TC 45

International Standard ISO 5893

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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 approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

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1 Scope and field of application

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 Reference

ISO 2573, *Tensile testing systems — Determination of K-value.*

3 Definitions

For the purpose of this International 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 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 specimen.

3.2 force: The force measured acting along the straining axis of the machine. According to the arrangement of grips or jigs, 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 piece when the machine is used for tests other than in tension.

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

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

3.5 precision 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 accuracy for a given true force: The difference between the true force and the arithmetic mean of readings corresponding to repeated applications of the force. It is expressed as a percentage of the true force.

NOTE — These definitions of precision and accuracy 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 A1, B1, C1, D1 or E1).

For example, a machine of the highest accuracy is designated as "Force: Grade A, Elongation (Deflection): Grade A1".

It is not implied that test machines are commercially available in all the 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 piece. 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 piece jig) and the correctly installed test piece shall be accurately aligned with the straining axis and the test axis of the test piece shall coincide with the direction of the applied force.

NOTE — 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.

5.3 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 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 slip 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, whilst one at least is automatically rotated by the machine at between 3 and 50 r/min to equalize the strain in the ring during the test. The pulleys shall be 25 mm diameter for large rings (52,5 mm OD) and 4,5 mm diameter for small rings (10 mm OD).

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

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

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 piece, preferably recorded automatically with a permanent indication of the maximum force, shall be provided.

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

NOTE — 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. 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 the figure. 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 the table 1. If the machine is to be used to measure cyclic loads, verification should be with both increasing and decreasing force.

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 sufffer 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 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 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.

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) accordingl remains constant at ± 1 kN.

Table 1 — Grades of accuracy for force measurement

Grade	Accuracy of verification devices	Certified range			
		One-fifth force to full force of machine scale		Below one-fifth of machine scale range	
		Requirement for precision	**Requirement for accuracy**	**Requirement for precision**	**Requirement for accuracy**
		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-force reading of the scale	At each verification force max. permissible error expressed as a percentage of the full-force reading of the scale
	%	%	%	%	%
A	± 0,2	1,0	± 1,0	0,2	± 0,2
B	± 0,3	2,0	± 2,0	0,4	± 0,4

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 :

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

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

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 pieces may be measured by methods of test utilizing

a) grip separation;

b) extensometers attached to the test piece;

c) optical or other 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.

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.

Table 2 — Grades of accuracy 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

10 Rate of movement of driven grip

The testing machine will 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
2 ± 0,4 mm/min
5 ± 1 mm/min
10 ± 2 mm/min
20 ± 2,5 mm/min
25 ± 2,5 mm/min
50 ± 5 mm/min
100 ± 10 mm/min
200 ± 20 mm/min
250 ± 25 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 verification of accuracy of rate of movement of the driven grip should be done whilst increasing 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 movement listed are those more generally in use. However, it should be noted that particular specifications may require rates (e.g. between 0,1 to 1 000 mm/min) and tolerances other than the above.

11 Machine stiffness

Machine stiffness (also referred to as hardness) is the ratio between force and the 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 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 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 ISO 2573.

12 Stability

The long term stability of electronic testing machines is influenced by a number of factors, the most important of which are temperature, mechanical hysteris 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 to be guaranteed;

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

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

13 Certification of verification

When a testing 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 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 International Standard, i.e. ISO 5893.

The testing 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.