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

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Foreword

This Japanese Industrial Standard has been revised by the Minister of Economy, Trade and Industry based on the provision of Article 14, paragraph (1) of the Industrial Standardization Act applied mutatis mutandis pursuant to the provision of Article 16 of the said Act in response to a proposal for revision of Japanese Industrial Standard with a draft being attached, submitted by The Japan Iron and Steel Federation (JISF), an accredited standards development organization. This edition replaces the previous edition (**JIS Z 2241** : 2011), which has been technically revised.

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Metallic materials — Tensile testing — Method of test at room temperature

Introduction

This Japanese Industrial Standard has been prepared based on **ISO 6892-1** : 2019, Edition 3, with some modifications of the technical contents.

In this Standard, Annex JA is specified based on **10.3.2** of **ISO 6892-1** with some modifications of the technical contents. Annex JB and Annex JC are unique to **JIS** and not given in the corresponding International Standard.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JD.

1 Scope

This Standard specifies the method for tensile testing of metallic materials and defines the mechanical properties thereof which can be measured at room temperature (between 10 °C and 35 °C).

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

ISO 6892-1 : 2019 *Metallic materials — Tensile testing — Part 1 : Method of test at room temperature* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard 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 of this Standard to establish appropriate safety and health practices.

2 Normative references

Part or all of the provisions of the following standards, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS B 7721 *Tension/compression testing machines — Calibration and verification of the force-measuring system*

NOTE Normative reference in the corresponding International Standard : ISO 7500-1 *Metallic materials — Calibration and verification of static uni-*

*axial testing machines — Part 1 : Tension/compression testing machines
— Calibration and verification of the force-measuring system*

JIS B 7741 *Calibration of extensometer systems used in uniaxial testing*

NOTE Normative reference in the corresponding International Standard : ISO 9513 *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

JIS G 0202 *Glossary of terms used in iron and steel (Testing)*

JIS Z 8401 *Rounding of numbers*

3 Terms and definitions

For the purpose of this Standard, the following terms and definitions, and those given in **JIS G 0202** apply.

3.1

gauge length

length of the parallel portion of the test piece on which elongation is measured

3.1.1

original gauge length, L_0

length between gauge length marks on the test piece measured at room temperature before the test

3.1.2

~~final gauge length after rupture~~, final gauge length after fracture, L_u

length between gauge length marks on the test piece measured after rupture, at room temperature

Note 1 to entry On the length measurement of the parallel length of the test piece where the elongation is measured, the two pieces shall be 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 the grips for unmachined test pieces.

3.3

elongation

increase in the original gauge length L_0 (3.1.1) at any moment during the test

3.4

percentage elongation

increase in the original gauge length L_0 (3.1.1), expressed as a percentage of the original gauge length

3.4.1

percentage permanent elongation

increase in the original gauge length L_0 (3.1.1) after removal of a specified stress from the test piece, expressed as a percentage of the original gauge length

3.4.2

percentage elongation after fracture, A

increase in the original gauge length L_0 (3.1.1) due to permanent elongation after fracture (3.11) ($L_u - L_0$), expressed as a percentage of the original gauge length

Note 1 to entry For further information, see 8.1.

Note 2 to entry Occasionally, the above is simply called elongation (see JIS G 0202).

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 physical properties based on elongation, such as R_p (3.10.3), A_e (3.6.3) and A_g (3.6.5), 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 L_e (3.5) at any moment during the test

3.6.1

percentage extension, strain, e

increase in the extensometer gauge length L_e (3.5), expressed as a percentage of the extensometer gauge length

Note 1 to entry e is commonly called engineering strain.

3.6.2

percentage permanent extension

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

3.6.3

percentage yield point extension, A_e

extension between the start of yielding and the start of uniform work-hardening, ex-

pressed as a percentage of the extensometer gauge length L_e (3.5), for materials displaying discontinuous yielding (see Figure 7)

3.6.4

percentage total extension at maximum force, A_{gt}

total extension (elastic extension plus plastic extension) at maximum force (3.9), expressed as a percentage of the extensometer gauge length L_e (3.5) (see Figure 1)

3.6.5

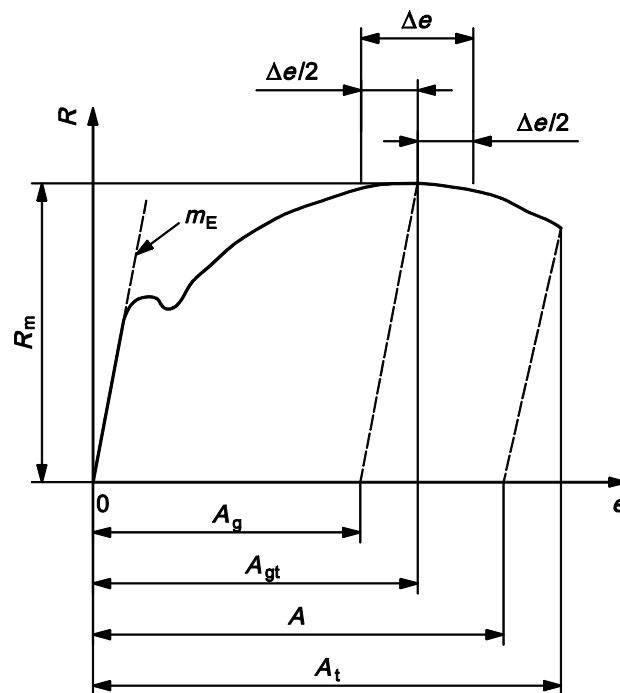
percentage plastic extension at maximum force, A_g

plastic extension at maximum force (3.9), expressed as a percentage of the extensometer gauge length L_e (3.5) (see Figure 1)

3.6.6

percentage total extension at fracture, A_t

total extension (elastic extension plus plastic extension) at the moment of fracture (3.11), expressed as a percentage of the extensometer gauge length L_e (3.5) (see Figure 1)



Key

e : percentage extension

R : stress

A : percentage elongation after fracture [measured with an extensometer or directly using test piece (see 20.1)]

A_g : percentage plastic extension at maximum force

A_{gt} : percentage total extension at maximum force

A_t : percentage total extension at fracture

m_E : slope of elastic region of stress-extension curve

R_m : tensile strength

Δe : plateau extent (for determination of A_g , see Clause 17, for A_{gt} , see Clause 18)

Figure 1 Definitions of extension

3.7

testing rate

rate used during the test

3.7.1

strain rate, $\dot{e}_{L_e}$

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

3.7.2

estimated strain rate over the parallel length, $\dot{e}_{L_c}$

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

piece

Note 1 to entry See Formula (JA.1).

3.7.3

crosshead separation rate, v_c

displacement of the crossheads per time

3.7.4

stress rate, $\dot{R}$

increase of stress per time

Note 1 to entry Stress rate should be used only in the elastic region of Test method 1 (10.3.2) (see 10.3.2).

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 .

Note 1 to entry See Formula (9).

3.9

maximum force

highest force that the test piece withstands during the test (see Figure 8)

Note 1 to entry For materials displaying no discontinuous yielding, see 3.9.1, and for materials displaying discontinuous yielding, see 3.9.2.

Note 2 to entry In this Standard, the designations of “force” and “stress”, or “extension”, “percentage extension” and “strain”, respectively, are used on various occasions (as the diagram axis indication or in the explanations for the definition of different properties). However, for a general description or definition of a well-defined point on a curve, the designations “force” and “stress” or “extension”, “percentage extension” and “strain”, respectively, are interchangeable.

3.9.1

maximum force, F_m

~~materials displaying no discontinuous yielding~~ highest force that the test piece withstands during the test [see Figure 8 a)]

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 [see Figure 8 b)]

Note 1 to entry For materials which display discontinuous yielding, but where no work-hardening can be established, the maximum force is not de-

defined in this Standard [see Note * to Figure 8 c)]

3.10

stress, R

at any moment during the test, force divided by the original cross-sectional area S_0 of the test piece

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

Note 2 to entry In this Standard, the designations of “force” and “stress”, or “extension”, “percentage extension” and “strain”, respectively, are used on various occasions (as the diagram axis indication or in the explanations for the definition of different properties). However, for a general description or definition of a well-defined point on a curve, the designations “force” and “stress” or “extension”, “percentage extension” and “strain”, respectively, are interchangeable.

3.10.1

tensile strength, R_m

stress (3.10) corresponding to the maximum force F_m (3.9.1 and 3.9.2)

3.10.2

yield strength, yield point

when the metallic material exhibits a yield phenomenon, stress corresponding to the point reached during the test at which plastic deformation occurs without any increase in the force

3.10.2.1

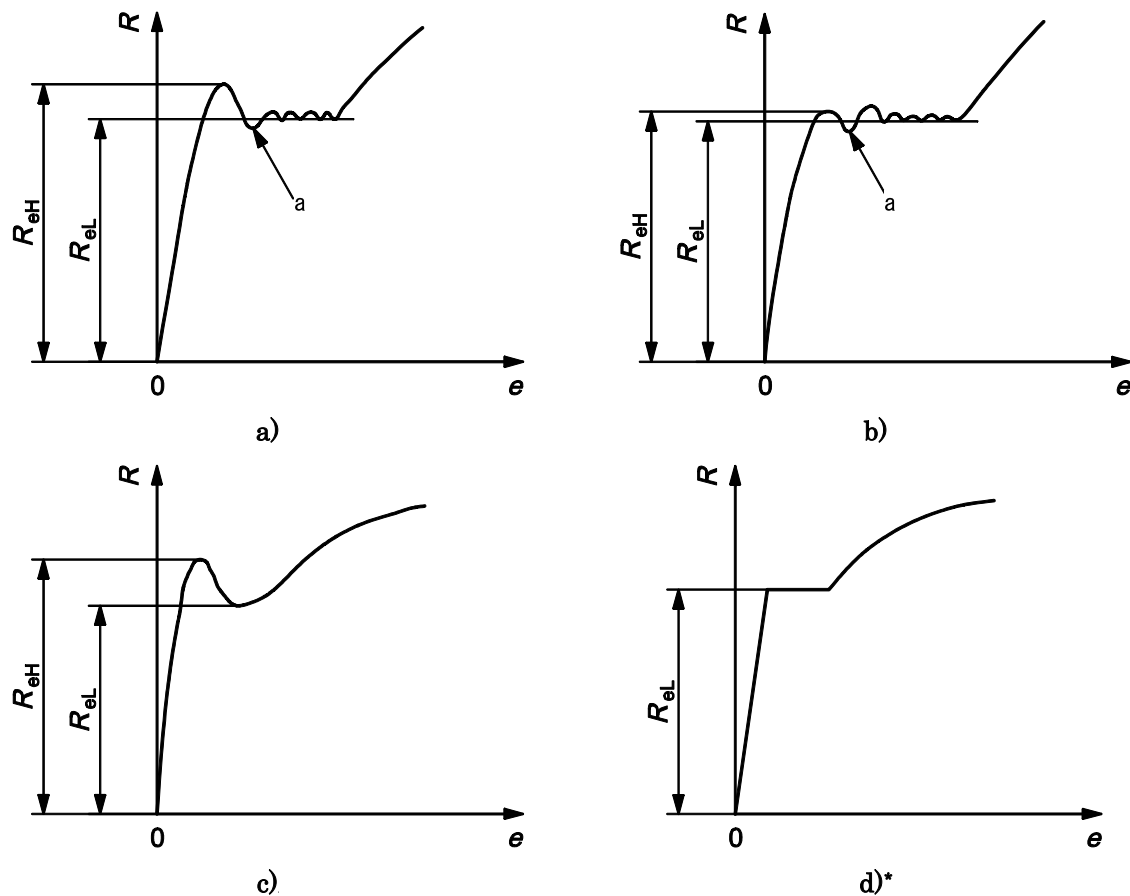
upper yield strength, upper yield point, R_{eH}

maximum value of stress (3.10) prior to the first decrease in force (see Figure 2)

3.10.2.2

lower yield strength, lower yield point, R_{eL}

lowest value of stress (3.10) during plastic yielding, ignoring any initial transient effects (see Figure 2)



Key

e : percentage extension

R : stress

R_{eH} : upper yield strength (upper yield point)

R_{eL} : lower yield strength (lower yield point)

a : initial transient effect

Note *..... R_{eL} may be called R_{eH} upon the agreement between the parties concerned.

Figure 2 Upper yield strength (upper yield point) and lower yield strength (lower yield point)

3.10.3

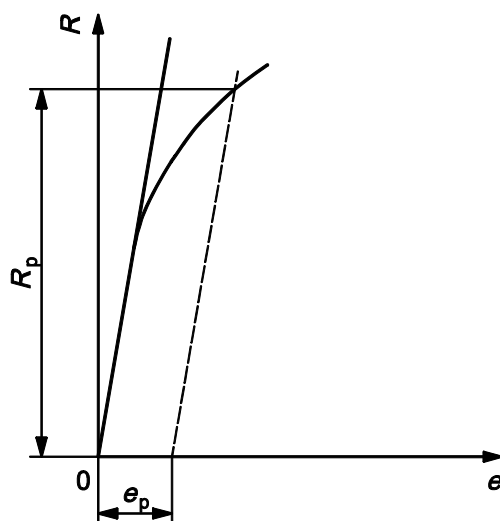
proof strength (plastic extension), R_p

stress at which the plastic extension is equal to a specified percentage of the extensometer gauge length L_e (3.5) (see Figure 3)

Note 1 to entry “proof strength, non-proportional extension” specified in **ISO/TR 25679 : 2005 [3]** is modified.

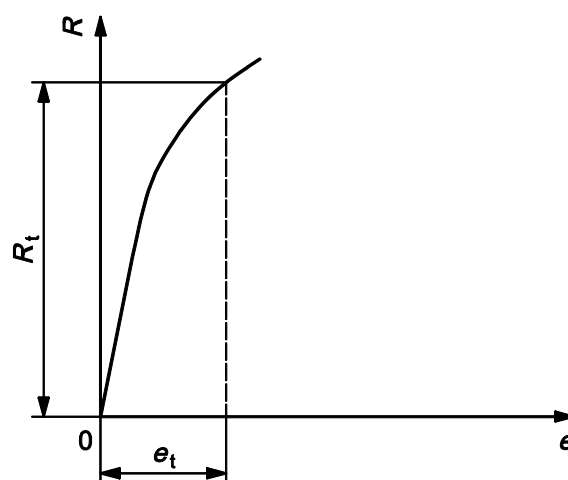
Note 2 to entry A suffix is added to the subscript to indicate the prescribed value, e.g. $R_{p0.2}$.

Note 3 to entry If the linear part of the stress-extension curve is not clearly defined, the alternative procedure specified in 13.1 should be used (see Figure 6).



Key
 e : percentage extension
 R : stress
 e_p : percentage plastic extension
 R_p : proof strength (plastic extension)

**Figure 3 Proof strength
(plastic extension)**



Key
 e : percentage extension
 R : stress
 e_t : specified percentage total extension
 R_t : proof strength (total extension)

**Figure 4 Proof strength
(total extension)**

3.10.4

proof strength (total extension), R_t

stress at which total extension (elastic extension plus plastic extension) is equal to a specified percentage of the extensometer gauge length L_e (3.5) (see Figure 4)

Note 1 to entry A suffix is added to the subscript to indicate the prescribed value of total extension, e.g. $R_{t0.5}$.

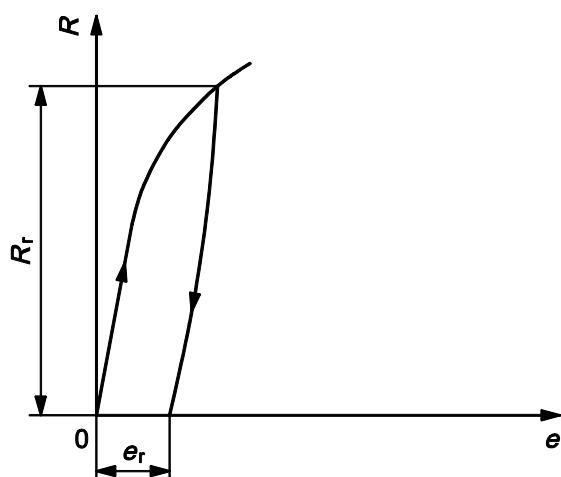
3.10.5

proof strength (permanent set strength), R_r

stress at which, after removal of force, a specified percentage permanent elongation or percentage permanent extension has not been exceeded

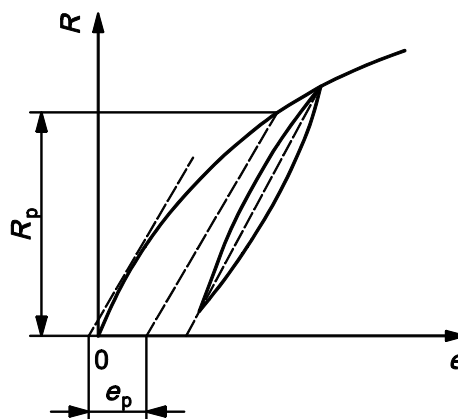
Note 1 to entry Percentage permanent elongation or percentage permanent extension is expressed respectively as a percentage of original gauge length L_o (3.1.1) or extensometer gauge length L_e (3.5) (see Figure 5).

Note 2 to entry A suffix is added to the subscript to indicate the specified value of the original gauge length L_o (3.1.1) or of the extensometer gauge length L_e (3.5), e.g. $R_{r0.2}$.



Key
 e : percentage extension
 R : stress
 e_r : specified percentage permanent elongation
 R_r : proof strength (permanent set strength)

Figure 5 Proof strength (permanent set strength)



Key
 e : percentage extension
 R : stress
 e_p : specified percentage plastic extension
 R_p : proof strength (plastic extension)

Figure 6 Proof strength (plastic extension) alternative procedure (see 13.1)

3.11

fracture, rupture

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.1.

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 ΔR and change of percentage extension Δe in the range of evaluation, multiplied by 100 %

Note 1 to entry $E = \frac{\Delta R}{\Delta e} \times 100$

It is recommended to report the value in GPa by deviding the result by 1 000 (GPa/MPa).

4 Symbols and designations

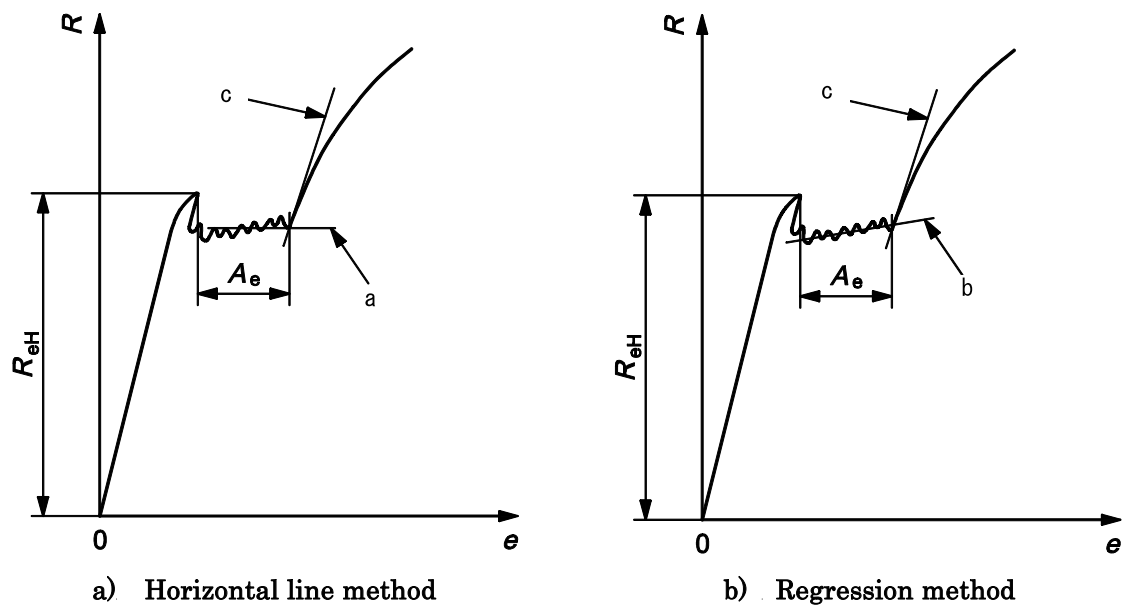
The symbols used in this Standard and corresponding designations are given in Table 1.

Table 1 Symbols and designations

Symbol	Unit	Designation
Test pieces		
a_o	mm	original thickness of plate test piece or wall thickness of tube
b_o	mm	original width of the parallel length of plate test piece, average width of the longitudinal strip test piece taken from tube or width of flat wire
d_o	mm	original diameter (or width across flats) of the parallel length of circular test piece ^{a)} or internal diameter of tube
D_o	mm	original external diameter of tube
L_o	mm	original gauge length
L'_o	mm	initial gauge length for determination of A_{wn} (see Annex J)
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 Annex J)
S_o	mm ²	original cross-sectional area of the parallel length
S_u	mm ²	minimum cross-sectional area after fracture
k	—	coefficient of proportionality (see 6.1.1)
Z	%	percentage reduction of area
Elongation		
A	%	percentage elongation after fracture (see 3.4.2)
A_{wn}	%	percentage plastic elongation without necking (see Annex J)
Extension		
e	%	percentage 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
ΔL_m	mm	extension at maximum force
ΔL_f	mm	extension at fracture
Rate		
$\dot{\epsilon}_{L_e}$	s ⁻¹	strain rate
$\dot{\epsilon}_{L_c}$	s ⁻¹	estimated strain rate over the parallel length
$\dot{R}$	MPa/s	stress rate
v_c	mm/s	crosshead separation rate
Force		
F_m	N	maximum force
Yield strength — Proof strength — Tensile strength		
R_{eH}	MPa ^{b)}	upper yield strength (upper yield point)
R_{eL}	MPa	lower yield strength (lower yield point)
R_m	MPa	tensile strength
R_p	MPa	proof strength (plastic extension)
R_r	MPa	proof strength (permanent set strength)
R_t	MPa	proof strength (total extension)
Modulus of elasticity — slope of the stress-percentage extension curve		
E	GPa ^{c)}	modulus of elasticity
m	MPa	slope of the stress-percentage extension curve at a given moment of the test
m_E	MPa	slope of the elastic region of the stress-percentage extension curve ^{d)}

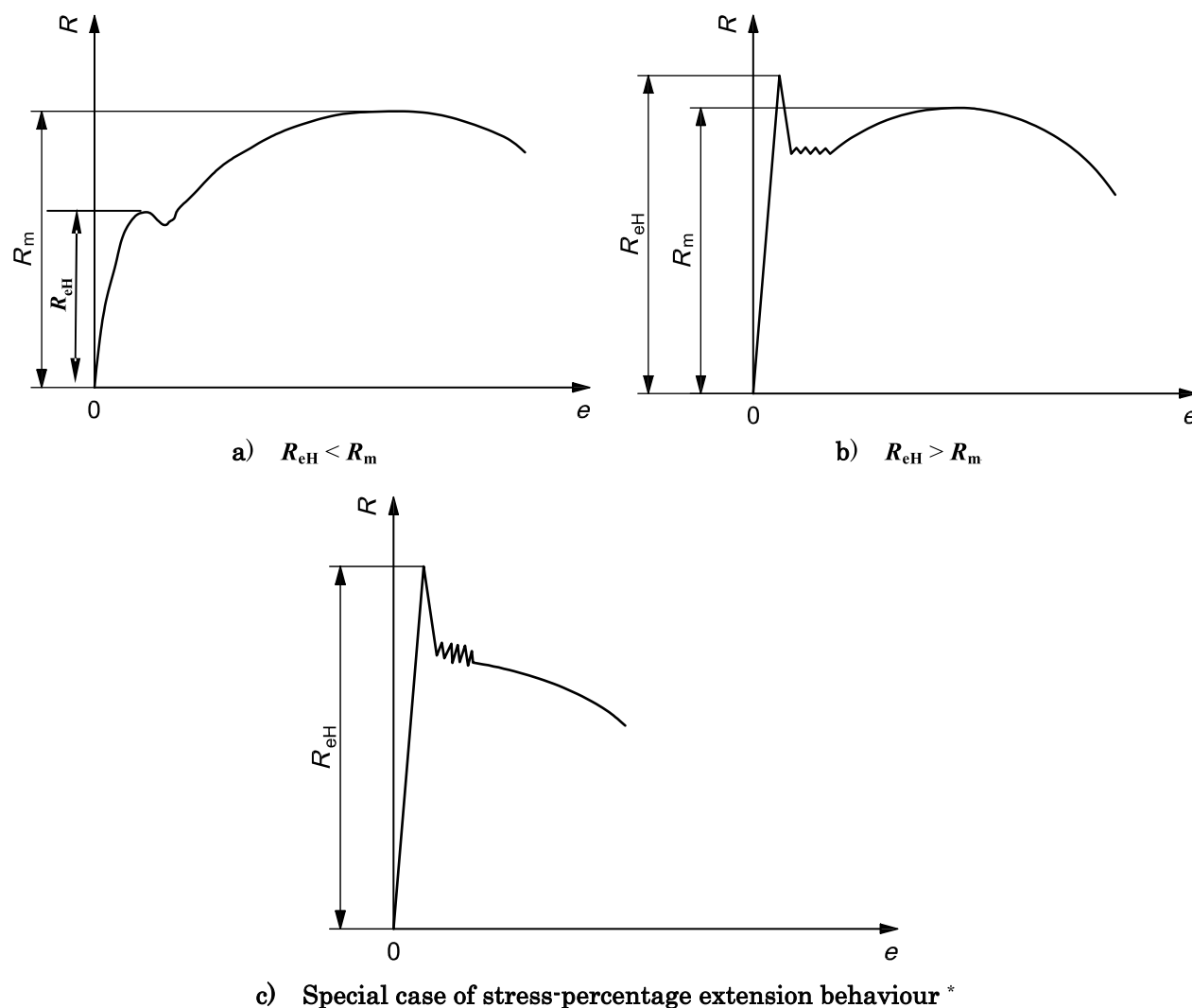
Table 1 (concluded)

NOTE	The factor 100 is necessary if percentage values are used.
Note a)	Machined cylindrical test pieces or unmachined test pieces taken from bars, wire rods and wires. When the diameters or widths across flats of bars, wire rods and wires are small, they are sometimes called lineal test pieces.
Note b)	1 MPa = 1 N/mm ²
Note c)	1 GPa = 1 000 N/mm ²
Note d)	In the elastic region 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 [high resolution, double-sided, averaging extensometers, perfect alignment of the test piece etc.] are used.



- Key
- e : percentage extension
 - R : stress
 - A_e : percentage yield point extension
 - R_{eH} : upper yield strength (upper yield point)
 - a : Horizontal line through the last local minimum point, prior to uniform work-hardening.
 - b : Regression line through the range of yielding, prior to uniform work-hardening.
 - c : Line corresponding to the highest slope of the curve occurring at the start of uniform work-hardening.

Figure 7 Different evaluation methods for percentage yield point extension A_e



Key

e : percentage extension

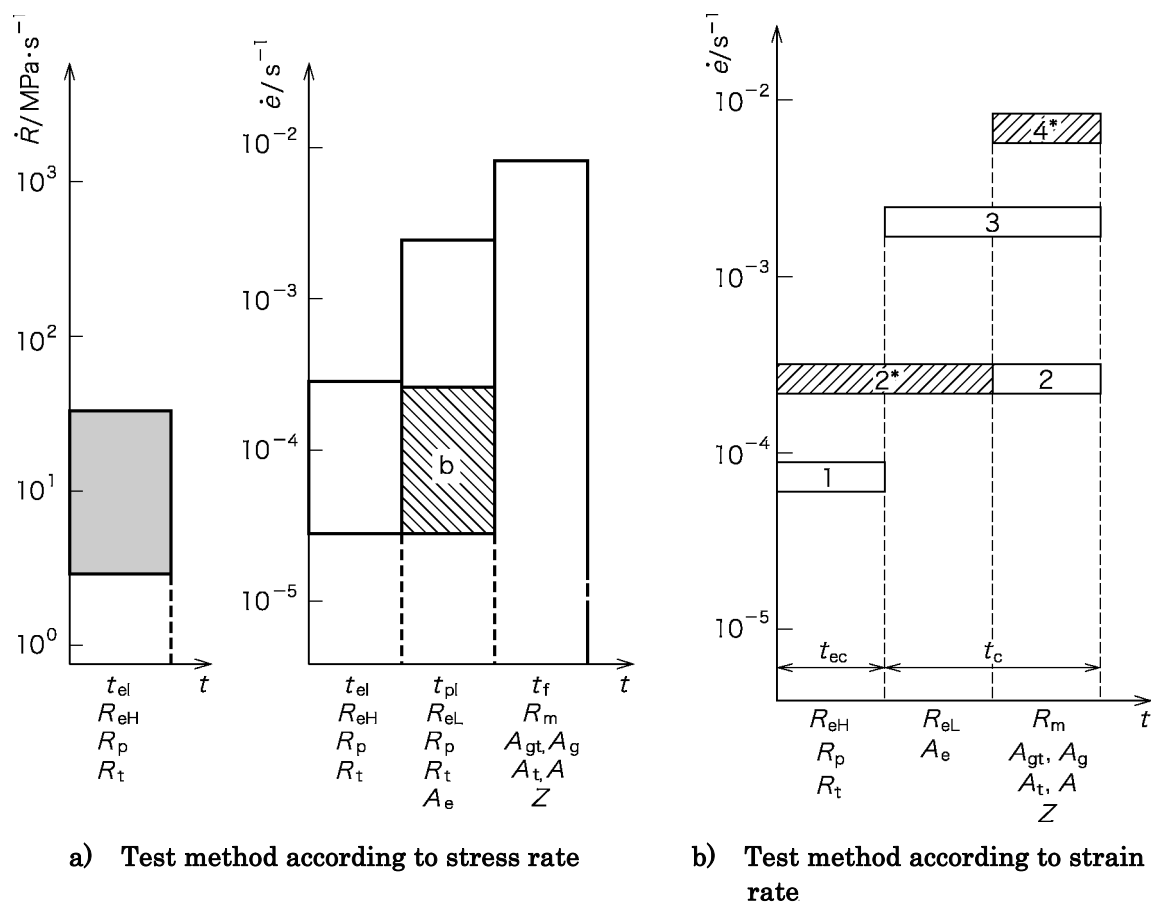
R : stress

R_{eH} : upper yield strength (upper yield point)

R_m : tensile strength

Note * For materials which display this behaviour, no tensile strength is defined according to this Standard. If necessary, separate agreements can be made between the parties concerned.

Figure 8 Different types of stress-extension curve for determination of tensile strength R_m



Key

$\dot{\epsilon}$: strain rate

$\dot{R}$: stress rate

t : time progress of tensile test

1 : Range 1 : $\dot{\epsilon} = (0.000\ 07 \pm 0.000\ 014)\ s^{-1}$

2 : Range 2 : $\dot{\epsilon} = (0.000\ 25 \pm 0.000\ 05)\ s^{-1}$

3 : Range 3 : $\dot{\epsilon} = (0.002 \pm 0.000\ 4)\ s^{-1}$

4 : Range 4 : $\dot{\epsilon} = (0.006\ 7 \pm 0.001\ 33)\ s^{-1} [(0.4 \pm 0.08)\ min^{-1}]$

t_c : time range controlled by crosshead separation rate

t_{ec} : time range controlled by extensometer or crosshead separation rate

t_{el} : time range of elastic behaviour for measurement of the parameters listed in Table 1

t_f : time range (usually up to fracture) for measurement of the parameters listed in Table 1

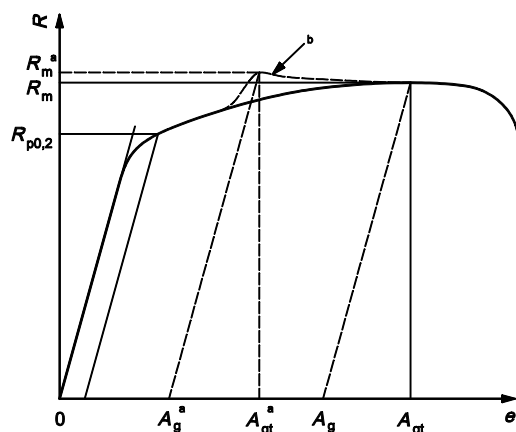
t_{pl} : time range of plastic behaviour for measurement of the parameters listed in Table 1

b : expanded range to lower rates, if testing machine cannot control the strain rate

NOTE Strain rate in the elastic region for the test method according to the stress rate is calculated from stress rate using a Young's modulus of 210 GPa (steel).

Note * Recommended.

Figure 9 Illustration of strain rates to be used during the tensile test for determination of R_{eH} , R_{eL} , R_p , R_t , R_m , A_e , A_g , A_{gt} , A_t and Z



Key

e : percentage extension

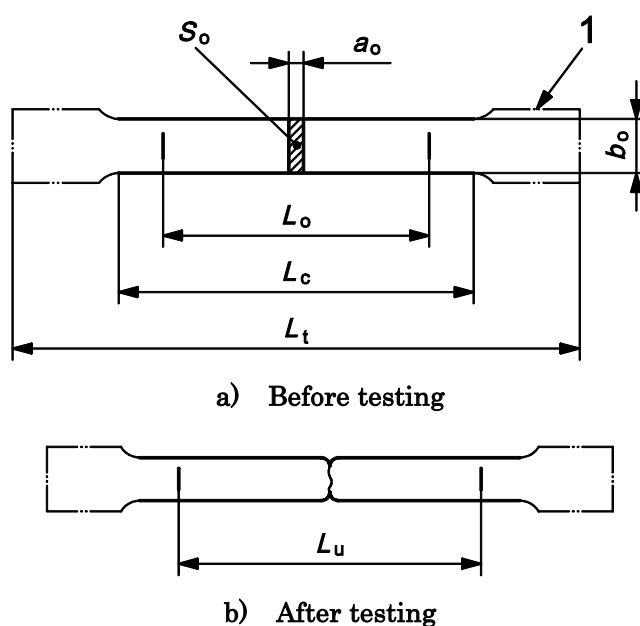
R : stress

a : False values, resulting from an abrupt strain rate increase.

b : Stress-extension behaviour, if strain rate is abruptly increased.

NOTE For parameter definitions, see Table 1.

Figure 10 Illustration of an inadmissible discontinuity in stress-extension curve



Key

a_o : original thickness of plate test piece

b_o : original width of the parallel length of plate test piece

L_c : parallel length

L_o : original gauge length

L_t : total length of test piece

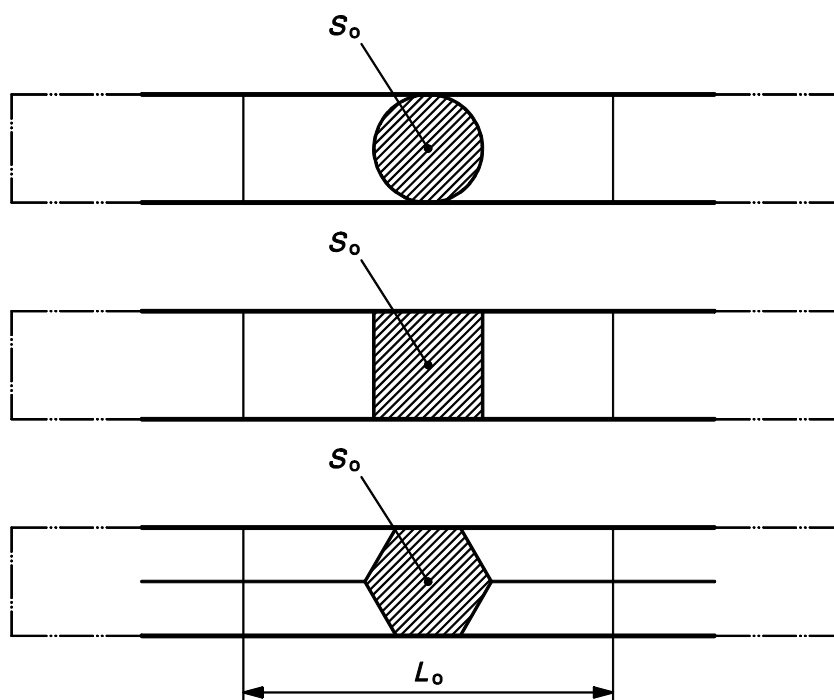
L_u : final gauge length after fracture

S_o : original cross-sectional area of the parallel length

1 : gripped ends

NOTE The shape of the gripped ends of test piece is only given as a guide.

Figure 11 Plate test pieces (see Annex B and Annex D)

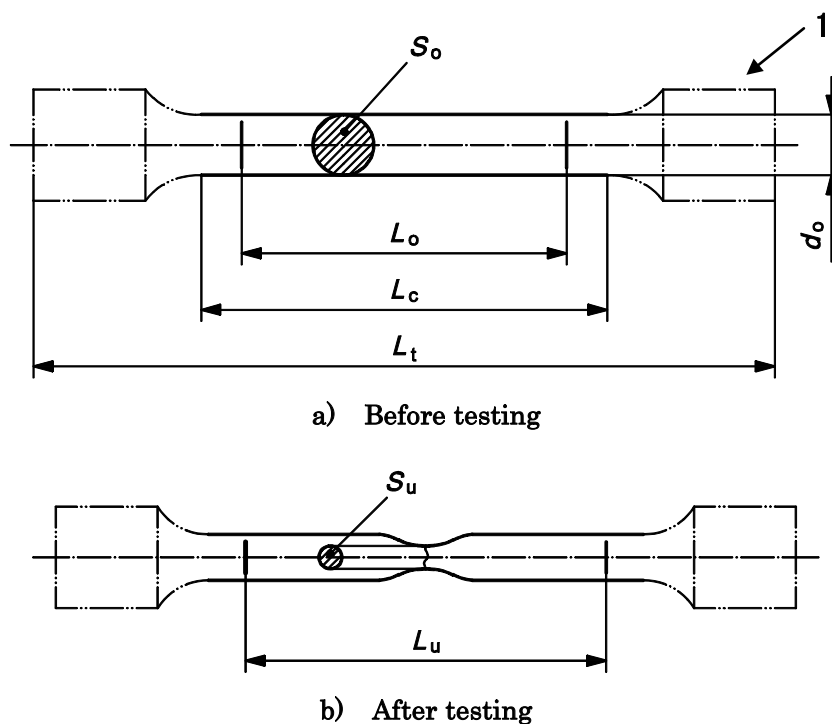


Key

L_o : original gauge length

S_o : original cross-sectional area of the parallel length

Figure 12 Circular test pieces (unmachined) (see Annex C)

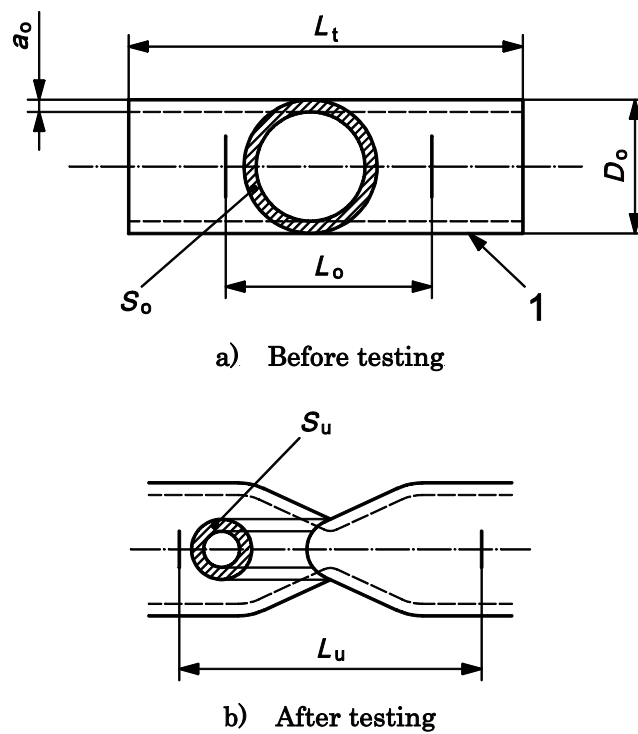


Key

- d_o : original diameter of the parallel length of circular test piece
- L_c : parallel length
- L_o : original gauge length
- L_t : total length of test piece
- L_u : final gauge length after fracture
- S_o : original cross-sectional area of the parallel length
- S_u : minimum cross-sectional area after fracture
- 1 : gripped ends

NOTE The shape of the gripped ends of test piece is only given as a guide.

Figure 13 Circular test pieces (machined) (see Annex D)

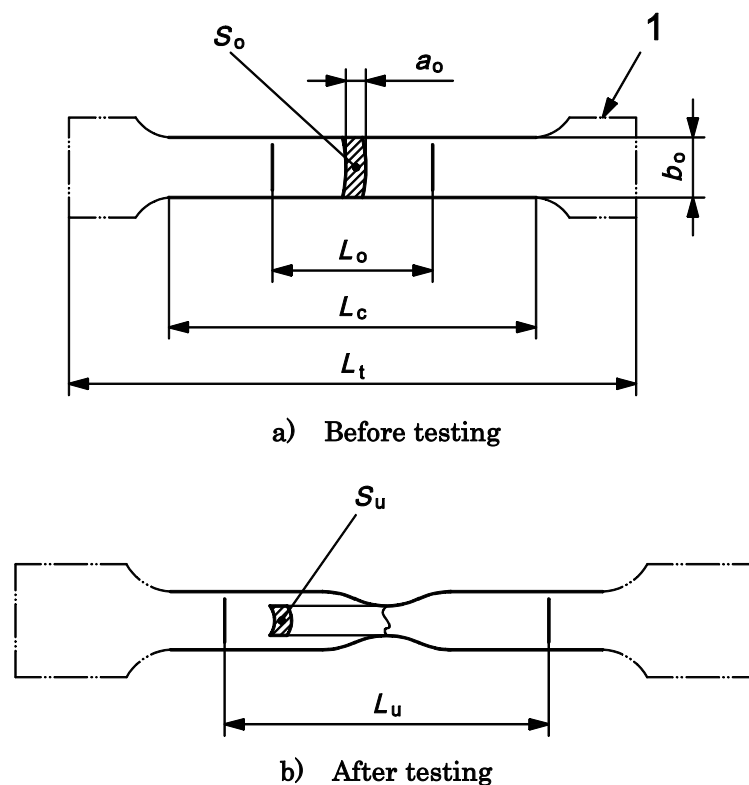


Key

- a_o : original wall thickness of tube
- D_o : original external diameter of tube
- L_o : original gauge length
- L_t : total length of test piece
- L_u : final gauge length after fracture
- S_o : original cross-sectional area of the parallel length
- S_u : minimum cross-sectional area after fracture
- 1 : gripped ends

NOTE The shape of the gripped ends of test piece is only given as a guide.

Figure 14 Annular test pieces (see Annex E)



Key

- a_o : original wall thickness of tube
- b_o : original average width of longitudinal strip test piece taken from tube
- L_c : parallel length
- L_o : original gauge length
- L_t : total length of test piece
- L_u : final gauge length after fracture
- S_o : original cross-sectional area of the parallel length
- S_u : minimum cross-sectional area after fracture
- 1 : gripped ends

NOTE The shape of the gripped ends of test piece is only given as a guide.

Figure 15 Longitudinal strip test piece (see Annex E)

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, the testing laboratory should 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.

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, wire rods 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.

The straightening of the test piece should be avoided as far as practicable; however when it is necessary, it shall be done by such a method that might not affect the mechanical properties of the test piece as far as practicable.

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 $L_0 = k\sqrt{S_0}$, and are called proportional test pieces. k is a coefficient of proportionality, and 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 for this requirement to be met with $k = 5.65$, a higher value (preferably 11.3) or a non-proportional test piece may be used.

NOTE By using an original gauge length smaller than 20 mm, the measurement uncertainty will be increased.

For non-proportional test pieces, the original gauge length L_0 is independent of the original cross-sectional area S_0 .

The dimensional tolerances of the test pieces shall be in accordance with Annex B to Annex E (see 6.2).

If separately specified in relevant product standards or test method standards, other test pieces may be used.

6.1.2 Machined test pieces

Machined test pieces shall incorporate a transition radius between the gripped ends and the parallel length if these have different dimensions. The dimensions of the transition radius are important and it is recommended that they be in accordance with the appropriate Annex in this Standard (see 6.2) if they are not given in the product specification.

The gripped ends may be of any shape to suit the grips of the testing machine. The

axis of the test piece shall coincide with the axis of application of the force.

The parallel length L_c or, in the case where the test piece has no transition radius, the free length between the grips, shall always be greater than the original gauge length L_0 .

The parallel length of a test piece may be tapered towards the middle within the tolerances on the dimensional change of the parallel length specified in Annex B to Annex E.

6.1.3 Unmachined test pieces

If the test piece consists of an unmachined length of the product or of an unmachined circular sample, the free length between the grips shall be sufficient for gauge marks to be at a reasonable distance from the grips (see Annex B to Annex E).

As-cast test pieces shall incorporate a transition radius between the gripped ends and the parallel length. The dimensions of this transition radius are important and it is recommended that they be defined in the product standard. The gripped ends may be of any shape to suit the grips of the testing machine. The parallel length L_c shall always be greater than the original gauge length L_0 .

6.2 Types

The main types of test pieces are defined in Annex B to Annex E according to the shape of material and type of product, as shown in Table 2 and Table 3. Other types of test pieces can be specified in product standards.

Table 2 Shape of material, type of product, and corresponding Annexes for sampling test pieces

Shape of material and type of product		Unit: mm
Strips — Plates — Flats	Wires/wire rods — Bars — Sections	Corresponding Annexes
 Thickness a_0	   Diameter or width across flats	
$0.1 \leq a_0 < 3$	—	Annex B
—	<4	Annex C
$a_0 \geq 3$	≥ 4	Annex D
Tube		Annex E

Table 3 Classification of test pieces

Shape of test piece	Plate test piece	Circular test piece	Annular test piece	Longitudinal strip test piece
Proportional test piece	No. 14B	No. 2, No. 14A	No. 14C	No. 14B
Non-proportional test piece	No. 1A, No. 1B, No. 5, No. 13A, No. 13B	No. 4, No. 10, No. 8A, No. 8B, No. 8C, No. 8D No. 9A, No. 9B	No. 11	No. 12A, No. 12B, No. 12C

NOTE For the test piece numbers and summaries, refer to Annex JC.

The selection of the test piece to be used shall be in accordance with the requirements of respective product standards. Unless otherwise specified, the division of use in Table 4 should be referred to.

Table 4 Division of use for test pieces

Shape and dimensions of material		Test pieces		Remarks	Corre- sponding Annex
Prod- uct divi- sion	Dimension	Propor- tional	Non-propor- tional		
Plate/flat/section/strip	Over 40 mm in plate thickness	No. 14A	No. 4, No. 10	For sampling of circular test piece	Annex D
		No. 14B	—	For sampling of plate test piece	
	Over 20 mm up to and incl. 40 mm in plate thickness	No. 14A	No. 4, No. 10	For sampling of circular test piece	
		No. 14B	No. 1A, No. 1B	For sampling of plate test piece	
	Over 6 mm up to and incl. 20 mm in plate thickness	No. 14B	No. 1A, No. 1B, No. 5, No. 13A, No. 13B	For sampling of plate test piece	
	3 mm or over up to and incl. 6 mm in plate thickness		No. 5, No. 13A, No. 13B		
	0.1 mm or over to and excl. 3 mm in plate thickness	—		Annex B	
Bar/wire/wire rod	Over 25 mm in diameter or width across flats	No. 14A	No. 4, No. 9A, No. 9B, No. 10	—	Annex D
	4 mm or over up to and incl. 25 mm in diameter or width across flats	No. 2, No. 14A	No. 4, No. 9A, No. 9B, No. 10	—	
	Under 4 mm in diameter or width across flats	—	No. 9A, No. 9B	—	Annex C
Tube	Tube of small external diameter	No. 14C	No. 11	For sampling of annular test piece	Annex E
	50 mm or under in external diameter	No. 14B	No. 12A	For sampling of longitudinal strip test piece	
	Over 50 mm up to and incl. 170 mm in external diameter		No. 12B		
	Over 170 mm in external diameter		No. 12C		
	200 mm or over in external diameter	No. 14B	No. 5	For sampling of plate test piece or longitudinal strip test piece	
	Tube of thick wall	No. 14A	No. 4	For sampling of circular test piece	
Casting	—	No. 14A	No. 4, No. 10	—	Annex D
	—	—	No. 8A, No. 8B, No. 8C, No. 8D	—	
Forging	—	No. 14A	No. 4, No. 10	—	Annex D

6.3 Preparation of test pieces

The test pieces shall be taken and prepared in accordance with the requirements of the relevant standards for the different materials (e.g. **JIS G 0416** [14]).

7 Determination of original cross-sectional area

The relevant dimensions of test piece should be measured at sufficient positions between gauge marks of the parallel length, perpendicular to the longitudinal direction.

A minimum of three cross-sections is recommended.

NOTE 1 Nominal dimensions, if applied, are specified in Annex B and Annex D. The concept where the measuring position is made to one is given in Annex JB.

Respective dimensions of test piece shall be in accordance with Annex B to Annex E. Unless otherwise specified in Annex B to Annex E, the dimensions shall be measured to the nearest 0.5 % or under of the numerical values. If the dimension to be measured is 2 mm or under, the minimum of the value to be measured may be down to 0.01 mm.

The original cross-sectional area S_0 is the average cross-sectional area, and shall be calculated from the measurements of appropriate dimensions.

Examples of the calculation method are as follows.

Example 1 The original cross-sectional area S_0 of the parallel length of the test piece except the annular test piece is obtained from the average of three measurements at the both ends and the centre between the gauge marks.

For the annular test piece, the original cross-sectional area S_0 is measured at the end of the test piece.

Example 2 The diameter used for obtaining the original cross-sectional area S_0 of the circular cross-section test piece and the annular test piece is the average of measurements in two orthogonal directions.

The wall thickness for obtaining the original cross-sectional area S_0 of the annular test piece is the average of not less than three measurements at the points on the circumference of the tube end part equally divided.

Example 3 The cross-sectional area of the tapered test piece is the minimum cross-sectional area.

NOTE 2 The average of the difference between internal and external diameters of annular test piece when measured in two orthogonal directions may be substituted by twice the average of the thickness at four points.

The accuracy of this calculation depends on the type and shape of the test piece. The evaluation methods of the original cross-sectional area S_0 for different types of test pieces are given in Annex B to Annex E.

8 Original gauge length and extensometer gauge length

8.1 Choice of the original gauge length

For proportional test pieces, if the original gauge length is not equivalent to $5.65\sqrt{S_0}$, where S_0 is the original cross-sectional area of the parallel length, the symbol of percentage elongation after fracture A should be supplemented by a subscript indicating the coefficient of proportionality used, e.g. $A_{11.3}$ indicates a percentage elongation of the original gauge length according to Formula (1).

$$L_0 = 11.3\sqrt{S_0} \quad \dots\dots\dots (1)$$

NOTE 1 $5.65\sqrt{S_0} = 5\sqrt{4S_0/\pi}$

NOTE 2 For non-proportional test pieces (see Annex B and Annex D), the symbol A is sometimes supplemented by a subscript indicating the original gauge length used, e.g. $A_{80 \text{ mm}}$ indicates a percentage elongation after fracture of a gauge length L_0 of 80 mm.

If the proportional constant of a proportional test piece or the original gauge length of a non-proportional test piece is known corresponding to the specified test conditions, the proportional constant or the original gauge length need not be added.

8.2 Marking the original gauge length

For the manual determination of the percentage elongation after fracture A , each end of the original gauge length L_0 shall be marked by means of fine marks, scribed lines, or punch marks, but not by marks which could result in premature fracture. For the test piece whose material is sensitive to scratch on the surface or extremely hard, the marks may be scribed on the surface of coating applied on the test piece. The original gauge length shall be marked to an accuracy of $\pm 1\%$. For proportional test pieces, the calculated value of the original gauge length may be rounded to the nearest multiple of 5 mm, provided that the difference between the calculated and marked gauge length is less than 10 % of L_0 .

If the parallel length L_c is much greater than the original gauge length, as, for instance, with unmachined test pieces, a series of overlapping gauge lengths may be marked.

In some cases, it can be helpful to draw a line parallel to the longitudinal axis, along which the gauge lengths are marked.

When measuring the extension using an extensometer, marking on the test piece is unnecessary (see 20.3).

8.3 Choice of the extensometer gauge length

For measurement of yield strength and proof strength L_c should span as much of the parallel length of the test piece as possible. Ideally, as a minimum, L_c should be greater than $0.50L_0$ but less than approximately $0.90L_0$. This should ensure that the extensometer detects all yielding events that occur in the test piece. Further, for measurement of parameters “at” or “after reaching” maximum force L_c should be approximately equal to L_0 .