The determination of the fatigue strength and endurance characteristics of real structures is associated with problems caused by the fact that it is not possible to carry out tests on a large number of expensive objects, and also by the long duration of the tests. Therefore, the methods of accelerated determination of the fatigue characteristics with a sufficient degree of accuracy are very important. The accelerated methods play a controlling role in the inspection of the quality of series production, and also in the rapid development of new structures and in ensuring their required life using various design and technological measures.

In testing structural members for fatigue life in testing units, it is possible to achieve a higher rate of development of damage than in service. The compulsory condition in this case is to ensure that the nature of failure is identical with that taking place in service. This is achieved by using the same range of variation of the test conditions in the critical region which defines the sphere of physical principle of failure.

The endurance limit is the most demonstrative characteristic of the resistance to fatigue failure in examining the effect of various design and technological measures on the reliability of structural members [1].


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The accelerated methods of determination of the endurance limit are based on the hypothesis of linear cumulation of fatigue damage

\[ \Sigma n_i/N_i = 1. \]

These methods include the methods developed by Locati, Prot, Enomoto, etc. The testing conditions are cyclic with increasing amplitude. The number of cycles to fracture or fracture stress is used as a measure of the damage cumulated in the tested structural member and makes it possible to determine the region of the corresponding endurance limit [2].

The Locati method [3] is one of the most extensively used methods of accelerated testing. In this method the specimen is subjected to cyclic loading, with the load increasing in steps and causing rapid damage cumulation. Loading starts at specific initial stress \( \sigma_0 \) and is repeated for \( n_0 \) cycles. Without intermediate "recovery," the stress increases by the value \( \Delta \sigma \) to the level \( \sigma_1 = \sigma_0 + \Delta \sigma \), and testing continues at this level for \( n_1 - n_0 \) cycles. With the load increasing in steps, testing continues in this manner up to fracture of the structural member. The mean rate of stress increase is maintained constant

\[ \alpha = \Delta \sigma/n_0. \] (1)

To estimate the accuracy of determination of the endurance limit in relation to the conditions of accelerated testing with the load increasing in steps, special investigations were carried out on smooth cylindrical specimens of type I (GOST 25.502--79) [4] (Fig. 1) and lugs (Fig. 2), which represent the most heavily loaded model of joints in aviation structures [5].

Specimens of steel 30KhGSNA and titanium alloy VT22 were tested in machine MUI-6000 by loading in pure bending with rotation. The lugs of steel 30KhGSNA were tested in hydraulic pulsator GRM-1 in repeated alternating tensile loading. The frequency of loading the specimens was 100 Hz, and in testing the lugs it was 10 Hz. The mechanical characteristics of the material of the specimens and lugs are presented in Table 1.

Initial stress \( \sigma_0 \), stress increment \( \Delta \sigma \), the duration of the loading step \( n_0 \), and, consequently, the mean rate of stress variation \( \alpha \) were varied in the investigations.

The endurance \( N \) was determined using the regression equation of the fatigue curve [6]

\[ X_p = \rho_x y_1 + \bar{X} - \rho_x \bar{Y} + t_p \bar{S}_x, \] (2)

where \( \rho_x \) is the regression coefficient; \( \bar{S}_x \), measure of individual variance of linear regression; and \( t_p \), quantile of distribution of endurance for various probabilities of failure.

To estimate the accuracy of determination of the endurance limit, the independent random quantity \( y \) in Eq. (2) was represented by the stress \( y_1 = \sigma \) or the logarithm of stress \( y_2 = \log \sigma \), and the dependent random quantity was represented by the logarithm of endurance \( x = \log N \). Therefore, Eq. (2) for determining the endurance assumes the following form:

\[ \lg N = A_{p1} - m \lg \sigma; \] (A)
\[ \lg N = A_{p2} - b \sigma, \] (B)

where Eq. (2) corresponds to the constant quantities \( A_p \):

\[ A_p = \bar{x} - \rho_x \bar{Y} + t_p \bar{S}_x. \] (3)

The expression for 50% failure probability corresponds to the main equation of the fatigue curve, and two other expressions were accepted for 10 and 90% failure probability. The numerical values of the statistical characteristics of the expressions (A) and (B) for