INTERNATIONAL STANDARD

ISO 9026

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Raw rubber or unvulcanized compounds — Determination of green strength

Caoutchouc brut ou mélanges de caoutchoucs non vulcanisés — Détermination de la cohésion à cru

Reference number
ISO 9026:1991(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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 9026 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Sub-Committee SC 2, *Physical and degradation tests*.

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Introduction

The stress-strain properties of unvulcanized rubber (either a prepared mix or in the raw state) are important to certain processing operations in the rubber industry. These unvulcanized-rubber properties are frequently referred to as "green strength", denoting that the final vulcanization cycle has not yet been achieved. The word "green" is thus a synonym for uncured or unvulcanized.

Green strength is determined primarily by the physical and chemical characteristics of polymers, such as molecular mass, tendency to crystallize, degree of branching, etc. It is also related to the compound formulation, particularly filler and plasticizer content and the presence of peptizers. It is a particularly important characteristic for all processing operations in which elongation predominates, for example elongation caused by the expansion of the green tyre during the building operation.

Green strength is dependent on the test piece preparation (thermal, mechanical), rate of extension and test temperature. Therefore a single-point method cannot be expected to give correlation between green strength and processing behaviour over the whole range of processing conditions.

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Raw rubber or unvulcanized compounds — Determination of green strength

1 Scope

This International Standard specifies a method for the determination of green strength of raw rubber or unvulcanized-rubber compounds using a tensile stress-strain test, the test pieces being prepared following standard test conditions, or cut from calendered sheets.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 37:—[1], *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties.*

ISO 471:1983, *Rubber — Standard temperatures, humidities and times for the conditioning and testing of test pieces.*

ISO 1796:1982, *Rubber, raw — Sample preparation.*

ISO 2393:—[2], *Rubber test mixes — Preparation, mixing and vulcanization — Equipment and procedures.*

ISO 4648:1991, *Rubber, vulcanized or thermoplastic — Determination of dimensions of test pieces and products for test purposes.*

ISO 5893:1985, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Description.*

3 Definition

For the purposes of this International Standard, the following definition applies.

3.1 green strength: The resistance of raw or unvulcanized compounded rubber to tensile deformation or fracture and thereby a measure of the ability of a rubber or rubber compound to resist tensile distortion during processing and in fabrication, e.g. tyre-building operations.

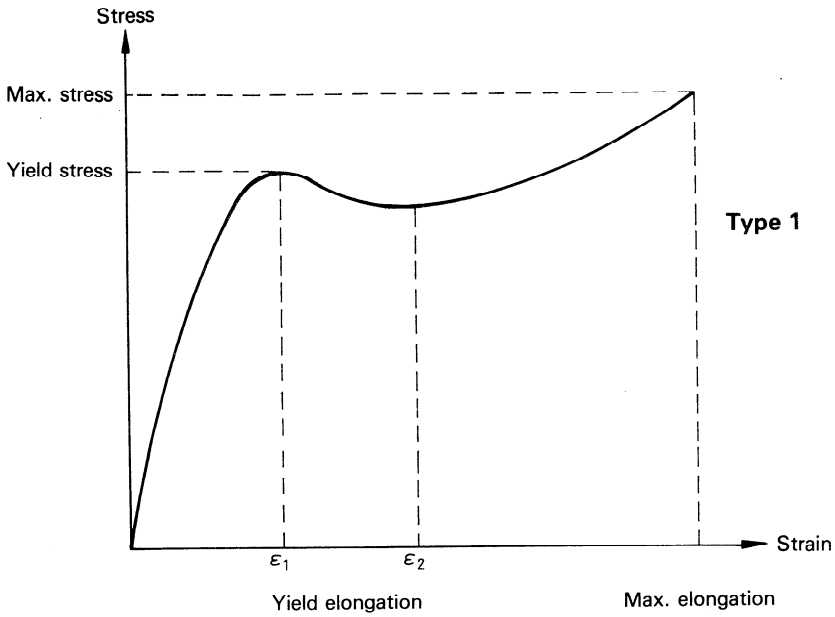
NOTE 1 Several types of curve may be obtained, according to the nature of polymer (see figure 1). Usually, the green strength is expressed by the yield stress or maximum stress.

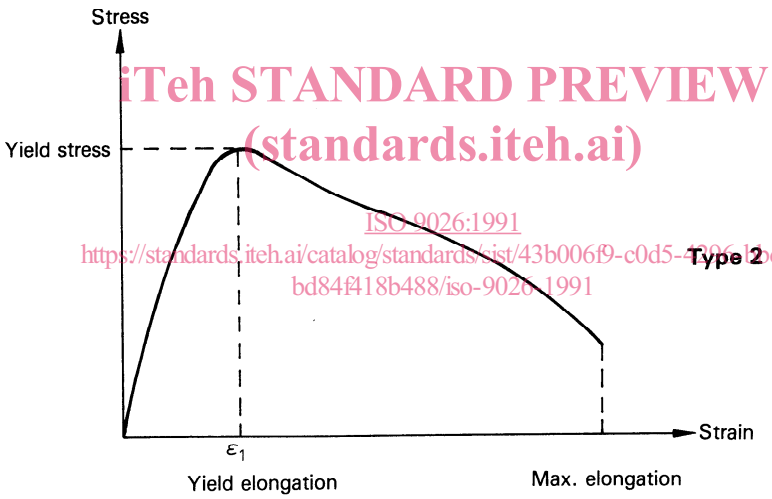
4 Principle

The tensile stress-strain characteristics of a dumbbell or another recommended test piece of raw or unvulcanized compounded rubber are determined on a tensile-testing machine capable of maintaining a substantially constant rate of separation of the jaws.

1) To be published. (Revision of ISO 37:1977)

2) To be published. (Revision of ISO 2393:1973)





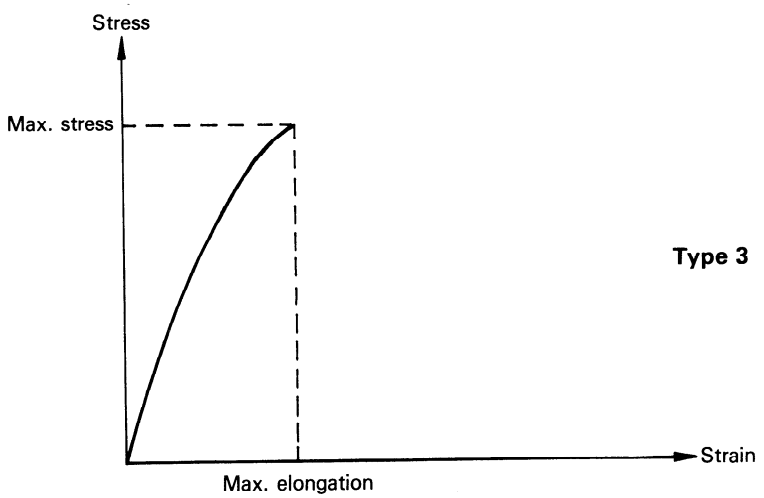


Figure 1 — Typical tensile stress-strain curves

5 Apparatus

5.1 Tensile-testing machine, in accordance with the requirements of ISO 5893:1985, grade B. It shall be capable of maintaining a constant rate of separation of the jaws at the preferred value of 100 mm/min. Other values may be used for special purposes.

It shall have means to test the force on the test piece and the elongation by the distance between the gauge marks on the dumb-bell. It shall be capable of recording the force/elongation curve obtained during the test.

NOTE 2 Inertia-type machines (pendulum dynamometers) may give results which differ because of frictional and inertial effects. An inertialess dynamometer (for example, using electronic or optical transducers) is to be preferred.

If an automatic extensometer is used, it shall be one of the non-contacting type.

5.2 Mould, which meets the requirements of ISO 2393. If the test piece with beaded ends (see 6.1) is required, a special grooved mould, capable of producing a sheet 2 mm in thickness and 50 mm in length with a bead at both ends, as shown in figure 2, shall be used.

5.3 Curing press, large enough to take the mould, meeting the requirements of ISO 2393.

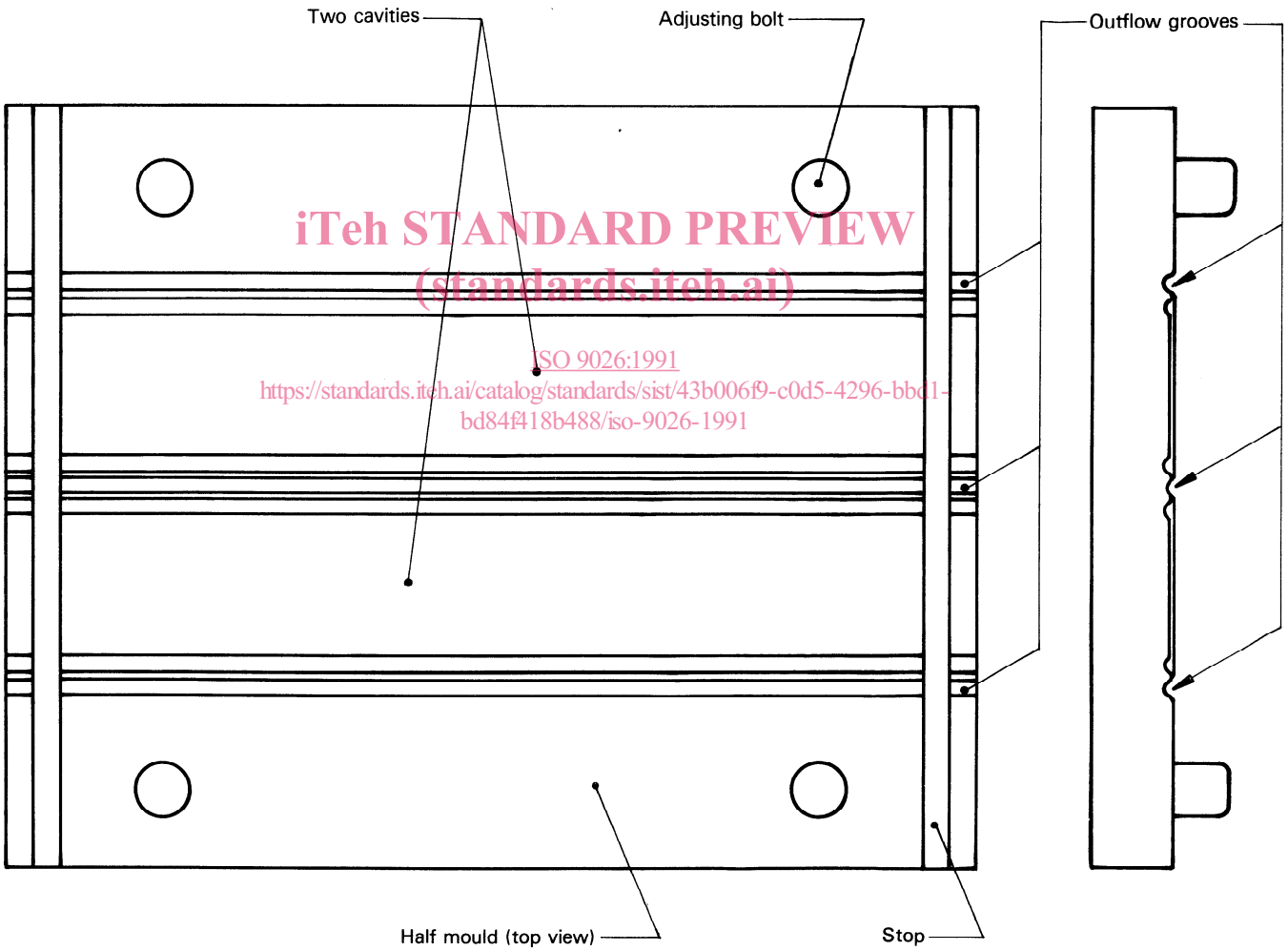


Figure 2 — Mould for test piece with beaded ends

5.4 Fixture for holding the test piece in the testing machine.

For the test piece with beaded ends, the fixture shall possess a suitable slot for gripping the test piece without any damage or slippage (see figure 3).

6 Test piece

6.1 Dimensions

The recommended type of test piece is the one with beaded ends, of which the shape and dimensions are given in figure 4. Dumb-bell test pieces of type 1 or type 2 in accordance with ISO 37 may be used, in which case the ends of test pieces held in the grips may be protected by low-hardness vulcanized rubber, to avoid any damage.

Since different types of test piece do not necessarily give the same values, comparison of the results obtained should be avoided.

6.2 Preparation

6.2.1 General

Standard test conditions shall be followed where determination of green strength of raw rubber or unvulcanized compounded rubber is to be made with no reference given to any particular process (see clauses 7 to 9).

Raw rubber shall be homogenized in accordance with ISO 1796.

6.2.2 Preparation of moulded test pieces

Raw rubber and unvulcanized rubber shall be sheeted out to approximately 2,2 mm thickness and placed in the mould with the grain direction oriented so as to have the grain direction along the length of the test pieces, care being taken that a suitable film is placed between the mould walls and the rubber compound in order to promote mould release. Polyester or PTFE film 0,25 mm thick has been found suitable. The sample shall be compressed for 5 min at 100 °C under 2,5 MPa platen pressure, then removed after cooling to laboratory temperature under pressure.

NOTES

3 For some raw rubbers, longer times or higher moulding temperatures may be necessary in order to obtain a smooth sheet free from porosity. For some compounds, a lower temperature may be necessary when there is a danger of scorch at the preferred temperature.

4 The cooling time depends on the apparatus used.

The test piece shall be cut from the sheet using a suitable die.

When it is necessary to characterize the behaviour of compounds intended to be used in a given application, the test pieces shall be prepared in such a way that the properties of the rubber are not additionally altered.

Dimensions in millimetres

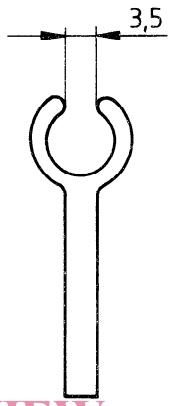


Figure 3 — Fixture with slot

Dimensions in millimetres

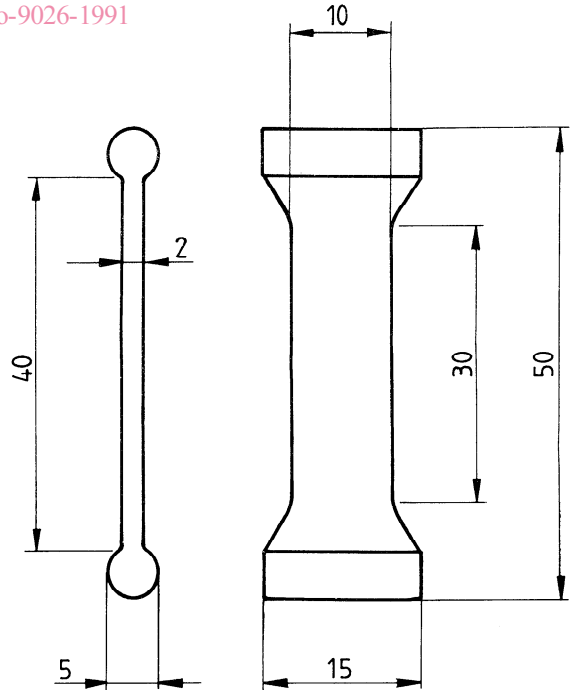


Figure 4 — Dumb-bell test piece with beaded ends

6.2.3 Preparation of test pieces from calendered sheet

The dumb-bell test pieces shall be prepared directly by die cutting the test pieces from a sheet calendered from 2 mm to 4 mm thickness.

6.3 Number of test pieces

The test shall be carried out on at least five test pieces.

6.4 Measurement

Thickness shall be measured using a micrometer gauge according to ISO 4648:1991, method A, with a pressure of 10 kPa $\pm$ 2 kPa on the rubber. The result shall be the median of 3 values.

The width shall be assumed to be equal to the width between the cutting edges of the central part of the die.

7 Conditioning

After suitable preparation, the test pieces shall be conditioned at the preferred standard temperature (see ISO 471) for a determined conditioning period between 24 h and 72 h.

The same conditioning period shall be used throughout any one test or series of tests intended for comparison.

8 Temperature of test

The test shall normally be carried out at the standard temperature (see ISO 471). Where other temperatures are used, take the preferred test temperatures as given in ISO 471.

The same temperature shall be used throughout any one test or series of tests intended for comparison.

9 Procedure

After removal of the mould-release film, when applicable (see 6.2.2), insert test pieces with beaded ends in the fixture illustrated in figure 3. Adjust the rate of displacement of the moving jaw to 100 mm/min and start the tensile test. If the test piece breaks at the grips, that result shall be discarded and a retest carried out.

NOTE 5 The preferred rate of separation of the jaws is 100 mm/min. In special cases, other rates may be used, but only tests carried out at the same rate can be compared.

10 Expression of results

Using the typical stress-strain curves given in figure 1, determine the yield stress or maximum stress in megapascals.

Other parameters may be determined, such as yield elongation (ε_1), or the stress at a definite reference elongation corresponding to the deformation entailed by a subsequent processing operation.

The stresses are calculated from the initial cross-sectional area of the parallel-sided portion of the dumb-bell.

The stresses and elongation shall be calculated using the procedure and formulae described in ISO 37.

11 Test report

The test report shall include the following information:

a) sample details, comprising:

   1) full description of the sample and its origin,

   2) method of preparation of the test pieces (i.e. time and temperature of moulding, if not standard conditions),

   3) type and dimensions of test piece,

   4) any relevant facts about the pre-test history of the test pieces;

b) test method and test details, comprising:

   1) reference number of this International Standard,

   2) standard temperature,

   3) time of conditioning,

   4) rate of separation of the moving jaw, if not the preferred rate of 100 mm/min,

   5) temperature of test;

c) test results, comprising:

   1) number of test pieces tested if more than five,

   2) medians and ranges of all results (i.e. yield stress, maximum stress, yield elongation — see clause 10);

d) date of test.