INTERNATIONAL STANDARD

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Rubber, vulcanized or thermoplastic — Determination of stress relaxation in compression at ambient and at elevated temperatures

Caoutchouc vulcanisé ou thermoplastique — Détermination de la relaxation de contrainte en compression à température ambiante et aux températures élevées

Reference number
ISO 3384:1991(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 3384 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Sub-Committee SC 2, *Physical and degradation tests*.

This third edition cancels and replaces the second edition (ISO 3384:1986), of which it constitutes a technical revision.

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Introduction

When a constant strain is applied to rubber, the force necessary to maintain that strain is not constant but decreases with time; this behaviour is called "stress relaxation". Conversely, when rubber is subjected to a constant stress, an increase in the deformation takes place with time; this behaviour is called "creep".

The processes responsible for stress relaxation may be physical or chemical in nature, and under all normal conditions both types of process will occur simultaneously. However, at normal or low temperatures and/or short times, stress relaxation is dominated by physical processes whilst at high temperatures and/or long times chemical processes are dominant. Hence it is neither safe to extrapolate time/stress relaxation curves in order to predict stress relaxation after periods considerably longer than those covered by the test, nor to use tests at higher temperatures as accelerated tests to give information on stress relaxation at lower temperatures.

In addition to the need to specify the temperatures and time intervals in a stress relaxation test, it is also necessary to specify the initial stress and the previous mechanical history of the test piece since these may also influence the measured stress relaxation, particularly in rubbers containing fillers.

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Rubber, vulcanized or thermoplastic — Determination of stress relaxation in compression at ambient and at elevated temperatures

1 Scope

This International Standard specifies three methods for determining the decrease in counterforce exerted by a test piece of vulcanized or thermoplastic rubber which has been compressed to a constant deformation and maintained thus at a predetermined test temperature.

Two forms of test piece are permitted: cylindrical test pieces and rings. Different shapes and sizes of test piece give different results, and comparison of results should be limited to test pieces of similar size and shape.

The use of ring test pieces is particularly suitable for the determination of stress relaxation in liquid environments.

Testing at temperatures below standard temperature is not specified.

The methods have been used for low-temperature testing, but their reliability under these conditions is not proven.

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 37:1977, *Rubber, vulcanized — Determination of tensile stress-strain properties.*

ISO 468:1982, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

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

ISO 1817:1985, *Rubber, vulcanized — Determination of the effect of liquids.*

ISO 1826:1981, *Rubber, vulcanized — Time-interval between vulcanization and testing — Specification.*

ISO 3383:1985, *Rubber — General directions for achieving elevated or subnormal temperatures for test purposes.*

ISO 3601-1:1988, *Fluid systems — Sealing devices — O-rings — Part 1: Inside diameters, cross-sections, tolerances and size identification code.*

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

ISO 4661-1:1986, *Rubber, vulcanized — Preparation of samples and test pieces — Part 1: Physical tests.*

3 Definition

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

3.1 compression stress relaxation: The reduction in compressive force, expressed as a percentage of the initial force, which occurs with time after the application of a constant compressive strain.

4 Principle

A test piece of vulcanized or thermoplastic rubber is compressed to a constant deformation and maintained at a pre-determined test temperature. The decrease in counterforce that is exerted is then measured.

In method A, the compression is applied and all counterforce measurements are made at the test temperature.

In method B, the compression is applied and all counterforce measurements are made at standard temperature. The test pieces are stored at the test temperature.

In method C, the compression is applied at standard temperature and all counterforce measurements are made at the test temperature.

NOTE 1 The three methods A, B and C of carrying out the measurement do not give the same values of stress relaxation, and comparison of values obtained from the three methods should be avoided. The method selected for use depends on the purpose of the test. Thus, for fundamental studies and in applications where sealing at elevated temperatures is a problem, method A or C may be preferred, and in applications where temperature cycling from normal to an elevated temperature is a problem, method B may be preferred.

5 Apparatus

5.1 Compression device, consisting of two parallel, flat, highly polished plates made from chromium-plated or stainless steel or other corrosion-resistant material, between the faces of which the test pieces are compressed.

Flatness, surface roughness, parallelism and rigidity of the plates are all important.

When the apparatus is disassembled, the compression plates shall be flat to within 0,01 mm. The finish of the surface shall not be worse than 0,4 μm Ra (see ISO 468). When the apparatus is assembled without a specimen test piece, the gap between the plates shall not vary by more than ± 0,01 mm.

When the test assembly is subjected to the test load with a test piece between the plates, neither compression plate shall bend by more than 0,01 mm.

The plates shall be of sufficient size to ensure that the whole of the compressed test piece is within the area of the plates.

For ring test pieces, the plates shall have holes of at least 2 mm diameter drilled through their centre portions to allow equalization of pressure and circulation of fluid inside the ring-shaped test piece.

It shall be possible to connect the compression device to suitable equipment for compressing the test piece to the specified compression at the specified speed and for measuring the counterforce exerted by the compressed test piece with an accuracy of 1 % of the measured value.

The device shall be capable of setting and maintaining the compression during the whole duration of the test and it shall be possible to keep it in an oven at the specified test temperature. Care shall be taken to ensure that there is no loss of heat from the test piece, for example by conduction through metal parts which are connected with the outside of the oven.

5.2 Counterforce-measuring device, capable of measuring compression forces in the desired range with an accuracy of 1 % of the measured value. The device may be one that monitors the test piece during the whole duration of test, in which case a continuous measurement of the change of counterforce with time is possible. The stiffness of the counterforce measuring device shall be sufficient for the change in compression of the test piece due to the relaxation of the load to be less than 0,02 mm.

Alternatively, a compression testing machine may be used to measure the counterforce at prescribed time intervals. In this case, the force necessary to cause a slight increase in the compression of the test piece is measured. This additional compression shall be as small as possible and in no case greater than a force of 1 N for balance-type machines, or greater than 0,05 mm for stress/strain-type machines, applied in either case without overshoot.

5.3 Test chamber, complying with the requirements of ISO 3383.

For tests in air, a well designed, uniformly heated air oven shall be used, provided with adequate temperature control to maintain the specified air temperatures within the tolerances specified in 8.2. Satisfactory circulation of the air shall be secured by means of a fan.

For tests in liquids, the compression device shall be totally immersed in the liquid in a bath, or a closed vessel for volatile and toxic fluids, such that free circulation of the liquid can take place through the holes in the compression plates. The liquid shall be maintained at the specified temperature by proper control of a heater and circulation of the liquid in the bath or, alternatively, by placing the liquid bath and compression device within an air oven as specified above.

5.4 Temperature-measuring equipment, with a sensing element, for example a thermocouple. The thermo-measuring element shall be mounted so that it is located no more than 2 mm from a surface of the test piece.