BS 3424 : Part 10 : 1987

UDC [677.077.652 : 678.066.2] : 677.017.48 : 531.43

British Standard

Testing coated fabrics

Part 10. Methods 12A and 12B. Determination of surface drag

Méthodes d'essai des supports textiles revêtus
Partie 10. Méthodes 12A et 12B. Détermination de la traînée superficielle

Verfahren zur Prüfung beschichteter Gewebe
Teil 10. Verfahren 12A und 12B. Bestimmung des Oberflächenreibungswiderstandes

IMPORTANT NOTE. It is recommended that this Part be read in conjunction with the information in Part 0 'Foreword and general introduction'.

Foreword

The frictional properties of coated fabrics are important for many applications. In clothing, footwear, upholstery, industrial belting, constructional applications and other end uses as well as during processing, friction is an important consideration. In some cases it is the frictional behaviour of the coating with itself that is of prime importance. In others it is the frictional behaviour of the coating with another surface that is the major consideration.

Invariably the static coefficient of friction is required to be known but also the kinetic coefficient can be as important. Similarly the differences between the two may, in some cases, have to be as small as possible, whilst the absolute value, be it high or low, may not be significant.

The methods included in this Part of BS 3424 will provide essential information on both static and kinetic coefficients of friction. Method A will provide both coefficients in a single operation. A means of quantifying the frictional properties is also provided. Method B on the other hand has been included because the instrument is simple and cheap to fabricate, both the method and equipment are well known within the industry and, if different modes of operation are employed, can give a measure of the static and kinetic coefficient of friction.

The determination of frictional coefficients of coated fabrics requires somewhat different considerations to be taken into account than is the case when testing other materials, for example metals. For a more detailed discussion of these considerations it is recommended that reference be made to BS 4618 : Section 5.6 including the bibliography.

This Part supersedes method 12 of BS 3424 : 1973.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standards Institution

1 Scope

This Part of BS 3424 describes two methods of assessing the frictional properties of coated fabrics.

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

2 Definitions

For the purposes of this Part of BS 3424 the following definitions apply.

2.1 coefficient of static friction (μ_s). The ratio of the force necessary to cause the tangential separation of two stationary surfaces to the perpendicular force acting upon the two surfaces.

2.2 coefficient of kinetic friction (μ_k). The ratio of the force necessary to maintain a constant velocity between two surfaces in contact to the perpendicular force acting upon the two surfaces.

2.3 kinetic angle of surface drag (D_k). The angle of the inclined plane at which the test sled will slide down the inclined plane when sliding is initiated by a standard impulse.

2.4 static angle of surface drag (D_s). The angle of the inclined plane at which the test sled will slide down the inclined plane under its own mass and momentum.

3 Method A. Flat bed method

3.1 Principle

A rectangular strip of the coated fabric is mounted with the coating outermost on a sled to which is attached a strain gauge and autographic recording device. The sled is caused to move over a rigidly mounted horizontal bed to which is fastened the comparator material (either a melton cloth or the coated fabric itself). The force necessary to initiate movement of the sled and thereafter maintain a constant velocity is measured.

3.2 Apparatus

3.2.1 *A sled,* 150 ± 1 mm long × 100 ± 1 mm wide having a mass of 700 ± 15 g to which is attached the coated fabric test specimen (see **3.3.1**) and a test specimen support of cellular rubber or plastics material 3 mm thick and of medium apparent density. The surface of the sled is flat and smooth or polished. The edges of the sled do not contain any burrs or roughnesses.

When laid upon the horizontal bed of the test instrument the sliding surface of the sled is parallel with the horizontal bed and in full planar contact and without distortion.

3.2.2 *A driving mechanism,* to move the sled or horizontal bed in such a manner that the relative movement of one with the other can be maintained at a constant velocity of 800 ± 80 mm/min.

The drive mechanism is automatically disengaged or de-energized at the end of the test run (see **3.2.3**).

3.2.3 *A flat bed* of rigid construction, having a smooth or polished surface to which the comparator material (see **3.3.2**) is fixed in such a manner that the comparator material is not stretched more than a necessary minimum to remove wrinkles or other non-permanent distortions. The flat bed is of a length to permit a relative surface travel during the test of approximately 400 mm and of a width to permit approximately 50 mm of clearance between the edge of the sled and any edge obstructions.

3.2.4 *A measuring device,* in the form of a strain gauge, is employed with an associated autographic recording instrument to determine accurately the force necessary to initiate movement and the force necessary to maintain a constant velocity thereafter. The response time of the recording instrument is less than 0.25 s.

3.3 Preparation of test specimens and comparator material

3.3.1 Cut two coated fabric specimens each measuring 250 mm × 100 mm, one in the longitudinal direction of the coated fabric and one in the transverse direction of the coated fabric.

3.3.2 Cut two comparator specimens each not less than 550 mm long × 200 mm wide, from either the coated fabric under test or from a woollen melton cloth* similar to OC 7 of BS 1771 : Part 1 : 1984.

*Information concerning sources of supply for the woollen melton cloth and the apparatus can be obtained by sending a stamped addressed envelope to Enquiry Section, BSI, Linford Wood, Milton Keynes MK14 6LE.

3.4 Procedure

Determine the mass in grams of the coated fabric test specimen (3.3.1). Mount the coated fabric test specimen on the sled (3.2.1) with the coated surface to be evaluated outermost (see figure 1). Ensure that the coated fabric test specimen is not unduly stretched but is under sufficient tension to prevent the material wrinkling or creasing during test as this would affect the results.

Mount the comparator specimen (3.3.2) on the flat bed (3.2.3) in a similar manner.

NOTE. It has been found convenient to overlap the comparator specimen over the edges of the flat bed and secure it underneath using adhesive tape. Alternatively the comparator may be taped securely within the vacuum channel, or, if the comparator is a thin single face coated fabric, it may be secured by vacuum suction as indicated in figure 1.

Ensure that both surfaces are free of irregularities and foreign matter.

Without exerting any additional downward force, place the sled on the flat bed, ensure that the autographic recording device (3.2.4) is registering zero and that the chart speed is approximately 600 mm/min.

Measure and record the ambient relative humidity and temperature.

Engage or energize the driving mechanism (3.2.2).

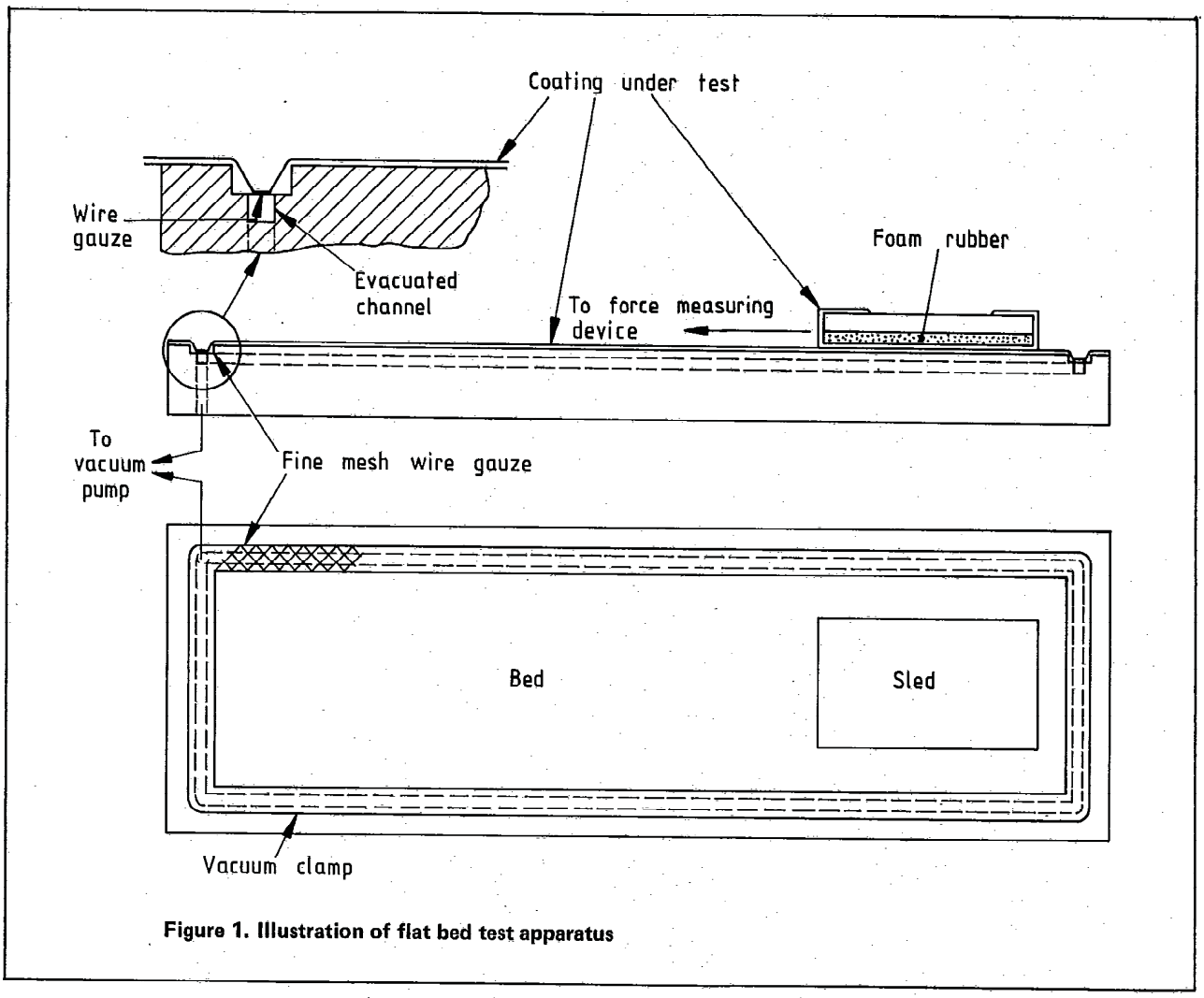


Figure 1. Illustration of flat bed test apparatus

3.5 Calculation and expression of results

3.5.1 *Coefficient of static friction* (μ_s). From the autographic record determine the maximum value necessary to initiate movement between the test surfaces.

Calculate the coefficient of static friction (μ_s) according to the following equation:

$$\mu_s = \frac{F}{W}$$

where

F is the maximum value necessary to initiate movement between the test surfaces (in g);

W is the mass of the sled and coated fabric test specimen (in g).

3.5.2 *Coefficient of kinetic friction* (μ_k). From the autographic record determine from the central 50 % of the trace (i.e. the 2nd and 3rd quartiles), the maximum and minimum deflections of the trace and calculate their mean value S (in g). (See figure 2.)

Calculate the mean coefficient of kinetic friction (μ_k) according to the following equation:

$$\mu_k = \frac{S}{W}$$

where

S is the mean value necessary to maintain a constant relative velocity between the test surfaces (in g);

W is the mass of the sled and coated fabric test specimen (in g).

3.5.3 *Percentage variability of kinetic friction* (V_k) (see figures 3 and 4). At ten equispaced positions along the length of the autographic trace, record the value (in g) of the maximum and minimum deflections on the autographic trace and calculate the percentage variability of kinetic friction (V_k) according to the following equation:

$$V_k\ \% = \frac{\sqrt{\frac{[(M_n - S)^2 + (S - m_n)^2] \times 100}{20}}}{S}$$

where

M_n are the maximum values of the kinetic frictional values at $M_1, M_2, M_3, \ldots M_{10}$;

m_n are the minimum values of the kinetic frictional values at $m_1, m_2, m_3, \ldots m_{10}$;

S is the mean value necessary to maintain a constant relative velocity between the test surfaces (in g) (see **3.5.2**).

The percentage value of V_k provides an indication of the amount by which the kinetic frictional value oscillates about the mean kinetic friction value. Examples of different values of V_k % related to different autographic traces are given in appendix B.

3.6 Test report

The test report shall include the following information:

(a) the description of the coated fabric;

(b) the ambient relative humidity and temperature in which the test was conducted;

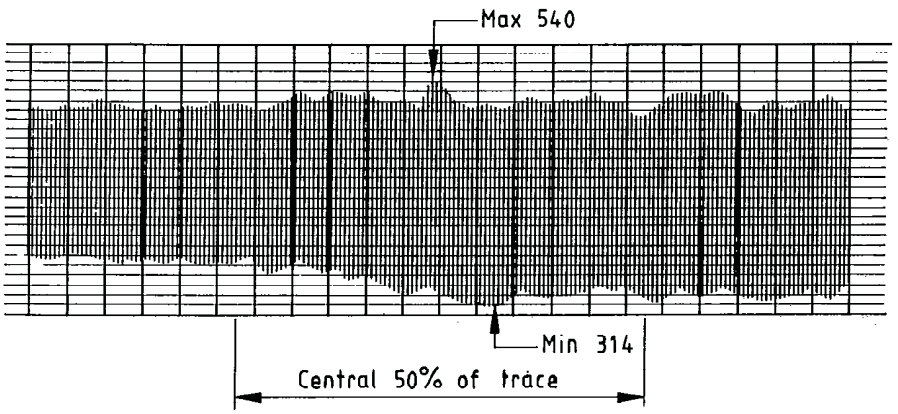


Figure 2. Autographic trace illustrating the method of plotting values for μ_k

(c) reference to this method of test, i.e. method 12A of BS 3424 : Part 10 : 1986;

(d) the description of the comparator material used (see **3.3.2**) and the relative orientation of the specimen under test and comparator material, where these are the same;

(e) the coefficients of static friction in both tests;

(f) the mean coefficients of kinetic friction in both tests;

(g) the variability of kinetic friction in both tests;

(h) details of any deviation from the standard test procedure.

4 Method B. Inclined plane method

4.1 Principle

A sled on which is mounted a coated fabric test specimen is placed on a bed of melton fabric that can be raised at an angle to the horizontal. The angle of the inclined plane is gradually increased until the sled slides down the inclined plane. The angle of inclination of the inclined plane is measured and reported as the angle of surface drag.

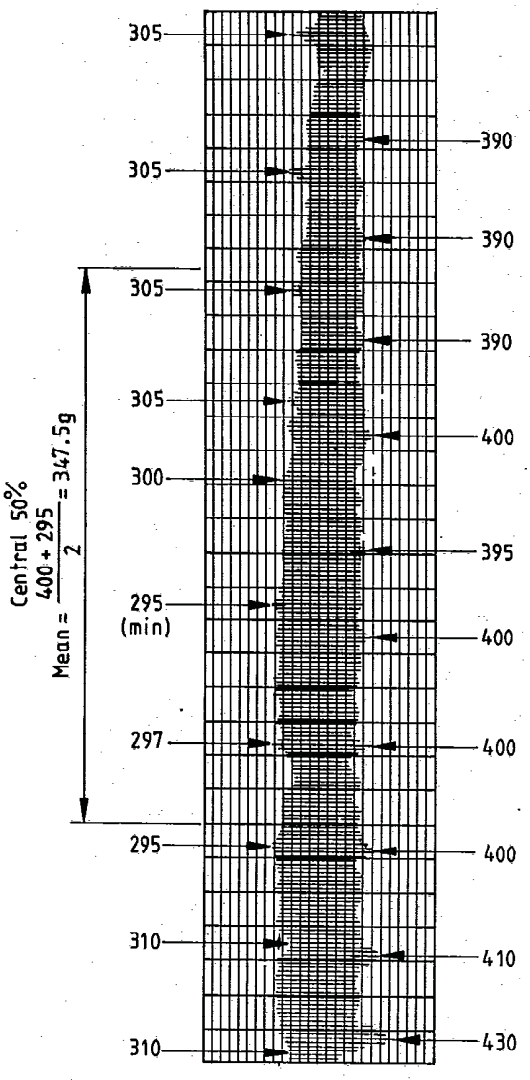


Figure 3. Autographic trace illustrating a coated fabric to melton friction test and the method of plotting values for V_k %

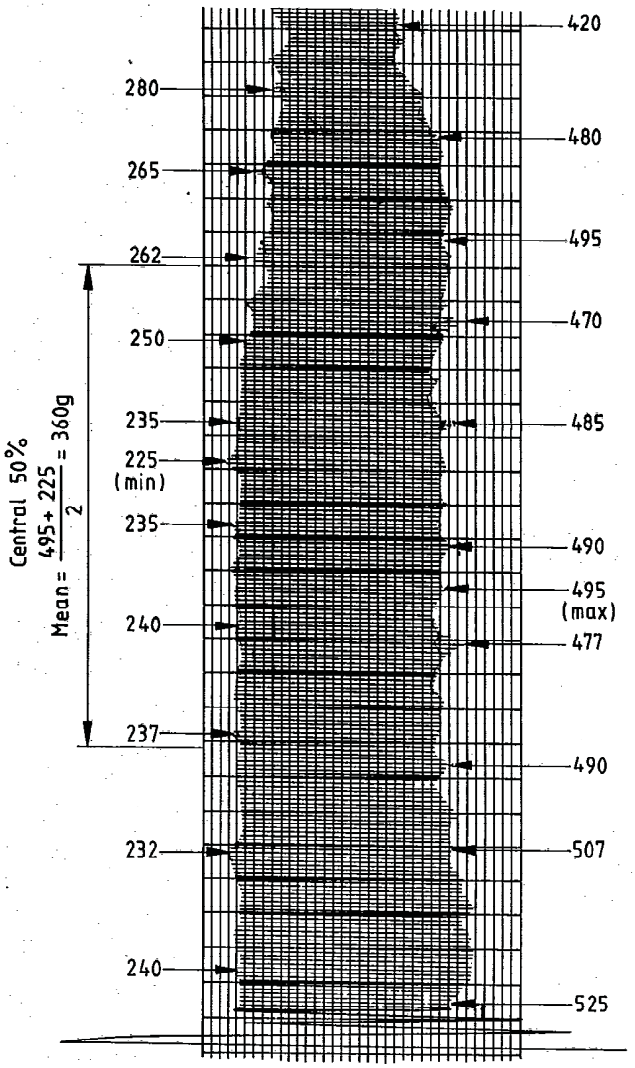


Figure 4. Autographic trace illustrating a coated surface to coated surface friction test and the method of plotting values for V_k %

4.2 Apparatus

4.2.1 *Instrument for determination of static angle of surface drag (D_s)*

4.2.1.1 *General.* The instrument for determination of D_s shall consist of the items detailed in **4.2.1.2** to **4.2.1.6.**

4.2.1.2 *Rigid platform,* not less than 300 mm long and not less than 100 mm wide and hinged at one end to a baseboard provided with levelling screws. The rigid platform is provided with a spirit level and means for measuring the angle of inclination with an accuracy of ± 0.5 °.

4.2.1.3 *A piece of woollen melton cloth,* similar to BS 1771 : Part 1, OC 7 and measuring approximately 250 mm long and 100 mm wide with its length in the cross direction and fixed under slight tension to the platform (**4.2.1.2**).

NOTE. The melton cloth should be covered when the apparatus is not in use. It should be replaced at intervals, or if contaminated.

4.2.1.4 *Specimen carrier,* which is of metal, and which has dimensions as illustrated in figure 5. The total mass of the carrier including the clamping screw is adjusted to 300 g by balanced boring out of the upper section of the carrier.

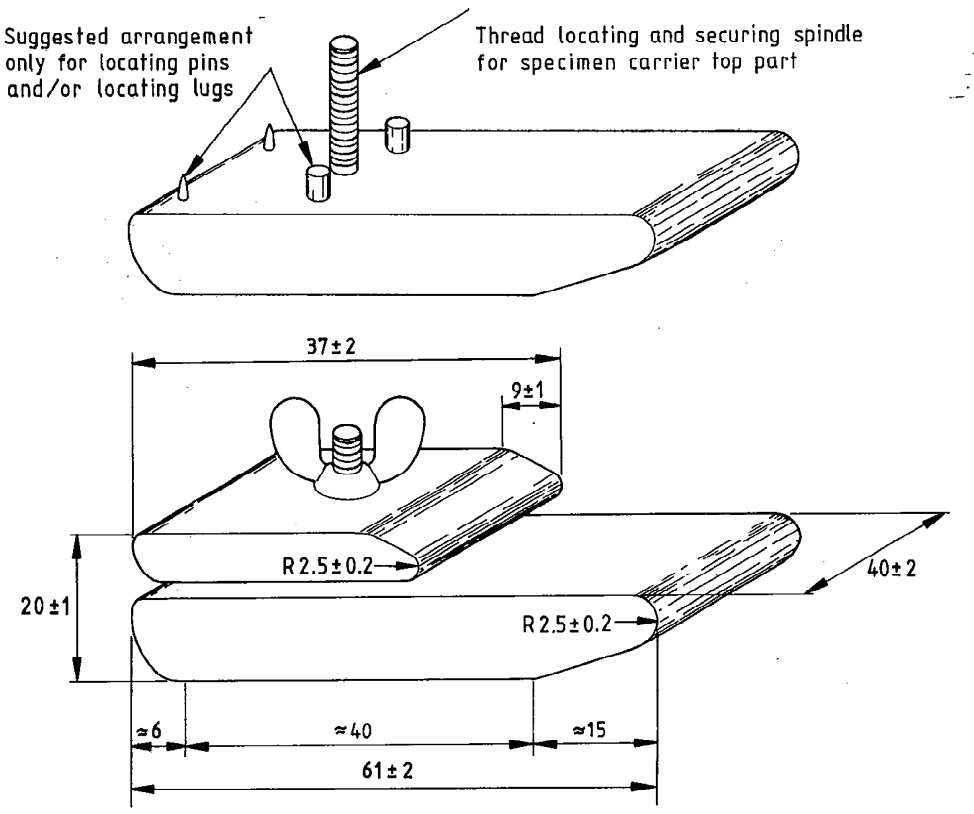
4.2.1.5 *Electric motor,* suitably geared to tilt the plane of the platform mechanically at a rate of 15 ± 2 °/min.

4.2.1.6 *Microswitch* (see BS 9562) included in the circuit in series with the electric motor (**4.2.1.5**). This is so positioned at the top end of the platform (**4.2.1.2**) that the actuating lever of the switch may be depressed by the back edge of the specimen carrier (**4.2.1.4**) resting on the melton cloth. A suitable stop is provided such that the distance of travel of the specimen carrier between the stop and the contact breaking position of the switch is 4.5 ± 0.5 mm. The force required to depress the actuating lever of the microswitch is between 40 mN and 80 mN.

A suitable apparatus is shown schematically in figure 6.

4.2.2 *Instrument for determination of kinetic angle of surface drag (D_k).* A suitable apparatus is shown in figure 7. The rigid platform (**4.2.1.2**) and the specimen carrier (**4.2.1.4**) are suitable. Means are provided for tilting the rigid platform so that it may be positioned accurately to within ± 0.5 ° of a required degree of inclination. Provision is made to impulse the back of the specimen carrier by a force of approximately 3 N in order to initiate sliding. (See **4.4.2.**)

NOTE. The impulse force of 3 N on the back of the specimen carrier can be achieved by a metal cylinder of appropriate dimensions and mass. This method is however subject to changes in resultant force at different inclinations of the platform.



All dimensions are in millimetres.

Figure 5. Specimen holder for method 12B

4.3 Test specimens

Cut six specimens each 50 mm wide x 120 mm long with their length in the cross direction from positions equally spaced across the width of the material but not within 50 mm of an edge.

4.4 Procedure

4.4.1 *Mode 1. Determination of static angle of surface drag* (D_s). Condition the test specimens and the melton cloth in accordance with method 4 of BS 3424 : Part 2 : 1982 unless otherwise stated, and carry out the tests in an atmosphere similar to that used for conditioning. Set the platform to 0 ° on the protractor scale and level the platform using the levelling screws on the baseboard.

Wrap a test specimen around the carrier and clamp it in position under slight tension. Place the test specimen carrier on the platform with the specimen in contact with the melton cloth and with the back of the carrier against the stop, thus actuating the microswitch. Switch on the motor. When the inclination of the platform is sufficient to cause the test specimen and carrier to slide over the melton cloth, the microswitch actuating lever is released, stopping the motor. Record the angle of inclination of the platform to the nearest 0.5 °.

Repeat the procedure with two further test specimens.

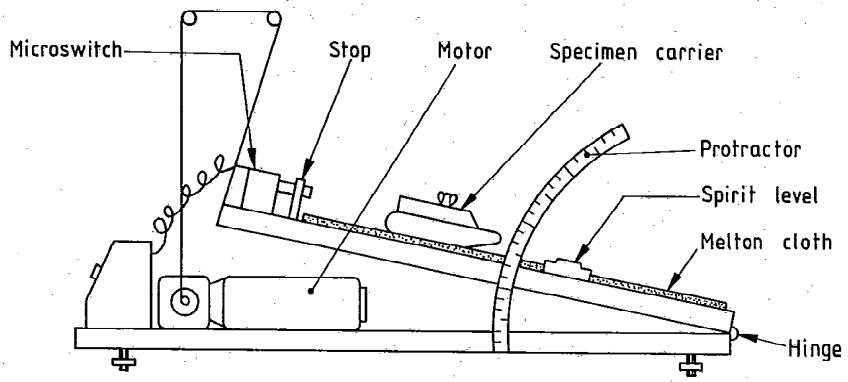


Figure 6. Apparatus for method 12B – Mode 1

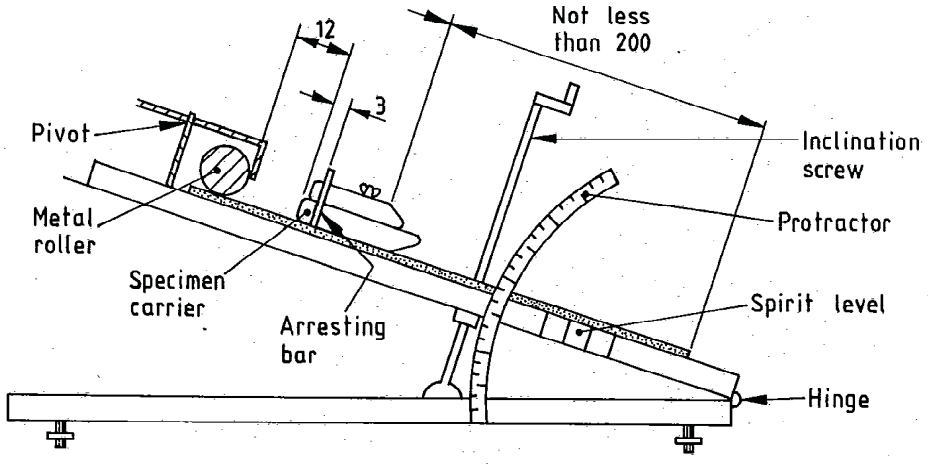


Figure 7. Apparatus for method 12B – Mode 2

4.4.2 *Mode 2. Determination of kinetic angle of surface drag* (D_k). Wrap a test specimen of coated fabric around the carrier and clamp it in position under slight tension. Place the specimen carrier on the platform with the specimen in contact with the melton cloth and with the back of the carrier against the stop. Raise the platform to an angle of 5 ° less than D_s. Impulse the back of the carrier by a force of approximately 3 N. Note whether the carrier slides freely down the platform for a distance of 200 mm. If the carrier does not slide freely, raise the angle of inclination by 1 ° and repeat the operation. Continue in this manner until the carrier slides freely down the platform for a distance of 200 mm.

Repeat the procedure with two further specimens.

4.5 Calculation and expression of results

4.5.1 *Static angle of surface drag.* Calculate the mean value of the angle of inclination determined at **4.4.1** and report this as the static angle of surface drag (D_s).

4.5.2 *Kinetic angle of surface drag.* Calculate the mean value of the angle of inclination determined at **4.4.2** and report this as the kinetic angle of surface drag (D_k).

The results given by method B are not expressed in absolute coefficients of friction but in degrees of inclination of the inclined plane. Interlaboratory trials have indicated that an angle of surface drag of 30 ° equates very approximately with a coefficient of friction of 0.9. In this regard attention is drawn to the graph in appendix A.

4.6 Test report

The test report shall include the following information:

(a) the description of the coated fabric;

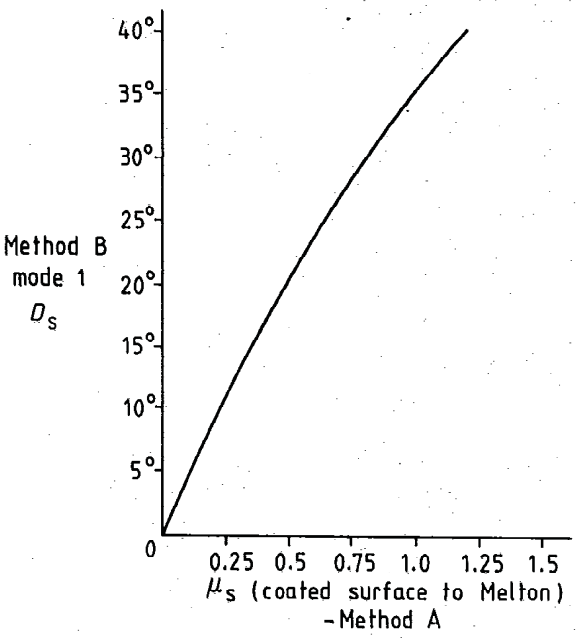
(b) the ambient relative humidity and temperature in which the test was conducted;

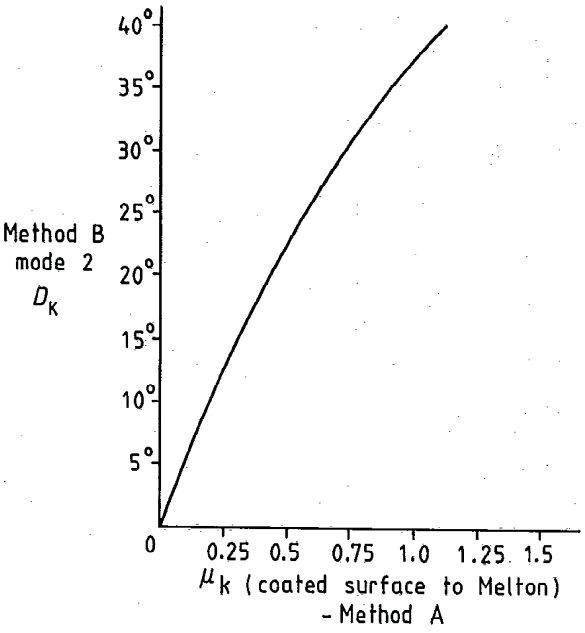
(c) reference to this method of test, i.e. method 12B of BS 3424 : Part 10 : 1987;

(d) the static and/or kinetic angles of surface drag (i.e. D_s and/or D_k);

(e) details of any deviation from the standard test procedure.

Appendix A. Graphical representation of friction test results on identical materials using method A and method B, Mode 1 and Mode 2





Appendix B. Examples of autographic traces of friction tests on coated fabrics and determination of the variability of kinetic friction

B.1 Coated fabric to melton

In interlaboratory tests the mass of the sled was 682.7 g and the mass of the coated fabric test specimen was 2.4 g. From the autographic trace (figure 3) it is found that in the central 50 % of the trace the maximum and minimum values of the frictional force are 400 g and 295 g respectively The mean kinetic frictional value (S) is therefore 347.5 g. The value of μ_k is then given by the following equation:

$$\mu_k = \frac{347.5}{(682.7 + 2.4)} = 0.507$$

The values of M are seen to be 430, 410, 400, 400, 400, 395, 400, 390, 390, 390.

The values of m are seen to be 310, 310, 295, 297, 295, 300, 305, 305, 305, 305.

The percentage value of V_k is therefore given by the following calculation:

$(M_n - S)^2$		$(S - m_n)^2$
$(430 - 347.5)^2 = 6806.25$		$1406.25 = (347.5 - 310)^2$
$(410 - 347.5)^2 = 3906.25$		$1406.25 = (347.5 - 310)^2$
$(400 - 347.5)^2 = 2756.25$		$2756.25 = (347.5 - 295)^2$
$(400 - 347.5)^2 = 2756.25$		$2550.25 = (347.5 - 297)^2$
$(400 - 347.5)^2 = 2756.25$		$2756.25 = (347.5 - 295)^2$
$(395 - 347.5)^2 = 2256.25$		$2256.25 = (347.5 - 300)^2$
$(400 - 347.5)^2 = 2756.25$		$1806.25 = (347.5 - 305)^2$
$(390 - 347.5)^2 = 1806.25$		$1806.25 = (347.5 - 305)^2$
$(390 - 347.5)^2 = 1806.25$		$1806.25 = (347.5 - 305)^2$
$(390 - 347.5)^2 = 1806.25$		$1806.25 = (347.5 - 305)^2$
(29412.5)	+	(20356.5)

$$= 49769$$

Thus:

$$V_k = \frac{\sqrt{\frac{49769}{20}}}{347.5} \times 100 = \underline{14.35\ \%}$$

i.e. the kinetic frictional values differ from the mean on average by 14.35 % for this particular coated fabric.

B.2 Coated surface to coated surface

The same coated fabric as that used in example **B.1** was tested for coated surfaces to coated surfaces. The autographic trace is illustrated in figure 4. The mass of the sled and coated fabric test specimen was the same, i.e. (682.7 + 2.4) = 685.1 g.

From the central 50 % of the autographic trace it is found that the maximum and minimum values of the trace are 495 g and 225 g respectively. The mean kinetic frictional value is therefore 360 g. μ_k is given by the following equation:

$$\mu_k = \frac{360}{685.1} = 0.525$$

The values of M are seen to be 525, 507, 490, 477, 490, 485, 470, 495, 480, 420.

The values of m are 240, 232, 237, 240, 235, 235, 250, 262, 265, 280.

The value of V_k % is therefore given by the following calculation:

$(M_n - S)^2$		$(S - m_n)^2$
$(525 - 360)^2$	= 27 225	14 400 = $(360 - 240)^2$
$(507 - 360)^2$	= 21 609	16 384 = $(360 - 232)^2$
$(490 - 360)^2$	= 16 900	15 129 = $(360 - 237)^2$
$(477 - 360)^2$	= 13 689	14 400 = $(360 - 240)^2$
$(490 - 360)^2$	= 16 900	15 625 = $(360 - 235)^2$
$(485 - 360)^2$	= 15 625	15 625 = $(360 - 235)^2$
$(470 - 360)^2$	= 12 100	12 100 = $(360 - 250)^2$
$(495 - 360)^2$	= 18 225	9 604 = $(360 - 262)^2$
$(480 - 360)^2$	= 14 400	9 025 = $(360 - 265)^2$
$(420 - 360)^2$	= 3 600	6 400 = $(360 - 280)^2$
	160 273	+ 128 692

= 288 965

Thus:

$$V_k\ \% = \sqrt{\frac{288\,965}{20}} \times \frac{100}{360} = 33\ \%$$

i.e. the kinetic frictional values differ from the mean on average by 33 %.

NOTE. The coated fabrics used in **B.1** and **B.2** are the same. Although the values of μ_k are similar, the values of V_k % are widely different because of the different comparator.

Publications referred to

BS 1771 Fabrics for uniforms and workwear
Part 1 Specification for fabrics of wool and wool blends

BS 4618* Recommendations for the presentation of plastics design data
Section 5.6 Guide to sliding friction

BS 9562 Specification for microswitches (sensitive switches) of assessed quality: generic data and methods of test: general rules for preparation of detail specifications. Basic and full assessment levels

*Referred to in the foreword only.

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