

BRITISH STANDARD

Metallic materials – Constant amplitude strain controlled axial fatigue – Method of test

ICS 77.040.10



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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 23 and a back cover.

Foreword

Publishing information

This British Standard was published by BSI and came into effect on 29 December 2006. It was prepared by Subcommittee ISE/NFE/4/6, *Fatigue testing of metals and metal matrix composites*, under the authority of Technical Committee ISE/NFE/4, *Mechanical testing of metals*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This British Standard supersedes BS 7270:1990, which is withdrawn.

Information about this document

This is a full revision of the standard, and introduces the following principal changes.

- a) New Annex on measurement of specimen bending (see Annex E).
- b) Reference to the use of electromechanical recording systems was deleted and is no longer recommended (see **6.4**).
- c) Recommended ambient temperature range is specified (see **6.5**).
- d) New subclause on test commencement (see **9.3**).

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

This British Standard describes a method of cyclically loading a metallic specimen under strain control between set strain limits to determine its fatigue resistance. The fatigue resistance is measured in terms of cycles to failure as a function of the applied strain range and the associated variations 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 where time-dependent deformation can be ignored. The method is applicable to both high- and low-cycle fatigue tests.

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

NOTE 2 Users should assure themselves that the test conditions used and the specimen orientation are relevant to their application.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 1134-1, *Assessment of surface texture – Part 1: Methods and instrumentation*

BS EN ISO 7500-1:2004, *Metallic materials – Verification of static uniaxial testing machines – Part 1: Tension/compression testing machines – Verification and calibration of the force-measuring system*

BS EN ISO 9513:2002, *Metallic materials – Calibration of extensometers used in uniaxial testing*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 stress

force applied to the specimen divided by the original cross-sectional area of its gauge section

NOTE Stress is considered positive when tensile forces are applied and negative when compressive forces are applied.

3.2 cycle

shortest complete sequence of strain values that is repeated periodically

NOTE See Figure 1.

3.3 maximum

greatest algebraic value of a variable within one cycle

3.4 maximum bending strain

largest value of the tensile bending strain in the cross-section at which bending is measured

3.5 minimum

smallest algebraic value of a variable within one cycle

3.6 mean

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

3.7 range

algebraic difference between the maximum and minimum values of a variable

NOTE See Figure 1 and Figure 2.

3.8 amplitude

half the range of a variable

3.9 total strain

extension of the specimen gauge length, divided by its original gauge length

NOTE Total strain is considered positive when the gauge length increases in length and negative when it contracts.

3.10 total strain range

algebraic difference between the maximum and minimum strain values within one cycle

NOTE See Figure 1 and Figure 2.

3.11 plastic strain range

width of the hysteresis loop of stress plotted against total strain, determined at the mean stress

NOTE See Figure 2.

3.12 elastic strain range

difference between the total strain range and the plastic strain range

3.13 frequency

number of cycles experienced by the specimen in 1 s

3.14 half-life

one-half of fatigue life

3.15 fatigue life

number of cycles to failure, N_f , in **9.5** and Figure 6

4 Symbols

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

$\Delta\epsilon_t$	total strain range (see Figure 1 and Figure 2)
$\Delta\epsilon_e$	elastic strain range (see 3.12)
$\Delta\epsilon_p$	plastic strain range (see Figure 2)
$\Delta\sigma$	stress range (see Figure 2)
N_f	number of cycles to failure (see 9.5 and Figure 6)
d	diameter of gauge section of cylindrical 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)
l_g	strain-gauge axial separation (see Figure E.1)
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)
ε_1 to ε_4	readings of individual strain gauges (see E.2 and Figure E.1)
ε_{bmax}	maximum bending strain (see E.2)

Figure 1 **One cycle, defined for sinusoidal and triangular waveform strain histories**

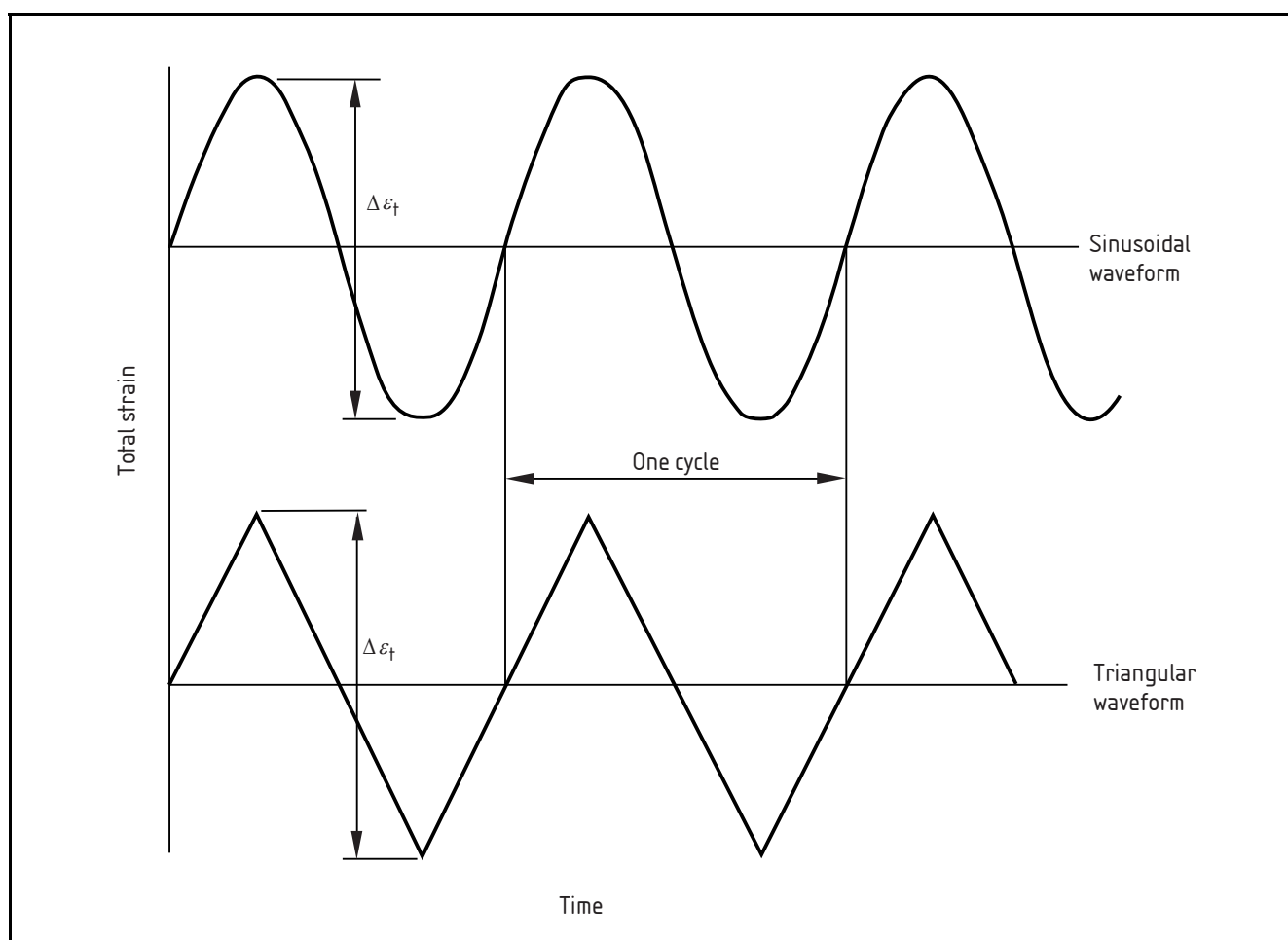
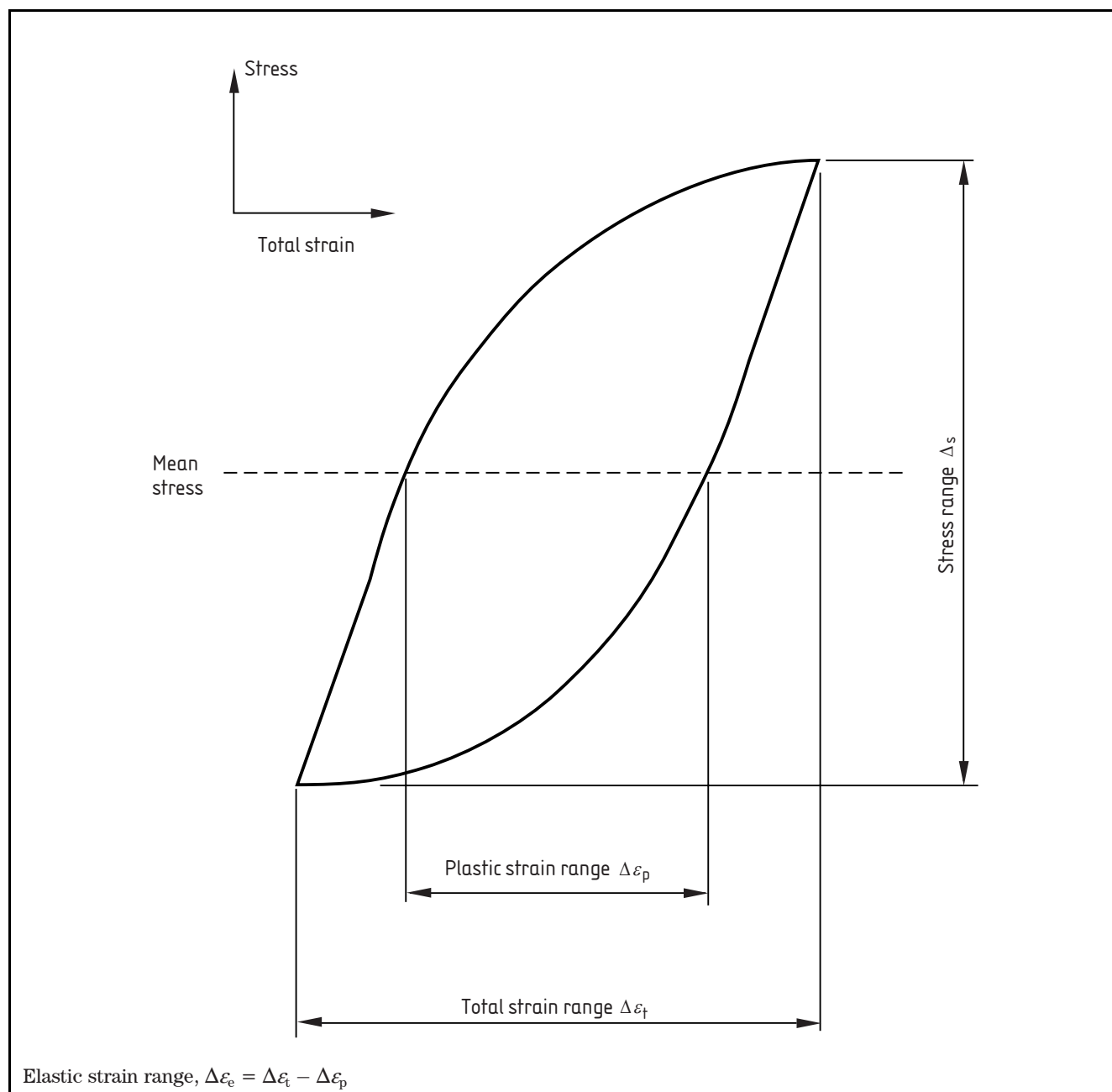


Figure 2 Stress-strain hysteresis loop



5 Principle

The method involves the cyclic application of axial strain to a specimen. The specimen has a gauge length of constant cross-section on which an axial extensometer is mounted and 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 strain and stress are monitored throughout the test. The number of cycles to failure is recorded and additionally the stress-strain hysteresis loops are recorded at intervals during the test. From these loops the stress range, mean stress, total strain range and plastic strain range are determined at half-life.

6 Test equipment and environment

6.1 Test machine and test fixtures

The test machine shall provide smooth start-up with no backlash.

NOTE An inadequately stiff machine (including frame and loading train) might cause specimen buckling during the compressive phase of a test cycle.

The test machine shall permit strain-controlled cycling to be carried out between predetermined limits. Its force measurement system shall have a digital output display and shall be verified in accordance with BS EN ISO 7500-1:2004, Class 1.0. The verified force measurement system shall also be able to display cyclic force maxima and minima at any time to three significant figures.

The test machine control system shall permit transfer from one mode of control to another without overshoots. In partially or completely reversed loading tests there shall be no backlash in the loading train.

The specimen grips shall transmit axial forces to the specimen to accurately and reproducibly locate the specimen.

NOTE 1 This to minimize bending.

NOTE 2 In the design of the test fixture, attention should be paid to maintaining axial alignment of the specimen in order to comply with Clause 8. Guidance notes on the design of fixtures are given in Annex B.

6.2 Extensometry

The extensometry system shall incorporate a digital output display able to show cyclic extension maxima and minima at any time to, at least, three significant figures. An axial extensometer shall be used to measure and control the extension of the specimen gauge length. For gauge lengths below 20 mm, the extensometer shall have a certificate of compliance with BS EN ISO 9513:2002, Class 0.5, issued within the previous 12 months. For gauge lengths equal to or greater than 20 mm, the extensometer shall have a certificate of compliance with BS EN ISO 9513:2002, Class 1, as a minimum, 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 using the same calibration factor for both positive and negative displacements. In addition, the procedure given in Annex C shall be followed to verify that the characteristics of the extensometer and its associated signal conditioning and recording equipment (see 6.4) are acceptable.

Extensometry shall not be used above the frequency at which conformity with Annex C has been demonstrated.

Cognizance shall be taken of the manufacturer's recommended operating limits and procedures in both selecting and using the extensometer (see 9.2).

6.3 Cycle counting

The number of cycles shall be recorded such that for tests lasting less than 10 000 cycles, individual cycles can be resolved. For longer tests the resolution shall be better than 0.1% of the indicated life.