

Methods for

Creep and rupture testing of metals —

Part 5: Production acceptance tests

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:

Associated Offices' Technical Committee*	Institute of Marine Engineers
Association of Consulting Engineers	Institution of Civil Engineers
Association of Mining, Electrical and Mechanical Engineers	Institution of Gas Engineers
Board of Trade	Institution of Heating and Ventilating Engineers
British Chemical Plant Manufacturers' Association	Institution of Mechanical Engineers
British Compressed Air Society	Institution of Mechanical Engineers (Automobile Division)
British Electrical and Allied Manufacturers' Association*	Institution of Production Engineers
British Gear Manufacturers' Association	Locomotive and Allied Manufacturers' Association of Great Britain
British Internal Combustion Engine Manufacturers' Association	London Transport Board
British Mechanical Engineering Federation	Machine Tool Trades Association
British Pump Manufacturers' Association	Ministry of Defence
British Steel Industry*	Ministry of Defence, Army Department
Crown Agents for Oversea Governments and Administrations	Ministry of Power
Department of Employment and Productivity (H.M. Factory Inspectorate)	Ministry of Public Building and Works
Electricity Council, the Central Electricity Generating Board and the Area Boards in England and Wales	Ministry of Technology*
Engineering Equipment Users' Association	Ministry of Technology — National Engineering Laboratory
Gas Council	Ministry of Transport
	National Coal Board
	National Physical Laboratory (Ministry of Technology)*
	Royal Institute of British Architects

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 British Standard:

Aluminium Federation	Ministry of Defence, Navy Department
British Cast Iron Research Association	Ministry of Technology — Building Research Station
British Non-Ferrous Metals Research Association	National Association of Drop Forgers and Stampers
Electrical Research Association	Scientific Instrument Manufacturers
Institution of Engineering Inspection	Spring Research Association
Institution of Production Engineers	Welding Institute
Ministry of Technology — Forest Products Laboratory	

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Foreword

This standard makes reference to the following British Standards:

BS 1041, *Code for temperature measurement.*

BS 1610, *Methods for the load verification of testing machines.*

BS 1826, *Reference tables for platinum/rhodium v. platinum thermocouples.*

BS 1827, *Reference tables for nickel/chromium v. nickel/aluminium thermocouples.*

BS 1828, *Reference tables for copper v. constantan thermocouples.*

BS 1829, *Reference tables for iron v. constantan thermocouples.*

BS 3846, *Methods for calibration and grading of extensometers for testing of metals.*

This British Standard, which was first issued in 1962, is one of a series dealing with the creep and rupture testing of metals and specifies the method for carrying out acceptance tests on both ferrous and non-ferrous metals. The standard will generally be used in conjunction with a specification for the material which has been accepted by both the purchaser and the supplier.

In carrying out this revision particular consideration has been given to the acceptance testing of aircraft materials which is at present described in BS 4A4-1.3¹⁾ and to bringing the standard into line with current practice including the adoption of metric units.

The standard specifies the methods to be used for production acceptance testing. It is not intended to be used for determining creep and rupture properties required for establishing design data, the tests for which are described in the other parts of BS 3500.

NOTE Information concerning SI units is given in Supplement No. 1 “*Additional tables for SI conversions*” to BS 350, “*Conversion factors and tables*”, and in PD 5686, “*The use of SI units*”.

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 12, 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⁾ BS 4A4, “*Test pieces and test methods for metallic materials for aircraft*”, Part 1, Section 3, “*Uninterrupted creep and rupture tests*”.

1 Scope

1.1 This British Standard describes tensile creep or rupture tests for determining compliance of a material with a specification either arranged directly between the purchaser and the supplier of the material or contained in a British Standard accepted by both the purchaser and the supplier, and any inspecting authority concerned. It defines the properties that may need to be determined and the terms used in describing tests and test pieces.

1.2 The duration of tests complying with this standard is within the range 10 h to 1 000 h.

1.3 The standard applies to tests on test pieces of circular and rectangular cross section, and on test pieces of circular cross section having a notch. The tests are carried out under nominally constant conditions throughout their duration.

1.4 Hereafter, for the purpose of this standard, "by agreement" means that specific agreement has been reached between the purchaser and the supplier, and any inspecting authority concerned.

2 Symbols and definitions

For the purposes of this British Standard the following symbols and definitions apply:

2.1 Symbols

The symbols used are as follows (see Figure 1 to Figure 4):

Symbol	Description
d	Diameter of test section of test piece of circular cross section.
D_n	Diameter of the parallel portion of a notched test piece of circular cross section.
d_n	Diameter of test piece at root of notch.
a	Thickness of test section of test piece of rectangular cross section.
b	Width of test section of test piece of rectangular cross section.
r_n	Notch root radius.
α	Notch angle.
K_t	Elastic stress concentration factor.
r	Transition radius.
L_o	Original gauge length.
L_e	Extensometer gauge length.
L_c	Parallel length of unnotched test piece.
L_n	Parallel length of notched test piece including the width of the notch.

Symbol	Description
L_t	Total length.
L_u	Final gauge length.
S_o	Original cross-sectional area of test section.
S_u	Minimum cross-sectional area of test section after rupture.
A	Percentage elongation after rupture.
A_p	Total plastic strain.
Z	Percentage reduction of area after rupture.

2.2 Definitions

2.2.1 Test piece

The portion of the test sample on which the creep strain or rupture test is carried out.

2.2.1.1 proportional test piece

a test piece of circular cross section with a gauge length having a specified relation to the square root of the cross-sectional area, e.g., an original gauge length equal to $5.65 \sqrt{S_o}$

2.2.1.2 non-proportional test piece

a test piece having a gauge length not specifically related to cross-sectional area

2.2.2 Gauge length

The prescribed part of the test piece on which extension measurements are made.

2.2.2.1 original gauge length (L_o)

the gauge length before the test piece is strained (This may also be used for measurement of creep strain.)

2.2.2.2 final gauge length (L_u)

the gauge length after the test piece has ruptured

2.2.2.3 extensometer gauge length (L_e)

the length of the parallel portion of the test piece used for the measurement of the extension by means of an extensometer. This length may be different from L_o

2.2.3 extension

the increase of the extensometer gauge length from the original at any moment during the test

2.2.4**percentage elongation after rupture (A)**

the permanent increase in length ($L_u - L_o$) of the gauge length expressed as a percentage of the original gauge length (L_o), i.e. $100 (L_u - L_o)/L_o$, all measurements being made at room temperature

2.2.5**percentage reduction of area after rupture (Z)**

the maximum decrease of the cross-sectional area ($S_o - S_u$) expressed as a percentage of the original cross-sectional area (S_o), i.e. $100 (S_o - S_u)/S_o$

2.2.6**stress**

in an unnotched test piece, the load on the test piece divided by the original cross-sectional area of the parallel portion

in a notched test piece, the stress, referred to as the "nominal stress", is the load divided by the initial cross-sectional area in the plane of minimum diameter, i.e. at notch root

2.2.7**total plastic strain (A_p)**

the total plastic extension of the gauge length, inclusive of both creep and any plastic extension during loading (i.e. the total extension excluding elastic extension), expressed as a ratio of the original gauge length (see Figure 5). This value may be expressed as a percentage, i.e. $A_p \times 100$

2.2.8**rupture**

complete fracture of the test piece within the original gauge length or at the root of the notch under constant load and at constant temperature

2.2.9**time to rupture**

the total time, at the test temperature and the test load, between the commencement of the test and the rupture of the test piece

2.2.10**elastic stress concentration factor (K_t)**

for notched test pieces, the ratio of the maximum axial stress calculated for elastic conditions to the nominal stress at the same load

3 Basis of test

The test consists of maintaining a test piece at a uniform temperature and subjecting it to a constant tensile load at that temperature.

4 Specification of test requirements

The specification accepted by the purchaser and the supplier shall state the following:

- 1) The type of test piece (see Clause 6).
- 2) The test temperature.
- 3) The test stress.
- 4) The time the test piece shall be under the conditions 2) and 3) simultaneously.
- 5) The maximum soaking time where applicable (see Clause 14).
- 6) The criterion of acceptance which may be one of the following:
 - a) A statement of the total plastic strain that shall not be exceeded.
 - b) A requirement that the test piece shall not rupture before the end of the period specified in 4) or,
 - c) Some other requirement specified by agreement.

5 Selection and preparation of test pieces

5.1 The selection and preparation of test samples and the location of test pieces shall be stated in the materials specification or agreed with the inspecting authority.

5.2 Care shall be taken in the selection and preparation to ensure that the metallurgical structure and mechanical properties of the test piece are representative of the original test material.

6 Test pieces**6.1 General**

6.1.1 The cross section of the parallel portion of the test piece shall be circular or rectangular. There shall be a gradual increase in cross-sectional area from the parallel length to the enlarged ends. Bars and wires may be tested in full section without machining.

6.1.2 Depending on the form of test piece to be used, test pieces shall, wherever practicable, be selected in accordance with the details given in Table 1, Table 2, Table 3 and Table 4 (see also 6.2.1 and 6.2.2). It is recommended that the largest practicable size of test piece be used.