INTERNATIONAL STANDARD ISO 3800/I

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Threaded fasteners — Axial load fatigue testing — Part I : Test methods

Éléments de fixation filetés — Essais de fatigue sous charge axiale — Partie I : Méthodes d'essai

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First edition — 1977-05-01

ISO 3800-1:1977
https://standards.iteh.ai/catalog/standards/sist/764f721b-c197-4ee0-837e-2a6230df6a73/iso-3800-1-1977

UDC 621.882 : 620.178.3

Ref. No. ISO 3800/I-1977 (E)

Descriptors : fasteners, threaded mechanical parts, bolts, screws, nuts (fasteners), tests, fatigue tests.

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3800/I was developed by Technical Committee ISO/TC 2, *Fasteners*, and was circulated to the member bodies in May 1975.

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It has been approved by the member bodies of the following countries :

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Threaded fasteners — Axial load fatigue testing — Part I : Test methods

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1 SCOPE AND FIELD OF APPLICATION

This International Standard specifies the conditions for carrying out axial load fatigue tests on threaded fasteners. ISO 3800/II[1] specifies methods of statistically determining fatigue strengths. The tests specified are of the fluctuating tension type as defined in ISO/R 373, sub-clause 3.2.3, and are carried out at room temperature, in air, the loading applied being along the longitudinal axis of the fastener. These methods allow the fatigue strength of threaded fasteners in open joints (clamped parts are not in contact) to be determined independently of their application.

Since the test fixtures can introduce variables in results, minimum requirements are specified to reduce their effect. Calibration and alignment control methods are included.

2 REFERENCES

ISO/R 80, *Rockwell hardness test (A and B scales) for steel.*

ISO/R 273, *Clearance holes for metric bolts.*

ISO/R 373, *General principles for fatigue testing of metals.*

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

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

ISO 1099, *Metals — Axial load fatigue testing.*

ISO 1101, *Tolerances of form and of position.*

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3 PRINCIPLE

Tests are made on threaded fasteners to determine fatigue properties such as those shown by the *S/N* curve (Wöhler curve) described in ISO/R 373.

Test threaded fasteners are mounted in an axial load fatigue testing machine and subjected to fluctuating tension type loading as defined in ISO/R 373, sub-clause 3.2.3.

Tests with constant mean stress σ_m or constant stress ratio $R_s = \sigma_{min}/\sigma_{max}$ may be used.

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. For threaded steel fasteners, the test may be discontinued at 5×10^6 cycles in general. The definition of failure is given in ISO/R 373.

1) In preparation.

4 DEFINITIONS AND SYMBOLS

In this International Standard the following symbols are used :

Symbol	Definition
d_a	Diameter at the point of tangency of the fillet
D	Major diameter of nut thread
D_h	Through hole diameter
P	Pitch
R_m	Minimum tensile strength
R_s	Constant stress ratio $\sigma_{min}/\sigma_{max}$
s	Width across flats of hexagons
σ_a	Stress amplitude
σ_A	Stress amplitude at endurance fatigue limit
σ_m	Mean stress
σ_{min}	Minimum stress
σ_{max}	Maximum stress
σ_{Min}	Minimum stress at endurance fatigue limit
σ_{Max}	Maximum stress at endurance fatigue limit
σ_{AN}	Fatigue strength at N cycles

In general, the stress amplitude as well as the high of low stress are related to the area at the basic minor diameter, but the mean stress is related to the nominal stress area. In the interests of uniformity, and also in view of the possibility of comparisons being made, the area at the basic minor diameter shall be chosen for the mean stress as well as for the stress amplitude.

Further symbols and definitions relating to fatigue testing are given in ISO/R 373.

5 APPARATUS

5.1 Testing machine

The testing machine shall be capable of maintaining the loads within ± 2 % of the required values 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 and 250 Hz. The testing machine shall induce a sinusoidal fluctuation in load in the test piece.

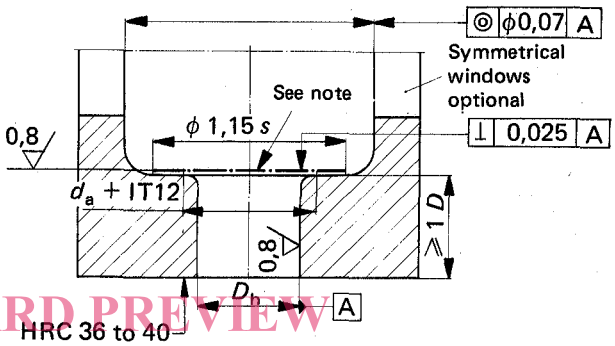
5.2 Test fixtures

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; if they are used, alignment shall be checked carefully.

5.3 Test alignment

Periodically, the alignment of the test setup shall be verified to ensure that the difference between the maximum stress and the average stress in a test specimen does not exceed 6 % of the average stress when measured at 50 % of the load range used on the machine. This may be determined by using a load cell with strain gauges located at 90° on a common centre line around the axis.

The free length of the strain gauged stud used to check the alignment shall be 4 times the diameter for comparison of possible bending stresses. Other equivalent methods for the alignment of the test setup are permissible.



D_h = Through hole diameter according to ISO/R 273, fine series

d_a = Transition diameter according to ISO 885, finished products

FIGURE 1 — **Fixture without insert**

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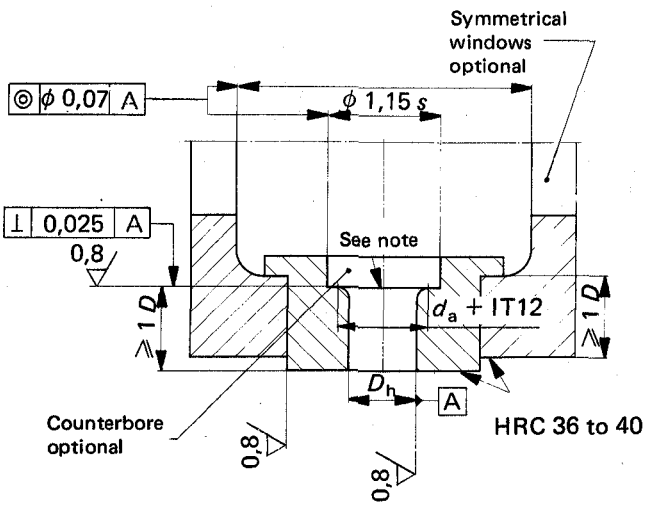

D_h = Through hole diameter according to ISO/R 273, fine series

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FIGURE 2 — **Fixture with insert**

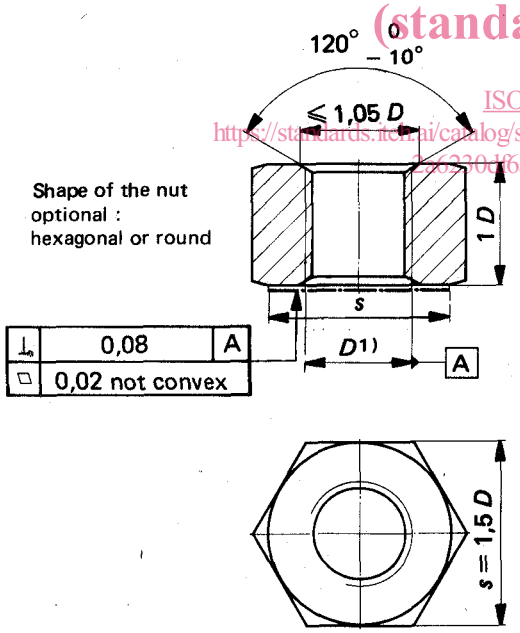
NOTE — Surface may be case-hardened 0,25 to 0,5 mm deep : maximum hardness HRC 60; minimum hardness 5 points HRC greater than test part.

5.4 Test nut

The test nut shall be an internally threaded part having a thickness of 1 *D* with a 120° included angle chamfer at each end and a maximum diameter equal to 1,05 *D*. The outside contour of the nut may be round or hexagonal with a diameter or across flats dimensions of 1,5 *D*. The maximum hardness of the nut shall not be greater than that of the bolt being tested, and the nut shall meet the proof load requirements (see the table). The finish on the test nut shall be smooth (figure 3).

TABLE — **Mechanical properties of fatigue test nuts**

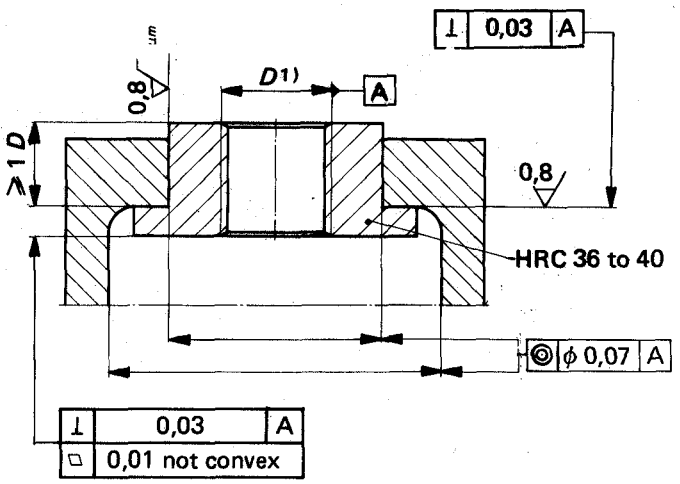
Characteristic	Bolt property class			
	8.8	10.9	12.9	other
Proof load stress (N/mm^2)	800	1 000	1 200	equal to R_m of bolt
Maximum hardness (HRC)	equal to bolt minimum			



1) Thread tolerance class 5 H.

FIGURE 3 — **Test nut**

For short bolts, threaded adapters may be used instead of test nuts.



1) Thread tolerance class 5 H.

FIGURE 4 — **Threaded test adapter**

If special bolt-nut combinations are tested, a precise description of the nut shall be given as prescribed in 9.3.

If threaded adapters according to figure 4 are used, they shall be described in accordance with 9.3.

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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 90° included angle chamfer shall be equal to the diameter at the point of tangency of the fillet with a + IT12 tolerance (figure 5). The faces of washers shall be parallel within 0,01 mm. The hardness of the washer shall be the same as the fixture.

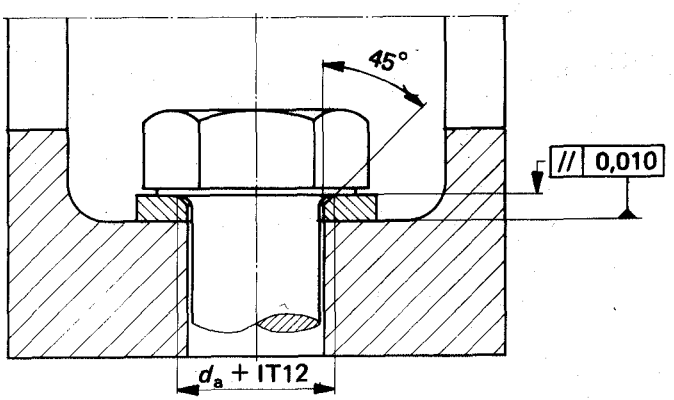

FIGURE 5 — **Test washer (assembly)**

6 TEST PROCEDURE

The size 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. The threaded fastener shall assemble freely in the fixtures without binding or forcing. No torsional load should be induced in the assembly by torquing the nut. The bearing face of the nut shall be located 4 to 8 pitches from the unthreaded portion of the shank and the nut threads shall be fully engaged; a bolt length of at least 1 P shall protrude beyond the test nut (figure 6). Test nuts shall be used once from each side; they may be used a maximum of six times as long as they assemble freely on the externally threaded part each time and no damage has been observed.

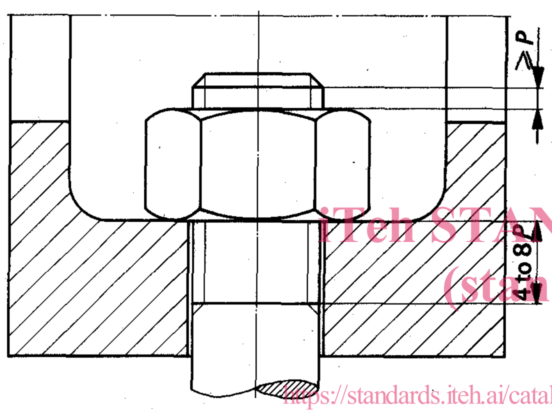

FIGURE 6 — **Location of the test nut**

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 may be affected by atmospheric conditions. Therefore, if possible, atmospheric conditions should be controlled in accordance with sub-clause 2.1 of ISO 554.

7 TEST PLANS

Tests shall be planned and test results presented in a uniform manner so that various tests may be compared. The following test plans may be used.

7.1 Finite fatigue life testing

Tests which result in finite fatigue life data are normally used for the control of production. When the product specification defines stress and stress cycles, generally a minimum of six parts should be tested (if not otherwise specified in the product specification). Both tests with constant mean stress σ_m or constant stress ratio R_s may be used.

7.2 Infinite fatigue life testing

In developing application limits, a more complete description of fatigue performance is required. This information can be obtained as follows :

7.2.1 *Development of a complete Wöhler-curve (S/N curve)*

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To achieve accurate determination of the fatigue strength (σ_{AN}) and the scatter of the data, a predetermined number of parts, depending on the statistical evaluation method used, shall be tested with constant stress ratio $R_s = +0,1$, i.e. $\sigma_m = 0,55\,\sigma_{max} = 1,22\,\sigma_a$, as follows :

a) X parts at a stress to yield about 10^5 stress cycles at failure;

b) X parts at a stress to yield about 10^6 stress cycles at failure;

c) Y parts to determine the fatigue (endurance) strength by a statistical evaluation method.

The numbers X and Y are defined by the selected statistical evaluation method, for example :

$X = 6$ as minimum number for linear regression analysis in the finite life range;

$Y = 15$ as minimum number for staircase method.

The data shall be plotted using semi-logarithmic coordinates as shown in figure 7. The probability of survival data points, for example for 10 %, 50 % and 90 %, can be obtained using statistical methods as defined in ISO 3800/II and stated in 9.8.

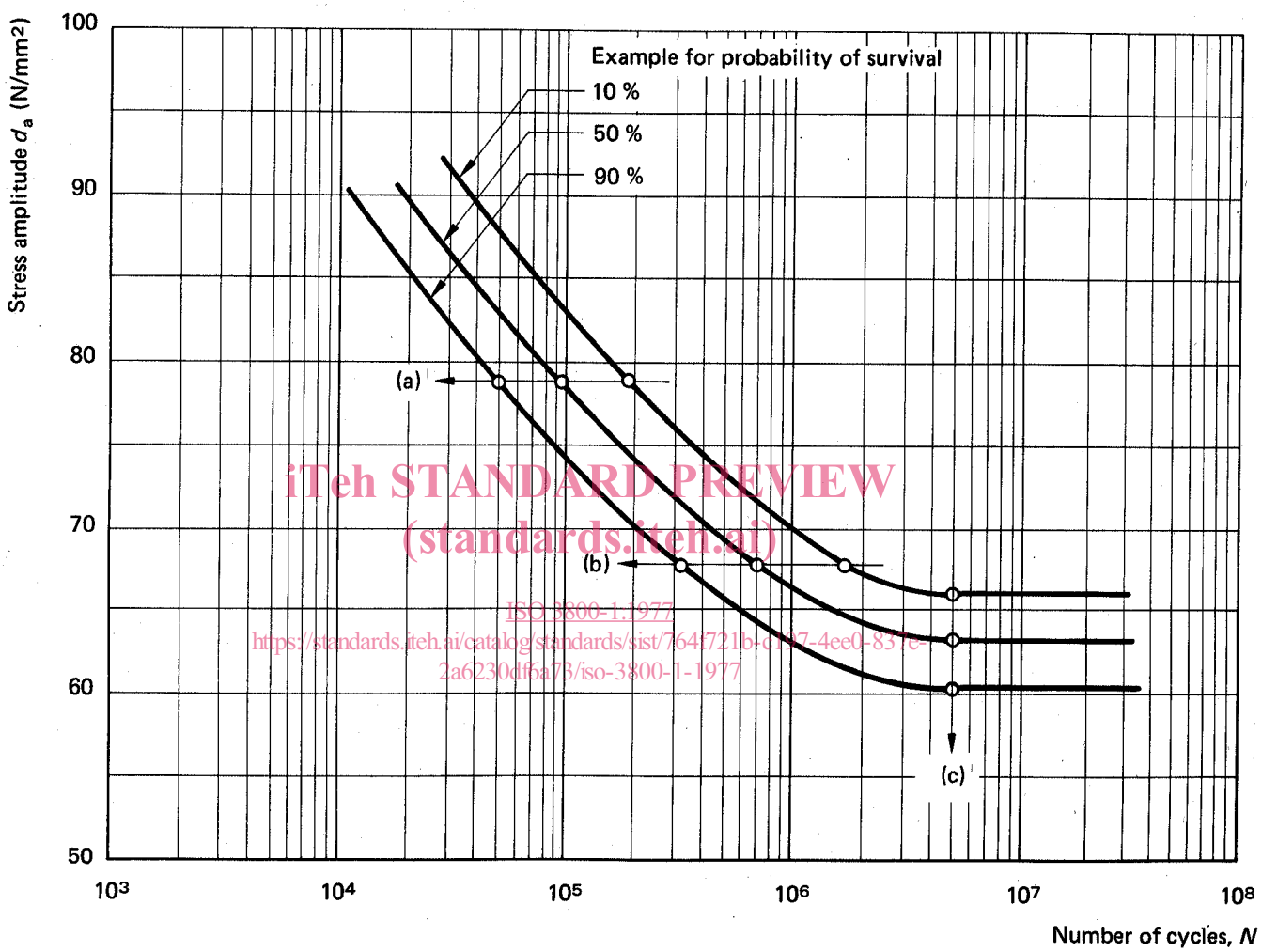

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FIGURE 7 — *S/N* curve (Wöhler curve)

7.2.2 *Development of a Haigh-diagram*

To select a fastener correctly, a designer may need additional information concerning the influence of mean stress on the fatigue strength. The Haigh-diagram (figure 8) presents the required data in a convenient form and shows the fatigue strength for the 10 %, 50 % and 90 % probability of survival.

Using statistical methods as defined in ISO 3800/II, this chart may be developed using a minimum number of parts, on each of the three following mean stress levels (for example, 45 for using the staircase method) :

a) high mean stress with constant mean stress $\sigma_m = 0{,}7\ R_m$;

b) medium mean stress with constant mean stress $\sigma_m = 0{,}4\ R_m$;

c) low mean stress $\sigma_m = 1{,}22 \times \sigma_A = 0{,}55 \times \sigma_{Max}$ derived from constant stress ratio $R_s = \frac{\sigma_{Min}}{\sigma_{Max}} = +0{,}1$.

For c), the results of 7.2.1 c) may be used.

8 APPLICATION OF STATISTICAL METHODS

Fatigue testing data tend to be variable and a fatigue determination using a small number of test pieces may give results which are not typical. It is desirable to adapt planned statistical methods to obtain reliable predictions. By determining fatigue strength for 10 %, 50 % and 90 % probability of survival, the inherent scatter in fatigue properties is considered. These statistical methods are defined in ISO 3800/II.

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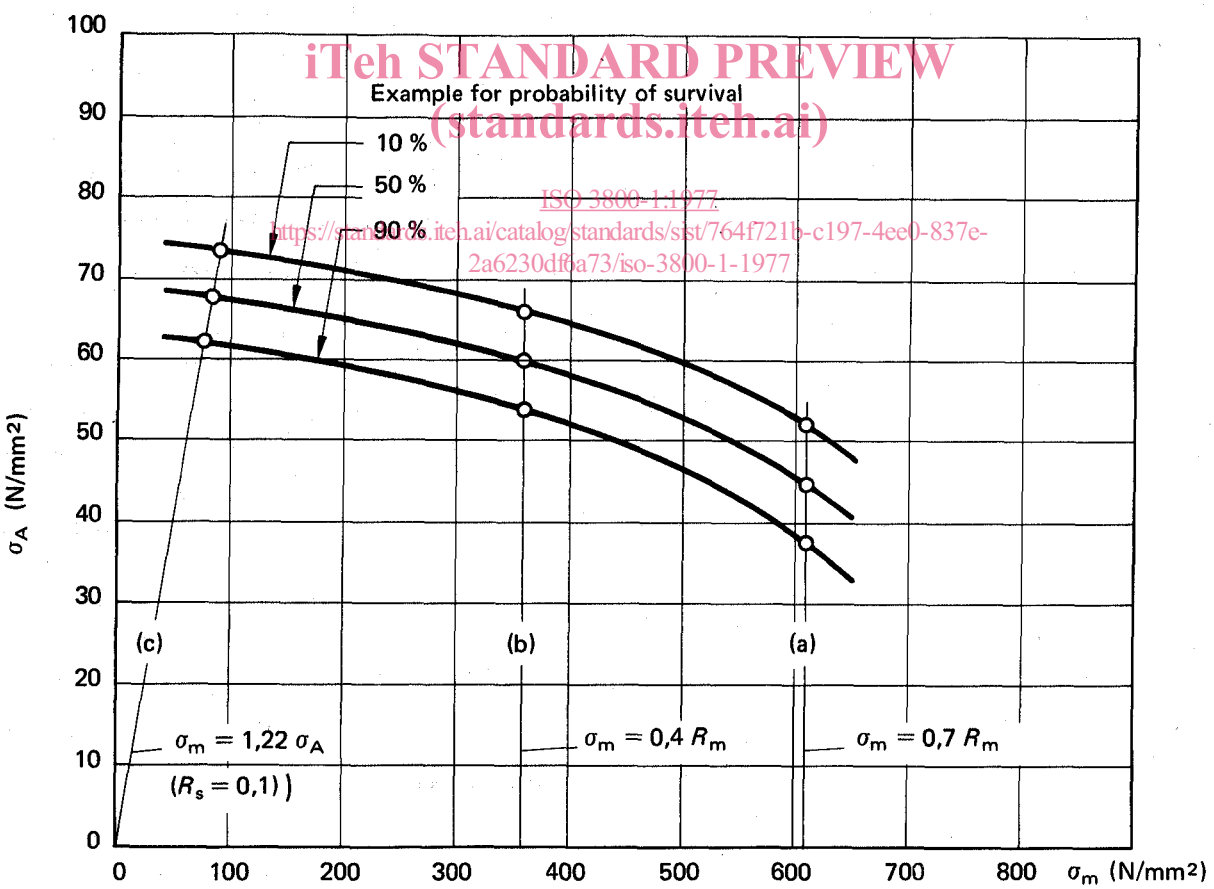

FIGURE 8 — **Haigh-diagram**

9 TEST REPORT

In reporting fatigue data, the test conditions shall be clearly defined and the test report shall include details of the following (deviations from this International Standard shall be pointed out clearly) :

9.1 Definition of externally threaded fastener :

a) Type and class

b) Thread size, pitch, length of fastener, thread tolerance and profile

c) Manufacturing method of fastener and thread

d) Tensile strength and 0,2 % yield strength

e) Surface treatment

f) Nut location (distance from nut face to thread runout).

9.2 Material in threaded fastener and how processed.

9.3 Test nut defintion :

a) Shape

b) Dimensions

c) Hardness

d) Material

e) Manufacturing method

f) Finish

9.4 Type of lubrication used on test parts.

9.5 Type and frequency of testing machine.

9.6 Type of stress cycle (for example, mean stress and stress amplitude or R_s and either σ_{min} or σ_{max}).

9.7 The mode and location of failure.

9.8 The applied statistical evaluation methods.

9.9 Atmospheric conditions.

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