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IMPROVEMENT OF SPARE PARTS STOCK MANAGEMENT SYSTEM FOR LOCOMOTIVE DEPOT

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Abstract *– This paper analyzes the inventory management system of spare parts for Locomotive Depot - Sofia. Considering the large inventory park of the depot, mainly the repair works related to the electric locomotives, series 44, 45, 61, as well as diesel-hydraulic locomotives, series 52 and 55 were considered. The periodicity of planned inspections and repairs is determined on the basis of traveled kilometers or working days. Exploitational inspections are provided for in the locomotive turnover schedule. In order to make an optimal delivery of spare parts in Locomotive Depot - Sofia, it is necessary to carry out analyzes and choose a system for managing the inventory. The decrease in the average availability of spare parts is related to an increase in the number of deliveries during the year, respectively a decrease in the quantity in one delivery. The higher the number of deliveries during the year, the higher the costs of deliveries. Inventory management is related to determining the optimal quantity in one delivery, as well as the optimal number of orders that will balance both types of costs and minimize them without affecting the continuous production.*

Keywords – inventory, parts stock, locomotive depot.

1. INTRODUCTION

Establishing an accurate spare parts supply model for the Locomotive Depot has tremendous benefits on the overall operation of the depot and the Train Running Schedule. In terms of their size, number, location and purpose, all facilities and equipment of the depot must correspond to the type and series of the serviced electric locomotives, and to ensure the performance of all work on their maintenance and repair, in accordance with the specified mileage, program and repair time. In accordance with the production program, the available materials and raw materials, stored in the warehouses of the depot/regions are checked and a request is prepared by product types for the deficient materials.

The supply of spare parts at the right time and in the right quantities, combined with an appropriate inventory model, will facilitate the supply management and repair activities at the depot, as well as minimize and balance the costs of these activities. This will lead to high-quality, accurate repair work, the implementation of the Annual Repair Plan, a reduction in the number of accidental repairs, which will also achieve greater accuracy in the application of annual requests for spare parts, and last but not least, you will ensure a reliable and fail-safe rolling stock to meet the needs of the Train Running Schedule.

The analysis is based on data from the Sofia Locomotive Depot. Considering the large inventory of the depot, mainly the repair works related to the electric locomotives of the 44, 45, 61 series, as well as the diesel-hydraulic locomotives of the 52 and 55 series were considered.

2. STRUCTURE OF THE LOCOMOTIVE DEPOT - SOFIA

The ongoing reforms in the system of "Holding - Bulgarian State Railways" EAD [1] provide clear outlines at the present moment for the function and purpose of the locomotive depot. Locomotive depot Sofia, with its Organization of work in repair [2] and improvement of working conditions [3] and their training [4] is a division included in the organizational and management structure of "BDZ - Passenger Transport" EOOD [5] and Division for passenger transport Sofia. The extent of inspections and repairs is determined by the Depot Repair Regulations [6], [7] and [8] for maintenance for individual series of locomotives and locomotives.

The planning of the repair [2] at the depot it is done for a year, quarterly, monthly and weekly. On the basis of the requests submitted by the regions, based on mileage and days worked, for Major Periodic Repair (MaRP), Hoist repair /HR/, Medium Repair (MR) and Capital Repairs (CR) based on mileage and days worked, the Locomotive Depot

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submits at the end of the current year, if necessary, the plans are added or updated. Purchasing planning is annual and operational /weekly and daily/, which is part of an organizational chart of material flows. Operational inspections are provided for in the schedule for the turnover of locomotives.

According to the reports made, a total of 312 repairs are planned by schedule at the Sofia Locomotive Depot for the year 2023, are shown in Tab. 1: Technical inspections /TI/; Minor periodical repair /MiPR/; Major periodical repair / MaRP /; Hoist repair /HR/, and 402 were implemented, which also depends on [9].

Tab. 1. Data on planned and occasional repairs in the Sofia Locomotive Depot by

for 2023 y.	TI		MiPR		MaPR		HR	
Locomotive series	schedule	implemented	schedule	implemented	schedule	implemented	schedule	implemented
52 00	71	82	19	16	6	7	1	3
55 00	75	97	18	23	1	2	2	1
44 00	16	22	11	9	2	4	4	5
45 00	38	41	10	12			5	2
61 00	15	54	14	19			4	3
	215	**296**	**72**	**79**	**9**	**13**	**16**	**14**

Between-repair runs for the inspections and repairs of series 44 and series 45 electric locomotives, are shown in Fig. 1.

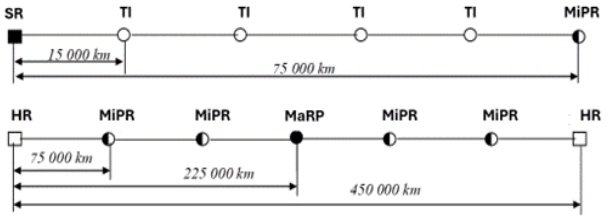

Fig.1. Between-repair runs for series 44 and series 45

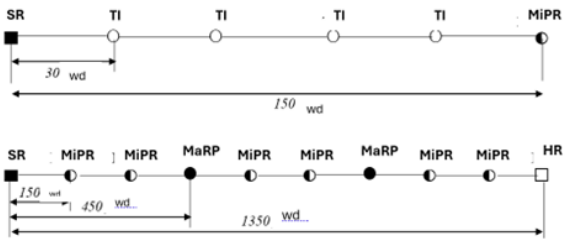

Fig.2. Between-repair runs for series 61

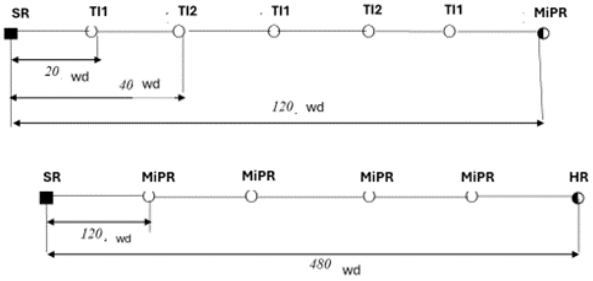

Fig.3. Between-repair runs for series 52

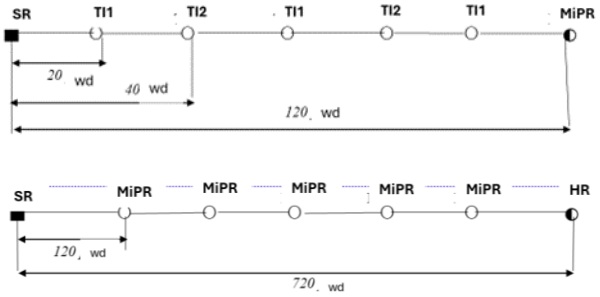

Fig.4. Between-repair runs for series 55

According to the Repair Plan for:

Tab. 2. Data on planned repairs at the Sofia Locomotive Depot by series and by month

month	series 44	series 45	series 61	series 52	series 55
January	14	1	6	6	2
February	9	1	3	1	1
March	11	1	5	6	2
April	10	1	4	0	1
May	12	1	5	5	2
June	8	1	3	1	1
July	9	1	5	5	2
August	9	1	2	0	1
September	8	1	5	5	2
October	7	1	3	1	1
November	11	1	4	6	2
December	10	1	3	1	1
total:	**118**	**12**	**48**	**37**	**18**

For the year 2023, the Sofia Locomotive Depot incurred costs for spare parts in the amount of 86,329,000 BGN. According to these prescriptions, the series of locomotives taken into account is as follows in [6], [2].

After a statistical analysis of the consumption of spare parts and due to their huge number, the report will consider the most frequently used in repairs for each of the presented series of locomotives:

- For Series 44: accumulator batteries, contacts, brake pads and brushes;
- For Series 45: flanges, brake pads, brushes;
- For Series 61: brake pads, brushes;
- For Series 52: accumulator batteries, semmering;
- For Series 55: accumulator batteries, brake pads, semmering;

3. INVENTORY MANAGEMENT SYSTEM

To do selection of a spare parts inventory management system at the Sofia Locomotive Depot and to determine the size and frequency of the order, we need to examine the 4 approaches and choose the one in which the costs are minimal. This is due to the fact that the organization of all deliveries is accompanied by costs that do not depend on the quantity of spare parts requested in them. These costs are minimal when the entire need for spare parts for the year is requested and delivered at once, but at the expense of increasing storage costs. We determine for an order approximately equal to 818 BGN, which

includes: salary costs of procurement employees and all related to the order, business trip costs, fuel costs, telephone costs, other transport costs for delivery, etc.. And the annual costs for storage for each spare part are approximately 28% of the unit price, including the costs of salaries of warehouse workers, security costs, depreciation, etc. The price of each item is in BGN.

- For Series 44 as the annual storage period we get for 1 item per: Accumulator batterie 147,98; Contact 7,88; Brake pad 30,65; Brushe 14,88;
- For Series 45 as the annual storage period we get for 1 item per: Rim 951,08; Brake pad 36,47; Brushe 17,21;
- For Series 61 as the annual storage period we get for 1 item per: Brake pad 32,04; Brushe 15,15;
- For Series 52 as the annual storage period we get for 1 item per: Accumulator batterie 271,16; Semmering 18,30;
- For Series 55 as the annual storage period we get for 1 item per: Accumulator batterie 271,57; Brake pad 33,74; Semmering 18,30;

4. USED SUPPLY MANAGEMENT MODELS

These are models of the type inventory comparison:

- One Time Buy;
- Lot For Lot;
- Simple Economic order quantity (EOQ);
- Silver-Meal Algorithm;

4.1. Application of used models

There is an opportunity to further reduce the cost of an order, and if possible, spare parts for several series of locomotives from the relevant company or another division of BDZ can be supplied with one order. In this case, it is possible to combine the optimal orders for the spare parts discussed in the following way:

Tab. 3. Presentation of optimal solutions by series

	Series 44				Series 45			Series 61		Series 52		Series 55		
Month	Accumulator batteries	Contacts	Brake pads	Brushes	Rims	Brake pads	Brushes	Brake pads	Brushes	Accumulator batteries	Semmering	Accumulator batteries	Brake pads	Semmering
January	13	195	6772	2636	9	6486	1099	6663	1008	16	3609	13	540	2636
February	0	0	0	0	0	0	0	0	0	0	0	0	650	0
March	0	0	0	0	0	0	0	0	0	0	0	0	850	0
April	0	0	0	0	0	0	0	0	1008	0	0	0	570	0
Maybe	0	0	0	0	0	0	1099	0	0	0	0	0	600	0
June	0	0	0	0	0	0	0	0	0	0	0	0	489	0
July	0	0	0	0	0	0	0	0	0	0	3163	0	486	0
August	0	0	0	0	0	0	1099	0	0	0	0	0	651	0
September	0	0	0	0	9	0	0	0	1008	0	0	0	398	0
October	0	0	0	0	0	0	0	0	0	0	0	0	678	0
November	0	0	0	0	0	0	0	0	0	0	0	0	440	0
December	0	0	0	0	0	0	0	0	0	0	0	0	462	0

If we assume that there is an opportunity to combine the orders, then the total costs for purchase, delivery and storage at the Sofia Locomotive Depot will be:

Tab. 4. Costs for ordering by series

	Costs	Costs of combined orders	Costs saved
Series 44	12401	9947	2454
Series 45	10212	8576	1636
Series 61	9264	8446	818
Series 52	9614	8796	818
Series 55	17392	15756	1636
	58882	**51520**	**7362**

So in the month of January, instead of making 18 orders, each of which costs BGN 818 or BGN 28,853, only 1 will be made with BGN 818 costs or BGN 13,906 less. In the months of April, May, August and September, one order was made at a cost of BGN 818. In this way, the total costs for orders and storage for the depot will be BGN 51,520, or BGN 7,362 less, instead of BGN 58,882.

4.2. Results

After the calculations made according to the listed inventory management models, are presented the optimal solutions, where the price of each item is in BGN:

For Series 44:

- 13 Accumulator batteries, which will be supplied on the model One Time Buy, with costs 1045,89;
- 195 Contacts, which will be supplied on the model One Time Buy, with costs 1006,10;
- 6772 Brake pads, which will be supplied on the model One Time Buy, with costs 7153,31;
- 2636 Brushes, which will be supplied on the model One Time Buy, with costs 3195,58;

For Series 45:

- 13 Rims, which will be supplied on the model Simple EOQ, with costs 2033,06;
- 6484 Brake pads, which will be supplied on the model One Time Buy, with costs 4881,83;
- 3076 Brushes, which will be supplied on the model Simple EOQ, with costs 3297,05;

For Series 61:

- 6663 Brake pads, which will be supplied on the model One Time Buy, with costs 4430,00;
- 2605 Brushes, which will be supplied on the model Simple EOQ, with costs 4834,12;

For Series 52:

- 16 Accumulator batteries, which will be supplied on the model One Time Buy, with costs 1368,45;
- 6772 Semmerings, which will be supplied on the model Silver-Meal Algorithm, with costs 8245,11;

For Series 55:

- 13 Accumulator batteries, which will be supplied on the model One Time Buy или Simple EOQ , with costs1236,22;
- 6814 Brake pads, which will be supplied on the model Lot For Lot, with costs 9816;
- 2636 Semmerings, which will be supplied on the model One Time Buy, with costs 6339,54;

Tab. 4. Inventory for each series, by months

Month	Series 44				Series 45			Series 61		Series 52		Series 55		
	Accumulator batteries	Contacts	Brake pads	Brushes	Rims	Brake pads	Brushes	Brake pads	Brushes	Accumulator batteries	Semmering	Accumulator batteries	Brake pads	Semmering
January	13	195	6772	2636	13	6486	3076	6663	2605	16	6772	13	6814	2636
February	11	173	5992	2335	11	5696	2875	5923	2305	14	5992	11	6274	2335
March	10	155	5452	2050	10	5176	2517	5403	2020	14	5452	10	5624	2050
April	9	140	4844	1830	9	4672	2297	4803	1800	11	4844	9	4774	1830
Maybe	8	123	4273	1584	8	4201	2051	4233	1560	11	4273	8	4204	1584
June	7	107	3661	1364	7	3580	1726	3613	1350	7	3661	7	3604	1364
July	6	92	3163	1110	6	2993	1472	3115	1100	7	3163	6	3115	1110
August	5	76	2479	890	5	2528	1070	2433	880	6	2479	5	2629	890
September	4	62	1918	701	4	1959	781	1898	700	6	1918	4	1978	701
October	3	46	1420	555	3	1457	645	1400	560	5	1420	3	1580	555
November	2	33	842	366	2	879	356	830	370	3	842	2	902	366
December	1	16	412	146	1	451	126	410	148	3	412	1	462	146

Thus, in the locomotive depot there will be the following stock of the examined spare parts for each series, by months.

5. CONCLUSION

Inventory management is related to determining the optimal quantity in one delivery, as well as the optimal number of orders that will balance both types of costs and minimize them without affecting continuous production.

Creating an accurate spare parts supply model for the Locomotive Depot has tremendous benefits on the overall operation of the depot. On-time delivery and in the right quantities of spare parts, combined with an appropriate inventory management model, will facilitate supply and repair activities in the depot, as well as minimize and balance the costs of these activities. This, in turn, will lead to quality repair work, accurate implementation of the Annual Repair Plan, reduction in the number of accidental repairs, which will result in greater accuracy in the development of annual requests for spare parts and, last but not least, ensuring reliable and trouble-free transportation of locomotives.

REFERENCES

[1] https://holding.bdz.bg/bg/

[2] Sbornik „Normativni dokumenti na Lokomotivnoto stopanstvo na BDZh" ot 1988g.naredba-13-30122005-osiguryavane-na-but-972.pdf (bdz.bg)

[3] Obshta harakteristika na lokomotivnoto depo. Spirachna vryzka - diplomna rabota (bobrodobro.ru)

[4] https://www.bdz.bg/bg

[5] Pravilnik za depovski remont i poddyrzhane na elektricheski lokomotivi na BDZh ot 01.01.1979.

[6] Pravilnik za depovski remont i poddyrzhane na dizel-hidravlicheski lokomotivi na BDZh ot 01.01.1979g.

[7] PLS 100-1 ot 01.10.2011g. za mezhduremontnite probezi i ciklichnostta na planovite pregledi i remonti na elektricheskite lokomotivi i elektricheskite motrisni vlakove na "BDZh – PP" EOOD

[8] Vanio Ralev, Dobrinka Atmadzhova, DURABILITY (RESOURCE) ON WHEELSETS FROM PASSENGER WAGONS, Nauchno spisanie „Mehanika, Transport, Komunikacii", ISSN 1312-3823, tom 20, broj 3, 2022 g., statija № 2233, (mtc-aj.com)

[9] Bowersox Closs and Cooper "Supply chain logistics management" McGraw Hill 2002