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**Reinforcement yarns — Determination of  
linear density**

*Fils de renfort — Détermination de la masse linéique*

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## Foreword

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

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 1889 was prepared by Technical Committee ISO/TC 61, *Plastics*, Subcommittee SC 13, *Composites and reinforcement fibres*.

This third edition cancels and replaces the second edition (ISO 1889:1987), as well as ISO 10120:1991, of which it constitutes a technical revision.

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# Reinforcement yarns — Determination of linear density

## 1 Scope

This International Standard specifies a method for the determination of the linear density of glass-fibre, carbon-fibre and aramid-fibre yarns.

It is applicable to all types of yarn, including single yarns, double and cabled yarns, textured yarns, rovings and staple-fibre yarns.

## 2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 291:—1), *Plastics — Standard atmospheres for conditioning and testing*.  
ISO 1889:1997  
https://standards.iso.org/standards/std/62c90030-062-498a-afaa-

ISO 1887:1995, *Textile glass — Determination of combustible-matter content*.  
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ISO 3344:1997, *Reinforcement products — Determination of moisture content*.

ISO 10548:1994, *Carbon fibre — Determination of size content*.

## 3 Definition

For the purposes of this International Standard, the following definition applies:

**3.1 linear density** (of a yarn): The mass per unit length of the yarn, with or without size. The unit generally used is the tex, which corresponds to 1 g per kilometre of yarn.

## 4 Principle

A yarn test specimen of known length, with or without size, is weighed and the mass per unit length calculated.

In the case where the yarn must be desized, this is done by extraction and drying (in the case of aramid fibre), by calcination (in the case of glass fibre) or by extraction or pyrolysis (in the case of carbon fibre).

1) To be published. (Revision of ISO 291:1977)

In the case of carbon-fibre yarns, the linear density of the desized yarn may also be calculated from the linear density of the sized yarn and the size content determined in accordance with ISO 10548. However, the result obtained in this way will include a small error due to the inherent error involved in determining the size content.

## 5 Apparatus

### 5.1 Apparatus for determinations on sized yarn

**5.1.1 Spool**, preferably with a circumference of 1 m. The spool is generally fitted with a traversing system to wind the yarn in thin layers. It may also include a tensioning system to tension the yarn while a test specimen is being taken.

The spool shall be calibrated in such a way that, for all specimen lengths, the actual length obtained is accurate to  $\pm 0,3\%$ . The calibration of the spool shall take into consideration the required specimen length, the type of yarn and the type of material. This calibration shall be carried out with a particular tension in the yarn, and the operator shall be made aware of this tension.

For specimens  $\leq 5$  m in length (in the case of certain carbon and aramid yarns and for glass rovings of 2 000 tex or greater), replace the wrap reel by other equipment enabling specimens to be cut to the required length with the required accuracy. A sketch of such equipment is shown in figure 1.

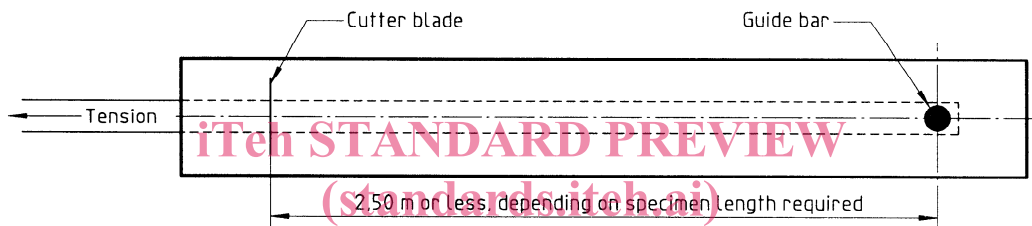


Figure 1 — Equipment for cutting test specimens up to 5 m in length

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**5.1.2 Specimen holder**, to hold the specimen before weighing and, if necessary, to hold the specimen in an oven and/or a muffle furnace.

**5.1.3 Forced-circulation oven**, with an air-change rate of 20 to 50 times per hour and capable of maintaining a temperature of  $105\text{ °C} \pm 3\text{ °C}$ .

**5.1.4 Analytical balance**, accurate to 0,1 mg.

**5.1.5 Suitable tool**, e.g. scissors or knife.

**5.1.6 Stoppered weighing bottle**, for weighing aramid yarn.

**5.1.7 Desiccator**, containing a suitable drying agent (e.g. silica gel).

**5.1.8 Stainless-steel tweezers**, for handling the specimens

### 5.2 Additional apparatus for determinations on desized yarn

#### 5.2.1 For glass fibre

Refer to ISO 1887, but essentially: **muffle furnace**, capable of maintaining a temperature of  $625\text{ °C} \pm 20\text{ °C}$ .

#### 5.2.2 For carbon fibre

Refer to ISO 10548, but essentially: **Soxhlet extractor** (method A), or **pyrolysis equipment** with a supply of nitrogen (method C).

### 5.2.3 For aramid fibre

Soxhlet extractor plus solvent (e.g. dichloromethane).

## 6 Test specimens

The determination is based, in principle, on the measurement of the linear density of one specimen per elementary unit<sup>2)</sup> or laboratory sample<sup>3)</sup>. Table 1 gives the length of yarn to be taken as a function of its nominal linear density.

Table 1

Type of yarn	Nominal linear density (tex)	Length of specimen (m)
Glass	$T_t < 25$	500
	$25 \leq T_t < 45$	200
	$45 \leq T_t < 280$	100
	$280 \leq T_t < 650$	50
	$650 \leq T_t < 2\,000$	10
	$2\,000 \leq T_t$	5
Carbon	$T_t < 50$	Length such that the mass is $\geq 0,25$ g
	$50 \leq T_t < 125$	5
	$125 \leq T_t < 250$	2
	$250 \leq T_t$	1
Aramid	—	Length such that the mass is between 3 g and 10 g

The product specification or the person requesting the determination may stipulate that the determination be performed on a (specified) higher number of specimens which are generally taken from adjacent positions in the elementary unit or laboratory sample.

Moreover, it may be stipulated that the determination be repeated at different places within the elementary unit or laboratory sample.

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## 7 Conditioning and test atmosphere

If the determination is to be carried out on a desized specimen, conditioning is not necessary. In other cases, ensure that the elementary units or laboratory samples to be examined are at a temperature defined in ISO 291 before beginning the test.

Carry out the determination itself in a standard atmosphere as defined in ISO 291.

For aramid yarns, use the atmosphere at  $20\text{ °C} \pm 2\text{ °C}$  and  $(65 \pm 5)\%$  relative humidity.

## 8 Procedure

NOTE — In the designation of a yarn, the linear density is generally that of the dry, desized yarn. However, linear density may be with or without size. Therefore, it is important to verify on which basis the yarn specification is written so as to provide clear instructions to the operator for the test procedure.

On the other hand, glass and carbon-fibre yarns contain a very small amount of moisture. If the amount does not exceed 0,2 %, measured in accordance with ISO 3344, the determination may be made on the undried, sized yarn.

2) The elementary unit (as defined in ISO 1886:1990, *Reinforcement fibres — Sampling plans applicable to received batches*), is the smallest normally commercially available entity of a given product.

3) A laboratory sample is a part of the elementary unit from which the specimen(s) will be selected for the test. A laboratory sample is taken when it is impractical to bring the elementary unit into the test laboratory.

## 8.1 Preliminary operations

Using the spool (or alternative equipment as specified in 5.1.1), take the specimen in accordance with the instructions in clause 6 from a yarn which shows no visible signs of damage. For yarn from a package, it is recommended that the outer layers, which may be partially damaged, be first removed.

Remove the specimen from the spool and fold it so that it can be placed on the balance (5.1.4) or in the weighing bottle (5.1.6) without difficulty.

## 8.2 Determination with desized specimen

If a specimen holder (5.1.2) or weighing bottle is used to weigh the specimen, stabilize its mass by bringing it to the temperature used to dry the specimen. Allow it to cool in desiccator until it reaches room temperature. Then proceed as described in 8.2.1, 8.2.2 or 8.2.3, depending on the type of yarn being examined.

### 8.2.1 Glass yarns or rovings

Lay the specimen flat on the support, and place the support in the muffle furnace (5.2.1) set at  $625\text{ °C} \pm 20\text{ °C}$ .

Calcinate for  $(20^{+10}_0)$  min, taking care that the specimen does not touch the muffle.

Allow the specimen to cool in the desiccator.

Weigh the specimen to the nearest 1 mg.

### 8.2.2 Carbon yarns

#### 8.2.2.1 Extraction method (ISO 10548:1994, method A)

Extract for 2 h using a Soxhlet extractor and a solvent such as methylethylketone, tetrahydrofuran, acetone, dichloromethane or dichloroethane.

Dry at  $105\text{ °C} \pm 3\text{ °C}$  for  $(90^{+10}_0)$  min.

Allow the specimen to cool in the desiccator.

Weigh the specimen to the nearest 1 mg.

#### 8.2.2.2 Pyrolysis method (ISO 10548:1994, method C)

Pyrolyse in an oven at  $450\text{ °C} \pm 5\text{ °C}$  in a stream of nitrogen for  $(15^{+10}_0)$  min.

Allow to cool in the desiccator.

Weigh the specimen to the nearest 1 mg.

### 8.2.3 Aramid yarns

Extract for 4 h using a Soxhlet extractor and a solvent such as dichloromethane.

Dry at  $105\text{ °C} \pm 3\text{ °C}$  for  $(30^{+10}_0)$  min.

Allow to cool in the desiccator.

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Weigh the specimen to the nearest 1 mg.

Take care to avoid any loss of material whenever handling the specimen.

### 8.3 Determination on a sized specimen

The procedure described provides for the drying of glass-fibre or carbon-fibre specimens if the product specification requires it (see the note in clause 8). For aramid-fibre yarns, drying is not required.

If the moisture content at the point where the specimen is taken is less than 0,2 %, proceed directly to weighing the specimen taken in 8.1.

It is necessary to dry the specimen for the determination, place the specimen in the oven (5.1.3) at  $105\text{ °C} \pm 3\text{ °C}$  for  $\left(60^{+10}_0\right)$  min, subsequently allowing it to cool in the desiccator until it reaches room temperature.

Weigh the specimen to the nearest 1 mg.

Take care to avoid any loss of material whenever handling the specimen.

If a specimen holder or weighing bottle is used to weigh the specimen, allow its mass to stabilize at the oven temperature and then leave to cool in the desiccator until ambient temperature is reached. Then proceed to drying the specimen.

## 9 Expression of results

**9.1** If weighing was carried out with a specimen holder or weighing bottle, deduct its mass in order to obtain the mass of the specimen.

**9.2** Calculate the linear density  $T_t$ , in grams per kilometre, using the equation

$$T_t = \frac{1\,000\,m}{L}$$

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where

$m$  is the mass, in grams, of the specimen;

$L$  is the length, in metres, of the specimen.

If more than one specimen was taken for the determination (see clause 6), the results obtained for the various specimens in each determination shall be dealt with in accordance with the referring specification or as specified by the person ordering the determination.

## 10 Precision

The precision of this test method is not known because interlaboratory data are not available. Interlaboratory data are being obtained and a precision statement will be added at the next revision.

## 11 Test report

The test report shall include the following information:

- a) reference to this International Standard;
- b) all details necessary for identification of the yarn examined;

- c) the specimen length and the number of specimens examined per elementary unit, together with details of their locations;
- d) details of the method, i.e.:
  - 1) desized specimen,
  - 2) dried sized specimen,
  - 3) as-received of sized specimen;
- e) the individual result of each determination and, depending on the case, the result for each specimen;
- f) details of any operation not specified in this International Standard, as well as any incident liable to have had an affect on the results;
- g) the date of the test.

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