METHODS OF TESTING VULCANIZED RUBBER

PART A14. DETERMINATION OF MODULUS IN SHEAR OF RUBBER (BONDED QUADRUPLE SHEAR TEST PIECE)

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THIS BRITISH STANDARD, having been approved by the Rubber Industry Standards Committee, was published under the authority of the Executive Board on 30th January, 1970.

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This standard makes reference to the following British Standard:

BS 1610. Methods for the load verification of testing machines.

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The following BSI references relate to the work on this standard:
Committee references RUC/10 and RUC/10/4
Draft for comment 68/5218

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

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*British Rubber Manufacturers' Association Ltd.
*Institution of the Rubber Industry
*Ministry of Technology
Natural Rubber Bureau
*Natural Rubber Producers' Research Association
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Rubber Growers' Association
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BRITISH STANDARD

METHODS OF TESTING VULCANIZED RUBBER

Part A14. Determination of modulus in shear of rubber (bonded quadruple shear test piece)

FOREWORD

This British Standard has been prepared under the authority of the Rubber Standards Industry Committee.

It is based on a document* which is now being considered by Technical Committee 45—Rubber, of the International Organization for Standardization (ISO).

METHOD

1. SCOPE

This British Standard describes the procedure for determining the modulus in shear of rubber bonded between four parallel plates.

The method is designed primarily to apply to test pieces prepared in the laboratory under standard conditions to provide data for the development and control of rubber mixes.

2. PRINCIPLE OF TEST

The test consists in measuring the forces required to obtain a range of predetermined shear distortions of a unit of standard dimensions comprising four parallelepipeds of rubber symmetrically disposed and bonded to four rigid parallel plates, the forces being parallel to the bonding surfaces and, as a rule, non-destructive, i.e. of maximum values appreciably lower than the bond strength.

3. APPARATUS

3.1 Testing machine. A tensile testing machine conforming to the requirements of BS 1610†, Grade B, shall be used; it shall be capable of accurately measuring the deformations and registering the applied forces during the test while maintaining the specified constant rate of separation of the jaws of 25 $\pm$ 5 mm per minute.

* At present Draft ISO Recommendation No. 1827.

† BS 1610, ' Methods for the load verification of testing machines '.

NOTE. Inertia (pendulum) type dynamometers are apt to give results which differ because of frictional or inertial effects. An inertialess (for example electronic or optical transducer) type dynamometer gives results which are free from these effects and is therefore to be preferred.

3.2 Fixtures. The fixtures for holding the test pieces in the grips shall be provided with a universal joint to permit accurate centring of the line of action of the applied force.

4. STANDARD TEST PIECE

4.1 Dimensions of test pieces. The standard test piece shall consist of four identical parallelepipedic rubber elements $4 \pm 0{\cdot}1$ mm thick, $20 \pm^{0}_{0{\cdot}1}$ mm wide and $25 \pm 0{\cdot}1$ mm long, bonded on each of their two largest opposite faces to the mating faces of four rigid plates of the same width and of appropriate lengths to obtain a symmetrical double sandwich arrangement, means being provided at the free external end of each central plate to secure its further assembly to the corresponding holding fixture. The thickness of the rigid plates shall be $5 \pm^{0}_{0{\cdot}2}$ mm. A typical test piece is shown in Fig. 1.

4.2 Preparation of test piece. The standard test piece shall be prepared as follows.

4.2.1 Rectangular rigid plates of the standard dimensions shall be prepared.

4.2.2 The plates shall be prepared and treated in accordance with a normal adhesion system.

4.2.3 Unvulcanized rubber blanks shall be cut using a die of such size that a limited amount of flash is obtained on moulding.

4.2.4 The rigid plates and rubber blanks shall then be disposed for vulcanization in the mould. Moulding may be performed in two different ways:

(1) Compression moulding, where individual rubber blanks treated in accordance with the adhesion system used are preassembled in the mould between the plates.

(2) Transfer moulding, where a single rubber blank is transferred into a plurality of cavities through appropriate nozzles.

A suitable type of transfer mould accommodating six test parts (24 cavities) is shown in Fig. 2.

4.2.5 During the preparation of the test pieces great care shall be taken to keep the exposed surfaces of the rubber and plates free from dust, moisture and foreign matter. The treated surfaces shall not be touched by hand during assembly.

4.2.6 The vulcanization shall be carried out by heating the mould under pressure for a definite time at a controlled temperature.

4.2.7 At the conclusion of the vulcanization, great care shall be taken in removing the test pieces from the mould to avoid undue distortion.

4.3 Number of test pieces. Three test pieces shall be tested.

4.4 Conditioning of test pieces. Unless otherwise specified for technical reasons the following procedures shall be used: for all test purposes the minimum time between vulcanization and testing shall be 16 hours.

For non-products tests the maximum time between vulcanization and testing should be 4 weeks.

For evaluations intended to be comparable, the tests should, as far as possible, be carried out after the same time interval.

Prepared test pieces shall be conditioned immediately before testing for a minimum of 16 hours at a temperature of 20 ± 2°C (this may be the same 16 hours as that between vulcanization and testing).

If a lower or higher temperature is used the temperature should be selected from the following preferred temperatures: −75, −55, −40, −25, −10, 0, +40, +50, +70, +85, +100, +125, +150, +175, +200, +250°C and the test pieces should be conditioned at the selected temperature for a period of time sufficient to reach temperature equilibrium with the testing environment immediately before testing.

5. PROCEDURE

The test piece shall be mounted in the testing machine, care being taken to ensure freedom of longitudinal self-alignment with the direction of force application. Prior to actual deformation measurement, at least five steady non-destructive traction loading and release cycles corresponding to the whole range of shear distortions under investigation shall be successively performed in order to reach a stabilized stress-strain behaviour of the rubber with regard to the so-called ' Mullins effect '. Then the force and deformation measuring apparatus shall be set to zero while a slight initial traction force, i.e. 70 N, is maintained. Increasing steady traction forces shall be immediately applied at the rate of separation of the jaws of 25 ± 5 mm per minute until the maximum shear distortion under investigation is reached.

The forces corresponding to the predetermined fixed values of deformation or alternatively the deformations at predetermined fixed forces shall be recorded.

6. EXPRESSION OF RESULTS

(1) The shear stress, expressed in bars*, is calculated by dividing the applied force by the total bonded area of one of the double sandwiches on the corresponding central rigid plate, i.e. $2 \times 20 \times 25$ mm².

* 1 bar = 10^5 N/m².

(2) The shear strain is equal to half the actual deformation, in millimetres, divided by the thickness of one rubber element (4 mm) i.e., sheer strain

$$= \frac{\text{actual deformation}}{2 \times 4}$$

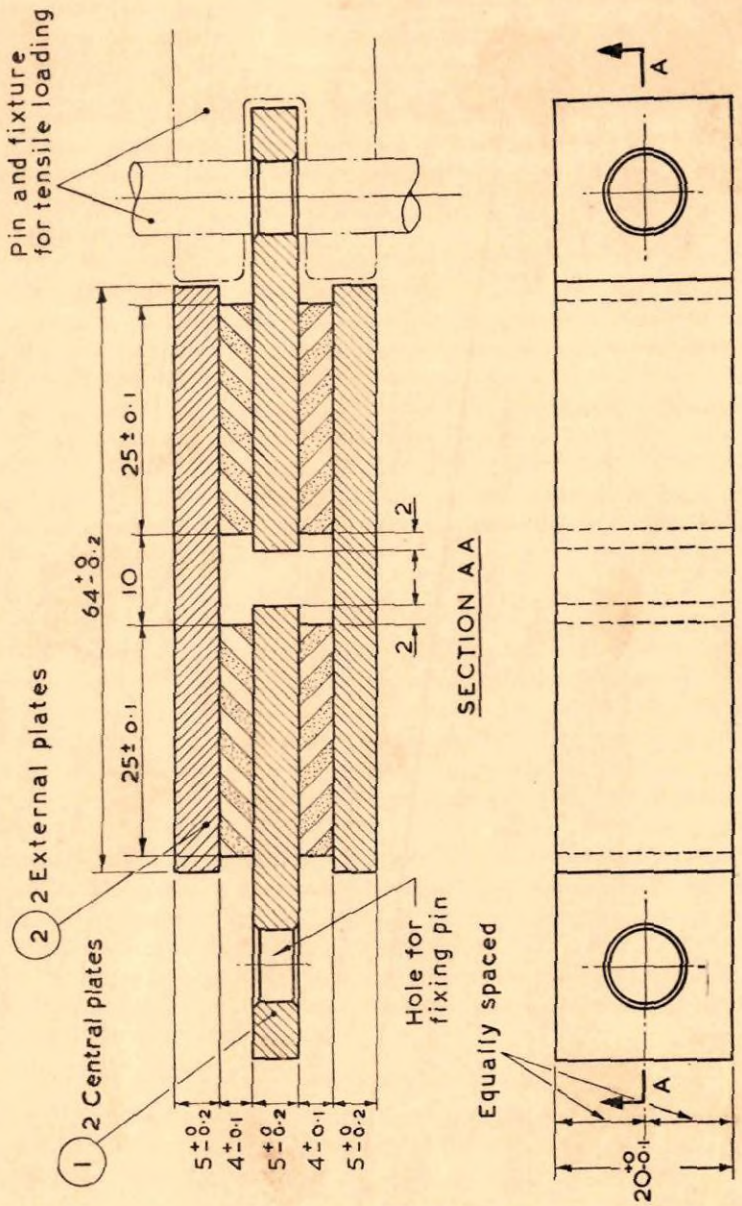
(3) The mean shear modulus, expressed in bars*, is, at any value of the shear strain, equal to the corresponding shear stress divided by the shear strain.

7. TEST REPORT

The test report shall state:

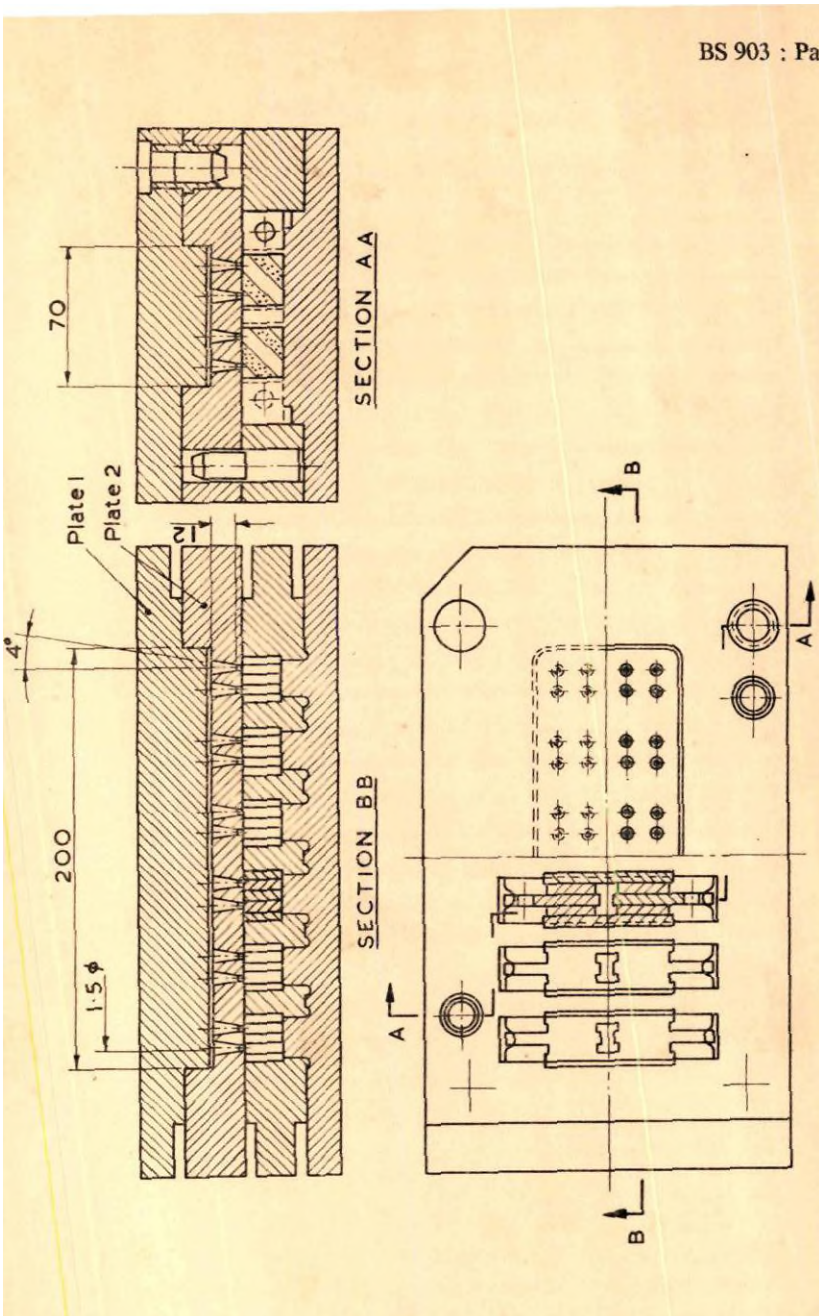
(1) The results, calculated in accordance with Clause 6, for the shear modulus value at various shear strains. All three sets of test results shall be stated.
(2) Identification of the rubber mix.
(3) Moulding process.
(4) Date of vulcanization.
(5) Date of test.
(6) Time and temperature of vulcanization.
(7) Temperature of test, if other than 20 $\pm$ 2 °C.
(8) Failure of test part, if any.

* 1 bar = 10^5 N/m^2.



All dimensions are in millimetres

Fig. 1. Typical test piece



All dimensions are in millimetres

Fig. 2. Suitable transfer mould

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