, and the time schedule. (Bobrek and Sokovic, 2005)

In case a new product or the change on the existing one is required by the customer, the preliminary plan starts. The first step during this phase is to define customer requirements. According to the information the design can start, or a redesign of the new product. In case the requirements are clear, then the quality process can be defined. Outputs of this APQP phase are quality targets and product design. The inputs can be points like historical issues, business plan, product and process assumptions. The next outputs from this phase can be preliminary bill of material and preliminary process flow, and list of special characteristics. (Stamatis, 2019, p. 29)

1.3.1.1 Product design and development

It is necessary to specify the function of the product and customer requirements including implementations in all involved parts. Internal and external effects, process capabilities and technical possibilities. (Cotter and Galli and Kush, 2016, p. 347)

During this phase of the APQP is the target for the product design. Outputs from this phase to the next are design FMEA, prototype control plan, engineering specification, new equipment, or tooling, material specification and more. (Stamatis, 2019, p. 30)

1.3.2 Process design and development

Validation is the summary of each tests and measurements provided on the product. The overview of the individual tests has to include description of the tests, results, and identification numbers. (Rydström, Viström, 2020, app. 2)

The manufacturing process for the new product including improved products, is developed during the phase of design and development. The main target is to consider quality and specification of the product, eventually to design the new production process including a concrete production manufacturing line, on which it will be possible to produce expected quantities in required cycle time Output from this phase can be the quality system review, process flowchart, packing standard, process FMEA, measurement system analysis, and more. The final product and manufacturing process have to be validated. It includes the capability of the process. The first trial manufacturing runs and products produced under this condition are tested. According to the results, the process can be modified before the next phase. Outputs

from this stage are the MSA results, process capability studies, production part approval process, production control plan, and more. (Stamatis, 2019, p. 30-31)

1.3.3 Importance of production part approval process in international project

PPAP is the automotive standard thought which is possible to reduce risks of the potential nonconformity before it will be occur in the serial production. It considers requirements, specifications, and design. The supplier, who is responsible for the PPAP, will guarantee that the production processes and manufacturing lines are capable to produce the required capacity and fulfilled the cycle time under the customer requirements and in the capable process. The PPAP is always required when some change of the process happen. It can be relocation, the supplier of some component has been changed, or in case of the new tooling (e.g. replacement, transfer). The PPAP helps to reduce warranty and prevents additional costs of poor quality. (Stamatis, 2019, p. 51)

The PPAP is the process of monitoring the approval process of each component incomes into the final product. At the end of the process, there is the final approval. The main point of the PPAP is to clarify, if all requirements have been handled in the way, when the process will be capable for the required capacity. (Nirupama, Vasanth, Shivaprakash, 2013, p. 180)

The required PPAP includes the following documents, reports which has been created on the basis of available data. The final customer can ask for the additional documents if both sides will agree on that. As Stamatis (2019, p. 62) described eighteen items, which can be provided by the supplier of OEM.

- Design FMEA.
- Engineering change documents.
- Process Flow Diagrams. Control plan.
- Measurement system analysis.
- Dimensional results. Initial process studies.
- Qualified laboratory documentation.
- Appearance Approval Report.
- Sample production parts.

- Master Sample.
- Checking Aids.
- Customer-specific requirements.
- Production part approval process submission warrant (PSW).

1.4 Manufacturing and engineering

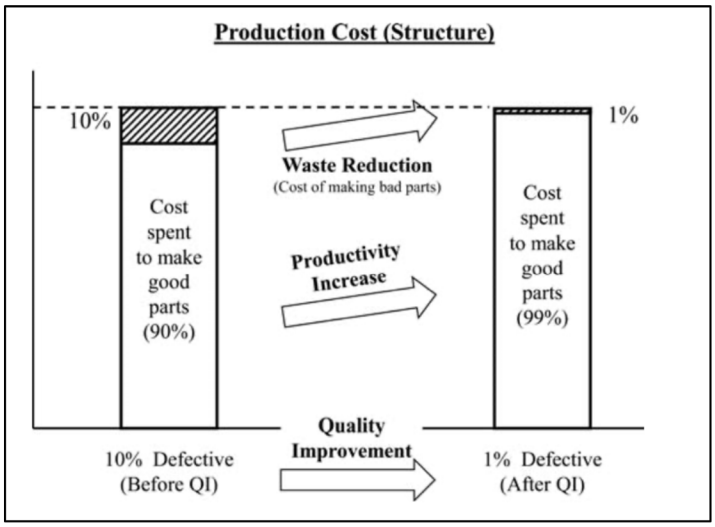
The engineering is the activity to create and realize the idea of some kind of the solution through the use of science. It considers construction design, production of the product, creation of the system, or service. The engineering activity has boundary conditions, they are the cost, delivery time, cycle time of the manufacturing line, customer requirements, the safety, function of the created product, reliability and lifetime of the product. However, the core of the engineering is the design of the product, of the system, or process. On the basis of the successful design it creates the manufacturing effectiveness. It includes the productivity, costs, technology, and quality. Design of the product, system, process, or the design of software. The target of the design is also to increase the productivity level in the modern manufacturing. The way how to do this is to use modern technologies and intelligent solutions. There can be two ways how to proceed. The first one to provide an upgrade of the older equipment on the basis of the modern technologies, or the second way can be to design and develop completely new equipment. However, if the manufacturing process is not optimized and capable, then the new automatization of the process will not be effective. The automatization and capability of the process create the quality and financial profit. The most time demanding processes in the manufacturing are processing, time of the inspection, quality control, and transportation. The design can increase the effectivity. As was mentioned,–one of the most time demanding processes is the quality control of manufactured parts. The quality control is provided according to set ups in the process and control plan. It is necessary to avoid potential nonconformities, so assuring the required quality target through process control it is necessary and it is the standard of the quality management. It is in the company's interest to carry our inspections efficiently and in the shortest time if it is possible. The typical example of the tool for the quality control in the production of the measurement equipment called GO/NO-GO. In case this tool is used, it is possible to detect, if the unfinished individual parts of the final product, are in the specified tolerance, or they are not. (Lim. 2020, p. 2-14)

1.4.1 Productivity

The automotive industry is one of the most complicated, which needs the systematic approach of increasing productivity. The reduction of the manufacturing cost is closely connected with the productivity. The lean manufacturing is the department which focuses on this topic. (Rosa, Silva, Ferreira, 2017, p.1)

Lim (2020, p. 8) described the productivity as the measurement of the efficiency of a person, machines, manufacturing plans, and of the whole system. Each process needs the complex design of the process management. There are several inputs, which affect how the process can be complicated. It can be deliveries of supplied components, planning of the production, income of the material and quality check and shipping. Then it can be the concrete process, for example the welding, machining, painting and assembling at the end. The process control plan is the standard and required tool for the effective manufacturing process. There it is necessary to have the correct prices of the supplied components as well as the quantity management of the stock, delivery time of products are highly affecting the final productivity of the manufacturing. The productivity is one of the main determinants of the manufacturing competitiveness. The calculation is made dividing average output per period by the total costs incurred or resources. (Lim, 2020, p. 8)

$$Productivity = \frac{Total\ value\ delivered}{Total\ cost\ incurrence}$$ *Equation 3: productivity*



Picture 5: Production cost control
Source: Lim, 2020

1.5 Quality costs

Illés, Mr Szuda a Dunay (2017, p. 101) described the cost of quality as methodology thanks to which it is possible to clarify how effective sources are, which prevents an insufficient required level of the quality. The eventual nonconformity is the result of the internal, or external failure. In case that responsible departments clarify the places in the organization, where the potential savings can be this kind of the information is appreciated. The reason is that after one can start the implementation of the process improvement. Activities concerning the quality, for which the company costs incurred (prevention, warranty, scrap, administration, quality management wages). The costs of the implementation of the quality standard, cost of the quality improvement, and for the target's fulfillment, they should be managed thoroughly to the long-term quality efficiency to achieve a desirable goal for the company.

According to Lim (2020, p.6) the main factors are the price and the costs of the purchasing and manufactured product. The connection between the value, price and cost is demonstrated below (figure 1). Design and development with the administration cost are the main factors, which composed the manufacturing cost, labour cost, warrant cost and the process in general.

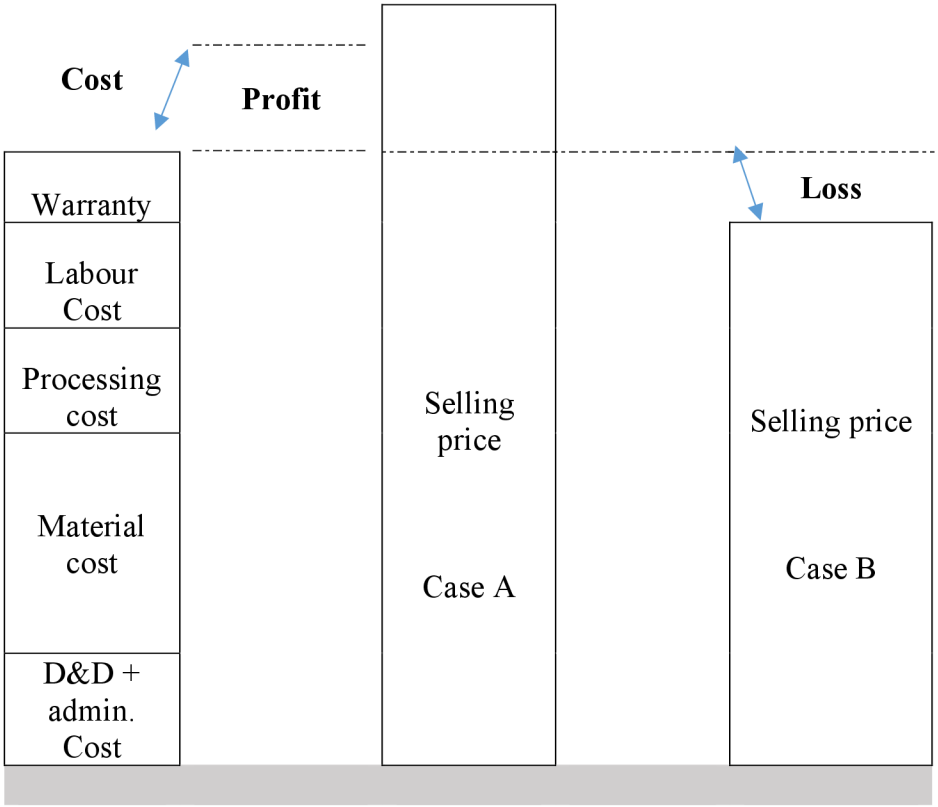
Figure 1: Cost, Price, Value

<table>
<tr><td colspan="3">Value (V)</td></tr>
<tr><td colspan="2">Price (P)</td><td>V - P</td></tr>
<tr><td>Cost (C)</td><td>P - C</td><td></td></tr>
</table>

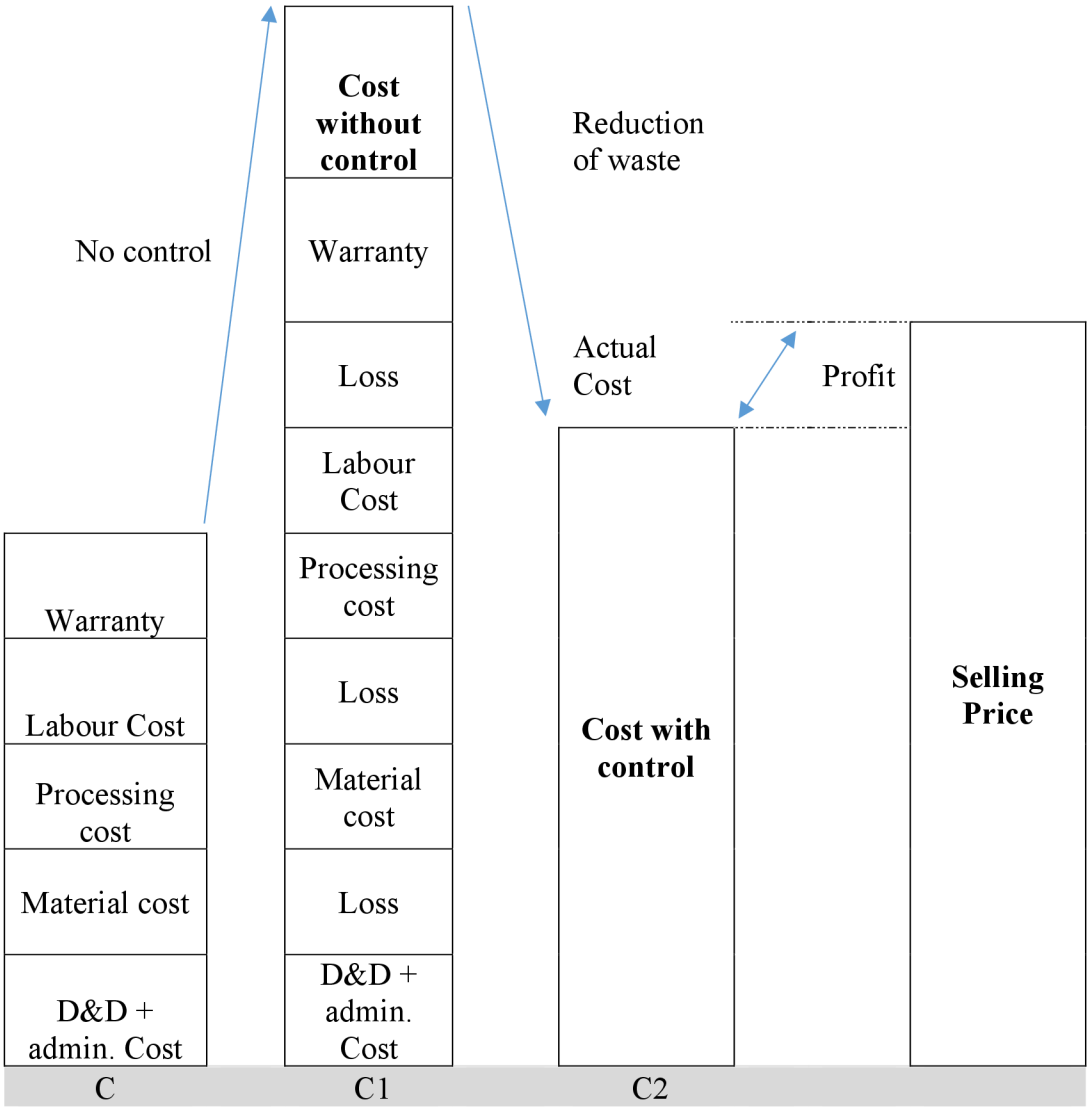
Source: Lim, 2020, p.6

- (V – P) = net benefit to the customer
- (P – C) = net benefit to the producer

The manufacturing cost strongly affects the final profit. This is the reason why continuous improvements are very important and required by the management of the company. Especially scrap and warranty are under the responsibility of the quality management. A potential high risk of the warranty and of the scrap, which can be occurred during the manufacturing process is eliminated through APQP phases before the start of the production. Overhead costs are under control of financial and controlling department. The evaluation of unexpected additional costs during the process can bring the corrective actions and save the financial losses of the company. The final price, for which there is the product selling, is very important for the financial effectiveness of the product including the return, and for the net profit as well.



Picture 6: Cost, Profit, Loss
Source: (Lim, 2020, p. 6)



Picture 7: Cost, Price, Profit with cost reduction
Source: (Lim, 2020, p. 6)

1.5.1 Divided quality costs

The importance of the quality strategy is essential. As Urbánová (2008, p. 38) divided the quality costs into four sectors. Prevention costs, Costs of evaluation, costs of the internal nonconformities, cost of the external nonconformities, costs of evaluation.

- **Prevention costs:** it helps to decrease the risk of the potential nonconformity. It includes costs:
    - for the quality management department,
    - for the implementation of the new quality tools,

- for the creation of the internal standards,
- for the ensuring,
- for the certification of the international standards,
- for the process capability,
- for the measurement systems,
- for the training of employees,
- for the market research of quality parameters,
- for the implementation of the six sigma,
- for the implementation of the automatization,
- for the implementation of APQP.

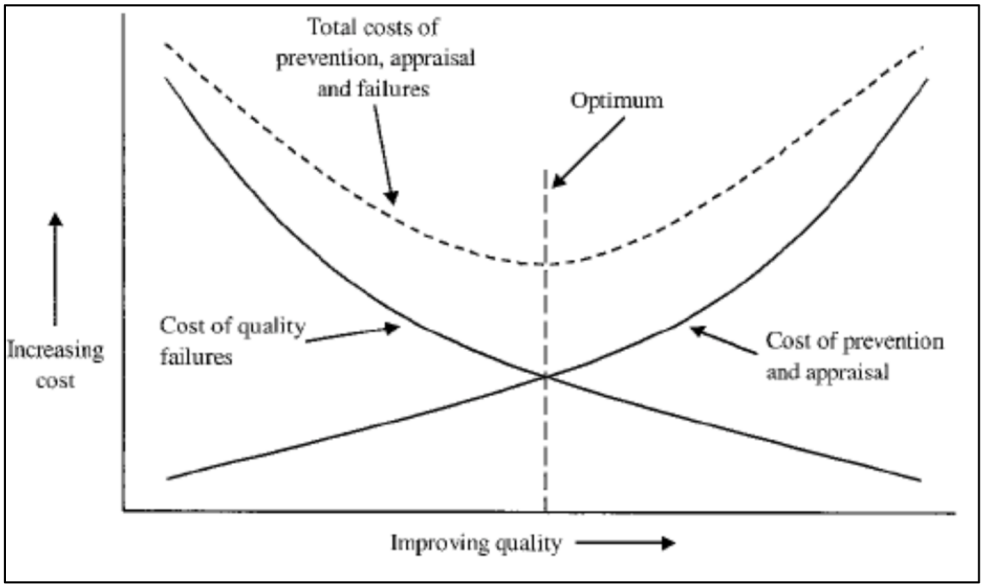
- **Costs of evaluation:** this cost expresses, if the quality targets and requirements has been achieved. It includes costs:
  - for the income, outcome quality control,
  - for the purchase measurement tools and equipment,
  - for the operating of the laboratory,
  - for the certification of the products.
- **Costs of the internal nonconformities:** this costs occurrence is on the basis of the non ok part produced during the manufacturing process. It includes costs:
  - for the downtime on the production line,
  - for the repetition of the quality check,
  - for removing the defect caused by the wrong manipulation,
  - for the scrap proceedings,
  - for the equipment for the necessary repairs,
- **Cost for the external nonconformities:** this cost occurrence is creating outside of the company after the product has been delivered to the customer manufacturing plant. It includes costs:
  - for the nonconformity solving, G8D process,
  - for the additional shipment,
  - for the repairs of warranty,
  - for the withdrawal of products from the market. (Urbánová 2008, p. 38-39)

The clever design can affect the final price and manufacture cost in a positive way. The engineering concepts. The engineer specifies the concept of the sources and manufacturing

costs, which is shared with the project manager and sales department. The final set up of the price is under the sales department responsibility and top management. Costs of the supplied parts and material are one of the main parts of the manufacturing costs. Also, the labour cost is very important, and it can affect the final price of the product. (Lim, 2020, p.15)

1.5.2 Prevention, appraisal and failure model (PAF)

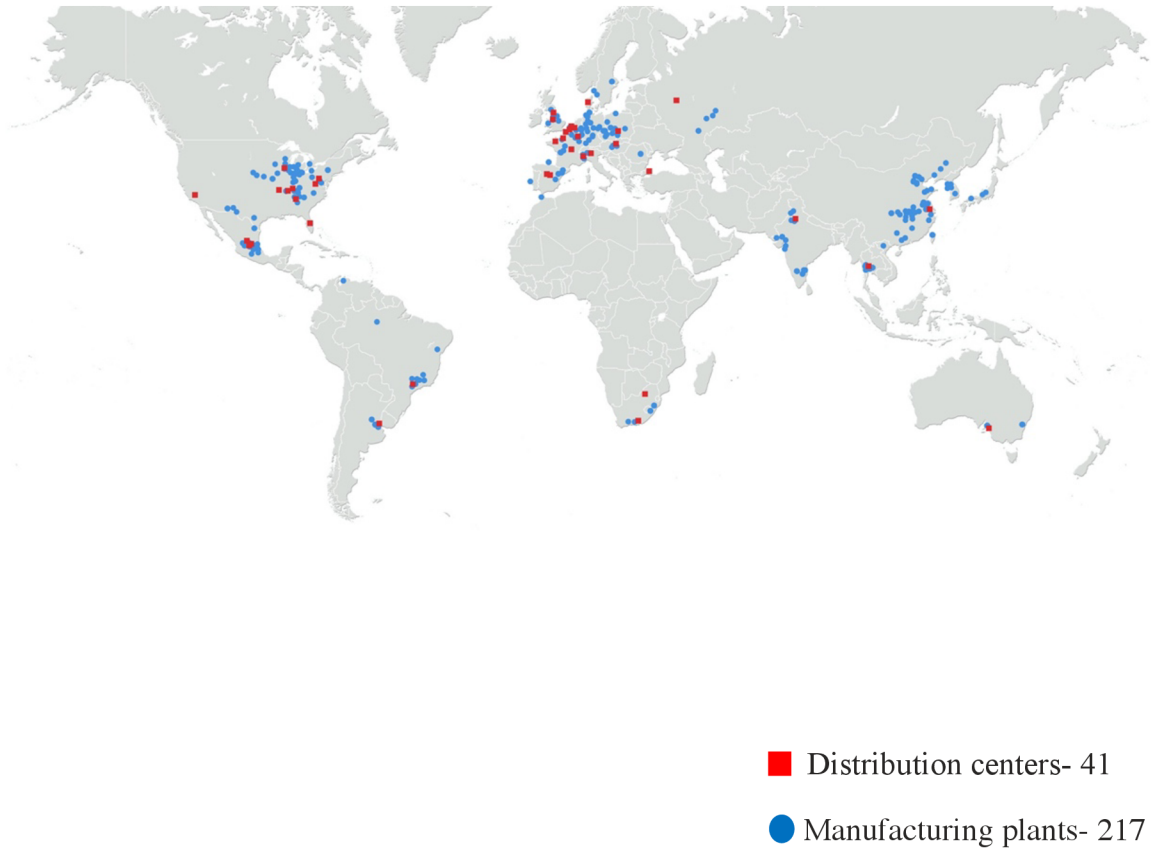
The PAF model has been created on the basis of four basic groups, which has been mentioned above. They are costs the of the internal and external nonconformities, for the evaluation and prevention. This model supports the monitoring of all additional costs and overhead costs of the quality management. (Urbánová 2008, p. 38-39)



Picture 8: PAF model
Source: Almeida, 2011, p. 3

2. Analysis of the chosen international company

The Tenneco is an international corporation with manufacturing plants and distribution centres situated around the World with headquarters in Lake Forest, Illinois. The corporation is focusing on margin expansion and cash generation with supplying the best solution and quality of their products. To reduce structural cost with lean corporate and operating group structure, they are focusing on the lower capital intensity through working expansion on capital turns. The third focus is on the business optimization with steps like alignment of business lines to portfolio position, also through value stream simplification. A large engine solution operating on three markets and advanced suspension technologies are steps to invest in growth targets. (Plant presentation, 2021)



Picture 9: Map of facilities
Source: Plant presentation 2021

The Monroe Czechia s.r.o. is a global leader in manufacturing ride control products including designing and engineering for small cars, SUVs, luxury limousines, sports cars and commercial trucks. Ride control means shock absorbers, struts, dampers. The added value of dampers is the possibility of tuning solutions for light and commercial vehicle application.

The company is located in the Hodkovice nad Mohelkou, on the north of the Czech Republic. Monroe is part of the Tenneco group, which is an international corporation delivering on world markets in several businesses sectors. There are passengers' cars, commercial vehicles, car accessories, locomotives marine, engines stationary, and engines. Customers can buy Tenneco products under the name Monroe Czechia s.r.o.. Information above has been provided internally and from www.driv.com.

Picture 10: Monroe products
Source: Driv.com

The company culture has been built on the five strength pillars. Creation of better tomorrows, changing problems into solution. We long to win. One team. Always be honest. (DRiV, 2022)

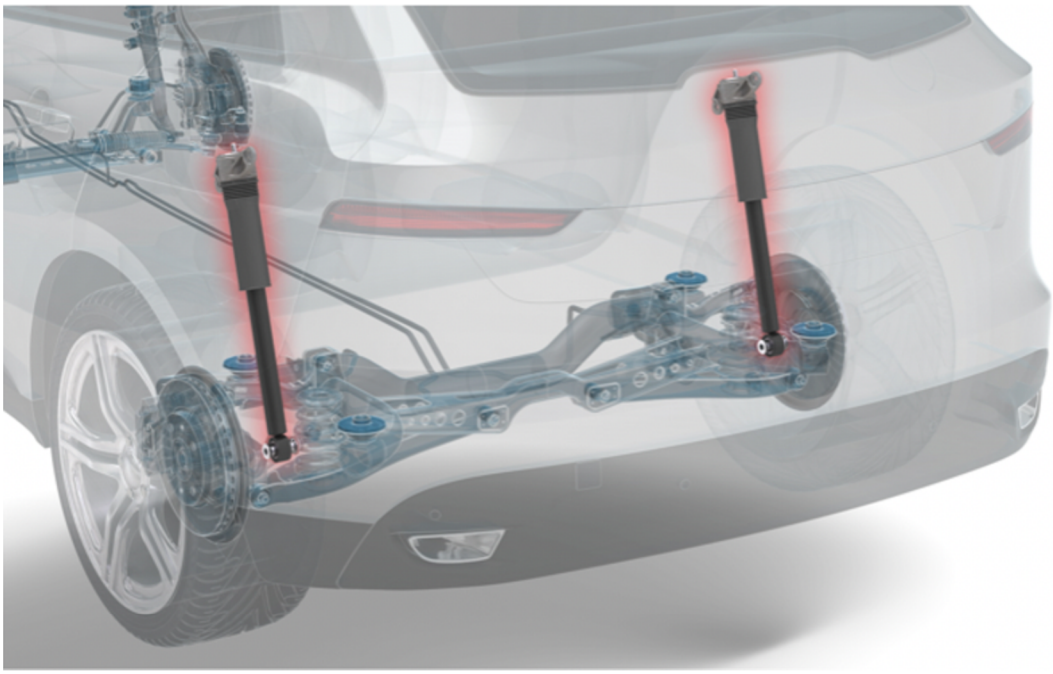
2.1.1 Ride Performance Segment

The Monroe Czechia s.r.o. is a global international leader serving conventional suspension solution on aftermarket and OE markets, selling more that 75 million OE shocks and struts globally. In addition to corporate social responsibility and sustainability by focusing on environmental, social issues and governance.

According to an environmental performance from 2019, the company reduced water withdrawal 11 %, and energy use 18,8 %, and overall waste 2,6 %, with a reduction in GHG emission intensity vs. 2017 baseline 11,3 %. The plan for the reduction targets set is 3 % for the year 2021. Achievement of the target is on the basis of continuing product innovations and fulfillment of reduction targets for energy, greenhouse gas emissions, and industrial waste.

Health and a safe workspace are some of the most important priorities, which a company has. Data from 2018, which has been evaluated in 2019, shows lower lost day case rate of about 13 %. The lower incident rate about 8 %, and 3 % of company's sites are OHSAS 18001 / ISO 45001 third party certified. 92 % of locations are certificated to IATF 16949 and to ISO 9001. An ethnic diversity of US employees is 23 %. 24 % of global team members are women, where 14,3 % are in leadership. In general, there is 16 000 diversity partnership through the local job network. (Plant presentation, 2021)

As mentioned, the Monroe Czechia s.r.o. is a global leader in the manufacturing ride control products including designing and engineering for small cards, SUVs, luxury limousines, sports cars and commercial trucks. Ride control products are shock absorbers, struts, dampers. The added value of dampers is the possible tuning solutions for light and commercial vehicle application.



Picture 11: Ride Performance visualization
Source: Plant presentation 2021

2.2 Local Quality manual addendum Hodkovice plant

The manual has been created on the basis of international specification requirements by ISO 9001:2015, ISO 16949:2016, ISO14001:2015, and all relevant stakeholder requirements are involved also. Specific customers' requirements have been evaluated and included in the scope of the organization's QMS. It applies also to all employees who perform activities affecting quality at Monroe Czechia s.r.o. Hodkovice nad Mohelkou. Outsourcing processes in cooperation with companies are part of the quality management system. The Monroe Czechia s.r.o. declares the establishment, implementation, and continuous improvement of the quality management system, including processes in accordance with requirements of interested parties and ISO 9001:2015, IATF 16949. (Local Quality manual addendum Hodkovice plant, 2021)

Responsibility and authority

Delegating responsibilities, processes, and process owners has been developed and identified by the top management of the company. Information is in the document called the Map of the processes. Plant Manager: responsibility is on the basis of fulfilled support for the customers in the whole organisation. It can be delegation of the responsibility for customer's Scorecards, service of the customer's portal, and for the communication with the customer. Process Owner: responsibility for updating the documentation for related processes and for the QMS. Quality manager and quality director: ensuring the fulfillment of the QMS requirements ISO 9001:2005 and IATF 16949:2016. Ensuring the fulfillment of the customers' requirements.

Organizational Context

It is necessary to identify internal and external topics and issues which are relevant to strategic direction (see figure . Senior management is continuously monitoring and providing revisions of existing changes at least once per year. It is input to Business Continuity Plan (BCP).

Figure 2: Organizational context (internal, external issues)

Internal Issues	External Issues
Organizational knowledge	Customer's Complaints
Turnover	Legal constraints
Safety Accidents	Market challenges
Downtime [equipment]	Social, economic challenges
Serious Illness	Competitors
Lack of standardization	Logistic challenges

Source: Local Quality Manual Addendum Hodkovice plant

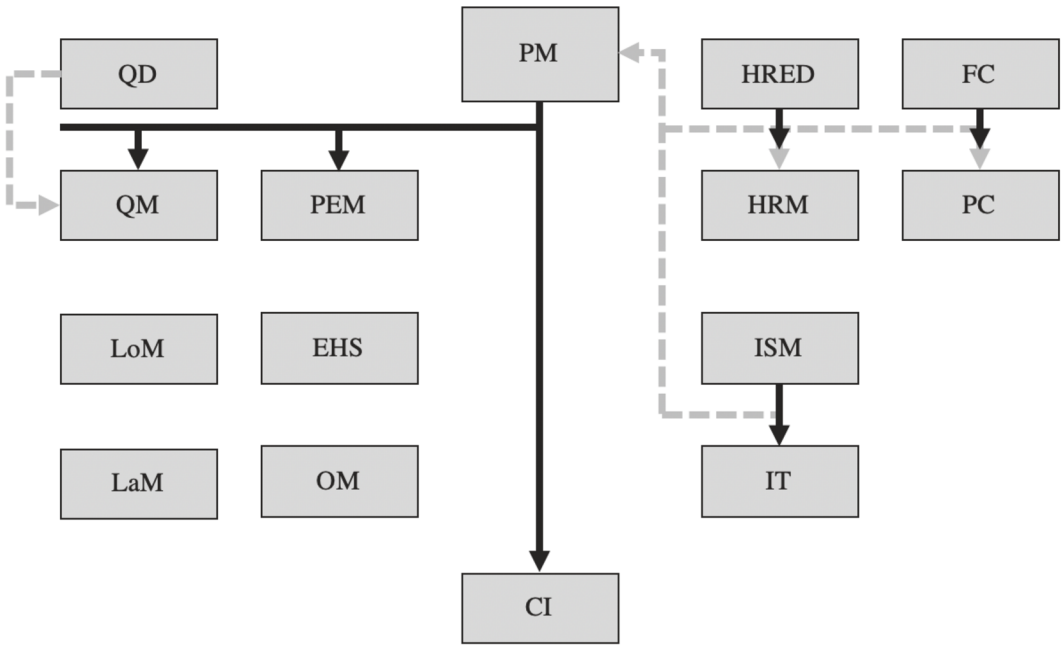
Interested Parties

An organizational ability is affected by the interested parties relevant to the QMS. The ability of the products offered and services, which are fulfilling the customer's requirements with statutory and regulatory requirements. Interested parties are:

- Customers;
- suppliers;
- employees;
- stakeholders;
- unions;
- governments;
- competitors;
- bankers;
- management board. (Local Quality manual addendum Hodkovice plant, 2021)

Requirements of involved parties are identified once per year and there are inputs to set up targets, control of management and processes, Business Continuity process.

2.3 Organizational structure



Picture 12: Organizational structure
Source: Monroe Czechia s.r.o.

PM – Plant manager, QD – Quality director, QM – Quality manager, PEM – Process Engineering Manager, LoM – Logistic Manager, EHS – Environmental, Health and Safety manager, LaM – Launch manager, OM – Operation manager, CI – CI manager, HRED – Human resources executive director, FC – Financial director, HRM – Human resources manager, PC – Plant controller, IS – IS manager, IT – IT specialist

2.4 SHOCK ABSORBER MEV1T1801

The MEV1T1801 is the internal identification number of the shock absorber used in the Monroe Czechia s.r.o. This number has been generated on the basis of customer requirements on the change of the setting on the existing product with the internal original number ME31F3401. Shock absorber MEV1T1801 has been choose as object for the diploma thesis.

The Monroe Czechia s.r.o. is supplying the researched shock absorber for the original equipment manufacturer (OEM) OPEL AG from Peugeot Société Anonyme group (PSA). It is necessary to fulfill all requirements which has been described in the supplier quality manual created by PSA group and which corresponds with specification IATF 16949 and ISO 9001. Shock absorbers are rear, and they are assembled into vehicle OPEL Grandland.

Picture 13: Opel Grandland

Source: www.opel.cz

2.5 PSA group Supplier Quality Manual

This document, which has been supplied to Monroe Czechia s.r.o., sets requirements important for the fulfillment of all necessary steps for the successful project and satisfaction for all sides involved. Source of this chapter is PSA Supplier Quality Manual. 01276_15_00082 v5, 2019.

It has been created on the basis of standard IATF 16949 with detailed information and extended requirements, especially for the management tools and communication between customer and supplier. There is a very important requirement before the project will start. PSA strictly requires the certification according to required standards IATF 16949 by accredited organization International automotive task force. Supplier quality manual has been created on the basis of the following fundamentals:

- Customer satisfaction and safety;

- planning and meeting objectives;
- conformity of all delivered supplies;
- transparency.

The next duties, which are also strictly required for the supplier, and on the basis of which all steps during the project are under specified instruments to fulfill suitable legislations to meet quality targets, is to notify any time of the resale or retransfer of supplies restricted by law, then inform PSA.

Requirements for the Product Process development phase

Monroe Czechia s.r.o. as the supplier can justify choices and technical solutions with clear arguments, through measurements and provide tests results of the shock absorber during the development phase. The company is also responsible for the manufacturing process, serial production and try outs. This responsibility includes the conformity of all supplied and delivered products.

2.6 Advanced Product Quality Planning

The PSA applied APQP process set out by the Automotive industry 5, which laid down in the document Advanced product quality planning and control plan. Monroe Czechia s.r.o. has to use the process and required management tools.

2.6.1 Activities and milestones

Development of the project shock absorber MEV1T1801 is split into five phases, each phase has milestone at the end.

Phase 1: Plan and define program. Definition of what customer needs, what is the target. In this case it is the rear shock absorber for the vehicle Opel Grandland. During this phase it is finalising the selection of the supplier, where Monroe Czechia s.r.o. has been selected as the supplier.

Phase 2: Product development. During phase two is the finalisation of the product's definition and design. Quality department and individual departments, which are cooperating on the release of the shock absorber can specify specific equipment if it is necessary for the project. It can be measurement equipment or tools for the production lines.

Phase 3: Creation of specific tools and production of the first off-tool parts. Involving the creation of specific tools and the production of the first off-tool parts. Customer provides the agreement of the first off tool parts. During this date, the customer provides the date prior to the launching of the first pre-production runs.

Phase 4: Product try out. It means the mass production try-out. It is finalised with the approved PPAP. Customer gives approval to Monroe Czechia s.r.o. for the delivery of products manufactured with the final process.

Phase 5: Ramp-up. The product and the process has been qualified. The Monroe Czechia s.r.o. shows and declares that the production process of the shock absorber is capable. During phase five final tasks such as capacity assessments, the finalisation of residual action plans and lessons learned, also long-term process capabilities are done. (PSA Supplier Quality Manual. 01276_15_00082 v5, 2019)

2.6.2 Management modes

PSA company has two development management modes, which are the Customer monitored (CM) and the Supplier monitored (SM). However, regardless of the management modes, there are the same requirements applied:

- Responsibility for the development and for the duty to alert and notify of any issues to PSA by the Monroe Czechia s.r.o..
- Approval of parts for assembly is necessary by the PSA.

Management in Customer Monitored mode

All of the milestones and these developments are monitored via progress reports and reviews. There is necessary to provide regular management reviews and APQP milestones. PSA determines whether or not the milestones are achieved.

Management in Supplier Monitored mode

The PSA is less involved in the management system. Individual controls are under Monroe Czechia s.r.o. responsibility. Activities like management reviews and decisions about APQP milestones are organised and prepared by this supplier. The decision making about the achievement of milestones is notified to PSA. However, the PSA reserves the possibility to revoke the supplier's decision.

Technical progress reviews

Both sides, the PSA as a customer and the Monroe Czechia s.r.o. as supplier are continuously cooperating and they are discussing the progress together. The purpose of this is to examine an individual development targets and concrete open points. For example, design supply and validation, design and set-up of the production and supply procurement system. In the case of nonconformity, or if it is necessary for the solving of problems, all steps are documented in the risk management plan.

Management reviews

The main point of management reviews is to analyse the progress of the project in connection with the planned development schedule and expected targets. In case that some deviation occurs against expected results, then these management reviews can set up a shorter time of review meetings together with the appropriate measures. It is also possible to provide audits by PSA. Both sides have to agree on the place of the meeting and on the time interval. It is also clearly specified the list of participants. There are usually representatives of the various areas according to if nonconformity occurred, usually there are managers from departments such as quality, design, production and also responsible project manager.

2.6.2.1 APQP milestones

A concrete milestone could be crossed just in case, that all agreed requirements was fulfilled. Especially the milestone for the end of phase four, approved PPAP. This procedure is in responsibility of the quality engineer and in case of the nonconformity is the current status discussed with the project manager. In case that nonconformity occurs it is necessary to set up an action plan for the expected targets as soon as possible with the management mode and the time interval of meetings between PSA and Monroe Czechia s.r.o..

2.7 Production Part Approval Process

The Monroe Czechia s.r.o. had to ensure that the PPAP (Production Part Approval Process) files comply with the Automotive Industry Action Group. Quality engineer received the formal approval from the PSA prior to the shipment of the shock absorber intended for use a saleable vehicle. It does not mean that approval by PSA transfers supplier's responsibility to PSA.

2.7.1 General PPAP approval process

All suppliers, supplying their products to PSA, are responsible for preparing and submitting the PPAP file for each supply. Quality department from Monroe Czechia s.r.o. had to deliver the required file. After the PSA received the sample of the shock absorber, the quality management on their side provided necessary tests. Test could be done also according previous experience to avoid potential nonconformity according to an experience with a similar product, however it is also included in FMEA. Routine tests, which can be standardly provided are damping forces, test on the level of the noise, individual measurements according to drawings and specifications, or material tests. Internal quality controls on PPAP samples, which must be sent by supplier in an agreed time period, are standard procedures in the automotive industry.

The PSA quality department is checking if points are in compliance of parts, capability of the assembly, absence of the packing degradation, absence of supply-related defects. In general, it is the completeness and the quality of the shock absorber manufactured by the Monroe Czechia s.r.o.. According results, the quality engineer received full approval from the PSA quality department. It means unreserved delivery of the shock absorber manufactured. However, it can be happening that suppliers receive an interim approval verdict. As a rule, it is expected on

correction of individual shock absorber parts, but the whole product can be used for a restricted period or a quantity. Corrective actions have to be implemented as soon as possible to resubmit the PPAP file with the request for the full approval.

Third situation, the verdict, which can be provide by PSA is to reject the product. The supplier is not authorised to deliver products. Corrected samples have to be sent as soon as possible and resubmit for the full approval. This kind of the situation is very complicated for all sides involved in the project.

2.7.2 PPAP file

Prior delivery of the shock absorber by Monroe Czechia s.r.o. to the PSA manufacturing plant, and before the shock absorber will be assemble to the saleable vehicle, the responsible quality engineer, has to submit PPAP file in the connection with requirements. (Figure 3)

Figure 3: PSA's requirement.

Point	Generic requirement	PSA's Requirement	Level				
			1	2	3	4	5
1	Design record	3 Types of design documents PPAP 1: officialised SPL plan PPAP 1 Bis: officialised TS PPAP 1 Ter: the approved Part Inspection Standard	R	S	S	*	R
2	Engineering change documents	All documents, which describe changes approved by PSA	R	S	S	*	R
3	PSA eng. approval	Homologation report For parts under regulations	R	S	S	*	R
4	Design FMEA	Monroe Czechia s.r.o. responsibility	R	S	S	*	R
5	**Process flow diagram**	Production flow chart after which the parts are produced	R	S	S	*	R
6	**Process FMEA**	Process FMEA report	R	S	S	*	R
7	**Control Plan**	Operational in production	R	S	S	*	R
8	**Measurement system analysis studies**	Measured by Repeatability and Reproducibility. Measurement system capability	R	S	S	*	R
9	**Dimensional results**	Measurement reports of sample parts included in PAPP file	R	S	S	*	R
10	Material and performance test results	Results of Monroe's validation plan included IMDS material data sheet.	R	S	S	*	R
11	**Initial process studies**	Process capability results. Short term capability on limited production levels, at least 30 parts	R	S	S	*	R
12	**Qualified laboratory documentation**	Certified documents of laboratory competency.	R	R1	R1	*	R
13	**Appearance approval report**	Approval of the appearance of manufactured parts	S	S	S	*	R
14	Sample production parts	Sample parts within PPAP file. Delivered in the mass production. From a representative production run	R	S	S	*	R

15	Master Sample	Physical master sample	R	R	R	*	R
16	Checking aid	Documents including photos, or defects manual, which helps to assess whether or not a part conforms	S1	S1	S1	*	R
17	Specific requirements	PPAP 17: The potential specific deliverables required by PSAPPAP 17 Bis: PPAP approval status report for all tier 2 partsPPAP 17 Ter: For parts, which need specific packaging.	R	R	S	*	R
17	Part Submission Warrant	Monroe Czechia s.r.o. authorised representative has to sign the PSW	S	S	S	S	R

Notes:	**1: m**easure adapted by PSA in line with the PPAP standard.
	S: Submit: deliverable submitted to PSA for approval.
	R: Retain: deliverable stored by the supplier, produced at PSA's request
	***: R or S:** To be determined on a case by case basis

Source: Supplier Quality Manual: PSA GROUPE, 2019.

The quality engineer responsible for the PSA project, has to supplied requirement documents and he is also responsible for all processes, which are the base for the preparation of the documentation. PSA required documentation from quality department are: 1) Process flow diagram. 2) Process FMEA. 3) Control plan. 4) Measurement system analysis studies. 5) Initial process studies. 7) Qualified laboratory documentation. 8) Appearance approval report

2.7.3 Process flow diagram (Process and control plan)

It is one of the key documents, which is a part of the PPAP file. The Process and control plan have been created in the cooperation between head of the process technologies, the project manager and the quality manager, all of them have to approve the document at the end. Generally, it is documented description of the production process of the shock absorber. Individual processes have been described in the flow chart. Thanks to this schema are individual steps organized. Between individual production steps has been defined concrete quality controls. Each control has defined operation description, specified production machine or equipment, also specification of the product, or process and individual tolerances, types of

the inspection, measurement tools, frequency and what has to do the responsible operator for the process control in case of the nonconformity will be occur. The concrete process and the control plan have been created for the researched shock absorber, the part of the control plan see (figure 4). Process and control plan are very helpful instrument to avoid protentional nonconformities and over costs of the manufacturing.

Figure 4: Process and control plan.

PSA GROUPE	**Process and control plan**							
	MONROE shock absorber number: MEV1T1801							
		Date:	28.1.2022					
		Version:	7					
Production Line H							TENNECO	
Mach	**Process name, operation description**	**Production machine, equipment, fixture, tool**	**Charact.**	**Methods**				**Response plan**
			Product	**Specification of product, process, tolerance**	**Type of inspection, measurement**	**Range**	**Frequency**	
MTPA (piston rods)								
422	Grinding before hardening	BBE1	External diameter	TD, BOM	Micrometre	1 pc	500	Changeover
Mach	**Process name, operation description**	**Production machine, equipment, fixture, tool**		**Methods**				**Response plan**
			Product	**Specification of product, process, tolerance**	**Type of inspection, measurement**	**Range**	**Frequency**	

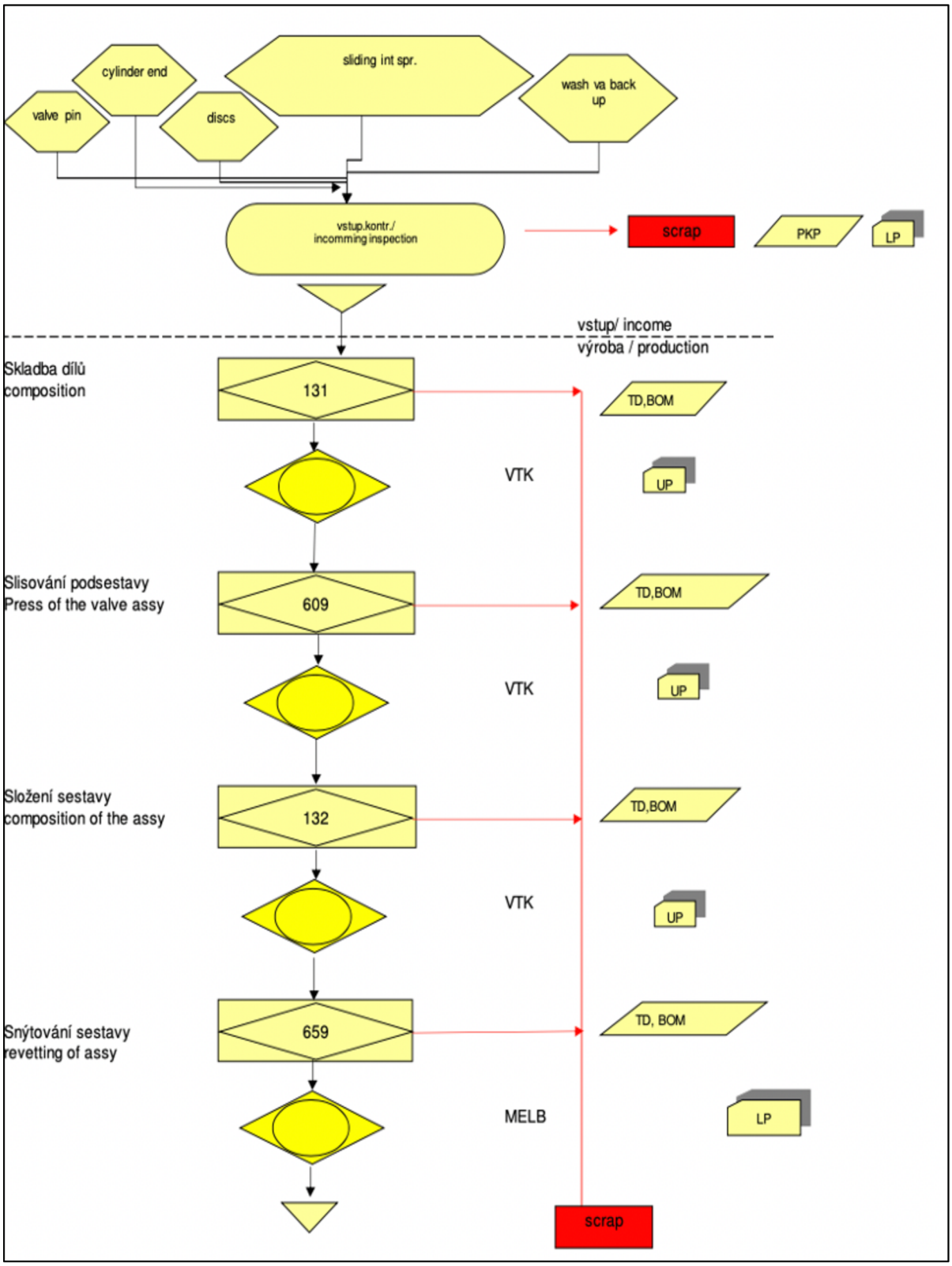
Source: Monroe Czehia s.r.o.

MTPA (piston rods)								
782	Surface hardening	Induction hardening machine EFD	Hardness - HRC	18.07.00.02, TD	Roughness meter	1 pc	1000	Notify setter
			Transition of hardened layer	B.O.M	Steel gauge	1 pc	1000	Changeover
			Annealing parameters			1 pc	Start, set-up	Changeover
			Peripheral run-out		Msp 0552	1 pc	1000	Notify setter
	Inspection of hardening depth	MELB	Depth of hardening	18.07.00.02 (point 3), TG 1	Hardness meter	1 pc from Ø rod 11 mm from MT line	1x/shift	VTK notice
320	Chrome plating	Dynachrome	Dia of rod	18.07.00.11	micrometre	3 pcs	1 hour	Changeover
			Mask of rods	Drawing	Comparison	3 pcs	1 hour	Changeover
			Thickness of chrome layer	TD	Thickness gauge	3 pcs	1 hour	Changeover
724	Eddy Current	N-Dect	Separation of defects	TD, BOM	Sample	1 x	Shift/dia. Change	VTK
			Separated parts check		Visual	100%		Changeover
			Position of probe from surface of rod		Distance elements	1 x	Shift/dia. Change	Changeover
324	Control of all dimension	MS	Dimension control - rod OD, dimensions related to groove	Drawings	Profile projector	3 pcs from line MT A from any project	Yearly	VTK notice
					Calliper			
	Roughness of surface	MS	Roughness of Cr	TM 1_4; 18072001 -	Roughness meter	3 pcs from line MT A from any project	Yearly	VTK notice

Source: Monroe Czehia s.r.o.

Mach	Process name, operation description	Production machine, equipment, fixture, tool	Charact.	Methods				Response plan
			Product	Specification of product, process, tolerance	Type of inspection, measurement	Range	Frequency	
MTPA (piston rods)								
324	Flexural test	MELB		18.07.20.07	Pull test machine	2 pcs from Ø of piston rod 11 mm from line MT A from any project	3 months	VTK notice
	Amount of microcracks in the chrome layer	MELB	Amount of microcracks in the chrome layer	18.07.00.50,	Optical microscope	2 pcs from Ø of piston rod 11 mm from line MT A from any project	Yearly	VTK notice
	Thickness of Cr layer	MELB	Thickness of Cr layer	18.07.20.07	Optical microscope	2 pcs from Ø of piston rod 11 mm from line MT A from any project	Yearly	VTK notice
	Piston rod corrosion test	Testing laboratory	Piston rod corrosion test	18.07.00.08		6 pcs	Yearly	Notify quality eng.
	chrome layer micro-hardness test)	MELB	chrome layer micro-hardness)	18.07.20.07) (point 3), TG 1_29	hardness meter)	1 pc from Ø of piston rod 11 mm from line MT A from any project)	3 months	VTK notice

Source: Monroe Czehia s.r.o.

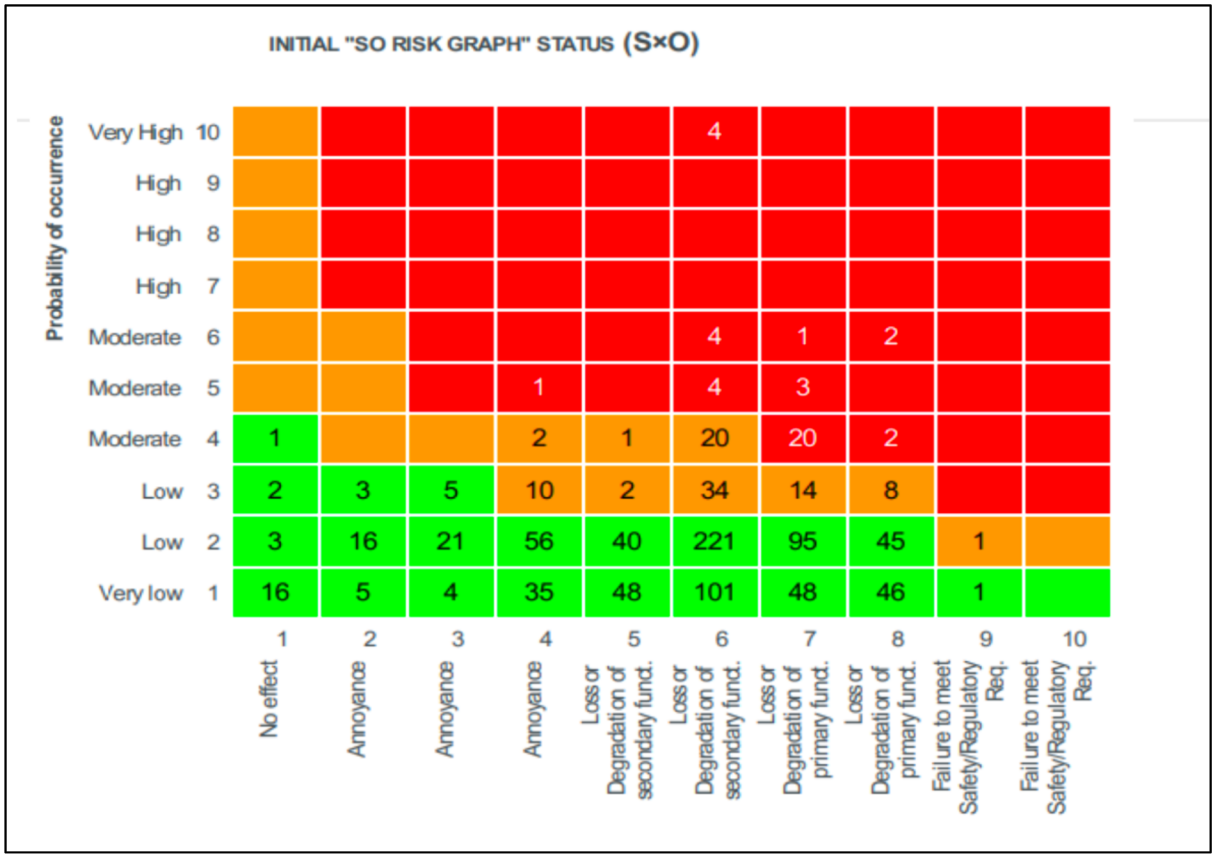


Picture 14: Flow Chart
Source: Monroe Czechia s.r.o.

2.7.4 Process FMEA

The FMEA means a failure mode and an effects analysis. Target of the FMEA analysis is to prevent and to avoid protentional failures during design and process phases. The responsible quality engineer supplied to PSA the process FMEA during the project in time of agreed time schedule.

Risk matrix: Current risk



Picture 15: FMEA Risk matrix: Current risk.
Source: Monroe Czechia s.r.o.

The company Monroe Czechia s.r.o. had to fulfil all requirements for all supplies before the manufacturing launch than the first vehicle has been produced. Latest date for the submitting of the PPAP file was three calendar weeks before shock absorbers has been sent to the PSA and assembled into first saleable vehicles. The PPAP file included all the information like are validation tests on dumping forces, lifetime cycles, IMDS report, master samples, and others necessary materials, which has been described in the figure 3.

2.7.5 Measurement system analysis studies

The most important dimensions of components entering into shock absorbers are defined as special characteristics. Usually there are dimensions, which are essential for the process and for the quality. One of the most important requirements is to have the official calibration of the measurement tools and in some intervals to measure special characteristics and noticed the results. Also, the same measurement procedures in laboratories on PSA and Monroe Czechia sides, especially in case of measurements during the PAPP phase. All required special characteristics has been measured, checked and validated. There is also necessary to record all the measurements (see Figure 5). There was not notice any nonconformity and all results was described in the report and share with the PSA.

Figure 5: PPAP measurement system analysis studies.

ID	Tool	Required criteria specification				Measurement readings on parts issued from the reference process (at a given stage of development)					
		Nominal	TI -	TI +	Units	S1	S2	S3	S4	S5	R
Strapping length	Height meter	365	5	5	mm	366,2	367,1	366,3	366,8	366,5	OK
Rod dia.	Caliper	12,4	0,1	0,1	mm	12,4	12,4	12,4	12,4	12,4	OK
Tube outer diameter	Caliper	45,4		max	mm	45,34	45,34	45,34	45,32	45,3	OK
Rod Thread	Gauge	M12 x 1,25 -6g				OK	OK	OK	OK	OK	OK
Rod length (UAE-rod end)	Caliper	40		0,3	mm	40,12	40,2	40,28	40,26	40,2	OK

Source: Monroe Czehia s.r.o.

ID	Tool	Required criteria specification				Measurement readings on parts issued from the reference process (at a given stage of development)					
		Nominal	TI -	TI +	Units	S1	S2	S3	S4	S5	R
Rod support diameter		20		max	mm	19,75	19,74	19,74	19,73	19,74	OK
Stem end Hexagon distance between 2 faces	Caliper	6	0,03	0,15	mm	6,09	6,12	6,11	6,11	6,1	OK
Hexagon hole depth	Caliper	9,5		min	mm	9,9	9,87	9,69	9,93	9,84	OK
Loop length		27,2	0,3	0,3	mm	27,1	27,17	27,17	27,11	27,14	OK
Lower bushing external diameter	Caliper	39,9	0,5	0,5	mm	40,08	40	39,98	40	39,98	OK
Lower bushing internal diameter	Caliper	12,1		0,2	mm	12,16	12,17	12,17	12,18	12,17	OK
Max. Length lower fixation	Caliper	62	0,3		mm	61,92	61,93	61,94	61,90	61,96	OK
Loop symetry / base assembly	Height meter	2			mm	1,99	1,93	1,91	1,06	1,86	OK
Rod reaction force	Tensile axis machine	6	2	2	daN	5,4	5,5	5,6	5,4	5,2	OK

Source: Monroe Czechia s.r.o

2.7.6 PPAP – overview of approved components

The responsible person for the control of supplier's entering components into shock absorbers is supplier quality engineer. There is the close cooperation between the project manager and the customer quality engineer. The work on the PPAP of individual components starts with delivery of first samples for each component. All samples have been checked if they have been produced on the base of the specification and the drawing. The supplier has to confirm the capability of the process. Samples for the PPAP have to be manufactured under satisfactory conditions of a serial production, which will not be change during the production of shock absorbers, where the supplied part enters.

In the case of any changes of the manufactured supplied components, or in case of the manufacturing location change, the supplier has to inform the Monroe Czechia s.r.o. and in the cooperation with the supplier quality engineer it is necessary to repeat the PPAP on the specific component. The supplier will provide the new PPAP samples and the component will be checked against the drawing and specification.

Figure 6: PPAP overview of approved components.

Component Name Désignation du composant	**Supplier Name Nom du fournisseur du composant**	**Supplier Manufacturing Plant**		**Status**
		Town / Ville	**Country / Pays**	
ROD STEEL	Ziehwerk Plettenberg	Plettenberg	Germany	Green
CHROME	Atotech CZ	Jablonec n/ N	Czechia	Green
Dynachrome A	Atotech CZ	Jablonec n/ N	Czechia	Green
CHROMIC ACID	Atotech CZ	Jablonec n/ N	Czechia	Green
COLLAR BUM STOP	Star Technik s.r.o	Zdanice	Czechia	Green
CIRCLIP	RPK Sociedad Cooperativa	VITORIA	Spain	Green
OIL SEAL	Freudenberg Sealing	North Shields	GB	Green
GLEITMO 577 601061615GLM1/60106 1608GLM2	Fuchs Lubritech	Plettenberg	Germany	Green

Source: Monroe Czechia s.r.o.

Component Name Désignation du composant	**Supplier Name** Nom du fournisseur du composant	**Supplier Manufacturing Plant**		**Status**
		Town / Ville	Country / Pays	
SUPPORT WASHER	Ningbo Jinheng Automobile	Ningbo	China	Green
Thread lock liquid-2701	Henkel ČR	Praha	Czechia	Green
NUT MRA2 CONV	Combori NV	Tilburg	NL	Green
VALVE PIN	Thomson Fasterners	Gananoque	Canada	Green
ldInt-X52/ MCA MEQ5V5302-502, HJD,LJC	RPK Sociedad Cooperativa	VITORIA	Spain	Green
CYLINDER END (5800-6H)	MFS Trapaga Sintering S.L.	Valle de Trapaga	Spain	Green
ORIFICE DISC	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
DISC	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
DISC	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
DISC	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
VALVE DISC AM	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
Valve disc	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
VALVE DISC	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
Valve disc	Tenneco Automotive Europe	Sint Truiden	Belgium	Green
PRESSURE TUBE	FMM	Tanvald	Czechia	Green
ID30.19/30.15xOD 32.27/32.19 STEEL TUBE	Kalibre Boru as	Izmit	Turkey	Green
Oil Titan 5045	Fuchs Lubritech	Plettenberg	Germany	Green
RESERVE TUBE	Kalibre Boru as	Izmit	Turkey	Green
BASE CUP	Cottinet SA	AILLY SUR NOYE	France	Green

Source: Monroe Czechia s.r.o.

Figure 7: PPAP overview

NAME	DESCRIPTION
PPAP01	References and index of the officialised supplier drawing related to the delivered PPAP parts. These references and index are registered in APQP grid.
PPAP01 bis	References and versions of the officialised Technical Specifications related to the delivered PPAP parts. Theses references and versions are registered in APQP grid.
PPAP01 ter	The PCP is validated. The validated PCP is registered in the PLM.
PPAP02	Additional engineering changes: all authorized engineering changes (FETE or amendment FIPA) not yet incorporated in the drawing but applied in the delivered PPAP parts. These documents or their references are registered in APQP grid.
PPAP03	For parts under government regulations: documents or evidence showing the parts are meeting these regulations have to be registered in APQP grid.
PPAP04	The Justification File is updated according to product design changes. The action plans are finalized, and risks are under control. The updated and validated Design FMEA can be consulted. The Design FMEA synthesis is registered in APQP grid. If necessary, the RAMS Customer Requirements are respected, in particular: 1/ The finalized and validated Safety Case is consultable and includes the required work products Confirmation Review reports of required work products are registered in APQP grid. 2/ The safety requirements for logistics, production, use, maintenance and decommissioning are available in APQP grid. 3/ The Safety Assessment report is registered in APQP grid. 4/ The release for road usage (or release for production) is registered in APQP grid. 5/ The Part Safety Report is available in the APQP grid and approved by PSA.
PPAP05	The PPAP parts are made by the final mass production process, including subcontracted, inspections and rework operations. The process flow diagram is registered in APQP grid.
PPAP06	The Process FMEA is updated according to process changes. Risks are under control. If not, they are monitored in the Control Plan. The process FMEA can be consulted. The process FMEA synthesis is registered in APQP grid.
PPAP07	The mass production control plan is in place. It is registered in APQP grid or at minima could be consulted.

PPAP08	The final measurement processes are in place. The capability is proved if required in PCP. The capability reports (R&R or equivalent) are available in the grid.
PPAP09	RCM are available in APQP grid. // For electronic parts, the following information must be dispatched for each part in addition to the RCM: Requirement compliance for functional and mechanical aspects, HW, SW, networks, diagnosis, etc.. Unit and integration test coverage and list of detected failure The differences compared to previous version and Meca, HW, SW, CAL compatibilities Memories and CPU load A pedigree chart (BOM differences between 2 successive deliveries)Failure detection method Limits and advice of use of the part (handling, setting up, operational use)."
PPAP10	The results of Supplier Design Validation Plan (included IMDS Material data sheet available with « accepted ») and of PSA Integration & Validation Plan are complying. There is no risk on still running verifications. The progress and results of Supplier Design Validation Plan are registered in APQP grid.

Source: Monroe Czechia s.r.o.

2.7.7 Process capability of the shock absorber

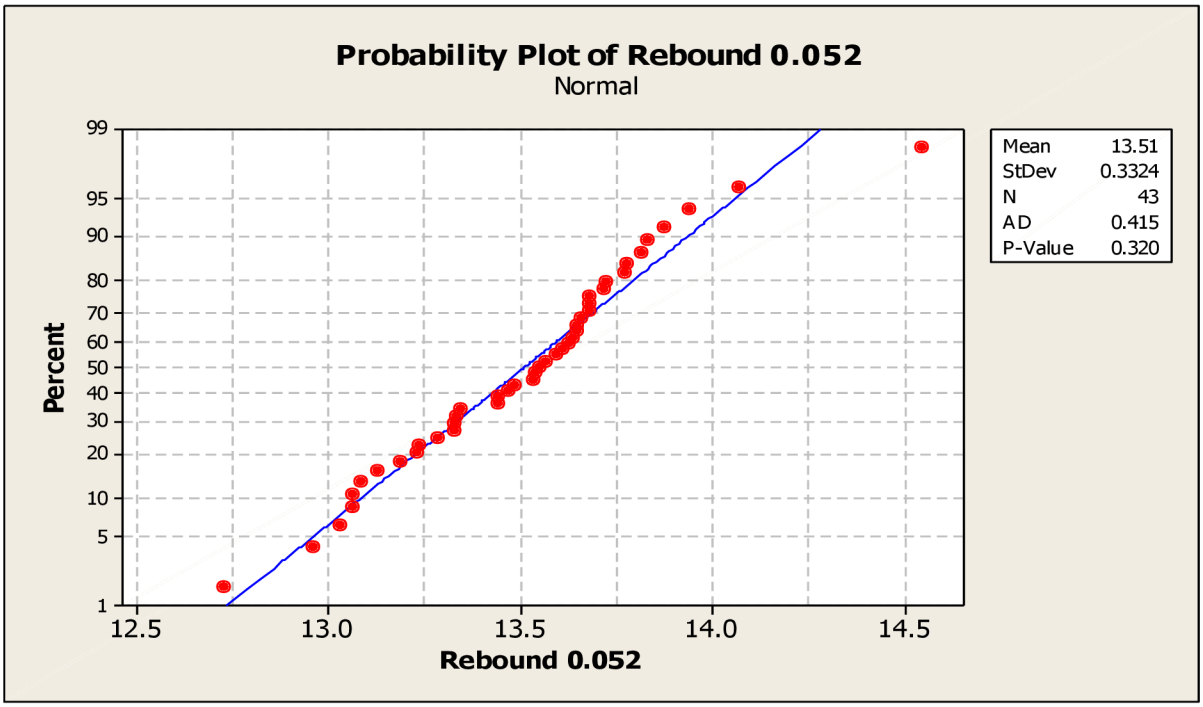
One of the most important PSA requirements regarding PPAP is the result of the process capability, where the damping forces has been measured. Software through which has been data evaluated is Minitab. (see pictures 16, 17). Limits are done by the specification. The information is possible to find in the drawing. Thanks to results of the process capability, the Monroe Czechia s.r.o. proofed that process is capable. PPM = 0. Cpk is bigger than 1,33.

Figure 8: Process capability data

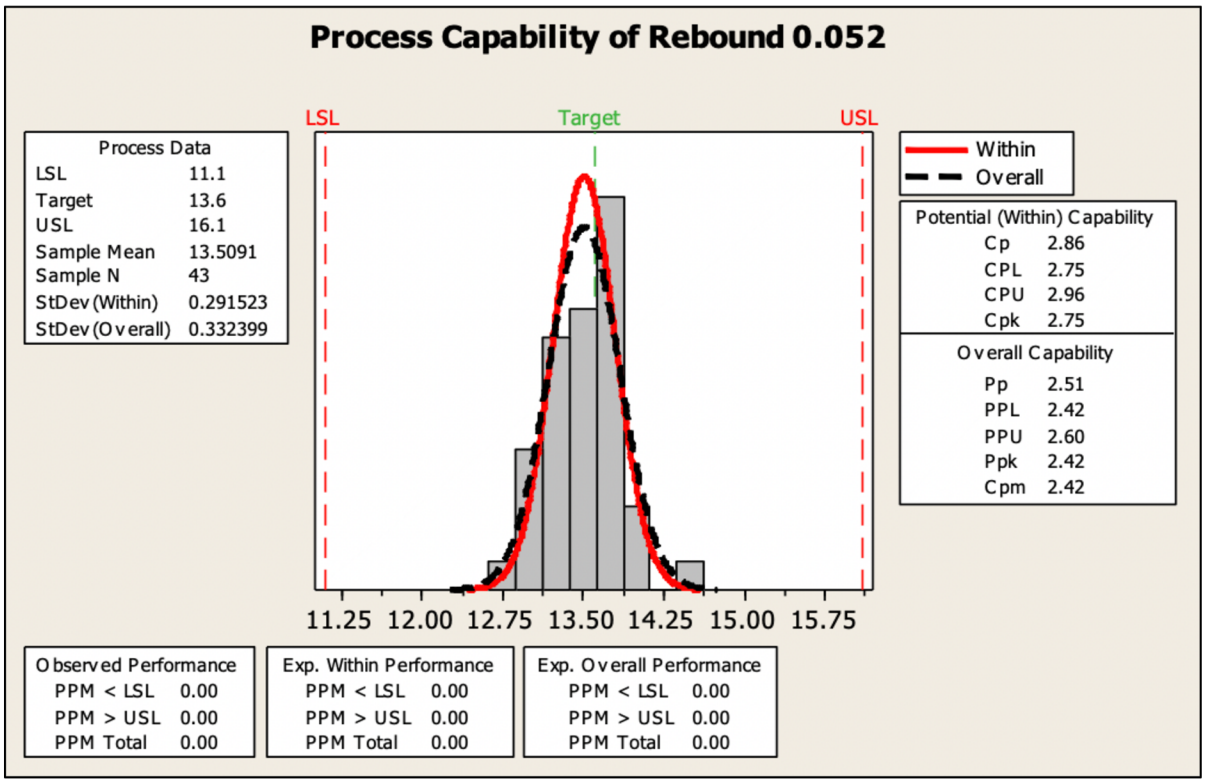
	Rebound								
vel [m/s]	**0,05**	**0,13**	**0,26**	**0,39**	**0,52**	**1,05**	**1,57**	**Friction:**	**Gas Force:**
High limit [daN]	16,10	44,20	97,20	120,50	141,70	217,70	278,30		
Mean [daN]	13,60	38,40	86,00	109,50	128,80	197,90	258,90		
Low limit [daN]	11,10	32,60	74,80	98,60	115,90	178,10	239,50		
Max[daN]	**14,54**	**41,40**	**85,39**	**108,77**	**128,27**	**193,46**	**254,32**		
Average [daN]	**13,51**	**39,69**	**82,21**	**104,47**	**122,74**	**187,13**	**248,55**		
Min [daN]	**12,73**	**37,00**	**78,75**	**100,75**	**118,36**	**181,82**	**244,74**		
1	13,4	40,0	82,2	103,5	120,9	186,7	246,7	1,8	3,8
2	13,6	40,1	84,4	106,9	125,4	189,9	247,9	1,8	3,6
3	14,5	40,3	82,0	103,9	123,3	185,4	252,6	2,3	3,9
4	14,1	40,5	84,0	106,9	125,8	190,7	249,5	1,9	4,0

5	13,4	40,1	84,2	107,8	128,3	193,0	254,3	2,2	3,3
6	13,8	40,2	83,1	105,6	124,0	189,5	250,6	1,8	4,0
7	13,6	40,0	83,2	107,1	125,0	189,4	246,0	2,2	3,7
8	13,7	39,3	79,6	101,2	119,2	182,8	251,8	2,5	3,9
9	13,6	39,4	81,2	103,4	121,1	184,7	248,7	2,1	4,3
10	12,7	37,0	81,0	103,8	121,8	186,5	245,5	1,7	3,6
11	13,3	39,2	80,1	102,0	118,6	182,6	248,6	2,3	3,5
12	13,5	39,1	81,5	103,9	122,8	186,5	246,2	2,7	3,8
13	13,6	41,4	82,8	104,4	122,8	186,0	245,0	2,0	4,4
14	13,8	40,2	81,3	103,7	123,1	185,2	248,9	2,2	4,0
15	13,1	38,3	81,7	104,7	124,6	189,5	248,1	1,9	4,3
16	13,7	40,2	82,2	104,7	122,2	186,0	249,3	1,7	4,4
17	13,7	40,2	82,7	104,3	121,0	184,6	248,4	2,4	4,8
18	13,7	40,4	83,3	106,3	124,8	188,9	248,9	1,9	4,9
19	13,0	39,2	78,9	100,7	118,4	181,8	249,3	2,1	3,8
20	13,7	40,1	81,6	103,4	121,6	186,3	245,6	1,9	4,2
21	13,9	40,1	83,0	105,2	123,3	188,3	246,5	2,3	4,8
22	13,6	40,8	82,2	104,2	122,2	185,5	245,1	2,1	4,4
23	13,7	39,3	84,0	107,1	125,8	192,2	250,1	2,5	3,6
24	13,3	38,7	80,4	105,3	122,9	187,0	246,4	1,9	5,0
25	13,5	39,2	81,2	104,3	122,1	187,3	248,1	2,7	4,0
26	13,5	39,7	85,4	108,8	128,1	193,5	254,0	2,4	4,0
27	13,5	41,0	83,6	104,7	122,5	187,5	246,1	2,6	4,2
28	13,8	39,9	83,8	105,4	123,3	187,0	245,8	3,1	4,2
29	13,6	40,1	83,5	105,0	123,4	188,6	248,0	2,7	3,8
30	13,9	40,4	82,0	102,5	121,2	183,8	247,3	2,1	4,1
31	13,2	39,2	82,0	103,7	122,2	187,4	248,2	1,8	4,6
32	13,6	39,5	82,5	106,5	126,4	193,4	250,5	2,3	4,9
33	13,3	39,5	81,5	103,9	120,2	183,9	252,0	1,8	4,4
34	13,1	38,6	80,8	101,7	119,4	183,6	248,6	2,0	4,4
35	13,1	38,8	84,5	107,2	125,2	191,0	251,5	2,1	4,5
36	13,3	40,6	82,9	104,7	123,3	187,4	247,3	2,1	4,2
37	13,0	38,6	82,9	104,2	121,8	184,4	250,7	2,2	3,9
38	13,2	39,5	84,1	106,2	124,6	191,3	250,1	2,0	4,9
39	13,8	39,1	80,2	101,8	120,7	183,7	249,6	2,2	4,4
40	13,3	39,9	79,7	101,4	119,3	184,4	244,7	2,4	3,9
41	13,6	39,5	83,0	105,4	123,9	189,1	248,3	2,3	5,3
42	13,2	41,1	82,2	102,8	121,9	184,7	246,0	1,9	4,0
43	13,1	38,2	78,8	101,8	119,8	185,6	250,9	2,1	4,5

Source: Monroe Czechia s.r.o.



Picture 16: Propability plot of the shock abosrber
Source: Monroe Czechia s.r.o. (software: Minitab)



Picture 17: Process capability of the shock absorber
Source: Monroe Czechia s.r.o. (software: Minitab)

Figure 9: PPAP-dimensional test results

	Monroe Czechia s.r.o.											
	Part Name: Shock absorber	**Production Part Approval**										
	Dimension / Specification											
	DIMENSIONS	**Dimensional Test Results**										
	Dimensions	1	2	3	4	5	6	7	8	9	10	OK
1.	**Machining of piston post 454**											
2.	Middle diameter of thread 5/16" (7,180-7,249)	7,19	7,19	7,18	7,19	7,20	7,19	7,21	7,20	7,20	7,21	**x**
3.	Big diameter of thread 5/16" (7,670-7,850)	7,73	7,72	7,71	7,77	7,77	7,76	7,78	7,77	7,76	7,78	**x**
4.	Concentricity 0,1 mm MAX	0,06	0,02	0,04	0,05	0,02	0,03	0,07	0,03	0,05	0,04	**x**
5.	**Machining of stem post 427**											
6.	Middle diameter of thread M8 x 1, 25 - 6g (7,042-7,160)	7,09	7,08	7,08	7,09	7,08	7,09	7,09	7,10	7,10	7,08	**x**
7.	Big diameter of thread M8 x 1, 25 - 6g (7,760-7,972)	7,84	7,85	7,86	7,87	7,88	7,88	7,87	7,88	7,86	7,88	**x**
8.	Concentricity 0,2 mm MAX	0,12	0,10	0,14	0,11	0,13	0,12	0,12	0,10	0,11	0,14	**x**
9.	Length of body rod (319 +/- 0,4)	320	319	320	319	319	319	320	320	320	320	**x**

	Dimensions	11	12	13	14	15	16	17	18	19	20	
1.	**Machining of piston post 454**											
2.	Middle diameter of thread 5/16" (7,180-7,249)	7,21	7,20	7,20	7,20	7,19	7,20	7,19	7,20	7,20	7,21	**x**
3.	Big diameter of thread 5/16" (7,670-7,850)	7,77	7,76	7,71	7,72	7,73	7,74	7,75	7,75	7,77	7,78	**x**
4.	Concentricity 0,1 mm MAX	0,03	0,02	0,06	0,05	0,03	0,04	0,07	0,04	0,07	0,04	**x**
5.	**Machining of stem post 427**											
6.	Middle diameter of thread M8 x 1, 25 - 6g (7,042-7,160)	7,09	7,08	7,08	7,09	7,08	7,09	7,09	7,10	7,09	7,09	**x**
7.	Big diameter of thread M8 x 1, 25 - 6g (7,760-7,972)	7,87	7,89	7,85	7,86	7,87	7,86	7,87	7,88	7,85	7,86	**x**
8.	Concentricity 0,2 mm MAX	0,13	0,11	0,14	0,12	0,10	0,11	0,12	0,11	0,13	0,12	**x**
9.	Length of body rod	320	320	320	320	320	320	320	320	320	320	**x**
	Dimensions	21	22	23	24	25	26	27	28	29	30	
1.	**Machining of piston post 454**											
2.	Middle diameter of thread 5/16" (7,180-7,249)	7,20	7,19	7,19	7,20	7,19	7,19	7,20	7,20	7,21	7,20	**x**
3.	Big diameter of thread 5/16" (7,670-7,850)	7,79	7,76	7,75	7,77	7,78	7,77	7,79	7,73	7,72	7,74	**x**
4.	Concentricity 0,1 mm MAX	0,04	0,06	0,05	0,03	0,06	0,02	0,05	0,07	0,03	0,04	**x**

5.	**Machining of stem post 427**											
6.	Middle diameter of thread M8 x 1, 25 - 6g (7,042-7,160)	7,08	7,09	7,08	7,09	7,08	7,07	7,08	7,10	7,10	7,11	**x**
7.	Big diameter of thread M8 x 1, 25 - 6g (7,760-7,972)	7,87	7,85	7,86	7,84	7,86	7,85	7,86	7,89	7,88	7,87	**x**
8.	Concentricity 0,2 mm MAX	0,10	0,11	0,12	0,13	0,12	0,14	0,10	0,11	0,12	0,13	**x**
9.	Length of body rod	320	320	320	320	320	320	320	320	319	319	**x**

Source: Monroe Czechia s.r.o.

All incoming components into shock absorber have to be measured and checked by the responsible supplier quality manager. You can see (figure 9) the measurement of the piston. This kind of the measurement has to be done for each incoming component.

Figure 10 shows how special characteristics handling. It is very important to evaluate all characteristics and measure them. They are involved in the process and control plan, process FMEA. All the special characteristics has been measured and evaluated. The result was shared with customer representative and approved.

Figure 10: Special characteristics

Special Characteristics Communication and Agreement

Special Characteristic T Note 1: Automatic calculation of totals (for guidance only). Note 2: Count of SCs may be less than count of Yss	**Special Characteristics Communication and Agreement for all UN content required to support UN design and development is required by UNV2. The remaining UN content not required to support UN design and development is required by <PA>.** **Special Characteristics Communication and Agreement for all UP content is required by UPV2.**

Stage 1. DFMEA **Stage 1A. PFMEA**

No.	Characteristic Description	Specification & Tolerance	DFMEA Class	PFMEA Class	Process Control Method
1	Closed Gap	0.25 to 0.50 mm	YC	CC	Vernier caliper
2	Axial Width	2.5 +0.01, -0.03 mm	YS	SC	go / no go fixture
3	Brake assembly caliper bolt torque	20 nm +/- 3 nm	YC	CC	DC nut runner
5	Body length	399,5 +/- 3	YS	SC	Measure Tube Length 373,95 +/- 0,1
6	Setting	ES 9CP1-18045-AB	YS	SC	Automatic 100% machine check in the
7	Shock extended length	670,45 +/- 3	YS	SC	Length from the loop axle to the rod shoulder without the load
8	Oil volume	161 +/- 2	YS	SC	Automatic 100% machine check in the production
9	Module Nut Torque	17.5 +/-2,5	YS	SC	Automatic 100% machine

					check in the production
10	Top mount stiffness	500 +/- 15%	YS	SC	SC at the supplier
11	Lower bush radial stiffness	1080 +/- 15%	YS	SC	SC at the supplier
12	Jounce bumper - load deflection curves	P1 = 6575 +/- 15%	YS	SC	SC at the supplier
13	Recycling	Unit recyclable - IMDS	YC		IMDS approval before the production launch
14	Reaction force after filling	192 +/- 30 N	YS	SC	Automatic 100% machine check in the production
15	Piston nut torque	16 +/- 2 Nm	YS	SC	Automatic 100% machine check in the production
16	Top mount - hole distance	90 +/- 0,5	YS		SC on the supplier drw.
17	Top mount - wing flatness	0,3	YS		SC on the supplier drw.
18	Top mount - surface roughness	Ra 25 MAX	YS		SC on the supplier drw.
19	Top mount - squareness of face (dia 20 to hole axis)	0,1	YS		SC on the supplier drw.
20	Top mount - washer flatness	0,2	YS		SC on the supplier drw.
21	Lower bush - sleeve flatness	0,2	YS		SC on the supplier drw.

Source: Monroe Czechia s.r.o.

2.8 Mass Production

The purpose of this phase is to guarantee the conformity with the contract and with the agreement during the all-time of shock absorbers manufacturing and for each delivered product.

2.8.1 Requirements for the mass production phase

The Monroe Czechia s.r.o. committed with the supply of rear shock absorbers for the vehicle Opel Grandland, which compliant with all characteristics. In the case, that the manufacturing process is not capable to produce compliant supplies, the Monroe Czechia s.r.o. has to guarantee the next delivery of conforming parts. The manufacturing plant produces in keeping with contractual obligations. The delivery schedule has been created on the base of structured planning with the strategic planning including the planning of the production. The PSA sets quality targets for the Monroe Czechia s.r.o. for each year. One of the most important indexes called Parts Per Million (PPM). It shows the quality performance of suppliers and fulfillment of the quality targets. The PSA sends to the logistic department in the Monroe Czechia s.r.o. a forecast of the delivery and schedules for supplies, each delivery is guaranteed, and it is under the protection of the supplier.

2.8.2 Spare parts management

The Monroe Czechia s.r.o. committed to supply conforming spare parts in the requested quantity and with the schedule requested by the PSA according the specification of the spare parts.

2.8.3 Change management

When it is necessary to change the production process, or the place of the manufacturing lines, it has to be provided the analysis on the impact of this change. On the base of the analysis created by Monroe Czechia s.r.o. has to inform the PSA and to send a preliminary request for the change of the process. The official request involves technical and the economic impacts also an information regarding the protection of next supplies of the shock absorbers. There is

also strictly requested the new updated PPAP file including the capability of the manufacturing process with special characteristics. New samples will be checked as soon as possible, after they will be producing on the updated manufacturing process.

Prior the shipment of the shock absorbers produced on the modified process, there is necessarily have the full approval, or at the latest an interim approval from PSA side. The transfer, or the change of the manufacturing process subjected to the specific process called Business Transfer Approval Board (BTAB). This process can lead to invoicing. (Supplier Quality Manual PSA, 2019)

2.8.4 Warranty

The supply contract between the PSA group and the Monroe Czechia s.r.o. describes the warranty period and all quality agreements. The terms of warranty also specify the distribution of warranty costs incurred by supply failures. For each new supply, the Monroe Czechia s.r.o., must use applicable part return centre (CRG) to determine terms for handling warranty returns including the technical and the financial points of view. When the wrong delivery of shock absorbers will find at customer side, for example during the incoming inspection, or in the worst case in the field, then process will be start in the cooperation with the PSA. The quality management at PSA side will be recovered parts of a sample from the PPAP procedure and they can check difference with detected wrong delivery of shock absorbers. The Monroe Czechia s.r.o. will ask for the return of not ok parts for the analysis, or for the measurement. The supplier will be proceeding according the standard procedure for the nonconformity solving including emergency action. The evaluation of the root cause, implementation of the corrective actions, and information about the result will be send to the responsible quality engineer at PSA side. In case that nonconformity rate of PPM will be affect the wrong brand image, then the PSA can initiate an introduction of quality crisis for customers and ask the Monroe Czechia s.r.o. for an extension of the warranty. (Supplier Quality Manual PSA, 2019)

When the PSA group deems, that risk of the nonconformity of vehicles on their side is higher and it is not acceptable for them, so than they can to decide and to start with preventive operations, in order to update vehicles involved. In this kind of the situation the Monroe Czechia s.r.o. has to propose to PSA a solution to perform upgrading campaign. It can be

interim, or permanent solutions, efficient repair methods, provision of required parts. (Supplier Quality Manual PSA, 2019)

2.8.5 Official customer's complaint

The official way how to receive a complaint is through a customer website. However, the first information usually the quality engineer receives by the phone, or an email. All process of the investigation, communication with the PSA, solution of the emergency steps, and implementation of the corrective actions, has been demonstrated on the example (figure 11). The responsible quality engineer received official claim of the shock absorber, where one not ok part has been detected during the customer's manufacturing.

The protentional reason of the nonconformity was the missing component called retainer. The PSA found the nonconformity during the assembly process in the manufacturing factory Sochaux.

Figure 11: G8D report – part Title to D0 symptoms.

<table>
<tr><td colspan="2">Title: NOK stem end – found online during assy process</td><td>Date: 26/2/2022</td><td>Last Updated: 16/3/2022</td></tr>
<tr><td rowspan="3">Vehicle: Peugeot

Model: P1UO

Plant: Sochaux</td><td colspan="3">Report: QAN 895 2021 2037</td></tr>
<tr><td colspan="3">Shock absorber rear DT</td></tr>
<tr><td colspan="3">TEN report nr.: PSA03 2021</td></tr>
<tr><td colspan="4">Customer responsible: Quality engineer PSA</td></tr>
<tr><td colspan="4">Number of accidents: 1</td></tr>
<tr><td colspan="4">Accepted: 1 pcs</td></tr>
<tr><td colspan="4">Conclusion: Claim accepted; missing component confirmed during the visual inspection of the shock. Temporary action implemented – extra operator for visual control. Permanent corrective action improvement of the JIDOKA installed + new visualization on the place + WI update.</td></tr>
<tr><td colspan="4">DØ Symptom (s):

Missing retainer – found on the line during assy process
TEN part number: MEQ1Q2510, ME3180007
Customer part number: 9824958980</td></tr>
</table>

Source: Monroe Czechia s.r.o.

The specification of the nonconformity was received, after that the quality engineer had to start with the emergency response actions. One of the first steps is to inform the production department about the potential problem and set up the investigation team. After this step is the manufacturing process checking and the information about results described in the G8D report. The next step for the investigation is to analyse the claimed shock absorber and before that it is necessary to ask PSA for a transport back of the part to the Hodkovice plant. The part of the interim corrective action was to prepare the document called quality alert and send it to concrete production stage. Next operator has been added to the final assembly for C-clip position and presence. Operators working on the same production stage has been informed and trained too.

Figure 12: G8D report D0 to D3 Source: Monroe Czechia s.r.o.

DØ Emergency Response Action(s):	Result:	Effective	Implemented
Process checked on the production line.	OK	100 %	26.2.2021
Part requested for analysis - send via Trigo delivered 26.2.2021	Delivered: 26.2.2021	100 %	26.2.2021
D1 Team: Champion: Quality manager Team leader: Quality engineer Team members: 1) Area leader 2) Quality area leader 3) Process technology 4) Claim analyser	**D2 Problem Description:** Stem end too long – detected during the assy on the car by operator. **Quantity defected:** 1 pcs **Date codes**: Date of production 07/02/2021 **Product returned?** Yes **Reoccurrences?** Yes		
D3 Interim Containment Action(s):	Verification / Validation:	Effective	Implemented:
Production informed 8.9.2019 on regular QRQC meeting		100 %	26/02/2021
Part requested for transport to Hodkovice for investigation.		100 %	26/02/2021
Final assembly process checked online by the process engineers + quality representatives.		100 %	26/02/2021
Quality alert created placed in production operators informed + trained.		100 %	26/02/2021
Complete actual production checked – visual appearance – no trouble found		100 %	26/02/2021
Extra operator added in the final assembly for C-clip position and presence		100 %	26/02/2021

Source: Monroe Czechia s.r.o.

The claimed shock absorber was analysed after the claim analyser received this part. Results of the investigation were discussing with the quality engineer and on the base of acceptance of the claim, it can be the process of the root cause finding to start. Important interim actions have been implemented and customer was informed about next steps. It is necessary to find the root cause and bring the permanent corrective actions to avoid the repetition of the nonconformity which was occur.

Figure 13: G8D D4 Root Causes(s) and Escape Point(s)

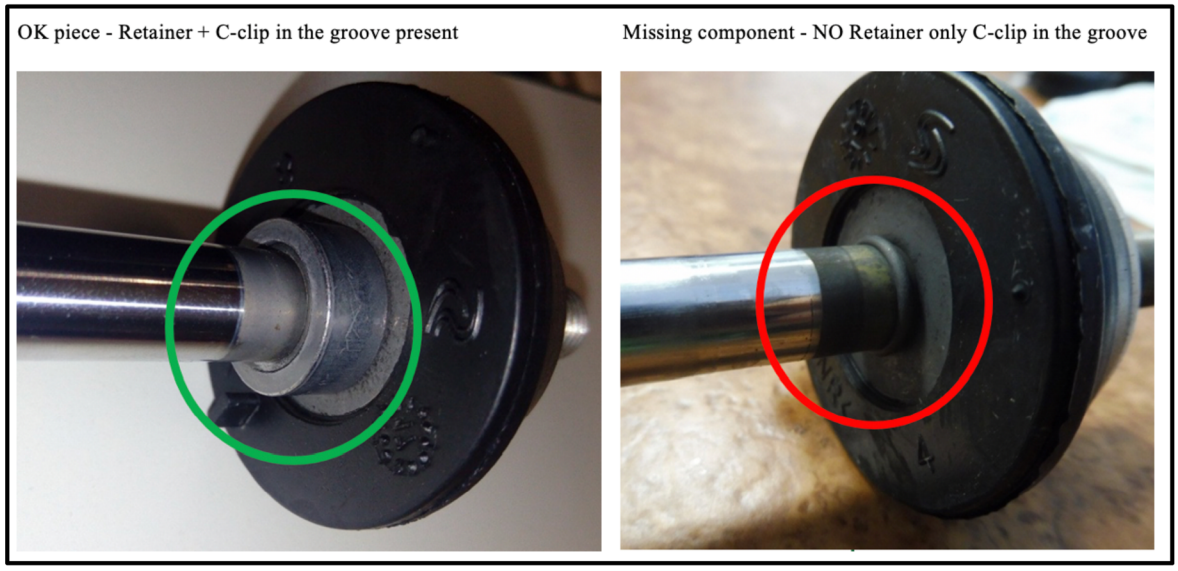
D4 Root Cause(s) and Escape Point(s):	Verification:	Date:	Contribution
Possible root causes:	Visually confirmed during the disassembly of the shock absorber	02/03/2021	100 %
	Job observation – design of experiment Simulation of the defect	02/03/2021	100 %

Physical (technical) occurrence:	Date :	Contribution
Retainer missing – confirmed. Fell down after the operation of the bushing press inside the loop.	02/03/2021	100 %
Operator discipline not followed - WI not followed including standard of the work.+	02/03/2021	100 %
Non detection / Escape point:		
JIDOKA tooling incorrect design.	02/03/2021	100 %
No connection if the JIDOKA stucked to the next operation to be stopped		

Source: Monroe Czechia s.r.o.

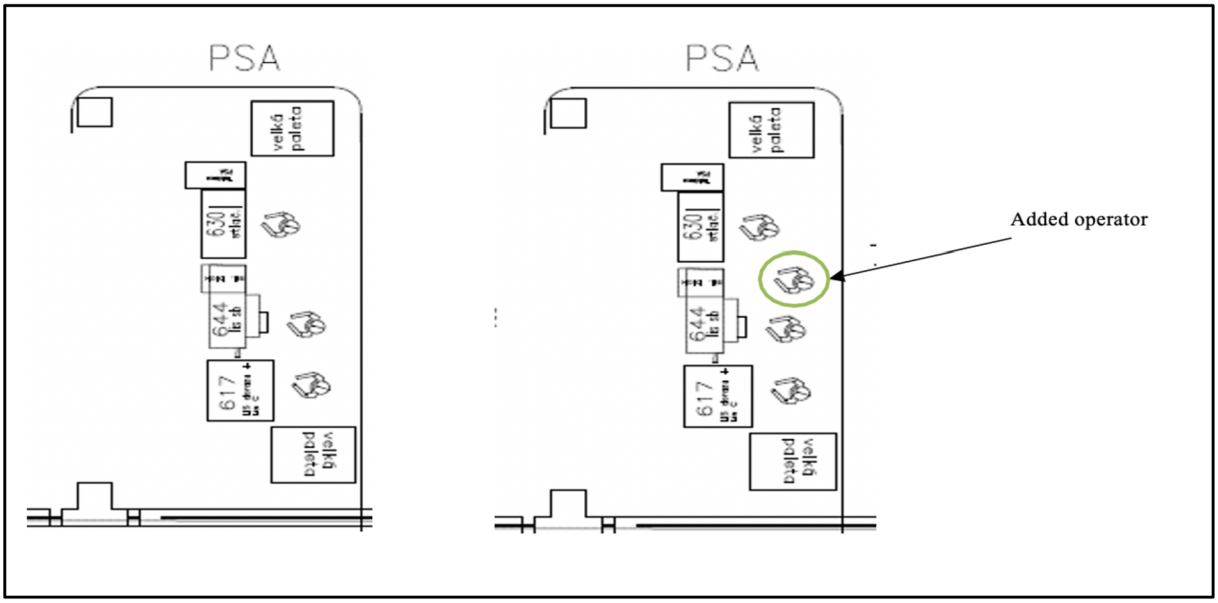
During the step D4 the claim has been accepted. During the analysis has been confirmed the retainer is missing. All technical occurrence has been described in the G8D report and the customer was informed by the quality engineer. The claim analyser confirmed the nonconformity quickly, the missing retainer was confirmed after disassembly of the shock absorber has been provided.

Picture 18: Disassembly of the shock absorber.
Source: Monroe Czechia s.r.o.



Picture 19: OK Retainer + C clip, NOK Retainer + C-clip
Source: Monroe Czechia s.r.o.

Inter departments cooperation was effective and the team created solution with the added value. The root cause has been detected. Together with the process engineer the team prepared solution for the permanent corrective actions. Effectiveness and verification have been checked. The quality engineer added all of information into the G8D report and the customer received the feedback regarding continuing of the solution. The next extra control stage has been added into the production line.



Picture 20: Layout of the added operator into the production line
Source: Monroe Czechia s.r.o.

The next very important corrective action which the team did it is the Jidoka tooling improvement. This kind of the upgrade will to stop the next process in the serial production of the shock absorber in case of the claimed nonconformity occur again. Stopping of the production line will be happen automatically. It is very effective system, because of the human supervision of the machine is very difficult and it can create errors. Together with this solution the quality engineer created the new definition of the work standard.

Figure 14: G8D. D5, D6, D7, D8.

D5 Chosen Permanent Corrective Action(s): Occurrence		Verification	Date	Effective
Extra operator added to the assembly process – after the operation of the bushing press. Extra operator control presence of the retainer + C – clip in the groove – confirm the control with the marking and do the operation of dirt shield assembly.		Records of NOK findings	26/02/2021	100 %
New definition of the work standard – only 5 Pcs in one moment on the workplace in one moment. Penalty defined for the operators for disobeying the work standard.		WI update	09/03/2021	100 %
JIDOKA tooling improvement – new design defines.		New design	12/03/2021	50 %
D6 Implemented Permanent Corrective Action(s):	Validation	Actual date	Responsible	Effective
* New definition of the work standard - only 5 Pcs in one moment on the workplace in one moment. * Penalty defined for the operators for disobeying the work standard. * Visualization on the place that only 5 parts JIDOKA tooling improvement - new design define. *Connection of the JIDOKA and the next operation machine each cycle of the JIDOKA OK evaluation enables production of only one part.	* New updated WI in place. *New tooling assembled. *Design of experiment	15/03/2021	Quality engineer	100 %
	*New tooling assembled.	16/03/2021	Process engineer	100 %
	*Design of experiment	02/03/2021	Process engineer	100 %
	TENNECO			

Source: Monroe Czechia s.r.o.

D7 Systemic Prevent Recommendations:		Responsibility:
Occurrence: Check the status on all other lines across the plant - verify that no possible similar issue potentially existing.		Quality engineer
D8 Team and Individual Recognition:	**Reported by:**	**Date closed:**
Thank you all for the cooperation.	Quality engineer	16.3.2021

Source: Monroe Czechia s.r.o.

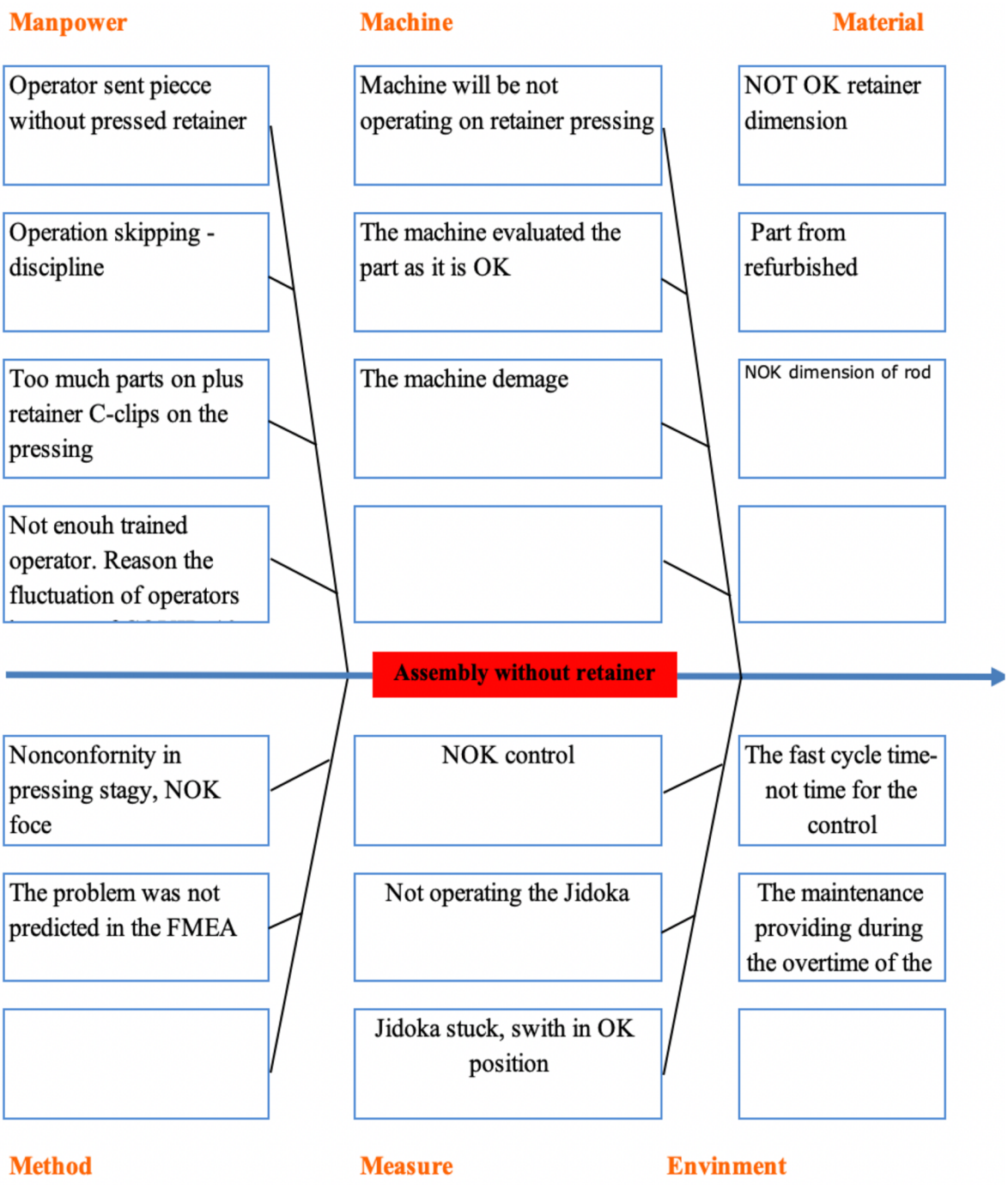
During the nonconformity solving has been used the 5 Why tool as a support for the evaluation of the occurred problem. How this analytical tool works is explained above. We can see how step by step the results of the root cause investigating was. (see figure 15)

Figure 15: 5 Why

3L SW	**Problem Definition**	**1st Why**	**2nd Why**
Causes - specific	**Missing retainer after the final assembly - delivered to customer's manufacturing plant**	Not done the operation of the retainer pressing.	Retainer just placed on the position and the shock moved to bushing press operation.
Causes - detection		Detection failed.	JIDOKA for the control of retainer did not work properly.
Causes- Systemic		Function of Jidoka was not evaluate properly.	No defined sample for JIDOKA function verification.
	3rd Why	**4th Why**	**5th Why**
Causes - specific	The full handling tooling to check the correct retainer press on the rod.	It was not following the defined number of parts in the production in one moment.	Operator did not follow working instruction.
Causes - detection	Jidoka stayed stuck in the OK position.	NOK dimension of the tooling affect not fully pressed retainer.	No set up if the Jidoka is stucked, the next operation will be stopped.

Source: Monroe Czechia s.r.o.

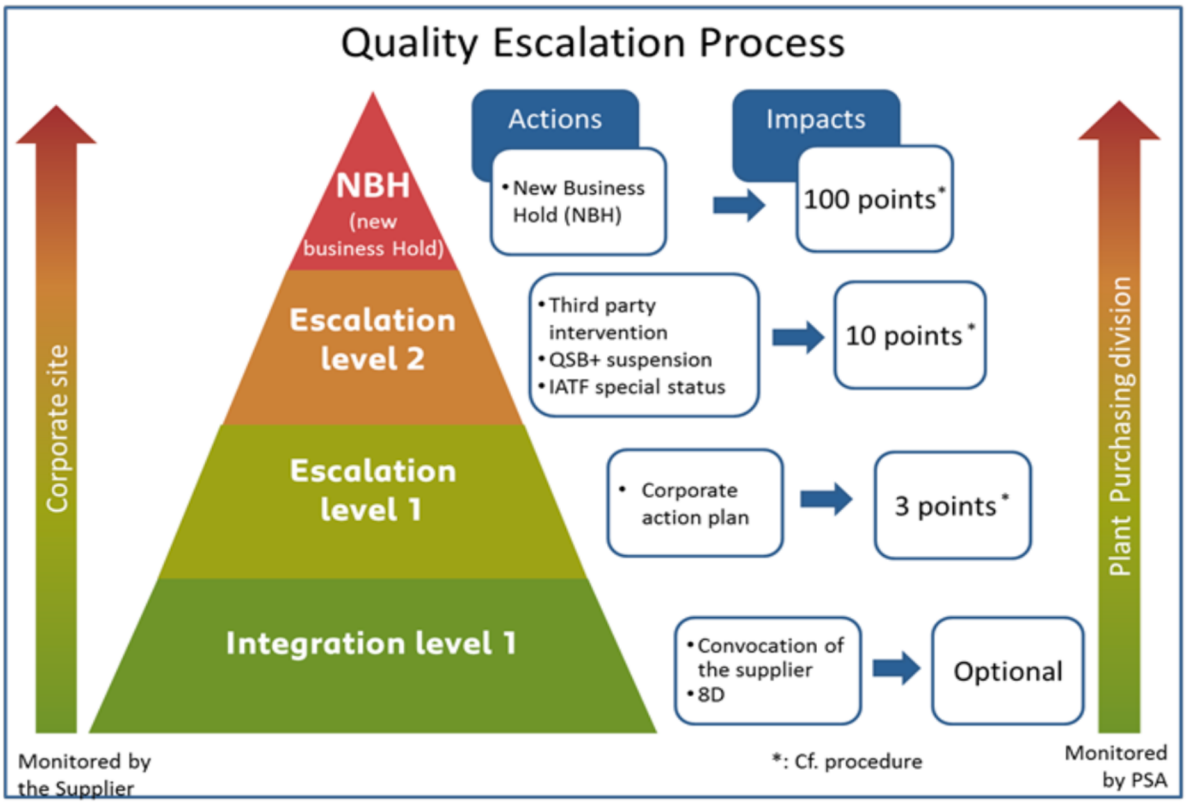
2.8.6 Ishikawa (fishbone) diagram



Picture 21: Ishikawa diagram, retainer
Source: Monroe Czechia s.r.o.

2.8.7 Mass production escalation process

When the Monroe Czechia s.r.o. will be to produce too many shock absorbers with nonconformities and official claims will be occur.



Picture 22: Quality Escalation Process.
Source: Monroe Czechia s.r.o.

Then the PSA can introduce incremental measures to handle the situation. In the worst case can the PSA to ask the responsible certificate company for the decertification process if it identifies a violation to the requirements of IATF 16949.

2.8.8 Lessons learned

All quality failures officially reported in the manufacturing plant, or infield levels must be to conduct an analysis. In the case of the technical, or system root cause it is necessary to implement appropriate corrective actions. The human error is not acceptable as the root cause, because the company should have mechanism how to avoid that. It can be Poka Yoka, or control stages during the production of shock absorbers and an effective output control.

The PSA company recognises all suppliers who are able to fulfilled their targets and they involved in the continuous improvement, in innovations, or in the competitiveness initiative. The choice of winning supplier is on the base of their quality and logistic performance during the serial production. The best supplier can win the Awards Best plants.

2.9 Calculation of the manufacturing

The responsible department, which is Accounting and financial controlling department at Monroe Czechia s.r.o. is responsible for the smooth financial continuing of the project. The controller has important role in the management of the company. Monitoring, controlling, planning and calculating of the process have essential importance.

2.9.1 Calculation of the rate per minute

The rate per minute index is using in the next steps of the calculation, which is influencing the final price of process. The index is equal to the budget of the individual cost centre divided to production minutes used. The difference between current and planned cost is equal to fix the component in the planned costs divided by the total capacity of the production line.

- RpM = cost centre budget / production minutes

Rate per minute is divided into three categories:

- Direct labour + fringes = wage costs of operators. Direct labour: basic part of wages.
- Fringes: overtime, bonuses, holidays, social and healthcare insurance.
- Machine cost: operating energy, maintenance, spare parts, indirect wages (offices, quality assurance in the production, team leader), depreciation.

Figure 16: Cost center group

Cost Center Group: RC-MAN-DIR
CZ20 Budget Tenneco Czechia
Fiscal year: 2022
Period: 1To 12

Cost Center	Acty Type	Cost center	Act. Type	Fix.+v lb.price	Vbl. price	Fixed Prices
RC1018	FRIN99	RC Base Assy	DL Fringes	6,56	6,56	0,00
	LAB99	RC Base Assy	DIRECT LABOR	5,15	5,15	0,00
	MACH99	RC Base Assy	MACHINE	27,62	20,58	7,04
	SET99	RC Base Assy	SET UP LABOR	3,57	3,57	0,00
RC1020	FRIN99	RC DIRT SHIELD	DL Fringes	11,35	11,35	0,00
	LAB99	RC DIRT SHIELD	DIRECT LABOR	8,91	8,91	0,00
	MACH99	RC DIRT SHIELD	MACHINE	8,99	8,66	0,33
	SET99	RC DIRT SHIELD	SET UP LABOR	3,57	3,57	0,00
RC1030	FRIN99	RC2WASHER PV DT	DL Fringes	3,83	3,83	0,00
	LAB99	RC2WASHER PV DT	DIRECT LABOR	3,00	3,00	0,00
	MACH99	RC2WASHER PV DT	MACHINE	25,51	16,29	9,22
	SET99	RC2WASHER PV DT	SET UP LABOR	3,57	3,57	0,00
RC1031	FRIN99	RC2WASHER PV MT	DL Fringes	4,20	4,20	0,00
	LAB99	RC2WASHER PV MT	DIRECT LABOR	3,29	3,29	0,00
	MACH99	RC2WASHER PV MT	MACHINE	31,75	23,59	8,16
	SET99	RC2WASHER PV MT	SET UP LABOR	3,57	3,57	0,00
RC1032	FRIN99	RC Tubes OPAV	DL Fringes	6,06	6,06	0,00
	LAB99	RC Tubes OPAV	DIRECT LABOR	4,76	4,76	0,00
	MACH99	RC Tubes OPAV	MACHINE	24,11	16,82	7,29
	SET99	RC Tubes OPAV	SET UP LABOR	3,57	3,57	0,00
RC1033	FRIN99	RC Tubes OPA. MT	DL Fringes	6,12	6,12	0,00
	LAB99	RC Tubes OPA. MT	DIRECT LABOR	4,80	4,80	0,00
	MACH99	RC Tubes OPA. MT	MACHINE	23,00	17,79	5,21

Source: Monroe Czechia s.r.o.

2.9.2 Divided complete process of the shock absorber

Data regarding the individual shock absorber is simply to see in the database. Including the information about the material, cost centres, work centres, total machine minutes, total labour minutes and material description.

Figure 17: Bill of Labour at Standard Minutes

Tenneco Automotive Bill of Labour at Standard Minutes						
Report YRV0L10 N					Date: 19/1/2022	
BOM	Material	Cost Center	Work Center	Total machine minutes	Total Labour Minutes	Set up min
0	MEV1T1801	RC1800	MOD_PSA	216,667	866,668	1,000
2	ME31F3401	RC1218	DT_E	120,000	639,600	1,000
2	ME31F3401	RC1127	DT_E_VS	75,000	174,750	1,000
2	ME31F3401	RC1710	MT_PAINT	56,667	283,335	1,000
2	ME31F3401	RC1031	OPL_7614	33,333	83,333	1,000
3	M772S2458	RC1122	MTPA_BRO	100,000	100,000	1,000
3	M772S2458	RC1142	MTPA_SF	100,000	100,000	1,000
3	M772S2458	RC1520	MT_CHROM	55,333	55,333	1,000
4	M7H002350	RC1129	HEXAGON	70,000	35,000	1,000
4	M7H002350	RC1135	MTPA_ZAP	108,333	54,167	1,000
4	M7H002350	RC1128	NB_SAY	108,333	108,333	1,000
4	M7H002350	RC1214	SV_AUTO	83,333	166,666	1,000
3	MT1325738	RC1031	OPL_7614	33,333	83,333	1,000
3	MT1325738	RC1018	DT_E_VV2	116,667	233,334	1,000
4	MAH001374	RC1033	OPAV_MT	53,333	106,666	1,000
4	MAH001374	RC1044	VV_7616	116,667	116,667	1,000
				1446,999	3207,185	16,000

Source: Monroe Czechia s.r.o.

Machine minutes are on the one thousand produced parts. Each thirteen seconds, production line double tube E, produces one shock absorber. The budget for cost centre is divided by allocation keys. Individual department defines their keys. Variable costs are divided by the current production plan. The fixed component is divided by the capacity of the line, so it is rate of one crown per minute. According the information from the technology department and

designers will be calculation of the production costs. After that all responsible managers have to confirm the result.

Figure 18: Calculation of the margin and net profit.

Calculation of the margin and net profit	
Cost of the quality department per year	29 333 333,00 CZK
All costs for the production per year	798 666 667,00 CZK
% of quality	3,7%
Total sold shock absorbers	412 000
Costs for one shock absorber	307,70 CZK
Selling price	339,87 CZK
Margin	32 CZK
Revenue per year	140 024 792,00 CZK
The net profit	13 252 392,00 CZK
% of the net profit	9%

Source: Monroe Czechia s.r.o.

The profit and margin are clear (see figure 18). The margin is 24 Czech crowns. The production plan has been set up on the base of the customer's requirements. The plan for the production was set up on 80 days in the first half of the year. Monroe Czechia s.r.o. planning to manufacturing on two shifts per day. Each thirteen seconds manufacturing line produces one shock absorber. One shift is 7,5 hours. The production line is capable to produce 4154 shock absorbers per day. The gross profit is 99 692 Czech crowns, it is equal to 4038 euros. The exchange rate is from 3.5.2022 and it is 24,69 CZK for 1 Euro. The final financial income is 7 975 385 Czech crowns for 80 production days. The APQP phase in terms of the quality, including individual quality costs, was costing at 1 593 108 Czech crowns. The financial return of the quality management, which was necessary to use before the start of production, is 14 days (see figure 19). The Monroe Czechia s.r.o. achieved this financial results thanks to used and implemented international quality standards.

Figure 19: Calculation of the quality management financial return

Calculation of the quality management financial return		
Margin	24	CZK
Working days	80	days
Shifts	2	
1 shift	7,5	h
Cycle time	13	s
Production capacity per day	4 154	parts
Gross profit per day [CZK]	99 692	CZK
Exchange rate 03/05/2022: 1 Euro	24,69	CZK
Gross profit per day [€]	4 038	Euro
Total gross profit plan [CZK]	7 975 385	CZK
Total gross profit plan [€]	323 021	Euro
Costs of the quality management before SOP	1 593 108	CZK
Return of the quality management	16	days

Source: Monroe Czechia s.r.o.

Conclusion

The increased attention on the quality of the supplied products is especially important today, when the manufacturing companies are affected by the international aspects, such are the supply distribution of the components, or because of the Covid-19 pandemic situation in the World. Emphasis is also placed on the lowest possible production costs while maintaining the appropriate quality standards and requirements, without damaging the company reputation and fulfilment of the customers wishes. These are the reasons why is necessary to make maximum use of quality tools to meet individual company targets. Targets such can be the net profit, the quality and the safety.

The analysis of this diploma thesis shows the tools of the quality management used in the international manufacturing company of the shock absorbers. The nonconformity causes the additional costs of human, material, or management sources. One of the main targets of Monroe Czechia s.r.o. is to avoid additional costs caused by the customer complaint.

The Monroe Czechia s.r.o. has the clear organizational structure with divided responsibilities. Implementation of the international quality standards has been done and subsequently implemented into individual internal processes. The chosen product is the shock absorber produced for Opel Automobile, the company is a part of the international corporation the PSA.

The target of the first part of analysis was to specify the PSA requirements, which was necessary to fulfilled by the Monroe Czechia s.r.o.. The analysis of diploma thesis focuses on APQP and on PSA requirements. Through G8D analysis the occurred nonconformity has been evaluated.

Thanks to the analysis was possible to identify tools that fundamentally affect financial return of the project. It was established that Monroe Czechia s.r.o. met all customer's requirements during the APQP phases from the quality engineering point of view. Subsequently, the shock absorber could be released into serial production and be delivered to final customer.

The PPAP is effective tool to detect eventual not ok supplied parts. In the case that the PPAP procedure is not use as the tool, then there is a big risk of failures associated with additional costs. The PPAP procedure is one of the most important in the automotive industry.

It fundamentally affects the financial return of the costs incurred for the project. During the approval of the shock absorber is necessary to do not only measurements of dimensions, but also there are necessary to do individual tests and evaluations.

The important part of the quality management is the G8D procedure. The functionality was analysed. The report captures occurred problem from serial production, which was identified by the customer. The final provided solution and implementation of corrective action affected that the problem did not occur again.

Individual tools are deeply described in the diploma thesis on the base of available data. Analysed tools and procedures were PPAP, Process Flow Diagram, Process and Control plan, individual measurements of special characteristics, process capability and G8D method. On the base of the provided analysis is possible to state, that Monroe Czechia s.r.o. fulfilled the international standards ISO 9001 and IATF 16949, together with the PSA requirements.

Thanks to diploma thesis is possible to clarify the manufacturing costing and successfully managed the financial return of the project in case that the company meets international standards and customer requirements in the field of quality management in the automotive industry. It was possible to clarify all quality management tools, which affects the final costs return. Costs return was calculated on the base of available information and on the results basis. The investments in quality management during the APQP phase can reduced the potential risks and additional costs. The acceptable period of costs return is in point of long-term lifetime of the project. Results of this diploma thesis can affect the importance and better understanding of quality management. The diploma thesis can be extended by the Lean manufacturing and Six Sigma at the future, to achieve the costs reduction of quality management in the serial production.

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