BS 5214 : Part 1 : 1975
UDC 678.01 : [620.172.05 + 620.173.05]

Specification for

Testing machines for rubbers and plastics

Part 1. Tensile, flexural and compression machines

Gr 6
British Standards Institution

This British Standard, having been approved by the Plastics and Rubber Industry Standards Committees, was published under the authority of the Executive Board on 30 May 1975.

ISBN: 0 580 08843 X

Contract requirements
Attention is drawn to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

Revision of British Standards
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.

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The following BSI references relate to the work on this standard:
Committee reference PLC/RUC/6 Draft for comment 73/53709 DC

Co-operating organizations

The Plastics and Rubber Industry Standards Committees, under whose supervision this British Standard was prepared, consist of representatives from the following Government departments and scientific and industrial organizations:

British Plastics Federation
British Resin Manufacturers' Association
*British Rubber Manufacturers' Association
Chemical Industries Association Ltd.
Department of the Environment–Building Research Establishment
Department of Industry–CT
Department of Trade–PSD
Electrical and Electronic Insulation Association
Electrical Installation Equipment Manufacturers' Association
Electrical Research Association
Engineering Equipment Users' Association
Malaysian Rubber Producers' Research Association
*Ministry of Defence
Plastics Institute
*Post Office
Royal Institute of British Architects
Royal Institute of Public Health and Hygiene
Rubber Growers' Association
*Rubber and Plastics Research Association of Great Britain
Society of Motor Manufacturers and Traders Ltd.

The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with individual experts, were directly represented on the committee entrusted with the preparation of this British Standard.

BSI

Amendment Slip No. 1
published and effective from 31 August 1981
to BS 5214 : Part 1 : 1975

Testing machines for rubbers and plastics
Part 1. Tensile, flexural and compression machines

Revised text

AMD 3568
August 1981

Front cover, title page and page 3

Delete the existing Part title and substitute the following in each case:

'Part 1. Constant rate of traverse machines'.

AMD 3568
August 1981

Clause 1. Scope

Delete the first sentence and substitute the following:

'This British Standard specifies requirements for tensile testing systems operating at constant rate of traverse and suitable for testing rubbers, plastics and adhesives'.

AMD 3568
August 1981

Clause 3.1 tensile testing system

At the end of the existing text insert the following note:

'NOTE. According to the arrangement of grips or jigs, the test specimen will be in tension, shear, compression or flexure. If the machine is used for tests other than in tension the term 'grip' should be taken to include a platen or other member for the application of force to the test specimen.'

AMD 3568
August 1981

Clause 3.2 force

Delete the existing term and definition and substitute the following.

'Text deleted'.

AMD 3568
August 1981

Clause 3.5 repeatability of force, elongation and deflection measurement

In the title insert an asterisk after the word 'force'.

Insert the following footnote:

'*The term force throughout this standard refers to the force acting along the straining axis of the machine.'

AMD 3568
August 1981

Clause 4. Designation of machine accuracy

In line 5 delete 'or D' and substitute ', D or E'.

Delete the paragraph starting 'It is not implied . . . '.

AMD 3568
August 1981

Clause 5.3. Specimen gaps

Delete the final paragraph and substitute the following:

'For testing ring specimens, the machine shall be provided with two pulleys, both of which are free to rotate, whilst one at least is automatically rotated by the machine at between 10 and 50 revolutions per minute to equalize the strain in the ring during the test. The pulleys shall be 25 mm diameter for large rings (52.5 mm o.d.) and 4.5 mm diameter for small rings (10 mm o.d.).'

AMD 3568
August 1981

Clause 9. Measurement of elongation (deflection)

In paragraph 1, line 5, delete item (c) and substitute the following:

'(c) optical or other non-attached extensometers'.

In paragraph 5, line 2, delete 'and D' and substitute ', D and E'.

In paragraph 5, line 7, delete 'and D' and substitute ', D and E'.

In the final paragraph delete the first sentence and substitute the following:

'The values in table 2 for grades B, C, D and E are given in percent of scale reading. The manufacturer shall state the lowest elongation at which the specified accuracy can be achieved.'

AMD 3568
August 1981

Table 2. Grades of accuracy for elongation (deflection) measurement

Delete the existing entries for grades B, C and D and substitute the following:

B	10 % on 25 mm (ΔL = 2.5 mm)	± 2 %	± 0.5 %	In accordance with BS 3846 (error only)	Rig with micrometer head to BS 870
C	50 % on 25 mm (ΔL = 12.5 mm)	± 2 %	± 0.5 %	In accordance with BS 3846 (error only)	Rig with scale to BS 4372 Rig with micrometer head to BS 870
D	1200 % on 20 mm (ΔL = 240 mm)	± 2 %	± 0.5 %	Rig with scale to BS 4372	Rig with scale to BS 4372
E	1200 % on 10 mm (ΔL = 120 mm)	± 2 %	± 0.5 %	Rig with scale to BS 4372	Rig with scale to BS 4372'.

In line 2 of the note under table 2 delete 'and D' and substitute ', D and E'.

AMD 3568
August 1981

Clause 11. Machine stiffness

Delete the first sentence of paragraph 2 and substitute the following:

'For a 'soft' machine, such as the pendulum type, the rate of traverse of the driven element is not necessarily the same as the rate of separation of the grips.'.

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BS 5214 : Part 1 : 1975

UDC 678.01:[620.172.05 + 620.173.05]

Specification for

Testing machines for rubbers and plastics

Part 1. Tensile, flexural and compression machines

Amendments issued since publication

Amd. No.	Date of issue	Text affected

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BS 5214 : Part 1 : 1975

Contents

Foreword

This British Standard has been prepared under the authority of the Plastics and Rubber Industry Standards Committees. It covers machines used for measuring the tensile, flexural and compression properties of plastics and rubbers. A variety of machines is used for determining these properties and indeed, the range of levels exhibited by different polymers requires machines of different capacities and operating speeds. However, the essential features are similar in all cases and a multi-range machine may be suitable for any material.

It is intended to produce further Parts of this standard dealing with other equipment used for testing plastics and rubber. It is the intention that the various Parts of this standard will be quoted in the corresponding British Standards covering methods of test, e.g. BS 903 'Methods of testing vulcanized rubber', BS 2782 'Methods of testing plastics', BS 4370 'Methods of test for rigid cellular materials' and BS 4443 'Methods of test for flexible cellular materials'.

Certification. Attention is drawn to the certification facilities described on the inside back cover of this standard.

British Standard Specification for

Testing machines for rubbers and plastics

Part 1. Tensile, flexural and compression machines

1. Scope

This British Standard specifies requirements for tensile testing systems suitable for testing rubbers and plastics although any one system may only be applicable to a narrower range of materials. It also covers such systems when used for flexural shear and compression tests.

2. References

The titles of the British Standards referred to in this standard are listed on the inside back cover.

3. Definitions

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

3.1 tensile testing system. A machine composed of a nominally fixed and a movable member to which may be attached suitable grips or fixtures for holding the test specimen. The movable member is power driven and may be equipped with adjustable speed control. The machine has a force measuring system complete with indicator and/or recorder. In addition there may be included a system for measuring the extension or deflection of a test specimen.

3.2 force. The force measured is that acting along the principal axis of the machine. According to the arrangement of grips or fixtures, the test specimen will be in tension, shear, compression or flexure.

NOTE. For the purpose of this definition, 'grip' is taken to mean 'platen' or other member for application of force to the test specimen when the machine is used for tests other than in tension.

3.3 elongation. The increase in the test length of a tensile test specimen.

3.4 deflection. The distortion in the direction of the applied force of a test specimen in compression, shear or flexure.

3.5 repeatability of force, elongation and deflection measurement. The greatest difference, at a given true value, between the indicated values corresponding to repeated applications of the true value.

3.6 error. The mean indicated value, at a given true value, corresponding to repeated applications of the true value, less the true value.

NOTE. These definitions of repeatability and error assume verification by observing the variation in indicated values obtained with repeated application of known values.

4. Designation of machine accuracy

Machines are designated according to accuracy in respect of the following parameters:

(a) measurement of force (grade A or B);

(b) measurement of elongation or deflection (grade A, B, C or D).

For example, a machine of the highest accuracy is designated as 'Force:Grade A, Elongation (Deflection):Grade A'.

It is not implied that test machines are commercially available in the eight theoretically possible designations.

If for any application it is not considered necessary to specify accuracy limits for either of these parameters, then no grade letters are quoted.

NOTE. Stringent specifications in respect of test machine accuracy are of little value unless testing technique is closely controlled. Correlation of test data from different laboratories depends as much upon testing techniques as on machine specifications. Operator errors, test specimen installation technique and test specimen variability are major sources of error.

Care should be taken to avoid exposure of the machine to draughts or to radiant heat.

5. Design features

5.1 Size and construction. The size and construction shall be such that the machine is able to test all materials for which it is intended to be used and has no features which may adversely affect test results.

The traverse of the moving grip shall be able to accommodate the maximum elongation of the test specimen. In the case of the more highly extensible materials, a traverse in excess of 1 m may be necessary.

5.2 Machine axial alignment. The coupling (between the force measuring system and the grips or test specimen jig) and the correctly installed test specimen shall be accurately aligned with the straining axis of the machine, and the test axis of the test specimen shall coincide with the direction of the applied force.

NOTE. Non-axial alignment of a test specimen in the grips and lack of test specimen symmetry are particularly important causes of variation in test results.

5.3 Specimen grips. For testing dumb-bell, parallel strip, and similar tensile test specimens, the machine shall be provided with a type of grip which closes automatically as the tension increases (e.g. wedge or pneumatic) and which exerts a uniform pressure across the width of the test specimen. The test specimen shall

be held in such a manner that slip relative to the grips is prevented as far as possible.

For testing ring test specimens, the machine shall be provided with two pulleys, both of which are free to rotate, whilst one at least is automatically rotated by the machine to equalize the strain in the ring during the test. The pulleys shall be 25 mm in diameter.

5.4 Drive characteristics. The moving crosshead of the machine shall be driven smoothly at all testing speeds and the drive shall be without significant backlash.

5.5 Jigs for use in compression, shear and flexure. Such jigs or fixtures shall conform with the relevant method of test or material specification. They shall not significantly affect the accuracy of the machine by the introduction of friction, backlash or nonalignment.

6. Types of force measuring system

In all cases a continuous indication of the force applied to the test specimen, preferably recorded automatically with a permanent indication of the maximum force, shall be provided.

Machines with low inertia in their force measuring systems are to be preferred; in particular, pendulum type machines may have friction and inertia which will significantly affect their dynamic response and decrease their accuracy.

7. Static force accuracy

For all scale ranges, two grades, A and B, are specified, as defined in BS 1610. The designation of each scale of a machine depends upon the values of repeatability and error found when it is verified in accordance with the methods described in section one of BS 1610:1964, except that calibration is made with both increasing and decreasing force. In general, method 1 is suitable only for verifying scales with a maximum force up to approximately 1500 N, whilst methods 2 and 3 are suitable for verifying all scales with a maximum force reading greater than 500 N.

The maximum permissible values for repeatability for grades A and B are given in table 1, based on BS 1610 and the error is illustrated in figure 1. When separate scales for use in compression or other modes of operation are provided, these shall be verified separately.

8. Dynamic force accuracy

Tensile testing machines fitted with electronic force measuring devices may be regarded as sufficiently free of inertia for the speeds of testing given in clause **10.** This does not necessarily apply to the electronic recorders normally used with them and in many cases the dynamic inaccuracy of these recorders considerably exceeds their static inaccuracy.

All electromechanical recorders suffer dynamic errors which are usually made up of acceleration errors stemming from the inertia of the device, and velocity lag errors due to viscous and coulomb friction. Measurement of recorder dynamic accuracy is best achieved by recording the error signal level during the test. This can be done without affecting the instrument performance but is usually technically difficult. It is therefore not considered practical at present to specify limits and a calibration procedure for dynamic accuracy in this standard. Consequently

Table 1. Grades of accuracy for force measurement

1	2	3	4	5	6	7
Grade	Accuracy of verification devices		Certified range			
	Force applied by weights or proving levers correct to within	Grading of elastic proving device	One-fifth force to full force of machine scale and all forces of a machine applying fixed forces		Below one-fifth of machine scale range	
			Requirement for repeatability	Requirement for accuracy	Requirement for repeatability	Requirement for accuracy
			At each verification force, maximum permissible difference between highest and lowest readings expressed as a percentage of the verification force	At each verification force, maximum permissible error expressed as a percentage of the verification force	At each verification force, maximum permissible difference between highest and lowest readings, expressed as a percentage of the full force reading of the scale	At each verification force, maximum permissible error expressed as a percentage of the full force reading of the scale
A	% ± 0.2	1	% 1.0	% ± 1.0	% 0.2	% ± 0.2
B	± 0.3	2	2.0	± 2.0	0.4	± 0.4

NOTE. The requirement for accuracy is a percentage of the true force within the range one-fifth force to full force of the machine scale but is a constant force error for forces below one-fifth of the scale. Thus at one-fifth scale on a 500 kN grade A machine scale, the maximum percentage error of applied force permitted is ± 1 %, and the force error is ± 1 kN. The permitted force error from zero to one-fifth of the scale (100 kN) accordingly remains constant at ± 1 kN.

the user is advised to obtain from the testing machine manufacturer dynamic accuracy figures for the recorder with which he can calculate the probable measurement error, and assess whether or not it is significant. In cases where it is, either the testing speed may be reduced, or the full scale range of the output device may be increased, in order to reduce the acceleration and velocity levels.

As a guide to recorder requirements, the response time for full scale travel should be considerably less than the rise time of the force, if the dynamic errors are to be comparable with the static inaccuracy. It is recommended therefore that the maximum *demanded* pen velocity, V_D, should be less than the maximum possible pen velocity, V_{max}, by a factor dependent on the machine grade as follows:

$V_D \leqslant \frac{V_{max}}{10}$ for grade A machines;

$V_D \leqslant \frac{V_{max}}{5}$ for grade B machines.

If only the recorder response time T is known, then V_{max} may be calculated approximately by means of the following equation:

$$V_{max} = \frac{R}{T}$$

where

R is the recorder full scale movement.

If the recommendations above are not followed, it is advised that recorder errors arising from dynamic operation should be obtained from the manufacturer.

9. Measurement of elongation (deflection)

The elongation (deflection) of rubber and plastics test specimens may be measured by methods of test utilizing:

(a) grip separation;

(b) extensometers attached to the test specimen;

(c) optical extensometers (non-attached).

In all cases a continuous indication of the elongation (deflection) and a permanent indication of the maximum elongation (deflection) shall be given. Preferably the elongation (deflection) should be recorded autographically in the form of a force/elongation (deflection) curve.

For some purposes, particularly the elongation of ring test specimens and for tests in flexure, shear or compression, the measurement of grip separation is the most convenient method. In such cases it is essential that there shall be no play in the elongation (deflection) measuring system, nor any slippage between the grips and the test specimen which will significantly affect the accuracy of the test results.

When an extensometer attached to the test specimen is used, there shall be no sign of distortion or damage to the test specimen nor any slippage between the extensometer grips and the test specimen which would significantly affect the test results.

When extensometer accuracy is specified, four grades, A, B, C and D, are recognized. The grading of each range of each measuring device depends on:

(a) for grade A: the values of gauge length error, discrimination, repeatability and error found when it is verified in accordance with BS 3846;

(b) for grades B, C and D: the values of error found when it is verified in accordance with the method given in table 2.

The values in table 2 for grades B, C and D are given in millimetres, and the corresponding error in strain units therefore depends upon the gauge length used. For all grades the gauge length and its accuracy shall be specified in the relevant method of test or material specification.

Table 2. Grades of accuracy for elongation (deflection) measurement

Grade	Approximate percentage maximum elongation (deflection) on given gauge length	Accuracy of measurement	Accuracy of verification device	Method of verification	
				For extensometer measurement	For crosshead displacement measurement
A	In accordance with grade C of BS 3846				
B	10 % on 25 mm ($\triangle L$ = 2.5 mm)	± 0.05 mm	± 0.01 mm	In accordance with BS 3846 (error only)	Rig with micrometer head to BS 870, i.e. ± 0.0015 mm
C	50 % on 25 mm ($\triangle L$ = 12.5 mm)	± 0.5 mm	± 0.1 mm	In accordance with BS 3846 (error only)	Rig with scale to BS 4372, i.e. ± 0.1 mm* Rig with micrometer head to BS 870, i.e. ± 0.0015 mm†
D	1200 % on 75 mm ($\triangle L$ = 900 mm)	± 1.0 mm	± 0.25 mm	Rig with scale to BS 4372, i.e. ± 0.25 mm	Rig with scale to BS 4372, i.e. ± 0.25 mm*

NOTE. It is probable that for tensile measurements extensometers attached to the test specimen will be used. However, for measurements to grades B, C and D, crosshead displacement will sometimes be suitable, and this may consist of a direct reading scale or a magnifying device. Alternative methods of verification are therefore proposed for extensometer and crosshead measurement. Furthermore, where crosshead displacement is a satisfactory measurement it is assumed that the deflection of the load measuring head of the machine is insignificant in relation to the deflection being measured.

* In these cases the verification device should comprise a scale and vernier to the required accuracy. One end is attached to the fixed part of the machine, e.g. the load measuring head, and the other to the moving crosshead. The attachment of the scale and vernier should be as near as possible to the loading axis of the machine, e.g. utilizing the machine grips.

† In this case the verification device should comprise a micrometer head to the required accuracy. The micrometer head should be attached to the fixed part of the machine, e.g. adjacent to the load measuring crosshead. The axis of the verification device should be as near as possible to the loading axis of the machine.

10. Rate of movement of driven grip

The testing machine shall be power driven and shall be capable of being set at one or more of the following rates of movement of the driven grip:

1 ± 0.5 mm/min
5 ± 1 mm/min
10 ± 2 mm/min
25 ± 2.5 mm/min
50 ± 5 mm/min
100 ± 10 mm/min
500 ± 50 mm/min.

After setting, the rate shall not vary during the course of any test or series of tests by more than ± 5 % of the mean rate and shall remain within the limits imposed in the above list.

The rates of movement listed are those more generally in use. However, it should be noted that particular specifications may require rates and tolerances other than the above.

11. Machine stiffness

Machine stiffness (also referred to as hardness) is the force required to produce unit deflection of the testing system. This includes the framework of the machine, the straining mechanism, the force measuring device and the grips and attachments by which the test specimen is held.

For a 'soft' machine, such as the pendulum type, the rate of grip separation is not necessarily the rate of extension. Consequently, the uncorrected crosshead movement cannot be used as a measure of test specimen deflection. Preference should therefore be given to a machine which is stiff in comparison to the test specimen so that the speeds of grip separation and, if required, their accuracy of measurement are in accordance with the requirements of clauses **10** and **9** respectively.

NOTE. A method of determining the K-value of a test machine, that is its apparent elastic compliance (deflection per unit force), is given in BS 4759.

12. Stability

The stability of electronic testing machines is influenced by a number of factors, the most important of which are temperature, mechanical hysteresis in the force sensing element, sensitivity to mains supply voltage and change in electronic component value.

The manufacturer shall therefore state in his specification, and in any instruction manual, such of the following requirements as may be necessary to maintain the stated accuracy of the machine.

(a) The maximum permissible temperature variation from standard conditions.
(b) The maximum permissible variation of supply voltage.
(c) The frequency at which it is necessary to adjust any manual control, e.g. for zero or span.

13. Certificate of verification

When a testing machine has been verified in accordance with this standard, the verifying authority shall issue a certificate stating the following.

(a) The identity of the machine and date of verification.
(b) The certified range and grade of each force or extension scale.
(c) The method of verification used and the identity of any calibrating devices employed.
(d) The ambient temperature at the time of verification.
(e) The accuracy of the rate setting (see clause **10**).
(f) The number of this British Standard, i.e. BS 5214:Part 1.

The testing machine shall be re-verified periodically to ensure that it continues to meet the grade(s) designated from this standard. The frequency of re-verification depends on the type of machine, the standard of maintenance, and the amount of usage. Normally, it is recommended that re-verification should be carried out at intervals not exceeding twelve months. However, a machine shall be re-verified if, in moving to a new location, it is dismantled, or if it is subject to major repairs or adjustments.

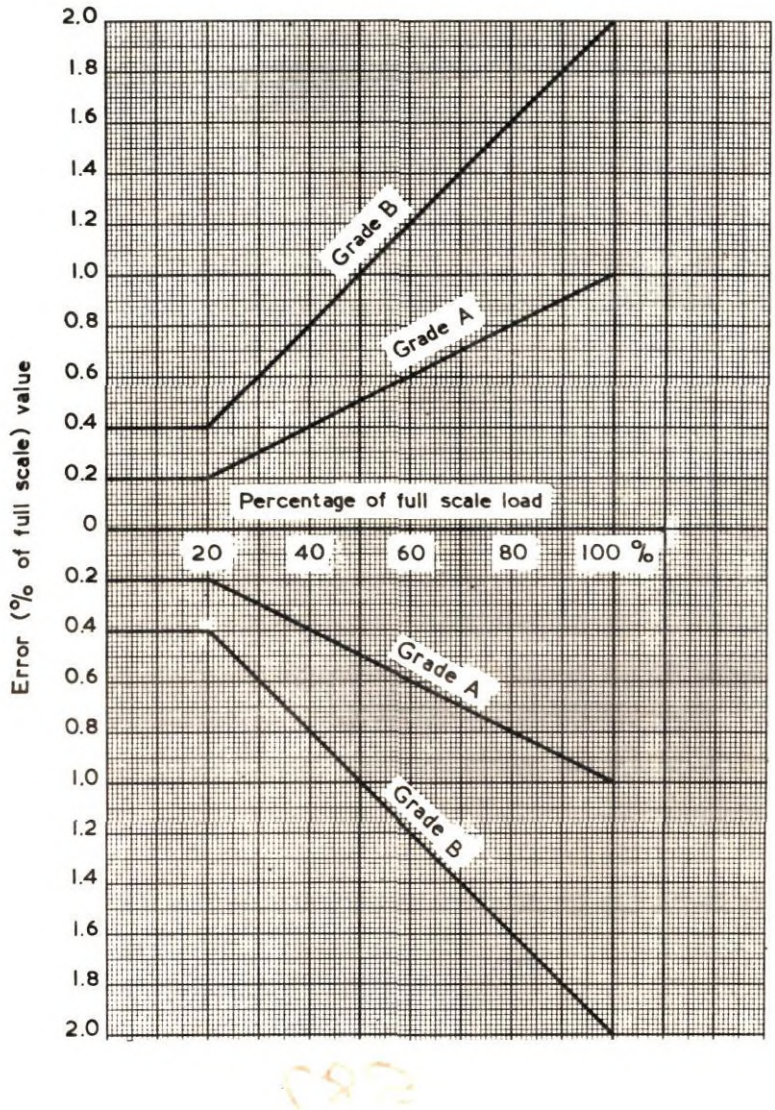

Figure 1. Machine accuracy gradings from BS 1610:

BSI publications referred to in this standard

This standard makes reference to the following British Standards:

BS 870 External micrometers
BS 1610 Methods for the load verification of testing machines
BS 3846 Methods for the calibration and grading of extensometers for testing of metals
BS 4372 Engineers' steel measuring rules
BS 4759 Method for determination of K-values of a tensile testing system

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ISBN: 0 580 08843 X

BS 5214 : Part 1 : 1975

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