INTERNATIONAL STANDARD

ISO 15113

Second edition
2005-10-15

Rubber — Determination of frictional properties

Caoutchouc — Détermination des propriétés frictionnelles

Reference number
ISO 15113:2005(E)

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15113 was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 2, *Testing and analysis*.

This second edition cancels and replaces the first edition (ISO 15113:1999), of which it constitutes a minor revision, the main purpose of which was to update the normative references clause. It also incorporates Technical Corrigendum ISO 15113:1999/Cor. 1:2001.

Introduction

Various geometrical arrangements can be used when measuring friction, but each is likely to give a different value for μ, the coefficient of friction. Each may be appropriate in particular circumstances, but it is desirable that some standard method utilizing specified test conditions be employed when comparisons between materials are undertaken.

Rubber samples are most readily available in sheet form, and for many practical applications measurement between two planar surfaces most nearly approaches service behaviour. Consequently, this is the most widely used geometry. For this geometry, the apparatus used needs careful design in order to ensure reproducible contact between the surfaces, and this is discussed in Annex A.

Where rubber moulding facilities are available, some workers prefer to use a hemispherical rubber slider and a planar test track. This gives a more definable contact area and minimizes the errors involved if the friction plane does not contain both the line of action of the load cell and that of the towing force. However, when this geometry is used, the frictional force is not proportional to the normal load (see Annex B), and the contact area is estimated from a knowledge of the modulus of the rubber. Hence care should be taken when quoting values for coefficients of friction. The big disadvantage of the method is that special test pieces need to be moulded from unvulcanized rubber, and rubber products cannot be accommodated. Finally, since some degree of wear is inseparable from friction, extended testing will produce a “flat” on the hemispherical test piece. Frequent inspection of the test surface is recommended, therefore, to ensure that the initial contact geometry is maintained.

The alternative “ball-on-flat” geometry where a hard ball slides on a flat rubber surface is not an exact equivalent. The ploughing action of the ball through the rubber results in an energy loss by hysteresis which gives a higher measured coefficient of friction. However, in some circumstances this may be an appropriate test procedure.

Although there may be some uncertainty in the contact area using plane-on-plane geometry, this International Standard is based on this geometry because of its wide practical applicability. However, it is emphasized that it is necessary to have a well designed apparatus with the line of action of the load cell included in the plane of contact of the test pieces (see Annex A). The method can be adapted to cover other contact geometries to suit particular products, including the ball-on-flat geometry set out in Annex B.

This International Standard is based on linear motion, and guidance on the experimental arrangement is given in Annex A. Because friction generates heat, it is usual to restrict testing to velocities typically below 1 000 mm/min in order to avoid a large temperature rise at the interface. If service conditions involve high speeds, then an entirely different method based on rotary motion is more appropriate as discussed in Annex A. The method of test set out here enables kinetic friction to be measured at a number of fixed velocities. It can be arranged that the lowest velocity is such that movement is barely discernible, and this gives an approximation to frictional behaviour close to zero velocity (static friction). This may be different from the starting friction, which may involve some element of adhesion (stiction) as discussed in Annex C. This method is suitable for measuring the initial friction only if the machine has a constant-rate-of-load facility and a sufficiently compliant load cell. A discussion on static friction and the correct approach to its measurement is given in Annex C.

Rubber friction is complex, and the coefficient of friction is dependent on the contact geometry, normal load, velocity and temperature, as well as the composition of the rubber. A discussion of the influence of these parameters and some other factors which affect measurement is presented in Annex D.

Rubber — Determination of frictional properties

1 Scope

This International Standard outlines the principles governing the measurement of coefficient of friction and describes a method suitable for measuring the coefficient of friction of a rubber against standard comparators, against itself, or against any other specified surface.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 5893:2002, *Rubber and plastics test equipment — Tensile, flexural and compression types (constant rate of traverse) — Specification*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
coefficient of friction
ratio of the frictional force opposing motion between two surfaces to the normal force between the surfaces under specified test conditions

NOTE Coefficient of friction is dimensionless and its value is not restricted to numbers less than unity.

3.2
area of contact
whole of the apparent area made between the two test surfaces (test track and test piece)

NOTE The real area of contact (see 3.3) may well be less than this.

3.3
real area of contact
sum total of the minute contact areas at which the two test surfaces touch

3.4
velocity of test
velocity with which one surface is driven relative to the other

NOTE If stick-slip (see 3.5) occurs, this will then be the mean velocity with which one surface moves relative to the other.

3.5
stick-slip
condition in which the actual velocity between the surfaces oscillates between two extremes about the test velocity, resulting in corresponding oscillations in the measured frictional force

3.6
test track
surface against which the rubber is to be tested

NOTE The test track may be made of the same material as the rubber under test or it may be different.

3.7
temperature of test
temperature of the test apparatus and its environment

NOTE Since friction generates heat, this may differ from the actual temperature of one or both of the test surfaces.

3.8
lubricant
substance introduced between two surfaces to lower the coefficient of friction

NOTE A lubricant is usually a liquid, but in some circumstances solid powders are used, e.g. talc. Usually, lubricants are introduced deliberately.

3.9
contaminant
any substance present on either test surface not of the same composition as that surface

NOTE A contaminant may act as a lubricant. Usually, in service, contaminants are introduced inadvertently.

3.10
stiction
force needed to move one surface over another when the external normal load is reduced to zero

NOTE This is an apparent frictional force, but no coefficient of friction can be calculated since the normal force is zero. See Annex C.

3.11
static friction
frictional force needed to start motion (i.e. the frictional force at zero velocity)

NOTE Where there is an external normal load, a coefficient of static friction can be calculated. Static friction often involves some element of stiction. See Annex C.

4 Principle

Two test surfaces are brought together under the action of a measured normal load. A mechanism slides one of the surfaces over the other at a measured velocity, and the force opposing motion is monitored and recorded. The ratio of this frictional force to the normal load at any instant is the coefficient of friction at that time. Since the test itself will alter the surfaces and may change the temperature at the interface, the measured coefficient of friction may change as the test proceeds.

In an ideal apparatus, the line of action of the force-measuring equipment will lie in the plane of the two contacting surfaces. This may be either a horizontal or a vertical plane.

5 Apparatus

5.1 Device, with provision for attaching two friction surfaces and capable of providing linear motion between the surfaces for a distance of typically 100 mm at a number of fixed velocities, typically between 0,5 mm/min and 1 000 mm/min. This may be a dedicated device or, alternatively, a tensile-testing machine may be adapted for the purpose.

5.2 Means of providing several measured normal loads between the surfaces within the range 1 N to 200 N. When the test track is horizontal, suitable weights may be used directly to provide the normal load, but on a machine with a vertical test track it will be necessary to use a bell crank lever system to convert the vertical gravitational force into a horizontal normal force.

5.3 Series of load cells or, alternatively, a **load cell with multiple ranging**, conforming to at least class 1 as defined in ISO 5893:2002, fitted with a means of recording the output and fastened to one of the friction surfaces, with ranging or other means of indicating the frictional force to an accuracy of ± 1% throughout the range of measurement.

NOTE Corresponding to the range of normal loads stated in 5.2, the measured frictional forces are likely to be within the range 0,1 N to 1 kN.

5.4 Environmental cabinet (if the effects of temperature are to be studied), to contain the apparatus and the two surfaces under test (but not the load cell), with a means of measuring and recording the temperature to an accuracy of ± 0,5 °C. The environmental chamber shall not make physical contact with any moving parts.

NOTE 1 The exclusion of a condensation-forming atmosphere from the test environment is extremely difficult, and the formation of ice crystals or particles or films on the test surfaces can only be assessed visually.

NOTE 2 To avoid the formation of ice when testing at temperatures at or below 0 °C, a very dry atmosphere (e.g. 5 % to 10 % r.h.) is needed.

5.5 Means of avoiding stick-slip, as the whole apparatus (including the load cell) needs to be as stiff as possible. All connections shall be made with rods and not with wire. Where an apparatus is designed to be attached to a tensile-testing machine, then a machine with a high degree of stiffness shall be chosen. In practice, this means a tensile-testing machine with a load capacity some 20 times greater than the maximum frictional force being measured.

5.6 Means of separating the surfaces under test, for use when the apparatus is reset to its initial position after each measurement. This is necessary because friction is very dependent on the history of the surfaces.

NOTE Separation of the surfaces may be carried out manually or automatically.

6 Test surfaces

6.1 General

For each test, two prepared surfaces shall be used, one manufactured from the rubber under test and the other (the test track) made either from this same rubber or, alternatively, from a specified material.

6.2 Test track

The test track shall be approximately planar but may have a patterned surface.

The material used to form the test track shall be larger in both linear dimensions than the test pieces (see 6.3). The longer dimension shall be sufficient to allow a linear travel of at least 50 mm.

The test track may be any surface agreed between the interested parties, but where comparisons have to be made it may be more appropriate to select one of the following:

a) The rubber under test with the surface moulded, split or buffed.

b) Float glass with the surface either polished or ground.

c) A specified stainless steel with the surface either polished or ground.

d) Cast iron with the surface ground to a specified finish.

e) Resin-bonded paper of specified grit size.

NOTE The measured coefficient of friction will depend not only on the material chosen but also on the surface finish of the test track (see Clause D.1).

6.3 Test pieces

Either moulded test pieces or test pieces cut from products may be used. Three test pieces shall be tested.

When planar test pieces are used, they shall be of smaller dimensions than the test track selected (see 6.2), so that it is possible to obtain linear motion between the two surfaces for at least 6 s, while maintaining contact (apparent contact) over the whole of the rubber surface throughout the test.

Test pieces shall normally be of a thickness between 1 mm and 8 mm. When the test surface is thinner than this, it shall be mounted on a support of adequate thickness using adhesive.

NOTE 1 In some circumstances, the contact area may be affected by the modulus of the underlying support, and it is then advisable to match as closely as possible the modulus of the test surface to that of the support.

The test piece shall not be stretched during mounting.

Any adhesive used shall not unduly swell or otherwise adversely affect the test piece.

Round off the leading edge of all planar test pieces to avoid buckling or digging in of this front edge.

NOTE 2 To reduce the possibility of stick-slip, it is advisable to keep the thickness of low-modulus test pieces below 4 mm.

When a test piece is made from a product, it may not be possible to cut a planar piece of adequate size. A suitable test piece may than be fabricated by mounting a number of small pieces cut from the product (for example, lengths of a windscreen-wiper blade may be mounted so that the wiping surfaces define a plane). Three small pieces, mounted at the corners of a triangle, will always define a plane. A greater number than this will need more careful mounting or perhaps additional preparation by buffing or abrasion. Alternatively, it may be better to use a different test geometry as discussed in Annex A.

7 Preparation

7.1 General

Materials may be tested as received, but where comparisons are to be made it is advisable to bring the surfaces to some standard condition. Texture is important since, in general, rough surfaces have a lower coefficient of friction than smooth surfaces when dry and a higher coefficient of friction than smooth surfaces when wet. Thus different coefficients of friction will be observed depending on the method of preparation used.

7.2 Surface texture

A test track made of float glass or mirror-finished metal shall be cleaned without other treatment (see 7.3). Other surfaces that need to be abraded shall be machine-ground, buffed or abraded by hand against resin-bonded paper of specified grit size.

Generally, test pieces prepared by splitting on a leather-splitting machine will need no further preparation other than cleaning.

7.3 Surface cleaning

Where contamination occurs in service and forms part of the agreed test conditions (see Clause 13), then it may be left, but where contamination is the result of the preparative procedure it shall, as far as possible, be removed.

It has to be recognized that complete removal of contaminants is not always possible, and sometimes the coefficient of friction is permanently altered by the residual contamination. For example, complete removal of silicone oil is rarely possible. For this reason, preparative techniques shall be chosen with great care. Where lubricants are needed for any abrasive, these should preferably be water-based rather than oil-based. Similarly, when mounting test pieces with adhesive great care shall be taken to keep the test surface free from adhesive. Care shall be taken not to contaminate the test surface with finger grease.

Where contamination has occurred, proceed as follows:

Blow all loose debris from the surface using a jet of clean, dry air or similar gas.

NOTE 1 A compressed-air line is not suitable as the air is usually wet and contaminated with oil.

Alternatively, brush debris away using a clean, dry, soft brush.

When the contaminants, such as grease, cling to the surface, select a suitable solvent from the following list:

a) distilled water plus a small amount of detergent;

b) distilled water only;

c) tap water;

d) ethyl alcohol;

e) isopropanol;

f) acetone;

g) butanone;

h) perchloroethylene;

i) toluene.

The chosen solvent shall not dissolve or unduly swell the surface being cleaned.

NOTE 2 Health and safety regulations apply to the use of some of these solvents.

In general, high-purity solvents are needed since it is only too easy to spread further contamination by using impure solvents. Similarly, any cloth or paper used for cleaning shall not be allowed to contact the neck of the storage vessel in order to avoid contaminating the solvent in the vessel.

