# FMEA ANALYSIS OF LOGISTIC PROCESSES IN THE INDUSTRIAL ENTERPRISE

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**Abstract**

The article presents the results of analysis of selected elements of the quality management system in a manufacturing company operating on the automotive market. The surveyed company belongs to an international company cooperating with such recipients as: Land Rover, Volvo, BMW, Toyota, Renault, Citroen, Peugeot, Audi. An important element of the study was FMEA analysis (Failure mode and effects analysis), which is used in the analyzed facility not only to assess individual stages of the production process, but also to auxiliary processes. In the group of auxiliary processes, apart from the supply control, identification and assessment of potential nonconformities in those logistics processes that have a direct impact on the final quality of the product were also made.

**Keywords:** Quality, logistics, failure mode and effects analysis

## 1. INTRODUCTION

The management function implemented in enterprises may be more or less complex depending on the size of the entity, the specificity of the business or priorities defined in the strategic plans. Among the components of management functions, there may be mutual relationships and dependencies that are often complex and difficult to identify as well as characterize. An in-depth understanding of these dependencies and including them in decision-making processes, undertaken actions and methods of achieving the assumed goals determines - on the modern market - the position of the company and the nature of competitive advantages possessed by the company. An example of such a broad and more comprehensive approach is, among others, modern quality management concepts implemented in industrial practice. In addition to the trend of the traditional definition of this concept, some researchers believe that quality as a discipline is becoming increasingly more "ubiquitous" [1]. Currently, the content of the concept of product quality includes not only the technical, production aspect, but also market and ecological aspects. Therefore, such a situation requires from a modern enterprise that the control and regulation of the product quality creation process should replace the management of this value in the context of its conscious formation, often referred to as "the control over quality" [2].

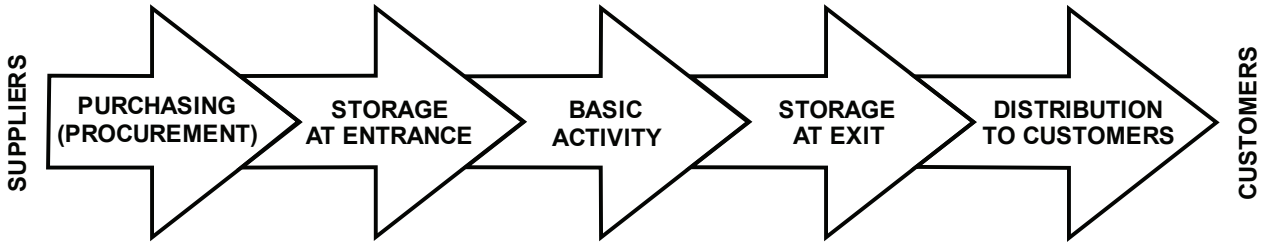


**Figure 1** Logistics supply chain [3]

The concept of "ubiquity" of quality does not result only from the fact of combining it with other previously neglected areas (e.g. ecology), but also from the fact that the quality level directly affects the processes or activities carried out in the organization, such as marketing or logistics.The article presents the results of FMEA

analysis for individual stages of production and ancillary processes, with particular emphasis on logistics aspects. The logistics supply chain presented in **Figure 1** as a sequence of processes can be subjected to qualitative assessment at every stage. At the same time, however, the quality of the product components and the product itself also affects the ongoing logistics processes.

## 2. FMEA ANALYSIS

The analyzed production company is part of an international company operating on the automotive market. Several hundred patents (around 500) and numerous awards (the Automotive News PACE 2006 prize, the global Six Sigma award) have made that among the company's clients there are such well-known car brands as: Volvo, Toyota, Peugeot, Citroen, Volkswagen, Renault, Jaguar, BMW, Porsche, Ford, Audi, Tesla. Approximately 800 people are employed in the examined plant, among which nearly 75 % of the people are employees directly or indirectly connected with production. Due to the nature of the production, the organizational structure is formalized which facilitates efficient and effective management of individual departments. The company in question has an integrated management system under which the principles of the ISO 9001 standard concerning the quality management system have been implemented. This standard has been extended with the technical specification of the automotive industry ISO/TS 16949 (currently IATF 16949: 2016). The ISO/TS 16949 standard was created by the International Automotive Task Force and introduces a number of additional requirements that result from the characteristics of the automotive industry. They particularly concern issues such as [4]: quality planning, technical documentation, purchasing, testing of products that do not meet requirements, analysis of measurement systems, conducting audits.

The last update of ISO 9001 from 2015 also forced changes in the structure of ISO/TS 16949, replacing it with the IATF 16049 standard as of September 14, 2018. The process approach and risk management were strengthened. New quality improvements were also introduced to solve problems appearing in the automotive industry including aspects such as [5]:

- requirements for safety related elements and processes,
- increased product traceability requirements to support recent regulatory changes,
- requirements for products with embedded software,
- warranty management process, including no trouble fund (NTF) and application of guidelines for the automotive industry,
- clarifying the sub-supplier management requirements and their development,
- adding corporate social responsibility requirements.

Maintaining quality standards obviously requires continuous improvement of processes, which in practice is implemented by applying appropriate methods and quality-oriented tools. IAFT 16049 imposes an obligation to use tools such as [6]: FMEA - Failure Mode and Effects Analysis, PPAP - Production Part Approval Process, APQP - Advanced Product Quality Planning, MSA - Measurement System Analysis, SPC - Statistical Process Control, 8D - Problem Solving.

In the opinion of experts, among the most important methods and techniques specific to the automotive industry (so-called core tools), FMEA analysis deserves special attention [7-9]. The FMEA method can refer to both the process and the product. In the latter case, it covers all the phases of its creation from the concept through production to exploitation. In the examined company, FMEA is used cyclically at all stages of the manufacturing process. These analyses relate both to individual stages of production and to auxiliary processes such as: logistics processes, delivery monitoring.

**Table 1** and **Figure 2** show the results of an exemplary FMEA analysis carried out for logistic processes.

**Table 1** FMEA analysis - logistics processes

| No. | PROCESS PHASE | TYPE OF ERROR | EFFECTS OF ERROR | ERROR FAULT | CAUSES OF ERROR | FREQUENCY | INSPECTION METHOD | | DETECTABILITY | RISIK PRIORITY NUMBER |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | PREVENTION | DETECTION | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 1. | External transport | Collision | Damage to employee's health, destruction of transported product | 9 | Independent of the driver | 1 | Medical examination, motivating conversation | Eye examination, inspection of medical certificates | 7 | 63 |
| 2. | External transport | Collision | Destruction of transported product | 9 | Poor weather conditions / driver inattention | 1 | Medical examination, motivating conversation | Eye examination | 7 | 63 |
| 3. | External transport | Non-delivery of finished goods to external warehouse | Stopping production at customer | 8 | Delays in external transport between external warehouses and plant / insufficient safety stock in external warehouses | 2 | Meeting with transport company, increasing safety stock in external warehouses | Regular monitoring of the stock zone | 6 | 96 |
| 4. | External transport | Fall of pallet with finished products after opening door of vehicle trailer | Destruction / damage of transported product | 8 | Incorrectly positioned pallets in vehicle trailer, lack of additional cargo securing | 1 | Purchase of load securing bar by transport campany | Self-check | 7 | 56 |
| 5. | Internal transport | Damage to production machines | Production interruption, partia lor total destruction of device | 7 | Inattention, poor visibility | 1 | Installing bumpers, installing mirros to facillitate visibillity | Visual inspection | 7 | 49 |
| 6. | Internal transport | Overturned pallet | Destruction / damage of transported product | 8 | Blocked communication route | 1 | 5S audit, position training | Self-check | 7 | 56 |
| 7. | Internal transport | Knocking down pedestrian by forklift | Bodily harm of pedestrian, permanent damage to health | 10 | Sudden entry of a pedestrian into forklift's path | 1 | Using sound signaling information for plant employees on how to move around warehouse | Self-check | 7 | 70 |
| 8. | Internal transport | Damage to warehouse / gate / ramo / wall | Destruction, breach of wall / gate / ramp structure | 9 | Inattention, carelessness, too large load on the forks | 1 | Motivating conversation | Ordinance audits | 7 | 63 |

**Table 1** Continued

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 9. | Storage of finished products | Label mistake | Stopping production at customer / shipping wrong parts to customer | 6 | Detachment of label from container / label peeling | 1 | Verification of pallets before shipment. In absence of labls - contact production area | When shipping, it is necessary to scan the shipping and production labels | 7 | 42 |
| 10. | Pallet storage in warehouse | Overturning pallet with profile during pallet stacking | Selecting profile on production, scrapping damaged profile | 8 | Lack of sufficient space for easy forklift maneuvering | 1 | Widening maneuvering area, increasing width of communication path | Visual inspection | 7 | 56 |
| 11. | Pallet storage in warehouse | Accident - overturning of pallets | Threat to health and life of employee | 10 | Employee moves in prohibited place in warehouse | 1 | Employee training - distribution of communication routes | Visual inspection | 7 | 70 |
| 12. | Pallet storage in warehouse | Overturning pallet with profile while moving in warehouse | Threat to health and life of employee. Selecting profile on production, scrapping damaged profile | 10 | Stacking pallets inconsistent with instructions on storage | 1 | Training of warehouse employees. Creating table with visualization of packaging used in plant | Visual inspection | 7 | 70 |
| 13. | External transport | Overturning of pallets in vehicle | Destruction / damage of transported product | 7 | Poor securing of goods in vehicle, bumpy road | 1 | Double checking of correct loading, proper securing of goods by driver | Visual inspection | 7 | 49 |
| 14. | Pallet storage in warehouse | Lack of protection of packaging stored outside plant | Wet packaging - threat of quality defects in packaged products | 7 | Poor packaging protection / bad weather | 1 | Protection of packaging against external factors - proper storage of containers | Visual inspection | 7 | 49 |
| 15. | Inspection station | Damaged components during inspection and transport | Difficulties in production caused by repair or shortages | 7 | Damaged measuring tool | 2 | Training of delivery inspection inspector, knowledge of measuring tools | Quick visual inspection at station | 7 | 98 |
| 16. | Inspection station | Mixed components during inspection and transport | Difficulties in production caused by repair or shortages | 6 | Putting component in wrong box - inspector error | 2 | Obligation to comply with 5S, comparing component marking with label on packaging | Quick visual inspection at station | 8 | 96 |
| 17. | Inspection station | Mixed components during inspection and transport | Difficulties in production caused by repair or shortages | 6 | Disorganization at inspection station not maintaining 5S standard | 2 | Obligation to comply with 5S, comparing component marking with label on packaging | Quick visual inspection at station | 8 | 96 |

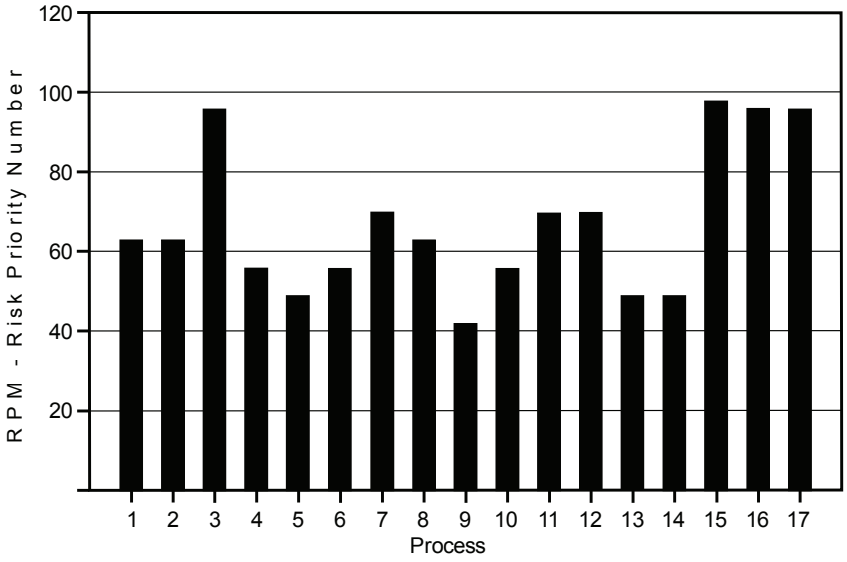


**Figure 2** Graphic summary of FMEA analysis data - logistic processes

In the presented results of the FMEA analysis, the Risk Priority Number = 100 was adopted as the critical level of the risk priority number value. This means that above this value preventive actions should be taken in specific cases. 17 logistic processes were subjected to assessment, none of which exceeded the priority limit value. The following processes received largest RPN values:

- process no. 3 - internal transport; non-delivery of finished products to external storage (type of error); delays in external transport between external warehouses and plant / insufficient safety stock in external warehouses (causes of error),
- process no. 15 - inspection station; damaged components during inspection and transport (type of error); damaged measuring tool (causes of error),
- process no. 16 - inspection station; mixed components during inspection and transport (type of error); putting component in wrong box - inspector error (cause of error),
- process no. 17 - inspection station; mixed components during inspection and transport (type of error); disorganization at inspection station not maintaining 5S standard (causes of error).

Other logistics processes (around 82 %) did not exceed the priority number value level above 70 points. An analogous summary for another auxiliary process - delivery inspection (109 processes evaluated) showed that:

- 3 processes (about 2.8 %) exceeded the priority number limit value,
- 18 processes (about 16.5 %) obtained a priority number in the range from 90 to 100 points.

## 3. CONCLUSION

The turbulent and complex nature of the modern market means that enterprises must modify both the methods and techniques of their operation as well as the principles of cooperation with external entities. Taking into account the assumptions of the value chain concept, it can be stated that each of the links in this chain contributes to the creation of final value for the client, which implies that the success of individual enterprises is to a certain extent mutually conditioned. In this context, it seems that an important aspect is the integration of activities carried out by individual entities. Unfortunately, the level of integration is often strongly limited by market realities (e.g. one supplier provides products to several competing entities). Despite this, enterprises should cooperate in certain areas that do not violate the purity of competitive struggle.

The international company presented in the article meets the quality criteria set on the automotive market, which allows it to cooperate with such renowned customers as: Volvo, Toyota, Peugeot, Citroen, Volkswagen, Renault, Jaguar, BMW, Porsche, Ford, Audi, Tesla. The data obtained as a result of the FMEA analysis indicate that in the case of such auxiliary processes as logistics processes and delivery inspection, no significant number of threats that could result in disruption of the production process were noticed. The assessment concerned only information obtained from the period of one month and it seems that when using the database, it would be necessary to compare individual analyses with particular attention to those processes that obtained a priority number in the range from 90 to 100 points.

In the studied company, the existing quality management system in the process of continuous improvement uses not only the tools recommended by IAFT standard 16049 (so-called core tools), but also others relevant to the current situation, e.g. Ishikawa cause and effect diagram, 5 Whys technique, or 8D in the case complaints.

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