

USE OF METHODS OF QUALITY MANAGEMENT FOR IMPROVING THE REPAIR PROCESS ILLUSTRATED WITH THE EXAMPLE OF ROLLING STOCK

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Abstract: The article describes the process of analysing and improving the rolling stock repair. The problem was ineffective qualification of additional works and elements to be replaced in the renovated wagons. The qualification is carried out before undertaking the repair activities. Improper qualification increases the cost of renovation and, in consequence, causes the customer to incur additional expenses, which lowers their trust in the enterprise. The aim was to reduce the number of elements qualified for renovation and, thus, lower the unplanned costs and the wagon repair time. Major problems involved in the process of qualification were identified and, owing to the use of the SD method, corrective and preventive actions were prepared and undertaken. The last stage consisted in the verification of the results obtained.

Keywords: quality, management, repair, railway wagon, improvement.

1. Introduction

Companies make every effort to convince a customer who has trusted the enterprise to come back with another project. Apart from the quality of work, the most important issue for each service-providing enterprise is the cost and completing the work on time. These are the direct factors influencing customer satisfaction (Biesok, and Wyród-Wróbel, 2016).

The owner of a wagon is legally (Ustawa o transporcie kolejowym, 2003) obligated to observe the inspection and repair cycles (Fig. 1) (Buks, 2015).

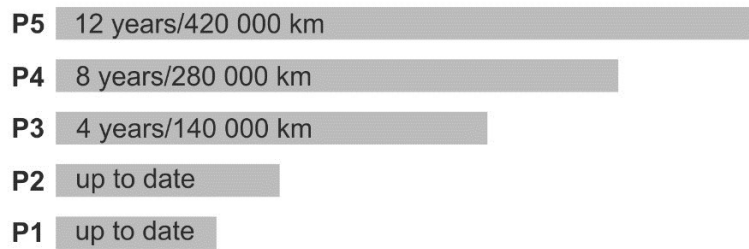


Figure 1. Cycle of rolling stock repairs and inspections. Source: own study based on (Rozporządzenie Ministra Infrastruktury, 2005).

The wagon lifecycle is divided into 5 stages:

- P1: inspection involving constant monitoring and inspection activities performed during the ongoing operation of the railway wagon. It is performed before the run or upon its completion;
- P2: visual inspection and assessment of the technical condition of the wagon performed at planned intervals related to the operation of the vehicle;
- P3: visual inspection after planned withdrawal of the wagon from service, including disassembly of its elements, carried out every 4 years or after every 140,000 km travelled;
- P4: a detailed inspection of the technical condition of the wagon carried out after 8 years or after 280,000 km travelled since the beginning of its operation;
- P5: activities aimed at increasing the standard of a railway vehicle or its renovation consisting in the dismantling of units and subassemblies and their replacement with new or regenerated ones. It is performed 12 years after the start of operation or when the wagon has travelled 420,000 km.

Steps P3, P4 and P5 must be carried out at an authorized workshop.

During the carriage repair, apart from basic works specified for particular inspection and repair cycles, additional works are also carried out. Additional works result from mechanical failures and their scope depends on the operating conditions of a freight wagon.

Before a wagon is sent for repair, its initial qualification is conducted, which informs the customer about the cost of repair of their rolling stock. The biggest problem are subassemblies in need of repair which have not been included in the qualification and are discovered during the repair, when the wagon is on the downstream line. The works have to be done due to the binding regulations, but the customer does not want to pay for additional works that have not been agreed on. A company which cares about their customer's satisfaction has set the goal to increase the effectiveness of qualification before a wagon rolls onto the downstream line.

2. Course of the process

Qualification of works takes place on a railway siding, using a universal qualification sheet. After the cost estimate has been prepared, the sheet is sent to the customer for approval of the scope of repair. The wagon with complete documentation is moved to the cleaning station. Having been cleaned, the wagon is transported to the downstream line. On this line, all the wagon elements are repaired in accordance with the established scope. Upon completion of the repair, the wagon is rolled onto the transfer tracks on the railway siding, which is adapted for inspection.

The qualification of a wagon before it rolls onto the downstream line is the responsibility of the quality assurance department. This operation consists in estimating the cost of the wagon repair and the scope of repair. The wagon repair cost estimate is delivered to the wagon owner. Upon the acceptance by the customer, the scope of repair is forwarded to the planner, who uses it as a basis for allocating an appropriate number of employees. In case of additional works, which have not been qualified beforehand, there is a risk of stopping the line. To ensure the continuity of production, it is necessary to increase the number of employees and order additional spare parts. The employees stop their previous tasks, which influences the quality and efficiency of work. Additional works have a negative impact on the relations with the customer, who has to incur additional costs for the wagon repair.

3. Description of the research problem

An analysis of documentation regarding 100 wagons repaired over a period of one month enabled the identification of 301 operations that were not taken into account during the qualification, which gives an average of 3 additional operations per 1 wagon. The analysis enabled the preparation of a Pareto chart which takes into account all the unqualified problems (Fig. 2).

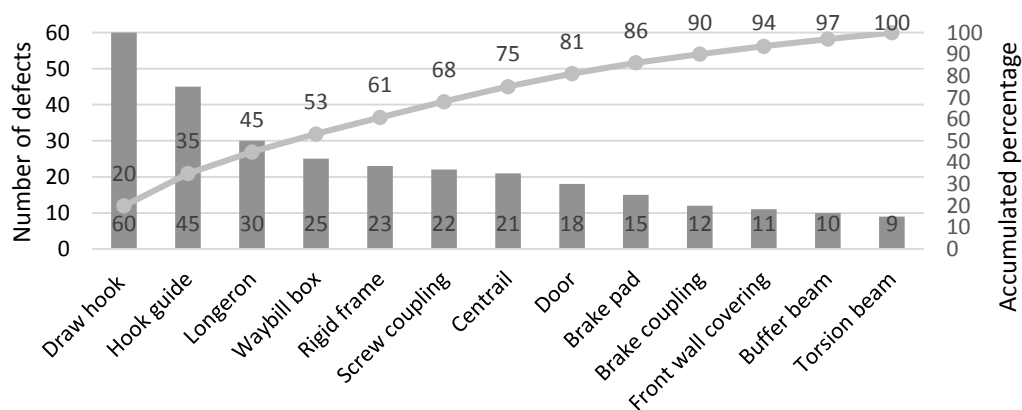


Figure 2. Pareto chart of unqualified repairs.

Verification of the draw hook elements proved to be the biggest problem. The operation of hook replacement accounts for nearly 20% of all additional operations carried out on the downstream line.

4. Analysis and improvement using the 8D method

The method known as 8D – 8 Disciplines Report is the most frequently applied in the automotive industry to solve problems related to improper quality of the parts manufactured by co-operators (Nowicka-Skowron, and Ulewicz, 2016; Skotnicka-Zasadzień, 2018; Stanek et al., 2011). An 8D report comes down to answering the most important questions after the problem has occurred: what was the cause of the problem? And what actions were undertaken to reduce or eliminate it?

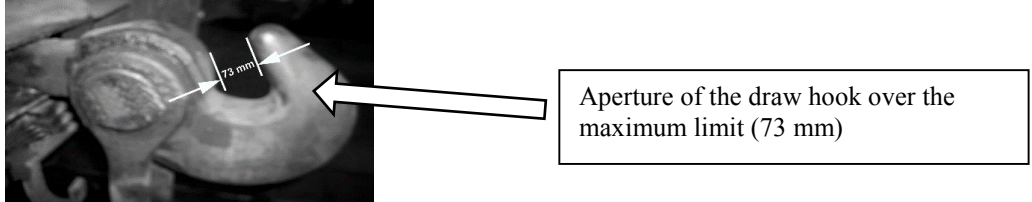
8D is a formalized method which, when accompanied by the use of additional tools, such as e.g. the Pareto chart or the Ishikawa Diagram (Zasadzień, and Midor, 2015; Hąbek, and Molenda, 2017; Wojtaszak, and Biały, 2015; Wolniak, and Zendla, 2015), helps to establish a course of action when solving a problem by moving from the first to the eighth step. The report can have any graphic form, but it should consist of the following elements (Łuczak, and Maćkiewicz, 2016):

- 1D – establishing an interdisciplinary team and choosing the leader;
- 2D – thorough and comprehensible description of the problem to be solved;
- 3D – preparation of actions aimed at providing an immediate, temporary solution;
- 4D – conducting an analysis so as to identify the root cause of the problem using quality management tools;
- 5D – preparation of corrective measures;
- 6D – preparation of preventive measures aimed at consolidating the changes made to the existing system;
- 7D – implementation of corrective and preventive measures as well as verification of their effects;
- 8D – final report on the actions conducted by the team.

Due to a limited size of the study, it describes only steps 2, 4, 5, 6 and 7.

The reason for replacing the draw hook in the wagons subjected to analysis was excessive aperture of the hook, over the maximum value, i.e. 73 mm. In extreme cases this may lead to the splitting of the train set. In case of such nonconformity, the employees must remove the draw hook from the wagon and install a new one. A description of the problem has been included in the 8D Report presented in Table 1.

Table 1.
8D Report – initial part

<i>Problem solving report</i>	
2D. Description of the problem	
Total number of unqualified items	60
	

Another step was conducting an analysis of causes and effects using the Ishikawa method. It was focused only on “man” and “method” elements. The remaining elements known from literature were not applicable in the discussed case (Tab. 2).

Table 2.
8D Report – analysis of causes and effects

4D. Ishikawa				
Who:	What:	Was:	Should be:	Status:
Man	Training	The employee conducting qualification is trained in the Facility Maintenance System	The employee conducting qualification is trained in the Facility Maintenance System	OK
Man	Knowledge of quality requirements	The employees know the quality requirements	The employees know the quality requirements	OK
Man	Too much work	The employees have time for thorough qualification	The employees have time for thorough qualification	OK
Man	Replacement during absence	No threat of failure to conduct correct qualifications	No threat of failure to conduct correct qualifications	OK
Methods	Place of qualification	There is no possibility of checking the hook aperture on the railway siding	There should be a possibility of seeing and measuring all the elements	NOK
Methods	Measuring instrument	Lack of measuring instruments, e.g. slide caliper	Availability of necessary measuring instruments	NOK
Methods	Measuring rod	Lack of measuring rods and standards	Availability of measuring rods and control standards	NOK
Methods	Check list	Lack of a check list	The qualification process should be conducted on the basis of a check list	NOK

Based on the Ishikawa Diagram, the potential causes of qualifying the draw hook for replacement during the initial qualification of the wagon have been identified – they are presented in Table 3.

Table 3.
8D Report – results of the analysis of causes

4D. Analysis results	
Direct cause of failure	The draw hook was not measured during qualification
Indirect cause of failure	No access to the hook during the wagons qualification. Lack of measuring instruments during the wagon qualification.

The major causes of the existing problem were:

- place of qualification. The qualification takes place on the railway siding, where the wagons are marshalled into a train. In such conditions the employee has no possibility of finding out whether the draw hook should be changed;
- lack of control and measurement instruments. The employees do not have measuring instruments. Without a measuring instrument, the employee cannot measure the draw hook aperture;

After the analysis, corrective actions were defined and persons responsible for their implementation were appointed (Table 4).

Table 4.

8D Report – corrective actions

5D. Corrective actions		
Task	Date	Person in charge
Purchase of slide caliper for employees		
Developing a control measuring rod		

First, corrective actions were carried out. The employees conducting the qualification were provided with 7 flashlights and 3 slide calipers. Next, two measuring rods to control the aperture of the hook with a width of 73 mm (upper value permitted by the regulations) were constructed. If the measuring rod penetrates through the hook in any place, the draw hook should be replaced during maintenance works (Fig. 3).

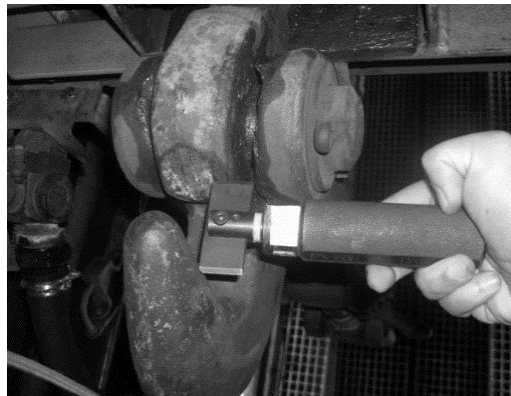


Figure 3. Control measuring rod.

After the analysis, preventive actions were defined – they have been included in the Report presented in Table 5.

Table 5.

8D Report – preventive actions

6D. Preventive actions		
Task	Date	Person in charge
Development of a check list		
Change of the wagon qualification place		

The employees conducting the qualification worked in varying atmospheric conditions, with wagons being shunted on the railway siding all the time, which distracted the employees. The employee responsible for qualification was not able to inspect the chassis and frontal collision elements, as the wagons were coupled with each other.

The preventive action consisted in changing the place of qualification from the railway siding to the production house equipped with hoists and lighting. The change of the wagon position involved additional manoeuvres on the railway siding, which take approximately 1.2 man-hours.

Another action consisted in developing a check list, containing all the elements which must be subjected to control. It was divided into particular wagon subassemblies. It helps the employees to check if all the elements of a wagon have been examined and makes them responsible for conducting the qualification procedure.

Table 6.

8D Report – verification of actions

7D. Verification of actions		
Date of verification:	Person in charge:	
Element of control	Number before	Number after
Number of unqualified elements	19.93%	8.00%

4 unqualified replacements of the hook were conducted, which accounts for merely 8% of all the wagons. Therefore, the number of unqualified failures of hooks decreased by 12 percentage points.

5. Conclusions

Lack of good qualification poses a problem, as it influences the efficiency and quality of the product being repaired; each unqualified work results in the destabilization of the service-providing process as well as an increase in the costs and repair duration. These phenomena also have an adverse effect on the image of the company and its customers' trust.

In the case discussed, the major problem turned out to be the unplanned replacement of the draw hook. It accounted for ca. 20% of all previously unqualified repairs.

The 8D method was used to identify the root causes of qualification mistakes as well as to develop corrective and preventive measures. These actions involved the purchase of measuring instruments, constructing a simple control measuring rod, changing the place of wagon qualification as well as developing a check list. All these actions were easy to implement and did not entail considerable costs for the enterprise.

The implemented actions enabled the decrease of the number of unqualified replacements of the hook from 20% to 8%.

According to the tenets of continuous improvement, the presented methodology should be used to solve the remaining problems with incomplete qualification.

Properly conducted actions included in the 8D method guarantee a reduction or elimination of the problem occurring in the process provided that:

- the problem has been properly identified,
- the analysis of the causes of defects has been conducted in a proper way.

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