BRITISH STANDARD

BS 2050:1978

Specification for

Electrical resistance of conducting and antistatic products made from flexible polymeric material

UDC 678 076:678.01:537.311:621.315.5

Cooperating organizations

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

British Plastics Federation*
British Rubber Manufacturers' Association*
Chemical Industries Association
Department of Industry (Chemicals and Textiles)
Department of Industry (National Physical Laboratory)
Department of the Environment (Building Research Establishment)
Electrical and Electronic and Insulation Association (BEAMA)
Electrical Installation Equipment Manufacturers' Association (BEAMA)
Electrical Research Association*
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Society of Chemical Industry
Society of Motor Manufacturers and Traders Limited
The Malaysian Rubber Producers' Research Association

The 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:

Association of Supervisory and Executive Engineers
British Surgical Trades Association Incorporated
Department of Health and Social Security
National Coal Board
Tyre Manufacturers' Conference (Service Committee)

This British Standard, having been prepared under the direction of the Plastics Standards Committee and the Rubber Standards Committee, was published under the authority of the Executive Board on
28 February 1978

First published December 1953
First revision February 1958
Second revision February 1961
Third revision February 1978

The following BSI references relate to the work on this standard:
Committee reference PLM/RUM/9
Draft for comment 75/52245 DC

ISBN 0 580 10014 6

Amendments issued since publication

Amd. No.	Date of issue	Comments
4280	July 1983	
4499	May 1984	Indicated by a sideline in the margin

Contents

Foreword

This standard has been prepared under the direction of the Plastics Standards Committee and the Rubber Standards Committee. It was originally published in 1953 and was revised in 1958 and 1961. The early editions covered conducting and antistatic rubber products deriving their electrical conductivity from carbon black. The 1961 edition and the present document have been extended to cover all types of flexible polymers and to permit the electrical conductivity to be derived from substances other than carbon black.

This standard is based on the following three draft International Standards (ISO/DIS) amended in accordance with the United Kingdom comments submitted on these draft standards.

ISO/DIS 2878, *Antistatic and conductive rubber products — Determination of electrical resistance.*

ISO/DIS 2882, *Antistatic and conductive products for hospital use — Electrical resistance.*

ISO/DIS 2883, *Antistatic and conductive products for industrial use — Electrical resistance.*

In this revision the electrical requirements for hospital products have been segregated from those for industrial products. The list of industrial products has been augmented by the addition of synchronous belts, textile cots and aprons and by the expansion of the requirements for tyres, solid and pneumatic, for various applications. In addition the distinction made in the definitions in the earlier editions between conductive and antistatic products has been found to be misleading and has therefore been omitted from this revision.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, 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

The elimination or reduction of static charges is important in many applications. While the antistatic properties of an article are influenced by the electrostatic charging characteristics, the only way to ensure that charges are never developed on an object is generally to provide suitable leakage paths. This British Standard deals exclusively with products which may form part of such leakage paths.

Polymeric compounds can be made into conductors of electricity by the incorporation in the compound of conducting particles, especially carbon black, or ionizable materials, or a combination of the two. The addition of carbon black to a polymer in sufficient quantities causes a conducting network of carbon particles to be formed within the mixture, and materials with a wide range of electrical conductivity can be produced. The carbon structure is sensitive to strain and the electrical resistance of the material depends on the degree of strain to which it has been subjected and the time and temperature history after strain.

Materials made conducting by the addition of ionizable materials are generally of a higher order of magnitude of resistivity than those containing carbon but do not change appreciably in resistivity with strain. Their resistivity decreases with increase in temperature.

During service the resistance of products made from both types of material may change significantly and it is therefore necessary to ensure that the product is capable of fulfilling its designed function of dissipating electrostatic charges and conducting electricity during the whole of its life. In general the resistance of new products should not exceed 10^7 Ω but in certain cases, or with certain materials, higher values may be permitted. Values lower than 5×10^4 may not give adequate protection against fire from ignition of the rubber and against dangerous electric shock where there is any risk of apparatus becoming defective when operating at a voltage of 250 V to earth.

A method for the measurement of the resistivity of specially prepared test pieces of antistatic and conducting rubber is described in BS 2044.

1 Scope and field of application

1.1 This British Standard specifies limits of electrical resistance for antistatic and conducting articles and products manufactured wholly or in part from natural or synthetic rubbers, from polyvinyl chloride, from other flexible polymeric materials or from mixtures of these. The electrical conductivity is derived from the addition of carbon black and/or other appropriate substances to the bulk of the material.

This British Standard does not apply to:

a) articles, the relevant surfaces of which are composed of mixtures of insulating and conducting areas; or to

b) articles with a substantial surface area of insulating material, except for

1) hoses that have only a conductive lining or a conductive cover, and

2) footwear, which does not normally have a conductive or antistatic upper.

The resistance values given have been found suitable for certain products for hospital and industrial uses and are given as a guide. When British Standard product specifications for individual products have been issued, test methods and resistance values given in the appropriate product specification should be used in preference to those given in this document.

1.2 This British Standard also describes methods of test to determine the electrical resistance of antistatic and conductive articles and products manufactured wholly or in part from a flexible polymeric material.

The tests are carried out on the finished product using a defined system of electrodes by a system suited to factory inspection or service testing. These methods are not appropriate where the measured resistance is greater than 3×10^8 Ω.

NOTE Only if their suitability has been established experimentally, should these methods of test be used for products not covered by this British Standard (e.g. products in which the electrical conductivity is not obtained by the addition of carbon black and/or other appropriate substances to the bulk material or which have a substantial area of insulating material).

2 References

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

3 Methods of test

The product shall be tested by the appropriate method described in Appendix A.

Table 1 — Electrical requirements for hospital products (See **1.1**)

Item	Product	Electrical resistance, Ω		Method of test (reference to clause in Appendix A)
		min.	max.	
1	Anaesthetic airways	—	10^6	**A.4.5**
2	Anaesthetic bellows	—	10^6	**A.4.2**
3	Anaesthetic face pieces	—	10^6	**A.4.2**, **A.4.3**
4	Anaesthetic tubing	3×10^4 per m	10^6 per m	**A.4.4** **A.4.5**
5	Breathing bags		10^6	**A.4.7**, **A.4.8**
6	Flooring material	5×10^4	2×10^6	**A.4.1**
7	Footwear	7.5×10^4	5×10^7	**A.4.15** a) and b)
8	Furniture buffers	—	10^6	**A.4.10**
9	Furniture feet	—	10^6	**A.4.9**
10	Hose	3×10^3 per m	10^6 per m	**A.4.5**[a] **A.4.6**
11	Mattresses and pads	10^4	10^6	**A.4.2**
12	Sheeting and articles made from sheeting (e.g. aprons) for hospital use: both surfaces to be tested	—	10^6	**A.4.1**
13	Tyres for castors and wheels for hospital furniture complying with the requirements of BS 2099	—	10^4	**A.4.3**
14	Non-wire-reinforced hose with permanently attached metal end fittings	3×10^3 per m	10^6 per m	**A.4.14**
15	Mouldings, small	—	10^6	**A.4.2**

NOTE Safety codes for antistatic products for use in anaesthetizing areas for hospitals usually require that the resistance shall not exceed 10^8 Ω at any time during their useful life.

[a] See, however, **A.4.6** if this method is used.

4 Requirements

The electrical resistance of the product, as supplied new, shall comply with the requirements given in Table 1 or Table 2, as appropriate.

5 Marking

Marking shall be indelible and clearly visible but of the smallest practicable area to avoid the introduction of unnecessary insulating material. The position of the marking shall be such that it will not materially affect the electrical resistance of the discharge path. The marking of any sheeting or hose shall be applied throughout the length at intervals of not more than 0.3 m for hospital products, but of not more than 3 m for industrial products, and 9 m for conveyor belting.

NOTE It is preferable that a floor should be marked with an installation test plate.

For hospital products each item shall be marked in lemon yellow colour and, where practicable, it shall include the word “antistatic”. For industrial products each article without a lower limit specified for resistance shall be marked with the words “electrically conducting”, preferably in red.

6 Number of tests

The number of tests shall be decided in accordance with the following criteria, in order of preference:

a) by reference to a British Standard for the particular product, if one exists;

b) by reference to the appropriate part of the appendix, if given there;

c) by applying the following principles:

1) for small articles such as furniture feet and for articles used between defined contact points, one test shall be made;

2) for other articles such as tyres, sheeting, belting and pads, at least five tests shall be made on different areas chosen so that the tests will be representative of the electrical properties of the whole article.

All the test results shall be within the specified limits.

Table 2 — Electrical requirement for industrial products (See **1.1**.)

Item	Product	Electrical resistance, Ω		Method of test (reference to clause in Appendix A)
		min.	max.	
1	Flooring for explosive handling areas	—	5×10^4	**A.4.2**
2	Flooring for antistatic purposes	5×10^4	10^8	**A.4.1**
3	Footwear, conducting (soles and heels), for explosive handling areas	—	1.5×10^5	**A.4.15** a)
4	Hose	3×10^3 per m	10^6 per m	**A.4.5**[a] **A.4.6**
5	Hose with conducting lining only	3×10^3 per m	10^6 per m	**A.4.12**
6	Hose with conducting cover only	3×10^3 per m	10^6 per m	**A.4.13**
7	Non-wire-reinforced hose with permanently attached metal end fittings	3×10^3 per m	10^6 per m	**A.4.14**
8	Tyres for explosives handling vehicles	—	5×10^5	**A.4.3** or **A.4.11**
9	Antistatic tyres	10^{4}[b]	10^7	**A.4.3** or **A.4.11**
10	Textile cots and aprons	—	10^8	**A.4.10**
11	Sheeting and articles made from sheeting; both surfaces to be tested	—	10^6	**A.4.1**
12	Footwear, antistatic soles and heels	7.5×10^4	5×10^7	**A.4.15** a) and b)
13	Transmission belting, flat[c], where L is dry distance between electrodes W is width of belt	—	$\frac{10^5 L}{8W}$	**A.4.16**
14	Wedge and V-belts[c], where L is dry distance between electrodes Z is sum of widths of the two driving surfaces of the belt	—	$\frac{5 \times 10^6 L}{8Z}$	As in BS 1440 and BS 3790
15	Conveyor belts for mining	—	3×10^8	As in BS 3289
16	Synchronous belts, where L is dry distance (measured in a straight line) between electrodes W is width of belt	—	$\frac{5 \times 10^6 L}{8W}$	**A.4.17**

[a] See, however, **A.4.6** if this method is used.

[b] This minimum value applies to new tyres; in use the resistance increases rapidly during the first few flexing and this low limit is necessary to ensure the retention of antistatic properties during a reasonable service life.

[c] These values apply to belts made conductive by carbon black. They do not necessarily apply to belts made conductive in other ways.

Appendix A Methods for the determination of electrical resistance

A.1 Apparatus

A.1.1 *Testing instruments*. The test shall be made with an instrument having a nominal open circuit voltage of 500 V d.c., preferably an insulation tester (ohm meter) or with any suitable instrument known to give comparable results.

The instrument shall be sufficiently accurate to determine the resistance to within 10 % and shall not dissipate more than 3 W in the test piece.

NOTE The insulation tester has an inherent characteristic of limited power output and also the voltage which it applies to the test piece decreases below its open circuit voltage at low resistance values of the test piece. This is a useful characteristic as it reduces the risk of shock and also of overheating the test piece. Insulation testers of this type may have manually or power driven generators or may be battery or mains operated multi-range instruments with similar electrical characteristics.

The resistance values obtained vary with the applied voltage and errors may occur when low test voltages are involved. In cases of dispute, the voltage applied to the test piece shall not be less than 40 V, except where this conflicts with the requirement not to dissipate more than 3 W in the test piece.

A.1.2 *Electrodes and contacts*. Except where otherwise stated in **A.4**, electrodes shall be formed on the surface by means of a conductive silver lacquer, colloidal graphite or a conductive liquid. The conductive liquid shall consist of:

	Parts by mass
Anhydrous polyethylene glycol of molar mass 600	800
Water	200
Wetting agent	1
Potassium chloride	10

When a conductive liquid is used, the electrode contact area shall be completely wetted and shall remain so until the end of the test.

The conductive silver lacquer or colloidal graphite shall be of a type that dries in air at room temperature, and the surface resistivity of the dried film shall be below 10^2 Ω.

Clean metal contacts shall be applied to the electrodes so that the contact area is approximately the same size but no greater than the electrodes, except where specified. With electrodes other than the liquid type and where specified below for the liquid electrodes, the product specification shall state the mass of the metal contacts.

The surface of the product shall not be deformed either during the application of the contacts or during the test, except as far as is necessary to insert the electrodes specified in **A.4.7** and **A.4.8**. The product shall be supported on an insulating surface except when otherwise specified.

A.2 Conditions of test

A.2.1 *Time lapse requirements*. For all test purposes the minimum time between manufacture and testing shall be 16 h.

NOTE Whenever possible, the time between manufacture and testing should not exceed three months. In other cases tests should be made within two months of the customer's date of receipt of the product.

A.2.2 *Measurement requirements*. Tests shall be carried out at a temperature of 23 ± 2 °C and a relative humidity of 50 ± 5 %.

If the articles are very large they shall be tested in the factory atmosphere and the temperature and humidity shall be recorded.

A.3 Procedure (general)

A.3.1 *Conditioning*. During the time lapse between manufacture and testing, or between receipt of the product and testing, subject the article to either of the following conditions.

a) Maintain in the undeformed state at 23 ± 2 °C without mechanically straining in any way.

b) Strain once to the maximum limit to which the product is to be subjected in normal use. Thereafter maintain in the unstrained state at 23 ± 2 °C for at least 24 h.

A.3.2 *Cleaning*. Clean the surface to be tested by rubbing with fuller's earth (magnesium aluminium silicate) and water, washing with distilled water and allowing to dry at a temperature of 23 ± 2 °C. The surfaces shall not be buffed or abraded, or cleaned with organic materials which attack or swell the materials to be tested.

NOTE In the case of hoses, dry fuller's earth should be used.

A.3.3 *Application of electrode*. Immediately apply the electrodes and metal contacts as appropriate to the article to be tested as described in **A.4**.

A.3.4 *Reconditioning*. Recondition the article for not less than 15 min or more than 2 h in the unstrained state at a temperature of 23 ± 2 °C and at a relative humidity of 50 ± 5 %.

A.3.5 *Testing*. Support the product on an electrically insulating surface except where otherwise specified. Apply the voltage in the manner appropriate to the article as described in **A.4**, taking the resistance reading 5 ± 1 s after the application of the voltage.

NOTE As some materials are sensitive to moisture, great care should be taken to avoid breathing on the samples prior to and during the resistance test.

A.4 Procedural details applicable to different articles

A.4.1 *Tests on one surface*. Apply electrodes to two areas, each a square with sides approximately 25 mm, such that the distance between the facing edges is 50 ± 5 mm, located on the same surface of the article to be tested.

Apply the metal contacts to the electrodes and measure the resistance.

A.4.2 *Tests between two surfaces*. Apply electrodes to two areas, each approximately 25 mm square.

The test areas shall be so located that the results represent the electrical resistance of the normal discharge path in the working conditions anticipated. Specifications for particular products shall state the location of the test areas.

Apply the metal contacts to the electrodes and measure the resistance.

A.4.3 *Tests on products bonded or clamped to one metal part*. Apply an electrode to an area as nearly as possible 25 mm square on the working surface of the product. The area shall not extend to other surfaces.

Apply a metal contact to the electrode and measure the resistance from this contact to the bonded or clamped metal.

NOTE For tyres for castors or wheels for hospital furniture, the test may be carried out by placing the tyre on an insulated wet metal plate and measuring the resistance between the plate and the hub of the wheel.

A.4.4 *Tests on products bonded or clamped to two metal parts*. Measure the resistance between the metal parts.

A.4.5 *Tests on hose and tubing*. Two tests shall be carried out:

a) Apply electrodes on the inside surface at one end (A) of the tube and on the outside surface at the other end (B). The electrodes shall be 25 mm wide bands applied around the circumference of the hose or tubing.

Apply the metal contacts to the electrodes and measure the resistance.

b) As a), but with the electrodes situated on the inside surface at end (B) and outside surface at end (A) of the tube.

NOTE Care should be taken to ensure that the hose or tubing is insulated from any leakage path in parallel with the length under test and that no electrically conducting contact takes place between successive coils along the length of the hose

A.4.6 *Tests on hose and tubing over 6 m in length on which tests are carried out on the ends only*. Apply electrodes on the inside surface at one end of the tube and on the outside surface at distances of 3 m and 6 m from the same end. The electrodes shall be 25 mm wide bands applied around or inside the circumference of the hose or tubing. Apply the metal contacts to the inside electrode and to the outside electrode at 3 m and measure the resistance.

NOTE Care should be taken to ensure that the hose or tubing is insulated from any leakage path in parallel with the length under test and that no electrically conducting contact takes place between successive coils along the length of the hose.

Repeat the measurement between the inside and the electrode at 6 m. The difference between these resistance values shall be recorded as the resistance for 3 m of the hose. If any reading exceeds 10^7 Ω, thoroughly check all electrodes and repeat the test.

A.4.7 *Tests on anaesthetic breathing bags with one neck*. Apply one electrode 25 mm square to the middle of the outer surface and the other electrode inside the neck of the bag. The latter shall be a 25 mm wide band applied to the inner circumference of the neck of the bag. A metal tube, 5 % to 10 % larger in diameter than the neck, shall be inserted in the neck. Measure the resistance between the tube and the central electrode.

A.4.8 *Tests on anaesthetic breathing bags with two necks*. Two tests shall be carried out. Apply electrodes inside the necks of the bag and to an area as nearly as possible 25 mm square in the centre of the outside surface of the bag. The former electrodes shall be 25 mm wide bands applied to the inner circumference of the necks. Insert in the necks of the bag metal tubes 5 % to 10 % larger in diameter than the necks.

Apply the metal contacts to the central electrode and to one of the tubes. Measure this resistance. Measure the resistance from the central electrode to the other tube.

A.4.9 *Tests on furniture feet*. Apply electrodes to the whole of the bottom surface of the cavity into which the leg of the furniture fits and to the whole of the surface normally in contact with the floor.

Apply the metal contacts to the electrodes and measure the resistance.

A.4.10 *Tests on furniture buffers, textile cots and aprons*. Apply electrodes to the surfaces which would normally make contact to provide the electrical path so that the resistance through the article is measured. The dimensions of the electrodes shall be as large as practicable but shall not extend beyond the contacting areas, and shall not exceed 25 mm square.

Apply the metal contacts to the electrodes and measure the resistance.

A.4.11 *Tests on detachable tyres having tread to rim conduction*. Apply electrodes to three areas each as nearly as possible 25 mm square. One test area shall be located on the external portion of each bead of the tyre which will be in contact with the flange of the rim, and the third on the centre line of the tread.

Apply a metal contact to the electrode on the centre line and to each of the others in turn and measure the resistances. Both readings shall fall within the specified limits.

A.4.12 *Tests on hose with conducting lining only*. Apply electrodes on the inside surface at each end of the hose. The wetted areas shall be 25 mm wide bands applied around circumference. Apply the metal contacts to the electrodes and measure the resistance.

A.4.13 *Tests on hose with conducting cover only*. Apply electrodes on the outside surfaces at each end of the hose. The electrodes shall be 25 mm wide bands applied around the circumference of the hose. Apply the metal contacts to the electrodes and measure the resistance.

NOTE Care should be taken to ensure that the hose or tubing is insulated from any leakage path in parallel with the length under test and that no electrically conducting contact takes place between successive coils or loops along the length of the hose.

A.4.14 *Tests on non-wire-reinforced hose with permanently attached metal end fittings*. Measure the resistance between the fittings.

A.4.15 *Tests on footwear*. Antistatic footwear shall be tested by methods a) and b) below and conducting footwear by method a) only.

a) *Wet/wet electrode system*. With the footwear resting with the heel and sole in contact with a metal plate, wetted with tap water containing a small quantity of a wetting agent, apply a metal contact to a liquid electrode 25 mm × 25 mm inside the footwear in the sole area of the insole and measure the resistance. Repeat this procedure with the liquid electrode in the heel area and measure the resistance. It is permissible to place a thoroughly wetted fabric pad between the metal plate and the footwear.

For antistatic footwear take the lower reading as the minimum resistance value.

For conductive footwear take the lower reading as the maximum resistance value.

In the case of dispute the resistance shall be measured with a force of 45 N applied to the 25 mm square electrode and a similar force applied in the sole area when the electrode is in the heel area and vice versa, and for antistatic footwear only, the test voltage shall be not less than 200 V d.c.

NOTE Combined electrodes consisting of a metal electrode enclosed in a moistened pad may be used in place of the internal liquid electrode/metal plate system.

b) *Wet/dry electrode system*. With the footwear resting with heel and sole in contact with a dry metal plate apply a metal contact to a 25 mm × 25 mm liquid electrode inside the footwear in the sole area of the insole and measure the resistance. Repeat the procedure with the electrode in the heel area and measure the resistance.

Take the lower reading as the maximum resistance value.

In the case of dispute the resistance shall be measured with a force of 45 N applied to the 25 mm square electrode and a similar force applied in the sole area when the electrode is in the heel area and vice versa.

NOTE Combined electrodes consisting of a metal electrode enclosed in a moistened pad may be used in place of the internal liquid electrode/metal plate system.

A.4.16 *Tests on flat transmission belting*. Apply electrodes to two areas each 25 mm wide and extending across the full width of the belt and separated by a dry distance of 600 ± 12 mm on the face of the belt which will make contact with the pulley. Apply the contacts to the electrodes and measure the resistance.

For endless belting less than 3 m long the dry distance shall be reduced to 100 ± 5 mm.

A.4.17 *Tests on synchronous belts (toothed transmission belts)*. Without cutting the belt, and using insulating clamps, lightly clamp flat a length of belt comprising at least 17 teeth (with the teeth uppermost) on to an insulating surface. Apply liquid electrodes to two areas on the toothed side of the belt and extending across the full width of the belt. The electrodes shall each cover the top surface of 3 adjacent teeth and the sides and bottoms of the 2 grooves between them and shall extend across the width of the belt. The dry distance between the electrodes shall span 7 grooves and 6 teeth. Apply to each electrode a flat metal contact which covers the top surfaces of the three teeth. Apply to these surfaces a pressure of between 10 kPa and 40 kPa.

Measure the resistance between the contacts.

A.5 Test report

The test report shall include the following particulars:

a) full identification of the article tested;

b) reference to the method of test used (e.g. BS 2050, **A.4.11**);

c) whether or not mechanically strained [**A.3.1** a) or b)];

d) the electrode material and size;

e) each individual test result;

f) the average test result.

Publications referred to

BS 1440, *Endless V-belt drives sections "Y", "Z", "A", "B", "C" and "D".*
BS 2099, *Castors.*
BS 2099-1, *Castors for hospital equipment for ward and theatre use.*
BS 3289, *Convey or belting for underground use in coal mines.*
BS 3790, *Endless wedge belt drives of SPZ, SPA, SPB and SPC sections.*
BS 2044, *Laboratory tests for resistivity of conducting and antistatic rubbers.*

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