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METHODOLOGY FOR CALCULATING THE COST OF WARRANTY OBLIGATIONS

The paper describes the methodology for calculating the cost of warranty obligations of products manufactured by a supplier that allows estimating a predicted repair cost over the period of warranty obligations and including it into the structure of a product's price on the basis of the duration of the warranty obligations period. The cost calculation is performed for various types of warranty obligations with consideration of different stages of operation of a product. Generally, a product consists of constituent parts manufactured by a producer, and parts purchased from other manufacturers. Warranty periods for self-produced constituents and for purchased parts can either coincide or differ.

Keywords: *warranty obligations, warranty period of operation, warranty storage life, warranty operating time, repair costs, failure rate, radio electronic equipment.*

As known, radio-electronic equipment (REE) produced in the domestic industry is the subject of specific warranty obligations. It means that over the time period imposed by these obligations, the supplier shall be ready to remove at its own expense the defects occurred as the result of the earlier performed works.

In accordance with GOST RV 15.306-2003 [1], warranty obligations are the obligations of the supplier or contractor to guarantee the purchaser (customer) quality conformance of the products supplied, the works (services) performed, with the regulations set by technical requirements, standards and (or) contract stipulations, during a certain time period (warranty period, warrant operating time), and, within the time period set by warranty obligations, to carry out a free of charge removal of the defects of products (works) occurred within a warranty period, by means of repair or replacement of the defected products (constituents), with the observation by a customer of the stipulated terms of operation (use), storage, transportation.

Warranty obligations are set in relation to manufactured products or products subjected to full repairs supplied by a supplier, as well as to midlife repair of products performed by a contractor and the contractor's works on putting products into operation (installation, commissioning).

The duration of a warranty obligations period is determined by warranty obligations criteria, such as:

- warranty period is a total calendar duration of storage and transportation of a product in delivery status, as well as of operation (use) by a customer during which warranty obligations are applied;
- warranty operating time is the operation time (scope of operation) of a product within warranty obligations.

Depending on the product's properties and designation, the warranty period is specified by the following types:

- warranty storage life – a calendar duration of storage and transportation of a product in delivery status, as well as installation up to putting into operation with the observation of measures to ensure storageability of a product during which warranty obligations apply;

- warranty period of operation – a calendar duration of the operation of a product by a customer during which warranty obligations are applied.

Paper [2] describes the attempt to estimate the costs of warranty obligations with consideration of a failure rate of the constituent parts of manufactured products and the duration of these obligations. Besides, it covers the ways of creation of reserve funds for warranty repair, which are not subject to profit tax, as per the Tax Code of the Russian Federation.

Products manufactured by a supplier generally consist of purchased constituent parts and self-produced constituents. And warranty periods established for these constituent parts can either coincide or differ.

If a plant has supplied products for several years, then in case of mass production the expected cost of warranty repairs shall be determined statistically based on percentage ratio of a total cost of product repairs (plant's expenses) $C_{\text{wr.pr}}$ for the time of warranty obligations to the costs of a product's manufacture $C_{\text{man.pr}}$ for previous years, by the following formula:

$$C_{\text{wr.pr}} = \Delta \cdot C_{\text{man.pr}} \cdot T_{\text{w.pr}},$$

where Δ is the percentage ration of a total cost of a product's repairs (plant's expenses) $C_{\text{wr.pr}}$ for the time of warranty obligations to the costs of a product's manufacture $C_{\text{man.pr}}$ for previous years;

$T_{\text{w.pr}}$ is the product's warranty period set by technical conditions (TC).

If a plant does not have the prescribed statistical values for the percentage ratio of $C_{\text{wr.pr}}$ to $C_{\text{man.pr}}$, the expected cost of a product's repairs during warranty obligations shall be determined by the following formula:

$$C_{\text{wr.pr}} = \sum_{i=1}^{m} C_{\text{wr.}i} \cdot N_i \cdot r_i \cdot T_{\text{w.}pr},$$

where $C_{\text{wr.}i}$ (rub.) is the average cost of one warranty repair (replacement) of the self-produced CP of the *i*-th type specified by an expert method upon the results of operation of similar CP (based on the practice, the value of $C_{\text{wr.}i}$ is usually 30-50% of the cost of CP of the *i*-th type);

m is the number of types of self-produced CP;

N_i is the number of self-produced CP of the *i*-th type;

r_i is the expected (for a year of warranty obligations) number of failures of self-produced CP of the *i*-th type during the product performance under specified conditions of operation, in terms of ground-based activity and in case of storage.

Generally, when the warranty period of a product is more than the warranty period of a purchased CP which are the part of a product, the total cost of a product's repairs (plant's expenses) during the period of warranty obligations is determined by the formula:

$$C_{\text{wr.pr}} = \left[\sum_{i=1}^{m} C_{\text{wr.}i} \cdot N_i \cdot r_i\right] \cdot T_{\text{w.pr}} + \\ + \left[\sum_{j=1}^{k} C_{\text{wr.}j} \cdot N_j \cdot r_j\right] \cdot (T_{\text{w.}pr} - T_{\text{w.cp.purch.}j}), \quad (1)$$

where $C_{\text{wr.}j}$ is the average cost of one warranty repair (replacement) of the purchased CP of the *j*-th type, rub., specified by an expert method upon the results of operation of similar CP;

$T_{\text{w.cp.purch.}j}$ is the warranty period established for the purchased CP of the *j-th* type, years;

r_j is the expected (for a year of warranty obligations) number of failures of the purchased CP of the *j*-th type, during the product performance under specified conditions of operation, in terms of ground-based activity and in case of storage;

N_j is the number of the purchased CP of the *j*-th type;

k is the number of types of a purchased CP.

The second summand of formula (1) includes only a purchased CP for which $T_{\text{w.pr}} > T_{\text{w.cp.purch.}j}$.

The warranty period $T_{\text{w.pr}}$ applies to different stages of a product's operating life, such as:

- functioning according to the designated use under the specified conditions of operation with duration T_{o} during a year with a failure rate of the CP of the *i*-th (*j*-th) type $\lambda_{\text{o.}i}$ ($\lambda_{\text{o.}j}$);

- storage (off mode) under the specified conditions of operation with duration $T_{\text{st.o}}$ during a year with a failure rate of the CP of the *i*-th (*j*-th) type $\lambda_{\text{st.o.}i}$ ($\lambda_{\text{st.o.}j}$);

- functioning in terms of ground-based activity (equipment check and adjustment, periodic inspections before functioning according to the designated use, etc.) with duration T_{gr} during a year with a failure rate of the CP of the *i*-th (*j*-th) type $\lambda_{\text{gr.}i}$ ($\lambda_{\text{gr.}j}$);

- storage (off mode) under ground-based conditions with duration $T_{\text{st.gr}}$ during a year with a failure rate of the CP of the *i*-th (*j*-th) type $\lambda_{\text{st·gr.}i}$ ($\lambda_{\text{st·gr.}j}$);

- storage of a product in delivery status under the conditions of any storage facilities with duration T_{st} during a year with a rate of failure of the CP of the *i*-th (*j*-th) type $\lambda_{\text{st.}i}$ ($\lambda_{\text{st.}j}$);

- transportation of a product in delivery status by any kind of transport with duration T_{tr} during a year with a failure rate of the CP of the *i*-th (*j*-th) type $\lambda_{\text{tr.}i}$ ($\lambda_{\text{tr.}j}$).

In general, a warranty period $T_{\text{w.pr}}$ includes storage, transportation and operation of a product at all stages described above. In that case the expected (for a year of warranty obligations) number of failures of one CP of a product shall be determined by the formula

$$r = \lambda_{\text{э}} \cdot T_{\text{э}} + \lambda_{\text{st·o}} \cdot T_{\text{st.o}} + \lambda_{\text{gr}} \cdot T_{\text{gr}} + \lambda_{\text{st·gr}} \cdot T_{\text{st.gr}} + \\ + \lambda_{\text{st}} \cdot T_{\text{st}} + \lambda_{\text{tr}} \cdot T_{\text{tr}}.$$

Therefore, formula (1) shall look like as follows

$$C_{\text{wr.pr}} = \left[\begin{array}{l} C_{\text{wr.}i} \cdot N_i(\lambda_{\text{o}.i} \cdot T_{\text{o}} + \lambda_{\text{st.o}.i} \cdot T_{\text{st.o}} + \\ \sum_{i=1}^{m} + \lambda_{\text{gr}.i} \cdot T_{\text{gr}} + \lambda_{\text{st.gr}.i} \cdot T_{\text{st.gr}} + \\ + \lambda_{\text{st}.i} \cdot T_{\text{st}} + \lambda_{\text{tr}.i} \cdot T_{\text{st}}) \end{array} \right] \cdot T_{\text{w.pr}} +$$

$$+ \left[\sum_{j=1}^{k} \begin{array}{l} C_{\text{wr}.j} \cdot N_j(\lambda_{\text{o}.j} \cdot T_{\text{o}} + \lambda_{\text{st.o}.j} \cdot T_{\text{st.o}} + \\ + \lambda_{\text{gr}.j} \cdot T_{\text{gr}} + \lambda_{\text{st.gr}.j} \cdot T_{\text{st.gr}} + \lambda_{\text{st}.j} \cdot T_{\text{st}} + \lambda_{\text{st}.j} \cdot T_{\text{tr}}) \end{array} \right] \times$$

$$\times \left(T_{\text{w.pr}} - T_{\text{w.cp.purch}.j}\right) \quad (2)$$

For other warranty obligations the following formulas shall be applicable

- for warranty period of operation

$$r = \lambda_{\text{o}} \cdot T_{\text{o}} + \lambda_{\text{st.o}} \cdot T_{\text{st.o}} + \lambda_{\text{gr}} \cdot T_{\text{gr}} + \lambda_{\text{st.gr}} \cdot T_{\text{st.gr}};$$

$$C_{\text{wr}.pr} = \left[\sum_{i=1}^{m} \begin{array}{l} C_{\text{wr}.i} \cdot N_i \cdot (\lambda_{\text{o}.i} \cdot T_{\text{o}} + \lambda_{\text{st.o}.i} \cdot T_{\text{st.o}} + \\ + \lambda_{\text{gr}.i} \cdot T_{\text{gr}} + \lambda_{\text{st.gr}.i} \cdot T_{\text{st.gr}}) \end{array} \right] \cdot T_{\text{w.pr}} +$$

$$+ \left[\sum_{j=1}^{k} \begin{array}{l} C_{\text{wr}.j} \cdot N_j \cdot (\lambda_{\text{o}.j} \cdot T_{\text{o}} + \\ + \lambda_{\text{st.o}.j} \cdot T_{\text{st.o}} + \lambda_{\text{gr}.j} \cdot T_{\text{gr}} + \\ + \lambda_{\text{st.gr}.j} \cdot T_{\text{st.gr}}) \end{array} \right] \cdot \left(T_{\text{w.pr}} - T_{\text{w.cp.purch}.j}\right); \quad (3)$$

- for warranty storage life

$$r = \lambda_{\text{st}} \cdot T_{\text{st}} + \lambda_{\text{tr}} \cdot T_{\text{tr}};$$

$$C_{\text{wr.pr}} = \left[\sum_{i=1}^{m} C_{\text{wr}.i} \cdot N_i \cdot (\lambda_{\text{st}.i} \cdot T_{\text{st}} + \lambda_{\text{tr}.i} \cdot T_{\text{tr}}) \right] \cdot T_{\text{w.pr}} +$$

$$+ \left[\sum_{j=1}^{k} C_{\text{wr}.j} \cdot N_j \cdot (\lambda_{\text{st}.j} \cdot T_{\text{st}} + \lambda_{\text{tr}.j} \cdot T_{\text{tr}}) \right] \cdot$$

$$\cdot \left(T_{\text{w}.pr} - T_{\text{w.cp.purch}.j}\right); \quad (4)$$

- for warranty operating time

$$r = \lambda_{\text{o}} \cdot T_{\text{o}} + \lambda_{\text{gr}} \cdot T_{\text{gr}};$$

$$C_{\text{wr.pr}} = \left[\sum_{i=1}^{m} C_{\text{wr}.i} \cdot N_i \cdot (\lambda_{\text{o}.i} \cdot T_{\text{o}} + \lambda_{\text{gr}.i} \cdot T_{\text{gr}}) \right] \cdot T_{\text{w.pr}} +$$

$$+ \left[\sum_{j=1}^{k} C_{\text{wr}.j} \cdot N_j \cdot (\lambda_{\text{o}.j} \cdot T_{\text{o}} + \lambda_{\text{gr}.j} \cdot T_{\text{gr}}) \right] \cdot \left(T_{\text{w.pr}} - T_{\text{w.cp.purch}.j}\right). \quad (5)$$

A warranty operating time is normally assigned within the limits of a prescribed warranty period. In this case all failures occurred during a warranty operating time are taken into account for the calculation of failures occurred within a warranty period. In other words, in this case the cost of a product's repairs during a warranty operating time is taken into account in the cost of repairs within a warranty period.

If formulas (2) – (5) are filled in with the values of a product's structure (m, N_i, k, N_j), values of failure properties of a product's CP ($\lambda_{\text{o}.i}$, $\lambda_{\text{st.o}.i}$, $\lambda_{\text{gr}.i}$, $\lambda_{\text{st.gr}.i}$, $\lambda_{\text{st}.i}$, $\lambda_{\text{tr}.i}$, $\lambda_{\text{o}.j}$, $\lambda_{\text{st.o}.j}$, $\lambda_{\text{gr}.j}$, $\lambda_{\text{st.gr}.j}$, $\lambda_{\text{st}.j}$, $\lambda_{\text{tr}.j}$), values of duration of product performance under warranty obligations (T_{o}, $T_{\text{st.o}}$, T_{gr}, $T_{\text{st.gr}}$, T_{st}, T_{tr}), values of duration of warranty obligations ($T_{\text{w.pr}}$, $T_{\text{w.cp.purch}.j}$), it is possible to calculate the value $C_{\text{wr.pr}}$ of the expected cost of a product's repairs (plant's expenses) for a prescribed time period of warranty obligations.

As can be seen from the above, the described methods can be used to calculate the expected cost of repairs (plant's expenses) under warranty obligations and to include it into the structure of a product's price, based on the duration of a period of warranty obligations.

References

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