

Physical testing of rubber —

Part A61: Determination of the frictional properties of rubber

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- British Railways Board
- British Rubber Manufacturers' Association
- GAMBICA (BEAMA Ltd.)
- Institution of Mechanical Engineers
- Institution of Water and Environmental Management
- Malaysian Rubber Producers' Research Association
- Ministry of Defence
- RAPRA Technology Ltd.
- SATRA Footwear Technology Centre
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Foreword

This Part of BS 903 has been prepared under the direction of the Plastics and Rubber Standards Policy Committee.

In preparing this Part of BS 903 the committee was concerned to develop a method of test, which provided the greatest degree of operational flexibility, for investigating the frictional properties of rubbers.

There are many applications in the Defence, Aerospace, Public sector and private industry where frictional properties are extremely important. Attention is drawn in particular to the considerations discussed in the introduction.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Introduction

Various geometrical arrangements can be used when measuring friction, but each is likely to give a different value for m , 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 the line of the towing force. However, when this geometry is used, frictional force is not proportional to normal load (see Annex B) and contact area is estimated from a knowledge of the modulus of the rubber. Hence care should be taken when quoting values for coefficient 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 Part of BS 903 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 contained by 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 Part of BS 903 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.

1 Scope

This Part of BS 903 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 References

2.1 Normative references

This Part of BS 903 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 903 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 903 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 903, the following definitions apply.

3.1 coefficient of friction

the 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

the whole of the apparent area made between the two test surfaces

NOTE The real area of contact may well be less than this.

3.3 real area of contact

the sum total of the minute contact areas at which the two surfaces touch

3.4 velocity of test

the velocity with which one surface is driven relative to the other

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

3.5 stick-slip

a 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

the surface against which the rubber is to be tested

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

3.7 temperature of test

the 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

a 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

the 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

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

NOTE When 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 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, which may be either a horizontal or a vertical plane.

5 Apparatus

5.1 A device, with provision for attaching two friction surfaces, 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.