

Method for

Constant amplitude strain controlled fatigue testing

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Iron and Steel Standards Policy Committee (ISM/-) and the Non-ferrous Metals Standards Policy Committee (NFM/-) to Technical Committee ISM/NFM/4, upon which the following bodies were represented:

- Aluminium Federation
- British Gas plc
- British Non-ferrous Metals Federation
- British Railways Board
- British Steel Industry
- Copper Development Association
- Department of Trade and Industry (National Engineering Laboratory)
- Department of Trade and Industry (National Physical Laboratory)
- ERA Technology Ltd.
- GAMBICA (BEAMA Ltd.)
- Ministry of Defence
- Society of British Aerospace Companies Ltd.
- Welding Institute

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

- BCIRA
- Electricity Supply Industry in England and Wales
- Portsmouth Polytechnic
- United Kingdom Atomic Energy Authority
- University College London
- University of Birmingham

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Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
1 Scope	1
2 Definitions	1
3 Symbols	2
4 Principle	2
5 Test equipment	2
6 Specimen geometry	3
7 Alignment of test fixtures	3
8 Test procedure	3
9 Test report	4
Appendix A Generation of data sets	10
Appendix B Test fixtures	10
Appendix C Dynamic verification of extensometers	13
Appendix D Specimen preparation	13
Figure 1 — One cycle, defined for sinusoidal and triangular waveform strain histories	5
Figure 2 — Stress-strain hysteresis loop	6
Figure 3 — Test section profile for cylindrical specimens	6
Figure 4 — Alternative test section profile for cylindrical specimens	7
Figure 5 — Test section profile for plate specimens	8
Figure 6 — Plot of maximum force against cycles for a cyclically softening material	9
Figure 7 — Schematic diagram of grips for threaded end specimens	11
Figure 8 — Schematic diagram of grips for button end specimens	12
Figure 9 — Schematic diagram of grips for conical end specimens	12
Figure 10 — Schematic diagram of hydraulically actuated grips for plate specimens	13
Table 1 — Cylindrical specimen geometry	7
Table 2 — Alternative cylindrical specimen geometry	7
Table 3 — Plate specimen geometry	8
Publication(s) referred to	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Iron and Steel and the Non-ferrous Metals Standards Policy Committees and describes a method of cyclically extending and compressing a metallic specimen between set extension limits to determine its fatigue resistance. It is thus complementary to BS 3518, which deals exclusively with testing under force control.

Testing of this nature raises questions concerning the dynamic calibration of extensometers and of the force measuring systems of fatigue testing machines. These have not as yet been fully resolved. In this document therefore reliance has, of necessity, been placed on static calibration and some hysteresis checks.

It has been assumed in the drafting of this British Standard that the execution of its provisions is entrusted to appropriately qualified and experienced people. The method also requires the use of relatively sophisticated test equipment compared to that described in BS 3518.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard describes a method of cyclically extending and compressing a metallic specimen under strain control between set strain limits to determine its fatigue resistance. This is measured in terms of cycles to failure, as a function of the applied total strain range and of the associated variation in stress range, mean stress and plastic strain range. The method is restricted to uniaxially loaded parallel section specimens tested in air at ambient temperature and to metals having a melting point not less than 2.5 times ambient temperature where both are expressed in degrees Kelvin. The method is applicable to both high and low cycle fatigue tests but is not suitable for testing material less than 3 mm thick.

NOTE 1 Advice on the generation of data sets from individual specimen results determined using this method, is given in Appendix A.

NOTE 2 The fatigue properties of metals are often directional and may be a function of the relative humidity of the air, the waveform and testing frequency. The user should assure himself that the test conditions used and the specimen orientation are relevant to his application.

NOTE 3 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1

stress

the force applied to the specimen divided by the original cross sectional area of its gauge section. It shall be considered positive when tensile forces are applied and negative when compressive forces are applied

2.2

cycle

the shortest complete sequence of strain values which is repeated periodically (see Figure 1)

2.3

maximum

the greatest algebraic value of a variable within one cycle

2.4

minimum

the least algebraic value of a variable within one cycle

2.5

mean

one-half of the algebraic sum of the maximum and minimum values of a variable

2.6

range

the algebraic difference between the maximum and minimum values of a variable (see Figure 1 and Figure 2)

2.7

amplitude

half the range of a variable

2.8

total strain

the extension of the specimen gauge length, divided by its original gauge length. It is taken to be positive when the gauge length increases in length and negative when it contracts

2.9

plastic strain range

the width of the hysteresis loop of stress plotted against total strain, determined at the mean stress (see Figure 2)

2.10

elastic strain range

the difference between the total strain range and the plastic strain range

NOTE to 2.9 and 2.10. The definitions given in 2.9 and 2.10 are working definitions which may not be strictly accurate in all cases.

2.11

frequency

the number of cycles experienced by the specimen in one second

2.12

resolution

the smallest change that can be resolved on a given measuring scale. Where digital instrumentation is used this shall be taken to be half the fluctuation of the display when the input is at a stable zero or the least significant figure of the display, whichever is the greater

2.13

life

the number of applied cycles to failure (see 8.5)

3 Symbols

For the purposes of this British Standard the following symbols and designations apply.

Symbol	Designation
$\Delta\epsilon_t$	Total strain range
$\Delta\epsilon_e$	Elastic strain range
$\Delta\epsilon_p$	Plastic strain range
$\Delta\sigma$	Stress range
N_f	Cycles to failure
d	Diameter of cylindrical gauge section of specimen (see Figure 3 and Figure 4)
b	Width of gauge section of plate specimen (see Figure 5)
t	Thickness of plate specimen (see Figure 4 and Figure 5)
l	Length of parallel section (see Figure 3, Figure 4 and Figure 5)
r	Transition radius from parallel section to grip end (see Figure 3, Figure 4 and Figure 5)
D	Diameter of grip end of cylindrical specimen (see Figure 3)
L	Length of grip end of plate specimen (see Figure 4 and Figure 5)
W	Width of grip end of plate specimen (see Figure 4 and Figure 5).

4 Principle

The method involves the cyclic application of axial force to a specimen. The specimen has a gauge length of constant cross section on which an axial extensometer is mounted and the applied force is varied such that the strain is controlled between set limits according to a cycle of chosen waveform. The test is continued until failure occurs. The maxima and minima of applied force and extension are monitored throughout the test. The number of cycles to failure is recorded and additionally the force extension hysteresis loop is recorded at intervals during the test. From these loops the stress range, mean stress, total strain range and plastic strain range are estimated at half-life.

5 Test equipment

5.1 Test machine and test fixtures

The test machine shall permit cycling to be carried out between predetermined limits of extension as measured by an extensometer mounted on the specimen. Its force measurement system shall have a digital output display and shall be verified as grade 1.0 in accordance with BS 1610-1. The verified force measurement system shall also be able to display cyclic force maxima and minima at anytime to three significant figures.

The test fixture shall transmit axial loads to the specimen (see clause 7) and shall accurately locate the specimen (see 8.1). There shall be no backlash in the loading train.

NOTE If, in the design of the test fixture, insufficient attention is paid to maintaining axial alignment of the specimen, difficulty will be encountered in complying with clause 7. Guidance notes on the design of fixtures are given in Appendix B.

5.2 Extensometry

The extensometry shall incorporate a digital output display able to show cyclic extension maxima and minima at any time to three significant figures. An axial extensometer shall be used to measure and control extension of the specimen gauge length. The extensometer shall hold a certificate of compliance with grade C of BS 3846 issued within the previous 12 months. If the extensometer is to be used for measuring both positive and negative displacements the grade of the extensometer shall be assessed by using the same calibration factor for both positive and negative displacements. In addition the procedure given in Appendix C shall be followed to verify that the characteristics of the extensometer and its associated signal conditioning and recording equipment (see 5.4) are acceptable.

Extensometry shall not be used above that frequency at which compliance with Appendix C has been demonstrated.

Cognisance shall be taken of the manufacturer's recommended operating limits and procedures, in both selecting and using the extensometer (see 8.2).

5.3 Cycle counting

A digital device shall be used to record the number of cycles applied to the specimen. For tests lasting less than 1 000 cycles, individual cycles shall be recorded. For longer tests the device shall have a resolution better than 0.1 % of the expected life or 1 % of the actual life.

5.4 Display of hysteresis loops

Force-extension hysteresis loops shall be recorded at intervals (see 8.4) without changing the test frequency.