

JIS

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JAPANESE INDUSTRIAL STANDARD

Testing Methods for Man-Made

Staple Fibres

JIS L 1015-1981



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JAPANESE INDUSTRIAL STANDARD

J I S

Testing Methods for Man-Made
Staple Fibers

L 1015-1981

1. Scope

This Japanese Industrial Standard specifies the testing methods for man-made staple fibers.

Remarks 1. This is also applicable to a single fiber in the tow of man-made fibers.

2. In this standard the units and numerical values in { } are in accordance with the International System of Units (SI), and are given for reference only.

2. Definition

The definitions of the terms used in this standard shall be as follows:

(1) standard condition of laboratory This shall be the condition under standard temperature and humidity of grade 2 (temperature $20 \pm 2^{\circ}\text{C}$, relative humidity $65 \pm 2\%$) specified in JIS Z 8703.

(2) standard condition of sample Carrying out preliminary drying in a dryer at $40 \pm 5^{\circ}\text{C}$, lower its water content down to the official regain or less, place the sample in a laboratory or apparatus under the standard condition and finally obtain moisture equilibrium.

Remarks 1. In the cases of viscose rayon, cupro, and acetate, the temperature for drying shall be $65 \pm 5^{\circ}\text{C}$.

2. In the case of the fibers whose official regain is zero, no predrying is needed.

(3) moisture equilibrium The condition of the sample when, after standing in the laboratory kept under a definite condition, the mass of the sample is weighed every hour or less often, and the difference of masses weighed before and after the interval has become 0.1 % or under of the mass weighed after.

(4) absolute dry condition of the sample This is the condition where constant weight is obtained after standing in a hot-air dryer at $105 \pm 2^{\circ}\text{C}$.

Remark: In the case of the fiber whose official regain is zero, the standard condition is regarded as the absolute dry condition.

(5) absolute dry mass This is the mass at the absolute dry condition.

Applicable Standards: See pages 55 to 57.

- (6) constant weight condition The condition where after heating in a dryer or others under a definite condition, the difference of masses of the sample weighed every 15 minutes or less often has become 0.1 % or under of the mass weighed after the interval.
- (7) constant weight condition. This is the mass at a constant weight condition.
- (8) official regain This is the moisture of a fiber decided officially.
- (9) corrected weight This is be the weight of absolute dry mass plus mass corresponding to the official regain.
- (10) fineness This is the unit representing the thickness of a fiber. The fineness used in this standard shall be as follows:
- (a) denier This is the number of grams per 9000 m in length.
- (b) tex This is the number of grams per 1000 m in length. One denier is equivalent to 0.11 tex.
- (11) apparent fineness This is the fineness at an arbitrary condition.
- (12) fineness based on corrected weight This is the fineness under the condition of the official regain.
- (13) pre-tension This is the load that makes a fiber not elongate but straighten.

3. Marking of Fineness

Fineness shall be marked as follows:

- (1) In the Case of Using Denier 1.5 denier 1.5 D
- (2) In the Case of Using Tex Follow the description in 7. Method of Marking in JIS L 0101.

4. Preparation of Sample

Prior to the tests⁽¹⁾ easily influenced by temperature or humidity, place the sample under standard condition prior to testing. However, in case of the tests such as moisture regain, the percentage of free water, and the moisture regain in bale, quickly pick suitable quantity from an original sample and keep them in a tightly stoppered container.

Note (¹) The tests easily influenced by temperature and moisture shall be as follows: fiber length, fineness, fineness of two corrected weight, tensile strength and elongation percentage, knot strength, loop strength, modules of elongation elasticity, initial tensile resistivity, crimp, coefficient of friction, tensile strength at wet condition after 5 % alkali treatment, 5 % elongation stress at wet condition, degree of water swelling, degree of alkali swelling, and so on.

Remark: When the laboratory or apparatus under standard condition is not available, let the sample become constant temperature ($20 \pm 2^{\circ}\text{C}$) by keeping in a closed container (placing 36 % sulfuric acid in it). In this case, this pursuit shall be noted supplementarily.

5. Testing Condition

5.1 Testing Place The tests(¹) influenced by temperature and humidity shall be carried out in the laboratory kept at standard condition.

Remark: When the tests(¹) influenced by temperature and humidity are carried out in the place other than the laboratory kept at standard condition, the temperature and humidity for testing shall be appended with a note.

5.2 Absolute Dry Mass For obtaining absolute dry mass, not only a hot air dryer but also infrared dryer, high-frequency dryer, or reduced pressure dryer may be used. In this case, the condition shall be added in a note.

In the case of the fiber that is sensitive to temperature, make use of the temperature lower than 105°C , and append the condition with a note.

5.3 Official Regain The official regain to in relation to the absolute dry mass shall be as shown in Table 1.

Table 1

Kind of fibers	Official regain %
Rayon	11.0
(Polynosic)	11.0
Cupro	11.0
Acetate	6.5
Triacetate	3.5
Nylon	4.5
Vynylon	5.0
Vinylidene	0
Polyvinyl chloride	0
Polyester	0.4
Acrylic	2.0
Modacrylic	2.0
Polypropylene	0
Polychlal	3.0

5.4 Initial Tension The following loads shall be adopted as the initial tension.

Rayon, cupro, and acetate

at standard condition Gram number of 1/20 of nominal
denier number { 4.41 mN of
nominal tex number }

at wet condition Gram number of 1/40 of nominal
denier number { 2.21 mN of
nominal tex number }

Nylon, vynylon, vinylidene, and polychlal

at both standard and wet .. Gram number of 1/20 of nominal
condition denier number { 4.41 mN of nominal
tex number }

Polyvinyl chloride, polyester, polypropylene

at both standard and wet .. Gram number of 1/15 of nominal
condition denier number { 5.88 mN of nominal
number }

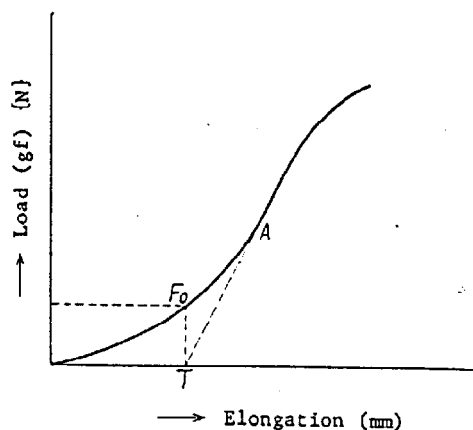
Acrylic, modacrylic

at both standard and wet .. Gram number of 1/10 of nominal
condition denier number 8.82 mN of nominal
number

In case, however, of unsuitableness of this load, the following shall be adopted; plotting the curve of load and elongation at initial stage as shown in Fig. 1, draw a tangent at the point A (the maximum tangential angle point) where the changing ratio of a load to an elongation is maximum, and find the point T where the tangent intersects the elongation axis. Draw a perpendicular from T, and, after finding the point F_0 where the perpendicular intersects the curve, make use of the load corresponding to F_0 as the initial tension.

Remark: This is applicable to the tests such as fineness of tow corrected weight, tensile strength and elongation percentage, knot strength, loop strength, modulus of elongation elasticity, initial tensile resistivity, coefficient of friction, tensile strength at wet condition after 5 % alkali treatment, and others.

Fig. 1



5.5 Measurement of Temperature and Humidity Measure the temperature and humidity by using a Meteorological Agency type prescribed in JIS Z 8806 or an Assmann type psychrometer, and find relative humidity from the humidity table by Sprung' formula.

6. Testing Items

Testing items shall be as follows:

- (1) Moisture regain and percentage of free water (applicable to synthetic fibers)
- (2) Moisture regain in bale

- (3) Equilibrium moisture regain
- (4) Fiber length
- (5) Fineness
- (6) Fineness of tow corrected weight
- (7) Tensile strength and elongation percentage
- (8) Knot strength
- (9) Loop strength
- (10) Modulus of elongation elasticity
- (11) Initial tensile resistivity
- (12) Crimp
- (13) Coefficient of friction
- (14) Specific gravity and density
- (15) Shrinkage percentage
- (16) Melting point and thermal shrinkage temperature (applicable to synthetic fibers)
- (17) Whiteness
- (18) Glossiness
- (19) Abnormal fibers
- (20) Ash content
- (21) Titanium oxide
- (22) Solvent extraction content
- (23) Tensile strength at wet condition after 5 % alkali treatment (applicable to rayon and cupro)
- (24) 5 % elongation stress at wet condition (applicable to rayon and cupro)
- (25) Degree of water swelling (applicable to rayon and cupro)
- (26) Degree of alkali swelling (applicable to rayon and cupro)

- (27) Skin ratio (applicable to rayon)
- (28) Sulfur content (applicable to rayon)
- (29) Mean polymerization degree (applicable to rayon and cupro)
- (30) Degree of exhaustion (applicable to rayon and cupro)
- (31) Degree of acetylation (applicable to acetate)

7. Testing Methods

7.1 Moisture Regain and Percentage of Free Water

7.1.1 Moisture Regain Take about 5 g of the sample, and after weighing its mass and absolute dry mass, calculate the moisture regain (%) according to the following formula. Carry out twice the test and express by the average of them (to the first decimal place).

$$\text{Moisture regain (\%)} = \frac{W - W'}{W'} \times 100$$

where W : mass of sample when sampled (g)

W' : absolute dry mass of sample (g)

Remark: This is applicable to the synthetic fibers other than those of 0 % of official regain.

7.1.2 Percentage of Free Water Take about 5 g of the sample and, after weighing its mass and the mass at standard condition, calculate free water percentage (%) according to the following formula. Carry out twice the test, and express the average of them (to the first decimal place).

$$\text{Percentage of free water (\%)} = \frac{W - W'}{W'} \times 100$$

where W : mass of sample when sampled (g)

W' : mass of sample under standard condition (g)

Remark: This is applicable to the synthetic fibers of 0 % official regain.

7.2 Moisture Regain in Bale Divide laterally the content of a sample bale half of which has been opened, and pick up quickly four samples of 50 to 100 g respectively as shown in Fig. 2 and, after weighing its mass and absolute dry mass, calculate the moisture regain in bale (%) according to following formula. Express the average of four measured values (to the first decimal place).

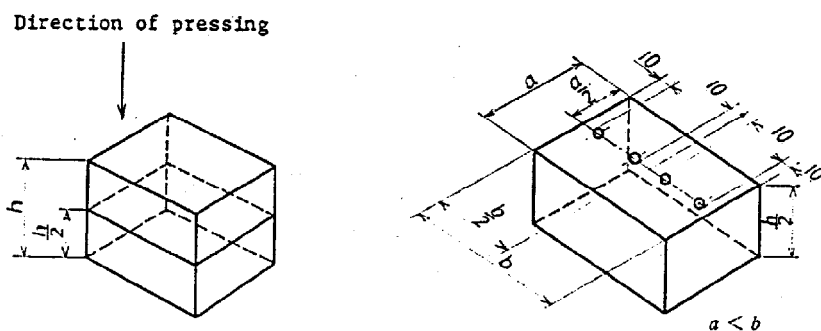
$$\text{Moisture regain in bale (\%)} = \frac{W - W'}{W'} \times 100$$

where W : mass of sample when sampled (g)

W' : absolute dry mass of sample (g)

Fig. 2

Unit: mm



7.3 Equilibrium Moisture Regain Take about 5 g of the sample that has been under moisture equilibrium and, after weighing its mass and absolute dry mass, calculate the equilibrium moisture regain (%) according to the following formula. Carry out twice the test, and express the average of them (to the first decimal place).

$$\text{Equilibrium moisture regain (\%)} = \frac{W - W'}{W'} \times 100$$

where W : mass of sample when sampled (g)

W' : absolute dry mass of sample (g)

7.4 fiber Length

7.4.1 Mean Fiber Length

Method A (Staple Diagram Method) Card the definite quantity⁽²⁾ of the sample, which is accurately weighed, by using a metal comb, and prepare a staple diagram of 25 cm wide by a Bear-type sorter. For preparing, the frequency of drawing with a clip in order to arrange all fibers on a velvet plate is about 70 times. On the plate, put the celluloid plate graduated by scale, and draw a diagram on a graph paper.

Divide equally the staple diagram made by above method into 50 divisions according to the length of each fiber, and measure the length of fibers that are positioned at both ends of this diagram and on the border of two adjacent divisions. Calculate the mean fiber length (mm) after dividing by 50 the total of the average of two fibers at both ends plus summed length of 49 fibers at borders of divisions. Carry out twice the test, and express the average of them (to the first decimal place).

Note (2) For rayon, cupro, and acetate, use the quantity obtained from the nomograph on Attached Figure, and for other fibers use the quantity which is obtained after multiplying the value of nomograph by $\rho/1.5$ [ρ : density of fiber (g/cm^3)] and which is rounded to 10 mg unit according to JIS Z 8401.

Method B (Corrected Staple Diagram Method) After having obtained the mean fiber length according to method A, pull out one fiber each from ten points on the straight part of the diagram, and measure the length of each fiber after making it straight fixing one end with a finger. After obtaining the average of these straightened ten fibers and then the average of them on the diagram, calculate the mean fiber length (mm) according to following formula. Carry out twice the test, and express the average of them (to the first decimal place).

$$\text{Mean fiber length (mm)} = \frac{l'}{l} \times L_0$$

where l : average of the lengths of ten fibers pulled out which are measured on diagram (mm)
 l' : average of the lengths of ten fibers pulled out (mm)
 L_0 : mean fiber length by Method A (mm)

- Remarks 1. When preparing the diagram referred to, it is admissible to use a thick ground paper applied vaseline and to arrange fibers on it in above-mentioned method to prepare staple diagram.
2. For the fiber having a serious crimp or thick fineness, Method B is suitable.

Method C (Direct Method) Pull out at random a single fiber one by one, and make it straight without elongation, measure the fiber length on a scale to the unit of mm. Measure 200 fibers, and express the average of them (to the first decimal place).

Remark: For the fiber which it is difficult to prepare a staple diagram for, apply Method C.

7.4.2 Weight Percentage of Staple-over-the-Limited-Cut-Length

Method A (Staple Diagram method) From the staple diagram prepared in 7.4.1, pick up the fibers which are longer than the mean fiber length plus 5.0 mm as an allowance, in the case of nominal fiber length shorter than 50 mm, and plus 10.0 mm as an allowance in the case of nominal fiber length 50 mm or more. Weigh the mass of these fibers, and express the percentage of the mass to whole mass (to the first decimal place).

Method B (Direct Method) From the fiber length diagram obtained in Method C of 7.4.1, pick up all fibers whose length is longer than the mean fiber length plus 5.0 mm as an allowance in the case of nominal fiber length shorter than 50 mm, and plus 10.0 mm as an allowance in the case of 50 mm or more. Then, sum up the lengths of these fibers. Calculate the weight percentage of staple over-the-limited-cut-length (%) according to the following formula (to the first decimal place).

$$\text{Weight percentage of staple over-the-limited-cut-length (\%)} = \frac{L'}{L \times 200} \times 100$$

where L' : sum of fiber length of fibers which are longer than length of mean fiber length plus allowance

L : mean fiber length of single fiber

Remark: This test is applicable to the equal cut fiber but not to the variable cut fiber.

7.5 Fineness7.5.1 Fineness Based on Corrected Weight

Method A Card in parallel the fibers of some quantity by using a metallic comb and, after putting them on flockpaper placed on a cutting board, press them with a gauge plate as they are stretched with a suitable force. Cut them 30 mm long by using a razor edge or the like, and weigh the mass of 300 pieces of fiber (in the case of shorter fiber, prepare 450 pieces of fiber that are cut to 20 mm in length), from which apparent fineness is calculated.

By means of the equilibrium moisture regain measured separately, calculate the fineness based on corrected weight (D) according to the following formula. Carry out five times the test, and express the average of them (to the second decimal place).

Fineness based on
corrected weight (D) {tex} = D' \times \frac{100 + R_e}{100 + R_o}

where D': apparent fineness (D) {tex}

R_o: official regain (%)

R_e: equilibrium moisture regain (%)

- Remarks 1. For the fiber whose official regain is zero, its apparent fineness shall be regarded to be the fineness based on corrected weight.
2. When preparing 300 pieces of the sample, it is preferable to count 30 pieces ten times for making of one set 300 pieces.

Method B (Easy Method) Making 200 pieces of single fiber one set, weigh the mass of them, and calculate the fineness based on corrected weight (D) by using the mean fiber length measured in 7.4.1, according to the following formula. Carry out five times the test, and express the average of them (to the second decimal place).

Fineness based on
corrected weight (D) {tex} = 9000 \times \frac{W}{200 \times L} \times \frac{100 + R_e}{100 + R_o} \left\{ 1000 \times \frac{W}{200 \times L} \times \frac{100 + R_e}{100 + R_o} \right\}

where W: mass of sample (mg)

L: mean fiber length of single fiber (mm)

R_o: official regain (%)

R_e: equilibrium moisture regain (%)

- Remarks 1. In the case of the fiber whose official regain is zero, calculate the fineness based on corrected weight according to the following formula:

Fineness based on
corrected weight (D) {tex} = 9000 \times \frac{W}{200 \times L} \left\{ 1000 \times \frac{W}{200 \times L} \right\}

2. For the fiber to which Method A is hardly applicable, Method B shall be applied. In the case using Method B, that shall be appended in a note.

[Reference Method]

Fineness (Vibration method)

After attaching a spring load⁽³⁾ to one end of a single fiber of the sample and attaching the other end to the thread holding clip of a vibration fineness tester, let it go through a vibrator edge and a lower edge, making the vibration length 2.5 cm or 5.0 cm. After letting a spring load suspend to the sample, adjust frequency by turn the frequency dial of a variable low frequency oscillator, and read the resonance frequency by observing the resonance point of the sample on the brown tube. Calculate the apparent fineness (D) according to the following formula 9 to the second decimal place).

$$\text{Apparent fineness (D) (tex)} = \frac{M \times 980 \times 9 \times 10^5}{4 l^2 f^2} \left\{ \frac{M \times 980 \times 10^5}{4 l^2 f^2} \right\}$$

where M : mass of spring load (g)

l : length of sample (cm)

f : frequency of oscillator (Hz)

Note (3) The spring load should give no transformation on the sample and be strong enough to eliminate its looseness, and be decided suitably for each denier. Report shall be appended with measuring condition. Generally 0.1 gf/D {8.82 mN/tex} is suitable.

- Remarks 1. Obtain the coefficient of variation from the values which are measured from the sample of 50 to 100 pieces, and append the number of pieces measured.
2. In the case of necessity of correction on a bending stiffness, sectional shape and others, calculate a correction factor K by the following formula, and correct by multiplying the apparent fineness obtained from the abovementioned method by this factor.

$$K = \frac{m_0}{m_v}$$

where K : correction factor

m_0 : apparent fineness obtained from mass method

m_v : apparent fineness obtained from vibration method

7.5.2 Coefficient of Variation of Fineness Simultaneously with sampling for measuring fineness, pick up respectively several fibers from 20 spots or more, and bundle them to make a fiber bundle after combing. Pass this in a suitable small hole in a metal plate, and cut perpendicularly both surfaces with a razor edge. By means of a microscope, measure sectional areas of 50 fibers displayed by Abbe's displaying apparatus⁽⁴⁾, the sectional photograph⁽⁴⁾, or the projection by a profile projector⁽⁴⁾, and calculate a coefficient of variation (%) (to the first decimal place).

Note ⁽⁴⁾ Make the sectional area of fibers not less than 100 mm².

- Remark 1. In the case of the fiber whose cross section is a circle, measure the diameter, and calculate the coefficient of variation (%) from the value squared respectively.
2. Instead of directly measuring area, the following is passable: after cutting out the section copied on a printing paper or graph paper, measure the mass of each section, and calculate the coefficient of variation.

7.6 Fineness of Tow Corrected Weight Take one piece of tow sample, and cut it exactly to 90 cm long under the condition of loading with pre-tension. Calculate apparent fineness from its mass. Then weigh the absolute dry mass of the sample, and calculate the fineness of tow corrected weight (D) according to the following formula. Carry out ten times the test, and obtain the average of them (to the third decimal place).

$$\text{Fineness of tow corrected weight (D) (tex)} = W \times 10000 \times \frac{100 + R_c}{100} \left\{ W \times 10000 \times \frac{100 + R_c}{100} \times 0.11 \right\}$$

where W : absolute dry mass (g)
 R_c : official regain (%)

Remark: In the case of seeking coefficient of variation on tow fineness, prepare 20 pieces of the sample.

7.7 Tensile Strength and Elongation Percentage

7.7.1 Test at Standard Time Draw sectioning lines on glossy and smooth paper as shown in Fig. 3 (spacing distance shall be 20 mm, but if the shortness of the fiber makes it impossible, let it be 10 mm). Fix one by one both ends of a fiber using adhesives⁽⁵⁾ in the manner that a fiber is loosely stretched across a section, and use this as a sample. Attach the sample to the grips of the tension tester for a single fiber and, after cutting the paper near an upper grip, carry out testing at either condition of those shown at Table 2. Read the elongation as a looseness (mm) when loading with pre-tension and, the load gf{N} and elongation (mm) when the sample is broken due to increasing load. According to the following formula, calculate a tensile strength (gf/D){N/tex} and elongation percentage (%). Carry out tests specified times⁽⁶⁾, and express the average of them (to the second decimal place for the tensile strength, and to the first decimal place for the elongation percentage).

$$\text{Tensile strength (gf/D) N/tex} = \frac{SD}{d}$$

where SD : strength when broken (gf){N}

d : fineness of corrected weight of sample (D) {tex}

$$\text{Elongation percentage (\%)} = \frac{E_2 - E_1}{L + E_1} \times 100$$

where E_1 : looseness (mm)

E_2 : elongation (mm) when broken or elongation (mm) at maximum loading

L : distance between grips (mm)

Fig. 3

Unit: mm

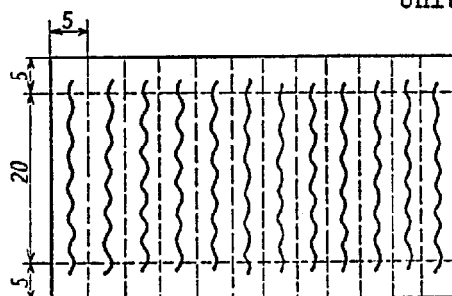


Table 2

Kind of tester	Distance of grips ⁽⁷⁾	Tensile speed
Constant-rate tension type	20 mm	20 ± 1 mm/min.
constant-rate loading type	20 mm	The rate by which all capacity is loaded for one minute. Example: In the case of tester having capacity 50 gf {490 mN}, loading rate is 50 gf/min { 490 mN/min }.
Constant-rate elongation type	20 mm	The rate at which 100 % or 50 % of grips distance is elongated per one minute.

Notes ⁽⁵⁾ Select suitable adhesive according to the kind of fiber, which shall give no damage to the fiber.

⁽⁶⁾ In the case of rayon and cupro, carry out 50 tests times, and in the case of other than these, 30 times.

⁽⁷⁾ When it is impossible to test by 20 mm because of the shortness of fiber, 10 mm is admissible.

Remarks 1. Carry out by using either one of abovementioned conditions tests, and append the kind, capacity, interval of grips, and rate of increasing tension of the tester used.

2. It is admissible to attach the sample to grips under the condition that pre-tension is loaded in the sample. In this case the looseness becomes 0 mm.

3. If necessary, carry out the test by controlling the time required until breaking to be 20 ± 3 s.

4. When the load at breaking is not the maximum load (or in other words, the load at breaking is smaller than the maximum), measure the maximum load and the elongation shown at that time.

5. If the fiber is broken at the spot being gripped, this test should be omitted.

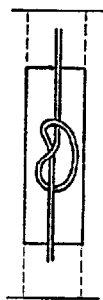
7.7.2 Test in Wet State Put the sample prepared in the way similar to 7.7.1 into another container and, after immersing it in water ($20 \pm 2^\circ\text{C}$) for two minutes to make it be sufficiently wet, measure and obtain tensile strength (gf) { N } and elongation percentage (%) in water⁽⁸⁾ similarly to 7.7.1 (to the second decimal place).

Note ⁽⁸⁾ In the case of rayon, cupro, and acetate, immerse the sample again in water after loading pre-tension and reading the looseness on the sample taken out from water.

7.8 Knot Strength

7.8.1 Test at Standard State On glossy and smooth paper, fix one by one both ends of a fiber similarly to 7.7.1 in such a manner that the fiber is loosely stretched and a knot made previously is set at center of a section as shown in Fig. 4, and use this as a sample. Grip the sample under the same condition as 7.7.1 so as to position the knot at center of two grips, and measure the knot strength (gf) { N } at breaking, and express the average (to the second decimal place).

Fig. 4



Remark: If the fiber is broken at a place except knot when testing, this test shall be rescinded.

7.8.2 Test in Wet State Put the sample prepared similarly to 7.8.1 into another container, and after immersion in water ($20 \pm 2^\circ\text{C}$) for two minutes to dampen it sufficiently, measure and obtain the knot strength (gf) { N } in water similarly to 7.8.1 (to the second decimal place).

Remark: This is mainly applied to synthetic fiber.