# METHODS OF TESTING VULCANIZED RUBBER

## PART A27. THE DETERMINATION OF RUBBER-TO-FABRIC ADHESION (DIRECT TENSION)

**BS 903 : Part A27 : 1969**

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BRITISH STANDARDS INSTITUTION

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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 5000, fully indexed and with a note of the contents of each, will be found in the British Standards Yearbook, price 15s. The BS Yearbook may be consulted in many public libraries and similar institutions.

This standard makes reference to the following British Standards:

BS 903. Methods of testing vulcanized rubber.
Part A12. Method for the determination of rubber-to-fabric adhesion (ply separation).

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

*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 BSI references relate to the work on this standard:
Committee references RUC/10, RUC/10/4
Draft for comment 47/5684

## CO-OPERATING ORGANIZATIONS

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:

British Rubber Manufacturers, Association
*Institution of the Rubber Industry
*Ministry of Technology
Natural Rubber Bureau
*Natural Rubber Producers' Research Association
Rubber Growers' Association
*Rubber and Plastics Research Association of Great Britain
*Society of Motor Manufacturers and Traders
Tyre Manufacturers Conference Ltd.

The Government department 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:

British Railways Board
British Rubber and Resin Adhesive Manufacturers' Association
British Society of Rheology
Chemical Industries Association
Electrical Research Association
Institution of Mechanical Engineers
Institution of Mechanical Engineers (Automobile Division)
Institution of Municipal Engineers
Institution of Water Engineers
Ministry of Defence, Air Force Department
Ministry of Defence, Army Department
Ministry of Defence, Navy Department
Ministry of Housing and Local Government
National College of Rubber Technology
National Physical Laboratory (Ministry of Technology)
Post Office
Royal Institute of Chemistry

BRITISH STANDARD

# METHODS OF TESTING VULCANIZED RUBBER

## Part A27. The determination of rubber-to-fabric adhesion (direct tension)

### FOREWORD

This British Standard has been published under the authority of the Rubber Industries Standards Committee. In deciding to issue a revision of the 1950 edition, it has also been considered desirable to publish BS 903 in separate parts. The group of parts in which the prefixed letter 'A' is used covers methods of testing the physical properties of rubber.

The present part is a new method not included in the 1950 edition.

### METHOD OF TEST

#### 1. SUMMARY AND EXPLANATORY NOTE

The method of test described below covers the preparation of test pieces and the procedure for measuring the force required to separate, by direct tension, a rubber layer from a fabric ply. This is achieved by cementing metal cylinders to the rubber faces with an adhesive giving a bond stronger than that between the rubber and the fabric. It is applicable when the surfaces are approximately plane and when the fabric ply is covered on both sides with a rubber layer. This method is not suitable for surfaces which contain sharp bends, angles or other gross irregularities that cannot be avoided, or for rubber-fabric composites where one side of the fabric is exposed.

The method may be used for multi-ply constructions but it is not usually possible to decide beforehand at which interface, or within which layer, failure will occur. It is therefore recommended that wherever possible in such cases the composite material is carefully separated by hand (using a suitable solvent if necessary to initiate peeling) to yield a sample of the construction described above containing the appropriate fabric layer. It should be noted that even with a single fabric layer, test piece failure may occur at either of the rubber-fabric interfaces depending on the relative adhesion levels. When attempting to evaluate rubber-fabric adhesion *per se* (as distinct from tests on finished products) by this method, it is important to use completely balanced textile and textile-rubber constructions. When testing finished products (e.g. double-sided proofing) the test will enable the strength of the weakest bond to be measured; other bonds must have a higher value than this but cannot be evaluated directly.

Although the method of test is less sensitive to the effects of rubber thickness and modulus than the stripping test*, care should be exercised in the inter-comparison of results obtained on materials of widely differing rubber layer thickness or modulus. It should also be noted that the results obtained by this test method will not necessarily correlate with the results from a peeling or stripping test.

## 2. TEST PIECE

The test piece shall be a $25{\cdot}2 \pm 0{\cdot}5$ mm diameter disc punched from the material under test and having its faces bonded by a suitable cold-setting adhesive† to the ends of two cylindrical metal test rods. The thickness of the test piece shall be the thickness of the material under test except that for materials containing only a single fabric ply, irrespective of whether or not these have been prepared from a multi-ply construction by hand peeling, no test piece shall have an overall thickness greater than 10 mm and the thickness of neither rubber layer shall exceed 5 mm. Where necessary the test piece shall be brought to the requisite thickness by buffing or other suitable means before proceeding with the test.

## 3. APPARATUS

**3.1 Test machine.** A power-driven tensile test machine equipped with a suitable dynamometer‡ and recording device to give the maximum force in newtons and conforming to the accuracy requirements of BS 1610§, grade B, shall be used. The moving grip of the machine shall travel at a rate of $25 \pm 5$ mm per minute. The capacity of the machine shall be such that the rate of separation of the grips shall be substantially constant during the application of the force.

**3.2 Holder and grip.** The fixtures for holding the test pieces in the grip will vary depending on the machine which is used but shall in all cases be fitted with self-aligning joints to permit accurate centring of the applied force during test.

**3.3 Calibration of test equipment.** The force scale shall be calibrated by a suitable method at least every six months to ensure that the error does not exceed 2% of the applied force or 0·4% of the maximum of the scale, whichever is the greater.

Methods for calibrating the scale of tensile testing machines are given in BS 1610, Part 1§, but a simpler and quicker method is to use steel calibrating springs.

* BS 903, 'Methods of testing vulcanized rubber', Part A12, 'Method for the determination of rubber-to-fabric adhesion (ply separation)'.

† For example a cyano-acrylate adhesive such as Eastman 910 may be used.

‡ Machines using inertia (pendulum) type dynamometers are apt to give results which differ because of frictional and inertial effects. An inertialess (e.g. electronic or optical transducer) type dynamometer gives results which are free from these effects and is therefore to be preferred. When the use of a dynamometer of considerable inertia cannot be avoided the capacity of the machine or the measuring scale selected should be such that the separation force reading lies between 15% and 85% of the rated capacity.

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

**3.4 Cutting tool.** The cutting tool shall be carefully maintained so that the edge is sharp enough to cut the sample cleanly and avoid leaving ragged edges.

## 4. PREPARATION OF TEST PIECES

**4.1 Number of test pieces.** Six test pieces shall normally be used, although the number may be reduced if the known reproducibility with any particular material justifies it. In no case, however, shall less than three test pieces be used.

**4.2 Preparation.** After any necessary preparation as described in Clause 2, circular discs 25·2 ± 0·5 mm in diameter shall be punched from the rubber-fabric composite. The outer rubber layers shall be cleaned by lightly wiping with a suitable solvent*, and roughened by hand using fine glass paper. The test pieces shall then be cemented immediately between the faces of two metal cylinders† whose diameters shall be within + 0 — 0·5 mm of that of the test pieces (see Fig. 1). The cylinder surfaces shall also be lightly wiped with solvent before cementing. During this operation care shall be taken to ensure coaxial alignment of the cylinders and the rubber test piece. A suitable jig for this purpose, for use in conjunction with an appropriate size G clamp, is shown in Fig. 2. The length of time the test piece remains in the clamp and the subsequent rest period between preparation and testing will depend on the adhesive used. The manufacturer's recommendations should in all cases be carefully followed.

After the cement has set the completed test pieces shall be conditioned as set out in 4.3.

**4.3 Conditioning of samples and test pieces.** The properties of vulcanized rubber change continually with time, these changes being particularly rapid immediately after vulcanization. No test should, therefore, be carried out within 16 hours of vulcanization and, for accurate comparisons between different rubbers and/or adhesion systems, it may be necessary to ensure that these are tested at substantially the same interval after vulcanization of the composite.

Samples and test pieces shall be protected from light as completely as possible during the interval between vulcanization and testing.

The test pieces shall be conditioned at 20 ± 2 °C for at least three hours immediately before test. If the test pieces are to be tested at a temperature other than 20 °C, they shall be conditioned at that temperature for not less than one hour immediately before test.

* For example acetone or butanone for natural or styrene-butadiene rubber, petroleum naphtha for oil resistant rubbers, etc. The amount of solvent used should be kept to a minimum to avoid impairing the adhesive bonds, and for the same reason the solvent should be allowed to evaporate before the next stage of test piece preparation.

† Polished copper, polished aluminium or etched brass have been found suitable.

## 5. PROCEDURE

The test piece shall be mounted in the test machine. Extreme care is necessary in centring and adjusting the test piece so that the tension is uniformally distributed over the cross section during the test. The machine shall be started and run at the specified rate of grip separation until separation of the plies takes place. The maximum force shall be recorded.

The separated test pieces shall be examined and the type of failure and its location within the construction (e.g. cohesive failure of the outer rubber layer, adhesive failure between rubber layer and cover cement, adhesive failure at primer/fabric interface etc.) recorded.

## 6. TEMPERATURE OF TEST

The test shall normally be carried out at 20 ± 2 °C. Since rubber and adhesives can have markedly lower adhesion properties at elevated temperatures, tests may have to be carried out at higher temperatures; such temperatures should preferably be selected from the following series: 70 °C, 100 °C, 125 °C, 150 °C, 175 °C, 200 °C.

## 7. EXPRESSION OF RESULTS

The test results shall be expressed in bars* by dividing the maximum force during rupture by the cross-sectional area of the test piece. In the case of complete or partial cohesive failure it should be recognized that the adhesion value is higher than is reported. All results shall be reported. Results from test pieces which show complete or partial failure at either interface of the cold setting cement used in the preparation of the test piece shall be discarded and an equal number of fresh test pieces prepared and tested.

## 8. REPORT

The report shall include:

(1) The results calculated in accordance with Clause 7. All results shall be reported, or alternatively the mean, population standard deviation, and number of test pieces may be quoted.

(2) A description of the type of failure in accordance with Clause 5 for each test piece, with the percentage of each type present.

(3) For referee purposes, where appropriate, the time between vulcanization and testing.

(4) The temperature of test if other than 20 °C.

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

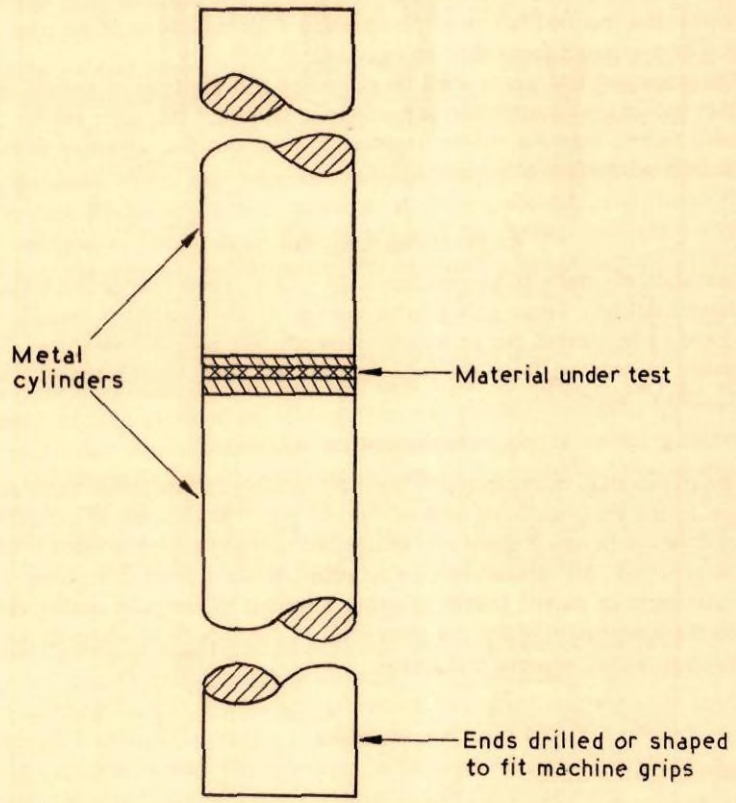


**Fig. 1. Construction of test piece**

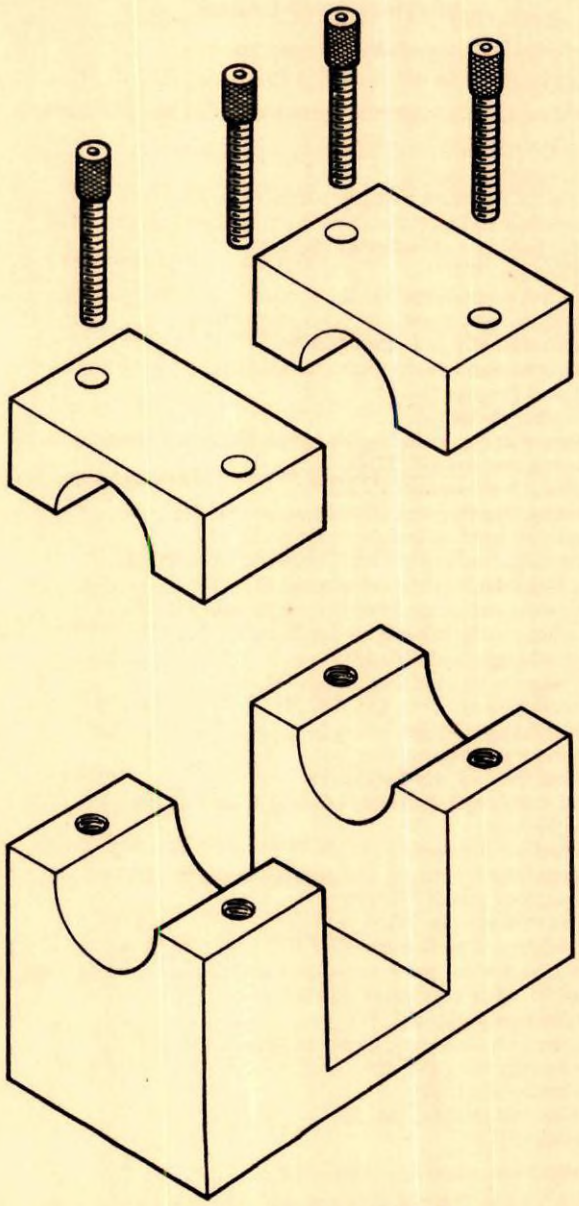

Fig. 2. Jig for test piece construction

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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.

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