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Rubber threads — Methods of test

Fils élastiques — Méthodes d'essai

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 45, *Rubber and rubber products*, Subcommittee SC 4, *Products (other than hoses)*.

This fourth edition cancels and replaces the third edition (ISO 2321:2006), which has been technically revised.

The main changes compared to the previous edition are as follows:

— Clause 3 has been added to list all the terms and definitions;

— the distance between cutting blades in Figure 1 has been added;

— the tensile testing of type A rings in Figure 2 has been added and all the figure numbers have been updated;

— a new test, namely tension set, has been added in Clause 13;

— the clause numbers in Table 1 and Table 2 have been updated;

— the unit of density has been changed from megagram per cubic metre (Mg/m^3) to gram per cubic centimetre (g/cm^3).

Rubber threads — Methods of test

1 Scope

This document specifies methods of test for determining general physical and mechanical properties of rubber threads, as well as specific mechanical properties of such threads in contact with fabrics. Owing to the comparatively small cross-section and the unusual conditions of service of this material, certain special methods have been developed.

Some of the tests included in this document are not entirely suitable for threads made from certain synthetic rubbers (e.g. urethane rubber). These tests are intended for natural or synthetic polyisoprene rubbers.

Comparisons can only be made on new rubber threads or on those with identical processing histories. In the interpretation of results from threads which have been subjected to spooling, fabrication or any other process, the previous history is important, and what is known of this and of any relaxation treatments used is intended to be reported.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 37, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 105-A02, *Textiles — Tests for colour fastness — Part A02: Grey scale for assessing change in colour*

ISO 105-A03, *Textiles — Tests for colour fastness — Part A03: Grey scale for assessing staining*

ISO 188, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 648, *Laboratory glassware — Single-volume pipettes*

ISO 1042, *Laboratory glassware — One-mark volumetric flasks*

ISO 1183-2, *Plastics — Methods for determining the density of non-cellular plastics — Part 2: Density gradient column method*

ISO 23529, *Rubber — General procedures for preparing and conditioning test pieces for physical test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
metric yield
unstretched length, in metres, of 1 000 g of the thread

3.2
density
<of thread> mass per unit volume of a test piece of thread measured at a standard laboratory temperature

Note 1 to entry: It is expressed in grams per cubic centimetre.

Note 2 to entry: The standard laboratory temperatures are given in ISO 23529.

3.3
tensile strength
stress at which the thread breaks when it is stretched under specified conditions, based on the initial cross-sectional area

Note 1 to entry: The value is expressed in megapascals (1MPa = 1N/mm^2).

3.4
modulus at 300 % and 500 %
stress calculated with respect to the original cross-sectional area, at 300 % and 500 % elongation

Note 1 to entry: It is measured in megapascals (1MPa = 1N/mm^2).

3.5
elongation at break
increase in length of the thread at break when it is stretched under the specified conditions, expressed as the percentage increase of the original length

EXAMPLE A test piece, 30 mm in length which increases in length to 210 mm at break, is said to give an elongation of 600 % at break.

3.6
Schwartz value
average of the stresses calculated with respect to the original cross-sectional area at a specified elongation measured on extension and retraction of a previously massaged (mechanically conditioned) thread

Note 1 to entry: It is expressed in megapascals (1MPa = 1N/mm^2).

Note 2 to entry: It is denoted by the abbreviated term, SV_n^c, where c is the massaging elongation (the elongation to which the test piece is stretched during mechanical conditioning) and n the elongation at which the readings are taken. Both c and n are expressed as percentages of the initial length as multiples of 100 and, unless otherwise specified, are chosen so that $c = n + 100$.

Note 3 to entry: The preferred values of n are 300 % and 500 %, depending on the type of thread under test.

3.7
Schwartz hysteresis ratio
ratio of the loads at a specified elongation measured on extension and retraction, after massaging (mechanical conditioning)

Note 1 to entry: It is denoted by the abbreviated term, SHR_n^c, where c is the massaging elongation (the elongation to which the test piece is stretched during mechanical conditioning) and n the elongation at which readings are taken. Both c and n are expressed as percentages of the initial length as multiples of 100 and, unless otherwise specified, are chosen so that $c = n + 100$.

Note 2 to entry: The preferred values of n are 300 % and 500 %, depending on the type of thread under test.

3.8
elongation under specified load
percentage elongation of a rubber thread when stressed by the application of a specified load per unit area

Note 1 to entry: It is determined by applying a load to an unmassaged thread (i.e. a thread which has not been mechanically conditioned) and so is liable to be affected by the age and previous history (including storage history and any conditioning) of the thread.

Note 2 to entry: It is normally determined at two levels of applied force: 15,5 kPa (= 15,5 mN/mm^2) and 27,4 kPa (= 27,4 mN/mm^2).

3.9
stress retention
residual load, expressed as a percentage of the original load on the thread, after the test piece has been maintained at a constant elongation (usually 100 %) for a specified time

3.10
tension set
elongation remaining in a test piece in the relaxed condition after it has been subjected to a constant elongation at a specified time, expressed as a percentage of the elongation

3.11
discoloration
change in the original shade of a product, resulting from outside influences

3.12
colour staining
undesired pick-up of colour by a fabric

a) when immersed in water, dry-cleaning solvent or a similar liquid medium, which contains dyestuffs or colouring material not intended for colouring the fabric;

b) by direct contact with other dyed material from which colour is transferred by bleeding or sublimation

4 Conditioning of samples or test pieces

The samples or test pieces shall be kept in a relaxed state in one of the standard atmospheres described in ISO 23529, for not less than 16 h before testing. The tests shall be carried out under similar atmospheric conditions. The test piece selected shall be clean, dry and free from any visual defects. Samples or test pieces shall not be allowed to come into contact with copper or manganese of their compounds during conditioning or testing.

5 Count

5.1 Sectional count

The sectional count of a rubber thread is given by the value of its cross-sectional area, expressed in square millimetres.

The sectional count corresponds to the tex count for a nominal density of 1 g/cm^3. The use of the sectional count is recommended.

5.2 Conventional count (size number)

5.2.1 The conventional count of a rubber thread is the number of threads which, when placed side by side, measure 25,4 mm.

The conventional count of a round thread is calculated by dividing 25,4 by the diameter, in millimetres, of the thread.

The conventional count of a square thread is calculated by dividing 25,4 by the length, in millimetres, of one of the sides of the thread.

The conventional count of a rectangular thread is generally quoted as the count of a square thread of equivalent cross-sectional area.

Thus, in the case of a round thread, the number, 100, is the conventional count of a thread, whose diameter is equal to 0,254 mm: In the case of a square thread, the number 40 is the conventional count of a thread whose sides are equal to 0,635 mm.

5.2.2 It is customary to quote the conventional count of a round thread, followed by the whole even number which is nearest to the actual conventional count of the square thread of equivalent cross-sectional area (count of round thread × 1,13 = actual count of square thread).

EXAMPLE A round thread of count 50 is indicated by 50/56.

5.2.3 The conventional count of a multi-filament round thread is expressed by stating successively the number of components, the count of the single round thread which would have the same total cross-sectional area as the component threads, and the count of the corresponding square thread.

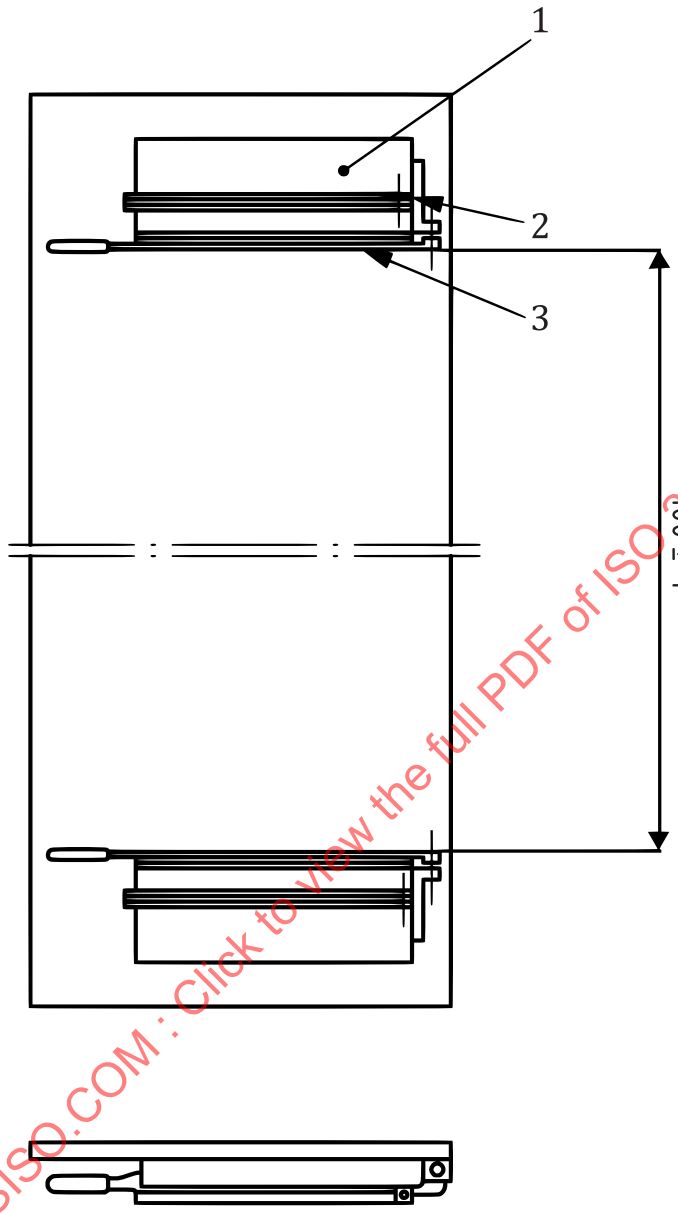
EXAMPLE The conventional count of a multi-filament round thread, made up of three components equal in total cross-sectional area to a round thread of count 32, is indicated by 3/32/36.

5.3 Apparatus

See Figure 1.

The apparatus for cutting the test pieces consists of a rectangular vertical frame at the upper and lower ends of which are mounted two metallic plates whose inside edges are parallel and sharp. Two cutting devices (the fixed blade of which consists of the inside edge of the metal plate) and two external clamps are provided. The clamps shall be of a spring-loaded type and the distance between the internal edges of the metal plates shall be 100 mm ± 1 mm.

Dimension in millimetres



Key

1 metal plate
2 clamp
3 cutting device

Figure 1 — Apparatus for cutting test pieces

5.4 Procedure

5.4.1 Cutting out the test pieces

Take five strips of thread samples and cut them to a length of approximately 110 mm.

Tear off threads equally from both edges of each strip until there are only 10 threads in each one. If these strips are taken from bobbins or from any other type of presentation in which the strip is under tension, heat-treat them for 30 min in a thermostatically controlled oven at a temperature of

70 °C ± 2 °C. After this heat treatment, condition the strip as specified in Clause 4. For strips taken from other forms of presentation where no tension is applied to the strip, condition as specified in Clause 4.

Suspend each conditioned strip from the upper clamp. When it has settled in the vertical position without stretch, fix it by means of the lower clamp. Cut the strip to the required length with the two cutting devices, using the lower one first.

5.4.2 Weighing the test pieces

Free the cut strips from any loose dusting powder by shaking or brushing them gently, and weigh to an accuracy of ±1 %.

5.5 Expression of results

5.5.1 The sectional count, S, is given by Formula (1):

$$S = \frac{m}{\rho} \times \frac{1}{1\,000} \tag{1}$$

where

ρ is the density, expressed in grams per cubic centimetre, of the thread, determined as specified in Clause 8;

m is the mass, in miligrams, of the strip.

5.5.2 The conventional count, C, is given by Formulae (2) and (3):

For round thread

$$C = 22{,}51\sqrt{\frac{\rho}{m}} \tag{2}$$

For square thread

$$C = 25{,}40\sqrt{\frac{\rho}{m}} \tag{3}$$

where

ρ is the density, expressed in grams per cubic centimetre, of the thread, determined as specified in Clause 8;

m is the mass, in milligrams, of the strip.

5.5.3 Express the count of the thread as the median of the values for the five test pieces, as indicated in Clause 5. The maximum and minimum values obtained shall also be stated.

6 Metric yield

6.1 Procedure

Determine the mass of each of five test pieces as specified in 5.4.2.

6.2 Expression of results

6.2.1 The metric yield of rubber thread, expressed in metres per kilogram, is given by Formula (4):

$$\frac{1\,000}{m} \tag{4}$$

where m is the mass, in grams, of 1 000 mm of thread.

6.2.2 Express the metric yield of the thread as the median of the values for the five test pieces.

7 Properties of rubber threads

Properties of rubber threads are made up of two kinds: general physical and mechanical properties, and specific mechanical properties of the threads in contact with fabrics. They shall be determined by the test methods specified in Table 1 and Table 2, respectively.

Table 1 — General properties of rubber threads

Physical and mechanical properties	Clause No.
Density	8
Tensile strength, modulus, elongation at break	9
Schwartz value (SV)	10
Elongation under a specified load	11
Stress retention	12
Tension set	13
Accelerated-ageing test on rubber threads in a relaxed state	14
Dry-heat resistance test	15

Table 2 — Specific properties of rubber threads

Mechanical properties in contact with fabrics	Clause No.
Ribbons: Degree of adhesion between threads	16
Resistance to copper staining during laundering	17
Effect of washing	18
Resistance to atmospheric fume staining	19

8 Density

8.1 Principle

Test pieces are placed in a suitable mixture of liquids, the density of which is adjusted until the test pieces neither float nor sink; this density is determined.

8.2 Method

8.2.1 Method A

8.2.1.1 Most of the rubber threads on the market have a density in the range of 0,90 g/cm^3 to 1,11 g/cm^3. It is necessary, therefore, to have a series of liquids having densities within this range. Mixtures of ethanol (0,79 g/cm^3) and ethylene glycol (1,11 g/m^3) are suitable.

For threads of greater density, a suitable inorganic salt solution can be used. A solution of sodium chloride is suitable.

8.2.1.2 Before the mixtures are used, it shall be ensured that they are homogeneous and free from air bubbles. They shall be kept in closed containers so as to avoid evaporation. They shall be used at a temperature of 20 °C ± 2 °C.

8.2.1.3 Apparatus

8.2.1.3.1 **Glass cylinder**, with a capacity of about 1 000 cm^3.

8.2.1.3.2 **Hydrometer** or **hydrostatic balance** or **other apparatus** allowing measurement of the density of liquids to an accuracy of at least 0,005 g/cm^3.

8.2.1.4 Procedure

8.2.1.4.1 Take four test pieces, approximately 10 mm long, from the sample. Dip each test piece in ethanol and then rub between the fingers to remove dusting powder and any air bubbles from the surface.

8.2.1.4.2 Take a suitable liquid mixture (see 8.2.1.1) and thoroughly homogenize it, taking care not to introduce any air bubbles. Place one of the test pieces in the liquid. Adjust the density of the liquid by the addition of the appropriate component, mixing thoroughly after each addition. Continue this adjustment until the test piece neither sinks nor floats.

8.2.1.4.3 Test the other three test pieces in the mixture; at least two of these three test pieces shall reach equilibrium within a period of 3 min to 10 min.

8.2.1.4.4 Determine the density of the liquid mixture to the nearest 0,005 g/cm^3.

8.2.2 Method B

Determine the density of the test pieces in accordance with ISO 1183-2.

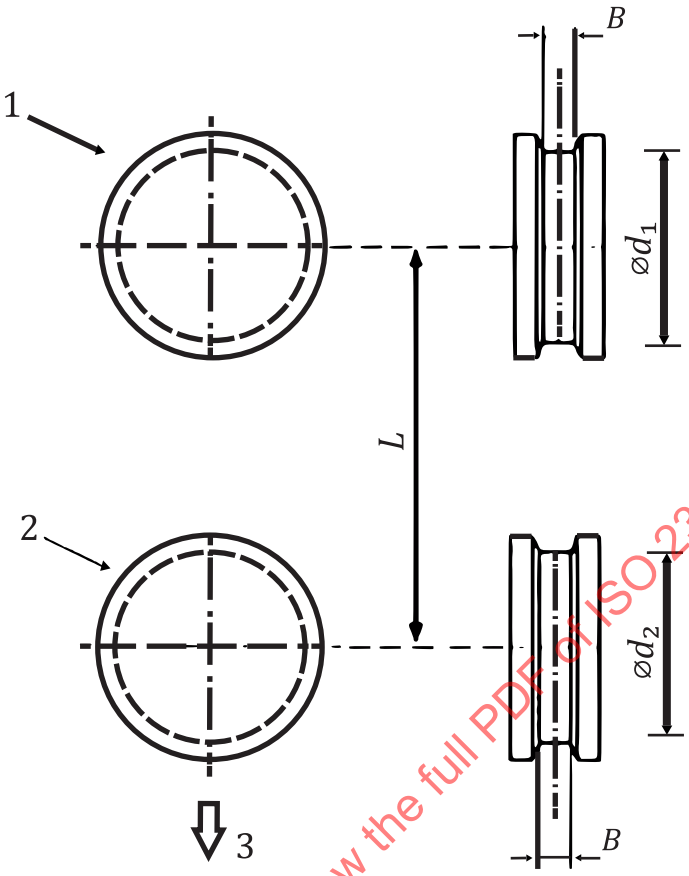
9 Tensile strength, modulus and elongation at break

9.1 Apparatus

9.1.1 Loop-forming machine

9.1.2 **Tensile-testing machine**, as described in ISO 37, with modified O-ring grips based on the standard pulleys for type A rings (see Figure 2).

For example, *B* can be 24 mm to be used conveniently.



Key

1	freely rotating pulley	$\varnothing d_1$	25 ± 0,05 mm
2	freely rotating pulley	$\varnothing d_2$	25 ± 0,05 mm
3	direction of extension	L	(circumference of sample − circumference of roller)/2

Figure 2 — Pulley arrangement for tensile testing of type A rings

9.2 Procedure

9.2.1 Test piece preparation

The thread test piece is allowed to relax at room temperature for 60 min to ensure that all stresses in the thread have been released. It is then weighed and the average diameter of the thread calculated.

Using a loop-forming machine, the rubber thread is made into a loop and the ends tied securely. The diameter of the loop is dependent on the distance between the two cylinders of the tensile-testing machine (see 9.2.2). Usually, these are set at 100 mm apart. The total number of loops for each sample is dependent on the count of the thread and the load capacity of the tensile tester. The more loops there are, the greater the total cross-sectional area, and hence the greater the force that will be needed to stretch the test piece to breaking point.

9.2.2 Loop formation and testing

The test piece is looped over the two cylinders of the tensile tester. The loop diameter shall be such that it fits exactly over the two cylinders without stretching.

The tensile tester is then run to stretch the test piece to breaking point. The machine is set to read the modulus at 300 % and 500 %, and the tensile strength and the elongation at break. Depending on the complexity of the machine, the cross-sectional area of the loop is usually entered into the machine,

and the modulus and tensile strength are then automatically calculated and printed out on a printer or displayed on a computer screen. The elongation at break, calculated as the percentage stretch relative to the original length (100 mm), is automatically displayed by the tensile tester on completion of the test.

Test five test pieces.

9.3 Expression of results

Results are calculated as follows:

$$\text{Modulus at 300 \% (in mN/mm}^2) = F_{300}/A \quad (5)$$

$$\text{Modulus at 500 \% (in mN/mm}^2) = F_{500}/A \quad (6)$$

$$\text{Tensile strength (in mN/mm}^2) = F_B/A \quad (7)$$

$$\text{Elongation at break (in \%)} = \frac{L_B - L_o}{L_o} \times 100 \quad (8)$$

where

F_{300} is the force, in millinewtons, necessary to stretch the test piece to 300 %;

F_{500} is the force, in millinewtons, necessary to stretch the test piece to 500 %;

F_B is the force, in millinewtons, necessary to stretch the test piece to the break point;

A is the total cross-sectional area, in square millimetres, of the test piece;

L_B is the length at break of the test piece;

L_o is the original length of the test piece.

Express the tensile strength, modulus and elongation at break of the thread as the median of the values for the five test pieces. The maximum and minimum values shall also be quoted. In addition, the test report shall indicate the type of apparatus used and the procedure followed.

10 Schwartz value (SV)

10.1 Apparatus

The apparatus described in 9.1 can be used.

10.2 Procedure

Prepare three test pieces each consisting of a loop, or a multiple loop, of thread, the length of the loop being 100 mm ± 1 mm and the number of turns being selected to suit the count of the thread and the capacity of the apparatus.

With a multiple loop, distribute the thread evenly between the turns by rotating the loop around the fingers before placing it over the O-ring grips.

Carry out six cycles of elongation and retraction without interruption to an elongation of c %. On the sixth cycle, take readings at n % elongation (during extension and again during retraction). Minimal pauses to take readings are permissible.

10.3 Expression of results

The Schwartz value, SV_n^c, in megapascals, and the Schwartz hysteresis ratio, SHR_n^c, expressed as a percentage, are given by Formulae (9) and (10):

$$SV_n^c = \frac{F_1 + F_2}{4SN} \tag{9}$$

$$SHR_n^c = \frac{F_2}{F_1} \times 100 \tag{10}$$

where

F_1 is the load, in meganewtons, at n % elongation on extension (6th cycle);

F_2 is the load, in meganewtons, at n % elongation on retraction (6th cycle);

S is the original cross-sectional area, in square metres, of the test piece;

N is the number of complete loops tested.

Express the Schwartz value and Schwartz hysteresis ratio of the thread as the median of the values obtained for the three test pieces. The test report shall also indicate the type of apparatus used and the procedure followed.

11 Elongation under a specified load

11.1 Test pieces

Use one or more pieces of thread, depending on the count, as the test piece. The length will depend on the apparatus used.

11.2 Apparatus

11.2.1 The essential requirements are that the apparatus is capable of stretching a test piece at a constant speed until the load reaches a predetermined value, and that it incorporates a graduated scale for reading the elongation.

11.2.2 A suitable apparatus is shown in Figure 3. It consists of the following:

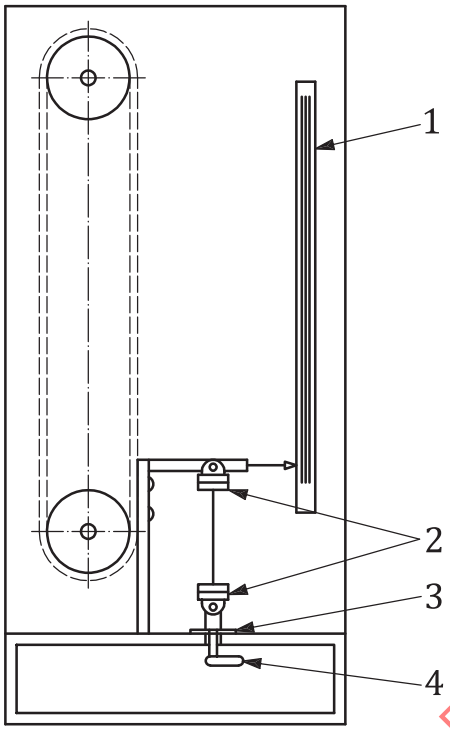
a) a graduated scale for reading the elongation of the test piece;

b) two clamps for gripping the ends of the test piece, the length between the clamps in the initial state being 150 mm ± 2 mm, together with a means of mechanically moving the upper clamp in a vertical direction to extend the test piece at a constant speed of 30 mm/s ± 10 mm/s;

c) a pan, attached to the lower clamp, to which the necessary weights can be added to make up the load appropriate to the count of the thread being tested;

d) an electric switch, situated immediately beneath the pan. When the weight of the pan is exceeded by the force exerted on it by the stretched thread, the pan is lifted and the switch stops the motor and applies the brake.

If, for this test, an apparatus differing from that described above but complying with 9.1 is used, the test report shall state the type of apparatus used and the procedure followed.



Key

1 graduated scale
2 clamps
3 pan for weights
4 electric switch

Figure 3 — Apparatus for determining the elongation under a specified load

11.3 Procedure

Prepare three test pieces of the kind specified in 11.1. Fix the ends of the first test piece in the clamps so that the test piece is taut but unstretched, and add the required weights to the pan. Start the motor and, when it is automatically stopped by the switch, measure the elongation of the test piece on the scale. Report the procedure for the other two test pieces.

11.4 Expression of results

11.4.1 The elongation, A, expressed as percentage, of the test piece under the specified load is given by Formula (11):

$$A = \frac{L_t - L_o}{L_o} \times 100 \qquad (11)$$

where

L_o is the original length, in millimetres, of the test piece;

L_t is the total length, in millimetres, of the extended test piece.

11.4.2 Express the elongation under specified load as the median of the values for the three test pieces.

12 Stress retention

12.1 Test pieces

Test pieces shall consist of loops of the type described in 10.2.

12.2 Apparatus

Figure 4 shows a simple apparatus for carrying out this test. One end of the test piece is passed around one peg, the other end being attached to the other peg by means of a wire clip. A spring dynamometer is attached to the other end of the wire clip and the load required to just lift the clip off the peg is measured. The distance between the two pegs shall be such that the thread is subjected to the specified elongation to within ±2 %.

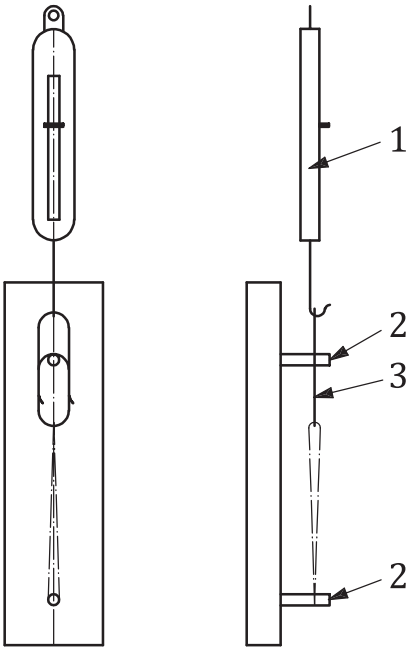
12.3 Procedure

12.3.1 Prepare three test pieces of the kind specified in 12.1. Pass the end of each test piece around the bottom peg and attach the other end to the wire clip as shown in Figure 4. Then, pass the inner loop of the wire clip over the top peg, thus subjecting the test piece to the specified elongation with an accuracy of ±2 % (usually 100 % ± 2 %). Maintain this extension during the test.

12.3.2 When a measurement of stress is to be made, attach the spring dynamometer to the outer loop of the wire clip and raise the dynamometer until the wire clip is just clear of its supporting peg. At this point, read the dynamometer, which just counterbalances the force exerted on the rubber thread.

12.3.3 Take the initial reading 30 min ± 1 min after the initial extension of the thread on the apparatus. Continue to take readings as required up to a maximum of 14 days.

12.3.4 The test may be carried out at ambient or elevated temperatures. The test conditions used and the duration of the test shall be stated in the test report.



Key

1 spring dynamometer
2 pegs
3 wire clip

Figure 4 — Apparatus for determining the stress retention

12.4 Expression of results

12.4.1 The stress retention, expressed as percentage, of the test piece, is given by the Formula (12):

$$\frac{F_2}{F_1}\times 100 \tag{12}$$

where

F_1 is the original load;

F_2 is the residual load.

12.4.2 Express the stress retention of the thread as the median of the values obtained for the three test pieces.

12.5 Test report

If the test elongation used differs from 100 %, this shall be recorded.

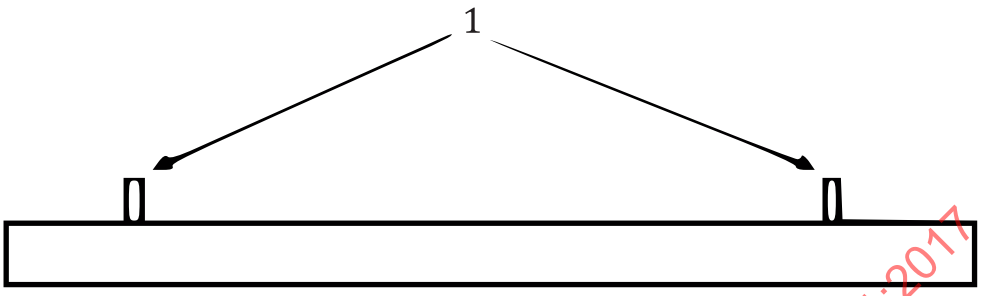
13 Tension set

13.1 Test piece preparation

Use one thread as the test piece. The length will depend on the apparatus used. Two reference marks shall be marked on the central part of the test piece at a distance of 100 mm ± 0,1 mm (L_1).

13.2 Apparatus

A simple apparatus for carrying out this test is shown in Figure 5. Each end of the test piece is attached to each peg. The distance between the two pegs shall be adjustable in such a way that the reference length of the test piece is subjected to the specified elongation to within ±2 %.



Key

1 pegs

Figure 5 — Apparatus for determining the tension set

13.3 Procedure

13.3.1 Fix the ends of the test piece at the pegs so that the test piece is taut but unstretched.

13.3.2 Stretch the test piece until the reference length is extended to the required strain, 80 % of the elongation at break as pre-determined from Clause 9, and hold at this strain for 60 min ± 5 min.

13.3.3 Release the strain, remove the test piece from the pegs and leave it to recover on a non-sticky flat surface for 120 min ± 5 min.

13.3.4 Measure the reference length (L_2).

13.4 Expression of results

The tension set, expressed as a percentage, of the test piece is given by Formula (13):

$$\frac{L_2 - L_1}{L_1} \times 100 \tag{13}$$

where

L_1 is the length between the two reference marks before stretching;

L_2 is the length between the two reference marks after recovery.

Report the result as the mean of the duplicate determinations and the units in which it is expressed. If the individual results differ by more than 0,5 units from the mean, repeat the determination.

14 Accelerated ageing test on rubber threads in a relaxed state

14.1 General

14.1.1 Accelerated-ageing tests on rubber threads in a relaxed state are made in order to determine the change in physical properties of a rubber thread subjected to hot-air treatment at atmospheric pressure, at a controlled temperature and for a specified time.

14.1.2 These accelerated-ageing tests have only a comparative value and cannot be taken as an exact indication of the storage life of rubber threads, as the test conditions cannot reproduce all the various aspects of storage.

14.2 Principle

14.2.1 The ageing properties of a rubber thread are normally evaluated by the following measurements:

a) tensile strength;

a) elongation at break;

b) Schwartz value.

14.2.2 These properties are first determined in accordance with Clauses 9 and 10 on unaged test pieces. The same properties are then determined on other test pieces after hot-air treatment at 70 °C ± 1 °C for 168 h ± 2 h, and compared with the properties of the unaged test pieces.

14.2.3 Other parameters can also be similarly compared.

14.3 Test pieces

A set of test pieces for each of the above properties shall be prepared and identified, as described in Clauses 9 and 10.

14.4 Apparatus

Required is a circulating-air oven, as described in ISO 188, capable of being maintained at 70 °C. A cell-type oven is preferred, as it has the advantage of maintaining test pieces from different samples in separate cells during the ageing process.

14.5 Procedure

14.5.1 Place the set of test pieces in the oven, previously regulated to 70 °C, and left in a relaxed state for 168 h ± 2 h. At the end of the treatment period, remove the set of test pieces from the oven, and leave for 16 h under the conditions described in Clause 4.

14.5.2 Determine the properties listed in 14.2.1 on the aged test pieces.

14.6 Expression of results

The results of this test shall include the following information:

a) the median of the values obtained for each physical property before ageing;

b) the median of the values obtained for each physical property after ageing;

c) the percentage variations in each physical property due to the ageing treatment, as given by Formula (14):

$$\frac{x_a - x_o}{x_o} \times 100 \quad (14)$$

where

x_o is the value of the property before ageing;

x_a is the value of the property after ageing.

15 Dry-heat resistance

15.1 General

15.1.1 Conventional rubber-ageing tests, which are normally carried out on unstretched test pieces, are of limited use in assessing the life of rubber threads, as these are usually continuously extended in use.

15.1.2 The following test provides an indication of the extent of deterioration, by measuring the retention of a selected physical property when a thread is maintained at a constant elongation under conditions more severe than those encountered in service.

15.1.3 The test is for comparative purposes only. It is not possible to correlate the results with the actual service life of the thread.

15.2 Principle

15.2.1 A selected physical property of the thread is determined by the appropriate test method. Test pieces form the same sample, maintained at 100 % elongation, are subjected to ageing in a circulating-air oven. The selected physical property is then measured again and the percentage retention is reported.

15.2.2 The physical property measured in the test can be any of those specified in Clauses 9 to 12. However, the most suitable are the Schwartz value (Clause 10) and the stress retention (Clause 12).

15.3 Apparatus

15.3.1 Test apparatus, suitable for measurement of the selected physical property, as described in 9.1, 10.1, 11.2 or 12.2.

15.3.2 Holders, suitable for maintaining the test pieces at 100 % elongation.

The holder shall be of a material of low thermal expansion and low thermal capacity to minimize dimensional changes on heating and the occurrence of "hot spots" where it is in contact with the thread. Metals, particularly those containing copper or manganese, shall not be used.

NOTE Suitable materials are available commercially. Details can be obtained from the secretariat of ISO/TC 45/SC 4.

15.3.3 Circulating-air oven, as described in ISO 188, capable of being maintained at 100 °C ± 1 °C or 150 °C ± 2 °C. A cell-type oven is preferred as it has the advantage of maintaining test pieces from different samples in separate cells during the ageing process.

15.4 Procedure

15.4.1 Determine the initial value of the selected physical property by the appropriate test method, using the specified number of test pieces.

If the Schwartz value is measured, it is advisable to restrict the maximum massaging extension (the extension to which the test piece is stretched during mechanical conditioning) to 300 % to avoid excessive test piece breakage during massaging after ageing.

If the stress retention at 100 % elongation is measured, massage the thread to 300 % extension for six cycles immediately before extending it to 100 % for the measurement.

15.4.2 Transfer the test pieces, maintained at 100 % extension, to the holders and leave for 60 min ± 10 min under the conditions described in Clause 4.

15.4.3 Place the test pieces, still on their holders, in the circulating-air oven and age under the appropriate conditions given in Table 3. The oven temperature shall be stabilized at the test temperature before the test pieces are inserted.

Precautions shall be taken to ensure that the temperature is not lowered significantly when the test pieces are inserted. An oven with high heat capacity and a minimum time for insertion is essential.

Table 3 — Conditions of ageing

Class of test	Temperature °C	Time h
A (normal)	100 ± 1	22
B (heat-resistant)	150 ± 2	2
NOTE Test B is more severe and is intended for use with threads classified as heat-resistant.		

15.4.4 Remove the test pieces from the oven and keep them under the conditions specified in Clause 4 for a minimum of 16 h.

15.4.5 Re-determine the selected physical property by the method used before ageing.

Breakage can occur at incorrectly tied knots. Test pieces failing in this way shall be re-tested.

15.5 Expression of results

The percentage retention of the initial value of the selected physical property is given by Formula (15):

$$\frac{x_a}{x_o} \times 100 \qquad (15)$$

where

x_o is the value of the property before ageing;

x_a is the value of the property after ageing.

Report the median value.

15.6 Test report

The test report shall contain the following information:

a) the full description of the sample and its origin;

b) the physical property selected and the test method and apparatus used;

c) the ageing time and temperature;

d) the percentage retention of the physical property and the initial value.

16 Ribbons: Degree of adhesion between threads

16.1 General

This method is intended for determining the degree of adhesion between the threads composing a rubber ribbon in order to predict the behaviour of the ribbon in practical use.

16.2 Principle

At one end of the ribbon, all the threads are separated for a short distance into two groups of alternate threads. The minimum force required to separate the threads in these two groups for a further specified distance under a specified rate of extension is determined.

In order to express the result independently of the thread count, the degree of adhesion is usually expressed as the length of ribbon tested whose weight is equivalent to the force required to separate the threads.

16.3 Apparatus

16.3.1 Tensile-testing machine, with a constant traverse rate of 5,0 mm/s ± 0,3 mm/s and with flat clamps so that the individual threads can be aligned parallel to each other. A capacity range from 0 N to 5 N is generally satisfactory. The use of a stress-strain recording paper is suggested.

16.3.2 Simpler apparatus can also be used, consisting of a support (hook or clamp) on which one of the two groups of threads can be hung, together with a pan which can be attached to the other set of threads and on which weights can be placed.

16.4 Test pieces

Each test piece shall normally consist of a piece of an entire ribbon, approximately 500 mm long (see, however, the Note to 16.6).

16.5 Procedure

16.5.1 Separate all the threads at one end of the test piece for about 50 mm.

16.5.2 When using the apparatus described in 16.3.1, group together all the even-positioned and all the odd-positioned threads in two separate groups by placing alternate individual threads on masking tape in order, one after the other. Maintain the alignment of the individual threads.

Set the jaw separation on the test machine at 75 mm.

Mount one set of threads in the upper jaw and the other set in the lower jaw, taking care to ensure parallel alignment of the threads. The free end of the ribbon shall be supported horizontally throughout the test.

Set the apparatus in motion, and record the average force required to separate the threads over a test length of 100 mm.

16.5.3 When using the apparatus described in 16.3.2, group together all the even-positioned and all the odd-positioned threads and knot the free ends. Hang one of the groups from the support, leaving the other free for the attachment of the pan.

Apply a force by adding weights of known mass to the pan until a slow but continuous separation for at least 50 mm of the ribbon is obtained.

16.5.4 During the test, note whether the separation takes place in a uniform manner across the whole of the ribbon; any irregularities indicate different degrees of adhesion for different threads.

16.6 Expression of results

The degree of adhesion of the threads is given by the length, in metres, of ribbon whose weight is equivalent to the average separation force determined.

NOTE In cases when fractions of an entire ribbon, for example 10 threads, are submitted to the test, the value of the degree of adhesion obtained will be multiplied by a correction factor which takes into account the different ratio in the two cases between the number of threads and the lines of adhesion, so that it can be compared with the value of the degree of adhesion for the entire ribbon. This ratio is expressed by the following formula:

$$\frac{(N-1)n}{(n-1)N}$$

where

N is the number of threads in the entire ribbon;

$N-1$ is the number of lines of adhesion in the entire ribbon;

N is the number of threads in the fraction of ribbon tested;

$n-1$ is the number of lines of adhesion in the fraction of ribbon tested.

16.7 Test report

The test report shall contain the following information:

a) all details necessary for complete identification of the ribbon tested;

b) the degree of adhesion, in metres;

c) whether the separation took place uniformly or not.

17 Resistance to copper staining during laundering

17.1 General

17.1.1 This method is intended for determining the amount of staining caused to adjacent textile materials and the amount of discoloration of a rubber thread when it is washed in water containing dissolved copper salts.

17.1.2 This test has only a comparative value, and might not indicate the exact performance of a thread in service because of the wide variation in copper contents of domestic water supplies.

17.2 Principle

The thread under test is placed in intimate contact with textile fabrics and heated in a washing solution containing a known concentration of copper. The amount of staining and discoloration is determined by visual inspection of the test pieces after the test, using an appropriate grey scale.

17.3 Reagents

17.3.1 Copper, standard solution corresponding to 1 g of Cu per cubic decimetre.

Dissolve 3,928 g of copper (II) sulfate pentahydrate ($CuSO_4.5H_2O$) in copper-free distilled water and add 100 cm^3 of 280 g/dm^3 analytical-grade ammonium hydroxide solution.

Transfer the solution quantitatively to a 1 000 cm^3 one-mark volumetric flask, dilute to the mark with copper-free distilled water and mix.

1 cm^3 of this standard solution contains 1 mg of Cu.

17.3.2 Copper, standard solution corresponding to 5 mg of Cu per cubic decimetre.

Transfer 5,0 cm^3 of the standard copper solution (see 17.3.1) to a 1 000 cm^3 one-mark volumetric flask, dilute to the mark with copper-free distilled water and mix.

1 cm^3 of this standard solution contains 5 µg of Cu.

Prepare this solution at the time of use.

17.3.3 Soap, standard solution, or **sodium dodecylbenzenesulfonate**.

Prepare the soap solution by dissolving 10 g of analytical-grade sodium hydroxide in 100 cm^3 of copper-free distilled water and adding 500 cm^3 of near-boiling copper-free distilled water. Stir into this solution 70,5 g of analytical-grade oleic acid and heat to 70 °C. When frothing has died down and the solution is cool, transfer it quantitatively to a 1 000 cm^3 one-mark volumetric flask, dilute to the mark with copper-free distilled water and mix.

17.4 Apparatus and materials

17.4.1 Aluminium plates, 50 mm × 50 mm ×3 mm.

17.4.2 Beakers, of capacity 250 cm^3.

17.4.3 Thermometer, range 0 °C to 100 °C, graduated in divisions of 0,2 °C.

17.4.4 One-mark volumetric flasks, of capacity 1 000 cm^3, complying with the requirements of ISO 1042.

17.4.5 Pipettes, 5 cm^3 and 1 cm^3, complying with the requirements of ISO 648.

17.4.6 Textile fabric samples: These may be either individual samples of white acetate, cotton, nylon and viscose fabrics, yarns, or multifibre fabric swatches[1)].

1) The multifibre fabric swatch consists of strips of acetate, cotton, nylon, polyester, acrylic and wool and can be obtained from Testafabrics Inc., 55 Van Dam St., New York, USA, from The Society of Dyers and Colourists, PO Box 244, Perkin House, 82 Grattan Rd, Bradford, BD1 2JB, England, or from Wentworth Instruments, North Green, Datchet, Slough SL3 9JH, England. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these suppliers.

17.4.7 Grey scale[2], complying with the requirements of ISO 105-A03, for assessing staining.

17.4.8 Grey scale[2], complying with the requirements of ISO 105-A02, for assessing change in colour.

NOTE Details of suitable materials can be obtained from the secretariat of ISO/TC 45/SC 4.

17.5 Test pieces

Each test piece shall consist of 0,5 g to 1,0 g of uncovered rubber thread.

17.6 Preparation of test pieces

17.6.1 General

Each test piece shall consist of an intimate assembly of the rubber thread under test and the various fabrics or yarns (see 17.4.6). The textile shall be free from finishing agents which might interfere with staining, and the amount of extractable matter in the textile shall not exceed 0,3 % (by mass). The following methods shall be used, depending on the fabric specimens available.

17.6.2 Individual samples of textile fabric

Take 0,5 g to 1,0 g of rubber thread and form it into a skein or hank of length approximately 75 mm. Place the skein on a piece of acetate fabric and place a piece of cotton fabric over the top. Roll at right angles to the rubber skein length to form a cylinder, and tie by wrapping with cotton thread. Repeat for nylon and viscose fabrics.

17.6.3 Individual textile yarns

Form skeins of all the yarns and the rubber thread on a textile "wrap reel". Cut each skein and take one cut end of the rubber, acetate and cotton skeins and tie together with cotton thread. Plait the three components together into an intimate assembly for a distance of approximately 75 mm and tie off as for the starting end. Make a second plaited assembly for the rubber, nylon and viscose fabrics.

17.6.4 Multifibre fabric swatches

Place a 50 mm length of multifibre fabric swatch on an aluminium plate (see 17.4.1). Wrap 0,5 g to 1,0 g of rubber thread on top of the fabric so that it crosses each of the fibres snugly but with a minimum of tension.

17.7 Procedure

17.7.1 Place 200 cm^3 of standard copper solution (see 17.3.2) in a beaker (see 17.4.2) and add either 1 cm^3 of standard soap solution or 1 g of sodium dodecylbenzenesulfonate (see 17.3.3).

17.7.2 Raise the temperature of the test solution to 70 °C ± 2 °C and add the test piece (see 17.6). Maintain at this temperature for 30 min, with occasional stirring.

17.7.3 Remove the test piece, rinse with cold distilled water and drain. Allow to dry in air on a watch-glass at a standard laboratory temperature (see ISO 23529).

2) The grey scales can be obtained from the Society of Dyers and Colourists, PO Box 244, Perkin House, 82 Grattan Rd, Bradford, BD1 2JB, England, or from the American Association of Textile Chemists and Colourists, PO Box 12215, Research Triangle Park, NC 27709, USA. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of these suppliers.

17.7.4 Remove the rubber thread from the textile samples and determine, using the appropriate grey scale, any staining of the textiles and any discoloration of the rubber thread.

17.7.5 Carry out a separate test for each rubber thread.

17.8 Test report

The test report shall contain the following information:

a) the numerical rating for the staining of each fabric, using the appropriate grey scale;

b) the numerical rating for the discoloration of the thread, using the appropriate grey scale.

If no staining or discoloration was evident, the test piece shall be reported as non-staining.

18 Effect of washing

18.1 General

18.1.1 Rubber threads, or garments containing them, are very often subjected to washing treatments which differ considerably in the composition of the washing liquid and in temperature. Information on the composition of commercial detergents is not readily available, and the same brand name can cover various compositions.

18.1.2 The following test provides an indication of the effect of washing on a rubber thread, by measuring the retention of a selected physical property when a thread is submitted to a standardized treatment of washing using a standard washing solution, drying and ageing.

18.1.3 The test is for comparative purposes only. It is not possible to correlate the results with the actual service life of the thread or of an article containing it.

18.2 Principle

18.2.1 A selected physical property of the thread is determined by the appropriate test method. Test pieces from the same sample, maintained to 100 % elongation, are then subjected to one cycle of washing, drying and air-oven ageing. The selected physical property is then measured again and the percentage retention is reported.

18.2.2 The physical property measured in the test can be any of those specified in Clauses 9 to 12. However, the most suitable are Schwartz value (see Clause 10) and the stress retention (see Clause 12).

18.3 Apparatus

18.3.1 Test apparatus, suitable for measurement of the selected physical property, as described in 9.1, 10.1, 11.2 or 12.2.

18.3.2 Holders, suitable for maintaining the test pieces at 100 % elongation.

Glass or stainless-steel holders are suitable for the washing treatment. For ageing, holders as described in 15.3.2 shall be used.

18.3.3 Standard textile wash wheel, or other apparatus capable of maintaining the washing solution at the correct temperature and providing mild agitation while holding the stretched test piece completely immersed in the solution.

If a standard textile wash wheel is used, the holders shall be fixed securely in the pots to avoid damage to the thread during agitation.

18.3.4 Circulating-air oven, as described in ISO 188, capable of being maintained at a temperature of 125 °C ± 1 °C. A cell-type oven is preferred as it has the advantage of maintaining test pieces from different samples in separate cells during the ageing process.

18.4 Standard washing solution

18.4.1 The standard washing solution shall contain the following ingredients per cubic decimetre of solution in distilled water:

— 1,0 g of sodium dodecylbenzenesulfonate;

— 1,5 g of anhydrous sodium tripolyphosphate;

— 0,5 g of sodium perborate;

— 0,5 g of anhydrous sodium silicate [$Na_2O{:}SiO_2$ (1 : 2)];

— 1,0 g of anhydrous sodium sulfate;

— 0,008 6 g of copper (II) sulfate pentahydrate.

18.4.2 Within 1 h of the washing test, prepare a sodium perborate solution by dissolving 2,0 g of sodium perborate in 98,0 g of distilled water at room temperature. Immediately before immersion of the test pieces, add 25 g of this solution to 975 g of a solution containing all the other chemicals heated to the washing temperature.

18.4.3 Use 100 g of the standard washing solution for each gram of thread to be tested. If the amount of washing solution needed to cover the test pieces exceeds this ratio, add more thread from the same sample to make up the deficiency.

18.5 Procedure

18.5.1 Determine the initial value of the selected physical property by the appropriate test method, using the specified number of test pieces.

If the Schwartz value is measured, it is advisable to restrict the maximum massaging extension (the extension to which the test piece is stretched during mechanical conditioning) to 300 % to avoid excessive test piece breakage during massaging after ageing.

If the stress retention at 100 % elongation is measured, massage the thread to 300 % extension for six cycles immediately before extending it to 100 % for the measurement.

18.5.2 Transfer the test pieces, maintained at 100 % elongation, to a stainless-steel or glass holder and allow to rest for 60 min ± 10 min under the conditions described in Clause 4.

18.5.3 Wash each type of thread in a separate wash bath in the standard washing solution at 85 ± 1 °C for 1 h with mild agitation.

18.5.4 Remove the holders from the solution, wash for 10 min in running water, blot free of excess water with an absorbent towel and dry for 110 min at room temperature.