

## Statistical estimates of the probability of fail-safe functioning of freight wagons in the interval between repairs

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**Summary.** During exploitation wagons must fully implement the transportation process safely. Wagons spend their own technical resources in the process of exploitation, and therefore they need to be restored. During the process of moving, accumulated defects in the moving part, axle boxes, brake equipment and in other knots of wagons, and the number of failures in wagons depend on the reliability of the construction and on the quantity of kilometers that the wagons have run.

**Key words:** REPAIR, WAGON, PROBABLY, INDIFFERENCE, RELIABILITY SERVICE LIFE, PRODUCTION, TECHNICAL CONDITION, STATISTICAL, QUALITY, MAINTENANCE.

### Introduction.

According to GOST 27.002.89 reliability is defined as the ability to maintain all the parameters (TS, maintenance, storage, transportation and movement) that characterize the functions of the

object (wagon) during technical exploitation within a specified period of time. The reliability of the object is characterized by complex indicators such as fail-safe functioning, durability, repairability, and maintenance [1.4].

Table 1,

Production year	Covered wagon	Platform	Gondola	Isothermic	PR	Cistern	Total
Until 1985	1006	436	850	511	909	712	4424
1986	125	114	-	-	-	141	380
1987	172	113	-	-	-	100	385
1988	95	127	-	16	116	72	426
1989	96	111	-	17	135	110	469
1990	69	104	-	15	80	96	364
1991	72	64	-	5	33	43	217
1992	21	3	-	-	-	4	28
1993	16	2	-	-	1	20	39
1994	2	-	-	-	-	-	2
1995	-	-	-	-	-	14	14
1998	-	-	-	-	-	4	4
1999	-	-	-	-	-	9	9
2000	-	-	-	-	-	4	4
2001	-	-	-	-	-	46	46
2002	-	-	-	-	-	51	51
2003	-	-	-	-	-	61	61
2015	401	400	1000	-	700	530	2031
2016	-	-	-	-	-	70	70
2021	40	30	50	-	60	76	256
Total	2115	1504	1900	564	1974	2087	10280
Exploitation period	32	32	22	30	30	32	-

**Main part.** According to GOST27.002.89, the object losing its self-sufficiency is called refusal. When it comes to the refusal of freight wagon (cistern), it is understood that wagon would lose its operational capability and go repair beyond the plan. In this section, key issues of the fail-safe functioning which are the key component for reliability will be analyzed. Fail-safe functioning is a feature of continuous maintenance of the working condition of the object (wagon) for a certain period or period of operation. The existing distribution features of the key parameters of reliability require more accurate approach to the fail-safe functioning in the possible aspect. The possible aspect is reflected in various indicators of reliability.

The database of the experimental research works in the article is based on the data of the "Automated Data Bank" of the Freight Wagons Fleet of the "Commonwealth of Independent States" information system. The Automated Databank of the Freight Wagons Fleet contains all information on wagon owner, its registration, technical characteristics, passage of planned and non-planned maintenance types, technical condition, modernization of wagons, etc. Table 1 shows age-structure of Freight Wagons Fleet of Azerbaijan Railways Closed Joint Stock Company (CJSC) [5,7]. The implementation of a new information resource at the Wagon Repair Enterprises of the CIS countries since 2009, on "Planned repair of freight wagons and a half-system of production quality

within the framework of expanding the functional capabilities of the integrated information system of wagon management" highlighted the fulfillment of the following issues:

Table 2

№	Parameters names	Units	Indicators
1	Model of wagon		15-1443
2	Assigned service life (ASL)	Year	32
3	The number of capital repairs during ASL	Year	2
4	Periodicity of conducting capital repairs	Year	13
5	1 <sup>st</sup> Planned repair after operation	Year	3
6	Periodicity of conducting warehouse repairs	Year	2
7	The number of warehouse repairs during ASL		12

- improving the accuracy of the assessment of production and repair quality assurance at the wagon manufacturing and repairing enterprises, based on the analysis of inter-service operation of repaired and produced wagons;

- improvement in quality of planned repair types (warehouse and capital) of freight wagons and performance of production at wagon repairing and manufacturing enterprises;
- increasing the number of work parks of the railway network;
- reducing operating expenses of freight wagons by reducing the number of wagons involved in current repair;

- organization of a single information database in the field of repair quality of freight wagons at the expense of the organization of an automated system for the control of wagon repair and exploitation quality [3,6].

Table 3

Operation, day	Warehouse Repair (WR)		Capital Repair (CR)		Increasing the service life of the Capital Repair		New wagon (NW)	
	Probability of fail-safe functioning	Probability of failure	Probability of fail-safe functioning	Probability of failure	Probability of fail-safe functioning	Probability of failure	Probability of fail-safe functioning	Probability of failure
30	0,9908	0,0092	0,9922	0,0078	0,9897	0,0103	0,9978	0,0022
90	0,9622	0,0378	0,9736	0,0264	0,9672	0,0328	0,9876	0,0124
150	0,9304	0,0696	0,9537	0,0463	0,9412	0,0588	0,9761	0,0239
210	0,8936	0,1064	0,9324	0,0676	0,9113	0,0887	0,9653	0,0347
270	0,8531	0,1469	0,9095	0,0905	0,8824	0,1176	0,9525	0,0475
330	0,8122	0,1878	0,8858	0,1142	0,8478	0,1522	0,9357	0,0643
390	0,7755	0,2245	0,8586	0,1416	0,8002	0,1998	0,9123	0,0877
450	0,7426	0,2574	0,8314	0,1686	0,7554	0,2446	0,8868	0,1132
510	0,7154	0,2846	0,8067	0,1933	0,7088	0,2912	0,8602	0,1398
570	0,6978	0,3022	0,7871	0,2129	0,6603	0,3397	0,8538	0,1662
630	0,6856	0,3144	0,7697	0,2303	0,6194	0,3806	0,8082	0,1918
690	0,6765	0,3235	0,7551	0,2449	0,5831	0,4169	0,7829	0,2171
750	0,6714	0,3286	0,7484	0,25160	0,5625	0,4375	0,7591	0,2409
810	-	-	-	-	0,5544	0,4456	0,7371	0,2629
870	-	-	-	-	0,5512	0,4488	0,7142	0,2856
930	-	-	-	-	0,5484	0,4515	0,6918	0,3082
990	-	-	-	-	0,5472	0,4528	0,6566	0,3434
1050	-	-	-	-	0,5464	0,4536	0,6465	0,3535
1080	-	-	-	-	0,5456	0,4544	0,6380	0,362

Taking into account the above mentioned requirements, the following indicators are used in the dissertation work to estimate the proposed and required quality of Azerbaijan Railways CJSC in the wagon economy:

- Indicator of fail-safe functioning- K is a numerical value indicating fail-safe functioning during exploitation or a specified period of exploitation within the movement and expressed in %;

- flow parameter of failure –  $\lambda_a$  is a ratio of the number of failures in wagons occurring during the period under review to the number of wagons in exploitation.

- average operating time to failure –  $T_a$  is expressed in km, and characterized by the ratio of the total number of the wagon operation.

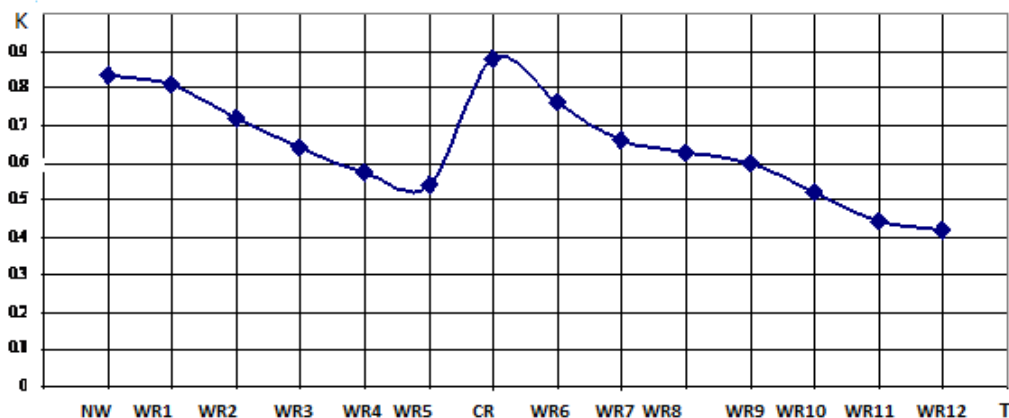


Figure 1. The schedule of change in the average limit probability of the fail-safe functioning of the cistern wagon in the interval between repairs.

The characteristics of the repair system of cistern wagon are given in Table.2 [2]. Estimate of the planned repair of freight wagons and quality of preparation (production) is carried out using the existing information technology in automated mode.

The survey estimates that are expressed in a day for the reliability indicators of the cistern wagon on performed work: production, warehouse repair, capital repair, capital repairs that lead to lengthening of useful life period, and the exploitation of wagons are determined according to the indicators of 2016. These reliability

indicators of the cistern wagons are shown in Table 1.3 in accordance with the data from “the Central Directorate for repair of freight wagons” of CIS countries [2]. Taking into account the degradation (aging) of the wagon construction, estimates of the probability of fail-safe functioning in the life cycle of the cistern wagon 15-1443 model are given in Table 4. Figure 1 shows the graphs of the probability of fail-safe functioning of the cistern wagon during the interval between repairs.

Table 4

Exploitation time, day	Estimate of the probability of the fail-safe functioning in the interval between repairs.													
	New wagon	WR1	WR2	WR3	WR4	WR5	CR	WR6	WR7	WR8	WR9	WR 10	WR 11	WR 12
30	0,998	0,992	0,883	0,786	0,699	0,643	0,992	0,888	0,781	0,715	0,706	0,624	0,555	0,527
90	0,989	0,962	0,856	0,764	0,678	0,636	0,975	0,862	0,760	0,705	0,694	0,612	0,531	0,506
150	0,977	0,931	0,829	0,737	0,658	0,612	0,956	0,839	0,738	0,691	0,672	0,598	0,512	0,496
210	0,966	0,895	0,795	0,708	0,632	0,596	0,933	0,812	0,719	0,678	0,650	0,573	0,498	0,472
270	0,954	0,853	0,761	0,675	0,603	0,574	0,909	0,791	0,695	0,653	0,631	0,551	0,473	0,450
330	0,935	0,812	0,722	0,645	0,576	0,552	0,887	0,774	0,671	0,631	0,612	0,530	0,455	0,432
390	0,914	0,777	0,692	0,618	0,548	0,524	0,859	0,751	0,653	0,614	0,598	0,514	0,434	0,408
450	0,888	0,743	0,662	0,587	0,524	0,503	0,833	0,733	0,631	0,603	0,572	0,495	0,414	0,392
510	0,861	0,717	0,638	0,567	0,509	0,488	0,807	0,711	0,614	0,595	0,551	0,471	0,395	0,374
570	0,835	0,698	0,622	0,554	0,494	0,463	0,787	0,690	0,596	0,571	0,524	0,452	0,378	0,352
630	0,809	0,684	0,611	0,541	0,482	0,441	0,771	0,669	0,572	0,554	0,501	0,430	0,364	0,335
690	0,784	0,677	0,603	0,537	0,479	0,438	0,758	0,638	0,512	0,501	0,470	0,401	0,352	0,301
750	0,759	0,672	0,599	0,533	0,474	0,434	0,742	0,633	0,503	0,494	0,465	0,394	0,341	0,296
810	0,738	-	-	-	-	-	-	-	-	-	-	-	-	-
870	0,716	-	-	-	-	-	-	-	-	-	-	-	-	-
930	0,693	-	-	-	-	-	-	-	-	-	-	-	-	-
990	0,669	-	-	-	-	-	-	-	-	-	-	-	-	-
1050	0,648	-	-	-	-	-	-	-	-	-	-	-	-	-
1080	0,639	-	-	-	-	-	-	-	-	-	-	-	-	-
Average limit	0,836	0,811	0,722	0,643	0,573	0,539	0,877	0,763	0,661	0,626	0,598	0,520	0,446	0,420

Table 5

№	Interval between repairs	The average probability of fail-safe functioning	Interval between repairs, monthly	Duration of fail-safe functioning, monthly
1	New wagon-warehouse repair (WR)№1	0,836	36	30,096
2	WR №1 -WR №2	0,836	24	19,464
3	WR №2 -WR №3	0,836	24	17,328
4	WR №3 -WR №4	0,836	24	15,432
5	WR №4 -WR №5	0,836	24	13,752
6	WR №5 – CR	0,836	24	12,936
7	CR - WR№6	0,836	24	21,048
8	WR №6 -WR №7	0,836	24	18,312
9	WR №7 -WR №8	0,836	24	15,864
10	WR №8 -WR №9	0,836	24	15,024
11	WR №9 -WR №10	0,836	24	14,352
12	WR №10 -WR №11	0,836	24	12,480
13	WR №11-WR №12	0,836	24	10,704
14	WR №12- wagon removal from the inventory park	0,836	24	10,088
15	Average estimate	0,836	-	16,205

The schedule change in the average limit of the probability of fail-safe functioning of the cistern wagon. The average estimates of the probability of fail-safe functioning of the cistern wagon in the interval between repairs are shown in table 1.5.

**Abstract.** The probability of the fail-safe functioning of the cistern wagon in the designated service period has been determined using the information resources of "the quality subsystem of the production and scheduled repair of freight wagons". The schedule change of the average limit of the probability of fail-safe functioning of the cistern wagon in the interval between repairs has been compiled.

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