

Methods of testing vulcanized rubber —

Part A9: Determination of abrasion resistance

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- National College of Rubber Technology
- Rubber and Plastics Research Association of Great Britain
- SATRA Footwear Technology Centre

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Foreword

This Part of BS 903 has been prepared under the direction of the Rubber Standards Committee and supersedes BS 903-A9:1957 which is withdrawn.

Four methods (A to D) are described in this Part of BS 903, because no single method has been found which will adequately simulate the various conditions to which rubber products may be subjected in service. A comparison of these methods and guidance on which method should be chosen for a particular application is given in Appendix A.

Method A is technically equivalent to ISO 4649:1985 "*Rubber — Determination of abrasion resistance using a rotating cylinder drum device*". Method B is a revised version of method C (using an Akron machine) of the 1957 edition; the main change in the revised method is the provision, as an option in the procedure, for the application of a dust during the test in order to prevent clogging of the abrasive wheel with rubber debris which would otherwise cause abnormally low losses of material due to abrasion. Method C is a revised version of method A (using a Du Pont machine) of the 1957 edition; the main change in the revised method is that the duration of a test run is now specified either as a time (as in the 1957 edition) or, alternatively, as a number of revolutions of the abrasive disc. Method D is technically similar to ISO 5470:1980 "*Rubber or plastics coated fabrics — Determination of abrasion resistance*", but it is applicable to flat rubber sheet instead of coated fabrics. Method B (using a Du Pont machine with constant torque modification) of the 1957 edition has not been included. Method D (using a Dunlop machine) of the 1957 edition was deleted by an amendment issued in 1974.

The methods for determining abrasion resistance are classified into two groups:

- a) continuous abrasion, for which the whole of the test surface is in contact with the abrading surface throughout the test; and
- b) discontinuous abrasion, for which any particular part of the test surface is only in intermittent contact with the abrading surface.

In each of the methods, rubber is abraded by cutting its surface by asperities. Depending on the method chosen, various abrasives, with different degrees of roughness, are used. The severity of the abrasive action between the rubber and the abrasive surface depends on the contact pressure, the slip velocity and the nature of the abrasive. The presence of particles in the abraded rubber in the interface between the test piece and the abrading surface can cause stickiness and variable loss of rubber; each method therefore incorporates a means of removing these particles as they are formed. The discontinuous methods are better in this respect because both the abrading surface and the test piece can be cleaned during the test.

The results obtained for various rubbers using one particular method may not be comparable (either absolutely or relatively) to those obtained using another method.

The expression of a result in the form of an abrasion resistance index, based on the abrasion loss of a standard rubber, is intended to help overcome the problem of the variability of abrasion loss found between different machines operating under essentially the same conditions.

The important parameters of each method are compared in Appendix A.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 16, 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.

0 Introduction

Abrasion is the loss of material (the wear) resulting from frictional action upon a surface. The resistance of rubbers to abrasion is one of their most important technological properties. However, the analysis of the processes of abrasion and of its measurement under laboratory conditions and in service has proved to be a difficult problem.

In performing laboratory tests it is generally necessary to obtain a significant amount of abrasion in a short time in order to have measurable mass losses. This has led to tests based on the use of sharp abrasive surfaces of corundum, high loads, and high slip velocities, although these conditions are not characteristic of service. Wear in service, for example, can take place not only on surfaces with sharp asperities but also on mechanically smooth surfaces such as glass or polished metal.

In the case of asperities, the predominant action is that of cutting or tearing of the surface, and loss of material occurs as asperities plough through the surface. It is found that the mass loss is directly related to the sliding distance and to the applied load; it is also very dependent upon the sharpness of the edges of the asperities and upon the hardness of the rubber.

With smooth surfaces, abrasion is due to different processes and is considered to arise from stress concentrations in the surface associated with the mechanism of friction of polymers. However, abrasion by friction forces between relatively smooth surfaces is not of sufficient interest to justify the preparation of a standard method at the present time.

No close relationship between the results of an abrasion test and service performance can be inferred.

1 Scope

This Part of BS 903 describes four methods (A to D) for determining the abrasion resistance of rubber by comparing the wear of the rubber under test with that of a standard rubber under the same conditions. Methods A and D are applicable to rubbers of any degree of hardness, whilst methods B and C are restricted to rubbers with a hardness in the range 55 to 95 IRHD.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

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

2.1

abrasion resistance

the resistance to wear of a rubber when its surface is subjected to mechanical action

the abrasion resistance can be expressed as an abrasion resistance index referred to a standard rubber, and this is applicable to all methods. For method A only, an alternative way of expressing the abrasion resistance is as a relative volume loss referred to a calibrated abrasive cloth

2.2

abrasion resistance index

the expression of abrasion resistance, being the ratio of the volume loss of a standard rubber to the volume loss of the rubber under test, determined under the same specified conditions, expressed as a percentage

2.3

relative volume loss

the volume loss in cubic millimetres of the test rubber when subjected to abrasion by an abrasive cloth which causes the appropriate standard rubber to lose a mass of 200 mg under the conditions of test for method A.1 (see 3.2 and 7.4.1)

2.4

slip velocity

the vectorial difference between travelling and circumferential velocities. It is calculated as $\Delta v = v \sin \theta$.

3 Principle of methods

3.1 Method A

The flat end of a cylindrical test piece is abraded against the surface of a rotating drum covered with an abrasive cloth, while the test piece is traversed from one end of the drum to the other to reduce contamination of the cloth.

In method A.1 the test piece is held stationary (i.e. non-rotating) in the holder during traverse along the drum.

In method A.2 the test piece is held stationary (i.e. non-rotating) or rotated in a plane tangential to the surface of the drum during its traverse.

NOTE The results of the two types of test may differ.

3.2 Method B

A rotating test piece in the form of a disc is abraded against an abrasive wheel under a specified load, the planes of the test piece and the wheel being inclined at an angle. A dust is applied, if required, during the test in order to prevent clogging of the abrasive wheel with rubber debris.

3.3 Method C

A flat test piece is abraded against a rotating abrasive disc under a specified load.

3.4 Method D

A flat test piece is subjected to rotary slip between itself and a pair of abrasive wheels. The test is carried out using one of a range of wheel loadings and abrasive surfaces, so that it is possible to choose test conditions that are relevant to conditions experienced in service.

NOTE 1 S1 is identical to the standard rubber specified in B.1 of ISO 4649:1985 and is used as the standard rubber for method A when relative volume loss measurements are required.

S2 is identical to the standard rubber specified in B.2 of ISO 4649:1985; it replaces standard rubber A (tyre-tread type) in BS 903-A9:1957.

S3 is a high abrasion resistance compound based on synthetic rubber and may be preferred when highly resistant rubbers are being evaluated.

S4 is a rubber of low abrasion resistance and may be preferred when less resistant rubbers are being evaluated; it replaces standard rubber B (sole and heel type) in BS 903-A9:1957.

NOTE 2 The choice of standard rubber will depend on the application for which the test is being carried out. The four standard rubbers are intended to cover a wide range of abrasion resistance.

NOTE 3 The variability between different batches of a standard rubber can be minimized by careful control of mixing and vulcanization. Two batches of the same standard rubber should suffer abrasion losses which agree to within $\pm 10\%$ when tested by the same method under the same conditions. To minimize variation, the quality of compounding ingredients should be in accordance with BS 4398, whenever this is appropriate.

4 Standard rubbers

The standard rubber compound to be used in a test shall be one of those listed in Table 1. The mixing and vulcanization procedures for S1 and S2, shall be in accordance with Appendix B and for S3 and S4 shall be in accordance with either Appendix B or BS 1674.

Table 1 — Standard rubber compounds

Standard rubber	S1	S2	S3	S4
Ingredients and their designations	Parts by mass	Parts by mass	Parts by mass	Parts by mass
Natural rubber (NR), SMR 5	100	100	—	100
Styrene-butadiene rubber (SBR) 1 500 (see note 1)	—	—	100	—
Stearic acid	—	2	1	2
Zinc oxide	50 (see note 2)	5	3	5
Oil furnace black (HAF), N330 (see note 3)	36	50	—	60
ISAF black, N220 (see note 4)	—	—	50	—
Whiting (see note 5)	—	—	—	60
Di-2-ethylhexylphthalate	—	—	—	3
CBS (see note 6)	—	0.5	1.0	0.6
Dibenzthiazyl disulphide	1.2	—	—	—
sulphur	2.5	2.5	2.0	2.5
Antioxidant (see note 7)	1.0	1.0	1.0	1.0
Vulcanization conditions				
Cure time, min	30	40	60	40
Cure temperature, °C	150	140	150	140
NOTE 1 In accordance with International Institute of Synthetic Rubber Producers (IISRP) No. 1500.				
NOTE 2 99.5 % ZnO of 9 m ² /g surface area (see BS 4398). The standard rubber quality is assessed by the tests described in Appendix B.				
NOTE 3 Designated in accordance with ASTM D1765 "Standard classification system for carbon blacks used in rubber products". For reference purposes, the current industry reference black should be used, but this may give slightly different results.				
NOTE 4 Designated in accordance with ASTM D1765.				
NOTE 5 Ground limestone, 79 % < 25 µm, 99.8 % < 75 µm.				
NOTE 6 N-cyclohexylbenzothiazole-2-sulphenamide.				
NOTE 7 N-isopropyl-N'-phenyl-p-phenylenediamine (IPPD).				