

The Calculation of the Spare Parts in the Auto-service Enterprise on the Base of Real Demand

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To cite this article:

Dyshin Oleg Aleksandr, Karimov Nijat Ashraf. The Calculation of the Spare Parts in the Auto-service Enterprise on the Base of Real Demand. *Engineering Science*. Vol. 2, No. 3, 2017, pp. 78-84. doi: 10.11648/j.es.20170203.14

Received: May 21, 2017; **Accepted:** June 12, 2017; **Published:** July 14, 2017

Abstract: The main goal of the work is the development of a methodology for calculating the spare parts of cars in a service center for the period of replenishment of spare parts, tools, accessories, the English version - spare parts, instruments, accessories - SPIA on the basis of analysis of statistical information on the failures of the details of each standard. This information should be accumulated on daily information about the replacement of spare parts of failed parts in vehicles that arrived during the entire period of replenishment for maintenance at this service station. Previously, from the totality of a finite number of competing hypotheses about a possible theoretical parametric distribution of failures (including diffusion distributions), the distribution function most consistent with the empirical distribution function is chosen by Kolmogorov-Smirnov's agreement criterion. When calculating the failure distribution function in the theory of system reliability, information is usually used about the main characteristic of failures—the time between failures, and in the absence of such information, they use the number of failures at certain points in time. To this end, the relationship between the expressions for the distribution function of the operating time to a fixed number of failures and the function of the distribution of the number of failures for a fixed operating time to failure is established in this paper. This makes it possible to calculate the planned need for spare parts on the basis of the available statistics of failure of parts (and replacement of their corresponding spare parts) in previous planning periods. Given that fatigue wear of one part, even before its complete failure, can diffusively affect the performance of other car parts, in the aggregate of competing functions for the distribution of failures of parts included diffusion monotonic (DM) and diffusion no monotonic (DM). The proposed methodology is approved for the calculation of spare parts for individual component sizes and, in general, for any car parts by the example of a particular auto service company in the replenishment period of the SPIA equal to one calendar month.

Keywords: Spare Parts, Replenishment Period, Adequacy Indicator of Spare Elements, Agreement Criterion, Operating Time to Failure

1. Introduction

In practice, the following methods for determining the need for spare parts are found [1], [2], [3], [4], [5]:

- according to the nomenclature norms, which establish the average annual consumption of a specific component for 100 vehicles per year;

- on actual demand for spare parts.

In the conditions of motor transport enterprise, when calculating the need for spare parts, the normative method of planning is widely distributed, and in the conditions of the workshop (car service station) - according to the actual

expenditure in the previous planning period. In most works (see, for example, the above works, and also [6] [7] [8]), in both planning methods it is assumed that the flow of service requests is the simplest (Poisson) and for large values of the number of spare parts The Poisson distribution is approximated by a normal distribution.

However, often all three requirements (stationary, absence of aftereffect and ordinariness), imposed on the Poisson flow, can be violated both individually and in aggregate, which leads to inaccurate and sometimes erroneous results in the planning of spare parts.

The most important a priori information, which ultimately determines the amount of spare parts, is the theoretical model

of failures, which is taken into account in calculating the number of failures [9], [10], [11].

Usually, when calculating the failure distribution function, the time between failures [12] is used, and in the absence of such information, information on the number of failures at certain points in time is used.

In the present paper it is shown that the processes of operating time to failure T and the appearance of the number of failures R are mutually invertible processes. As the competing hypotheses, six known parametric distribution functions are tested (exponential, normal, lognormal, Weibull, diffusion no monotonic and diffusion monotonous). For fixed t , each of these distributions corresponds uniquely to the distribution function $F_R(r)$ of the failure rate R and vice versa, to each fixed number of failures r , the distribution function $F_T(t)$ of the running time T uniquely corresponds. Among the six distribution functions $F_R(r)$ For the best one is accepted that, according to Kolmogorov-Smirnov's agreement, is most adequate to the empirical model of the distribution of the random variable R for a given level of significance α .

Under refusal we will understand the failure of some part of the car entering one of the standard terminals: 1) engine; 2) suspensions; 3) body. It is necessary to calculate the need for spare parts of each type in the planned period for a particular service center, assuming that the faulty part (part) is replaced by a spare one.

The best models for the distribution of failures of arbitrary parts of cars $F_R^*(r)$ and details of each i -th model nominal number $F_{(R,i)}^*(r)$, constructed in the above way on the basis of failure statistics of parts in previous planning periods, Development of a methodology for calculating spare parts for an auto service company for the subsequent period of replenishing spare parts.

In the selection of the best models for the distribution of failures, the diffusion no monotonic (DM) and diffusion no monotonic (DN) distributions, which belong to the class of probability-physical methods, are considered as competing, along with the traditional parametric models (exponential, normal, lognormal and Weibull), Which serve as the basis for a new technology to study the reliability of machines and equipment [15].

In the particular case where the distribution of the operating time to the failure of the elements included in the (SPIA) is described by the DN distribution, the procedure for calculating spare parts was proposed in [14], and it is considered that this distribution is the most universal and adequate model of failures of electronic and electrical Products.

In the development of the algorithm for calculating spare elements in single sets (SPIA-S), the following assumptions are accepted [15]: the equipment under investigation consists of non-renewable elements connected in series (which are replaced by spare ones if they fail, and those that are refused are sent to the repair base); The reliability of the workers and spare parts of each standard is the same; During storage, spare parts are not refused; All operating elements are

refused independently.

Depending on the purpose of the equipment, its maintenance and repair, the reliability requirements of the equipment in agreement with the supplier of spare parts, the replenishment period (T_{pz}) can be taken equal to a quarter, half a year, to one or several years, although the proposed algorithm for calculating the planned capacity of spare parts is acceptable and for longer periods.

2. Competing Theoretical Distribution Functions

Exponential distribution (E).

$$F_T(t; \mu_T) = 1 - \exp\left(-\frac{t}{\mu_T}\right) \quad (1)$$

where $\mu_T = 1/\lambda$, λ is the intensive change T ; μ_T is the mathematical expectation of random variable of operating time T .

Normal distribution (N):

$$F_T(t; \mu_T, \nu_T) = \Phi\left(-\frac{t - \mu_T}{\mu_T \cdot \nu_T}\right) \quad (2)$$

where $\Phi(z)$ is standardized normal distribution; $\nu_T = \sqrt{D_T}/\mu_T$ is the coefficient variation and D_T is the dispersion of r.v. T .

Logarithmic normal distribution (LN)

$$F_T(t; \mu_T, \nu_T) = \Phi\left(\frac{\ln\left[\frac{t(1+\nu_T^2)}{\mu_T}\right]}{[\ln(1+\nu_T^2)]^{1/2}}\right) \quad (3)$$

Weibull distribution (W)

$$F_T(t; \mu_T, \nu_T) = 1 - \exp\left\{-\left[\frac{t\Gamma(1+\nu_T)}{\mu_T}\right]^{1/\nu_T}\right\} \quad (4)$$

where $\Gamma(z)$ is gamma function.

Diffusion non-monotonic distribution (DN)

$$F_T(t; \mu_T, \nu_T) = \Phi\left(\frac{t - \mu_T}{\nu_T \sqrt{t \cdot \mu_T}}\right) + \exp\left(\frac{2}{\nu_T^2}\right) \cdot \Phi\left(-\frac{t + \mu_T}{\nu_T \sqrt{t \cdot \mu_T}}\right) \quad (5)$$

Diffusion monotonic distribution (DM)

$$F_T(t; \mu_T, \nu_T) = \Phi\left(\frac{t - \mu_T}{\nu_T \sqrt{t \cdot \mu_T}}\right) \quad (6)$$

In Section 5, random variables (r.v) T_{r_0} and R_{r_0} are taken into consideration for an arbitrary vehicle part, and for a part of the i -th type random values of T_{i,r_0} and R_{i,r_0} are taken into consideration. In this case, T_{r_0} is a random variable with values $t, t \leq t_{r_0}$, where $t_{r_0} = r_0 \cdot T_0$, T_0 , T_0 is mathematical expectation of the operating time until failure of any parts; R_{r_0} is a random value of failures with values $r, r \leq r_0$, $r_0 = t_{r_0}/T_0$. The validity of the equalities is confirmed.

$$\mu_{T_{r_0}} = T_0 \cdot \mu_{R_{r_0}} \quad (7)$$

$$v_{T_{r_0}} = v_{R_{r_0}} \tag{8}$$

For any part and equalities, the followings are taken:

$$\mu_{T_{r_{i,0}}} = T_{0,i} \cdot \mu_{R_{r_{i,0}}} \tag{9}$$

$$v_{T_{r_{i,0}}} = v_{R_{r_{i,0}}} \tag{10}$$

for the parts of i type, where $T_{r_{i,0}}$ – r.v. with values of $t, t \leq t_{r_{i,0}}, t_{r_{i,0}} = r_{i,0} \cdot T_{0,i}, T_{0,i}, T_{0,i}$ is the mathematical expectation of the operating time until failure of the i type part, $R_{r_{i,0}}$ – r.v. failures with values $r_i, r_i \leq r_{i,0}, r_{i,0} = t_{r_{i,0}}/T_{0,i}$.

The distribution functions of the quantities T_{r_0} и R_{r_0} and R_{r_0} are related by the following relation:

$$F_{T_{r_0}}(t; \mu_{T_{r_0}}, v_{T_{r_0}}) = F_{R_{r_0}}(r; \mu_{R_{r_0}}, v_{R_{r_0}}),$$

which allows to pass from the distribution functions 1⁰-6⁰ for the value of T to the distribution functions of the quantity R .

The number of the parts of type i ($i = 1, 2, 3$) in the car $l_1 = 403, l_2 = 373, l_3 = 1158$ is considered in the auto-service enterprise. A set of parts of i – nominal type standard is called i -type node (or i type item) of the car. Assume, M_k is the number of cars serviced in the car auto-service station during the k working day and $r_{i,k}$ is the number of i type parts replaced on the k working day.

The initial data on the failure parts replaced at the auto-service enterprise in the order of incoming vehicles in each of the 27 working days is given in table 1.

Table 1. Initial data on the receipt of applications.

Days	Engine	Suspension	Body	Total	The number of incoming cars
1	35	2	2	39	13
2	18	3	2	23	8
3	33	10	4	47	16
4	33	5	5	43	18
5	28	5	3	36	13
6	28	3	6	37	17
7	37	7	3	47	21
8	66	3	9	78	28
9	26	8	3	37	15
10	38	6	4	48	17
11	17	9	2	28	8
12	32	3	8	43	19
13	37	27	3	67	38
14	40	8	80	128	36
15	48	15	10	73	34
16	41	9	77	127	35
17	25	4	3	32	11
18	25	13	8	46	26
19	14	3	1	18	12
20	48	4	4	56	25
21	37	7	7	51	22
22	50	10	7	67	38
23	20	2	10	32	13
24	14	3	13	30	11
25	58	15	71	144	61
26	37	7	17	61	25
27	34	13	14	61	31

On the base of the initial data from table 1 on the failure details r_k ($k = 1, \dots, n_0; n_0 = 27$) in the k working days of a month, the accumulated amount of failures of parts by the time is calculated $r_k^H = \sum_{k'=1}^k r_k$ and a step function of continuous time t is introduced on a time scale t with a unit of measurement for one working day, $r^H(t) = \sum_{k \leq t} r_k$.

The results of the calculations are given in table 2.

Table 2. Determination of the best failure distribution of any part and the parts of each nominal type.

Method	Engine		Suspension		Body		Total	
	D	α	D	α	D	α	D	α
1	0,172	0,95	0,196	0,95	0,32	0,95	0,198	0,95
2	0,89	0	0,899	0	0,99	0	0,923	0
3	4,27	0	14,3	0	8,3	0	4,5	0
4	0,675	0	0,5	0	0,32	0,99	0,53	0
5	0,16	0,95	0,182	0,95	0,29	0,95	0,172	0,95
6	8,9	0	79,1	0	47,1	0	11	0

It is seen from table 2 and 3 that, for any part of the best distribution function is $F(r^H) = F_5(r^H)$, and for the parts of the nominal type it is $F^*(r_i^H) = F_5(r^H)$, for $i = 1, 2$, $F(r_i^H) = F_4(r_i^H)$ for $i = 3$.

Consequently, in the considered examples diffusion non-monotonic distribution (DN) is the most concordant with empirical distribution of the failures both in case of any part and for any part of $i = 1$, and $i = 2$.

3. Reliability Evaluation of the of Parts and Sufficiency Indicators of SPIE

The required level of the "reliability" indicator of the products (nodes) at the end of the replenishment period T_{RP} will be established: the probability of failure-free operation the R_{prod}^{req} , for example, $R_{prod}^{req} = 0,9$ (this means that at the end of the T_{RP} period there at least $0,1 \cdot N$ details must remain from the planned store of spare parts (N).

The sufficiency indicators of the SPIE π_s is determined on the base of the analysis of expected ($R_0(T_{RP})$) and required R_{prod}^{req} reliability indicators ($\pi_\delta \geq R_{prod}^{req}/R_0(T_{RP})$) rounding to the nearest values of the series:

$$0.9; 0.95; 0.99; 0.995; 0.999; 0.9995; 0.9999 \tag{11}$$

It should be noted that the sufficiency index of SPIA π_s can be set by the customer independently of the expected reliability of the product.

To evaluate the sufficiency of single complex of SPIA-S products with non-recoverable spare elements, π_s is used as the probability so that during the operating time T_{RP} , of the product will occur in no failures of SPIA. The probability π_s is used to estimate the sufficiency of a set of SPIA provided that, all store in this set are replenished periodically with identical periods and the reliability indicators of the product is the probability of failure-free operation. The initial data for calculating the sufficiency index π_s of the SPIA-S are the expectal probability of failure-free operation on the final replenishment period of SPIA and the requirements for the

reliability index of the product R_{prod}^{req} .

If it is not known $R_0(T_{RP})$, then it is calculated

$$R_0(T_{RP}) = 1 - F^*(r(T_{RP})) \quad (12)$$

where $F^*(r)$ is the most adequate theoretical model of the failures distribution of any type of products, the choice of which is described in section 2. For π_s , the number rounding to the nearest values of the series (11) is adopted. If $R_{prod}^{req}/R_0(T_{RP}) = 0,9$, then $\pi_s = 0,9$.

4. Evaluation of the Required Probability of Failure-Free Operation of the Elements

A value of R_{prod}^{req} is adopted satisfying the relation $R_{prod}^{req} \leq R_0(T_{RP})$ and according to the value of the series (11), the sufficiency index of a set of SPIE-O is determined by the ratio $\pi_s \geq R_{prod}^{req}/R_0(T_{RP})$. If $R_0(T_{RP})$ is less than 0.9, then the value $\pi_s = R_{prod}^{req}$ is accepted from reasoning on importance of feasible functions and the importance of the economic expediency.

Further, the required probability level of fail-free operation is calculated R_i^{req} for the elements of the i nominal type ($R_i^{req} = (R_{prod}^{req})^{\frac{1}{m}}$), rounding to the nearest value of the series (11), where m is the total number of car's nominal types (nodes) (in our case $m = 3$).

5. Probability Evaluation of Fail-Free Operation and Sufficiency of any Type of Spare Elements

The calculation of the probability of failure-free operation of i type elements R_i at the considered period $(0, t_{\Sigma} + T_{II3})$ will be carried out by the formula:

$$R_i = 1 - F_i^*(r_i^H(t_{\Sigma} + T_{RP})) \quad (13)$$

where $F_i^*(r_i^H)$ is the most adequate theoretical distribution model of the failure of i -th type of elements; t_{Σ} is the total operating time of the products at the beginning of the replenishment period, taking into account the intensity coefficient at the operation during this period.

According to the values of R_i and R_i^{req} , the sufficiency index π_s for the guarantee of to provide i type non-

consequently,

$$\mu_{T_{r_0}} = T_0 \cdot \mu_{R_{r_0}} \quad (19)$$

Denote $t_k = t_{r_k}$, $t_0 = t_{r_0} = t_{r_{k_0}}$, but further the notation T_{r_0} and T_{t_0} will not be distinguished.

recoverable spare parts is determined (rounding to the nearest larger value from the recommended series (11) by the formula (by the condition $R_i < R_i^{req}$)

$$\pi_{si}^{req} = \begin{cases} 1 - \frac{1-R_i^{req}}{1-R_i}, & \text{at } R_i < (\pi_s)^{1/m}, \\ (\pi_s)^{1/m}, & \text{at } R_i \geq (\pi_s)^{1/m} \end{cases} \quad (14)$$

If $R_i \geq R_i^{req}$, then the elements of this type are n't included in the nomenclature of SPIE (in this case the number of the spare parts a_i in the planned period is accepted equal $a_i = 0$); m is the total number of i type (in our case $m = 3$).

6. The Calculation of Mean Operating Time Until the Failures of Constituent Elements

Suppose that T is a random variable (abbreviated r.v) of operating time until failure (i.e. the time between two consistent failures) with the values t , but T_r - r.v. operating time until r -th failure (beginning from the initial moment of the time) with the values t_r . Suppose, further R is r.v. of the failure member with values r and R_{r_0} is r.v. with values $r \leq r_0$, where r_0 is some fixed natural number. Suppose that, $\{r_k\}, k = 1, \dots, n$ is a given sample of observations random variable R and $\{t_k\}$ is the corresponding (unobservable) sequence of a values random variable T with mathematical expectation $\mu_T = T_0$, where T_0 is the quantity to be determined.

It is obvious that,

$$t_r = r \cdot T_0 \quad (15)$$

consequently,

$$t_{r_k} = r_k \cdot T_0 \quad (16)$$

Taking into account random variable T_{r_0} with values $t \leq t_{r_0}$, where

$$t_{r_0} = r_0 \cdot T_0 \quad (17)$$

Suppose $r_0 = r_{k_0}$ is the clement of sequence $\{r_k\}, r_1 < r_2 < \dots < r_n$.

The sampling estimation of the mathematical expectation $\mu_{T_{r_0}}$ is the quantity

$$\hat{\mu}_{T_{r_0}} = \sum_{k=1}^{k_0} t_{r_k} = \sum_{k=1}^{k_0} r_k \cdot T_0 = T_0 \cdot \sum_{k=1}^{k_0} r_k = T_0 \quad (18)$$

It is obvious that,

$$v_{T_{r_0}} = v_{R_{r_0}} \quad (20)$$

Taking into account (19) - (20), distribution functions of values T_{r_0} R_{r_0} is connected with the relation

$$F_{T_{r_0}}(t; \mu_{T_{r_0}}, \nu_{T_{r_0}}) = \text{Bep}(T \leq t | r \leq r_0) = F_{T_{r_0}}(t; \mu_{R_{r_0}} \cdot T_0, \nu_{T_{r_0}}) = F_{R_{r_0}}(r; \mu_{R_{r_0}}, \nu_{R_{r_0}}), \quad (21)$$

where the replacement was made.

$t/T_0 = r$ is under the condition of $t = t_r$. Thus, process T_{t_0} is the operating time until failure and the process R_{r_0} of the number of failures, under the condition of (21) $r \leq r_0$ are mutually invertible. Their interrelation is determined by the relation (21). For a fixed r_0 the latter expression represents the distribution function of the r.v. T_{t_0}

$$F_{T_{t_0}}(t) = F_{T_{t_0}}(t; \mu_{T_{t_0}}, \nu_{T_{t_0}}), t_0 = r_0 \cdot T_0 \quad (22)$$

and during the operating time fixation t_0 this expression represents the distribution function of r.v. R_{r_0}

$$F_{R_{r_0}}(r) = F_{R_{r_0}}(r; \mu_{R_{r_0}}, \nu_{R_{r_0}}), r = t_0/T_0 \quad (23)$$

Using equalities (19) - (21), an estimate of the value of $T_{0,i}$ can be obtained for each of the distribution functions 1^0-6^0 , writing the last one for r.v. T_{r_c} at $t = T_{RP}$ and $r_0 = r_{i,n}^H$.

Let's set $\alpha_i = \pi_{s_i}^{req}$, where $\pi_{s_i}^{req}$ defined by the formula (14) and define $T_{0,i}$ as α_i - quantile of the distribution function $F_{T_{r_{i,n}^H}}(T_{RP})$, i.e. solve the equation as the following:

$$F_{T_{r_{i,n}^H}}(T_{RP}) = \alpha_i \quad (24)$$

The solution of equation (24) for the exponential distribution (1) gives the followings:

$$T_{0,i} = \frac{T_{RP}}{\mu_{R_{r_{i,n}^H}} \cdot \ln\left(\frac{1}{1-\alpha_i}\right)} \quad (25)$$

For the Weibull distribution (4):

$$T_{0,i} = \frac{T_{PZ} \cdot \Gamma\left(1 + \nu_{R_{r_{i,n}^H}}\right)}{\mu_{R_{r_{i,n}^H}} \cdot \left[\ln\left(\frac{1}{1-\alpha_i}\right)\right]^{1/\nu_{R_{r_{i,n}^H}}}} \quad (26)$$

While the equation (24) is being solved for a function $F_{T_{t_0}}(t)$ containing the function $\Phi(x)$ of a standardized normal distribution, the expansions in (20) can be used and Newton's method can be applied to the equation.

$$f(x) = 0,$$

being given by the initial approximation x_0 in the iteration procedure

$$x_{m+1} = x_m - \frac{f(x_m)}{f'(x_m)} \quad (27)$$

where $x = T_{0,i}$, $f(x) = F_{T_{r_{i,n}^H}}(T_{RP}) - \alpha_i$. As an initial approximation one of two simple estimates can be taken $\hat{T}_{0,i}^{(1)}$ and $\hat{T}_{0,i}^{(2)}$

$$T_{0,i}^{(1)} = \frac{1}{n} \sum_{k=1}^n \frac{1}{r_{i,k}}, T_{0,i}^{(2)} = \frac{1}{n} \sum_{k=1}^n \frac{k}{r_{i,k}^H} \quad (28)$$

7. The Calculation of the Spare Parts of i Nominal Type

Suppose $F_i^*(r_i^H)$ is the best distribution function for the parts of i type. Optimal number is $a_i = r_i^{H,opt}$ of the spare parts of i nominal type - it is such a value r_i^H that, which simultaneously satisfies two conditions.

$$F_i(r_i'') \geq \pi_{s_i}^{req} \text{ и } r_i'' \cdot T_{0,i} \geq RP$$

As an initial approximation for a_i expectation value is taken a_i^{expect} , which can be defined as follows. Since the cars are received for technical service on k -th work day, which can be queued and serviced by an auto enterprise both on the same day and the next $(k + 1)$ working day, then starting from $k \geq 2$ average number $\bar{r}_{l,k}$ of the i type parts, replaced in the k working day, it is appropriately counted as follows:

$$\bar{r}_{l,k} = \frac{1}{2}(r_{i,k-1} + r_{i,k}).$$

Then the average expected share of the replaced parts of i type from the total number of the parts of this type in cars received by the auto service enterprise during the entire period of replenishment of T_{RP} (in our case it is $n_0 = 27$. Working days) will be equal to:

$$\bar{v}_i = \frac{1}{n_0} \left(\frac{r_{i,1}}{M_i \cdot l_i} + \sum_{k=2}^{n_0} \frac{\bar{r}_{l,k}}{M_k \cdot l_i} \right),$$

where M_k is the number of the cars received for the service by this enterprise in k working day, l_i is the number of the parts of i type in one car.

The value a_i^{expect} is defined as follows:

$$a_i^{expect} = M \cdot l_i \cdot \bar{v}_i = \frac{M}{n_0} \left(\frac{r_{i,1}}{M_1} + \sum_{k=2}^{n_0} \frac{\bar{r}_{l,k}}{M_k} \right),$$

where

$$M = \sum_{k=1}^{n_0} M_k.$$

Algorithm (calculation a_i)

- (1) $r_i^H = a_i^{expect}$, $\chi = 1$
- (2) If $F_i^*(r_i^H) \geq \pi_{s_i}^{req}$ and $r_i^H \cdot T_{0,i} \geq T_{RP}$, then go to item 4.
- (3) If $\chi = 2$, then go to item 8, else go to item 5.
- (4) If $\chi = 3$, then go to item 7, else go to item 6.
- (5) $r_i^H = r_i^H + 1$, $\chi = 3$ and go to item 9.
- (6) $r_i^H = r_i^H - 1$, $\chi = 2$ and go to item 9.
- (7) $a_i = r_i^H$ and go to item 10.
- (8) $a_i = r_i^H + 1$ and go to item 10.
- (9) Calculate $F_i^*(r_i^H)$

(10) If $\chi \neq 1$ and go to item 2.

(11) Print $F_i^*(a_i)$, $\pi_{s,i}^{req}$, a_i .

The results of the calculation a_i on this algorithm is given in table 3 (with $T_{0,i}$, calculated by the formula (25) – (27)) and table 4 (with $T_{0,i}$, defined by the second formula (28)).

Table 3. The calculation of the spare parts (with $T_{0,i}$, computed by the formula (25)–(27)).

	F	$\pi_{s,i}$	α_1
1	0,9398	0,9333	921
2	0,9561	0,9539	206
3	0,999	0,9655	374

Table 4. The calculation of the spare parts (with $T_{0,i}$, computed by the formula (28)).

i	F	$\pi_{s,i}$	α_1
1	0,940	0,934	919
2	0,965	0,954	205
3	0,999	0,966	375

8. Conclusion

When solving maintenance tasks and using spare parts in a service center, it is usually assumed that the flow of service requests is the simplest (Poisson) flow, i.e. Satisfies three requirements: stationary, absence of consequences and ordinarieness. Taking into account that for large values of the number of spare parts (the number of applications k), the Poisson distribution with a good approximation can be described by the normal distribution law, in practice the normal distribution of applications is used.

However, often the requirements for a Poisson flow of applications can be violated both individually and in aggregate, which casts great doubt on the appropriateness of using the normal application law. In this regard, the primary task in the calculation of spare parts for the period of replenishment of the SPIA is a gap in the identification of the distribution of spare parts requests, most consistent with the empirical distribution of these applications.

To this end, when calculating spare parts, first of all, it is necessary to solve the above problem of identifying the best model for the distribution of requests for maintenance. For this purpose, from the set of known parametric distributions including diffusion (monotonic and no monotonic) distributions, using the Kolmogorov-Smirnov matching criterion, a theoretical distribution function is chosen that is best in this sense for a given empirical function of the distribution of applications (refusals of parts in vehicles received for maintenance in This auto service plant.

The main result of this work is the establishment of the reciprocity of the distribution function of the operating time to a fixed number of failures and the function of the distribution of the number of failures for a fixed operating time to failure, which makes it possible to calculate the need for spare parts on the basis of available statistical information on actual demand in the previous planning period.

The final result of the work is the development of an

algorithm for calculating the required number of spare parts for individual component sizes and their totals on the basis of accumulated daily demand. The optimal number of spare parts of the standard i is at simultaneous fulfillment of two conditions:

A) the adequacy of spare elements i is not less than the required indicator of sufficiency of elements of this type;

B) the average time to failure of this number of spare parts of this type is not less than the time of the entire replenishment period T_{PS} .

The expected average value of the number of spare parts of the i -th type a_i^{expect} at the initial step of the algorithm is determined taking into account that the cars received for maintenance on the k -th working day can queue and be serviced by this auto service enterprise both on the same day and for the next $(k + 1)$ th working day.

The proposed methodology for calculating spare parts of any type for a car service center can be used with an arbitrary finite number of competing theoretical distribution functions and is applicable in other technical branches.

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