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Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Description

Appareils d'essai du caoutchouc et des plastiques — Types pour traction, flexion et compression (vitesse de translation constante) — Description

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 5893 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Sub-Committee SC 2, *Physical and degradation tests*.

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Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Description

1 Scope

This International Standard specifies requirements for tensile-testing systems operating at constant rate of traverse suitable for testing rubbers, plastics and adhesives, 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 Definitions

For the purposes of this International Standard, the following definitions apply.

2.1 tensile-testing system: A machine composed of a nominally fixed member and a movable member, to which may be attached suitable grips or jigs for holding the test piece. 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 piece.

2.2 applied force: The force which produces the distortion in the test piece, measured along the strain axis of the machine. Depending on the arrangement of the grips or jigs, the test piece will be in tension, shear, compression or flexure.

NOTE 1 For the purpose of this definition, "grip" is taken to mean "platen" or other member for application of force to the test piece when the machine is used for tests other than tensile tests.

2.3 elongation: The increase in the test length of a tensile test piece.

2.4 deflection: The distortion, in the direction of the applied force, of a test piece in compression, shear or flexure.

2.5 precision of force, elongation and deflection measurement: The greatest difference, at a given true value, between the indicated values obtained by repeated measurement of the true value.

NOTE 2 This definition of precision assumes verification by observing the variation in the indicated values obtained by repeated application of known values.

2.6 accuracy for a given true force: The difference between the true force and the arithmetic mean of readings obtained by repeated application of the force. It is expressed as a percentage of the true force.

NOTE 3 This definition of accuracy assumes verification by observing the variation in the indicated values obtained by repeated application of known values.

3 Designation of machine accuracy

Machines are designated according to their accuracy in measuring the following parameters:

a) force (grade A or B),

b) elongation or deflection (grade A^1, B^1, C^1, D^1 or E^1).

For example, a machine of the highest accuracy is designated "Force: grade A; Elongation (deflection): grade A^1".

It is not implied that test machines are available commercially in all the theoretically possible grades.

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

NOTE 4 Stringent specifications 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 piece installation technique and test piece variability are major sources of error.

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

4 Design features

4.1 Size and construction

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

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

4.2 Axial alignment of the machine

The coupling between the force-measuring system and the test piece grips or jigs shall be accurately aligned with the strain axis. When fitted in place, the test piece shall also be accurately aligned with the strain axis, and the test axis of the test piece shall coincide with the direction of the applied force.

NOTE 5 Non-axial alignment of a test piece in the grips and lack of test piece symmetry are particularly important causes of variation in test results.

4.3 Test piece grips

For testing dumb-bell, parallel-strip and similar tensile-test pieces of flexible materials, 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 whole width of the test piece. For rigid materials, screw-action grips are also suitable. The test piece shall be held in such a manner that slippage relative to the grips is prevented as far as possible.

For testing ring test pieces, the machine shall be provided with two pulleys, both of which are free to rotate; one at least is automatically rotated by the machine at between 3 r/min and 50 r/min to equalize the strain in the ring during the test. The pulleys shall be 25 mm in diameter for large rings (52,5 mm OD) and 4,5 mm in diameter for small rings (10 mm OD).

For testing adhesion in the peel mode, the machine shall be provided either with the grips described in the relevant test method or with grips which exert a uniform pressure across the whole width of the test piece.

The test piece shall be held in such a manner that slip relative to the grips is prevented. When an adhesion test piece is made from different adherends, then grips of a different design may be required for each adherend.

4.4 Drive characteristics

The moving crosshead of the machine shall be driven smoothly at all test speeds, and the drive shall be without any significant backlash.

4.5 Jigs for use in compression, shear and flexure testing

Such jigs or fixtures shall conform with requirements of 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 misalignment.

5 Types of force-measuring system

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

Machines with low-inertia force-measuring systems are preferred.

NOTE 6 Pendulum-type machines may have levels of friction and inertia which will significantly affect their dynamic response and decrease their accuracy.

6 Steady-state machine accuracy

For each force scale, an accuracy grade A or B is specified (see clause 3). The designation of each scale of a machine depends upon the values of precision and accuracy found when the machine is verified.

The maximum permissible values for precision and accuracy for grades A and B are given in table 1, 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.

The method of verification shall be in accordance with national standards, subject to the verification device being within the accuracy limit given in table 1. If the machine is to be used to measure cyclic loads, verification shall be carried out for both increasing and decreasing force.

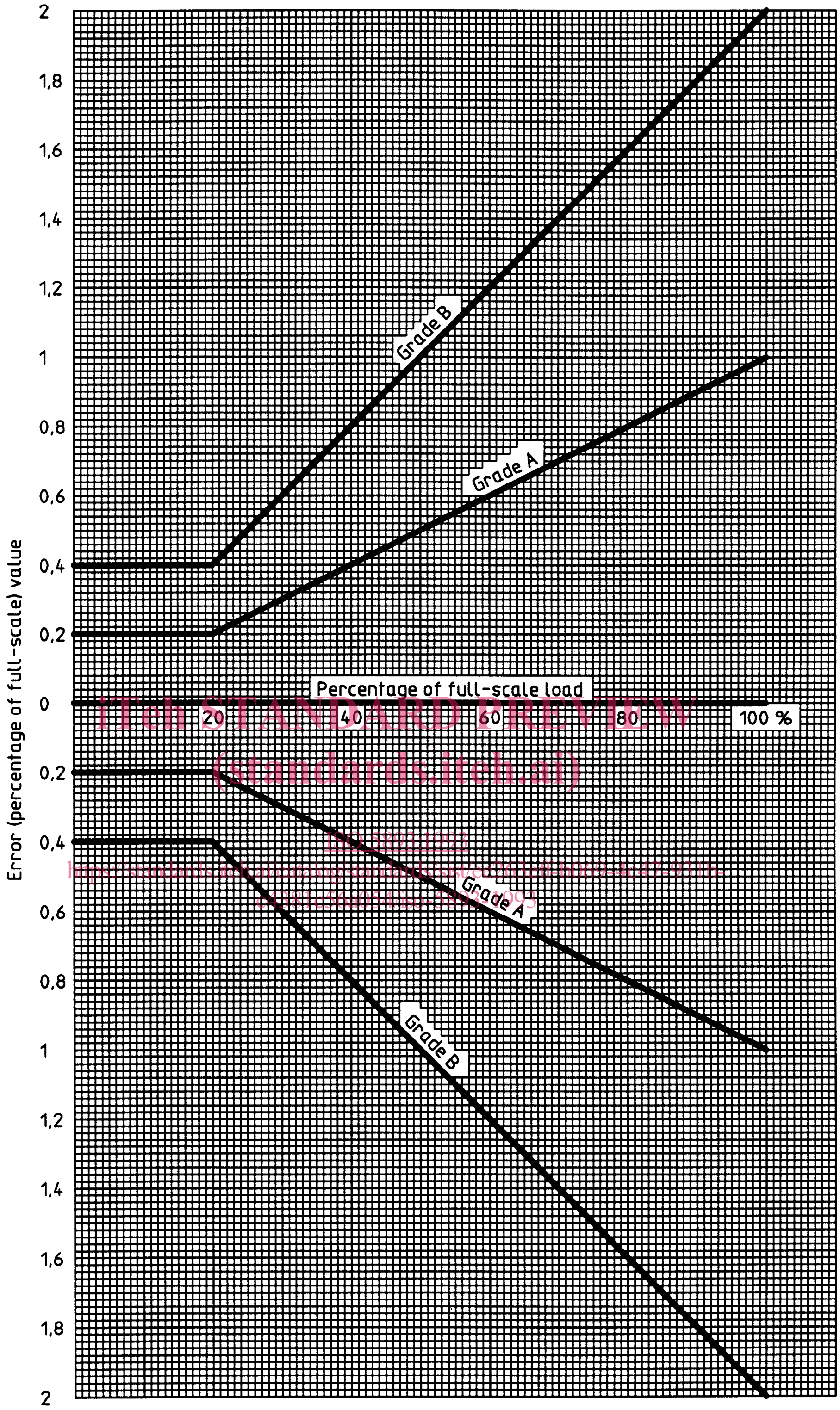

Figure 1 — Machine accuracy gradings

Table 1 — Force-measurement accuracy grades

Grade	Accuracy of verification device	Certified range			
		One-fifth of full scale to full scale		Below one-fifth of full scale	
		Precision requirement	Accuracy requirement	Precision requirement	Accuracy requirement
		At each verification force, max. permissible difference between highest and lowest readings, expressed as a percentage of the verification force:	At each verification force, max. permissible error, expressed as a percentage of the verification force:	At each verification force, max. permissible difference between highest and lowest readings, expressed as a percentage of the full-scale reading:	At each verification force, max. permissible error, expressed as a percentage of the full-scale reading:
	%	%	%	%	%
A	± 0,2	1,0	± 1,0	0,2	± 0,2
B	± 0,3	2,0	± 2,0	0,4	± 0,4

7 Dynamic machine accuracy

Tensile-testing machines fitted with electronic force-measuring devices may be regarded as sufficiently free of inertia at the test speeds given in clause 9. 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 steady-state inaccuracy.

All electromechanical recorders suffer from dynamic errors which are usually made up of acceleration errors, stemming from the inertia of the device, and pen lag errors due to mechanical and electrostatic friction effects. Measurement of dynamic recorder accuracy is best achieved by recording the error-signal level during the test. This can be done without affecting instrument performance, but it is usually technically difficult. It is therefore not considered practicable at present to specify limits and a calibration procedure for dynamic accuracy in this International Standard. Consequently, the user is advised to obtain from the test-machine manufacturer dynamic-accuracy figures for the recorder with which he/she can calculate the probable measurement error, and assess whether or not it is significant. In cases where it is, either the test speed can be reduced, or the full-scale reading of the output device can be increased, in order to reduce the acceleration and velocity levels.

NOTE 7 The accuracy requirement is expressed as a percentage of the true force over the range one-fifth of full scale to full scale but is a constant error for forces below one-fifth of full scale. Thus at one-fifth of full scale on a 500 kN grade A machine, the maximum percentage error permitted for the applied force is ± 1 %, corresponding to an absolute error of ± 1 kN. The permitted error from zero to one-fifth of full scale (i.e. 100 kN) is therefore constant at ± 1 kN.

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 steady-state 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:

$$v_D \leqslant \frac{v_{max}}{10} \quad \text{for grade A machines}$$

$$v_D \leqslant \frac{v_{max}}{5} \quad \text{for grade B machines}$$

If only the recorder response time T is known, then v_{max} may be calculated approximately from the following equation:

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

where R is the recorder full-scale deflection.

If the above recommendations are not followed, the user is advised to obtain details of recorder errors arising from dynamic operation from the manufacturer.

8 Measurement of elongation (deflection)

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

a) grip separation;

b) extensometers attached to the test piece;

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

When elongation is measured, a continuous indication of the elongation (deflection), preferably recorded autographically in the form of a force/elongation (deflection) curve, and a permanent indication of the maximum elongation (deflection) shall be given.

For some purposes, particularly the elongation of ring test pieces 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 piece 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 piece nor any slippage between the extensometer grips and the test piece which would significantly affect the test results.

Table 2 — Accuracy grades for elongation (deflection) measurement

Grade	Approximate percentage maximum elongation (deflection) on given gauge length	Maximum permissible error %	Accuracy of verification device %
A1	5 % on 25 mm (ΔL = 1,25 mm)	± 2	± 0,5
B1	10 % on 25 mm (ΔL = 2,5 mm)	± 2	± 0,5
C1	50 % on 25 mm (ΔL = 12,5 mm)	± 2	± 0,5
D1	1 200 % on 20 mm (ΔL = 240 mm)	± 2	± 0,5
E1	1 200 % on 10 mm (ΔL = 120 mm)	± 2	± 0,5

When extensometer accuracy is specified, five grades, A1, B1, C1, D1 and E1 are recognized. The grading of each range of each measuring device depends on the maximum error when the extensometer is verified.

The values in table 2 for error are given in percent of scale reading. The manufacturer shall state the lowest elongation at which the specified accuracy can be achieved. For all grades, the gauge length shall be specified in the relevant method of test or material specification; the gauge length shall be accurate to within ± 1 %. The method of verification shall be in accordance with national standards, subject to the verification device being within the accuracy limit given in table 2.

9 Rate of displacement of driven grip

The test machine will be power-driven, and shall be capable of being set at one or more of the following rates of displacement of the driven grip.

1 mm/min ± 0,2 mm/min

2 mm/min ± 0,4 mm/min

5 mm/min ± 1 mm/min

10 mm/min ± 2 mm/min

20 mm/min ± 2,5 mm/min

25 mm/min ± 2,5 mm/min

50 mm/min ± 5 mm/min

100 mm/min ± 10 mm/min

200 mm/min ± 20 mm/min

250 mm/min ± 25 mm/min

500 mm/min ± 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.

Verification of the accuracy of the rate of displacement of the driven grip shall be done whilst increasing the load uniformly from zero to some specified maximum within the machine force range. Unless otherwise stated, this maximum shall be the normal maximum force capacity of the machine. Verification can be achieved by obtaining a displacement/time recording. To make a realistic assessment of the rate of displacement of the driven grip, the displacement of the driven grip during the verification test shall be at least 10 mm and the duration of the verification test shall be at least 1,0 min.

The rates of displacement listed are those more generally in use. However, it should be noted that particular specifications may require rates (e.g. between

0,1 mm/min to 1 000 mm/min) and tolerances other than the above.

10 Machine stiffness

Machine stiffness (also referred to as hardness) is the ratio between the force and the deflection of the test system. This includes the frame of the machine, the strain-application mechanism, the force-measuring device and the grips and attachments by which the test piece is held.

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. Consequently, the uncorrected crosshead movement cannot be used as a measure of test piece deflection. Preference should therefore be given to a machine which is stiff in comparison to the test piece so that the speeds of grip separation and, if required, their accuracy of measurement are in accordance with the requirements of clauses 9 and 8, respectively.

11 Stability

The long-term stability of electronic test 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 temperature range over which the machine accuracy is guaranteed;

b) the variation of supply voltage over which the machine accuracy is guaranteed;

c) the frequency at which it is necessary to adjust any manual control, e.g. for zero or span.

12 Certificate of verification

When a test machine has been verified in accordance with this International Standard, the verifying authority shall issue a certificate stating the following:

a) the identity of the machine and date of verification;

b) the range certified and the grade of each force or extension scale;

c) the method of verification used and the identity of any calibration devices employed;

d) the ambient temperature at the time of verification;

e) the accuracy of the rate setting (see clause 9);

f) the number of this International Standard, i.e. ISO 5893.

The test machine shall be re-verified periodically to ensure that it continues to meet the grade(s) designated from this International 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 12 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.

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