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**Testing methods for textile glass
products**

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Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Economy, Trade and Industry, through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Glass Fiber Association of Japan (GFA)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently, **JIS R 3420 : 2006** is replaced with this Standard.

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Testing methods for textile glass products

Introduction

This Japanese Industrial Standard has been prepared based on the third edition of **ISO 1887** published in 1995, the third edition of **ISO 1888** published in 2006, the second edition of **ISO 2558** published in 2010, the fifth edition of **ISO 2559** published in 2011, the third edition of **ISO 3341** published in 2000, the fourth edition of **ISO 3342** published in 2011, the third edition of **ISO 3343** published in 2010, the third edition of **ISO 3374** published in 2000, the second edition of **ISO 3375** published in 2009, the second edition of **ISO 3616** published in 2001, the third edition of **ISO 4602** published in 2010, the second edition of **ISO 4603** published in 1993, the second edition of **ISO 4604** published in 2011, the second edition of **ISO 4606** published in 1995, the second edition of **ISO 4900** published in 2011 and the second edition of **ISO 5025** published in 1997 by incorporating the parts corresponding to this Standard with some modifications of the technical contents.

The portions given sidelines or dotted underlines are the matters in which the contents of the corresponding International Standards have been modified. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies the general methods of testing of continuous glass fibres and products made of continuous glass fibres such as glass fabrics and glass mats (hereafter generically referred to as “fabrics” and “mats” respectively).

NOTE : The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

ISO 1887 : 1995 *Textile glass — Determination of combustible-matter content*

ISO 1888 : 2006 *Textile glass — Staple fibres or filaments — Determination of average diameter*

ISO 2558 : 2010 *Textile glass chopped-strand mats for reinforcement of plastics — Determination of time of dissolution of the binder in styrene*

ISO 2559 : 2011 *Textile glass — Mats (made from chopped or continuous strands) — Designation and basis for specifications*

ISO 3341 : 2000 *Textile glass — Yarns — Determination of breaking force and breaking elongation*

ISO 3342 : 2011 *Textile glass — Mats — Determination of tensile breaking force*

ISO 3343 : 2010 *Reinforcement yarns — Determination of twist balance index*

ISO 3374 : 2000 *Reinforcement products — Mats and fabrics — Deter-*

mination of mass per unit area

ISO 3375 : 2009 *Textile glass — Determination of stiffness of rovings*

ISO 3616 : 2001 *Textile glass — Chopped-strand and continuous-filament mats — Determination of average thickness, thickness under load and recovery after compression*

ISO 4602 : 2010 *Reinforcements — Woven fabrics — Determination of number of yarns per unit length of warp and weft*

ISO 4603 : 1993 *Textile glass — Woven fabrics — Determination of thickness*

ISO 4604 : 2011 *Reinforcement fabrics — Determination of conventional flexural stiffness — Fixed-angle flexometer method*

ISO 4606 : 1995 *Textile glass — Woven fabric — Determination of tensile breaking force and elongation at break by the strip method*

ISO 4900 : 2011 *Textile glass — Mats and fabrics — Determination of contact mouldability*

ISO 5025 : 1997 *Reinforcement products — Woven fabrics — Determination of width and length* (overall evaluation : MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standards and JIS are IDT (identical), MOD (modified), and NEQ (not equivalent) according to ISO/IEC Guide 21-1.

WARNING Persons carrying out tests based on this Standard should be familiar with normal laboratory practice. This Standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user to establish appropriate safety and health practices.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) listed below shall be applied.

JIS B 7502 *Micrometer callipers*

JIS K 0119 *General rules for X-ray fluorescence analysis*

JIS K 7100 *Plastics — Standard atmospheres for conditioning and testing*

JIS K 8121 *Potassium chloride (Reagent)*

JIS K 8150 *Sodium chloride (Reagent)*

JIS K 8180 *Hydrochloric acid (Reagent)*

JIS K 8223 *Perchloric acid (Reagent)*

JIS K 8819 *Hydrofluoric acid (Reagent)*

JIS K 8951 *Sulfuric acid (Reagent)*

JIS P 3801 *Filter paper (for chemical analysis)*

JIS P 8115 *Paper and board — Determination of folding endurance — MIT method*

JIS R 3103-1 *Viscosity and viscometric fixed points of glass — Part 1 : Determination of softening point*

JIS R 3410 *Glossary of terms relating to textile glass*

JIS R 3413 *Textile glass yarns*

NOTE : Corresponding International Standard : ISO 2078 : 1993 *Textile glass — Yarns — Designation* (MOD)

JIS R 3911 *Reinforcement yarns — Determination of linear density*

NOTE : Corresponding International Standard : ISO 1889 : 1997 *Reinforcement yarns — Determination of linear density* (MOD)

JIS R 3912 *Reinforcement yarns — Determination of twist*

JIS R 3913 *Reinforcement products — Determination of moisture content*

NOTE : Corresponding International Standard : ISO 3344 : 1997 *Reinforcement products — Determination of moisture content* (MOD)

JIS Z 8401 *Guide to the rounding of numbers*

JIS Z 8703 *Standard atmospheric conditions for testing*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in JIS R 3410 and the following apply.

3.1 linear density

the mass per unit length of glass fibre yarn, with or without size

The unit used is the tex (g/1 000 m).

3.2 mass of fabric and mat (mass)

the weight per unit area or unit length

3.3 moisture content

percentage of water contained in the sample specified in JIS R 3913

The unit used is the mass fraction (%).

3.4 combustible-matter content

the ratio of the mass of the dried test specimen to the mass of the organic material, such as sizes, removed on calcination

The unit used is the mass fraction (%).

3.5 tensile breaking force

the maximum force applied to a test specimen in stretching it to rupture

It is expressed by the load per unit width for fabrics, and it can be expressed by the load per linear density (tex) for glass yarns and rovings if required.

3.6 twist

the number of turns in the direction of yarn axis per 1 m or 25 mm in length specified in JIS R 3912

There are S twist and Z twist.

3.7 diameter of single fibre

the thickness of filament (single fibre) of glass fibre

The unit used is the micrometres (μm).

3.8 width of fabric and mat

the width of fabric is the distance, measured perpendicular to the warp yarns, between the outside edges of the outermost warp yarns at the both sides of fabric in the form of a roll

The width of mat is the length of the both edges measured perpendicular to them.

3.9 length of fabric and mat

the length of product in a roll

3.10 length of chopped-strand

the length of strand chopped

3.11 density (weaving density)

the number of glass fibre yarn of warp and weft per unit length

It is expressed by the number of glass yarn per 10 mm or 25 mm.

3.12 thickness of fabric and mat

the vertical distance between the surfaces measured under the specified pressure

3.13 alkali content

the content of sodium oxide (Na_2O) and potassium oxide (K_2O) in glass

The unit used is the mass fraction (%).

3.14 styrene solubility of binders

the solubility of the binder used for chopped-strand mat to styrene monomer

The unit used is the seconds.

3.15 permeability of fabric

the scale to express the degree of aeration of fabric

The unit used is the $\text{cm}^3 \cdot \text{cm}^{-2} \cdot \text{s}^{-1}$.

3.16 folding resistance strength of fabric

the durability when fabric is repeatedly bent under a definite tension

It is expressed by the common logarithm of the number of reciprocating bending until break.

3.17 softening point

the characteristic value of the viscosity of glass by the measuring method specified in JIS R 3103-1

The viscosity of about $10^{7.6}$ dPa · s can be corresponded to the softening point of glass having the physical properties of density $\rho = 2.5$ g/cm³ and surface tension $\gamma = 300$ mN/m.

3.18 tear strength of fabric

the maximum load when a notched fabric is torn

The unit used is the newtons (N).

3.19 contact mouldability of fabric and mat

the ease with which the mat or fabric, when it is wetted out with resin, can be made to conform permanently to a mould of specified configuration

3.20 tensile breaking force of mat

the maximum tensile load per specified width applied when stretching to rupture

The unit used is the newtons (N).

3.21 twist balance index of glass yarn

the index to express the balance between the upper twist and the lower twist of twisted glass yarn

3.22 hardness of roving

the distance between the both ends of specimen when a roving is suspended at the central part in longitudinal direction

The unit used is the millimetres (mm).

3.23 conventional flexural stiffness of fabric

the degree hard to bend when a fabric is under by its own weight

It is calculated from the overhanging length and mass per unit area of specimen at the measurement by a fix-angle flexometer.

3.24 appearance

the external condition of product

4 Standard condition and test condition of laboratory

The standardized condition and test condition of laboratory shall be either of the following a) or b). However, when there is the agreement between the interested parties,

it may be in accordance with other conditions.

- a) For the product standard or test standard specifying the standard atmosphere in conditioning or test condition, the standard atmosphere of standard condition or test condition in laboratory shall be the ambient temperature at 18 °C to 28 °C specified in JIS K 7100.
- b) For the product standard or test standard not specifying conditioning or test condition, the standard atmosphere of standard condition or test condition in laboratory shall be the ordinary temperature (5 °C to 35 °C) specified in JIS Z 8703.

5 Test report

The test report shall include the following information. However, a part of information to be included in the test report may be omitted or added according to the agreement between the interested parties.

- a) The number of this Standard
- b) All details necessary to identify the sample tested
- c) The specimen length and the number of specimens examined per elementary unit, together with details of their locations
- d) The method and the result of each test. And, depending on the case, the individual result for each test specimen
- e) Details of any operation not specified in this Standard, as well as of any incident liable to have had an effect on the results
- f) The date of the test
- g) The writer's name of the test report

6 Test items

The test items shall be as follows.

- | | | |
|--|---|--|
| a) Linear density | j) Thickness of fabric and mat | s) Twist balance index of glass yarn |
| b) Mass of fabric and mat (mass) | k) Alkali content | t) Hardness of roving |
| c) Moisture content and combustible-matter content | l) Styrene solubility of binder | u) Conventional flexural stiffness of fabric |
| d) Tensile breaking force | m) Permeability of fabric | v) Appearance |
| e) Number of twist | n) Folding endurance of fabric | |
| f) Diameter of single fibre | o) Softening point | |
| g) Width and length of fabric and mat | p) Tear strength of fabric | |
| h) Length of chopped-strand | q) Contact mouldability of fabric and mat | |
| i) Density (Weaving density) | r) Tensile breaking force of mat | |

7 Test Method

7.1 Linear density

7.1.1 Apparatus

The apparatus shall be for glass fibre specified in clause 5 of JIS R 3911 or shall have the precision of not less than 1/100 of 1 m in length.

7.1.2 Test specimens

For the test specimens, the type of yarn specified in clause 6 of JIS R 3911 shall be glass.

7.1.3 Conditioning and test atmosphere

Conditioning and test atmosphere shall be as follows.

- a) **Conditioning** The conditioning is not required. However, when the conditioning is carried out according to the related JIS or the agreement between the interested parties, it shall be carried out in the standard atmosphere specified in 4 a).
- b) **Test atmosphere** The control of test atmosphere is not required. However, when it is required according to the related JIS or agreement between the interested parties, the test shall be carried out under a definite condition of the standard atmosphere specified in 4 a).

7.1.4 Procedure

The procedure shall be in accordance with the glass yarns or rovings in clause 8 of JIS R 3911.

7.1.5 Calculation and expression of results

The expression of results shall be carried out on the linear density and the coefficient of variation and percentage of deviation, of linear density of glass yarn according to clause 9 of JIS R 3911.

- a) **Linear density** Calculate the linear density according to the following formula, round off the value according to Rule B of JIS Z 8401, and express it in three significant figures for glass yarns and in an integer for rovings

$$t = \frac{m}{l} \times 1000$$

where, t : linear density (tex)
 m : mass of the specimen (g)
 l : length of the specimen (m)

- b) **Variation and deviation, of linear density of glass yarn** For the variation and the deviation, of linear density of glass yarn, calculate them from the linear density obtained in a) according to the following formulae, and round off the value to one decimal place according to Rule B of JIS Z 8401.

$$v = \frac{\sqrt{\sum(t_i - \bar{t})^2 / (n-1)}}{\bar{t}} \times 100$$

$$d = \frac{|\bar{t} - b|}{b} \times 100$$

- where,
- v : variation of linear density (%)
 - d : deviation of linear density (%)
 - t_i : measured value (tex)
 - $\bar{t}$: mean value of linear density t_i (tex)
 - n : number of times of measurement
 - b : standard value of linear density (tex)

7.2 Mass of fabric and mat (mass)

7.2.1 General matter

The method for determining and calculating the mass per unit area or unit length of fabric and mat which are manufactured with glass fibre is specified.

7.2.2 Apparatus

For the apparatus, the following shall be used.

- a) **Polished metal template**, which yields a test specimen and its surface is flat and smooth, and is made of hard material.
 - 1) **For fabrics** A square or circular shape of area 100 cm² or a square 300 mm on a side.
 - 2) **For mats** A square shape of area 1 000 cm² or a square 300 mm on a side.
 - 3) **Others** Other dimensions of template than 1) and 2) are determined according to the agreement between the interested parties. In such cases, the permissible error in the area shall be 1 % or less.
- b) **Trimming tool**, for example, knife, scissors or cutter.
- c) **Balance**, having the characteristics in Table 1.

Table 1 Resolution of balance

Material	Measuring capability	Limit of permissible error	Resolution
Fabrics 200 g/m ² or over	0 to 150 g	±10 mg	1 mg or under
Fabrics under 200 g/m ²	0 to 150 g	±1 mg	0.1 mg or under
Mats	0 to 150 g	±0.5 g	0.1 g or under

When the mass of one roll is determined, a balance having a resolution of not more than 1/ 1 000 of mass shall be used.

- d) **Drying apparatus** When specimens are dried, the following apparatus shall be used.

- 1) **Ventilated drying oven**, capable of being maintained at $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.
- 2) **Desiccator**, containing a suitable drying agent, for example silica gel, calcium chloride or diphosphorous pentoxide.

7.2.3 Sample and test specimen

Unless otherwise specified in the related **JIS** or agreed between the interested parties, sample and test specimen shall be taken as follows.

- a) Cut a strip at least 350 mm across the entire width of the fabric or mat as the sample.
- b) For fabrics, one 100 cm² specimen per 500 mm of width shall be taken. Cut the specimen using the trimming tool [see 7.2.2 b)]. The distance from the edge/selvedge shall be at least 50 mm. Suggested method for cutting specimens are shown in Figure 1 and Figure 2. If necessary, place the specimens in a holder so as not to touch it by hands.
- c) For mats, three 1 000 cm² specimens per metre of width shall be taken. When three specimens are not able to be taken, a minimum of two specimens shall be taken. In practice, normally one specimen for every 316 mm across the width of the mat shall be taken. The distance from the edge may be zero for trimmed mats, but the distance from any untrimmed edges shall be at least 100 mm. Suggested method for cutting specimens are shown in Figure 3 and Figure 4. If necessary, place the specimens in a holder so as not to touch it by hands.
- d) For fabrics and mats, except for b) and c), when square shaped specimens 300 mm on a side are taken, specimens 300 mm instead of 316 mm on a side shall be taken according to the procedures in b) and c).
- e) For fabrics narrower than 250 mm and mats narrower than 316 mm, the specimen type and dimensions shall be agreed between the interested parties.

7.2.4 Conditioning and test atmosphere

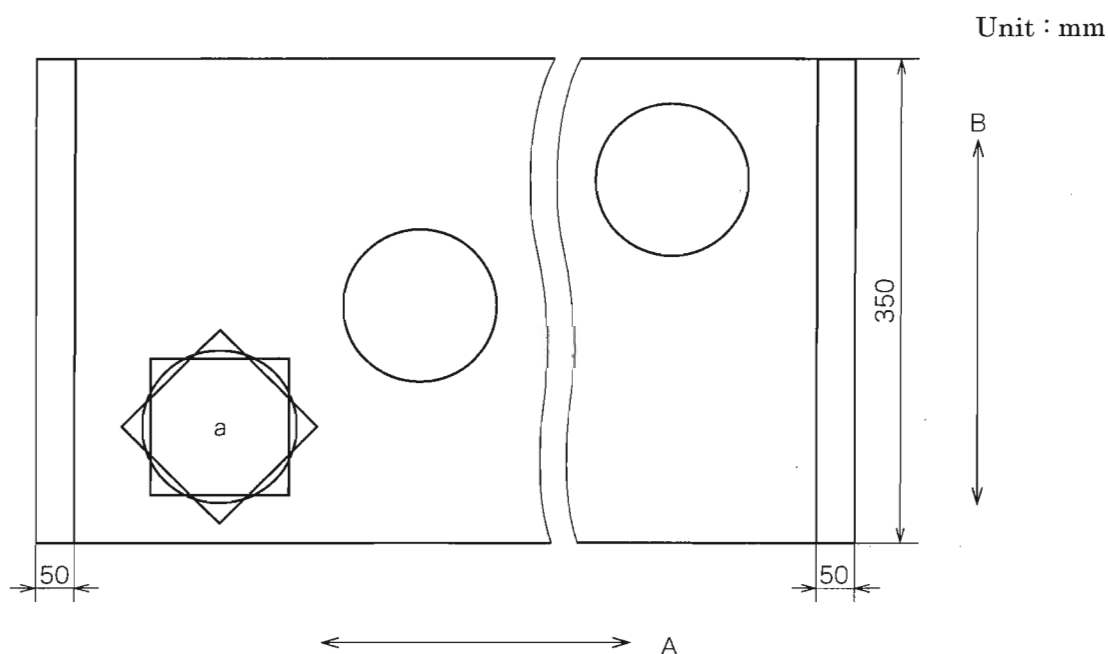
The conditioning and test atmosphere shall be as follows.

- a) **Conditioning** Condition the test specimen in the standard atmosphere specified in 4 a).
- b) **Test atmosphere** The test shall be carried out in the standard atmosphere specified in 4 a).

7.2.5 Operation

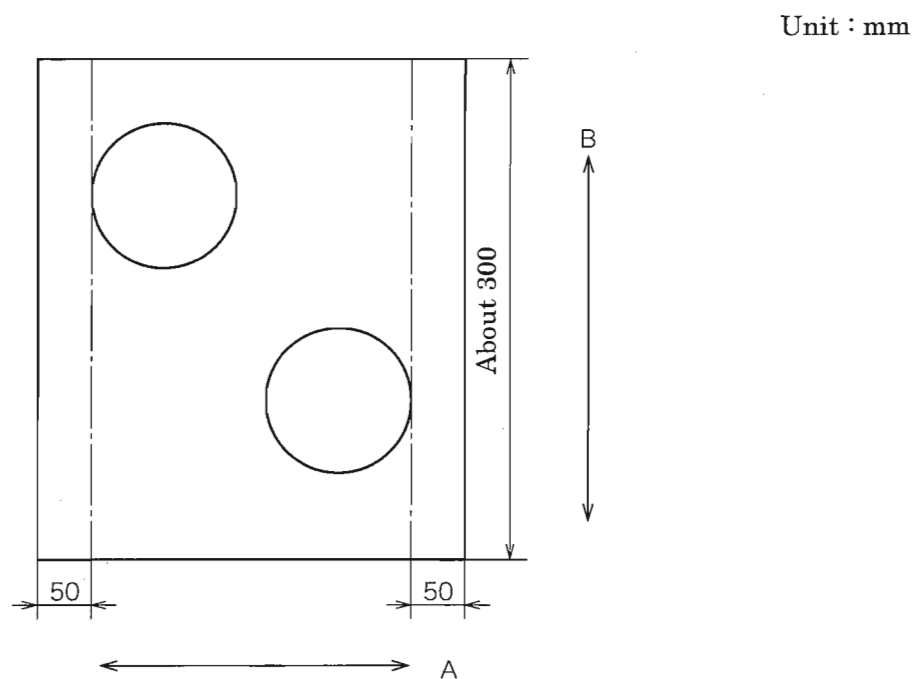
The operation shall be as follows.

- a) Dry the specimens at $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ for 1 h in cases when the mat or fabric contains more than 0.2 % moisture.
- b) Weigh each test specimen using the balance having the precision specified in 7.2.2 c).



- A Direction of fabric width
B Warp direction
a Instead of circular specimens, square specimens may be taken oriented either parallel to or diagonally across the yarns.

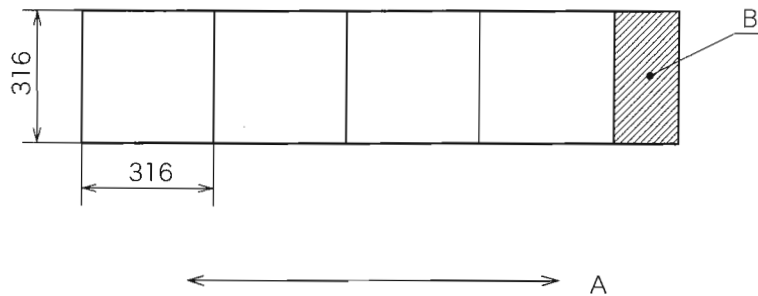
Figure 1 Suggested method for cutting out 100 cm² fabric specimens



- A Direction of fabric width
B Warp direction

Figure 2 Suggested method for cutting out 100 cm² fabric specimens (narrower wide)

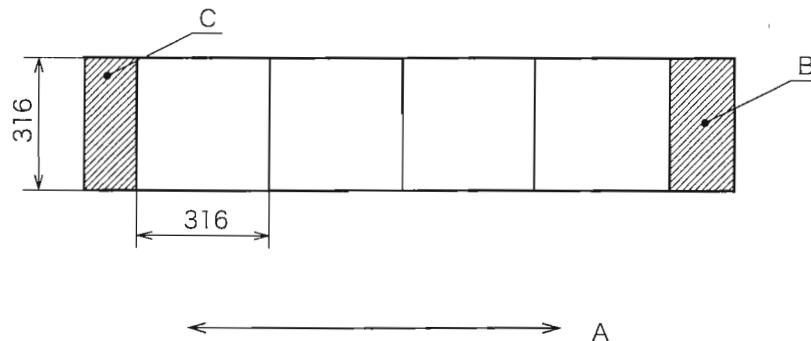
Unit : mm



- A Direction of mat width
B The part narrower than 316 mm. Discard this part.

Figure 3 Suggested method for cutting out 1 000 cm² mat specimens without selvage

Unit : mm



- A Direction of mat width
B The part narrower than 316 mm. Discard this part.
C The part wider than 100 mm from the end of selvage. Discard this part.

Figure 4 Suggested method for cutting out 1 000 cm² mat specimens with selvage

7.2.6 Calculation and expression of results

Calculation and expression of results shall be as follows.

- a) **The mass per square metre** The mass per square metre shall be calculated as follows.
- 1) Calculate the mass per unit area by the measured mass according to the following formula. The result shall be the value obtained from one specimen or the average value of results for each individual specimen. Round off the value to three significant figures according to Rule B of JIS Z 8401 for mats and fabrics weighing 200 g/m² or more. Round off the value to the nearest 0.1 g/m² according to Rule B of JIS Z 8401 for fabrics lighter than 200 g/m².

$$\rho_A = 10^4 \times \frac{m_s}{A}$$

where, ρ_A : mass per square metre (g/m²)
 m_s : mass of the specimen (g)
 A : area of the specimen (cm²)

- 2) Weigh the net mass of one roll of fabric by using a balance having the resolution of not more than 1/ 1 000 of its mass, calculate the mass per square metre according to the following formula, and round off the value to three significant figures according to Rule B of JIS Z 8401.

$$\rho_B = \frac{b-c}{d \times e} \times 10^6$$

where, ρ_B : mass per square metre (g/m²)
 b : mass of the specimen with the reel (kg)
 c : mass of the reel (kg)
 d : width of the sample (mm)
 e : length of the sample (m)

b) Mass per 300 mm × 300 mm

- 1) **Mass** Weigh a square shape of specimen 300 mm on a side. The result shall be the value obtained from one specimen or the average value of results for each individual specimen, round off the value to the nearest 0.1 g according to Rule B of JIS Z 8401.
- 2) **Maximum deviation of mass** Calculate the maximum deviation of mass according to the following formula, on the value having the largest difference from the standard mass per 300 mm × 300 mm among the values obtained in 1), and round off the value to one decimal place according to Rule B of JIS Z 8401.

$$d_{\max} = \frac{|m-n|}{n} \times 100$$

where, $d_{\max}$: maximum deviation of mass per 300 mm × 300 mm (%)
 m : value having the largest difference from the standard mass per 300 mm × 300 mm (g)
 n : standard mass per 300 mm × 300 mm (g)

- c) **Mass per metre** Weigh the net mass of one roll by using a balance having the resolution of not more than 1/ 1 000 of its mass, calculate the mass per metre according to the following formula, and round off the value to three significant figures according to Rule B of JIS Z 8401.

$$a = \frac{b-c}{d}$$

where, a : mass per metre (g)
 b : mass of the specimen with the reel (g)
 c : mass of the reel (g)
 d : length of the sample (m)

7.3 Moisture content and combustible matter content

7.3.1 Moisture content

7.3.1.1 Apparatus

The apparatus shall be in accordance with clause 5 of JIS R 3913 as follows.

- a) **Air-circulation oven**, capable of being maintained at $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ or the chosen drying temperature $\pm 5\text{ }^{\circ}\text{C}$.
- b) **Desiccator**, in accordance with 7.2.2 d) 2).
- c) **Specimen holder**, made from a material stable at the test temperature, allowing the best possible air circulation around the test specimen and designed to prevent loss of material. The holder may be an porcelain crucible, a basket made of stainless-steel gauze, etc.
- d) **Stainless-steel tongs**, for handing test specimens and holders.
- e) **Balance**, graduated to 0.1 mg or less.
- f) **Polished metal template**, in accordance with 7.2.2 a).
- g) **Trimming tool**, in accordance with 7.2.2 b).
- h) **Measuring container with cap**, capable of being sealed with a cap. It is used when the moisture content of specimen is less than 0.2 %.

7.3.1.2 Operation

The operation shall be as follows.

- a) **Sample and test specimen** Unless otherwise specified in the related JIS or agreed between the interested parties, samples and test specimens shall be taken as follows.
 - 1) For glass yarns, sliver yarns and rovings, after the outer layer of roll is removed, specimens shall be taken. Each specimen taken should have a mass of not less than 5 g. Count and the length of specimen are shown as examples in Table 2. The number of specimen shall be one.

Table 2 Count and the length of specimen

Count tex				Length of specimen m
	T	$\leq$	25	500
25	$< T$	$\leq$	45	200
45	$< T$	$\leq$	280	100
280	$< T$	$\leq$	650	50
650	$< T$	$\leq$	2 000	10
2 000	$< T$			5

- 2) For fabrics, cut off the sample of appropriate size, capable of taking specimen of not less than 100 cm² in area. Specimen shall not be taken from the part of 10 mm inside from the corner or end of sample. The number of specimen shall be one.

- 3) For mats, cut off the sample of appropriate size, capable of taking square specimens $316 \text{ mm} \pm 1 \text{ mm}$ or not less than $300 \text{ mm} \pm 1 \text{ mm}$ on a side. The number of specimens shall be not less than three. When three specimens are not able to be taken, a minimum of two specimens shall be taken.
- 4) For chopped-strands and milled fibres, each specimen may have a mass of not less than 5 g (preferably between 15 g to 30 g). The number of specimen shall be one.
- b) **Conditioning of specimens** For the sample containing moisture less than 0.2 %, store it in the standard atmosphere specified in 4 a). And for the sample containing moisture not less than 0.2 %, put it in a sealed container immediately after the specimen is taken.
- c) **Measurement** Place the specimen holder [see 7.3.1.1 c)] in the air-circulation oven maintained at $105^\circ\text{C} \pm 5^\circ\text{C}$ with the stainless-steel tongs [see 7.3.1.1 d)], remove the holder from the oven, and place it in the desiccator [see 7.3.1.1 b)]. Weigh the specimen holder removed from the desiccator and note the mass in the unit of not more than 0.1 mg. Repeat this operation until constant mass is reached. In order to weigh the specimen before drying, cut off a specimen and put it in the specimen holder. Weigh the specimen with the specimen holder and note the mass in the unit of not more than 0.1 mg. In order to weigh the specimen after dried, place the specimen holder with the specimen in the air-circulation oven [see 7.3.1.1 a)] maintained at $105^\circ\text{C} \pm 5^\circ\text{C}$ or the chosen temperature $\pm 5^\circ\text{C}$ and heat it for at least 1 h. After heated, remove the holder with the specimen, transfer to the desiccator and allow to cool to the ambient temperature. Weigh the specimen holder with the specimen and note the mass in the unit of not more than 0.1 mg.

7.3.1.3 Calculation and expression of results

The moisture content (%) is obtained as H_1 , and the calculation method is expressed in the following formula. The result shall be the value obtained from one specimen or the average value of results for each individual specimen. Round off the value to two decimal places according to Rule B of JIS Z 8401.

$$H_1 = \frac{m_1 - m_2}{m_1 - m_0} \times 100$$

where,

- m_1 : mass of the specimen and the specimen holder before drying (g)
- m_2 : mass of the specimen and the specimen holder after dried (g)
- m_0 : mass of the specimen holder (g)

7.3.2 Combustible-matter content

7.3.2.1 Aparatus

For the apparatus, in addition to that used in 7.3.1, the following are used.

- a) **Muffle furnace**, capable of being maintained, with a tolerance of $\pm 20^\circ\text{C}$, at any desired temperature up to 625°C , the temperature being measured at the centre of the muffle furnace

7.3.2.2 Test specimens

The specimens shall be taken in accordance with 7.3.1.2 a).

7.3.2.3 Conditioning of specimens

For the sample containing moisture under 0.2 %, store it in the standard atmosphere specified in 4 a). And for the sample containing moisture not less than 0.2 %, put it in a sealed container immediately after the specimen is taken.

7.3.2.4 Measurement

- a) **Drying** Place the holder [see 7.3.1.1 c)] with the specimen in the oven [see 7.3.1.1 a)] maintained at $105\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ and dry for at least 30 min. After drying, remove the holder plus specimen, transfer to the desiccator [see 7.3.1.1 b)] and allow to cool to ambient temperature. Weigh the holder plus specimen and note the mass in the unit of not more than 0.1 mg. Repeat the drying, cooling and weighing until the constant mass is reached.
- b) **Combustible-matter content** Place the holder plus dried specimen in the muffle furnace [see 7.3.2.1 a)] maintained at $625\text{ }^{\circ}\text{C} \pm 20\text{ }^{\circ}\text{C}$ or at the chosen temperature between $500\text{ }^{\circ}\text{C}$ to $600\text{ }^{\circ}\text{C}$, close the door of the furnace and heat for at least 10 min. Before the door is closed, the specimen may be burnt for 5 min with the door of furnace open. If a temperature is $500\text{ }^{\circ}\text{C}$ to $600\text{ }^{\circ}\text{C}$, the heating time shall be at least one hour. Remove the specimen and specimen holder from the muffle furnace, transfer to the desiccator and allow to cool to standard temperature. Weigh the holder plus specimen and note the mass in the unit of not more than 0.1 mg. Repeat the heating, cooling and weighing operations until constant mass is reached.

NOTE : In the case where measument are carried out regularly, a minimum number of times for the repetition of heating, cooling and weighing may be defined by experimentation.

7.3.2.5 Calculation and expression of results

The combustible-matter content [mass fraction (%)] is obtained as H_2 and the calculation method is expressed in the following formula. Result shall be the value obtained from one specimen or the average value of results for each individual specimen. Round off the value to two decimal places according to Rule B of JIS Z 8401.

The unit of measurement may be determined according to the agreement between the interested parties.

$$H_2 = \frac{m_1 - m_2}{m_1 - m_0} \times 100$$

where, m_1 : mass of the specimen and the specimen holder after dried (g)
 m_2 : mass of the specimen and the specimen holder after dried and heated (g)
 m_0 : mass of the specimen holder (g)

7.4 Tensile breaking force

7.4.1 Method of tensile test

Method of tensile test shall be in accordance with any one of the followings.

- a) **Testing method by constant-rate-of-extension (CRE)** The method using a machine capable of producing a constant extension rate for specimens.
- b) **Testing method by constant-rate-of-traverse (CRT)** The method using a machine having a pendulum type or spring type of loading mechanism and capable of producing an increasing load for specimens by traversing the clamps at a constant rate.
- c) **Testing method by constant-rate-loading (CRL)** The method using a machine capable of producing an increasing load for specimens at a constant rate.

7.4.2 For fabrics

7.4.2.1 General matter

For fabrics, the tensile breaking force means the maximum force observed during a test in which the specimen is stretched to rupture. It is applicable to unimpregnated textile glass fabric and to textile glass fabric that have been impregnated with sizing or stiffening materials, but not to fabric coated with rubber or plastics.

7.4.2.2 Principle

A strip of fabric is stretched to rupture by a suitable mechanical apparatus which indicates the breaking force and the elongation at break. The breaking force and the elongation at break may be determined either by taking readings directly from the indicating instruments on the apparatus or from an autographic force/extension curve. Provision is made for three different types of test specimens as shown in Table 3. Type I is intended for use with stiff fabrics (e.g. scrim fabrics made with coarse yarns, i.e. yarns with a linear density greater than or equal to 300 tex, or fabrics in which the yarns are bonded to each other by a finish or stiffening). Type II is intended for more pliable fabrics. Type III is applicable for any fabric of type I and type II.

Table 3 Test specimens and test parameters

Test parameters	Units	Specimen		
		Type I	Type II	Type III
Length of specimen	mm	350	250	250 or 300
Width of specimen (before unravelling)	mm	65	40	30
Gauge length	mm	200 ± 2	100 ± 1	150 ± 2
Width of specimen (after unravelling)	mm	50	25	25
Rate of extension	mm/min	100 ± 5	50 ± 3	200 ± 10

7.4.2.3 Apparatus

For the apparatus, the following shall be used.

- a) **Tensile testing machine** The tensile testing machine shall comprise the elements

described as follows.

- 1) **Pair of clamps, suitable for holding the specimen** The clamps shall be wider than the unravelled specimen [see 7.4.2.5 a) and 7.4.2.5 b)] {i.e. more than 50 mm or more than 25 mm wide [see 7.4.2.5 a)] }. The faces of the clamps shall be flat and parallel and shall exert a uniform pressure over the entire width of the specimen. They shall not allow the specimen to slip or to become damaged in any way (a hydraulic or a pneumatic pressure system, for example). The faces of the clamps should preferably be smooth, but when specimens cannot be held satisfactorily, even with packing, serrated or corrugated clamps may be used. Paper, felt, leather or sheets of plastic or rubber may be used as jaw-packing materials. The clamps shall be designed so that the axis of the test specimen remains aligned with the direction of the applied force throughout the test.
- 2) **Performance of tensile testing machine** The reference system being a constant-rate-of-extension machine (hereafter referred to as “CRE machine”) capable of producing a specimen-extension rate specified in Table 3. Other types of machines may be used, i.e. constant-rate-of-traverse machine (hereafter referred to as “CRT machine”) and constant-rate-of-loading machine (hereafter referred to as “CRL machine”), but there may be no overall correlation between the results obtained with the CRE machine and those obtained with other machines. In cases of dispute, the CRE method shall be the reference method. In the case of CRT and CRL machines, the speed of operation of the machine shall be set to break the specimen within $5 \text{ s} \pm 2 \text{ s}$ or, by agreement between the interested parties, within a period of time calculated from the extension at break using the following formula.

$$T_B = \frac{E_L \times 60}{V_{CRE}}$$

where, T_B : time to break (s)

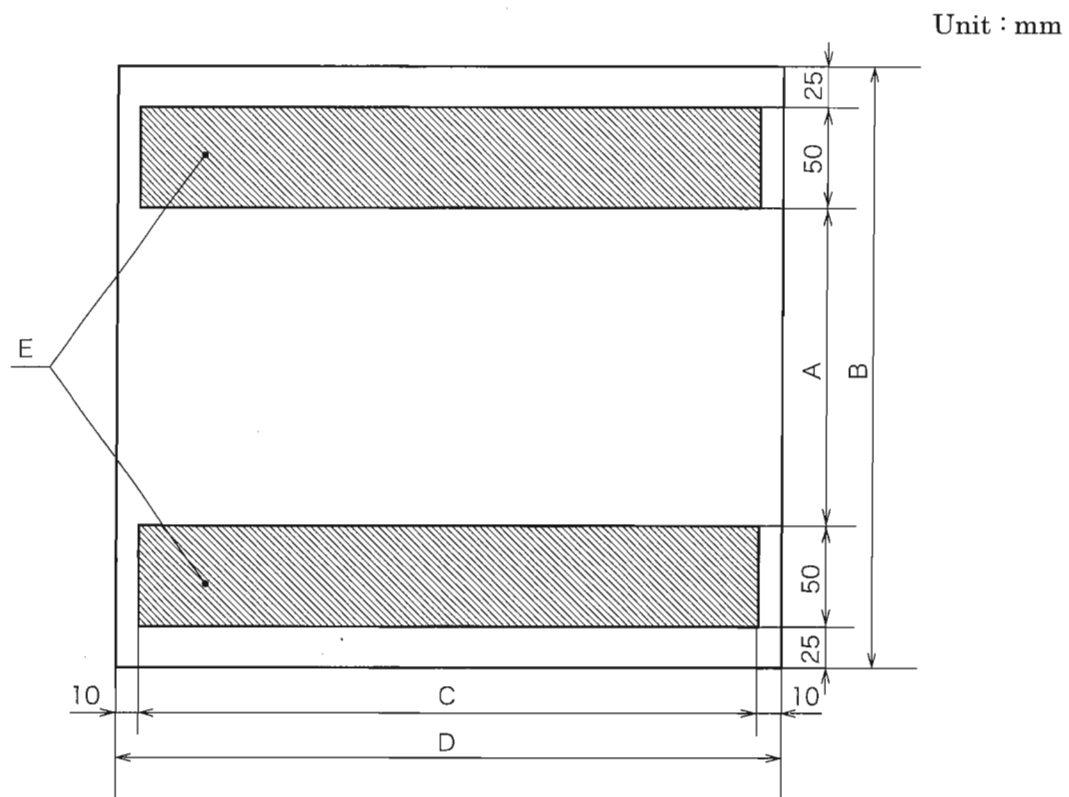
E_L : extension at break (mm)

V_{CRE} : constant rate of extension (mm/min) (taken from Table 3)

- 3) The mechanism for indicating and recording the force applied to the specimen shall be practically free from inertia at the specified speed of testing. The maximum error in the indicated force shall not, under the conditions of use, be greater than 1 % of the actual force.
 - 4) The mechanism for indicating and recording the specimen extension shall be practically free from inertia at the specified speed of testing and accurate to within 1 % of the measured value, or better.
 - 5) The results obtained with test specimens of different dimensions and with different rates of extension are not equivalent, and cannot be compared in most cases.
- b) **Other equipment**
- 1) **Template**, which yields a test specimen and its surface is flat and smooth, and is made of hard material. It is for use in cutting out from a sample measuring 350 mm × 370 mm if type I test specimens are to be prepared or 250 mm × 270 mm if

type II test specimens are to be prepared. The template has two “apertures” for marking out the limits of the central (test) portion of the specimens (the gauge length). And template for taking specimens for type III should be used correspondingly to the above (See Figure 5).

- 2) **Trimming tool**, in accordance with 7.2.2 b).



A Gauge length	200 mm for type I specimen, 100 mm for type II specimen.
B Length of specimen	350 mm for type I specimen, 250 mm for type II specimen.
C Width of apertures	350 mm for type I specimen, 250 mm for type II specimen.
D Length of sample	370 mm for type I specimen, 270 mm for type II specimen.
E Apertures	

Figure 5 Example of template

7.4.2.4 Taking of sample

Unless otherwise specified by the agreement between the interested parties, take a sample approximately 1 m long after having removed the outer layer of the roll or piece of fabric, which is susceptible to damage (remove at least 1 m).

7.4.2.5 Test specimens

The test specimens shall be as follows.

a) **Dimensions** (see Table 3)

- 1) **Type I test specimen** The length of the test specimen shall be 350 mm to allow a

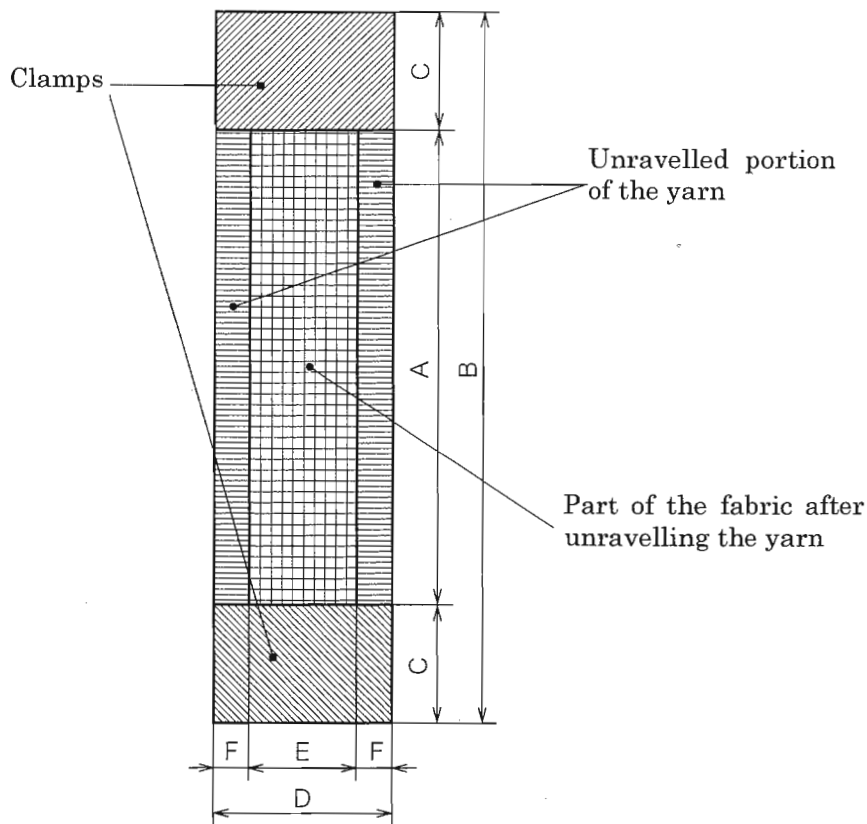
gauge length of 200 mm $\pm$ 2 mm. The width of the test specimen, excluding any fringes (unravalled portions of specimen), shall be 50 mm.

- 2) **Type II test specimen** The length of the test specimen shall be 250 mm to allow a gauge length of 100 mm $\pm$ 1 mm. The width of the test specimen, excluding any fringes (unravalled portions of specimen), shall be 25 mm.
 - 3) **Type III test specimen** The length of the test specimen shall be 250 mm or 300 mm to allow a gauge length of 150 mm $\pm$ 2 mm. The width of the test specimen, excluding any fringes (unravalled portions of specimen), shall be 25 mm.
 - 4) **Alternative widths** If the number of yarns in the warp and/or weft of the fabric is very small (less than 3 per centimetre, for instance), a width of more than 50 mm may be used for type I test specimens and a width of more than 25 mm for type II test specimens.
- b) **Example of preparation** Special preparation of the test specimens is necessary to prevent the ends of the specimen from being damaged by the clamps of the test machine. The following method shall be used.
- 1) Take a sheet of stiff paper or cardboard with dimensions at least as large as those of the template. Spread the fabric out completely flat on the stiff paper or cardboard, ensuring that the warp and weft yarns are completely straight and perpendicular to one another.
 - 2) Place the template on the fabric so that the whole of the template lies over the stiff paper or cardboard and, using the trimming tool, cut through the fabric and paper or cardboard round the outside of the template to produce an intermediate sample with the same external dimensions as the template. For warp-direction specimens, the gauge length side of the template shall lie parallel to the warp threads; for weft-direction specimens, the gauge-length side of the template shall lie parallel to the weft threads.
 - 3) With a soft pencil (2B to 4B in lead) and the like, and taking care not to fray the yarns, trace a line along the inside edge of each of the two template apertures shown in Figure 5. Remove the template.
 - 4) Impregnate the ends of the fabric up to a point 75 mm in from each end with a suitable adhesive, and bond the ends to the paper or cardboard backing, leaving the central portion between the two pencil lines untreated.

Note : Example for adhesives to impregnate the ends of the specimens, there are natural rubber or neoprene solution, a solution of polybutyl methacrylate in xylene, a solution of polymethyl methacrylate in diethyl ketone or methyl ethyl ketone, epoxy resin particularly for high-strength materials, polyvinyl alcohol aqueous solution, vinyl acetate resin emulsion, polyvinyl butyl sheets (The fabric may also be impregnated by placing each end between polyvinyl butyl sheets to leave the central area uncovered. The top surface of the sandwich is covered with a second sheet of stiff paper or cardboard and an electric iron is applied to soften the polyvinyl butyl and cause it to penetrate into the fabric.), and the like.

- 5) After the sample has dried, cut it, perpendicular to the two pencil lines, into strips 65 mm wide for type I test specimens, thus giving specimens measuring 350 mm $\times$ 65 mm, and into strips 40 mm wide for type II test specimens, giving specimens measuring 250 mm $\times$ 40 mm, and into strips 30 mm wide for type III test specimens, giving specimens measuring 250 mm or 300 mm $\times$ 30 mm. Each specimen thus has an untreated central portion of length 200 mm for type I specimens, 100 mm for type II specimens and 100 mm or 150 mm for type III specimens, as well as bonded end tabs each of length 75 mm.
- 6) Remove yarns in approximately equal numbers from each of the long edges of each specimen as shown in Figure 6, by careful cutting and unravelling until the width of the unravelled portion of the specimen is 50 mm (type I) or 25 mm (type II and type III), or as near to these values as possible. In the case of fabrics made from yarns 300 tex (e.g. woven rovings) and open-weave fabrics, remove a whole number of threads, ensuring that the specimen width is as near as possible to, but not less than, 50 mm (type I) or 25 mm (type II and type III), or the alternative width chosen. In such a case, all test specimens from the same fabric shall contain the same number of threads; the actual width of each specimen shall be measured, the arithmetic mean of the five specimens calculated, the mean value reported, the value rounded off according to Rule B of JIS Z 8401 expressing it in the unit of millimetre (mm), in the test report.

Unit : mm



- A Gauge length
- B Length of specimen
- C Length of clamp
- D Width of specimen (before unravelling)
- E Width of specimen (unravelling width)
- F Width of the unravelling portion of the yarn

Figure 6 Example of test specimen

7.4.2.6 Conditioning and test atmosphere

Conditioning and test atmosphere shall be as follows.

- a) **Conditioning** Condition the test specimens in the standard atmosphere specified in 4 a) for 16 h or for a period of time agreed between the interested parties. However, when elongation is not measured, or agreed between the interested parties, the conditioning may be omitted.
- b) **Test atmosphere** The test shall be carried out under a definite condition of the standard atmosphere specified in 4 b).

7.4.2.7 Operation

The operation shall be as follows.

- a) Ensure the clamps 200 mm $\pm$ 2 mm apart for type I specimens, 100 mm $\pm$ 1 mm apart for type II specimens and 150 mm $\pm$ 2 mm for type III test specimens. Ensure that the clamps are properly aligned with each other and parallel. Secure the

specimen in one clamp so that its longitudinal axis passes through the centre points of the front edges of the clamps.

- b) Set the moving clamp in motion and stretch the specimen to rupture under the conditions appropriate for the type of machine and test specimen being used, as specified in 7.4.2.3 a) and 7.4.2.5 a), respectively.
- c) Record the resultant breaking force. When a fabric breaks in two or more stages, as with double fabrics and more complex weave structures, record the maximum force indicated during the breaking of the first set of yarns as the breaking force for the fabric.
- d) Record the elongation at break in the unit of millimetre (mm).
- e) If rupture of any test specimen starts within 10 mm of either of the clamps, record this fact in the test report, but reject the results for calculation of the breaking force and the elongation at break and repeat the test with a new test specimen.

NOTE : There are three causes of rupture at or near the clamps as follows.

- a) weak points in the fabric (these will be distributed at random)
- b) concentrations of stress in the neighbourhood of the clamps
- c) damage caused to the specimen by the clamps

7.4.2.8 Expression of results

The expression of results shall be as follows.

- a) **Tensile breaking force** For each direction (warp and weft), calculate the arithmetic mean of the breaking force in newtons (N), and round off the value to one decimal place according to Rule B of JIS Z 8401. In cases where the actual width of the test specimen differs from 50 mm or 25 mm, convert the result to a width of 50 mm or 25 mm.
- b) **Elongation at break** For each direction (warp and weft), calculate the arithmetic mean of the elongation at break, expressed in percentage (%) of the initial length of the test specimen between the clamps, and round off the value to one decimal place according to Rule B of JIS Z 8401.

7.4.3 For glass yarns and rovings

7.4.3.1 Principle

The tensile breaking force and the elongation at break are determined by elongating a specimen by suitable mechanical means until rupture. Elongation at a specified force, or alternatively the force at a specified elongation, may also be determined if required.

The value of the tensile breaking force per unit linear density of the yarn and the roving, i.e. the breaking strength, may also be calculated if requested.

7.4.3.2 Apparatus

The apparatus shall be as follows.

- a) **Tensile testing machine** The tensile testing machine shall be as follows.

- 1) In this Standard, the method is designed for test machines with constant rate of elongation (CRE). If other machines, such as constant rate of loading (CRL) or constant rate of traverse (CRT), are used, the results will be different from those obtained with the reference CRE machine. All test machines shall have the following mechanism.
 - 1.1) A pair of suitable clamps to grip the specimen
 - 1.2) Means for elongating the specimen
 - 1.3) A mechanism which will indicate or record the load applied to the specimen and the corresponding elongation.

For preventing the distortion in the force-elongation curve, the recorder with a small inertia shall be used.

An autographic recorder is desirable for recording the elongation corresponding to a specified force. The inertia of the recording system shall be sufficiently low to avoid distortion of the force-elongation curve.

- 2) The maximum error in the indicated force, at any point in the range in which the machine is used, shall not exceed 1 % of the true force. The error in the indicated clamp separation shall not exceed 1 mm.
- 3) The clamps shall be capable of holding the specimens without slippage and without visible damage. Typical commercially available test machines have either flat or radiussed clamps, and the results obtained can vary from one type to the other. Figure 7 shows examples of suitable radiussed and flat clamps. For the radiussed clamps, the radius "r" shall be comprised between 12 mm and 25 mm for yarns or rovings with a linear density lower than 500 tex, and between 25 mm and 45 mm for yarns or rovings with a higher linear density. The two faces of the grips which hold the specimen shall be protected or covered with adhesive tape to maintain the yarn or roving correctly in position without damaging it.

NOTE : Comparison of results from different laboratories will be valid only if the same type of clamp is used.

- 4) The test machine shall be adjustable to give a constant rate of extension of 200 mm (± 20 mm), 250 mm (± 20 mm) or 300 mm (± 20 mm) per minute. Typical nominal gauge length are 500 mm for flat clamps, and 250 mm to 350 mm for radiussed clamps.