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**Metallic materials — Tensile testing —  
Part 1:  
Method of test at room temperature**

*Matériaux métalliques — Essai de traction —*

*Partie 1: Méthode d'essai à température ambiante*

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ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

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# Contents

	Page
Foreword.....	v
Introduction.....	vi
<b>1 Scope.....</b>	<b>1</b>
<b>2 Normative references.....</b>	<b>1</b>
<b>3 Terms and definitions.....</b>	<b>1</b>
<b>4 Symbols.....</b>	<b>6</b>
<b>5 Principle.....</b>	<b>8</b>
<b>6 Test pieces.....</b>	<b>8</b>
6.1 Shape and dimensions.....	8
6.1.1 General.....	8
6.1.2 Machined test pieces.....	9
6.1.3 Unmachined test pieces.....	9
6.2 Types.....	9
6.3 Preparation of test pieces.....	10
<b>7 Determination of original cross-sectional area.....</b>	<b>10</b>
<b>8 Original gauge length and extensometer gauge length.....</b>	<b>10</b>
8.1 Choice of the original gauge length.....	10
8.2 Marking the original gauge length.....	10
8.3 Choice of the extensometer gauge length.....	11
<b>9 Accuracy of testing apparatus.....</b>	<b>11</b>
<b>10 Conditions of testing.....</b>	<b>11</b>
10.1 Setting the force zero point.....	11
10.2 Method of gripping.....	11
10.3 Testing rates.....	12
10.3.1 General information regarding testing rates.....	12
10.3.2 Testing rate based on strain rate (method A).....	12
10.3.3 Testing rate based on stress rate (method B).....	14
10.3.4 Report of the chosen testing conditions.....	15
<b>11 Determination of the upper yield strength.....</b>	<b>16</b>
<b>12 Determination of the lower yield strength.....</b>	<b>16</b>
<b>13 Determination of proof strength, plastic extension.....</b>	<b>16</b>
<b>14 Determination of proof strength, total extension.....</b>	<b>17</b>
<b>15 Method of verification of permanent set strength.....</b>	<b>17</b>
<b>16 Determination of the percentage yield point extension.....</b>	<b>17</b>
<b>17 Determination of the percentage plastic extension at maximum force.....</b>	<b>17</b>
<b>18 Determination of the percentage total extension at maximum force.....</b>	<b>18</b>
<b>19 Determination of the percentage total extension at fracture.....</b>	<b>18</b>
<b>20 Determination of percentage elongation after fracture.....</b>	<b>18</b>
<b>21 Determination of percentage reduction of area.....</b>	<b>19</b>
<b>22 Test report.....</b>	<b>20</b>
<b>23 Measurement uncertainty.....</b>	<b>20</b>
23.1 General.....	20
23.2 Test conditions.....	21
23.3 Test results.....	21

<b>Annex A (informative) Recommendations concerning the use of computer-controlled tensile testing machines</b> .....	<b>34</b>
<b>Annex B (normative) Types of test pieces to be used for thin products: sheets, strips, and flats between 0,1 mm and 3 mm thick</b> .....	<b>40</b>
<b>Annex C (normative) Types of test pieces to be used for wire, bars, and sections with a diameter or thickness of less than 4 mm</b> .....	<b>43</b>
<b>Annex D (normative) Types of test pieces to be used for sheets and flats of thickness equal to or greater than 3 mm and wire, bars, and sections of diameter or thickness equal to or greater than 4 mm</b> .....	<b>44</b>
<b>Annex E (normative) Types of test pieces to be used for tubes</b> .....	<b>48</b>
<b>Annex F (informative) Estimation of the crosshead separation rate in consideration of the stiffness (or compliance) of the testing equipment</b> .....	<b>50</b>
<b>Annex G (normative) Determination of the modulus of elasticity of metallic materials using a uniaxial tensile test</b> .....	<b>52</b>
<b>Annex H (informative) Measuring the percentage elongation after fracture if the specified value is less than 5 %</b> .....	<b>61</b>
<b>Annex I (informative) Measurement of percentage elongation after fracture based on subdivision of the original gauge length</b> .....	<b>62</b>
<b>Annex J (informative) Determination of the percentage plastic elongation without necking, <math>A_{wn}</math>, for long products such as bars, wire, and rods</b> .....	<b>64</b>
<b>Annex K (informative) Estimation of the uncertainty of measurement</b> .....	<b>65</b>
<b>Annex L (informative) Precision of tensile testing — Results from interlaboratory programmes</b> ..	<b>69</b>
<b>Bibliography</b> .....	<b>76</b>

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## Foreword

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

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

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

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

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

This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing*.

This third edition cancels and replaces the second edition (ISO 6892-1:2016), of which it constitutes a minor revision. The changes compared to the previous edition are as follows:

- correction of the title of a standard in [Clause 2](#);
- correction of the designation "coefficient of determination" ("coefficient of determination" instead of "coefficient of correlation");
- correction of [Formula \(1\)](#);
- wording in [10.3.2.1](#);
- wording in the key of [Figure 9](#);
- wording in [Table B.2](#);
- wording in [Table D.3](#);
- correction of the references.

A list of all parts in the ISO 6892 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html).

## Introduction

During discussions concerning the speed of testing in the preparation of ISO 6892, it was decided to recommend the use of strain rate control in future revisions.

In this document, there are two methods of testing speeds available. The first, method A, is based on strain rates (including crosshead separation rate) and the second, method B, is based on stress rates. Method A is intended to minimize the variation of the test rates during the moment when strain rate sensitive parameters are determined and to minimize the measurement uncertainty of the test results. Therefore, and out of the fact that often the strain rate sensitivity of the materials is not known, the use of method A is strongly recommended.

NOTE In what follows, the designations “force” and “stress” or “extension”, “percentage extension”, and “strain”, respectively, are used on various occasions (as figure axis labels or in explanations for the determination of different properties). However, for a general description or point on a curve, the designations “force” and “stress” or “extension”, “percentage extension”, and “strain”, respectively, can be interchanged.

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# Metallic materials — Tensile testing —

## Part 1: Method of test at room temperature

### 1 Scope

This document specifies the method for tensile testing of metallic materials and defines the mechanical properties which can be determined at room temperature.

NOTE [Annex A](#) contains further recommendations for computer controlled testing machines.

### 2 Normative references

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

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

### 3 Terms and definitions

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

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

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

#### 3.1

##### gauge length

$L$

length of the parallel portion of the test piece on which elongation is measured at any moment during the test

##### 3.1.1

##### original gauge length

$L_0$

length between *gauge length* (3.1) marks on the test piece measured at room temperature before the test

##### 3.1.2

##### final gauge length after fracture

$L_u$

length between *gauge length* (3.1) marks on the test piece measured after rupture, at room temperature, the two pieces having been carefully fitted back together so that their axes lie in a straight line

**3.2  
parallel length**

$L_c$   
length of the parallel reduced section of the test piece

Note 1 to entry: The concept of parallel length is replaced by the concept of distance between grips for unmachined test pieces.

**3.3  
elongation**

increase in the *original gauge length* (3.1.1) at any moment during the test

**3.4  
percentage elongation**

*elongation* (3.3) expressed as a percentage of the *original gauge length* (3.1.1)

**3.4.1  
percentage permanent elongation**

increase in the *original gauge length* (3.1.1) of a test piece after removal of a specified stress, expressed as a percentage of the *original gauge length* (3.1.1)

**3.4.2  
percentage elongation after fracture**

$A$   
permanent *elongation* (3.3) of the gauge length after fracture ( $L_u - L_0$ ), expressed as a percentage of the *original gauge length* (3.1.1)

Note 1 to entry: For further information, see 8.1.

**3.5  
extensometer gauge length**

$L_e$   
initial gauge length of the extensometer used for measurement of *extension* (3.6)

Note 1 to entry: For the determination of several properties which are based (partly or complete) on extension, e.g.  $R_p$ ,  $A_e$  or  $A_g$ , the use of an extensometer is mandatory.

Note 2 to entry: For further information, see 8.3.

**3.6  
extension**

increase in the *extensometer gauge length* (3.5), at any moment during the test

**3.6.1  
percentage extension  
strain**

$e$   
*extension* (3.6) expressed as a percentage of the *extensometer gauge length* (3.5)

Note 1 to entry:  $e$  is commonly called engineering strain.

**3.6.2  
percentage permanent extension**

increase in the *extensometer gauge length* (3.5), after removal of a specified *stress* (3.10) from the test piece, expressed as a percentage of the extensometer gauge length



**3.6.3****percentage yield point extension** $A_e$ 

<discontinuous yielding materials> *extension* (3.6) between the start of yielding and the start of uniform work-hardening, expressed as a percentage of the *extensometer gauge length* (3.5)

Note 1 to entry: See [Figure 7](#).

**3.6.4****percentage total extension at maximum force** $A_{gt}$ 

total *extension* (3.6) (elastic extension plus plastic extension) at maximum force, expressed as a percentage of the *extensometer gauge length* (3.5)

Note 1 to entry: See [Figure 1](#).

**3.6.5****percentage plastic extension at maximum force** $A_g$ 

plastic *extension* (3.6) at maximum force, expressed as a percentage of the *extensometer gauge length* (3.5)

Note 1 to entry: See [Figure 1](#).

**3.6.6****percentage total extension at fracture** $A_t$ 

total *extension* (3.6) (elastic extension plus plastic extension) at the moment of fracture, expressed as a percentage of the *extensometer gauge length* (3.5)

Note 1 to entry: See [Figure 1](#).

**3.7****testing rate**

rate (resp. rates) used during the test [ISO 6892-1:2019](#)

**3.7.1****strain rate** $\dot{\epsilon}_{L_e}$ 

increase of strain, measured with an extensometer, in *extensometer gauge length* (3.5), per time

**3.7.2****estimated strain rate over the parallel length** $\dot{\epsilon}_{L_c}$ 

value of the increase of strain over the *parallel length* (3.2) of the test piece per time based on the *crosshead separation rate* (3.7.3) and the parallel length of the test piece

**3.7.3****crosshead separation rate** $v_c$ 

displacement of the crossheads per time

**3.7.4****stress rate** $\dot{R}$ 

increase of *stress* (3.10) per time

Note 1 to entry: Stress rate is only used in the elastic part of the test (method B) (see also [10.3.3](#)).

**3.8  
percentage reduction of area**

$Z$

maximum change in cross-sectional area which has occurred during the test ( $S_o - S_u$ ), expressed as a percentage of the original cross-sectional area,  $S_o$ :

$$Z = \frac{S_o - S_u}{S_o} \cdot 100$$

**3.9 Maximum force**

**3.9.1  
maximum force**

$F_m$

<materials displaying no discontinuous yielding> highest force that the test piece withstands during the test

**3.9.2  
maximum force**

$F_m$

<materials displaying discontinuous yielding> highest force that the test piece withstands during the test after the beginning of work-hardening

Note 1 to entry: For materials which display discontinuous yielding, but where no work-hardening can be established,  $F_m$  is not defined in this document [see footnote to [Figure 8 c](#)].

Note 2 to entry: See [Figure 8 a](#)) and b).

**3.10  
stress**

$R$

at any moment during the test, force divided by the original cross-sectional area,  $S_o$ , of the test piece

Note 1 to entry: All references to stress in this document are to engineering stress.

**3.10.1  
tensile strength**

$R_m$

stress ([3.10](#)) corresponding to the *maximum force* ([3.9.2](#))

**3.10.2  
yield strength**

when the metallic material exhibits a yield phenomenon, *stress* ([3.10](#)) corresponding to the point reached during the test at which plastic deformation occurs without any increase in the force

**3.10.2.1  
upper yield strength**

$R_{eH}$

maximum value of *stress* ([3.10](#)) prior to the first decrease in force

Note 1 to entry: See [Figure 2](#).

**3.10.2.2  
lower yield strength**

$R_{eL}$

lowest value of *stress* ([3.10](#)) during plastic yielding, ignoring any initial transient effects

Note 1 to entry: See [Figure 2](#).

**3.10.3****proof strength, plastic extension** $R_p$ 

*stress* (3.10) at which the plastic *extension* (3.6) is equal to a specified percentage of the *extensometer gauge length* (3.5)

Note 1 to entry: Adapted from ISO/TR 25679:2005, "proof strength, non-proportional extension".

Note 2 to entry: A suffix is added to the subscript to indicate the prescribed percentage, e.g.  $R_{p0,2}$ .

Note 3 to entry: See [Figure 3](#).

**3.10.4****proof strength, total extension** $R_t$ 

*stress* (3.10) at which total *extension* (3.6) (elastic extension plus plastic extension) is equal to a specified percentage of the *extensometer gauge length* (3.5)

Note 1 to entry: A suffix is added to the subscript to indicate the prescribed percentage, e.g.  $R_{t0,5}$ .

Note 2 to entry: See [Figure 4](#).

**3.10.5****permanent set strength** $R_r$ 

*stress* (3.10) at which, after removal of force, a specified permanent *elongation* (3.3) or *extension* (3.6), expressed respectively as a percentage of *original gauge length* (3.1.1), or *extensometer gauge length* (3.5), has not been exceeded

Note 1 to entry: A suffix is added to the subscript to indicate the specified percentage of the original gauge length,  $L_o$ , or of the extensometer gauge length,  $L_e$ , e.g.  $R_{r0,2}$ .

Note 2 to entry: See [Figure 5](#).

**3.11****fracture**

phenomenon which is deemed to occur when total separation of the test piece occurs

Note 1 to entry: Criteria for fracture for computer controlled tests are given in [Figure A.2](#).

**3.12****computer-controlled tensile testing machine**

machine for which the control and monitoring of the test, the measurements, and the data processing are undertaken by computer

**3.13****modulus of elasticity** $E$ 

quotient of change of stress  $\Delta R$  and change of percentage extension  $\Delta e$  in the range of evaluation, multiplied by 100 %

$$E = \frac{\Delta R}{\Delta e} \cdot 100 \%$$

Note 1 to entry: It is recommended to report the value in GPa rounded to the nearest 0,1 GPa and according to ISO 80000-1.

**3.14****default value**

lower or upper value for *stress* (3.10), respectively *strain* (3.6.1), which is used for the description of the range where the *modulus of elasticity* (3.13) is calculated

**3.15**  
**coefficient of determination**  
 $R^2$

additional result of the linear regression which describes the quality of the stress-strain curve in the evaluation range

Note 1 to entry: The used symbol  $R^2$  is a mathematical representation of regression and is no expression for a squared stress value.

**3.16**  
**standard deviation of the slope**  
 $S_m$

additional result of the linear regression which describes the difference of the *stress* (3.10) values from the best fit line for the given *extension* (3.6.1) values in the evaluation range

**3.17**  
**relative standard deviation of the slope**  
 $S_{m(rel)}$

quotient of the *standard deviation of the slope* (3.16) and the slope in the evaluation range, multiplied by 100 %

$$S_{m(rel)} = \frac{S_m}{E} \cdot 100 \%$$

**4 Symbols**

The symbols used in this document and corresponding designations are given in [Table 1](#).

**Table 1 — Symbols and designations**

Symbol	Unit	Designation
<b>Test piece</b>		
$a_o, T^a$	mm	original thickness of a flat test piece or wall thickness of a tube
$b_o$	mm	original width of the parallel length of a flat test piece or average width of the longitudinal strip taken from a tube or width of flat wire
$d_o$	mm	original diameter of the parallel length of a circular test piece, or diameter of round wire or internal diameter of a tube
$D_o$	mm	original external diameter of a tube
$L_o$	mm	original gauge length
$L'_o$	mm	initial gauge length for determination of $A_{wn}$ (see <a href="#">Annex J</a> )
$L_c$	mm	parallel length
$L_e$	mm	extensometer gauge length
$L_t$	mm	total length of test piece
$L_u$	mm	final gauge length after fracture
$L'_u$	mm	final gauge length after fracture for determination of $A_{wn}$ (see <a href="#">Annex J</a> )
<p><sup>a</sup> Symbol used in steel tube product standards.</p> <p><sup>b</sup> 1 MPa = 1 N mm<sup>-2</sup>.</p> <p><sup>c</sup> The calculation of the modulus of elasticity is described in <a href="#">Annex G</a>. It is not required to use <a href="#">Annex G</a> to determine the slope of the elastic part of the stress-percentage extension curve for the determination of proof strength.</p> <p><sup>d</sup> In the elastic part of the stress-percentage extension curve, the value of the slope may not necessarily represent the modulus of elasticity. This value may closely agree with the value of the modulus of elasticity if optimal conditions are used (see <a href="#">Annex G</a>).</p> <p><b>CAUTION — The factor 100 is necessary if percentage values are used.</b></p>		

Table 1 (continued)

Symbol	Unit	Designation
$S_o$	mm <sup>2</sup>	original cross-sectional area of the parallel length
$S_u$	mm <sup>2</sup>	minimum cross-sectional area after fracture
$k$	—	coefficient of proportionality (see 6.1.1)
$Z$	%	percentage reduction of area
<b>Elongation</b>		
$A$	%	percentage elongation after fracture (see 3.4.2)
$A_{wn}$	%	percentage plastic elongation without necking (see Annex I)
<b>Extension</b>		
$e$	%	extension
$A_e$	%	percentage yield point extension
$A_g$	%	percentage plastic extension at maximum force, $F_m$
$A_{gt}$	%	percentage total extension at maximum force, $F_m$
$A_t$	%	percentage total extension at fracture
$\Delta L_m$	mm	extension at maximum force
$\Delta L_f$	mm	extension at fracture
<b>Rates</b>		
$\dot{\epsilon}_{Le}$	s <sup>-1</sup>	strain rate
$\dot{\epsilon}_{Lc}$	s <sup>-1</sup>	estimated strain rate over the parallel length
$\dot{R}$	MPa s <sup>-1</sup>	stress rate
$v_c$	mm s <sup>-1</sup>	crosshead separation rate
<b>Force</b>		
$F_m$	N	maximum force
<b>Yield strength — Proof strength — Tensile strength</b>		
$R$	MPa <sup>b</sup>	stress
$R_{eH}$	MPa	upper yield strength
$R_{eL}$	MPa	lower yield strength
$R_m$	MPa	tensile strength
$R_p$	MPa	proof strength, plastic extension
$R_r$	MPa	specified permanent set strength
$R_t$	MPa	proof strength, total extension
<b>Modulus of elasticity — slope of the stress-percentage extension curve</b>		
$E$	GPa	modulus of elasticity <sup>c</sup>
$m$	MPa	slope of the stress-percentage extension curve at a given moment of the test
$m_E$	MPa	slope of the elastic part of the stress-percentage extension curve <sup>d</sup>
$R_1$	MPa	lower stress value
$R_2$	MPa	upper stress value
<p><sup>a</sup> Symbol used in steel tube product standards.</p> <p><sup>b</sup> 1 MPa = 1 N mm<sup>-2</sup>.</p> <p><sup>c</sup> The calculation of the modulus of elasticity is described in Annex G. It is not required to use Annex G to determine the slope of the elastic part of the stress-percentage extension curve for the determination of proof strength.</p> <p><sup>d</sup> In the elastic part of the stress-percentage extension curve, the value of the slope may not necessarily represent the modulus of elasticity. This value may closely agree with the value of the modulus of elasticity if optimal conditions are used (see Annex G).</p> <p><b>CAUTION — The factor 100 is necessary if percentage values are used.</b></p>		

Table 1 (continued)

Symbol	Unit	Designation
$e_1$	%	lower strain value
$e_2$	%	upper strain value
$R^2$	—	coefficient of determination
$S_m$	MPa	standard deviation of the slope
$S_{m(\text{rel})}$	%	relative standard deviation of the slope
<p><sup>a</sup> Symbol used in steel tube product standards.</p> <p><sup>b</sup> 1 MPa = 1 N mm<sup>-2</sup>.</p> <p><sup>c</sup> The calculation of the modulus of elasticity is described in <a href="#">Annex G</a>. It is not required to use <a href="#">Annex G</a> to determine the slope of the elastic part of the stress-percentage extension curve for the determination of proof strength.</p> <p><sup>d</sup> In the elastic part of the stress-percentage extension curve, the value of the slope may not necessarily represent the modulus of elasticity. This value may closely agree with the value of the modulus of elasticity if optimal conditions are used (see <a href="#">Annex G</a>).</p> <p><b>CAUTION — The factor 100 is necessary if percentage values are used.</b></p>		

## 5 Principle

The test involves straining a test piece by tensile force, generally to fracture, for the determination of one or more of the mechanical properties defined in [Clause 3](#).

The test shall be carried out at room temperature between 10 °C and 35 °C, unless otherwise specified. For laboratory environments outside the stated requirement, it is the responsibility of the testing laboratory to assess the impact on testing and/or calibration data produced with and for testing machines operated in such environments. When testing and calibration activities are performed outside the temperature limits of 10 °C and 35 °C, the temperature shall be recorded and reported. If significant temperature gradients are present during testing and/or calibration, measurement uncertainty may increase and out of tolerance conditions may occur.

Tests carried out under controlled conditions shall be made at a temperature of 23 °C ± 5 °C.

If the determination of the modulus of elasticity is requested in the tensile test, this shall be done in accordance with [Annex G](#).

## 6 Test pieces

### 6.1 Shape and dimensions

#### 6.1.1 General

The shape and dimensions of the test pieces may be constrained by the shape and dimensions of the metallic product from which the test pieces are taken.

The test piece is usually obtained by machining a sample from the product or a pressed blank or casting. However, products of uniform cross-section (sections, bars, wires, etc.) and also as-cast test pieces (i.e. for cast iron and non-ferrous alloys) may be tested without being machined.

The cross-section of the test pieces may be circular, square, rectangular, annular or, in special cases, some other uniform cross-section.

Preferred test pieces have a direct relationship between the original gauge length,  $L_0$ , and the original cross-sectional area,  $S_0$ , expressed by the formula  $L_0 = k\sqrt{S_0}$ , where  $k$  is a coefficient of proportionality, and are called proportional test pieces. The internationally adopted value for  $k$  is 5,65. The original gauge length shall be not less than 15 mm. When the cross-sectional area of the test piece is too small