

METHODS FOR
MECHANICAL TESTING
OF METALS

At Elevated Temperatures

Part 1. Tensile Testing

METRIC UNITS

B.S. 3688 : Part 1 : 1963

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THIS BRITISH STANDARD, having been approved by the Mechanical Engineering Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 26th November, 1963.

The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 4000, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 15s.

This standard makes reference to the following British Standards:

B.S. 1041. Code for temperature measurement.

B.S. 1610. Methods for the load verification of testing machines.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following B.S.I. references relate to the work on this standard:
Committee reference MEE/37/13. Draft for comment D62/3160

CONTENTS

Co-operating organizations	Page
Foreword	5
	6

METHOD OF TEST

1. Scope	6
2. Basis of test	6

SECTION ONE: SYMBOLS AND DEFINITIONS

3. Symbols	7
4. Terms and definitions	7

SECTION TWO: TEST PIECES

5. General	10
6. Form of test piece	10

SECTION THREE: TESTING EQUIPMENT

7. Testing machine	12
8. Extensometer	13
9. Heating apparatus	13
10. Measurement of temperature	13

SECTION FOUR: TEST PROCEDURE

11. Measurement of cross-sectional area	13
12. Marking the original gauge length	13
13. Heating of test piece	14
14. Straining of test piece	14
15. Measurement of strain	14
16. Measurement of test piece after fracture	15

SECTION FIVE: DETERMINATION OF PROPERTIES

17. Young's modulus of elasticity	17
18. Proof stress	17
19. Lower yield stress	18
20. Tensile strength	19
21. Percentage elongation and reduction of area after fracture	19

B.S. 3688 : Part 1 : 1963

	Page
SECTION SIX: PRESENTATION OF RESULTS	
22. Requirements	20
SECTION SEVEN: NOTES AND RECOMMENDATIONS	
23. Notes and recommendations	20

TABLES

1. Recommended dimensions for round test pieces. Gauge length = $5.65\sqrt{S_0}$	11
2. Recommended dimensions for rectangular section test pieces	11

FIGURES

1. Test piece of circular cross-section	9
2. Test piece of rectangular cross-section	9
3. Strip test piece cut from tube	9
4. Characteristic stress-strain diagram without yield	17
5. Stress-strain diagram with a yield	18
6. Stress-strain diagrams showing other forms of yield	19

CO-OPERATING ORGANIZATIONS

The Mechanical Engineering Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- Admiralty
- Air Ministry
- Associated Offices' Technical Committee
- Association of Consulting Engineers (Incorporated)
- Association of Mining Electrical and Mechanical Engineers
- British Chemical Plant Manufacturers' Association
- British Compressed Air Society
- British Electrical and Allied Manufacturers' Association
- British Gear Manufacturers' Association
- British Internal Combustion Engine Manufacturers' Association
- British Iron and Steel Federation
- British Mechanical Engineering Federation
- British Railways Board
- Crown Agents for Oversea Governments and Administrations
- D.S.I.R.—National Engineering Laboratory
- Electricity Council, The Generating Board and the Area Boards in England and Wales
- Engineering Equipment Users' Association
- Gas Council
- High Commission of India
- Institute of Marine Engineers
- Institute of Petroleum
- Institution of Civil Engineers
- Institution of Gas Engineers
- Institution of Heating and Ventilating Engineers
- Institution of Mechanical Engineers
- Institution of Mechanical Engineers (Automobile Division)
- Institution of Production Engineers
- Locomotive and Allied Manufacturers' Association of Great Britain
- Machine Tool Trades Association
- Ministry of Labour (H.M. Factory Inspectorate)
- Ministry of Power
- Ministry of Public Building and Works
- Ministry of Transport
- National Coal Board
- National Physical Laboratory (D.S.I.R.)
- Radio Industry Council
- War Office

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the Committee entrusted with the preparation of this standard:

- Aluminium Federation
- British Cast Iron Research Association
- British Non-ferrous Metals Federation
- British Non-ferrous Metals Research Association
- Copper Development Association
- D.S.I.R. Building Research Station
- D.S.I.R. Forest Products Laboratory
- Electrical Research Association
- Institute of Welding
- Institution of Engineering Inspection
- Lloyd's Register of Shipping
- Ministry of Aviation
- National Association of Drop Forgers and Stampers
- Society of British Aircraft Constructors
- United Kingdom Atomic Energy Authority
- Testing machine manufacturers and individual firms

B.S. 3688 : Part 1 : 1963

BRITISH STANDARD METHODS FOR MECHANICAL TESTING OF METALS AT ELEVATED TEMPERATURES

Part 1. Tensile Testing

METRIC UNITS FOREWORD

This British Standard is one of a series dealing with the mechanical testing of metals at elevated temperatures.

Whereas B.S. 18, 'Methods of testing for metals', covers the tensile testing of metals at room temperature, this standard gives definitions and describes procedures relating to tensile testing at elevated temperatures. During its preparation account has been taken of relevant documents prepared by Technical Committees of the International Organization for Standardization (ISO).

Sections of the standard replace B.S. 3082, Part 1, for the determination of proof stress of steel, and Section A of B.S. 1094 for the short time tensile testing of light alloys at elevated temperatures. The standard gives specific requirements for the control of strain rate when determining values of lower yield stress and proof stress.

'In order to promote the unification of testing methods, the forms and dimensions of metric test pieces have been brought into line with those given in other tensile testing standards. Notes for general guidance are also included.'

'NOTE. Information concerning SI Units is given in Supplement No. 1, 'Additional tables for SI conversions' to B.S. 350, 'Conversion factors and tables', and PD 5686, 'The use of SI units'.'

METHOD OF TEST

SCOPE

1. This British Standard deals with the tensile testing of metals at elevated temperatures. It defines the properties which may be determined and the terms used in describing tests and test pieces. It specifies a standard method of testing and includes recommendations for the form of the test piece and its dimensions.

BASIS OF TEST

2. The test consists of maintaining a test piece at a uniform temperature and subjecting it to increasing extension under tensile load at that temperature in order to determine specified properties.

SECTION ONE: SYMBOLS AND DEFINITIONS

SYMBOLS

3. In this British Standard the following symbols apply:

Symbol	Description
d	{ Diameter of test section of test piece of circular cross-section. Bore of tube, or inside diameter.
D	Outside diameter of tube.
a	Thickness of test section of test piece.
b	Width of test section of test piece.
r	Transition radius.
L_0	Original gauge length.
L_e	Extensometer gauge length.
L_c	Parallel length.
L_t	Total length.
L_u	Final gauge length after fracture.
S_0	Original cross-sectional area of test section.
S_u	Minimum cross-sectional area after fracture.
A	Percentage elongation after fracture.
Z	Percentage reduction of area after fracture.
k	Ratio of L_0 to $\sqrt{S_0}$.
F_e	Load at lower yield stress.
F_m	Maximum load.
R_e	Lower yield stress.
R_p	Proof stress.
R_m	Tensile strength.

NOTE. All the dimensions of the test piece are measured at room temperature.

TERMS AND DEFINITIONS

4. For the purpose of this British Standard the terms used in the tensile testing of metals at elevated temperatures are defined as follows:

Gauge length. Any length of the parallel portion of the test piece defined and used for measurement of extension. The term is hereafter used in this standard to denote the original gauge length (L_0) marked on the test piece for the determination of the percentage elongation after fracture (A).

NOTE. A gauge length other than L_0 may be employed for determination of properties necessitating use of an extensometer; this is designated the 'extensometer gauge length'.

Extensometer gauge length (L_e). The length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer (see Clause 23d).

B.S. 3688 : Part 1 : 1963

Proportional test piece. A test piece with a gauge length having an agreed relation to the square root of the cross-sectional area, e.g. one with a gauge length equal to $5.65\sqrt{S_0}$.

Non-proportional test piece. A test piece having a gauge length not specifically related to cross-sectional area.

Extension. The increase of a gauge length from its original value at any moment during the test.

Stress (Nominal stress). The load divided by the original cross-sectional area of the parallel portion of the test piece.

Strain. The extension per unit length.

Young's modulus of elasticity. The value of the increment in stress divided by the corresponding increment in strain for the straight portion of the stress-strain (or load-extension) diagram.

NOTE. Some materials do not give a clearly defined straight stress-strain line, and for these materials the stress limits between which the apparent modulus of elasticity is determined should be stated.

Proof stress (R_p). The stress which produces, while the load is still applied, a non-proportional extension equal to a specified percentage of the extensometer gauge length. (See Fig. 4.)

NOTE. When quoting the specified percentage of the extensometer gauge length, the symbol is given the appropriate suffix, e.g. $R_{p0.2}$.

Yield. An increase of strain without increase of stress which occurs only in particular metals under certain conditions of test.

Upper yield stress. The stress at which yield begins.

Lower yield stress (R_e). The lowest stress during yielding excluding transient effects. (See Clause 19.)

Maximum load (F_m). The highest load which the test piece withstands during the test.

Tensile strength (R_m). The maximum load divided by the original cross-sectional area of the test piece.

Percentage elongation after fracture (A). The permanent increase in length ($L_u - L_0$) of the gauge length expressed as a percentage of the original gauge length (L_0), i.e. $100 \frac{(L_u - L_0)}{L_0}$.

Percentage reduction in area after fracture (Z). The maximum decrease of the cross-sectional area ($S_0 - S_u$) expressed as a percentage of the original cross-sectional area (S_0), i.e. $100 \frac{(S_0 - S_u)}{S_0}$.

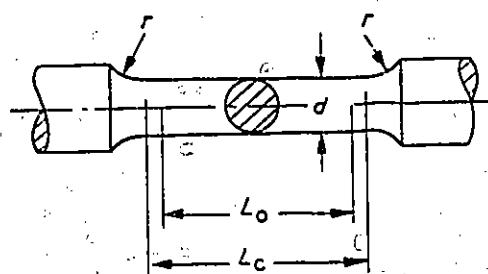


Fig. 1. Test piece of circular cross-section

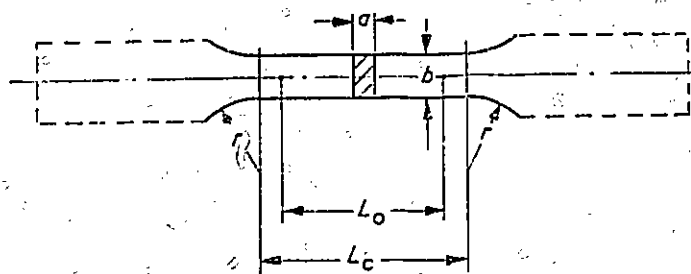


Fig. 2. Test piece of rectangular cross-section

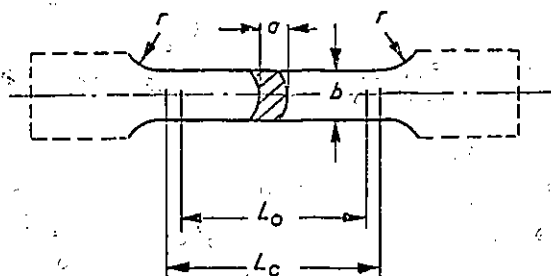


Fig. 3. Strip test piece cut from tube