Technical Service Quality Management

G V Redreev¹, V M Pomogaev¹, A A Luchinovich¹
¹FSBEI «Omsk State Agrarian University», Omsk, Russia

E-mail: fareastcon2019@gmail.com

Abstract. The technical product efficiency can be one of the options to confirm the technical service quality after the service works. However, this requires the knowledge of the factor influence that determine the service quality on the performance indicators of the technical product. This is especially true for complex technical facilities, which are the samples of the mobile agricultural equipment. It is advisable to present the technical use coefficient in the form of a product of its basic value by the technical service quality factor. In turn, the technical service quality factor is defined as the product of the degrees of conformity of the technical service components. It is the degree of conformity of the executed work volumes with the required volumes; the degree of conformity of the maintenance frequency with the required values; the degree of conformity of the technology maintenance and repair processes occurring in the subsystems of the serviced machines; the degree of conformity of the work performers to the implemented technologies; the degree of conformity of the technical service performers to the machines serviced by the units. The equation research, which is analytically describe the technical service system operation, made it possible to establish that the technical service quality ratio is equal to the square of the degree of conformity of the performer qualifications with the structures of the served machines. In turn, the degree of conformity of the performer qualifications with the structures of the serviced machines is equal to the product of the degree of conformity of the performer qualifications with the technologies of the technical service and the degree of conformity of the technologies with the designs of the serviced machines. To take into account the heterogeneity of the machines fleet and the novelty of service technologies, the following coefficients were introduced: the heterogeneity of the serviced machine fleet according to the applied technologies; the novelty of the applied technologies of technical service; the heterogeneity of the serviced machine fleet by the performer qualifications. The impact on the technical service quality is established.

1. Introduction
The product quality is the most important criterion for evaluating and the success of the enterprise in the relevant market. However, fairly simple ways to prove the quality of the tangible product are not suitable for confirming the service quality. One of the options for confirming the quality of the technical service is the technical product efficiency after performing the service work. It requires the knowledge of the factor influence determining the service quality on the performance indicators of the technical product. This is especially true for complex technical facilities, which are the samples of the mobile agricultural equipment. Such technical facilities are characterized by the separation in time of possible facts of the decrease in the operation quality from the moment of service completion, the obvious ambiguity of the technical service quality concept.
2. Efficiency indicator of tractor units

The tractor unit productivity is the main indicator of its efficiency. It determines the permissible level of possible downtime, and its reduction negatively affects the agricultural product loss.

We express the tractor unit productivity through the technical use coefficient:

\[ W_a = k W_h K_{uc}, \]  
(1)

where \( k \) – correction factor,
\( W_h \) – hour productivity, ha/h;
\( K_{uc} \) – technical use coefficient.

Thus, the technical service purpose is to maintain such a value of the technical use coefficient, which ensures the required unit productivity [1].

We introduce the concept of the basic value of the technical use coefficient. In this case, the technical use coefficient can be determined:

\[ K_{mu} = K_{uc}^b K_{\mu}, \]  
(2)

where \( K_{uc}^b \) – basic value of the technical use coefficient,
\( K_{\mu} \) – technical service quality factor.

The quality factor is determined by the dependence:

\[ K_{\mu} = \prod_{i=1}^{n} \mu_i, \]  
(3)

as \( i=1–5 \). Where \( \mu_1 \) – the degree of conformity of the executed works with the required volumes; \( \mu_2 \) – the degree of conformity of the maintenance frequency with the required values; \( \mu_3 \) – the degree of conformity of maintenance and repair technologies to the processes in the subsystems of the serviced machines; \( \mu_4 \) – the degree of conformity of the performer qualifications with the implemented technologies of maintenance and repair; \( \mu_5 \) – the degree of conformity of the technical service performers to the machines served by the units.

3. Determination of technical service quality indicator

The required amount of the maintenance work is determined from the formula:

\[ W_M = \sum_{k,l=1}^{K,L} A_k M A_k S_l \tau_l, \]  
(4)

where \( A_k \) – serviced units, \( k = l + K \);
\( M A_k \) – the number of machines in the \( k \)-unit;
\( S_l \) – the number of subsystems (assembly, assembly components) in the machine \( l = l + L \);
\( \tau_l \) – the duration of maintenance of the \( l \)-subsystem (assembly, assembly components).

To ensure the normal process course in the technical system, the actual work amount on technical service should not be less than the required:

\[ W_{M,act} \geq W_M, \]  
(5)

The applied types of work maintenance and repair must correspond to the processes in the assembly (subsystems, assembly components) of the machine units [2–5]:

\[ \mu_3 \sum_{j=1}^{M} TX_j \equiv \sum_{k,l=1}^{K,L} A_k M A_k S_l, \]  
(6)

where \( \mu_3 \) – the degree of conformity, the values of which can be determined by the method of expert assessments or ranking [6–8];
\( TX_j \) – the applied technologies of maintenance and repair, \( j = l + M \).
The Ferhulst’s logistic function is the best suited to describe the degree of conformity [9]. The canonical form of this function is:

\[ P(t) = \frac{K P_0 e^{rt}}{K + P_0 (e^{rt} - 1)}, \]  

(7)

As \( K=1 \) and \( P_0=0.5 \), with reference to our case, the function will have the form (Figure 1):

**Figure 1.** The logistic function of the conformity of the maintenance and repair technologies to the processes in the subsystems of the machine units.

\[ \mu_3 = \frac{e^{x-C}}{1 + e^{x-C}}, \]  

(8)

where \( x \) – the ratio value of the technology current set to the full set,

\( C \) – the displacement of the inflection point of the curve along the abscissa axis.

While implementing the maintenance and repair work, there is the increase in the technical device reliability for a certain time, corresponding to the increase in the operating time of the unit. In terms of reliability, as the property of preserving operability, the value of the recovered operating time should be compared with the required uptime. [10–11].

On the abscissa axis, the amount of the reset operating time (the frequency of the next service) is deposited, corresponding to the performance of the certain maintenance operation (Figure 2):

**Figure 2.** Logistic function (membership function).
\[\mu_2 = 1 - \frac{e^{p-B}}{1 + e^{B-B}},\]  
(9)

where \(p\) – the ratio of the current maintenance periodicity to the normative,  
\(B\) – the displacement of the inflection point of the curve along the abscissa axis.

To ensure significant periods of fail-safe operation, it is necessary to apply the improved technology maintenance, which would ensure the appropriate maintenance frequency or the significant reduction in the duration of the maintenance operations [11].

The number of the maintenance and repair performers should be the minimum necessary [8]:

\[N = \sum_{j=1}^{N} N_j \rightarrow N_{\text{min}}.\]  
(10)

In this case, the performer qualifications must be sufficient for the implementation of the maintenance technologies:

\[\mu_4 \sum_{i=1}^{N} N_i K_i \approx \sum_{j=1}^{M} TX_j,\]  
(11)

where \(\mu_4\) - the logistic function of the performer qualifications of the technologies for maintenance and repair,  
\(N_i\) – \(i\)-performer of maintenance and repair, \(i = 1 \div N\);  
\(K_i\) – \(i\)-performer qualifications;  
The logistic function value is determined from the formula:

\[\mu_4 = \frac{e^{y-D}}{1 + e^{y-D}},\]  
(12)

where \(y\) - the ratio value of the conformity set for the implementation of maintenance and repair technologies to the full set,  
\(D\) – the displacement of the inflection point of the curve along the abscissa axis.

The list of works potentially performed by the technical service performers should be sufficient to service the certain type of units [12–13]:

\[\mu_5 \sum_{i=1}^{N} N_i K_i > \sum_{k=1}^{K} A_k M A_k S_k,\]  
(13)

where \(\mu_5\) - the logistic function of the performer qualifications to the subsystems of the machine units:

\[\mu_5 = \frac{e^{z-E}}{1 + e^{z-E}},\]  
(14)

where \(z\) - the ratio value of the performer qualifications to the full set,  
\(E\) – the displacement of the inflection point of the curve along the abscissa axis.

Professor Solomkin A.P. was proposed to assess the implementation quality of maintenance technology on the totality of the three components - thoroughness, completeness and timeliness [14]. This approach is important when comparing the work of different performers or groups of maintenance performers while servicing units of the same composition. At the same time, for the operation of the units, it is necessary to ensure the required reliability, regardless of which performers serviced this or that unit. It can be noted that in the considered approach to the assessment of technical maintenance, the main role should be given to timeliness [8, 15].

Any of the technical service performers must have certain qualifications - the certain amount of knowledge and skills. The actual scope of competence may not correspond to the volume that is necessary for the technical service implementation [16].

The work volume, which is performed by a group of maintenance and repair performers, must comply with the required work volume for the technical service of the machine units:
\[
\mu_1 \sum_{i=1}^{N} N_i k_N t \geq \sum_{k,l=1}^{K,L} A_k M A_k S_l \tau_l ,
\]
(15)

where \( \mu_1 \) – the degree of conformity of the work volume with the required volumes;
\( t \) – the maintenance time, hour;
\( k_N \) – the correction factor which take into account the reduction in the duration of maintenance in the work of the group of maintenance and repair performers.

The degree of conformity \( \mu_1 \) is determined by the logistic function:
\[
\mu_i = \frac{e^{v-A}}{1 + e^{v-A}} ,
\]
(16)
where \( v \) - the ratio value of the actual work volume performed to the total volumes,
\( A \) – the displacement of the inflection point of the curve along the abscissa axis.

Obviously, while working together with the contractor for maintenance and repair, it is not enough to take into account the conformity of their qualifications with the applied maintenance and repair work. It is also necessary to take into account the correspondence of the actions of the performers to the processes occurring in the machine units as technical systems, and to the goals of the technical maintenance [8].

4. Theoretical research of the technical service system operation
The analytical description of the technical service system operation state is as follows.:
\[
\mu_1 \cdot \sum_{i=1}^{N} N_i \cdot k_N \cdot t = \sum_{k,l=1}^{K,L} A_k \cdot M A_k \cdot S_l \cdot \tau_l 
\]
(17)

\[
P_{ACT} = \mu_2 P_{NORM}
\]
(18)

\[
\mu_3 \sum_{j=1}^{M} TX_j = \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]
(19)

\[
\mu_4 \sum_{i=1}^{N} N_i K_i = \sum_{j=1}^{M} TX_j
\]
(20)

\[
\mu_5 \sum_{i=1}^{N} N_i K_i = \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]
(21)

The task of fulfilling the required amount of maintenance work, provided that the duration of machine downtime is reduced, was solved by us earlier [17], taking into account the provision of the standard maintenance frequency. One of the ways to ensure compliance with the work volumes and the frequency of the service normative values is the improvement of the technical condition control means.

To ensure the technical service system operation, it is important to establish a rational balance between the qualifications of the technical service performers, the technologies which are used and the characteristics of the served machines. We take \( \mu_1 = 1.0 \) and \( \mu_2 = 1.0 \) for further discussion. In this case, the mathematical model will look like this:
\[
\mu_3 \sum_{j=1}^{M} TX_j = \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]
(22)
\[
\mu_3 \sum_{i=1}^{N} N_i K_i = \sum_{j=1}^{M} TX_j \\
\mu_5 \sum_{i=1}^{N} N_i K_i = \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]

Substituting the formulation for \(\Sigma TX\) from (23) and the formulation for \(\Sigma (MA \cdot S)\) from (24) into the formulation (22), we obtain:

\[
\mu_3 \cdot \mu_4 = \mu_5
\]

Then

\[
(\mu_3 \mu_4)^2 = K_\mu
\]

or

\[
\mu_5^2 = K_\mu
\]

Therefore, the minimum values of the individual degrees of conformity are determined:

\[
\mu_5 \geq \sqrt{K_\mu},
\]

\[
\mu_3 = \frac{\mu_5}{\mu_4}, \quad \mu_4 = \frac{\mu_5}{\mu_3}
\]

Based on Siberian Research Institute of Mechanization and Electrification of Agriculture data and practice analysis, the actual value of the technical use coefficient is within 0.55 ± (0.02–0.03) [18].

For the purposes of the theoretical research, the following variation limits of the base value \(K_{\mu_1}^{\delta}\) and the corresponding minimum values of the quality factor \(K_\mu\) can be proposed. \(K_{\mu_1}^{\delta} = (0.7 – 0.9)\), \(K_\mu = (0.8 – 0.6)\).

We define the allowable limits for the change in the quality components \(\mu_1\). The results of calculations for \(K_\mu = (0.8 - 0.6)\) can be graphically represented as follows (Figure 3)

Figure 3. Minimum calculated values \(\mu_3, \mu_4\)
Based on the possible minimum value of \( \mu_3 \) (or \( \mu_4 \)) on the abscissa axis, the minimum value of \( \mu_4 \) (or \( \mu_3 \)) on the ordinate axis is determined with different values of \( K_\mu \) from 0.6 to 0.8 in increments of 0.1. The value \( \mu_5 \) is defined as the product of \( \mu_3 \cdot \mu_4 \). The graphic image of the dependence of \( \mu_5 \) values on \( K_\mu \) is presented in Figure 4:

![Figure 4. The dependence of the values of the degree of conformity of the performer qualifications and the serviced machines \( \mu_5 \) from the quality factor \( K_\mu \)](image)

In addition to the presented general case, the following seven variants of production situations are possible.

### 5.1. Variant 1
The applied technologies can be used to service the diverse machine fleet.

\[
\mu_5 \sum_{j=1}^{M} TX_j \geq \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]

\[
\mu_4 \sum_{i=1}^{N} N_i K_i = \sum_{j=1}^{M} TX_j
\]

\[
\mu_5 \sum_{i=1}^{N} N_i K_i = \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]

To determine the values of \( \mu_\), it is necessary to go into a strict equation in the dependence (30)
\[ \mu_3 \sum_{j=1}^{M} TX_j = K_{MT} \sum_{k,l}^{K,L} MA_k \cdot S_l \]  

(33)

where \( K_{MT} \) – the heterogeneity coefficient of the machine fleet according to the applied maintenance and repair technologies. Obviously, it is \( K_{MT} > 1 \).

Having made substitutions similar to substitutions with the formulations (22)–(24), we obtain:

\[ \mu_5 = \frac{\mu_3 \cdot \mu_4}{K_{MT}} \]  

(34)

Respectively:

\[ \mu_5 = \sqrt{\frac{K_\mu}{K_{MT}}} \]  

(35)

\[ \mu_3 = \frac{\mu_5 \cdot K_{MT}}{\mu_4} \]  

(36)

As follows from the formulations (34) - (36), the increase in the heterogeneity of the machine fleet according to the technologies used for maintenance and repair leads to the increase in the technical service quality factor.

5.2. Variant 2

The performer qualification allows to expand the list of the technical service applied technologies. The performer qualifications should be sufficient for the implementation of the technical service new technologies.

\[ \mu_3 \sum_{j=1}^{M} TX_j = \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

(37)

\[ \mu_4 \sum_{i=1}^{N_i} N_i K_i \geq \sum_{j=1}^{M} TX_j \]  

(38)

\[ \mu_5 \sum_{i=1}^{N_i} N_i K_i = \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

(39)

To determine the values of \( \mu_\ast \), it is necessary to go into a strict equation in the dependence (38):

\[ \mu_4 \sum_{i=1}^{N_i} N_i K_i = K_{TH} \sum_{j=1}^{M} TX_j \]  

(40)

where \( K_{TH} \) – the novelty coefficient of the technical service applied technologies. Obviously, it is \( K_{TH} > 1 \).

After similar substitutions we get:

\[ \mu_5 = \frac{\mu_3 \cdot \mu_4}{K_{TH}} \]  

(41)
\[ \mu_5 = \sqrt{\frac{K_\mu}{K_{TH}}} , \]  
\[ \mu_3 = \frac{\mu_5 \cdot K_{TH}}{\mu_4} \]  

From the formulation (41) it follows:
\[ \mu_5 \leq \frac{1}{K_{TH}} , \]  

Similar to the previous variant, the development of the maintenance and repair new technologies leads to the increase in the technical service quality.

5.3. Variant 3
The performer qualifications should be sufficient to service the different machine fleet.

\[ \mu_5 \sum_{j=1}^{M} TX_j = \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  
\[ \mu_4 \sum_{i=1}^{N} N_i K_i = \sum_{j=1}^{M} TX_j \]  
\[ \mu_5 \sum_{i=1}^{N} N_i K_i \geq \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

To determine the values of \( \mu_5 \), it is necessary to go into a strict equation in the dependence (47):

\[ \mu_5 \sum_{i=1}^{N} N_i K_i = K_{MH} \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

where \( K_{MH} \) – the heterogeneity coefficient of the machine fleet according to the performer qualifications. Obviously, it is \( K_{MH} > 1 \).

After similar substitutions we get:

\[ K_{MH} = \frac{\mu_5}{\mu_3 \cdot \mu_4} \]  

Respectively:
\[ \mu_5 = \sqrt{K_\mu K_{MH}} , \]  
\[ \mu_3 = \frac{\mu_5}{K_{MH} \mu_4} \]
5.4 Variant 4

The performer qualifications allows the use of technical service new technology. The applied technologies allow servicing differently-varied machine fleet.

\[ \mu_5 \sum_{j=1}^{M} TX_j \geq \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

(52)

\[ \mu_4 \sum_{i=1}^{N} N_i K_i \geq \sum_{j=1}^{M} TX_j \]  

(53)

\[ \mu_5 \sum_{i=1}^{N} N_i K_i = \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

(54)

We turn in the dependencies (52) and (53) to a strict equation:

\[ \mu_5 \sum_{j=1}^{M} TX_j = K_{MT} \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

(55)

\[ \mu_4 \sum_{i=1}^{N} N_i K_i = K_{TH} \sum_{j=1}^{M} TX_j \]  

(56)

After similar substitutions we get:

\[ K_{MT} K_{TH} = \frac{\mu_3 \mu_4}{\mu_5} \]  

(57)

Respectively:

\[ \mu_5 = \sqrt{\frac{\mu_3}{K_{MT} K_{TH}}} \]  

(58)

\[ \mu_3 = \frac{\mu_4 K_{MT} K_{TH}}{\mu_5} \]  

(59)

Similar to variants 1 and 2, increasing the heterogeneity of the machine fleet according to the maintenance and repair applied technologies and the novelty of the technologies used in maintenance and repair increases the technical service quality.

5.5. Variant 5

The applied technologies and performer qualification allow servicing of differently-varied machine fleet.

\[ \mu_5 \sum_{j=1}^{M} TX_j \geq \sum_{k,l=1}^{K,L} MA_k \cdot S_l \]  

(60)

\[ \mu_4 \sum_{i=1}^{N} N_i K_i = \sum_{j=1}^{M} TX_j \]  

(61)
\[ \mu_5 \sum_{i=1}^{N} N_i K_i \geq \sum_{k,j=1}^{K,L} MA_k \cdot S_i \]  \hfill (62)

We turn in the dependencies (60) and (62) to strict equations:

\[ \mu_3 \sum_{j=1}^{M} TX_j = K_{MT} \sum_{k,j=1}^{K,L} MA_k \cdot S_i \]  \hfill (63)
\[ \mu_5 \sum_{i=1}^{N} N_i K_i = K_{MH} \sum_{k,j=1}^{K,L} MA_k \cdot S_i \]  \hfill (64)

After similar substitutions we get:

\[ \frac{K_{MT}}{K_{MH}} = \frac{\mu_4 \mu_5}{\mu_5} \]  \hfill (65)

Respectively:

\[ \mu_5 = \sqrt{\frac{K_{MT} K_{MH}}{K_{MT} K_{MH}}}, \]  \hfill (66)
\[ \mu_3 = \frac{K_{MT} \mu_5}{K_{MH} \mu_4} \]  \hfill (67)

In accordance with the formulation (66) with the increase in the heterogeneity of the machine fleet simultaneously for the service providers and the technologies used for maintenance and repair, the technical service quality can remain unchanged.

5.6 Variant 6

The performer qualifications allows to apply the technical service new technologies and maintain the diverse machine fleet.

\[ \mu_3 \sum_{j=1}^{M} TX_j = \sum_{k,j=1}^{K,L} MA_k \cdot S_i \]  \hfill (68)
\[ \mu_4 \sum_{i=1}^{N} N_i K_i \geq \sum_{j=1}^{M} TX_j \]  \hfill (69)
\[ \mu_5 \sum_{i=1}^{N} N_i K_i \geq \sum_{k,j=1}^{K,L} MA_k \cdot S_i \]  \hfill (70)

We turn in the dependencies (69) and (70) to strict equations:

\[ \mu_4 \sum_{i=1}^{N} N_i K_i = K_{MT} \sum_{j=1}^{M} TX_j \]  \hfill (71)
\[ \mu_5 \sum_{i=1}^{N} N_i K_i = K_{MH} \sum_{k,j=1}^{K,L} MA_k \cdot S_i \]  \hfill (72)

After similar substitutions we get:
\[
\frac{K_{MH}}{K_{TH}} = \frac{\mu_5}{\mu_3 \mu_4}
\]  

(73)

\[
\mu_3 = \frac{\mu_5 K_{TH}}{\mu_4 K_{MH}}
\]  

(74)

The formulation (74) is similar to the formulation (67), therefore, with the simultaneous application of the maintenance and repair new technologies and the increase of the heterogeneity of the machine fleet by the performers, the technical service quality can remain unchanged.

5.7 Variant 7

The performer qualification allows to apply the new technologies of technical service and service the differently-varied machine fleet.

\[
\mu_3 \sum_{j=1}^{M} TX_j \geq \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]  

(75)

\[
\mu_4 \sum_{i=1}^{N} N_i K_i \geq \sum_{j=1}^{M} TX_j
\]  

(76)

\[
\mu_5 \sum_{i=1}^{N} N_i K_i \geq \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]  

(77)

We turn in the dependencies (75-77) to strict equations:

\[
\mu_3 \sum_{j=1}^{M} TX_j = K_{MT} \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]  

(78)

\[
\mu_4 \sum_{i=1}^{N} N_i K_i = K_{TH} \sum_{j=1}^{M} TX_j
\]  

(79)

\[
\mu_5 \sum_{i=1}^{N} N_i K_i = K_{MH} \sum_{k,l=1}^{K,L} MA_k \cdot S_l
\]  

(80)

After similar substitutions we get:

\[
\frac{\mu_3 \mu_4}{\mu_5} = \frac{K_{MT} K_{TH}}{K_{MH}}
\]  

(81)

Respectively:

\[
\mu_5 = \sqrt{\frac{K_{\mu} K_{MH}^2}{K_{MT} K_{TH}}},
\]  

(82)

\[
\mu_3 = \frac{\mu_5 K_{MT} K_{TH}}{\mu_4 K_{MH}}
\]  

(83)
As follows from the formulation (82) while simultaneously increasing the heterogeneity of the machine fleet using the maintenance and repair technologies and work performers, as well as increasing the novelty of the maintenance and repair technologies, the technical service quality will most likely increase.

6. Conclusions
The technical service quality is an important task that is solved by the relevant maintenance and repair services and dealer enterprises. In addition to the regulated service frequency and the implementation of the service work planned volumes, it is important to confirm the performer qualifications to the consumer. In the proposed model of the technical service system, the technical service quality is defined as the degree of conformity of the performer qualifications, applied technologies and designs of the serviced technical products. The heterogeneity of the serviced machine fleet and the novelty level of the technical service technologies are also taken into account.

References
[1] Redreev G V 2016 The issue of ensuring the operability of machine-tractor units Electronic scientific-methodical journal of the Omsk State Agrarian University 3(6) URL http://e-journal.omgau.ru/index.php/2016-god/5/29-statya-2016-2/380-00130 ISSN 2413-4066
[2] Meshcheryakov V T 1974 Compliance as a relation and principle (L.) Publishing House "Science", Leningrad. Dep. 104 p
[3] Gulati R 2013 Maintenance and Reliability: Best Practices Ramesh Gulati: New York Industrial Press Inc. 495 p
[4] Higgins L 2002 Maintenance Engineering Handbook Lindley Higgins New York, McGraw–Hill Companies Inc. 1297 p
[5] Mobley R K 2004 Maintenance Fundamentals Mobley: Burlington (USA) Elsevier Inc. 418 p
[6] Beshleev S D 1980 Mathematical and statistical methods of expert assessments 2nd ed. (M.) Statistics 263 p
[7] Pytнев Yu P Opportunity Elements of the theory and application (M.: Editorial URRS) 192 p.
[8] Redreev G V 2014 The interaction of maintenance and repair performers while ensuring the operability of machine-tractor units Modern problems of science and education 2 URL: www.science–education.ru/116–12434
[9] Ebeling V 1979 Formation of structures in irreversible processes. Introduction to the theory of dissipative structures Trans. with. A S Dobrovolsky Ed. prof. Yu L Klimantovich (M.) Mir 139 p
[10] GOST 27.002–89 Reliability in technology. Basic concepts, terms and definitions (M.: Izd. Standards) 39 p
[11] Redreev G V 2014 The interaction of maintenance and repair performers while ensuring the operability of machine-tractor units Modern problems of science and education 5 URL: www.science–education.ru/119–14864
[12] Kendal M 1975 Rank correlations Foreign statistical studies. (M.) "Statistics" 216 p
[13] Smirnov A E 2010 Methods and algorithms for the recognition of indistinctly defined states of technical systems: author's abstract ... Cand. tech. Sciences: 05.13.17 (M.) 19 p
[14] Solomkin A P 1984 Formation and availability of tractor (for example, tractors «Kirovets»): diss. PhD. techn. Sciences: 05.20.03 Alekseevka 460 p
[15] Mukhametshin A A 2013 Improving the efficiency of the use of tractor by optimizing the timing and volume of repair and servicing impacts (on the example of the farms of the Republic of Tatarstan): author’s abstract. ... Cand. tech. Sciences: 05.20.03 (Ufa) 16 p
[16] Knyazevev V A 2005 Technology assessment of the level of activity of operators in man-machine systems: author’s abstract. ... Cand. tech. Sciences: 19.00.03 (SPb) 20 p
[17] Redreev G V 1996 Justification of the process of maintenance of tractors by a group of artists during field work: author’s abstract. ... Cand. tech. Sciences: 05.20.03 (Chelyabinsk) 16 p
[18] Nemtsev A E 2009 Basics of the formation of a technical service system in the agricultural sector of Siberia Russian agricultural academy Sib. region. Dept.; Siberian Research Institute of Mechanization and Electrification of Agriculture (Novosibirsk) 153 p

[19] Redreev G V 2018 Quality assessment of technical service of agricultural machinery Omsk State Agrarian University «Vestnik» 1(29) pp 117-123

[20] Redreev G V 2017 Machine units as the objects of technical service British Journal of Innovation in Science and Technology T 2 1 pp 33-40