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**Vijačne zveze - Utrujanje z osno obremenitvijo - Preskusne metode in vrednotenje rezultatov**

Threaded fasteners -- Axial load fatigue testing -- Test methods and evaluation of results

Éléments de fixation filetés -- Essais de fatigue sous charge axiale -- Méthodes d'essai et évaluation des résultats

**Ta slovenski standard je istoveten z: ISO 3800:1993**

SIST ISO 3800:2000  
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21.060.01      Vezni elementi na splošno      Fasteners in general

**SIST ISO 3800:% - \***

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# INTERNATIONAL STANDARD

**ISO**  
**3800**

First edition  
1993-12-15

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## **Threaded fasteners — Axial load fatigue testing — Test methods and evaluation of results**

iTeh **STANDARD PREVIEW**

*Éléments de fixation filetés — Essais de fatigue sous charge axiale —  
Méthode d'essai et évaluation des résultats*

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Reference number  
ISO 3800:1993(E)

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 3800 was prepared by Technical Committee ISO/TC 2, *Fasteners*, Subcommittee SC 1, *Mechanical properties of fasteners*.

SIST ISO 3800:2000

This first edition of ISO 3800 cancels and replaces ISO 3800-1:1977, which has been technically revised.

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# Threaded fasteners — Axial load fatigue testing — Test methods and evaluation of results

## 1 Scope

This International Standard specifies the conditions for carrying out axial load fatigue tests on threaded fasteners, as well as recommendations for the evaluation of the results.

Unless otherwise agreed, the tests are of the fluctuating tension type and are carried out at room temperature, the loading applied being centric along the longitudinal axis of the fastener. The influence of the compliance of clamped parts on the strain of the fastener is not taken into account.

This method allows determination of the fatigue strength of threaded fasteners.

The test results can be influenced by the test conditions. For this reason, minimum requirements are specified to reduce this effect. In addition, calibration and centring control methods for the testing apparatus are included.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements

based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 273:1979, *Fasteners — Clearance holes for bolts and screws*.

ISO 554:1976, *Standard atmospheres for conditioning and/or testing — Specifications*.

ISO 885:1976, *General purpose bolts and screws — Metric series — Radii under the head*.

ISO 4032:1986, *Hexagon nuts, style 1 — Product grades A and B*.

ISO 4033:1979, *Hexagon nuts, style 2 — Product grades A and B*.

ISO 8673:1988, *Hexagon nuts, style 1, with metric fine pitch thread — Product grades A and B*.

ISO 8674:1988, *Hexagon nuts, style 2, with metric fine pitch thread — Product grades A and B*.

## 3 Symbols and their designations

See table 1.

Table 1 — Symbols and their designations

Symbol	Designation	Symbol	Designation
$A_{d3}$	Area at nominal minor diameter, $A_{d3} = \pi d_3^2/4$	$R_s$	Constant stress ratio $\sigma_{\min}/\sigma_{\max}$
$A_s$	Stress area $A_s = \frac{\pi}{4} \left( \frac{d_2 + d_3}{2} \right)^2$ Area to be used in calculations of mean stress and stress amplitude. By agreement between the user and supplier, $A_{d3}$ may be used.	$s$	Width across flats of hexagons
$d$	Nominal size of the thread of the load verification stud	$S(F_A)$	Standard deviation of the fatigue load
$d_1$	Basic minor diameter of the thread	$S(\sigma_A)$	Standard deviation of the fatigue strength
$d_2$	Basic pitch diameter of the thread	$S(\log N)$	Standard deviation of logarithm of the fatigue life
$d_3$	Nominal minor diameter of the thread, $d_3 = d_1 - \frac{H}{6}$	$\alpha, \beta$	Coefficients of regression line for the inclined part of $S/N$ curve
$d_a$	Diameter at the point of tangency of the fillet	$\sigma_a$	Stress amplitude
$d_h$	Clearance hole diameter	$\sigma_A$	Stress amplitude at endurance fatigue limit
$d_s$	Shank diameter of the load verification stud	$\sigma_{ax}$	Axial tensile stress
$D$	Nominal thread diameter of the threaded test adaptor	$\sigma_b$	Bending stress
$F$	Tensile load	$\sigma_m$	Mean stress
$F_{0,2}$	Tensile load at proof stress $R_{p0,2}$	$\sigma_{\min}$	Minimum stress
$F_a$	Load amplitude	$\sigma_{\max}$	Maximum stress
$\Delta F_{aII}$	Difference of load amplitudes in the transition range	$\sigma_{Min}$	Minimum stress at endurance fatigue limit
$F_A$	Load amplitude at endurance fatigue limit	$\sigma_{Max}$	Maximum stress at endurance fatigue limit
$F_m$	Mean load	$\sigma_{AN}$	Fatigue strength at $N$ cycles
$H$	Height of the fundamental triangle of the thread	$\sigma_{AA}$	Estimated value of finite life strength at $N = 5 \times 10^4$
$N$	Number of stress cycles	$\sigma_{AB}$	Estimated value of finite life strength at $N = 1 \times 10^6$
$N_G$	The number of stress cycles in the case where the test has discontinued without failure	$\sigma_{a,i}$	Stress amplitude of the $i^{\text{th}}$ test in the finite life range
$p$	Failure probability	$\sigma_{a,j}$	Stress amplitude of the $j^{\text{th}}$ test by staircase method
$p_f$	Failure probability in the finite life range	$\Delta \sigma_{aI}$	Interval of stress amplitude of the test at the finite life range (inclined part of $S/N$ curve)
$p_t$	Failure probability in the transition range	$\Delta \sigma_{aII}$	Difference in levels of stress amplitude in the transition range
$P$	Pitch of the thread		
$R_{m,min}$	Minimum tensile strength		

## NOTES

1 The symbol  $\wedge$  is used in the case of estimated values. For example, the estimated value  $\hat{\sigma}_{AN}$  of the fatigue strength at the number of cycles  $N$ .

2 The symbol  $-$  is used in the case of  $\sigma_a$  or  $\log N$  values which are derived from the regression line; e.g.  $\bar{\sigma}_a$  or  $\log \bar{N}$ .

## 4 Principle

Test are made on threaded fasteners to determine fatigue properties such as those shown by the Wöhler curve ( $S/N$  curve).

Threaded fasteners to be tested are mounted in an axial load fatigue testing machine and subjected to fluctuating tension type loading.

Tests with constant mean stress  $\sigma_m$  or constant stress ratio  $R_s = \sigma_{\min}/\sigma_{\max}$  may be used. Constant mean stress is used generally to determine infinite life [see case (c) in figure 10].

Constant stress ratio is generally for quality acceptance testing [see case (a) in figure 10].

The test is continued until the test piece fails, or until a predetermined number of stress cycles has been exceeded. Generally the number of test cycles is determined by the material or by the endurance fatigue strength of the test specimen. Unless otherwise specified, the definition of failure is complete separation of the fastener into two parts.

## 5 Apparatus

### 5.1 Testing machine

The testing machine shall be capable of maintaining automatically the loads to within  $\pm 2\%$  of the required values throughout the test and shall be equipped with a device for counting and recording the

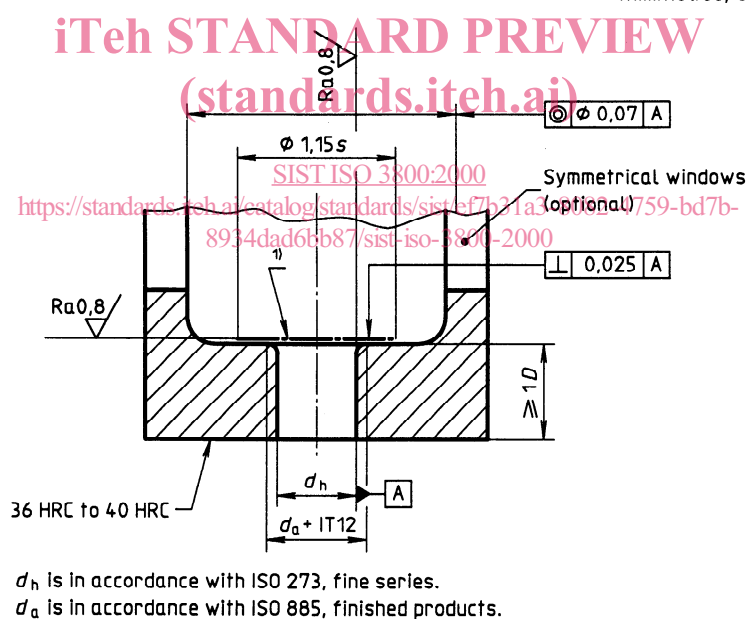
total number of cycles per test. The testing machine shall be calibrated periodically to ensure this accuracy. The frequency range of testing shall be between 4,2 Hz and 250 Hz. The testing machine shall induce a sinusoidal fluctuation in load in the test piece.

The testing machine shall have a device to prevent its automatic restarting after stopping due to electrical power service interruption.

## 5.2 Test fixtures

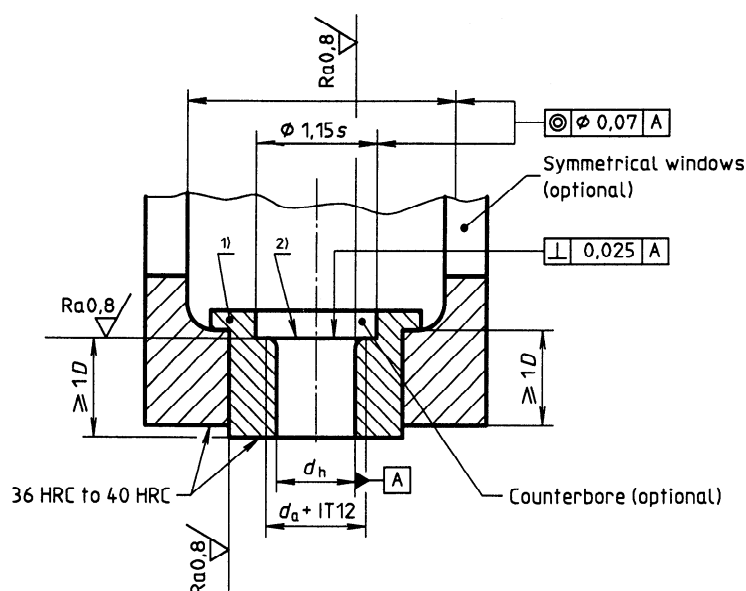
The test fixtures shall be capable of transmitting an axial load to the test piece. Figures 1 and 2 give basic requirements. Self-aligning devices are not recommended, see 5.3.

Perpendicularity and concentricity tolerances in millimetres, surface roughness in micrometres



**Figure 1 — Fixture without insert**

Perpendicularity and concentricity tolerances in millimetres, surface roughness in micrometres



$d_h$  is in accordance with ISO 273, fine series.

$d_a$  is in accordance with ISO 885, finished products.

- 1) The use of an insert shall not affect the rigidity of the test fixture.
- 2) Surface may be case-hardened 0,25 mm to 0,5 mm deep: maximum hardness, HRC 60; minimum hardness, 5 points HRC greater than that of the test part.

**Figure 2 — Fixture with insert**

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### 5.3 Test alignment

Periodically, the alignment of the test set-up shall be verified. This shall be determined by using a load verification stud (see figure 3) with four strain gauges located at 90° on a common centreline around the axis. The length of the parallel part of the load verification stud shall be four times its diameter. When measured at 50 % of the load range used on the machine, the difference between the maximum stress  $\sigma_{ax} + \sigma_b$  and the nominal tensile stress  $\sigma_{ax}$  shall not exceed 6 % of the nominal tensile stress (see figure 4).

Self-aligning devices are not recommended. If they are used, alignment shall be checked carefully since

any excentric loading may cause fatigue test results to vary widely.

### 5.4 Internally threaded component

For fatigue testing of standard products, the appropriate size and property class of nut in accordance with ISO 4032, ISO 4033, ISO 8673 or ISO 8674 or a threaded adapter shall be used.

If special bolt-nut combinations are tested, a precise description of the nut shall be given as specified in 8.2.

If threaded adapters according to figure 5 are used, they shall be described in accordance with 8.2.



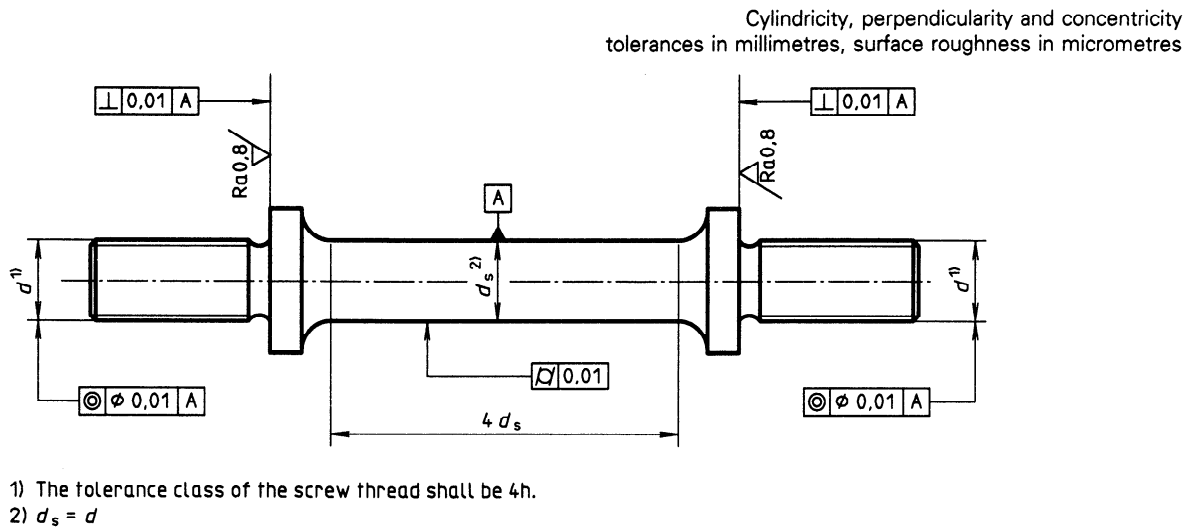


Figure 3 — Load verification stud

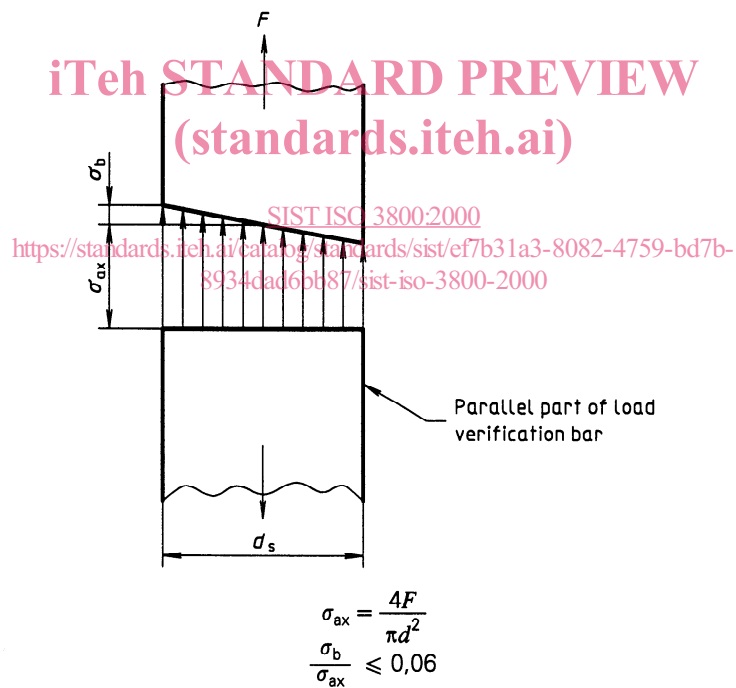
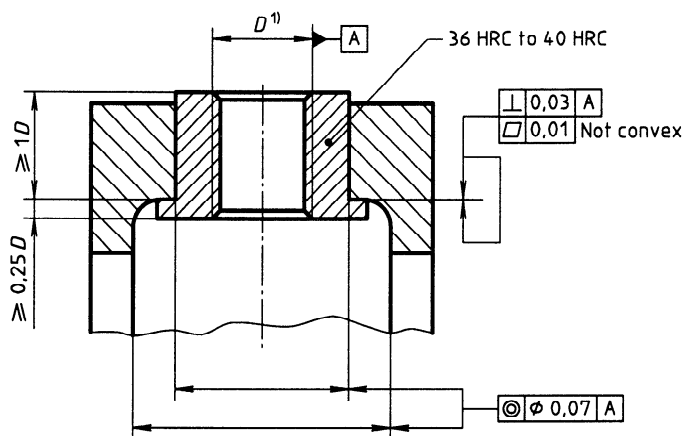


Figure 4 — Stress distribution in the shank of the load verification stud

Flatness, perpendicularity and concentricity tolerances  
in millimetres



1) Thread tolerance 6H.

Figure 5 — Threaded test adapter

## 5.5 Test washers

A chamfered test washer may be used under the bolt head to provide clearance for the head-to-shank fillet or the fixtures may be chamfered. The maximum diameter of the 45° included angle chamfer shall be equal to the diameter at the point of tangency of the fillet ( $d_f$ ) with a + IT12 tolerance (see figure 6). The faces of washers shall be parallel to within 0,01 mm. The hardness of the washer shall be the same as that of the fixture.

Where a test washer is used, it shall be indicated in the test report (see 8.3).

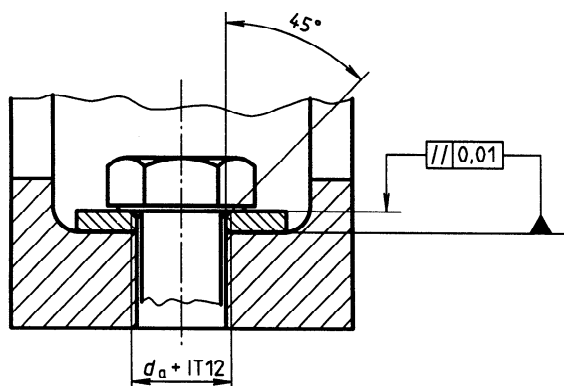


Figure 6 — Test washer (assembled)

## 6 Test procedure

The capacity of the testing machine shall be selected so that the maximum load on the test specimen is equal to or greater than 10 % of the maximum scale capacity of the machine in the test configuration selected. The bearing face of the nut or the face of the threaded adapter shall be located at least four pitches from the unthreaded portion of the shank and the nut threads shall be fully engaged; a bolt length of at least 2P shall protrude beyond the test nut (see figure 7). Test nuts shall be used once only.

Threaded test adapters may be used continually as long as they assemble freely on the externally threaded part each time and no damage has been observed.

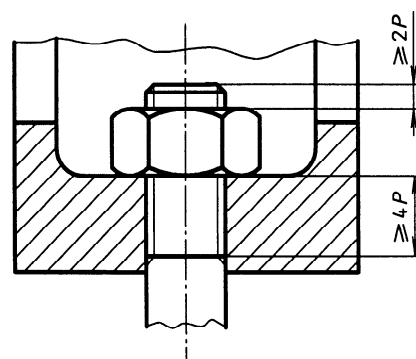


Figure 7 — Location of test nut

The specimen shall be assembled freely in the fixture without binding or forcing. No torsional stress shall be induced in the assembly by torquing the nut; i.e. the load shall be induced in the assembly by the testing machine.

The threaded fastener and test nut shall be thoroughly cleaned and then coated with SAE 20 oil or equivalent prior to testing.

The test frequency shall be selected so that the temperature of the test specimen does not rise more than 50 °C during the test period. The temperature should be measured at the first engaged thread.

At frequent intervals throughout the test period, the load shall be monitored to ascertain that the load conditions have not changed.

Results of fatigue tests are affected by atmospheric conditions. Therefore, if possible, atmospheric conditions, particularly humidity, should be checked in accordance with ISO 554:1976, 2.1.

## 7 Evaluation of results

A comparative assessment of fatigue strength values is only possible when the tests and the evaluation of results are carried out in a uniform manner.

Fatigue strength values can be determined in the finite life range (failure of all test pieces before a predetermined number of stress cycles is reached) and in the transition range where, up to the predetermined number of stress cycles (in general  $5 \times 10^6$  to  $10^7$  stress cycles), failures as well as non-failures will occur (see figure 10). As a function of the test objective, the fatigue tests are carried out and evaluated according to two methods:

- a minimum number of stress cycles is reached at a predetermined stress amplitude in the finite life range and transition range, respectively;
- the position and size of scatter of the finite life range and transition range, respectively, are determined using statistical evaluation methods.

### 7.1 Tests in the finite life range

The test in the finite life range is the test for obtaining the finite fatigue life data of threaded fasteners and is generally applied for production control of products, quality assurance at delivery and the like. When the product specification defines the stress and the number of stress cycles and the other conditions are not specified, generally a minimum of six products should be tested.

Furthermore, this test shall be made by using either the method to keep the mean stress ( $\sigma_m$ ) constant or the method to keep the ratio ( $R_s$ ) of the maximum stress and the minimum stress constant ( $R_s = 1/10$  is generally used).

#### 7.1.1 Quality control test

A statistically valid sample shall be taken for test purposes as agreed between the user and supplier. The sample should be increased by at least 10 % to allow for unforeseen testing difficulties.

#### 7.1.2 Determination of position and slope of the finite life range (Design test)

The scatter in the number of stress cycles in the finite life range can economically only be approximated using statistical calculation methods.

For assessment of the finite life range, the fatigue tests shall be carried out on at least two stress levels, which should be chosen so that numbers of stress cycles are obtained between  $10^4$  and  $5 \times 10^5$ .

The number of tests (sampling size) per stress level depends on the selected statistical evaluation method and the required prediction reliability for the probabilities of failure  $p_f$ ; e.g.  $p_f = 10\%$ ,  $50\%$  or  $90\%$ .

The minimum number of test pieces should not be less than six.

The scatter in the finite life range on one stress level can then be determined by taking as a basis, for example, the normal Gaussian distribution in the Gaussian probability net and by using the estimator

$$p_f = \frac{3i - 1}{3n + 1}$$

where

$p_f$  is the assessed value for the probability of failure in the finite life range;

$i$  is the ordinal number of a test piece;

$n$  is the number of test pieces tested.

The following example explains the procedure:

$n = 8$  bolts are tested with the constant stress amplitude  $\sigma_a = 150 \text{ N/mm}^2$ . The stress cycles reached until failure are, in chronological order:

$$N = (169, 178, 271, 129, 405, 115, 280, 305) \times 10^3.$$

At first the numbers of stress cycles are arranged according to size, and ordinals  $i$  are assigned to them.