POŽIADAVKY NA ZDROJE V SYSTÉMOCH ÚDRŽBY

RESOURCES REQUIREMENTS IN MAINTENANCE SYSTEMS

Ľudmila ZÁVODSKÁ

Abstract
In the article is elaborated information regarding resources requirements within maintenance, specifically human resources, material resources and technical resources. Management and procurement of these resources belong to the supporting maintenance processes therefore is necessary take them into account when planning maintenance.

Key words
Resources, maintenance, spare parts, ABC analysis, assessment, criticality

Introduction

Enterprises use human, material and technical resources in all areas. When we plan maintenance, it is necessary to clarify the need of them. In case of human resources we define job descriptions, qualifications, responsibilities. Within material resources is important inventory management of spare parts. For technical resources is appropriate to consider the need of diagnostic tools, ensuring technical documentation etc.

1 Human resources requirements

When human resources are planned, it is necessary to deploy functional posts and to determine their job descriptions. Also it is necessary to deploy maintenance departments and to determine their competence. Companies also can decide to outsource maintenance services. In this case it is necessary to decide on the share of outsourced maintenance in the company as a whole and the individual shares of maintenance processes and production facilities. An important indicator is the ratio of the costs of outsourced maintenance to total maintenance costs. When personnel are planned, it is necessary to specify the number of staff, their qualification and required training.

2 Material resources requirements

Maintenance quality is generally associated with replacing worn or damaged parts with new parts, so-called spare parts and materials.
Maintenance planning also means planning of inventory of spare parts and materials. For machinery maintenance are spare parts an integral part. In the absence of an item there is a danger of halting the production, which means downtime at work, waiting and production losses. The value of these losses often exceeds the value of the spare part, which would be needed for repair. Spare parts need planning is complicated by the fact that this need arises randomly. However, if the maintenance of machines is planned, there is also a group of spare parts, which has depended need. Therefore it is possible to keep a lower level of inventory of this group, respectively obtain them precisely on the planned date and not to hold inventory.
Spare parts and materials can be divided into two groups:

- Spare parts and materials with dependent need – the company knows, when it will need certain spare parts and materials and it does not have to keep inventory.

- Spare parts and materials with independent need – the need arises randomly after machine failure. If certain spare part will not be available, threatens losses in production.

Planning and management of spare parts is one of the key elements of right function of maintenance and service of machines and equipment. Spare parts inventory management system should allow a comprehensive analysis of inventory of spare parts and materials, electronic searching of spare parts and materials and ordering spare parts and materials.
Inventory of spare parts with independent need can be analyzed using the ABC analysis. ABC analysis determines which parts should be given the most attention. Then it is needed to calculate the size of the safety stock, the ordering batch size and replenishment system.
Ordering batch size that minimizes the total cost of inventory is calculated as:

$$\boldsymbol{Q_0 = EOQ = \sqrt{\frac{2C_oD}{C_h}},}$$

where:
C_h – the total cost of holding one unit in stock for a period of time,
C_o – the total costs of placing an order,
D – demand (units per period of time).

Safety stock is calculated as:

$$\boldsymbol{S = z\sigma_d\sqrt{L},}$$

where:
σ_d – standard deviation of daily demand,
z – number of standard deviations corresponding to a specified probability of service level,
L – continuous delivery time (time units).

2.1 ABC analysis

ABC analysis works through the Pareto rule, where 80 % of all the consequences caused about 20% of the causes.

Table 1. Comparison of items of ABC analysis

Category of items	Proportion (%) of the total value of the parameter	Proportion (%) of the total number of elements	Examples
Group A - important	70 – 80 % proportion	10 – 15 % proportion	Material with high consumption, ordering is done at shorter intervals and has significant importance to reduce costs.
Group B - less important	15 – 20 % proportion	15 – 20 % proportion	Fast moving items that are made and delivered in a very short time, they are ordered at longer time intervals, and they do not have such a significant impact on costs.
Group C - unimportant	5 – 10 % proportion	60 – 80 % proportion	Materials required from the manufacture and slow moving items that are procured always at the request.

General procedure for the classification of items according to ABC method is following:

- select the parameter that best captures the essence of the reference problem,

- calculate the percentage of each element of the total value of the parameter and the total number of elements (Table 1),
- sort elements in ascending order of the percentage of the monitored parameters,
- compile a graph in coordinates: percentage of the total number of elements and the percentage of the total value of the parameter (Figure 1).

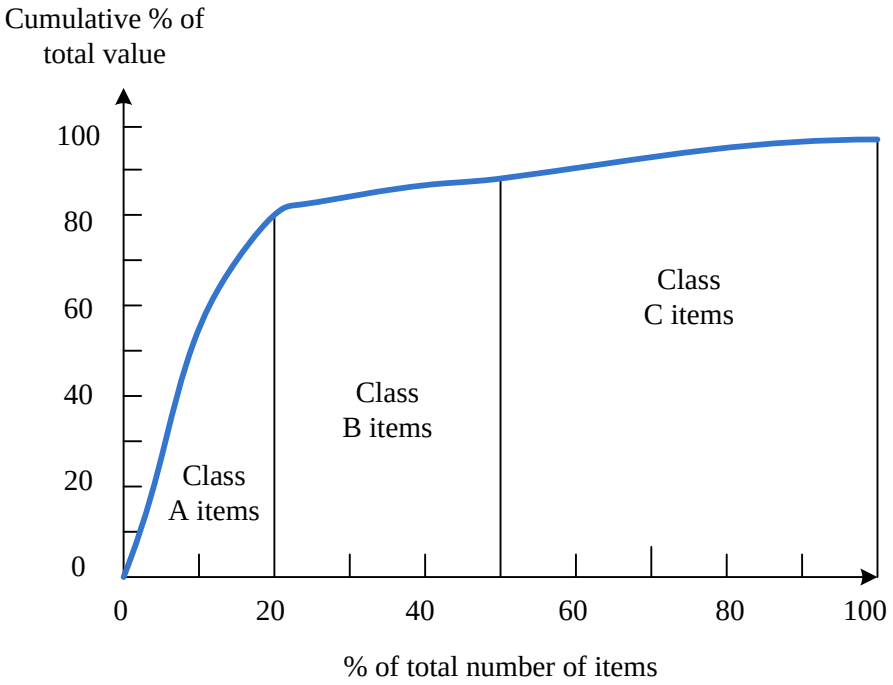

Figure 1. Pareto curve for items in a warehouse

In supplying is often used the principle of Just-In-Time (JIT). Table 2 shows appropriate and inappropriate types of inventory for JIT supplying. Inventory of spare parts are not appropriate items for JIT, because their consumption is not regular.

Table 2. Suitable and unsuitable types of inventory for JIT

Appropriate	Inappropriate
Large-volume or small products grouped into handling units	Small volume of products
High values	Low values
Big amount	Small amount
For different variants	For high acquisition costs
Small procurement risk	For long lead times and large procurement risk
Small production times at customers	Urgently required parts (spare parts)

2.2 Assessment of criticality of spare parts and materials

Assessment of criticality of spare parts and materials can be performed by two ways:

- expert evaluation – this is difficult in terms of time consumption, labour intensity and qualification of the evaluators,
- quantitative calculation – from the data accessible in information systems.

The best is to combine both ways. First to separate uncritical items from the data available and after that to determine criticality by the expert evaluation for the rest. That is how to save the time of experts which they can spend on critical items.

2.3 Assessment of suppliers of spare parts and materials

Even at the procurement of machines it is needed to have a requirement of reliable delivery as one of the requirements to supplier. During the planning of maintenance it is necessary to choose a way of assessment of suppliers not just of purchased spare parts and materials but also of all maintenance services. Selection of appropriate supplier should include comparison of various attributes of several suppliers. The most companies find the best supplier amongst others by means of scoring or various evaluations using different methods. The company also stands in front of the decision either to have more suppliers of spare parts and materials or just one. The Table 3 compares advantages and disadvantages of purchasing from one and from several suppliers.

Table 3. Advantages and disadvantages of gaining sources from one and from several suppliers

	ONE SUPPLIER	SEVERAL SUPPLIERS
ADVANTAGES	- Potentially better quality - Stronger relationships that are more resistant - Bigger dependence supports bigger effort and determination - Better communication - Economies of scale - Higher confidentiality	- Possibility of replacing sources in case of failure - Possibility of using wide sources of knowledge - The buyer can influence the price reduction by means of tender
DISADVANTAGES	- The bigger probability of threat in case of failure of the supply - Supplier is more suggestible by the amount of fluctuations - Possibility of pushing the price to rise if there is no alternative supplier	- It is necessary to develop greater effort in communication - It is less probable that suppliers will invest into new processes - It is difficult to achieve economies of scale

3 Technical resources requirements

Buildings and machines represent a big part of assets of manufacturing companies. For the management of these assets, maintenance workers should have technical documentation available which includes all the equipment, whether manufacturing or outer technical equipment of buildings, safety equipment, utilities and information networks.

Companies have to maintain **technical documentation** – passport which they get from suppliers or manufacturers of particular pieces of equipment.

Basic documents that shall be contained in the passport are:

- description of the machine,
- instructions for transport and installation,
- scheme of the piece of equipment,
- lubrication plan and guide,
- instructions for operation and maintenance,
- certifications and revisions,

- catalogue of spare parts,
- safety regulations and standards,
- program and plan of maintenance,
- program and plan of preventive maintenance – diagnostics,
- records of failures and their removal,
- warranty and its conditions,
- patterns and influence of the equipment on the environment,
- summary of all documents in electronic form.

Other technical resources that are needed for maintenance are various **tools and measuring and diagnostic devices.** Some of them are part of the supply of purchased manufacturing or technical equipment, other have to be bought separately. During the planning of need of tools it is necessary to evaluate requirements, analyse devices that are available at present and determine what tools are needed to buy.
The right placement of maintenance shop also belongs to technical support. When placing the maintenance shop it is necessary to consider categories of individual workplaces, machines, distance from workplaces, distance from warehouses, workplaces of external maintenance, maintenance information systems.

Conclusion
Maintenance systems cannot exist without resources planning. Segmentation of spare parts through ABC analysis is very important. When the company knows groups of spare parts, it has to define economic order quantity and safety stock. Other important thing is assessment of suppliers. Failure of spare parts supplier can cause losses in manufacturing. In addition to material resources is necessary to ensure human and technical resources to the maintenance.

Key words
Zdroje, údržba, náhradné diely, ABC analýza, hodnotenie, kritickosť

Abstract
V článku sú spracované informácie týkajúce sa požiadaviek na zdroje v rámci údržby, konkrétne požiadaviek na ľudské, materiálové a technické zdroje. Riadenie a obstarávanie týchto zdrojov patrí medzi podporné procesy údržby, preto je potrebné brať ich do úvahy pri plánovaní údržby.

References
[1] HLADÍK, T. – ŠUCHA, M. – TULACH, P.: Efektivní řízení zásob náhradních dílů v údržbě. (dostupné on-line 12.11.2014) (http://www.logio.eu/wp-content/uploads/2009/11/efektivni-rizeni-zasob-nahradnich-dilu-v-udrzbe.pdf)
[2] LEGÁT, V. a kol.: Management a inženýrství údržby: Professional Publishing, Praha 2013. 570 s. ISBN 978-80-7431-119-2
[3] SLACK, N. - CHAMBERS, S. - JOHNSTON, R.: Operations management. Pearson Education, Harlow 2007. 728 s. ISBN 978-0-273-70847-6
[4] STEHLÍK, A.: Logistika - strategický faktor manažerského úspěchu. 1. vyd. Brno: Studio Contrast, 2002. 236 s. ISBN 80-238-8332-1
[5] ŠTEFKO, R - RÁKOŠ, J.: Logistika a jej význam pre manažment podniku, In: Zborník vedeckých prác katedry ekonómie a ekonomiky ANNO 2008 [elektronický zdroj] / Rastislav Kotulič. - Prešov: Prešovská univerzita, 2008. - ISBN 978-80-8068-798-4. - S. 333-371.

[6] WATERS, D.: Logistics. Palgrave Macmillan, Hampshire 2003. 354 s. ISBN 0-333-96369-5

Contact address

Ing. Ľudmila Závodská
ŽU, Strojnícka fakulta, Katedra priemyselného inžinierstva,
Univerzitná 1, 010 26 Žilina, Slovakia, ludmila.zavodska@fstroj.uniza.sk