INTERNATIONAL STANDARD 2062

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

Textiles — Yarn from packages — Method for determination of breaking load and elongation at the breaking load of single strands — (CRL, CRE and CRT testers)

First edition — 1972-09-01

UDC 677.017.422.2/.4 : 620.172.24

Ref. No. ISO 2062-1972 (E)

Descriptors : textiles, yarns, tension tests, tests, determination, breaking load, elongation.

Price based on 9 pages

FOREWORD

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Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 2062 was drawn up by Technical Committee ISO/TC 38, *Textiles.*

It was approved in December 1970 by the Member Bodies of the following countries :

Chile	Israel	South Africa, Rep. of
Czechoslovakia	Italy	Spain
Denmark	Japan	Sweden
Finland	Korea, Rep. of	Switzerland
France	New Zealand	Thailand
Germany	Norway	Turkey
Greece	Poland	United Kingdom
Hungary	Portugal	U.S.A.
India	Romania	U.S.S.R.

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Belgium
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Printed in Switzerland

Textiles – Yarn from packages – Method for determination of breaking load and elongation at the breaking load of single strands – (CRL, CRE and CRT testers)

1 SCOPE AND FIELD OF APPLICATION

1.1 This International Standard specifies a method for the determination of the breaking load and breaking elongation of various types of yarn. It is designed primarily for yarn in package form but can be used for single strands extracted from a fabric.

1.2 This method[1] is applicable to

a) single yarns (spun, monofilament or multifilament);

b) folded (plied) yarns;

c) cabled yarns.

1.3 This method is not applicable, except by agreement, to yarns which stretch more than 0.5 % when the tension increases from 0.5 to 1.0 centinewton per unit of linear density of the yarn in tex. Such yarns may be tested under special conditions which are accepted by all the parties interested in the test results.

1.4 The method is not applicable to yarns having a linear density greater than 2 000 tex. For such yarns, other skein lengths and special conditions of reeling may be adopted by agreement of all parties interested in the test results.

1.5 Optional procedures for determining the breaking load and elongation at the breaking load are included. Option I covers tests based on specimens in equilibrium with the standard atmosphere for testing; Option II covers tests based on specimens in the wet state.

1.6 The method authorizes the use of the following types of testing machines in common use for measuring the breaking load and elongation at the breaking load of yarns :

a) constant-rate-of-load (CRL) (see Option IA, section 12);

b) constant-rate-of-specimen-extension (CRE) (see Option IB, section 13);

c) constant-rate-of-traverse of the driven clamp (CRT), with pendulum or spring weighing mechanism (see Option IC, section 14).

The three types of testing machines do not necessarily give the same breaking load for the same yarn. The type of tester used must accordingly be agreed upon by all parties interested in the test results, and must be reported. It has been found that the breaking loads obtained on different types of tester agree best when the time to break is the same. Therefore, this method provides for testing at a specified time to break (20 ± 3 s), and no provision is made for specified rates of loading, elongation or traverse.

NOTE – Excellent experimental agreement has been reported in the literature between CRE and CRT testers if the time to break was the same. Results of CRL testers have in some cases been reported to differ somewhat from those obtained on CRE and CRT testers even if the time to break was the same.

1.7 Automatic testing machines may be used provided that they can be operated under the specified conditions.

2 REFERENCES

ISO/R 139, *Standard atmospheres for conditioning and testing textiles.*

ISO/R 1139, *Textiles – Designation of yarns.*

ISO 2060, *Textiles – Yarn from packages – Method of test for linear density (mass per unit length) – Skein method.* (At present at the stage of draft.)

3 DEFINITIONS

3.1 breaking load : The maximum load (or force) applied to a specimen in a tensile test carried to rupture. It is expressed in newtons, centinewtons or millinewtons.

3.2 elongation : Increase in length; extension; the increase in length of a specimen during a tensile test expressed in units of length, for example, centimetres.

1) See also ISO . . ., *Determination of the breaking strength and breaking elongation of glass yarns taken from packages* (in preparation, at present document ISO/TC 61 N 1829) which was prepared especially for the needs of glass textile technology.

3.3 elongation, per cent : The increase in length of a specimen expressed as a percentage of the original length; extension per cent.

NOTE – In a tensile test, the elongation per cent, or extension per cent, is calculated on the basis of the nominal gauge length of a pre-tensioned specimen.

3.4 elongation at the breaking load : The elongation produced by the breaking load, i.e. the maximum load.

3.5 elongation at rupture : The elongation occurring at the final rupture of the specimen. The elongation at rupture is usually, but not always, identical with the elongation at the breaking load.

3.6 tenacity : The ratio of the tensile tension to the linear density of the unstrained specimen; for example, centinewtons/tex.

3.7 breaking tenacity : The tenacity corresponding to the breaking load.

NOTE – The breaking tenacity is calculated from the breaking load and the linear density of the unstrained specimen, or obtained directly from tensile testing machines which can be suitably adjusted to indicate tenacity instead of breaking load, for specimens of known linear density.

3.8 breaking length : A measure of the breaking stress of a yarn or fibre; the calculated length of a specimen whose weight is equal to its breaking load.

NOTE – The value obtained is dependent on the local value of gravitational acceleration (g).

3.9 moisture equilibrium : The condition reached by a sample at a closely defined temperature and relative humidity when the net difference between the amount of moisture absorbed and the amount desorbed, as indicated by a change in mass, shows no trend and becomes insignificant.

3.10 moisture equilibrium for testing : A textile material is in moisture equilibrium with the ambient atmosphere when it does not exchange water with this atmosphere; its mass remains constant as long as the experiment is carried out in an unchanged atmosphere. For test purposes, moisture equilibrium must be reached by absorption, starting from a relatively low moisture content. Moisture equilibrium for testing is considered as having been reached when the rate of increase in mass of a sample or specimen does not exceed that prescribed for the material being tested. (See ISO/R 139.)

3.11 nominal gauge length : The length of a specimen under specified pre-tension, measured from nip to nip of the jaws of the holding clamps in their starting positions and including any portion of the specimen in contact with snubbing surfaces.

3.12 yarn package : A length or lengths of yarn in a form suitable for use, handling, storing or shipping. Packages may be unsupported, such as balls, skeins or cakes or supported, such as bobbins, cops, cones, pirns, spools, tubes, or beams.

3.13 strand

a) A single fibre, filament, or monofilament.

b) An ordered assemblage of textile fibres having a high ratio of length to diameter and normally used as a unit, including slivers, rovings, single yarns[1], plied yarns, and cords.

3.14 time-to-break : The interval, measured in seconds, from the moment when, with the apparatus in operation, the force exceeds the pre-tension, until it attains the maximum value.

4 PRINCIPLE

4.1 Elongation of the specimen until rupture, by a suitable mechanical means which indicates the maximum load and elongation at the breaking load. The testing machine shall be operated at such a rate that the average time-to-break of a group of specimens falls within specified time limits. Elongation at specified load, or load at specified elongation, may be reported if desired.

4.2 The specified limits for the average time-to-break is 20 ± 3 s.

4.3 The derived value for breaking load per unit yarn linear density, i.e the breaking tenacity or the breaking length, is calculated if desired.

5 APPARATUS

5.1 Tensile testing machine

5.1.1 All tensile testing machines shall include a pair of suitable clamps to grip the specimen, a means of loading or elongating the specimen at suitable rates, and a load-indicating mechanism which will indicate or record continuously the load applied to the specimen and the accompanying elongation. An autographic recorder is desirable for the determination of elongation at a specified load. The dynamic response rate of any recorder must be sufficiently rapid that it will accurately record the steepest part of the load-elongation curve.

5.1.2 The maximum error of the indicated load at any point in the range in which the machine is used shall not exceed 1 %. The error for indicated clamp separation shall not exceed 1 mm. Before use, verify the accuracy of the

1) The term "yarn" is fully defined in ISO/R 1139.

graduated scale of the apparatus dynamically, for example by means of calibrated springs of appropriate characteristics.

5.1.3 The testing machine shall be capable of testing specimens having a nominal gauge length of 500 mm.

5.1.4 The jaws of the clamps shall be smooth, flat, and capable of holding the specimens without slippage and without apparent damage. When specimens cannot be satisfactorily held with unlined flat-faced jaws, then lined jaws or, if necessary, bollard clamps or other type of snubbing device which are mutually agreeable to all parties interested in the test results, may be used. Such use shall be noted in the report and attention drawn to the fact that the specimen length is not determined precisely and consequently the indicated elongation should not be compared with that obtained with unlined flat jaws.

5.1.5 All testing machines shall include facilities for producing different constant rates of operation in order to break specimens in the specified average time-to-break of 20 ± 3 s. Different rates can be obtained most readily by means of a continuously variable drive but satisfactory results can be obtained by means of a series of steps, provided that the latter are small enough. Steps varying in a ratio of not more than 125 : 100 are recommended.

5.2 Equipment for producing and maintaining the standard atmosphere for testing in the laboratory (see section 6).

5.3 Equipment for producing and maintaining a suitable atmosphere for pre-conditioning (see section 6).

5.4 Equipment in which skeins or specimens can be immersed in water preparatory to wet testing (see Option II, section 15).

5.5 Equipment for reeling laboratory sample skeins

Reels shall be fitted with a traversing mechanism that will avoid bunching the yarn and with suitable tensioning devices.

5.6 Stop watch or **Interval timer.**

5.7 Distilled or demineralized water for wetting out yarn specimens.

5.8 Non-ionic wetting agent or **surfactant.**

6 STANDARD ATMOSPHERE

The standard atmospheres for conditioning and testing textiles are those defined in ISO/R 139.

NOTE — Air at 20 °C and 65 % R.H. has a water vapour pressure of 1 515 N/m² and when heated to 47 ± 3 °C will produce an atmosphere having a relative humidity of 12.3 to 16.7 %. Air at the maximum limit of 22 °C and 67 % R.H. has a water vapour pressure of 1 770 N/m² which, heated to 44 to 50 °C, results in humidites in the range of 14.3 to 19.4 %. If it is desired to keep the R.H. below 10 % and not to exceed a temperature of 50 °C, then the original air must have a water vapour pressure below 1 230 N/m², equivalent to 53 % R.H. at 20 °C or 30 % R.H. at 27 °C.

7 SAMPLES

7.1 Samples shall be taken in one of the following ways :

a) according to the directions, if any, given in the material specification;

b) according to the procedures approved by ISO for textile products, if directions for sampling are not included in the material specification;

c) according to the method given in Appendix Y, if neither a) nor b) is applicable.

7.2 The bulk sample and laboratory sample packages shall be taken as directed in Appendix Y.

7.3 Laboratory sample skeins may be taken to accelerate pre-conditioning and to serve as the source of specimens. They shall be representative of the bulk sample. In reeling the skein, take the yarn from the end of the package if this is the normal method of use, otherwise take the yarn using the least tension practicable. Skeins shall be reeled under conditions which avoid tension above that needed to lay the yarn smoothly on the reel. The skeins shall be of the length required for the number of tests to be made. (See section 8.)

7.4 Conditioning of laboratory sample skeins and packages shall be carried out as follows :

7.4.1 Pre-condition the laboratory sample packages or laboratory sample skeins from which specimens are to be taken by exposing them to freely moving air in the special atmosphere for pre-conditioning (see section 6) for a minimum time of 4 h.

7.4.2 After pre-conditioning as described in 7.4.1, bring the specimens to moisture equilibrium for testing by exposing the skeins to the appropriate standard atmosphere for testing for a minimum period of 24 h or by exposing original tightly wound packages for 48 h (see also Appendix Z).

8 SPECIMENS

8.1 Length

Individual specimens shall have a minimum length of 600 mm of yarn; a length of 1 000 mm facilitates handling and preservation of twist.

8.2 Number of specimens

8.2.1 Test the number of specimens required in the material specification, when applicable.

8.2.2 In the absence of material specification, all parties interested in the test results shall agree upon

a) the acceptable level of probability of the test results;

b) the desired precision of the test result;

c) representative values for the coefficient of variation, or the standard deviation of the type of yarn to be tested.

The number of tests shall then be calculated according to accepted statistical methods. If, for any reason, it is impractical to make the indicated number of tests, it will be necessary to revise the specified precision or probability or both.

8.2.3 When the directions given in 8.2.1 and 8.2.2 do not apply or are inoperable, choose a number of specimens which will give a precision (maximum permissible error of the mean) of ± 4 % at a probability level of 90 %. The number of specimens can be calculated as $0.17\ V^2$, where V is the coefficient of variation of the individual breaks. V should preferably be based on long past experience with yarns of a type similar to that being tested.

8.2.4 If V is not known, test the number of specimens given in Table 1 below. The coefficients of variation V on which these numbers of tests are based are also indicated.

TABLE 1 — **Number of tests to obtain a precision of ± 4 % at a probability level of 90 %**

Type of yarn	Number of tests	V %
Single spun	60	18.5
Plied spun Single multifilament	30	13
Plied multifilament Cabled spun yarns	20	11

NOTE — The values of V assumed in Table 1 are somewhat higher than will be found in practice in most cases. By knowing the value of V which actually applies to the yarn under test, it will usually be possible to make fewer tests than specified in Table 1.

8.2.5 Take, as nearly as possible, the same number of specimens from each of the packages, of which there should be no fewer than ten (see Appendix Y, section Y.2).

8.3 Selection

8.3.1 Depending on the purpose of the test and the equipment to be used, specimens may be taken from either

a) laboratory sample skeins, or

b) laboratory sample packages.

The alternative selected shall be agreeable to all parties interested in the test results. In either case, the specimens shall be selected at random.

8.3.2 If more than one specimen is to be taken from a laboratory sample skein, cut the skein and secure the ends with clamps to prevent loss of twist. Withdraw test specimens at random.

8.3.3 If more than one test specimen is taken from an individual package, select them at random in such a manner as to minimize the effect of cyclic variations introduced during the manufacturing process, for example, at intervals of at least 1 m between successive specimens along the yarn. If more than five specimens are taken from an individual package, groups of specimens, not more than five to a group, shall be taken at intervals of several metres. When taking individual specimens or reeling laboratory sample skeins, discard the few metres of yarn at the beginning and end of the package in order to avoid damaged sections.

8.3.4 Take precautions to avoid any loss of twist in the individual specimen before it has been secured in the clamps of the testing machine. Take the yarn from the package as directed in 7.3.

9 PROCEDURE

9.1 Check the testing machine to make sure that the clamps are the specified distance apart, 500 ± 1 mm. See that the clamps are properly aligned and parallel so that the subsequent application of force to the specimen will not cause any angular deflection of either clamp. Determine that the appropriate standard atmosphere for testing prevails. (See section 6.) Make sure that any recording mechanism is operating properly.

NOTE — By mutual agreement, the nominal gauge length of 250 ± 0.5 mm may be used, though under these conditions, results for breaking load are likely to be slightly higher than those obtained with a gauge length of 500 mm.

9.2 Mount the specimen (after pre-conditioning and conditioning to moisture equilibrium for testing as directed in 7.4.1 and 7.4.2) in the testing machine so that the axis of

the specimen is at right angles to the edges of the clamps and place the specimen under the prescribed pre-tension (see 9.3). Do not touch the part of the specimen which will subsequently be stressed (i.e. the length between the clamps) with the bare hand.

9.3 Apply a tension equal to 0.50 ± 0.1 cN/tex, calculated from the nominal linear density of the yarn, unless this tension stretches the specimen more than 0.5 %, in which case a mutually acceptable lower tension should be applied.

9.4 Set the moving clamp in motion at a rate estimated to result in an average time-to-break of 20 ± 3 s. After the specimen has broken, note the maximum load. Note the elongation at breaking load (maximum load) and if required, at rupture. Note the time-to-break. Return the moving clamp to its zero position and remove the ends of the broken specimen.

9.5 If the average time-to-break of the first five tests does not fall within the specified limits of 20 ± 3 s, discard the results. Make the necessary mechanical or electrical adjustments designed to secure an average time-to-break within the specified limits. Make five more tests under the adjusted conditions, note the average time-to-break, and make further adjustments if necessary.

9.6 After obtaining five tests with an average time-to-break within 20 ± 3 s, make the required number of observations on individual specimens under essentially the same conditions. Note the time-to-break for each specimen, or for all specimens, and if the average time required for the needed number of specimens does not fall within the specified limit, discard the results and make a further adjustment of the rate of operation of the machine.

9.7 Discard all observations secured on specimens which slip between the jaws, or break in the clamps, or break within 5 mm of the edge of the clamps. The number of observations discarded as directed above shall be noted. If it exceeds 10 % of the number of specimens tested, the jaws of the clamps shall be overhauled. If necessary, the specimens shall be tested with bollard clamps or other type of snubbing device, though under these conditions, observed values for elongation will not be comparable with those obtained with regular clamps.

9.8 Specimens of very low twist multifilament yarns of which more than 10 % of the specimens break in the clamps shall be given 120 ± 10 turn/m twist prior to being tested for breaking load.

10 CALCULATION OF RESULTS

10.1 Units — All tests

The breaking load shall be expressed in newtons, centinewtons or millinewtons. The observed elongation shall be recorded in millimetres and calculated as a percentage of the nominal gauge length of the unstrained specimen.

10.2 Calculation of breaking (maximum) load and elongation at breaking load

10.2.1 Average breaking load

$$= \frac{\text{sum of observed values for breaking loads}}{\text{number of observations}}$$

Calculate the average breaking load to four significant figures and round it off to three significant figures.

10.2.2 Elongation at breaking load or at rupture of individual specimens, in per cent,

$$= \frac{\text{observed elongation at breaking load or at rupture, in millimetres} \times 100}{\text{nominal gauge length of specimen, in millimetres}}$$

10.2.3 Average elongation at breaking load or at rupture, in per cent,

$$= \frac{\text{sum of observed elongation at breaking load, in per cent}}{\text{number of observations}}$$

Round off the average elongation at breaking load or at rupture to the nearest 0.2 % when the average elongation is below 10 %, to the nearest 0.5 % when the average is over 10 % and below 50 %, and to the nearest 1.0 % for elongation of 50 % or greater.

10.3 Precision of observations

Calculate the coefficient of variation of the breaking load and of the elongation at breaking load or at rupture by recognised statistical procedures, assuming that all results come from a single population, i.e. make no allowance for within and between package variation.

10.4 Breaking tenacity

If desired, calculate the breaking tenacity from the breaking load determined as directed in this International Standard and the linear density determined by the method specified in ISO 2060. Round off the calculated value to three significant figures.

Average breaking tenacity in centinewtons/tex,

$$= \frac{\text{average observed breaking load, in centinewtons}}{\text{average determined linear density, in tex}}$$

10.5 Breaking length

The average breaking length, in kilometres, is equal to the breaking tenacity, in centinewtons/tex, divided by 0.98.

11 TEST REPORT

The test report shall state that the tests were performed in accordance with this International Standard and shall indicate which of any alternative or optional requirements have been met. In addition, it shall give the following information :

a) the type of yarn package (i.e. cone, spool, etc.), its condition (i.e. dyed, bleached, etc.) and the manner in which the yarn was withdrawn from the package;

b) for each package, the average breaking load in newtons, centinewtons or millinewtons;

c) for all packages, the average breaking load in newtons, centinewtons or millinewtons;

d) for each package, the average elongation at breaking load or at rupture, in per cent;

e) for all packages, the average elongation at breaking load or at rupture, in per cent.;

f) the coefficient of variation of the breaking load;

g) the coefficient of variation of the elongation at breaking load;

h) the sampling scheme employed;

i) the number of specimens tested;

j) the method used, including the method of pre-conditioning and conditioning, specimen length, and the average time-to-break;

k) the type and capacity of the testing machine used, and the type of clamps employed;

l) the linear density[1] of the bulk sample in units of the Tex System;

m) the average breaking tenacity[1], in newtons, centinewtons or millinewtons per unit of linear density expressed in units of the Tex System; or the average breaking length, in kilometres.

12 OPTION IA — CONSTANT-RATE-OF-LOAD TYPE TESTING MACHINE

12.1 Principle

The specimen is subjected to an increasing load at a predetermined constant rate such that the average time-to-break will fall within the specified limits.

12.2 Apparatus

12.2.1 Constant-rate-of-load tensile testing machine meeting the specifications stated in 5.1.1, 5.1.2, 5.1.3 and 5.1.4. The rate of increase of load per unit of time shall be uniform within ± 10 % after the first 2 s of the test operation. The machine shall be capable of applying a range of constant rates of loading such that, regardless of the strength of the specimen, the breaking load (maximum load) required can be applied within 20 ± 3 s.

12.2.2 Items 5.2 to 5.6 listed in section 5.

12.3 Procedure

Check the testing machine as directed in 9.1 and mount the properly conditioned specimen as directed in 9.2 and 9.3. Set the machine in operation and break the required number of specimens as directed in 9.4, 9.5, 9.6, 9.7 and 9.8.

12.4 Calculation

Calculate the average breaking load and the average elongation at breaking load or at rupture and derived values, if desired, as directed in section 10.

12.5 Test report

Report the information required in the list given in section 11.

13 OPTION IB — CONSTANT-RATE-OF-SPECIMEN-EXTENSION TYPE TESTING MACHINE

13.1 Principle

The specimen is elongated at a predetermined constant rate such that the average time to reach the breaking elongation will fall within the specified limits.

13.2 Apparatus

13.2.1 A constant-rate-of-specimen-extension testing machine meeting the specifications stated in 5.1.1, 5.1.2, 5.1.3 and 5.1.4. The rate of increase in the distance between the clamps shall be uniform within ± 5 % after the first 2 s of the operation. The testing machine shall be capable of operating at different constant rates of elongation such that, regardless of the elongation of the specimen, the latter is elongated to the point of maximum load within 20 ± 3 s.

13.2.2 Items 5.2 to 5.6 as listed in section 5.

13.3 Procedure

Check the testing machine as directed in 9.1 and mount the properly conditioned specimens as directed in 9.2 and 9.3. Set the machine in operation and break the required number of specimens as directed in 9.4, 9.5, 9.6, 9.7 and 9.8.

1) If it has been decided to make this test.

13.4 Calculation

Calculate the average breaking load, and the average elongation at breaking load or at rupture and derived values, if desired, as directed in section 10.

13.5 Test report

Report the information required in the list given in section 11.

14 OPTION IC – CONSTANT-RATE-OF-TRAVERSE TYPE TESTING MACHINE

(Pendulum or spring weighing mechanism)

14.1 Principle

The specimen is subjected to an increasing load by traversing the driven clamp at a constant rate such that the average time-to-break will fall within the specified limits.

14.2 Apparatus

14.2.1 Constant-rate-of-traverse testing machine with a pendulum or spring weighing mechanism, meeting the specifications stated in 5.1.1, 5.1.2, 5.1.3 and 5.1.4. The machine shall be capable of applying a range of loads in such a manner that, regardless of the strength of the specimen, the breaking load (maximum load) required can be applied within 20 ± 3 s.

14.2.2 Items 5.2 to 5.6 listed in section 5.

14.3 Procedure

Check the equipment as directed in 9.1 and mount the properly conditioned specimen in the clamps as directed in 9.2 and 9.3. Set the machine in operation and break the required number of specimens as directed in 9.4, 9.5, 9.6, 9.7 and 9.8.

14.4 Calculation

Calculate the average breaking load and the average elongation at breaking load or at rupture and derived values, if desired, as directed in section 10.

14.5 Test report

Report the information required in the list given in section 11.

15 OPTION II – TEST ON WET SPECIMENS

15.1 Preparation of specimens

Prepare the specimens as directed in sections 7 and 8 but do not pre-condition or condition the samples as directed in 7.4.1 and 7.4.2. Clamp a group of specimens by both ends to prevent loss of twist and lay them on the surface of distilled or de-mineralized water at a temperature of 20 ± 2 °C until they sink under their own weight; or alternatively, forcibly immerse them for a minimum time of 1 h. On those occasions when the complete wetting-out of yarns normally resistant to wetting is essential, an aqueous solution of a non-ionic wetting agent of a concentration not exceeding 0.1 % may be used. In all cases care must be taken to avoid loss of twist or stretching of the specimens during the wetting-out operation. If a wetting agent has been used, the specimen must be thoroughly rinsed in distilled or de-mineralized water before making the test.

15.2 Procedure

Mount the specimens as directed in 9.2 and 9.3 but use a pre-tension of 0.25 ± 0.025 cN/tex instead of the 0.5 cN/tex specified in 9.3. Transfer the wet specimens directly from the wetting-out tank to the testing machine and break the specimens at once, and in any case, within 2 min after removing them from the water bath. Use the type of testing machine specified in Option IA, IB or IC as mutually agreed upon.

15.3 Calculation

Calculate the average breaking load and the average elongation at breaking load or at rupture and derived values if desired, as directed in section 10.

15.4 Test report

Report the information required in the list given in section 11.