

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

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Policy Committee (GME/-) to Technical Committee GME/9, upon which the following bodies were represented:

BEAMA Ltd.
British Constructional Steelwork Association Ltd.
British Industrial Fasteners Federation
British Railways Board
British Steel Industry
British Steel Industry (Wire Section)
Gauge and Tool Makers' Association
Society of Motor Manufacturers and Traders Ltd.
Washer Manufacturers' Association of Great Britain

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

British Turned-parts Manufacturer's Association
Institute of Metal Finishing
Metal Finishing Association
Stainless Steel Fabricators' Association of Great Britain
National Centre of Tribology

This British Standard, having been prepared under the direction of the General Mechanical Engineering Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 August 1994

© BSI 1994

The following BSI references relate to the work on this standard:
Committee reference GME/9
Draft for comment 91/83077 DC

ISBN 0 580 23243 3

Amendments issued since publication

Amd. No.	Date	Text affected

Contents

	Page
Committees responsible	Inside front cover
National foreword	ii
Specification	
1 Scope	1
2 Normative references	1
3 Symbols and their designations	1
4 Principle	2
5 Apparatus	3
6 Test procedure	6
7 Evaluation of results	7
8 Test report	16
Tables	
1 Symbols and their designations	2
2 Order system for the statistical evaluation of 8 fatigue tests with a stress amplitude of $\sigma_a = 150 \text{ N/mm}^2$ in the finite life range	8
3 Example of the evaluation of fatigue tests by the staircase method	11
Figures	
1 Fixture without insert	3
2 Fixture with insert	4
3 Load verification stud	5
4 Stress distribution in the shank of the load verification stud	5
5 Threaded test adapter	6
6 Test washer (assembled)	6
7 Location of test nut	6
8 Probability of failure p_f and number of stress cycles in the finite life range, determined on the basis of 8 fatigue tests with $\sigma_a = 150 \text{ N/mm}^2$	9
9 Example of the execution and evaluation of fatigue tests according to the boundary method	12
10 Wöhler curve (S/N curve) $\sigma_a = f(N)$	13
11 Example of basic pattern of combined test method with 14 specimens	14
12 Example of Wöhler curve (S/N curve)	17
13 Haigh diagram	17

National foreword

This British Standard has been prepared under the direction of the General Mechanical Engineering Standards Policy Committee and is identical with ISO 3800 : 1993 *Threaded fasteners — Axial load fatigue testing — Test methods and evaluation of results*, published by the International Organization for Standardization (ISO).

Cross-references

International standard	Corresponding British Standard
ISO 273 : 1979	BS EN 20273 : 1992 <i>Fasteners. Clearance holes for bolts and screws</i> (Identical)
ISO 885 : 1976	BS 4183 : 1967 <i>Specification for machine screws and machine screw nuts. Metric series</i> (Technically equivalent) BS 4190 : 1967 <i>Specification for ISO metric black hexagon bolts, screws and nuts</i> (Technically equivalent) BS 4395 <i>Specification for high strength friction grip bolts and associated nuts and washers for structural engineering</i> Part 1 : 1969 <i>General grade</i> (Technically equivalent) Part 2 : 1969 <i>Higher grade bolts and nuts and general grade washers</i> (Technically equivalent)
ISO 4032 : 1986	BS EN 24032 : 1992 <i>Hexagon nuts, style 1. Product grades A and B</i> (Identical)
ISO 4033 : 1979	BS EN 24033 : 1992 <i>Hexagon nuts, style 2. Product grades A and B</i> (Identical)
ISO 8673 : 1988	BS EN 28673 : 1992 <i>Hexagon nuts, style 1, with metric fine pitch thread. Product grades A and B</i> (Identical)
ISO 8674 : 1988	BS EN 28674 : 1992 <i>Hexagon nuts, style 2, with metric fine pitch thread. Product grades A and B</i> (Identical)

The Technical Committee has reviewed the provisions of ISO 554 : 1976 to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

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
A_{d3}	Area at nominal minor diameter, $A_{d3} = \pi d_3^2/4$
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.
d	Nominal size of the thread of the load verification stud
d_1	Basic minor diameter of the thread
d_2	Basic pitch diameter of the thread
d_3	Nominal minor diameter of the thread, $d_3 = d_1 - \frac{H}{6}$
d_a	Diameter at the point of tangency of the fillet
d_h	Clearance hole diameter
d_s	Shank diameter of the load verification stud
D	Nominal thread diameter of the threaded test adaptor
F	Tensile load
$F_{0,2}$	Tensile load at proof stress $R_{p0,2}$
F_a	Load amplitude
ΔF_{aII}	Difference of load amplitudes in the transition range
F_A	Load amplitude at endurance fatigue limit
F_m	Mean load
H	Height of the fundamental triangle of the thread
N	Number of stress cycles
N_G	The number of stress cycles in the case where the test has discontinued without failure
p	Failure probability
p_f	Failure probability in the finite life range
p_t	Failure probability in the transition range
P	Pitch of the thread
$R_{m,min}$	Minimum tensile strength

Symbol	Designation
R_s	Constant stress ratio $\sigma_{min}/\sigma_{max}$
s	Width across flats of hexagons
$S(F_A)$	Standard deviation of the fatigue load
$S(\sigma_A)$	Standard deviation of the fatigue strength
$S(\log N)$	Standard deviation of logarithm of the fatigue life
α, β	Coefficients of regression line for the inclined part of S/N curve
σ_a	Stress amplitude
σ_A	Stress amplitude at endurance fatigue limit
σ_{ax}	Axial tensile stress
σ_b	Bending stress
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
σ_{AA}	Estimated value of finite life strength at $N = 5 \times 10^4$
σ_{AB}	Estimated value of finite life strength at $N = 1 \times 10^6$
$\sigma_{a,i}$	Stress amplitude of the i^{th} test in the finite life range
$\sigma_{a,j}$	Stress amplitude of the j^{th} test by staircase method
$\Delta\sigma_{aI}$	Interval of stress amplitude of the test at the finite life range (inclined part of S/N curve)
$\Delta\sigma_{aII}$	Difference in levels of stress amplitude in the transition range
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 σ_a or $\log N$ values which are derived from the regression line; e.g. $\overline{\sigma_a}$ or $\overline{\log N}$.	

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 σ_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

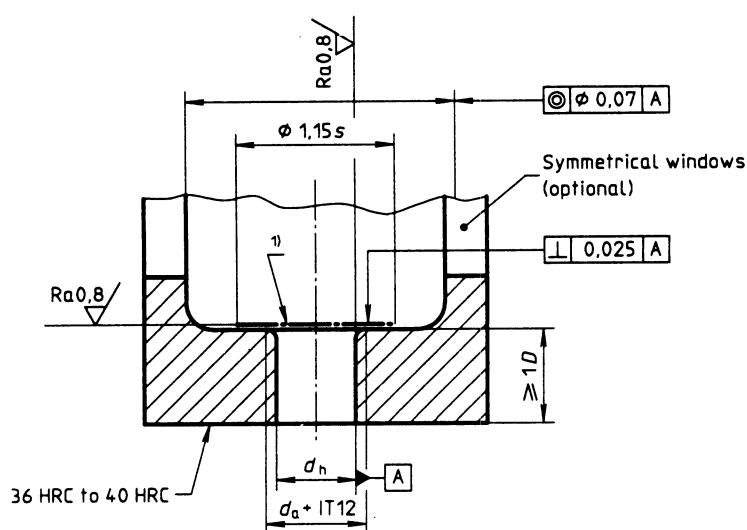
total number of cycles per test. The testing machine shall be calibrated periodically to ensure this accuracy. The frequency range of testing shall be between 4,2 Hz and 250 Hz. The testing machine shall induce a sinusoidal fluctuation in load in the test piece.

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



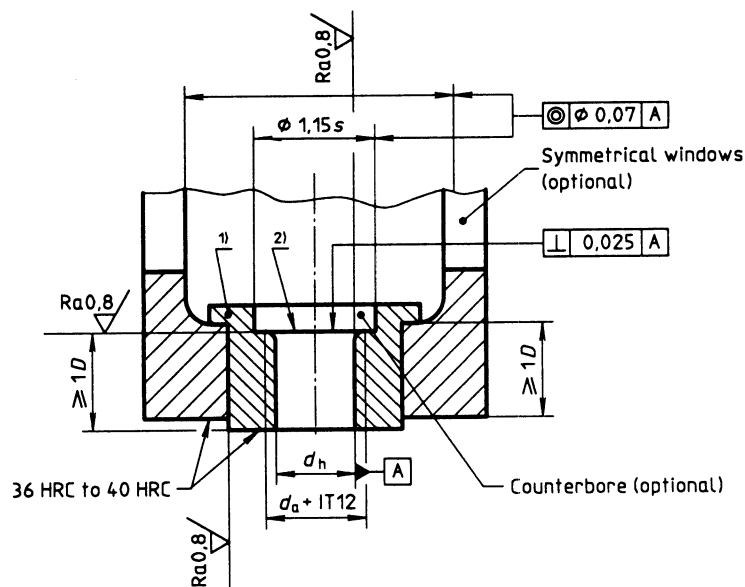
d_h is in accordance with ISO 273, fine series.

d_a is in accordance with ISO 885, finished products.

1) 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 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

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 σ_{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.