BRITISH STANDARD

METHODS OF TESTING VULCANIZED RUBBER

PART A 11. DETERMINATION OF RESISTANCE TO CRACK GROWTH

B.S. 903 : Part A 11 : 1956

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BRITISH STANDARDS INSTITUTION

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BRITISH STANDARDS HOUSE, 2 PARK ST., LONDON, W.1

TELEGRAMS: STANDARDS, AUDLEY, LONDON TELEPHONE: MAYFAIR 9000

THIS BRITISH STANDARD, having been approved by the Rubber Industry Standards Committee and endorsed by the Chairman of the Chemical Divisional Council, was published under the authority of the General Council on 1st May, 1956.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 2500, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 12s. 6d.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following B.S.I. references relate to the work on this standard:—
Committee reference RUC/10/14 Draft for comment CV(RUC) 6363

CO-OPERATING ORGANIZATIONS

The Rubber Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and industrial organizations:—

Board of Trade
*British Rubber Producers' Research Association
*Federation of British Rubber and Allied Manufacturers' Associations
*Institution of the Rubber Industry
*Ministry of Supply
Natural Rubber Development Board
*Research Association of British Rubber Manufacturers
*Rubber Growers' Association

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:—

Admiralty
Air Ministry
Association of British Chemical Manufacturers
British Chemical Plant Manufacturers' Association
British Electrical and Allied Industries Research Association
British Railways, The British Transport Commission
British Rubber Adhesive Manufacturers' Association
Department of the Government Chemist
General Post Office
Institute of Brewing
Institution of Chemical Engineers
Institution of Gas Engineers
Institution of Mechanical Engineers
Institution of Mechanical Engineers (Automobile Division)
Institution of Municipal Engineers
Institution of Water Engineers
London Advisory Committee for Rubber Research (Ceylon and Malaya)
Ministry of Housing and Local Government
Ministry of Works
National College of Rubber Technology
National Physical Laboratory
Royal Institute of Chemistry
Rubber Trade Association of London
Society of Motor Manufacturers and Traders Ltd.

BRITISH STANDARD

METHODS OF TESTING VULCANIZED RUBBER

Part A 11. Determination of Resistance to Crack Growth *

FOREWORD

This British Standard has been published under the authority of the Rubber Industry Standards Committee. In deciding to issue a revision of the 1950 edition, it has also been considered desirable to publish B.S. 903 in separate parts.

The group of parts in which the prefix letter 'A' is used covers methods of testing the physical properties of rubber. Further parts in this group have been issued as follows:—

Part A 1. Determination of density and specific gravity.
Part A 2. Determination of tensile stress-strain.
Part A 3. Determination of tear strength.
Part A 10. Determination of flex cracking.
Part A 16. Determination of swelling.
Part A 18. Determination of equilibrium water vapour absorption.
Part A 19. Accelerated ageing tests.

SECTION 1 SUMMARY AND EXPLANATORY NOTE

Repeated bending or flexing of a rubber vulcanizate causes cracks to develop in that part of the surface where tension stress is set up during flexing, or, if this part of the surface contains a crack, causes this crack to extend in a direction perpendicular to the stress. Certain soft vulcanizates, notably vulcanizates of some butadiene styrene copolymers, show marked resistance to crack-initiation, but it is possible for these compounds to have a low resistance to crack growth.

It is important therefore to measure both the resistance to crack-initiation (see B.S. 903 : Part A 10 †) and the resistance to crack growth.

The test described below is intended for use in comparing the resistance of rubbers to the growth of cracks when subjected to repeated flexing on the De Mattia machine (see Fig. 1).

* This method is substantially that being considered by the technical committee of the International Organization for Standardization (ISO) dealing with rubber.
† B.S. 903 : Part A 10, 'Determination of resistance to flex cracking'.

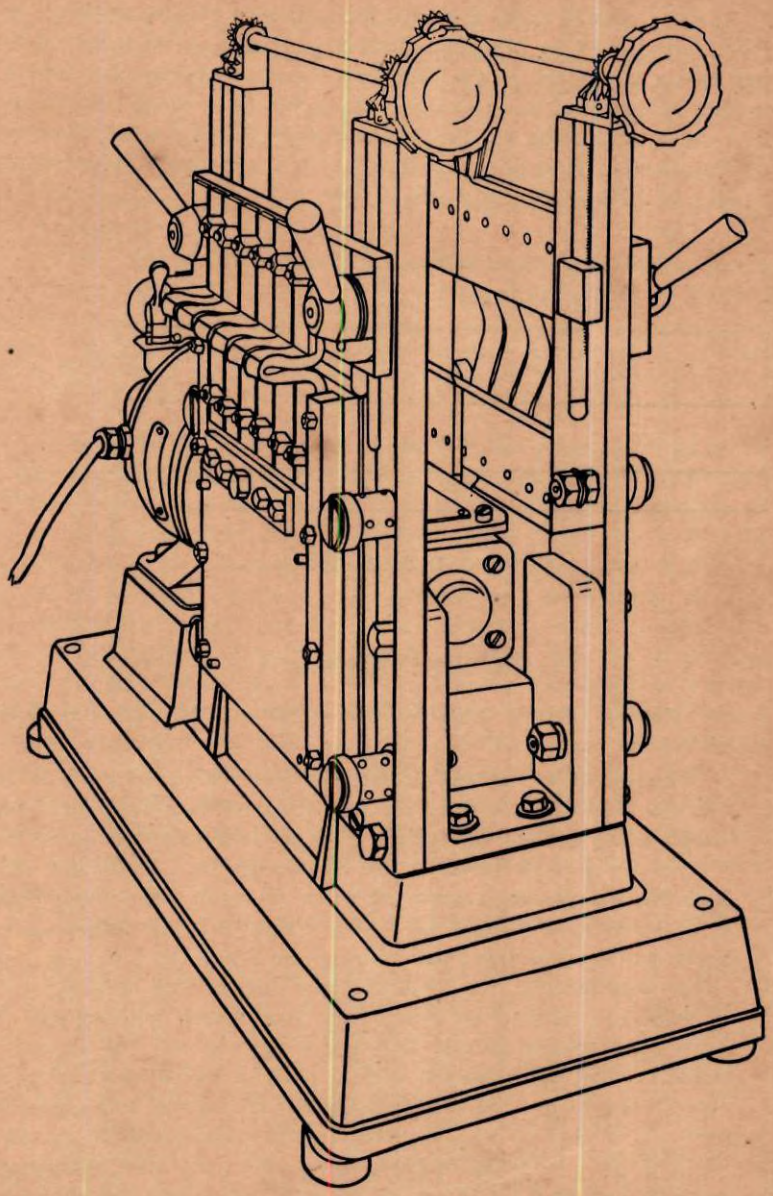

Fig. 1. De Mattia machine

SECTION 2 TEST PIECE

The test piece shall be a strip with a moulded groove, as shown in Fig. 2; strips may be moulded individually, or may be cut from a wide slab having a moulded groove. The groove in the test piece shall have a smooth surface, and be free from irregularities from which cracks may start prematurely. The groove shall be moulded into the test piece or slab by a semi-cylindrical ridge in the centre of the cavity, the ridge having a radius of 2·38 ± 0·03 mm (0·094 ± 0·001 in.).

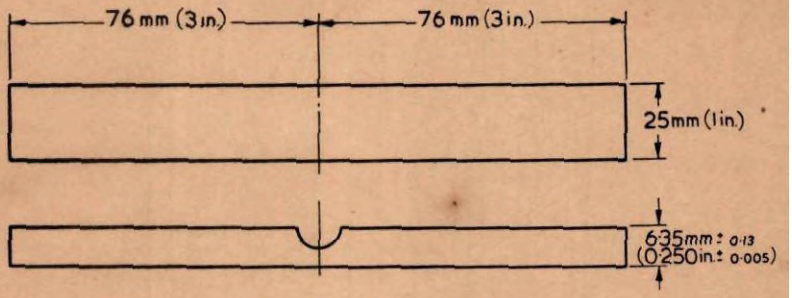

Fig. 2. De Mattia test piece

SECTION 3 APPARATUS

The essential features of the De Mattia machine (see Fig. 1) shall be as follows:—

There shall be stationary parts, provided with grips for holding one end of each of the test pieces in a fixed position, and similar but reciprocating parts for holding the other end of each of the test pieces.

The travel shall be 57·15 ± 0·10 mm (2·250 ± 0·005 in.) and such that the maximum distance between each pair of opposing grips is 76·0 + 0·2 − 0·0 mm (2·99 + 0·01 − 0·00 in.). The reciprocating parts shall be so arranged that their motion is in the direction of, and in the same plane as, the common centre lines of each opposing pair of grips. The planes of the gripping surfaces of each opposing pair of grips shall remain parallel throughout the motion. The eccentric which actuates the reciprocating parts shall be driven by a constant-speed motor to give 300 ± 10 flexing cycles per minute, with sufficient power to flex at least six and preferably twelve test pieces at one test. The grips shall hold the test pieces firmly, and shall enable individual adjustment to be made to the test pieces to ensure accurate insertion.

NOTE. It is useful to arrange the test pieces in two equal groups, so that one group is being flexed while the other group is being straightened, thus reducing the vibration in the machine.

SECTION 4 PROCEDURE

4.1 Conditioning of samples and test pieces. The properties of vulcanized rubber change continuously with time, these changes being particularly rapid during the first 24 hours after vulcanization. Tests should therefore be carried out not less than 24 hours after vulcanization, and for accurate comparisons between different rubbers it may be necessary to ensure that these are tested at substantially the same interval after vulcanization.

Samples and test pieces shall be protected from light as completely as possible.

The test pieces shall be kept at a temperature of 20 ± 2°C for a period of not less than 12 hours immediately prior to being measured and tested.

NOTE. A single temperature for conditioning is not yet practicable for all countries since 20 ± 2°C is difficult to maintain in certain cases. In climates where it is not possible to maintain this temperature, a temperature of 27 ± 2°C is permitted provided the temperature of conditioning is stated in the test report.

4.2 Preparation of the test piece. Each test piece shall be prepared by piercing the bottom of the groove at a point equidistant from the sides. The tool shall be maintained perpendicular to both the transverse and longitudinal axes. The cut shall be parallel to the longitudinal axis of the groove and accomplished by a single insertion and withdrawal of the tool. Lubrication with water containing a suitable wetting agent may be used.

Although it is not necessary to include exact details of a suitable jig for holding the cutting tool it may be useful to state the basic principles governing the design of such a jig. The test piece shall be held flat in a solid support; the cutting tool shall be normal to the support and placed centrally with respect to the groove of the test piece, with the edge of the chisel parallel to the axis of the groove. Means shall be provided for passing the cutting tool through the entire thickness of the rubber, and the support shall have a hole of a size just sufficient to permit the cutting tool to project through the base of the test piece to a minimum distance of 3 mm.

The piercing tool shall conform to the dimensions given in Fig. 3.

4.3 Method for determining resistance to crack growth. The pairs of grips shall be separated to their maximum extent, and the test pieces inserted so that they are flat and not under tension, with the groove in any particular test piece midway between the two grips in which that test piece is held, and on the outside of the angle made by the test piece when it is bent. The machine shall be started and the time recorded.

The machine shall be stopped at frequent intervals to measure the length of the crack, e.g. at the 1, 3 and 5 kilocycle periods and at such further or intermediate periods as appears necessary. At each observation the grips shall be separated to a distance of 65 mm and the length of crack shall be measured, preferably by using a low powered microscope.

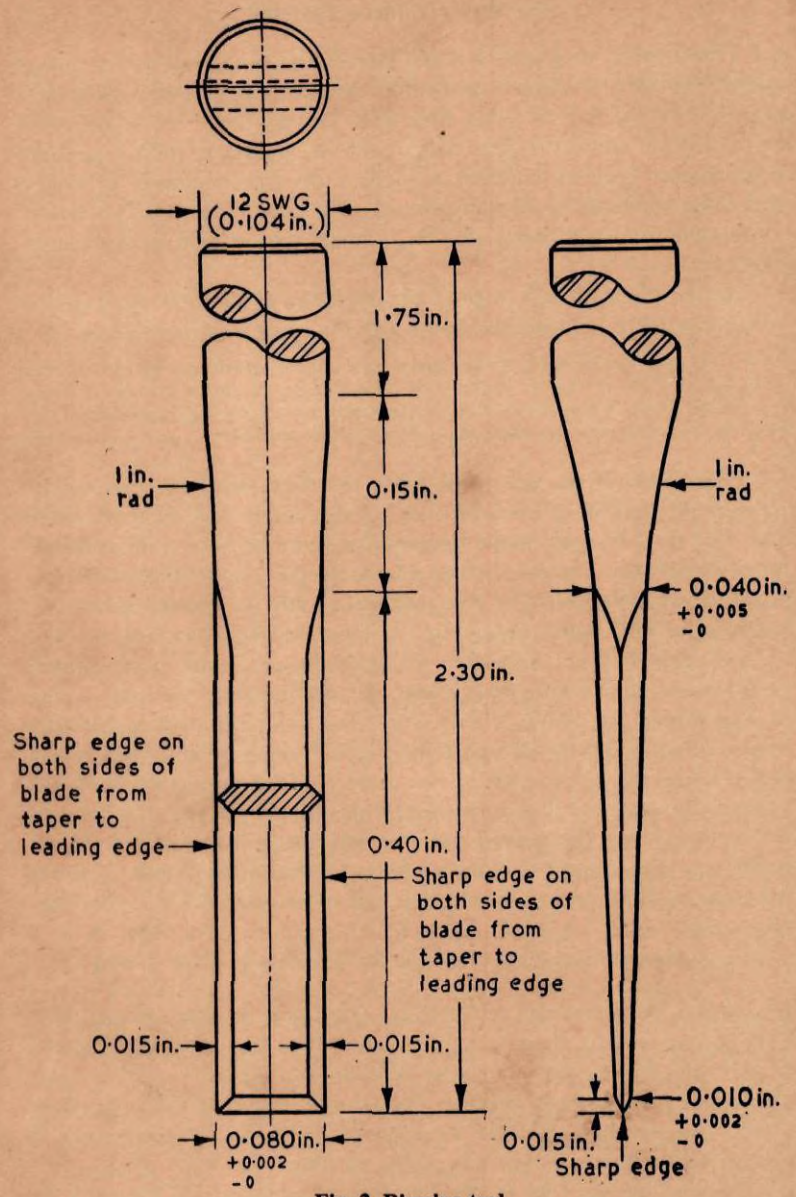

Fig. 3. Piercing tool

in.	0·002	0·005	0·010	0·015	0·040	0·080	0·104	1·00	1·75	2·30
mm	0·05	0·13	0·25	0·38	1·02	2·03	2·64	25·4	44·4	58·4

At least three, and preferably six, test pieces from each rubber shall be tested, and the results averaged. One or more test pieces shall be tested simultaneously with those of other rubbers with which comparison is to be made.

4.4 Expression of results. A smooth curve shall be drawn by plotting length of crack against number of flexing cycles, and readings shall be taken from it of :

1. The number of kilocycles for the crack to extend from 2 to 4 mm.
2. The number of kilocycles for the crack to extend from 4 to 8 mm.
3. If desired the number of kilocycles for the crack to extend from 8 to 12 mm.

SECTION 5 TEMPERATURE OF TEST

A close tolerance on temperature is not required and tests are normally performed at room temperature, although elevated temperatures may often be used with advantage.

SECTION 6 REPORT

The report shall state:

1. The number of kilocycles for the crack to extend from 2 to 4 mm.
2. The number of kilocycles for the crack to extend from 4 to 8 mm.
3. If desired the number of kilocycles for the crack to extend from 8 to 12 mm.
4. The number of test pieces used.
5. The temperature of test.

BRITISH STANDARDS INSTITUTION

The British Standards Institution was founded in 1901 and incorporated by Royal Charter in 1929.

The principal objects of the Institution as set out in the charter are to co-ordinate the efforts of producers and users for the improvement, standardization and simplification of engineering and industrial materials; to simplify production and distribution; to eliminate the waste of time and material involved in the production of an unnecessary variety of patterns and sizes of articles for one and the same purpose; to set up standards of quality and dimensions, and to promote the general adoption of British Standards.

In carrying out its work the Institution endeavours to ensure adequate representation of all viewpoints. Before embarking on any project it must be satisfied that there is a strong body of opinion in favour of proceeding and that there is a recognized need to be met.

The Institution is a non-profit-making concern. It is financed by subscriptions from firms, trade associations, professional institutions and other bodies interested in its work, by a Government grant and by the sale of its publications. The demands on the services of the Institution are steadily increasing and can only be met if continuing and increased financial support is provided.

Membership of the Institution is open to British subjects, companies, technical and trade associations, and local and public authorities.

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