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Unification of Terms of Maintenance and Repair of Passenger Railway Cars and Their Elements as the Main Part of Implementation of the Operational Stage of the Life Cycle Contract

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ABSTRACT

The article is devoted to consideration of issues of analysis of units and parts used in newly built rolling stock, their systematisation and formation of an accounting algorithm, as well as to the issues of their replacement with determination of problematic aspects and ways to level them. The service life of main elements and units used in passenger rolling stock has been studied, allowing to determine the terms of their periodic replacement, maintenance and repair, and to propose an algorithm for their control.

The study refers to the issues of replacement or maintenance of individual units, parts and elements of passenger cars with reference to the period of scheduled preventive maintenance, as well as to the need to consolidate individual requirements at the stage of designing the rolling stock and its elements in the regulatory and legal field to improve the efficiency of using rolling stock at the operational stage of its life cycle and minimise the transfer of rolling stock to the non-working fleet withdrawing it from transportation activity.

The studies of the regulatory documentation supplied during manufacture of a car are followed by the analysis and systematisation of the service life of the car itself, as well as of its main units and assemblies.

This study is intended to improve the efficiency of rolling stock operation, systematise and, in some cases, establish requirements for the service life of individual units, mechanisms and elements in manufacture and design of passenger cars, simplify and optimise assessment of the life cycle cost of a car, synchronise the stages of the life cycle of individual elements of the rolling stock with the life cycle (cyclic replacement) of units and parts used in the rolling stock.

Keywords: *railway transport, passenger car, repair, maintenance, unification, model, design.*

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INTRODUCTION

One of the main directions in increasing the efficiency of rolling stock use is minimising its withdrawal from operational activities due to transfer to non-working fleet, which leads to a decrease in the efficiency of use and increases the costs of maintenance at the operational stage of the life cycle [1].

The issue of using the resources of service life of traction and rolling stock is systematically considered when forming both technical specifications for the manufacture of new products and in operation, including in terms of dependability and durability parameters [2]. At the same time, there are situations when manufacturers of individual units and assemblies supplied to passenger cars specify service life less than the service life of the car itself, or assume the possibility of their multiple replacement with reference to scheduled preventive maintenance or to its appointed term, which leads to an increase in the costs of car maintenance during the operational period of the life cycle [3].

Thus, from the analysis of domestic practices of operation of the main units and parts installed on passenger cars of models 61–4465, 61–4523, 61–4472, it follows that a significant number of car elements require periodic replacement of units and parts without reference to the next scheduled preventive repairs or they work out their standard service life before the end of the standard service life of the passenger car itself.

Thus, periodic replacement of such elements as a high-voltage converter, a system of environmentally friendly toilet complexes, etc. significantly reduces the rate of unscheduled withdrawal of the car from operation for replacement of elements following their assigned service life[1].

The work carried out in recent years on interstate standardisation of the main requirements in the railway industry and, in particular, those imposed on passenger rolling stock, does not affect the issue of unification of service life of units and parts installed on manufactured or repaired rolling stock, since the regulatory framework, as a rule, regulates only the general principles, criteria and requirements for units in terms of ensuring their dependability, strength, electrical and fire safety, as well as a number of other parameters[2].

The objective of the study is to analyse the regulations and technical documentation used in manufacture, maintenance and repair of passenger cars, their units and parts. The study uses methods of normative and legal analysis, engineering modelling and comparative research.

RESULTS

In accordance with the requirements of the Technical Regulations of the Customs Union «On Safety of Railway Rolling Stock» (TR CU 001/2011)[3], it is stipulated that safety of railway rolling stock and its components must be ensured, among other things, by establishing designated service life and (or) product useful life (resource), as well as by conducting technical maintenance and repairs with the required frequency. At the same time, there are no requirements for mandatory linking of repair or maintenance of all units, parts and components of a car to technical maintenance of the car or scheduled preventive maintenance of the car itself.

Thus, to provide access for passengers with limited mobility, hydraulic lifts KPV-1[4] or KPV-2[5] are used, for which the frequency of maintenance in the volumes of TMR-1 [technical maintenance and repair], TMR-2 and TMR-3 is regulated before the next trip of the car (train), once a month and once every six months, respectively. However, according to regulatory requirements for the frequency of technical maintenance of rolling stock in the volumes of TMR-2 and TMR-3, it is carried out in preparation for summer and winter

[1] Double-deck passenger cars. «Guidelines for depot and major (KR-1) repairs» 060 PKB TsL, 2014 RD, Moscow, JSC «Russian Railways», 205 p.

[2] GOST [Russian State standard] 15.016–2016 «System for developing and putting products into production. Technical specifications. Requirements for content and design». Moscow, Standartinform publ., 2020, 31 p. [Electronic resource]: http://gost.gtsever.ru/Data/642/64271.pdf. Last accessed 26.10.2023.

[3] Technical Regulations of the Customs Union «On Safety of Railway Rolling Stock» (TR CU 001/2011). [Electronic resource]: http://www.eurasiancommission.org/ru/act/texnreg/deptexreg/tr/Documents/TR%20Podvignoisostev%20PID.pdf.
Last accessed 26.10.2023.

[4] Set of car lifts KPV-1. «Passport OP.K92 PS». St.Petersburg. VNITI publ.2001, 43 p.

[5] Set of car lifts (Model KPV-2). «Passport OL.K112PS». St.Petersburg. VNITI publ. 2003, 50 p.

transportation, and in the volume of TMR-3 annually.

For autonomous operation during long-term parking, several passenger car series have an autonomous power supply system using diesel generator units[6], for which the frequency of maintenance is calculated in engine hours, however, the frequency of maintenance of the car itself is calculated in calendar or running periods. Thus, the risk of violation or failure to comply with scheduled periods of maintenance or repair of individual units, parts or assemblies of the car, including those providing for placement of rolling stock in some cases for a long period in repair positions in repair and maintenance workshops, increases. This factor also reduces the efficiency of using rolling stock, which in turn affects the need for maximum use of rolling stock.

At the same time, based on the results of the analysis of such components used in passenger rolling stock as hydraulic vibration dampers, universal shock absorbers, brake equipment parts (anti-skid valve, pulse sensor), interior equipment components (regulating flaps, fire-resistant doors of passenger cars, video surveillance and registration system, mobile information, communication and configuration system), it was revealed that no standard service life has been established for them. The standard service life of 16 years has been established for components of electrical and high-voltage equipment (lighting fixtures, high-voltage cables and sockets, alarms). The service life of several types of equipment (environmentally friendly toilet complexes, cold and hot water supply units, window frames, on-board measuring complex for monitoring axle box heating, etc.) varies from 20 to 28 years. A service life of 40 years, similar to the designated service life of the double-decker passenger car itself, is regulated only for the body, bogies and inter-car gap-free coupling device (Table 1).

The results of the analysis of the nomenclature of manufacturers of units and parts used in double-decker passenger cars show that when developing repair and maintenance manuals, there was no coordination between the service life and frequency of repair or maintenance of elements, units or parts of cars with the frequency of service life, repair and service of the car itself, which is necessary [4].

Along with the issues arising due to desynchronisation of the frequency of repair and maintenance of rolling stock, there is also the issue of the efficiency of using newly installed units on rolling stock. For example, after replacing the environmentally friendly toilet complex during operation, the car where it is installed could be written off with these units that have worked out only a third of the standard service life of the newly installed complex. And the use of this equipment when writing off the car itself can be predicted according to the following scenarios: writing off this complex together with the car or its dismantling, storage, relocation (if necessary) and placement on another car, which will require additional financial costs and additional distraction of personnel to carry out work on dismantling/installing the equipment, to use premises for its temporary storage.

DISCUSSION

Thus, the issue of linking the frequency of repair and maintenance of parts, units and assemblies installed during construction of passenger rolling stock, as well as regulating the requirements for synchronising the frequency of maintenance, repair or the frequency of their replacement during the operational period of the car is very relevant [5].

It is possible to mitigate these risks in the following way.

1. At the stage of forming the technical assignment, the customer, when concluding a contract for purchase of rolling stock (in case that the owner of rolling stock will carry out maintenance and repairs on his own), shall regulate the requirements for synchronous frequency of repairs and maintenance of both the car as a whole and all its elements. When implementing it, risks may arise in finding alternative suppliers of individual elements of the car, which will ultimately lead to a change in the cost of the car, and additional time will be required to implement procedures related to approval of changes in design of the passenger car being developed.

2. When concluding a life cycle contract for manufacture and maintenance of rolling

[6] Undercar diesel generator set. Operation manual 076.01.00.00.00.000 RE, Voronezh, branch of JSC Vagonremmash, Voronezh Carriage Repair Plant, 2016, 34 p.

Table 1

Main service life and frequency of repair of elements of a double-decker passenger car

№	Product name	Service life	Repair frequency
Chassis and undercarriage equipment			
1	ZF Sachs vibration dampers	not regulated	not regulated
2	Shock absorber, universal	not regulated	depot repair – once every three years; major repairs – once every six years
3	Absorbing device with polymer elastic elements for automatic coupling devices of passenger rolling stock	recommended service life 28 years	repair of the device is carried out in accordance with the operations manual of the coupling device, in which it is integrated
4	Inter-carriage gapless coupling device	40 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
5	Set of closed rotary footrests	not less than 28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
6	Bogie	40 years for the frame, bolster beam	600 000 km or three years
7	Torsion stabilizer	1 million load cycles	600 000 km or three years
Brake and auto brake equipment			
8	Tank	20 years	not regulated
9	Tank	20 years	not regulated
10	Anti-skid valve	not regulated	not regulated
11	Pulse sensor	not regulated	according to operations manual, repair and technical documents
12	Brake control device	20 years	according to operations manual, repair and technical documents
13	Tong mechanisms	not regulated	selective major repairs after three years of operation, according to the maintenance plan
14	Air distributor 242–1	20 years	according to operations manual, repair and technical documents for brake equipment
15	Electric air distributor 305	20 years, general	according to operations manual, repair and technical documents for brake equipment
16	Electric air distributor 305	15 years, coil	according to operations manual, repair and technical documents for brake equipment
17	Axial brake disc	by condition	turning according to condition
18	Collets	600 000 km	no
19	Pressure alarm	10 years	not established
20	Pressure relay	15 years	not established
21	FLEXBALL Remote Control Cable	16 years with KR-2	with KR-1 (4–5 years)
Electrical equipment			
22	Electrical equipment kit	not established	not established
23	Maintenance-free battery	average service life 12 years	not repairable
24	Door diagnostic unit	not less than 28 years	produced only by employees of the manufacturing plant
25	Automatic door control unit	not less than 28 years	produced only by employees of the manufacturing plant
26	Water heater	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
27	Lamp	16 years	once every two weeks
28	Heater ENZhV	20 years	
29	Axial fan	not regulated	every six months
30	Information panel	not regulated	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
31	Route panel	not regulated	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
32	Information panel controller	not regulated	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
33	Air disinfection plant	20 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
34	Low pressure amalgam bactericidal lamp	8000 hours or 4 years, or 5000 turning on	according to operations manual and repair and technical documents for equipment
35	Electronic starting control device	before KR-1, but not more than 8 years	according to operations manual and repair and technical documents for equipment
36	Socket MVS-1M-R185/ 2x95–4000/800	16 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
37	Receiver idle	16 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents

№	Product name	Service life	Repair frequency
38	Plug with cable	16 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
39	Plug with cable	16 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
40	Socket MVS-2-R185/2x95–4000/800	16 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
41	Set of converters for passenger cars with power supply from high-voltage mains	28 years	according to operations manual and repair and technical documents for equipment
42	Voltage converter	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
43	Control unit for car power supply with converter BUEV-P	not regulated	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
44	High voltage box	not regulated	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
45	Water disinfection plant	20 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
Internal and peripheral equipment			
46	Sealed inter-carriage passage	at least 16 years	1. monthly service 2. semi-annual service
47	Fire damper	not regulated	not regulated
48	Regulating valve	not regulated	preventive and periodic inspections of the valve at least once a year
49	Footrest rotating closed right	at least 28 years	not regulated
50	Footrest swivel closed left	at least 28 years	not regulated
51	Shower kit	resource 30000 hours, service life 16 years	not regulated
52	Mobile information, communication and configuration system	not regulated	not regulated
53	Fireproof door for passenger cars	not regulated	not regulated
54	Automatic air vent	not regulated	not regulated
55	Single-leaf side door with electromechanical drive	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
56	Double-leaf end door with electromechanical drive	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
57	Air duct kit	28 years	once every three years
58	Aluminium-plastic frames	28 years	after 600 000 km, once every 4–5 years
59	Installation of fire alarm and fire extinguishing systems	not regulated	not regulated
60	On-board measuring complex for temperature control of axle boxes of passenger cars	20 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
61	Control and diagnostic system for car electrical equipment	not regulated	not regulated
62	Controller for control of electric equipment of the car	not regulated	not regulated
63	Mixer	16 years	not regulated
64	Video surveillance and registration system	not regulated	not regulated
Elements of environmentally friendly toilet complexes and supply of cold and hot water			
65	Vacuum installation UVSh	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
66	Vacuum toilet	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
67	Toilet complex TK-05	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
68	Storage tank	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
69	Liquid level alarm	16 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents
70	Installation of cold and hot water supply	28 years	frequency of repair and technical maintenance coincides with operations manual, repair and technical documents

stock throughout the operational stage of the rolling stock life cycle, these risks will be on the side of the contractor, who himself, at the stage of rolling stock development, will be interested in synchronising this process and minimising the withdrawal of rolling stock from operation.

In the current conditions, when the rolling stock has already been purchased, and the issues of maintenance and repair are the responsibility of the owner, the most appropriate mechanism for carrying out maintenance and repair is to proceed according to a hybrid system with the linkage of replacement of car units and parts both to the term of maintenance in the amount of TMR-3 or scheduled preventive maintenance, and/or with formation of separate programs for their replacement according to a separate schedule. To accomplish this task, it is necessary to develop software capable of tracking and automatically predicting replacement of individual elements of the rolling stock decommissioned according to the calendar or running period.

CONCLUSIONS

The following effects are achieved by switching to the proposed system of repair and maintenance of passenger rolling stock.

1. Increased traffic safety. It will be possible to identify and eliminate rolling stock malfunctions during scheduled repairs or maintenance of rolling stock, i. e. before they cause an incident or equipment failure.

2. Cost reduction. Due to this approach, timely replacement or repair will reduce the risk of a car being idle for a long time in a non-operating yard when a critical malfunction of a rolling stock unit or assembly occurs or develops.

3. Increased dependability due to timely and complete scheduled maintenance and repair work on rolling stock, as well as timely replacement of car units and parts that have reached the limits of their standard service life.

4. Improving the quality of service and introducing advanced diagnostic tools, automatic control, digitalisation of rolling stock repair and maintenance processes, allowing to identify systemic faults of individual elements of cars, eliminate the risks of receiving individual faulty elements or a batch of products both during construction of rolling stock and during maintenance or repair, which will have a positive effect on the quality of services provided and will improve the comfort of passenger travel.

In general, the use of a hybrid repair and maintenance system has many positive effects for ensuring high-quality operation of rolling stock and achieving a high level of dependability, ensuring safety and efficiency of passenger rolling stock.

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