Abstract: The presented paper deals with problems of possibility of vehicle maintenance optimalization. The procedure has been worked out by using the RCM (Reliability Centred Maintenance) method, which is suitable for the creation of optimal - dynamic programme of vehicles maintenance. Even if practical presentation is only focused on vehicle brakes, the applied methods and procedures are of general utilisation and can be used where the introduction of the maintenance dynamic programme is required.

Key Words: RCM (Reliability Centred Maintenance), FEM, brakes, SAE, DOT

1. Introduction

Quality properties of products are created in the draft stage, the phase of development and then they are practically applied and verified in the period of production and installation. The most significant phase of any product is the period of operation and maintenance because they are applied in practice during that period of their life cycle. One of the principal methods of influencing the affection of the product quality properties is proper operation and maintenance.

Three fundamental policies of vehicle maintenance can be mentioned: scheduled maintenance (i.e. preventive maintenance), maintenance after a failure (i.e. corrective) and maintenance according to the actual technical condition (i.e. diagnostic maintenance). A question can arise: Which of these maintenance policies is the best one? This is the problem the present paper deals with.

2. The option of maintenance optimisation method

A broad range of methods can be used for the maintenance optimisation project [1]. When selecting a method it is necessary to start from the condition which is most emphasized, i.e. whether it is freedom from disturbances, labour activity, economy in operation, etc. Reliability is significant with safety components of vehicles. Therefore the maintenance method concentrated on trouble-free operation (RMC – Reliability Centred Maintenance) has been described in this article and is assigned for the programming of vehicle safety component maintenance [2].

The RMC method has been originally developed for the civil aircraft industry in the sixties of the last century. It is a method establishing preventive maintenance programme which allows reasonable achievement of required safety level and availability of equipment and structures and has been designed to improve complete safety, availability and economy of operation. This method can be used either for preliminary stages of production or for the operation period.

Basic steps of the RCM analysis are as follows [2]:

A) definition of system and/or subsystem limits;
B) definition of all system and/or subsystem functions;
C) identification of functionally significant items (FSI);
D) identification of related reasons of FSI functional failure, prediction of these failure results and probability of their occurrence;
E) logical decision tree application for the classification of the FSI failure results;
F) identification of applicable maintenance tasks presenting initial maintenance programme;
G) in case no applicable maintenance steps can be identified, the equipment or process design shall be revised;
H) establishment of dynamic maintenance programme resulting from routine and systematic updating of the initial maintenance programme and its revising through monitoring (systematic monitoring), collection and analysis of operational data;

The first step when programming the maintenance by the RCM method is the definition of the system limits and/or subsystem limits. It means that the system/product should be divided into items of lower complexity level. The itemization classifies the system as follows: SYSTEM → SUBSYSTEM → MODULE → ITEM. Individual functions are defined for each subsystem through each item.

The second step is the identification of functionally significant items (FSI). Those items are significant from the maintenance standpoint and show principal influence over safety, dependability and economy of vehicles operation.

The following step identifies relevant causes of FSI function failure, their results and occurrence probability. Both qualitative methods (based on collective professional opinion and practical experience) and quantitative methods (e.g. FMEA method or risk analysis method) can be used for the identification of relevant causes and results of the FSI function failure. The serviceability of maintenance steps has been based on the competent analysis and consideration of importance of the relation FAILURE → CAUSE → CONSEQUENCE.

Logical decision tree shown in the Fig. 1 [2] is used for the classification of the FSI failure results. Questions in three spheres are answered.

In the first sphere the question identified by number 1 (Fig.1) is answered first, either YES or NO. In case the answer to this
question is NO, it is a latent function failure. In case the answer is
YES, it is an obvious function failure.

In the second sphere in case of latent function failure, the
question 3 is answered (Fig.1). If the reply is YES, the results
identified by number 8 affect the safety. In case the reply to the
question 3 is NO then the results (identified by number 9) do not
affect the safety. In case of obvious function failure questions 2
and 4 are answered, then individual function failures are divided
into three basic groups identified by number 5 (results affecting
operation safety), number 6 (results affecting the safety) and
number 7 (results affecting expenses) in Fig. 1.

![Diagram of logical progress chart for the maintenance](image)

In the third sphere – see Fig. 1 the next tree of logical
questions (identified by 5, 6, 7, 8) are answered. Only summary
and chronology of questions to be answered, in case of latent causes
affecting safety (this group is identified by number 8 in the Fig.1),
are shown in the Fig. 2. Similar tree of logical questions for 5, 6, 7
and 9 groups is published in [2]. Actual tasks of the maintenance
programme (inspection, adjustment, other service activities,
overhaul, etc.) are specified by means of these questions and
replies.

The following step identifies applicable and effective
maintenance tasks representing the initial maintenance programme.
It means that periodicity of scheduled maintenance steps is defined
in compliance with selected maintenance policy. Previous
knowledge of similar systems and complete test data from the
producer’s testing can be the initial guidance.

If no applicable maintenance steps can be identified then
either the equipment or process design shall be revised. This final
task of the algorithm need not be necessarily applied however the
possibility of design modification of the vehicle safety elements,
which the service brakes undoubtedly are, shall always be
considered.

![Diagram of classification of consequences and definition
of maintenance programme tasks](image)

3. Practical demonstration of the maintenance programme
creation

Individual steps in this contribution have been analysed with the
help of the above described method and procedure for one of the
most important safety systems, i.e. for the service brakes of
motorcars. With respect to limited extent of this paper, the analysis
of all brake elements will not be demonstrated but only of some of
them. Brake segments and brake liquid (its quantity and quality) are
critical elements for the safety. The analysis procedure has been
demonstrated just with the brake segment example. The logical
procedure and mutual link-up is obvious from the Fig. 3.
4. Conclusion

The presented paper deals with the optimization problems of selected safety elements of vehicles. Utilizing the RCM method (Reliability Centred Maintenance) a procedure suitable for the maintenance dynamic programme creation of vehicle safety elements has been designed. In spite of the fact that practical demonstration is aimed at brake segment in the vehicle service brake only, the methods and procedures applied are general and can be applied where the dynamic maintenance programme shall be introduced.

The present contribution resulted from the research task of the department of MO0FVT0000401 specialty.

References:
2. ČSN IEC 60300-3-11, Management spolehlivosti. Část 3-11: Návod na použití – Údržba zaměřená na bezporuchovost.