

# JIS

JAPANESE  
INDUSTRIAL  
STANDARD

Translated and Published by  
Japanese Standards Association

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**JIS Z 2241** : 2011

(JISF)

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

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ICS 77.040.10

**Reference number : JIS Z 2241 : 2011 (E)**

Z 2241 : 2011

Date of Establishment: 1952-07-22

Date of Revision: 2011-02-21

Date of Public Notice in Official Gazette: 2011-02-21

Investigated by: Japanese Industrial Standards Committee  
Standards Board  
Technical Committee on Iron and Steel

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JIS Z 2241:2011, First English edition published in 2012-05

Translated and published by: Japanese Standards Association  
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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Printed in Japan

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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 The Japan Iron and Steel Federation (JISF) 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Consequently **JIS Z 2241:1998** and **JIS Z 2201:1998** have been revised and withdrawn, respectively, and replaced with this Standard.

This JIS document is protected by the Copyright Law.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public or utility model right. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public or utility model right.

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

## Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **ISO 6892-1** published in 2009 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 Standard have been modified. A list of modifications with the explanations is given in Annex JC.

## 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 6892-1:2009 *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

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) indicated below shall be applied.

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

**NOTE :** Corresponding International Standard: ISO 7500-1:2004 *Metallic materials—Verification of static uniaxial testing machines—Part 1: Tension/compression testing machines—Verification and calibration of the force-measuring system* (MOD)

JIS B 7741 *Verification of extensometers used in uniaxial testing*

**NOTE :** Corresponding International Standard: ISO/DIS 9513:1996 *Metallic materials—Verification of extensometers used in uniaxial testing* (MOD)

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

JIS Z 8401 *Guide to the rounding of numbers*

### 3 Terms and definitions

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

#### 3.1 gauge length $L$

length of the parallel portion of the test piece on which elongation is measured, which is particularly classified as follows

##### 3.1.1 original gauge length $L_0$

gauge length (3.1) marked on the test piece measured at room temperature before the test

##### 3.1.2 final gauge length after rupture, final gauge length after fracture $L_u$

gauge length (3.1) marked on the test piece measured at room temperature after rupture

At the measurement, two fractured parts of the test piece 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 portion where the cross-sectional area of the test piece is reduced

NOTE : For the unmachined test pieces, the parallel length is replaced by the distance between grips.

#### 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, expressed as a percentage of the original gauge length

##### 3.4.2 percentage elongation after fracture $A$

permanent elongation ( $L_u - L_0$ ), expressed as a percentage of the original gauge length  $L_0$  (3.1.1)

NOTE : 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 parallel portion), the symbol  $A$  should be supplemented by a subscript indicating the coefficient of proportionality used.

$A_{11.3}$  : percentage elongation after fracture of gauge length of  $11.3\sqrt{S_0}$

Note <sup>1)</sup>  $5.65\sqrt{S_0} = 5\sqrt{\frac{4S_0}{\pi}}$

For non-proportional test pieces (see Annex B), the symbol  $A$  should be supplemented by a subscript indicating the original gauge length used, expressed in millimetres.

$A_{80\text{ mm}}$  : percentage elongation after fracture of gauge length of 80 mm

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

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

See figure 1.

NOTE : In ISO 6892-1, the definitions in 3.4.3 to 3.4.6 of this Standard are described in 3.6 of ISO 6892-1 as that relevant to the extension.

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

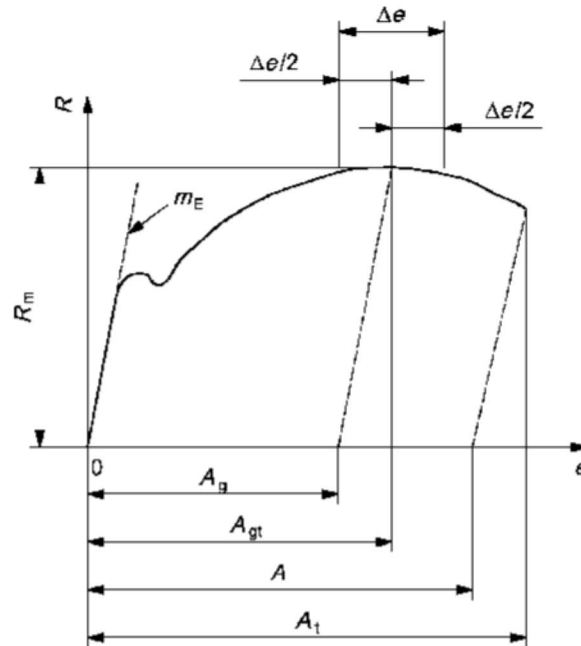
total extension (elastic extension plus plastic extension of extensometer) at the maximum force, expressed as a percentage of the extensometer gauge length  $L_e$  (3.5)

See figure 1.

**3.4.5 percentage plastic extension at maximum force  $A_p$**

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

See figure 1.



- $A$  : percentage elongation after fracture [measured by extensometer or directly from 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
- $e$  : percentage extension
- $m$  : slope of elastic part of stress-percentage extension curve
- $R$  : stress
- $R_m$  : tensile strength
- $\Delta e$  : plateau extent (for definitions, see clause 17 for  $A_g$  and clause 18 for  $A_{gt}$ )

**Figure 1 Definitions of extension**

### 3.4.6 percentage yield point extension $A_e$

extension between the start of yielding and the start of uniform workhardening in discontinuous yielding materials, expressed as a percentage of the extensometer gauge length  $L_c$  (3.5)

See figure 7.

### 3.5 extensometer gauge length $L_c$

extensometer gauge length before the test used for measurement of extension by means of an extensometer

**NOTE :** For the measurement of yield point and proof strength, the extensometer gauge length  $L_c$  should span as much of the parallel portion of the test piece as possible. Ideally, as a minimum of  $L_c$  should be greater than  $0.50 L_0$  but less than approximately  $0.90 L_c$ . 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  $L_0$ .

### 3.6 extension

increase in the extensometer gauge length  $L_e$  (3.5) at any moment during the test

#### 3.6.1 percentage extension

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

#### 3.6.2 percentage permanent extension

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

### 3.7 testing rate

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

increase of strain per time measured from the extensometer gauge length  $L_e$  (3.5)

NOTE : See 3.5.

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

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

#### 3.7.3 crosshead separation rate $v_c$

displacement of the crosshead per time

#### 3.7.4 stress rate $\dot{K}$

increase of stress per time

NOTE : The stress rate should be applied only in the elastic part.

### 3.8 percentage reduction of area $Z$

maximum change in cross-sectional area ( $S_0 - S_u$ ) which has occurred during the test, expressed as a percentage of the original cross-sectional area  $S_0$

$$Z = \frac{S_0 - S_u}{S_0} \times 100$$

### 3.9 maximum force

NOTE 1 When specifying the maximum force for the materials exhibiting discontinuous yielding but subjected to no workhardening, it shall be upon the agreement between the parties concerned with delivery.

NOTE 2 See figure 8 c).

#### 3.9.1 maximum force $F_m$

highest force that the test piece withstands during the test for the case of materials exhibiting no discontinuous yielding

NOTE : See figure 8 a).

### 3.9.2 maximum force $F_m$

highest force that the test piece withstands after the beginning of workhardening for the case of materials exhibiting discontinuous yielding

NOTE : See figure 8 b).

### 3.10 stress $R$

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

NOTE 1 All references to stress in this Standard are to engineering stress.

NOTE 2 In what follows, the designations of “force” and “stress”, or “extension”, “percentage extension” and “strain”, respectively, are used on various occasions (as figure axis labels or in 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 corresponding to the maximum force  $F_m$  (3.9)

#### 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) $R_{eH}$

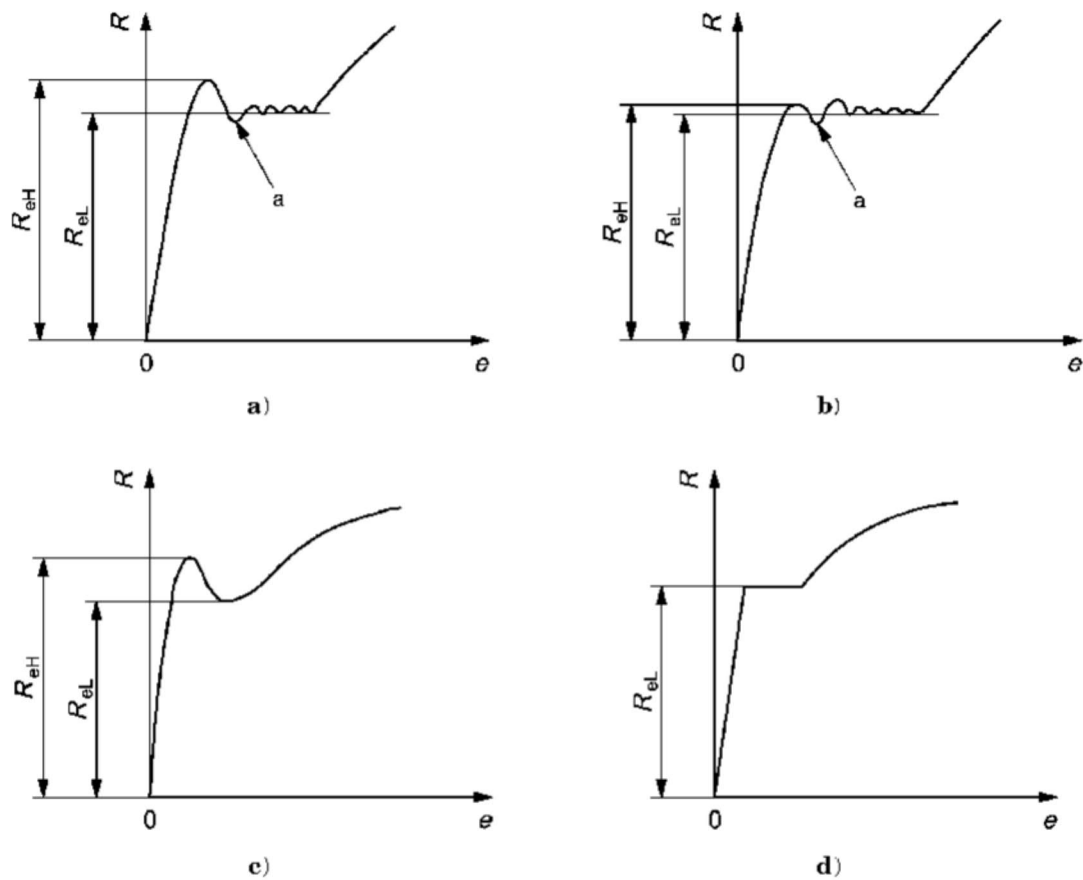
maximum value of stress (3.10) prior to the first decrease in force

See figure 2.

##### 3.10.2.2 lower yield strength (lower yield point) $R_{eL}$

minimum value of stress (3.10) during plastic yielding, ignoring any initial transient effects

See figure 2.



- $e$  : percentage extension
- $R$  : stress
- $R_{eH}$  : upper yield strength (upper yield point)
- $R_{eL}$  : lower yield strength (lower yield point)
- $a$  : initial transient effect

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

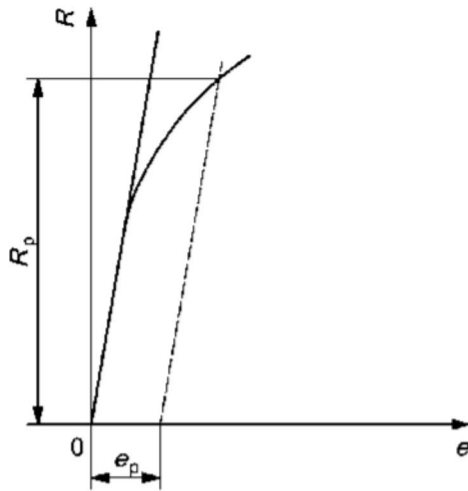
### 3.10.3 proof strength, plastic extension $R_p$

stress at which the plastic extension is equal to a specified percentage of the extensometer gauge length  $L_c$  (3.5)

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

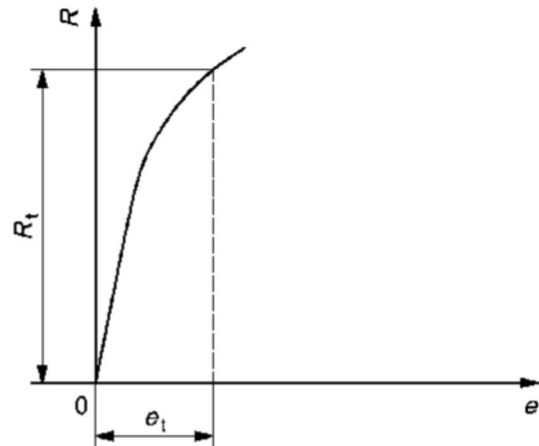
See figure 3.





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

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



$e$  : percentage extension  
 $e_t$  : specified percentage total extension  
 $R$  : stress  
 $R_t$  : 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 of extensometer) is equal to a specified percentage of the extensometer gauge length  $L_e$  (3.5) (see figure 4)

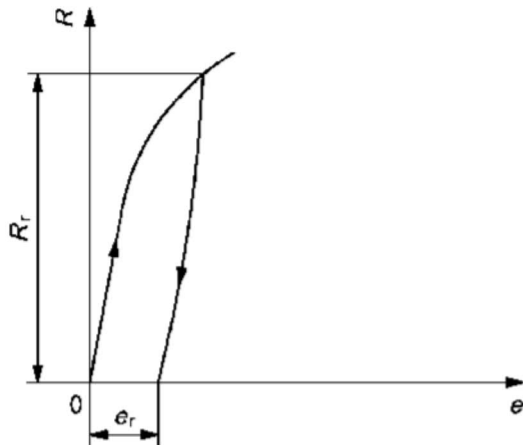
NOTE : A suffix is added to the subscript to indicate the prescribed percentage (e.g.,  $R_{t0.5}$ ).

### 3.10.5 permanent set strength $R_r$

stress at which the plastic deformation of the specified percentage permanent elongation or the percentage permanent extension or under occurs, after removal of force

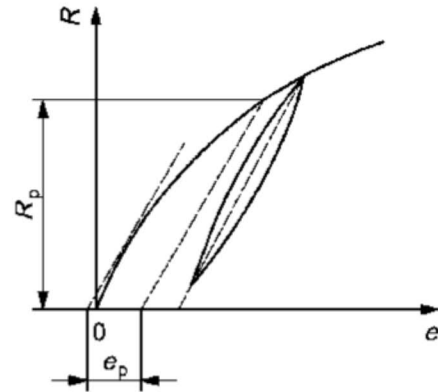
The percentage permanent elongation or the percentage permanent extension are expressed as a percentage of the original gauge length  $L_o$  (3.1.1) and the extensometer gauge length  $L_e$  (3.5), respectively (see figure 5).

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



$e$  : percentage extension  
 $e_r$  : percentage permanent set extension  
 $R$  : stress  
 $R_r$  : permanent set strength

**Figure 5 Permanent set strength**



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

**Figure 6 Proof strength  
 (plastic extension)  
 (see 13.1)**

### 3.11 fracture, rupture

phenomenon which is deemed as the occurrence of total separation of the test piece

NOTE : Criteria for fracture which may be used for computer-controlled tests are given in figure A.2 of **ISO 6892-1**.

## 4 Symbols and designations

The symbols and corresponding designations are given in table 1.

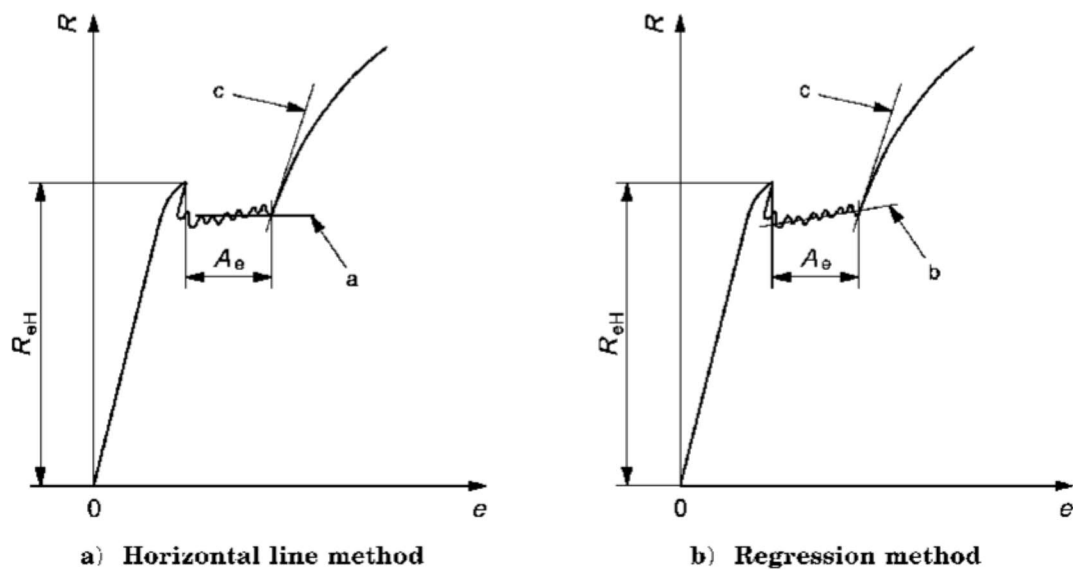
**Table 1 Symbol and designation**

Symbol	Unit	Designation
Test piece		
$a_0$	mm	Thickness of flat-form test piece or wall thickness of tube before test
$b_0$	mm	Width of parallel portion of flat-form test piece, average width of strip-form test piece taken from tube or width of flat wire before test
$d_0$	mm	Diameter (or width across flats) of parallel portion of bar-form test piece, diameter of wire or inside diameter of tube before test
$D_0$	mm	Outside diameter of tube before test
$L_0$	mm	Original gauge length
$L'_0$	mm	Initial gauge length at measurement of $A_{wh}$ (see Annex I)
$L_c$	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 at measurement of $A_{wh}$ (see Annex I)
$S_0$	mm <sup>2</sup>	Original cross-sectional area of parallel portion
$S_u$	mm <sup>2</sup>	Minimum cross-sectional area after fracture
$k$	—	Coefficient of proportionality (see 6.1.1)
$Z$	%	Percentage reduction of area
Elongation		
$A$	%	Percentage elongation after fracture (see 3.4.2)
$A_{wh}$	%	Percentage plastic elongation without necking (see Annex I)
Extension		
$A_e$	%	Percentage yield point extension
$A_p$	%	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
Testing rate		
$\dot{\epsilon}_{L_c}$	s <sup>-1</sup>	Strain rate
$\hat{\epsilon}_{L_c}$	s <sup>-1</sup>	Estimated strain rate over parallel portion
$\dot{R}$	MPa · s <sup>-1</sup>	Stress rate
$\nu_c$	mm · s <sup>-1</sup>	Crosshead separation rate
Force		
$F_m$	N	Maximum force

**Table 1** (concluded)

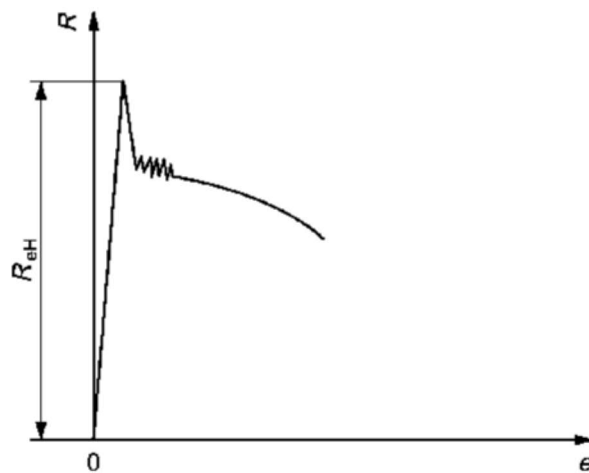
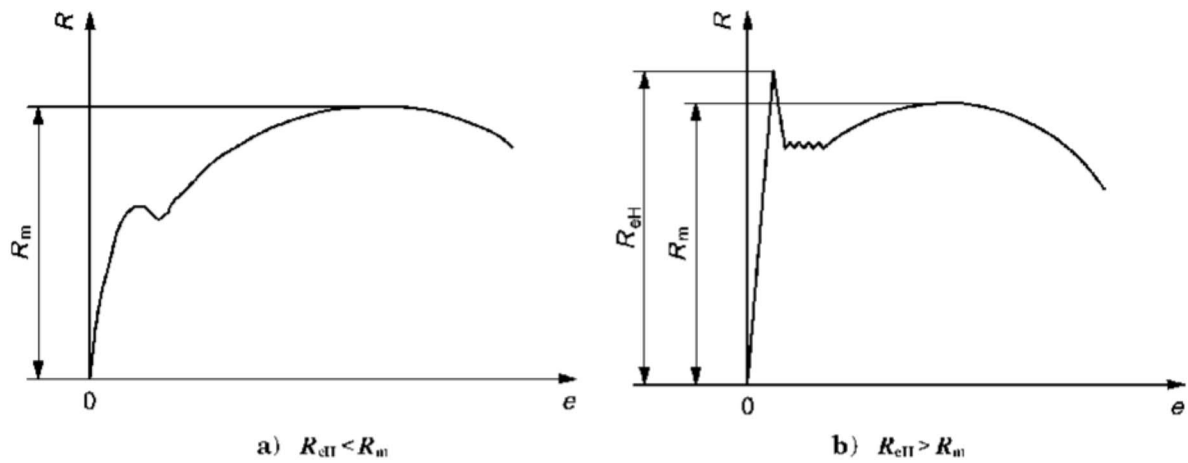
Symbol	Unit	Designation
Yield strength-proof strength-tensile strength		
$E$	MPa <sup>a)</sup>	Modulus of elasticity
$m$	MPa	Slope of stress-percentage extension curve at any moment of test
$m_1$	MPa	Slope of elastic part of stress-percentage extension curve <sup>b)</sup>
$R_{eH}$	MPa	Upper yield strength (upper yield point)
$R_{eL}$	MPa	Lower yield strength (lower yield point)
$R_m$	MPa	Tensile strength
$R_p$	MPa	Proof strength (plastic extension)
$R_t$	MPa	Permanent set strength
$R_l$	MPa	Proof strength (total extension)

NOTE : The factor 100 is necessary, if percentage values are used.  
Notes <sup>a)</sup> 1 MPa = 1 N/mm<sup>2</sup>  
<sup>b)</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 can 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.



- $A_e$  : percentage yield point extension
- $e$  : percentage extension
- $R$  : stress
- $R_{eH}$  : upper yield strength (upper yield point)
- a : horizontal line through the last local minimum point prior to uniform workhardening
- b : regression line through the range of yielding prior to uniform workhardening
- c : line corresponding to the highest slope of the curve occurring at the start of uniform workhardening

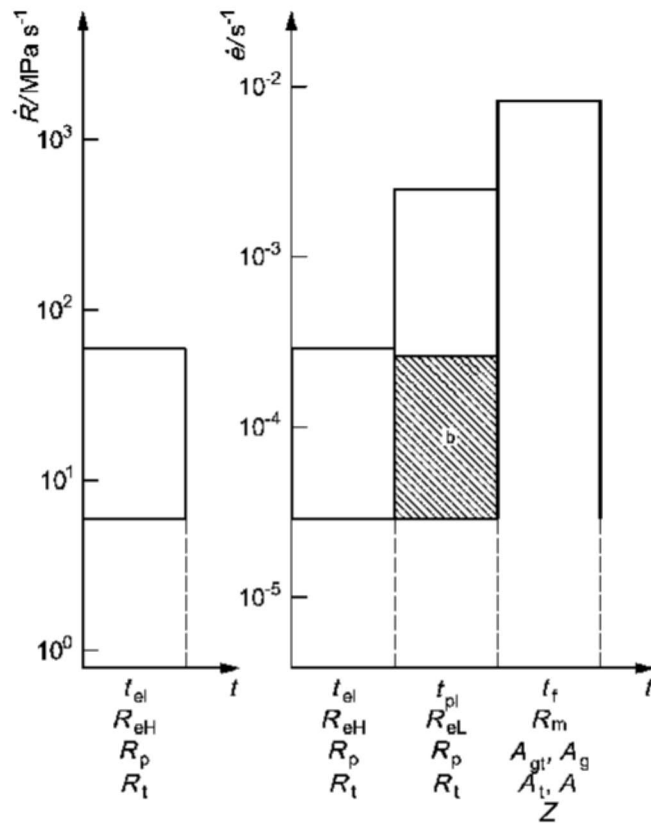
**Figure 7 Different evaluation methods for percentage yield point extension  $A_e$**



- $e$  : percentage extension
- $R$  : stress
- $R_{eH}$  : upper yield strength (upper yield point)
- $R_m$  : tensile strength

Note <sup>a)</sup> For materials which exhibit this behaviour, the tensile strength is not specified in this Standard. If necessary, this may be determined upon the agreement between the parties concerned with delivery.

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



$\dot{\epsilon}$  : strain rate

$\dot{R}$  : stress rate

$t$  : time progress of the tensile test

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

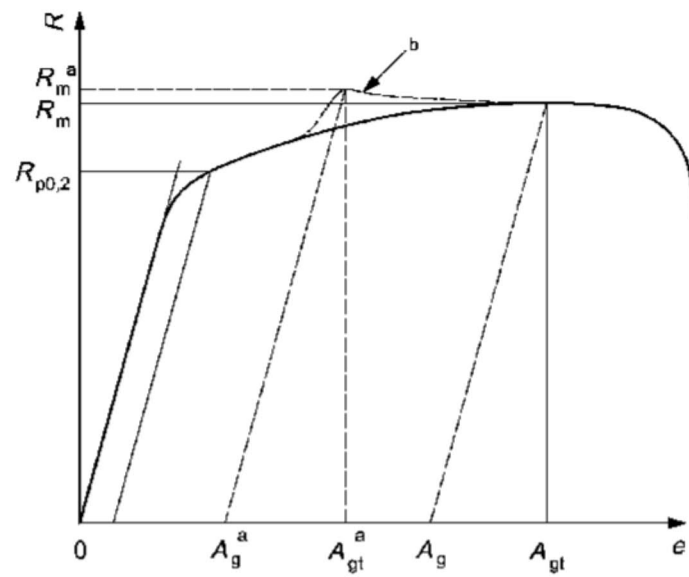
$t_f$  : time range (usually up to fracture) for measurement of the parameters listed in table 1

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

b : expanded range to lower rates, if testing machine is not capable of controlling the strain rate

NOTE : Strain rate in the elastic part obtained from stress rate using a Young modulus of 210 000 MPa (steel) (see 10.3.2.5)

**Figure 9 Illustration of strain rate to be used during test if  $R_{eH}$ ,  $R_{eL}$ ,  $R_p$ ,  $R_t$ ,  $R_m$ ,  $A_g$ ,  $A_{gt}$ ,  $A$ ,  $A_t$  and  $Z$  are measured**



$e$  : percentage extension

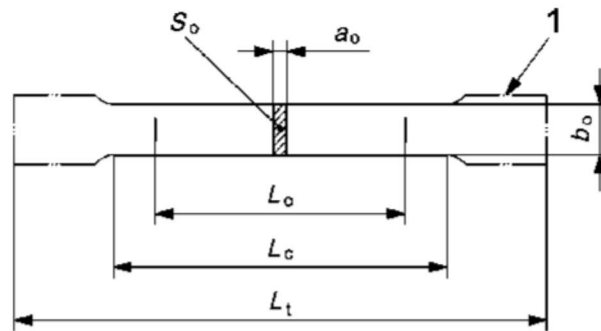
$R$  : stress

$a$  : false value resulting from abrupt strain rate increase

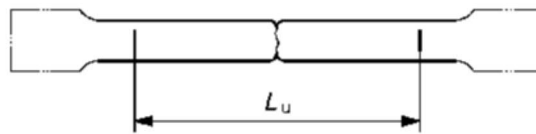
$b$  : stress-strain behaviour if strain rate is abruptly increase

NOTE : For the definitions of parameters, see table 1.

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



a) Before test



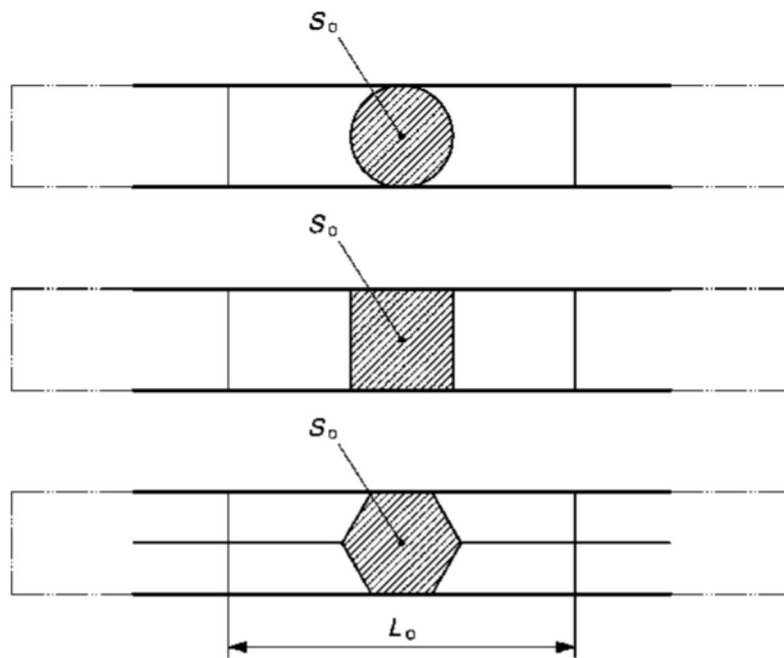
b) After test

- $a_o$  : thickness of flat-form test piece before test
- $b_o$  : width of parallel portion of flat-form test piece before test
- $L_o$  : 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 parallel portion
- 1 : gripped end

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

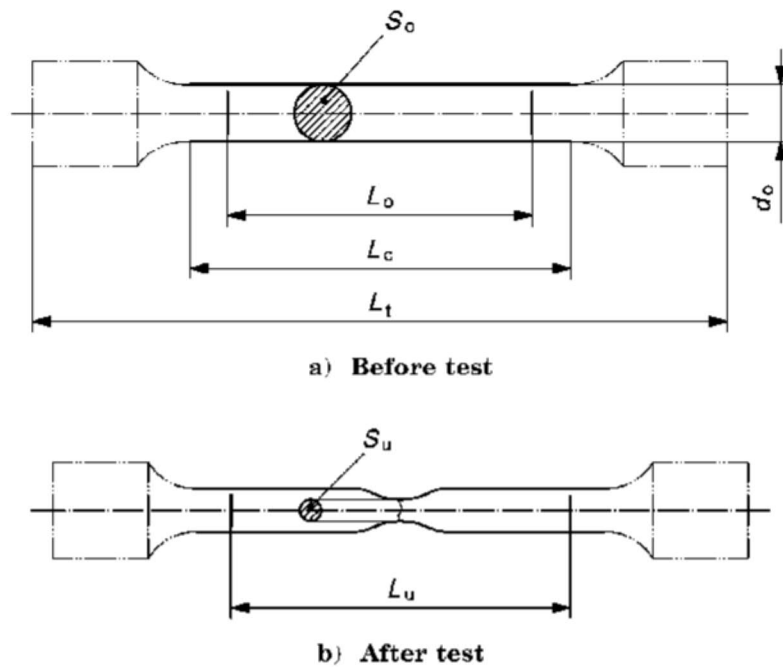
**Figure 11 Flat-form test piece (see Annex B and Annex D)**





$L_0$  : original gauge length  
 $S_0$  : original cross-sectional area

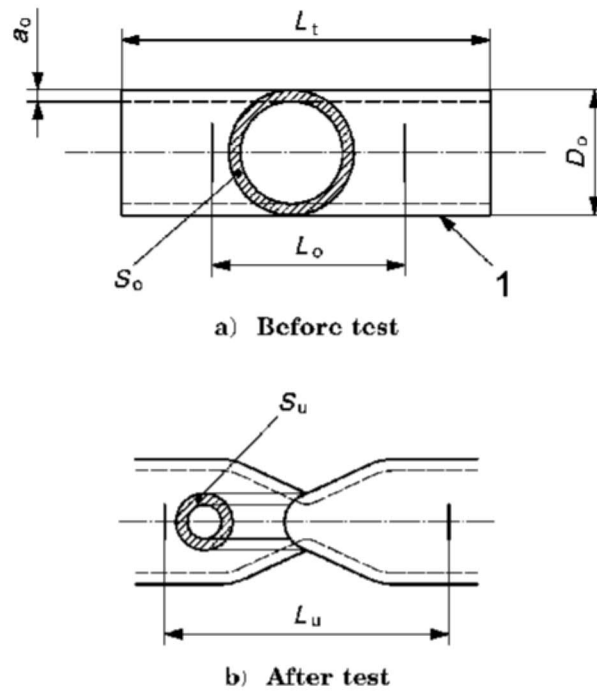
**Figure 12 Bar-form and wire-form test pieces (unmachined)  
(see Annex C)**



- $d_0$  : diameter of the parallel portion of a bar-form test piece before test  
 $L_0$  : parallel length  
 $L_c$  : original gauge length  
 $L_t$  : total length of test piece  
 $L_u$  : final gauge length after fracture  
 $S_0$  : original cross-sectional area of parallel portion  
 $S_u$  : minimum cross-sectional area after fracture

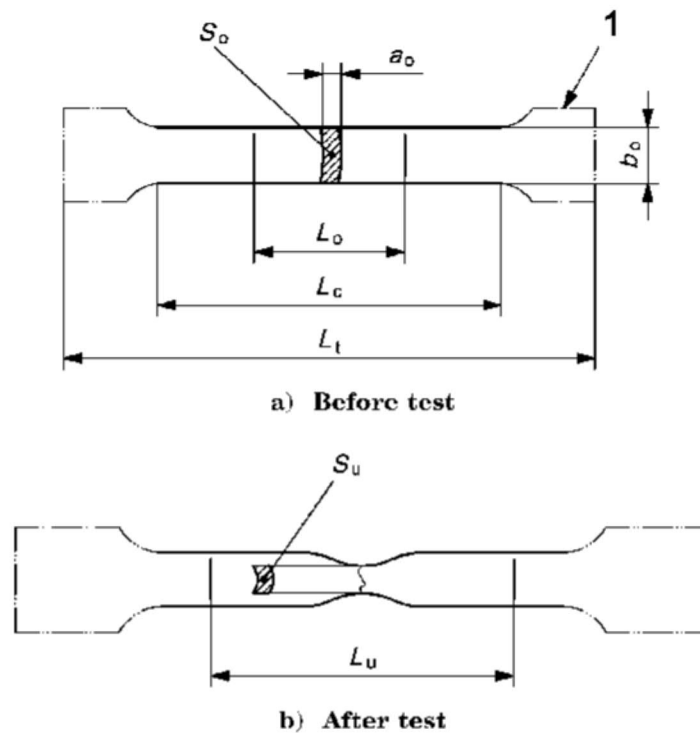
NOTE : The shape of gripped ends of test piece is only given as a guide.

**Figure 13 Bar-form test piece (machined) (see Annex D)**



- $a_0$  : wall thickness of a tube before test
- $D_0$  : outside diameter of a tube before test
- $L_0$  : original gauge length
- $L_t$  : total length of test piece
- $L_u$  : final gauge length after fracture
- $S_0$  : original cross-sectional area of the parallel portion
- $S_u$  : minimum cross-sectional area after fracture
- 1 : gripped end

**Figure 14 Tube-form test piece (see Annex E)**



- $a_0$  : wall thickness of tube before test
- $b_0$  : average width of strip-form test piece taken from tube
- $l_p$  : parallel length
- $L_0$  : original gauge length
- $L_t$  : total length of test piece
- $L_u$  : final gauge length after fracture
- $S_0$  : original cross-sectional area of parallel portion
- $S_u$  : minimum cross-sectional area after fracture
- 1 : gripped end

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

**Figure 15 Strip-form test piece (see Annex E)**

## 5 Principle

The test involves straining a test piece by tensile force, generally to fracture, for the measurement of one or more of the mechanical properties defined in clause 3.

The test shall be carried out at a room temperature between 10 °C and 35 °C, unless otherwise specified. Tests carried out under controlled conditions shall be made at a temperature of 23 °C ± 5 °C.

## 6 Test piece

### 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 material from which the test pieces are taken.

The test piece shall be usually prepared by machining a sample from the metallic material, or punching or casting. However, the metallic materials of uniform cross section (sections, bars, wires, etc.) and also as-cast test pieces (i.e., for cast iron and non-ferrous metals) 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 shall be avoided as far as practicable; however when it is necessary, it shall be done by such a method that might not effect the mechanical properties of the test piece as far as practicable.

The proportional test piece shall be that having a relationship of  $L_0 = k\sqrt{S_0}$  between the original gauge length  $L_0$  and the original cross-sectional area  $S_0$ . The internationally adopted value for  $k$ , which is the coefficient of proportionality, 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 (e.g., 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 is increased.

For non-proportional test pieces, the original gauge length  $L_0$  and the original cross-sectional area  $S_0$  are independently determined.

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

### 6.1.2 Machined test pieces

The machined test pieces shall incorporate a transition radius between the gripped ends and the parallel portion, if these have different cross-sectional dimensions. The dimensions of the transition radius are important and it is recommended that they be defined in the product standard, if they are not given in the appropriate Annex (see 6.2).

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 length between the grips shall always be greater than the original gauge length  $L_0$ .

The parallel portion of a test piece may be tapered towards the middle within the tolerances on the dimensional change of the parallel portion 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 bar-form specimen, 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).

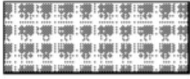
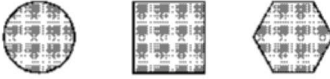
As-cast test pieces shall incorporate a transition radius between the gripped ends and the parallel portion. The dimension of this transition radius is important and it is recommended that they be defined in the product standard. The gripped ends may be of any shape to suit the grips of the testing machine.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

## 6.2 Types of test pieces

The main types of test pieces are defined in Annex B to Annex E according to the shape and type of product, as given in table 2.1 and table 2.2. Other types of test pieces may be specified in product standards.

**Table 2.1 Main types of test piece according to type of product**

Unit: mm

Type of product		Corresponding Annex
strip-sheet-plate	wire-bar-section	
 thickness $a_0$	 diameter or width across flats	
$0.1 \leq a_0 < 3$	—	Annex B
—	$< 4$	Annex C
$a_0 \geq 3$	$\geq 4$	Annex D
Tube		Annex E

**Table 2.2 Classification of test pieces**

Shape of test piece	Flat-form test piece	Bar-form test piece	Tube-form test piece	Strip-form test piece	Wire-form 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. 11	No. 12A, No. 12B, No. 12C	No. 9A, No. 9B
NOTE : No. 1B test pieces shall be used in the case where the test pieces shown in table 2.3 are not suitable to be used.					

The selection of the test piece to be used shall be in accordance with the requirements of respective product standards; however, the division of use in table 2.3 should be referred to.

**Table 2.3 Division of use of test pieces**

Product		Test piece		NOTE	Corresponding Annex
Division	Dimension	Proportional	Non-proportional		
Sheet, plate, section, strip	Over 40 mm in thickness	No. 14A	No. 4, No. 10	For bar-form test piece	Annex D
		No. 14B	—	For flat-form test piece	
	Over 20 mm to and incl. 40 mm in thickness	No. 14A	No. 4, No. 10	For bar-form test piece	
		No. 14B	No. 1A	For flat-form test piece	
	Over 6 mm to and incl. 20 mm in thickness	No. 14B	No. 1A, No. 5	For flat-form test piece	
	Over 3 mm to and incl. 6 mm in thickness		No. 5, No. 13A, No. 13B		
3 mm or under in thickness	—	—	—	Annex B	
Bar	—	No. 2, No. 14A	No. 4, No. 10	—	Annex C Annex D
Wire	—	—	No. 9A, No. 9B	—	—
Tube	Tube of small outside diameter	No. 14C	No. 11	For tube-form test piece	Annex E
	50 mm or under in outside diameter	No. 14B	No. 12A	For strip-form test piece	
	Over 50 mm to and incl. 170 mm in outside diameter		No. 12B		
	Over 170 mm in outside diameter		No. 12C		
	200 mm or over in tube diameter	No. 14B	No. 5	For flat-form test piece or strip-form test piece	
	Tube of thick wall	No. 14A	No. 4	For bar-form test piece	
Casting	—	No. 14A	No. 4, No. 10	—	—
	—	—	No. 8A, No. 8B, No. 8C, No. 8D	Used when elongation value is not required. Taken from specimen casted for test piece.	
Forging	—	No. 14A	No. 4, No. 10	—	—

### 6.3 Preparation of test pieces

The test pieces shall be taken and prepared in accordance with the requirements of the relevant standards for respective products (e.g., **JIS G 0416**).

### 7 Measurement of original cross-sectional area

The respective dimensions of the test piece should be measured at sufficient points between gauge marks.

A minimum of three cross-sections are recommended.

NOTE : Nominal dimensions are specified in Annex B and Annex D. The concept where the measuring position is made to one point is given in Annex JA.

Respective dimensions of the test piece shall be measured at least to the nearest 0.5 % of the numerical values, provided that the dimensions of 2 mm or under may be limited to the nearest 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. However, for the test piece tapered for a proper reason, the original cross-sectional area shall be that measured at the smallest cross section.

Examples of the calculation method are as follows.

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

For the tube-form test piece, the original cross-sectional area  $S_0$  is measured at the end part of the test piece.

Example 2 The diameter used for obtaining the original cross-sectional area  $S_0$  of the test piece with circular cross section and the tube-form 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 tube-form test piece is the average of not less than three measurements at the points on the circumference of the tube end part equally divided.

NOTE : The average of the difference between inside and outside diameters of a tube-form test piece when measured in two orthogonal directions may be substituted by the twice of average of the thickness at four points.

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

## 8 Marking of original gauge length

Each end of the original gauge length  $L_0$  shall be marked by means of fine marks (c.g., punches, scribed lines), but not by notches 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.

For the 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  $L_0$ . The original gauge length shall be marked to an accuracy of  $\pm 1$  %.

The original gauge length shall be measured at least to the nearest 0.1 mm. The extensometer gauge length may be used as the designated original gauge length when the error to the designated original gauge length is within 1.0 %.



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

In some cases, it may be helpful to draw, on the surface of the test piece, a line parallel to the longitudinal axis, along which the gauge lengths are marked.

NOTE : It is unnecessary to put the gauge marks, if the required elongation is measured by an employment of the extensometer (see 20.2).

## 9 Accuracy of testing machine

### 9.1 Testing machine

The testing machine used for the tensile test shall be Class 1 or better specified in **JIS B 7721**.

### 9.2 Extensometer

For the measurement of proof strength (plastic extension or total extension), the extensometer to be used shall be Class 2 or better specified in **JIS B 7741** within the application range of extension.

NOTE : In **ISO 6892-1**, Class 1 specified in **JIS B 7741** is designated.

## 10 Conditions of testing

### 10.1 Setting of zero point of force

The force-measuring system shall be set to zero after the force loading train has been assembled, but before the test piece is actually gripped at both ends. Once the force zero point has been set, the force-measuring system may not be changed in any way during the test.

NOTE : The use of this method ensures, that the weight of the gripping device is compensated for in the force measurement and also, any force resulting from the clamping operation does not affect this measurement.

### 10.2 Method of gripping

The test piece shall be clamped by suitable means, such as wedges, screwed grips, parallel jaw faces or shouldered holders.

It shall be ensured that test pieces are held in such a way that the force is applied as axially as possible to minimize the bend (more information is given in **ASTM E 1012**, for example). This is of particular importance when testing brittle materials or when measuring the proof strength (plastic extension or total extension) or yield strength.

In order to obtain a straight test piece and ensure the alignment of the test piece and grip arrangement, a preliminary force may be applied, provided that it does not exceed 5 % of the specified yield strength or expected yield strength. A correction of the extension should be carried out to take into account the effect of the preliminary force.

### 10.3 Testing rate

NOTE : In ISO 6892-1, the method based on the strain rate control is made as method A, and the method based on the stress rate control is made as method B. In this Standard, method A is described as Annex JB.

#### 10.3.1 General

The testing rates shall conform to the following requirements depending on the materials. Unless otherwise specified, any convenient speed of testing may be used up to the force equivalent to half of the specified yield strength. The testing rates above this point shall be as follows (see figure 9).

#### 10.3.2 Yield strength and proof strength

##### 10.3.2.1 Upper yield strength $R_{eH}$

The stress rate shall be as given in table 3. If it is controlled by the crosshead separation rate, the rate shall be kept as constant as possible within the limits corresponding to the stress rate of table 3.

NOTE : For information, typical materials having a modulus of elasticity smaller than 150 000 MPa include magnesium, aluminium alloys, brass, and titanium. Typical materials with a modulus of elasticity greater than 150 000 MPa include iron, steel, tungsten, and nickel-based alloys.

**Table 3 Stress rate**

Modulus of elasticity of material $E$ MPa	Stress rate $\dot{R}$ MPa · s <sup>-1</sup>	
	Min.	Max.
System		
<150 000	2	20
≥150 000	3	30
NOTE : In ISO 6892-1, the stress rate for the modulus of elasticity ≥150 000 is specified so as to be 6 MPa · s <sup>-1</sup> to 60 MPa · s <sup>-1</sup> .		

##### 10.3.2.2 Lower yield strength $R_{eL}$

If only the lower yield strength is being measured, the strain rate during yield of the parallel portion of the test piece shall be between 0.000 25 s<sup>-1</sup> and 0.002 5 s<sup>-1</sup>. The strain rate within the parallel portion shall be kept as constant as possible. If the strain rate cannot be regulated directly, the crosshead separation rate shall be fixed within the limits corresponding to the stress rate just before yield begins, the controls of the machine not being further adjusted until the completion of yield.

In no case shall the stress rate in the elastic part exceed the range given in table 3.

##### 10.3.2.3 Upper yield strength and lower yield strength $R_{eH}$ and $R_{eL}$

If both the upper yield strength and the lower yield strength are measured, the conditions for measuring the lower yield strength shall be conformed to (see 10.3.2.2).

**10.3.2.4 Proof strength (plastic extension) and proof strength (total extension)  $R_p$  and  $R_t$**

The stress rate shall be as given in table 3. If it is controlled by the crosshead separation rate, the rate shall be kept as constant as possible within the limits corresponding to the stress rate of table 3.

Within the plastic part and up to the proof strength (plastic extension or total extension), the strain rate shall not exceed  $0.0025 \text{ s}^{-1}$ .

**10.3.2.5 Crosshead separation rate**

If the testing machine is not capable of measuring or controlling the strain rate, the crosshead separation rate equivalent to the stress rate given in table 3 shall be applied until the completion of yield.

**10.3.2.6 Tensile strength  $R_m$ , percentage elongation after fracture  $A$ , percentage total extension at maximum force  $A_{gt}$ , percentage plastic extension at maximum force  $A_g$  and percentage reduction of area  $Z$**

After the measurement of the required yield strength/proof strength, the testing rate (the strain rate or the crosshead separation rate) shall be as given in table 4.

If only the tensile strength of the material is to be measured, table 4 shall be applied.

**Table 4 Testing rate when measuring only tensile strength after measuring yield strength/proof strength**

Unit:  $\text{s}^{-1}$

Material	Minimum rate	Maximum rate
Steel	0.003	0.008
Others	—	0.008

The application of the strain rate (or crosshead separation rate) over  $0.008 \text{ s}^{-1}$  shall be in accordance with the product standards of **JIS**.

The tensile strength shall be calculated according to the following equation.

$$R_m = \frac{F_m}{S_0} \dots\dots\dots (1)$$

where,  $R_m$  : tensile strength (MPa)  
 $F_m$  : maximum force (N)  
 $S_0$  : original cross-sectional area ( $\text{mm}^2$ )

**11 Measurement of upper yield strength  $R_{eH}$**

$R_{eH}$  shall be measured from the force-extension curve or the peak load indicator, and defined as the maximum value prior to the first decrease in force. The upper yield strength is obtained by dividing this force by the original cross-sectional area  $S_0$  of the test piece.

The upper yield strength shall be calculated according to the following equation.

$$R_{eH} = \frac{F_{cH}}{S_0} \dots\dots\dots (2)$$

- where,  $R_{eH}$  : upper yield strength (MPa)  
 $F_{cH}$  : maximum force corresponding to upper yield strength (N)  
 $S_0$  : original cross-sectional area (mm<sup>2</sup>)

NOTE : The maximum force  $F_{cH}$  (N) prior to the first decrease is obtained according the force-extension curve for obtaining the upper yield strength.

Also, the measurement by the peak load indicator is applicable (see figure 2).

**12 Measurement of lower yield strength  $R_{eL}$**

$R_{eL}$  shall be measured from the force-extension curve, and defined as the minimum value of stress during the plastic yielding, ignoring any initial transient effect. The lower yield strength is obtained by dividing this force by the original cross-sectional area  $S_0$  of the test piece.

The lower yield strength shall be calculated according to the following equation.

$$R_{eL} = \frac{F_{cL}}{S_0} \dots\dots\dots (3)$$

- where,  $R_{eL}$  : lower yield strength (MPa)  
 $F_{cL}$  : minimum force corresponding to lower yield strength (N)  
 $S_0$  : original cross-sectional area (mm<sup>2</sup>)

NOTE : The minimum force  $F_{cL}$  (N), ignoring any initial transient effect, is obtained according the force-extension curve for obtaining the lower yield strength (see figure 2).

For the productivity of testing,  $R_{eL}$  may be reported as the minimum stress within 0.25 % strain after  $R_{eH}$  ignoring any initial transient effect. After measuring  $R_{eL}$  by this procedure, the testing rate may be increased in accordance with **10.3.2.6**. Use of this shorter procedure should be recorded on the test report.

NOTE : This clause only applies to materials having yield phenomena, when  $A_0$  is not to be measured.

**13 Proof strength (plastic extension)  $R_p$**

**13.1**  $R_p$  shall be obtained from the force-extension curve by drawing a line parallel to the linear portion of the curve and at a distance from this equivalent to the prescribed plastic percentage extension, e.g., 0.2 %. The point at which this line intersects the force-extension curve gives the force corresponding to the desired proof strength (plastic extension). The proof strength is obtained by dividing this force by the original cross-sectional area  $S_0$  of the test piece (see figure 3).

NOTE : In ISO 6892-1, as the method when the straight portion of the force-extension curve is not clearly defined, the method given in figure 6 is specified.

**13.2** This property ( $R_p$ ) may be obtained by using automatic devices without plotting the force-extension curve.

#### **14 Proof strength (total extension) $R_t$**

**14.1**  $R_t$  shall be obtained from the force-extension curve by drawing a line parallel to the ordinate axis (force axis) and at a distance from this equivalent to the prescribed total extension, and the point at which this line intersects the force-extension curve gives the force corresponding to the desired proof strength (total extension). The proof strength (total extension) is obtained by dividing this force by the original cross-sectional area  $S_0$  of the test piece (see figure 4).

**14.2** This property ( $R_t$ ) may be obtained by using automatic devices without plotting the force-extension curve.

#### **15 Method of verification of permanent set strength $R_r$**

The test piece shall be subjected to a force corresponding to the specified stress for 10 s to 12 s. This force shall be obtained by multiplying the specified stress by the original cross-sectional area  $S_0$  of the test piece. After removing the force, it is then confirmed that the permanent set extension or elongation is not more than the percentage specified for the original gauge length (see figure 5).

NOTE : This is a pass/fail test, which is not normally carried out as a part of the standard tensile test. The stress applied to the test piece and the permissible permanent set extension or elongation are specified either by the product standards or the requester of the test. For example, reporting " $R_{t0.5} = 750$  MPa, Pass" indicates that a stress of 750 MPa was applied to the test piece and the resulting permanent set was 0.5 % or under.

#### **16 Measurement of percentage yield point extension $A_e$**

For materials exhibiting discontinuous yielding,  $A_e$  shall be obtained from the force-extension curve by subtracting the extension at  $R_{cH}$  from the extension at the start of uniform workhardening. The extension at the start of uniform workhardening shall be defined by the intersection of a horizontal line through the last local minimum point, or a regression line through the range of yielding, prior to uniform workhardening, and a line corresponding to the highest slope of the curve occurring at the start of uniform workhardening (see figure 7).  $A_e$  shall be expressed as a percentage of the extensometer gauge length.

The measurement method equivalent to this may be used.

The method used [see figure 7 a) or figure 7 b)] should be recorded in the test report.

**17 Measurement of percentage plastic extension at maximum force  $A_g$**

The method consists of obtaining the extension at maximum force on the force-extension curve obtained with an extensometer and subtracting the elastic strain.

The percentage plastic extension at maximum force  $A_g$  shall be calculated according to the following equation.

$$A_g = \left( \frac{\Delta L_m}{L_e} - \frac{R_m}{m_E} \right) \times 100 \dots\dots\dots (4)$$

- where,  $L_e$  : extensometer gauge length
- $m_E$  : slope of elastic part of stress-percentage extension curve
- $R_m$  : tensile strength
- $\Delta L_m$  : extension at maximum force

NOTE : For materials which exhibit a plateau at maximum force, the percentage plastic extension at maximum force shall be the extension at the mid-point of the plateau (see figure 1).

**18 Measurement of percentage total extension at maximum force  $A_{gt}$**

The method consists of obtaining the extension at maximum force on the force-extension curve obtained with an extensometer.

The percentage total extension at maximum force  $A_{gt}$  shall be calculated according to the following equation.

$$A_{gt} = \frac{\Delta L_m}{L_e} \times 100 \dots\dots\dots (5)$$

- where,  $L_e$  : extensometer gauge length
- $\Delta L_m$  : extension at maximum force

NOTE : For materials which exhibit a plateau at maximum force, the percentage total extension at maximum force shall be the extension at the mid-point of the plateau (see figure 1).

**19 Measurement of percentage total extension at fracture  $A_f$**

The method consists of obtaining the extension at fracture on the force-extension curve obtained with an extensometer.

The percentage total extension at fracture  $A_f$  shall be calculated according to the following equation.

$$A_f = \frac{\Delta L_f}{L_e} \times 100 \dots\dots\dots (6)$$

- where,  $L_e$  : extensometer gauge length
- $\Delta L_f$  : extension at fracture

**20 Measurement of percentage elongation after fracture A**

**20.1** The percentage elongation after fracture A shall be obtained according to the definition of 3.4.2.

For this purpose, the two fractured parts of the test piece shall be carefully fitted back together so that their axes lie in a straight line.

Special precautions shall be taken to ensure proper contact between the fractured parts of the test piece when measuring the final gauge length. This is particularly important for test pieces of small cross section and those having low elongation values.

The percentage elongation after fracture A shall be calculated according to the following equation.

$$A = \frac{L_u - L_o}{L_o} \times 100 \dots\dots\dots (7)$$

where,  $L_o$  : original gauge length  
 $L_u$  : final gauge length after fracture

Elongation after fracture ( $L_u - L_o$ ) shall be measured to the nearest 0.25 mm or better using a measuring device with sufficient resolution.

If the specified minimum percentage elongation is less than 5 %, it is recommended that special precautions be taken (see Annex G). The result of this measurement is valid only if the distance between the fracture and the nearest gauge mark is not less than 1/4 the original gauge length  $L_o$ . However, the test is valid, irrespective of the fracture location, if the percentage elongation after fracture is equal to or greater than the specified value.

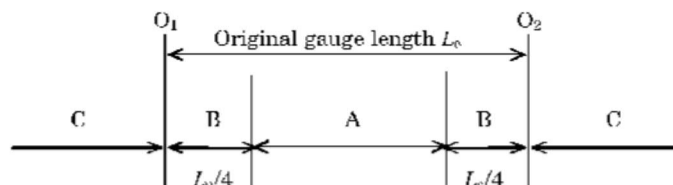
**NOTE 1** **ISO 6892-1** describes that the result is valid only if the distance between the fracture and the nearest gauge mark is not less than 1/3 the original gauge length.

**NOTE 2** If required, the fracture location of the test piece shall be identified by adding the following symbols.

**A:** fracture at 1/4 or more of original gauge length ( $L_o$ ) apart from nearest gauge mark (location A in figure 16)

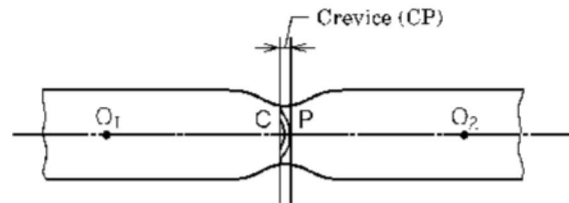
**B:** fracture at less than 1/4 of original gauge length ( $L_o$ ) within nearest gauge mark (location B in figure 16)

**C:** fracture outside gauge marks (location C in figure 16)



**Figure 16 Fracture location and symbol of test piece**

**NOTE 3** If the crevice (CP) exists in the middle of breadth (figure 17), when the fractured parts of a flat-form test piece are fitted together, the elongation after fracture shall be calculated with the whole length between the gauge marks  $O_1O_2$  including this distance CP of the crevice.



**Figure 17 Example of breadth fitted together**

**20.2** When the extension at fracture is measured using an extensometer, it is not necessary to put the gauge marks on the test piece. The percentage elongation after fracture should be obtained with the elastic elongation subtracted from the extension at fracture. However, unless otherwise specified, the length between gauge marks at fracture of the test piece may be used for  $L_0$ . To obtain comparable values with the method of fitting the fractured parts of the test piece together, additional adjustments may be applied.

Principally, the test is valid only if the fracture has occurred within the extensometer gauge length  $L_c$ . The test is valid regardless of the fracture location, if the percentage elongation after fracture is equal to or greater than the specified value.

The extensometer to be used in this case shall have a gauge length equal to the original gauge length of the test piece, and shall be able to measure the extension with an accuracy of  $\pm 0.5\%$  of the gauge length.

**20.3** If the elongation of the non-proportional test piece is measured over the original gauge length thereof, it may be converted to the elongation of the proportional gauge length using the conversion formulae or tables upon the agreement between the parties concerned with delivery (e.g., **ISO 2566-1** and **ISO 2566-2**).

**NOTE :** The comparison of percentage elongation is possible only when the original gauge length or the extensometer gauge length, the shape and the cross-sectional area are same or when the coefficient of proportionality  $k$  is same.

## **21 Measurement of percentage reduction of area Z**

The percentage reduction of area shall be measured according to the definition of **3.8**.

If necessary, the two fractured parts of the test piece shall be carefully fitted back together so that their axes lie in a straight line.

The percentage reduction of area  $Z$  shall be calculated according to the following equation.



$$Z = \frac{S_0 - S_u}{S_u} \times 100 \dots\dots\dots (8)$$

where,  $S_0$  : original cross-sectional area of parallel portion  
 $S_u$  : minimum cross-sectional area after fracture

NOTE : **ISO 6892-1** describes that the minimum cross-sectional area after fracture  $S_u$  shall be measured with an accuracy of  $\pm 2 \%$ ; however, on small bar-form test pieces or test pieces with other cross-sectional geometries, this may not be possible.

## 22 Test report

The test report shall contain at least the following items unless otherwise agreed between the parties concerned with delivery.

However, a part of the following items may be omitted upon the agreement between the parties concerned with delivery.

- a) Reference to this Standard: **JIS Z 2241**
- b) Identification of test piece
- c) Type of material (if known)
- d) Shape of test piece
- e) Sampling position and sampling direction of test pieces (if known)
- f) **Test results** Test results should be rounded to the following accuracies or better, if not specified in the product standards. The rounding method of numerical values shall be in accordance with **JIS Z 8401**.

- value of strength: whole number in unit of  $\text{MPa}^2$
- percentage yield point extension  $A_e$ : 0.1 %
- percentage elongation after fracture: 1 %
- other percentage extension and elongation: 0.5 %
- percentage reduction of area: 1 %

Note <sup>2)</sup> 1 MPa = 1 N/mm<sup>2</sup>

## 23 Measurement uncertainty

### 23.1 General

The measurement uncertainty analysis is useful for identifying major sources of inconsistencies of measured results.

Product standards, and material property databases based on this Standard and earlier editions of this Standard have an inherent contribution from measurement uncertainty. It is therefore inappropriate to apply further adjustments for measurement uncertainty and thereby risk failing product which is compliant. For this reason, the estimates of uncertainty derived by following this procedure are for information only, unless otherwise specifically instructed by the customer.

### **23.2 Conditions of testing**

The conditions of testing and limits defined in this Standard shall not be adjusted to take account of uncertainties of measurement, unless otherwise specifically instructed by the customer.

### **23.3 Test results**

The estimated measurement uncertainties shall not be used to assess compliance to product standards, unless otherwise specifically instructed by the customer.

NOTE : In **ISO 6892-1**, the guidance for the determination of uncertainty related to metrological parameters and the values obtained from the inter-laboratory tests on a group of steels and aluminium alloys are provided in Annex J and Annex K.

**Annex A (informative)**  
**Recommendations concerning the use of**  
**computer-controlled tensile testing machine**  
(The description of the corresponding International Standard is not adopted).

## Annex B (normative)

### Types of test pieces used for thin products of 0.1 mm or over to and excluding 3 mm in thickness

NOTE : For products of less than 0.5 mm in thickness, special precautions may be necessary.

#### B.1 Shape of test piece

Generally, the thickness of the test piece shall be the original thickness of the product, and the gripped ends shall be wider than the parallel length. The parallel length  $L_c$  shall be connected to the gripped ends by means of transition radius as given in table B.1. The width of gripped ends should be 1.2 times or more of the width of the parallel portion  $b_o$ .

Upon the agreement between the parties concerned with delivery, the test piece may also consist of a strip with parallel sides (parallel sided test piece). For products of width equal to or less than 20 mm, the width of the test piece may be the same as that of the product (see figure 11).

#### B.2 Dimensions of test piece

Three different non-proportional test pieces are widely used (see table B.1).

The parallel length  $L_c$  shall not be less than  $L_o + b_o/2$  except No. 5 test piece in table B.1.

In case of dispute, the parallel length  $L_c$  should be  $L_o + 2b_o$ , unless there is insufficient length of the product.

For the parallel sided test pieces of under 20 mm in width, unless otherwise specified in the product standards, the original gauge length  $L_o$  of the test piece shall be equal to 50 mm. For this type of test piece, the free length between the grips shall be equal to  $L_o + 3b_o$  or more.

When measuring the dimensions of the test piece, the tolerances on dimensional change given in table B.1 shall apply.

For the parallel sided test pieces where the width is the same as that of the sample, the original cross-sectional area  $S_o$  shall be calculated on the basis of the measured dimensions of the test piece.

The nominal width of the test piece may be used, when the tolerances on nominal dimensions conform to table B.2 by avoiding the measurement of the width of the test piece at the time of the test.

**Table B.1 Dimensions of test piece**

Unit: mm

Type of test piece	Width of parallel portion $b_0$	Tolerances on dimensional change of parallel portion <sup>c)</sup>	Original gauge length of test piece $L_0$	Transition radius $R$	Parallel length $L_c$		Minimum free length between grips for parallel sided test piece	Type of test piece in ISO Standard <sup>d)</sup>
					Min.	Recommended		
No. 13B	12.5 ± 0.5 <sup>b)</sup>	0.06	50	20 to 30	57	75	87.5	1
No. 13A	20 ± 0.7 <sup>b)</sup>	0.10	80	20 to 30	90	120	140	2
No. 5	25 ± 0.7 <sup>b)</sup>	0.10	50 <sup>a)</sup>	20 to 30	60 <sup>a)</sup>	—	Not specified	3

NOTE : In the earlier editions of this Standard, the original gauge length  $L_0$  is expressed as the gauge length  $L$ . In Annexes hereafter, the expression, the original gauge length  $L_0$ , is used similarly.

Notes <sup>a)</sup> The ratio  $L_0/b_0$  of No. 5 test piece is very small compared to that of No. 13B test piece and No. 13A test piece. As a result, the measurement results (absolute values and range of variation) obtained by using this test piece may be different from those of test pieces of other types.

<sup>b)</sup> Range of the width permissible to respective types of the test piece (The test piece shall be prepared in the range of these tolerances).

<sup>c)</sup> The maximum value of dimensional change permissible on the whole parallel length  $L$  of the test piece.

<sup>d)</sup> The type of test piece specified in Annex B of ISO 6892-1.

**Table B.2 Tolerances on width for calculation of original cross-sectional area by using nominal width without measurement**

Unit: mm

Nominal width of test piece	Tolerances on nominal width <sup>a)</sup>
12.5	± 0.02
20	± 0.02
25	± 0.04

NOTE : In ISO 6892-1, larger tolerances than those on this nominal width are specified.

Note <sup>a)</sup> When the tolerances are within these values, the nominal value may be used for the calculation of the original cross-sectional area  $S_0$  without measurement.

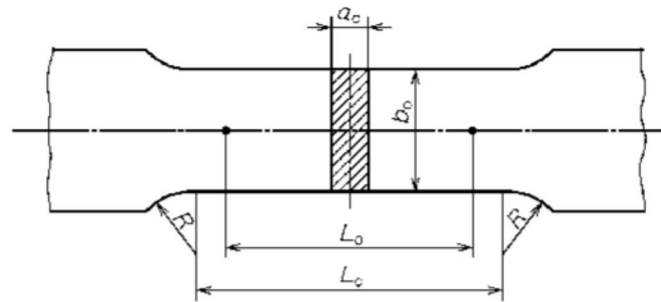


Figure B.1 No. 5 test piece

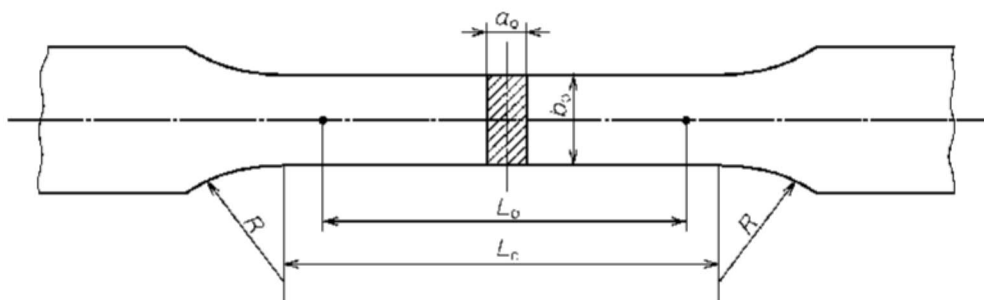


Figure B.2 No. 13 test piece

### B.3 Preparation of test piece

The test pieces shall be prepared so as not to affect the properties of the sample. Any areas which have been hardened by shearing or pressing shall be removed by machining, when the effects thereof on the test results are recognized.

These test pieces are predominantly prepared from the sheet or the strip. If possible, as-rolled surfaces should not be removed.

NOTE : The preparation of these test pieces by punching may result in significant changes to the properties, especially the yield point or proof strength (due to workhardening). Products which exhibit high workhardening should, generally, be prepared by milling, grinding etc.

For very thin products, it is recommended that strips of identical widths should be cut and assembled into a bundle with intermediate layers of a paper which is resistant to the cutting oil. Each small bundle of strips should then be assembled with a thicker strip on each side, before machining to the final dimensions of the test piece.

The tolerances given in table B.2, for example,  $\pm 0.02$  mm for a nominal width of 12.5 mm, means that no test piece shall have a width outside the two values given below, if the nominal value of the original cross-sectional area  $S_0$  is to be included in the calculation without having to measure it.

$$12.5 \text{ mm} + 0.02 \text{ mm} = 12.52 \text{ mm}$$

$$12.5 \text{ mm} - 0.02 \text{ mm} = 12.48 \text{ mm}$$

#### **B.4 Determination of original cross-sectional area $S_0$ .**

The original cross-sectional area  $S_0$  shall be calculated from measurements of the dimensions of the test piece. However, the nominal dimensions may be used in the case of Note <sup>a)</sup> of table B.2.

**NOTE :** **ISO 6892-1** specifies that the error in determining the original cross-sectional area shall not exceed  $\pm 2\%$  and the error in measurement of the width shall not exceed  $\pm 0.2\%$ .

In order to achieve test results with a reduced measurement uncertainty, it is recommended that the original cross-sectional area be obtained with an accuracy of  $\pm 1\%$  or better. For thin products, special measurement techniques may be required in some cases.

## Annex C (normative)

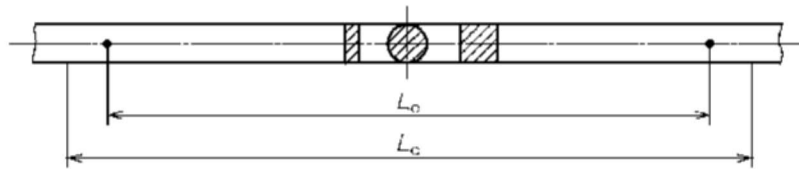
### Types of test pieces used for wires and bars with diameter or traverse of less than 4 mm

#### C.1 Shape of test piece

The test piece generally consists of an unmachined portion of the product (see figure 12).

#### C.2 Dimensions of test piece

The dimensions of the test piece shall be as given in figure C.1.



Unit: mm

Type of test piece	Original gauge length of test piece $L_0$	Distance between grips <sup>a)</sup>
No. 9A	100 ± 1	150 min.
No. 9B	200 ± 2	250 min.

NOTE : ISO 6892-1 describes that the free length between the grips shall be  $L_0 + 3b_0$ , or more.

Note <sup>a)</sup> When the measurement of the elongation after fracture is not required, the minimum 50 mm may be applied to the distance between grips.

**Figure C.1 Dimensions of test piece**

#### C.3 Preparation of test piece

If the product is delivered coiled, care shall be taken in straightening it.

#### C.4 Determination of original cross-sectional area $S_0$

For the product with circular cross section, the original cross-sectional area may be calculated from the arithmetic mean of two measurements carried out in two perpendicular directions.

NOTE : ISO 6892-1 describes that an accuracy of the original cross-sectional area shall not exceed ± 1 %.

Also, the original cross-sectional area may be calculated from the mass of a known length and its density according to equation (C.1).

$$S_0 = \frac{1\,000 \times m}{\rho \times L_t} \dots\dots\dots (C.1)$$



where,  $m$  : mass of test piece (g)  
 $l_t$  : total length of test piece (mm)  
 $\rho$  : density of material of test piece ( $\text{g} \cdot \text{cm}^{-3}$ )

## Annex D (normative)

### Types of test pieces of sheets of 3 mm or more in thickness, and wires and bars of 4 mm or more in diameter or width across flats

#### D.1 Shape of test piece

In the case where the test piece is machined, the parallel portion shall be connected by means of transition having a certain radius to the gripped ends which may be of any suitable shape for the grips of the testing machine (see figure 13). The minimum transition radius between the gripped ends and the parallel portion shall be as follows.

- a)  $0.75 d_0$  ( $d_0$  is the diameter of parallel portion): wire-form or bar-form cylindrical test pieces
- b) 12 mm: other test pieces

Wires and bars may be tested using the unmachined parallel sided test piece. The cross section of the test piece may be circular, square, rectangular or, in special cases, some other shape.

For test pieces with the rectangular cross section, it is recommended that the width to thickness ratio should not exceed 8:1.

In general, the diameter of wire-form or bar-form test pieces with circular cross section which has been machined shall not be less than 3 mm.

#### D.2 Dimensions of test piece

##### D.2.1 Parallel portion of machined test piece

The parallel length  $l_c$  shall be as follows.

- a)  $l_0 + d_0/2$  or more for cylindrical wire-form or bar-form test pieces
- b)  $L_0 + 1.5\sqrt{S_0}$  or more for other test pieces

In cases of dispute, the length  $l_0 + 2d_0$  or  $L_0 + 2\sqrt{S_0}$  should be used depending on the type of test piece, unless there is insufficient length of the sample.

##### D.2.2 Length of unmachined test piece

The free length between the grips of the testing machine shall be adequate for the gauge marks to be at least a distance of  $\sqrt{S_0}$  from the grips.

##### D.2.3 Original gauge length of test piece $L_0$

###### D.2.3.1 Proportional test pieces

In general, the proportional test pieces are used where  $L_0$  is related to the original cross-sectional area  $S_0$  according to equation (D.1).

$$L_0 = k\sqrt{S_0} \dots\dots\dots (D.1)$$

where,  $L_0$  : original gauge length  
 $k$  : 5.65  
 $S_0$  : original cross-sectional area of parallel portion

Alternatively, 11.3 may be used as the value of  $k$ .

The wire-form or bar-form test pieces with circular cross section are shown in figure D.1. They should preferably have one set of dimensions given in table D.1.

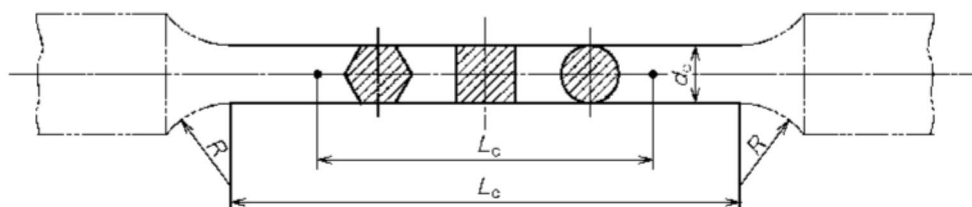
**Table D.1 Wire-form or bar-form test pieces with circular cross section**

$k$	Diameter of parallel portion $d_0$ mm	Original gauge length of test piece $L_0 = k\sqrt{S_0}$ mm	Minimum parallel length $L_c$ mm
5.65	$20 \pm 0.7^{a)}$	100	110
	$14 \pm 0.7^{a)}$	70	77
	$10 \pm 0.7^{a)}$	50	55
	$5 \pm 0.5^{a)}$	25	28

NOTE : The parallel length  $L_c$  means the distance between the grips.  
 Note <sup>a)</sup> Range of the diameter permissible to respective types of the test piece (The test piece shall be prepared in the range of these tolerances).

**D.2.3.1.1 No. 14 test piece**

The shape and dimensions of No. 14A test piece shall be as given in figure D.1.



Unit: mm

Original gauge length of test piece $L_0$	Parallel length $L_c$	Transition radius $R$
$5.65\sqrt{S_0}$	$5.5 d_0$ to $7 d_0$	15 min.

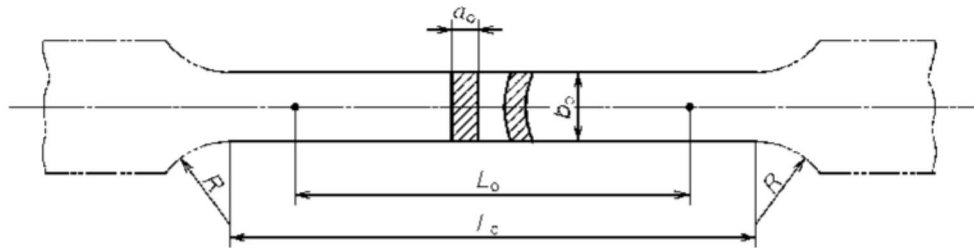
**Figure D.1 No. 14A test piece**

For the parallel portion with the square cross section, the parallel length may be made as  $L_c = 5.65 d_0$ , and for that with the hexagonal cross section,  $L_c = 5.26 d_0$ .

The parallel length should be made as  $L_c = 7 d_0$  as far as practicable.

The diameter of gripped ends of No. 14A test piece may be made the same dimension as that of the parallel portion. In this case, the distance between grips shall be  $L_c \geq 8 d_0$ .

The shape and dimensions of No. 14B test piece shall be as given in figure D.2.



Unit: mm

Width	Original gauge length of test piece	Parallel length	Transition radius	Thickness
$b_0$	$L_0$	$L_c$	$R$	$a_0$
$8 a_0$ max.	$5.65\sqrt{S_0}$	$L_0 + 1.5\sqrt{S_0}$ to $L_0 + 2.5\sqrt{S_0}$	15 min.	Original thickness of product

**Figure D.2 No. 14B test piece**

The parallel length of No. 14B test piece shall be  $L_0 + 2\sqrt{S_0}$  as far as practicable.

In the case of applying No. 14B test piece to the test of tubes, the cross section of the parallel portion shall be as cut out of the tube.

The width of gripped ends of No. 14B test piece may be the same as that of the parallel portion. In this case, the parallel length shall be  $L_0 + 3\sqrt{S_0}$ .

No. 14B test piece, the standard dimensions of which are given in table D.2, should be used by grouping by dimension in every reasonable sheet thickness category.

**Table D.2 Standard dimensions of No. 14B test piece (informative)**

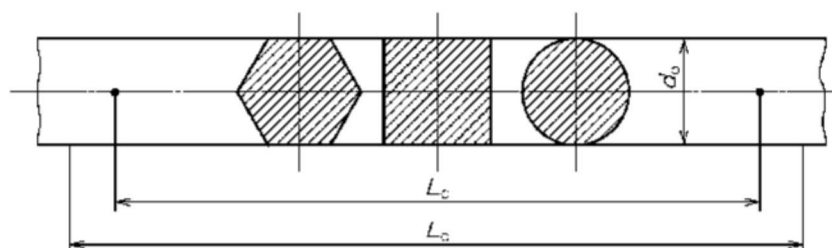
Unit: mm

Thickness	Width $b_0$	Original gauge length $L_0$	Parallel length $L_c$
Over 5.5 to and incl. 7.5	$12.5 \pm 0.5$	50	80
Over 7.5 to and incl. 10		60	
Over 10 to and incl. 13	$20 \pm 0.7$	85	130
Over 13 to and incl. 19		100	
Over 19 to and incl. 27	$40 \pm 0.7$	170	265
Over 27 to and incl. 40		205	

**D.2.3.1.2 No. 2 test piece (specific to JIS)**

The shape and dimensions of No. 2 test piece shall be as given in figure D.3.

No. 2 test piece shall be used for the bar of not more than 25 mm in nominal diameter (or width across flats).



Unit: mm

Diameter or width across flats	Original gauge length of test piece $L_0$	Parallel length $L_c$
Original diameter or width across flats of product	$8 d_0$	$L_0 + 2 d_0$ min.

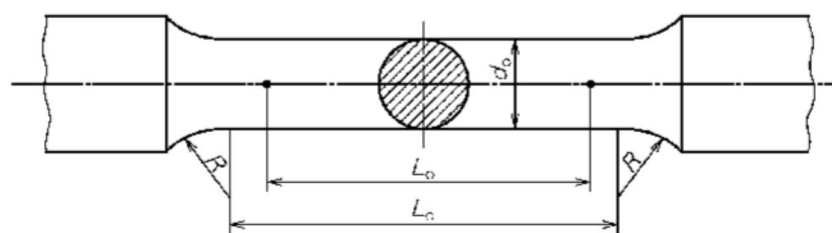
**Figure D.3 No. 2 test piece**

**D.2.3.2 Non-proportional test piece**

The parallel length  $L_c$  shall be  $L_0 + b_0/2$  or more. In case of dispute, the parallel length  $L_c = L_0 + 2 b_0$  should be used unless there is insufficient length of the sample.

**D.2.3.2.1 No. 4 test piece (specific to JIS)**

The shape and dimensions of No. 4 test piece shall be as given in figure D.4.



Unit: mm

Diameter $d_0$	Original gauge length of test piece $L_0$	Parallel length $L_c$	Transition radius $R$
$14 \pm 0.5$	50	60 min.	15 min.

**Figure D.4 No. 4 test piece**

The parallel portion of No. 4 test piece shall be finished by machining.

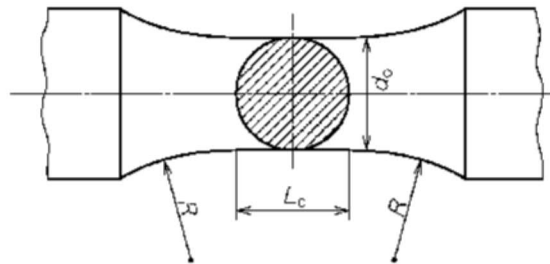
When No. 4 test piece of the dimensions of figure D.4 cannot be prepared, the diameter of the parallel portion and the gauge length may be determined according to  $L_0 = 4\sqrt{S_0}$ .

**D.2.3.2.2 No. 8 test piece (specific to JIS)**

NOTE : No. 8 test piece shall be used for the tensile test of the products such as iron castings which do not require elongation values.

The shape and dimensions of No. 8 test piece shall be as given in figure D.5.

No. 8 test piece shall be taken from the sample subjected to casting to the dimensions given in the table.



Unit: mm

Type of test piece	Casting dimensions of sample (diameter)	Parallel length $L_c$	Diameter $d_o$	Transition radius $R$
8A	approx. 13	approx. 8	8	16 min.
8B	approx. 20	approx. 12.5	12.5	25 min.
8C	approx. 30	approx. 20	20	40 min.
8D	approx. 45	approx. 32	32	64 min.

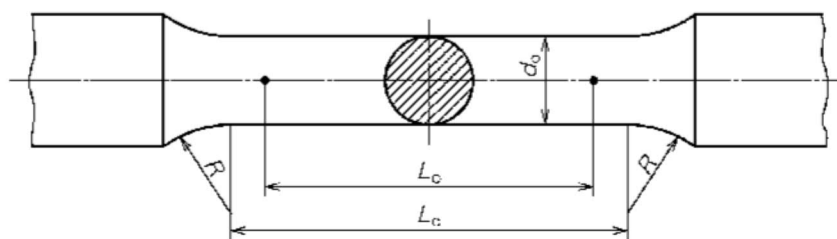
**Figure D.5 No. 8 test piece**

**D.2.3.2.3 No. 9 test piece**

No. 9 test piece shall be as given in figure C.1.

**D.2.3.2.4 No. 10 test piece (specific to JIS)**

The shape and dimensions of No. 10 test piece shall be as given in figure D.6.



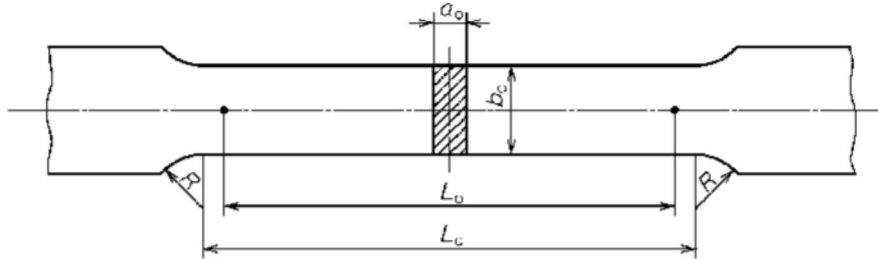
Unit: mm

Diameter $d_o$	Original gauge length of test piece $L_o$	Parallel length $L_c$	Transition radius $R$
$12.5 \pm 0.5$	50	60 min.	15 min.

**Figure D.6 No. 10 test piece**

**D.2.3.2.5 No. 1 test piece**

The shape and dimensions of No. 1 test piece shall be as given in figure D.7.



Unit: mm

Type of test piece	Width $b_0$	Original gauge length of test piece $L_c$	Parallel length $L_p$	Transition radius $R$	Thickness $a_0$
1A	$40 \pm 0.7$	200	220 min.	25 min.	Original thickness of product
1B	$25 \pm 0.7$	200	215 min.	25 min.	Original thickness of product

NOTE : In ISO 6892-1, the test piece of 80 mm in the original gauge length is specified.

**Figure D.7 No. 1 test piece**

**D.2.3.2.6 No. 5 test piece**

No. 5 test piece shall be in accordance with **B.2**; however, the transition radius shall be 15 mm or more.

**D.2.3.2.7 No. 13 test piece**

No. 13 test piece shall be in accordance with **B.2**.

**D.3 Preparation of test piece**

The tolerances on the width, diameter or traverse of machined test pieces shall be as given in table D.3 and table D.4.

An example of the application of these tolerances shall be as follows.

a) **Machining tolerances when using nominal dimension for calculation**

When using the nominal dimension other than the measured value for the calculation of the original cross-sectional area  $S_0$ , no test piece shall have the dimension outside the two values given in table D.4, for example,  $\pm 0.02$  mm for a nominal diameter of 10 mm.

$$10 \text{ mm} + 0.02 \text{ mm} = 10.02 \text{ mm}$$

$$10 \text{ mm} - 0.02 \text{ mm} = 9.98 \text{ mm}$$

b) **Tolerances on dimensional change** The tolerances given in table D.3 means that, for a test piece with a nominal diameter of 10 mm which satisfies the machining conditions given in a), the deviation between the smallest and largest diameters measured shall not exceed 0.04 mm.

Consequently, if the minimum diameter of the test piece is 9.99 mm, its maximum diameter shall not exceed 9.99 mm + 0.04 mm = 10.03 mm.

**Table D.3 Tolerances on dimensional change for width, diameter or traverse of test piece**

Unit: mm

Designation	Nominal width, diameter or traverse	Tolerances on dimensional change <sup>a)</sup>
Diameter of test piece with circular cross section and four transverses of test piece with rectangular/square cross section	≥ 3 ≤ 6	0.03
	> 6 ≤ 10	0.04
	> 10 ≤ 18	0.04
	> 18 ≤ 30	0.05
Width of flat-form test piece machined only on both sides in width direction	≥ 3 ≤ 6	0.03
	> 6 ≤ 10	0.04
	> 10 ≤ 18	0.06
	> 18 ≤ 30	<u>0.10</u>
	> 30 ≤ 50	<u>0.10</u>
Note <sup>a)</sup> Difference between the maximum value and the minimum value of width, diameter or traverse along the entire parallel length ( $L_c$ ) of the test piece.		



**Table D.4 Tolerances when using nominal dimension for calculation of original cross-sectional area**

Unit: mm

Designation	Nominal width, diameter or traverse	Machining tolerances on nominal dimension <sup>a)</sup>
Diameter of test piece with circular cross section and four transverses of test piece with rectangular/square cross section	≥ 3 ≤ 6	± 0.01
	> 6 ≤ 10	± 0.02
	> 10 ≤ 18	± 0.03
	> 18 ≤ 30	± 0.06
Width of flat-form test piece machined only on both sides in width direction	≥ 3 ≤ 6	± 0.01
	> 6 ≤ 10	± 0.02
	> 10 ≤ 18	± 0.03
	> 18 ≤ 30	± 0.06
	> 30 ≤ 50	± 0.10
<p>Note <sup>a)</sup> These tolerances are applicable if the nominal value of the original cross-sectional area <math>S_0</math> is to be included in the calculation without having to measure it. If these machining tolerances are not conformed, every individual dimension of the test piece shall be measured.</p>		

#### D.4 Determination of cross-sectional area $S_0$

The nominal dimension of the test piece with circular cross section and that with rectangular/square cross section on which four surfaces are machined, and the width of the flat-form test piece only both sides of which are machined that satisfy the tolerances given in table D.4 may be used for the calculation of the original cross-sectional area. For all other shapes of test pieces, the original cross-sectional area shall be calculated from measurements of the appropriate dimensions.

**NOTE :** ISO 6892-1 specifies that the measurement shall be carried out with an error not exceeding ±0.5 % on each dimension.

## Annex E (normative)

### Types of test pieces used for tubes

#### E.1 Shape of test piece

The shape of test piece shall be a tube-form test piece, longitudinal strip-form test piece having the original wall thickness of the tube or the traverse flat-form test piece (see figure 14 and figure 15). Also, there is the bar-form test piece taken from the cross section of the tube.

Machined longitudinal and transverse, and bar-form test pieces are in accordance with in Annex B for the tube with a wall thickness of less than 3 mm, and Annex D for that with a wall thickness is equal to or greater than 3 mm. The longitudinal test piece is generally used for the tube with a wall thickness of more than 0.5 mm.

#### E.2 Dimensions of test piece

##### E.2.1 Tube-form test piece

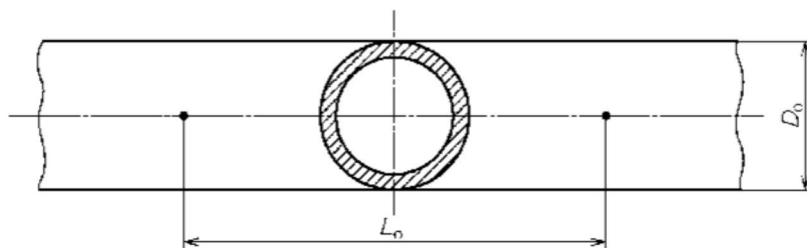
The tube-form test piece may be plugged at both ends. The interval between each plug and the nearest gauge mark shall be greater than  $D_o/4$ . In case of dispute, the interval shall be over  $D_o$  unless there is insufficient length of the sample.

The length of the plug projecting beyond the grips of the testing machine in the direction of the gauge marks shall not exceed  $D_o$ , and its shape shall be such that it does not interfere with deformation of the tube within the gauge length.

##### E.2.1.1 Proportional test piece

###### E.2.1.1.1 No. 14C test piece

The shape and dimensions of No. 14C test piece shall be as given in figure E.1. The cross section of No. 14C test piece shall be as cut out from the product of tube. No. 14C test piece shall be plugged at gripped ends. In this case, the length of the part which is allowed to deform without touching the plugs shall be within the range from  $\left(L_o + \frac{D_o}{2}\right)$  to  $(L_o + 2D_o)$ , but  $(L_o + 2D_o)$  is preferable.



Original gauge length  $L_o = 5.65\sqrt{A}$  (where,  $A$  is cross-sectional area of test piece)

**Figure E.1 No. 14C test piece**

### E.2.1.2 Non-proportional test piece

#### E.2.1.2.1 No. 11 test piece (specific to JIS)

The shape and dimensions of No. 11 test piece shall be as given in figure E.2.

The cross section of No. 11 test piece shall be as cut out from the product of tube. The gripped ends shall be inserted with metal plugs or pressed flat by hammering.

In the latter case, the parallel length shall be not less than 100 mm.

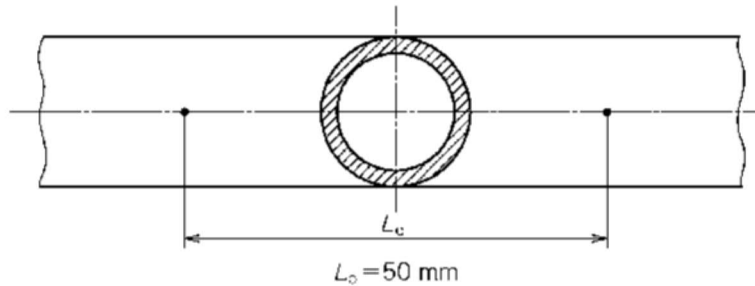


Figure E.2 No. 11 test piece

### E.2.2 Longitudinal strip-form test piece or traverse flat-form test piece

The parallel length  $L_c$  of the longitudinal strip-form test piece shall not be flattened; however, the gripped ends of the test piece may be flattened.

Dimensions of longitudinal strip-form test piece or traverse flat-form test piece other than those given in Annex B and Annex D shall be in accordance with the product standards.

Special precautions shall be taken when flattening the transverse flat-form test piece.

#### E.2.2.1 Proportional test piece

##### E.2.2.1.1 No. 14B test piece

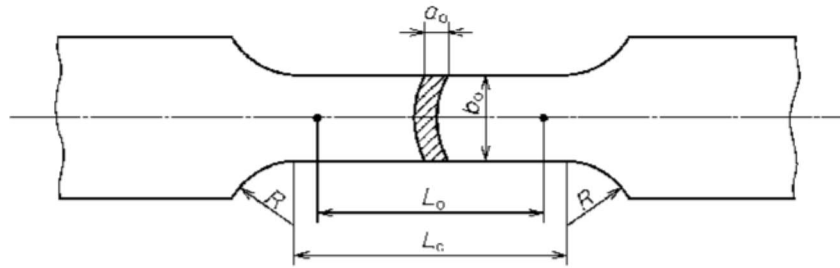
No. 14B test piece shall be as given in figure D.2.

#### E.2.2.2 Non-proportional test piece

##### E.2.2.2.1 No. 12 test piece (specific to JIS)

The shape and dimensions of No. 12 test piece shall be as given in figure E.3.

The cross section of parallel portion of No. 12 test piece shall be as cut out from the product of tube; however, the gripped ends may be flattened by hammering at room temperature.



Unit: mm

Type of test piece	Width $b_0$	Original gauge length $L_0$	Parallel length $L_c$	Transition radius $R$	Wall thickness $a_0$
12A	$19 \pm 0.7$	50	Approx. 60	15 min.	Original thickness of product
12B	$25 \pm 0.7$	50	Approx. 60	15 min.	Original thickness of product
12C	$38 \pm 0.7$	50	Approx. 60	15 min.	Original thickness of product

Figure E.3 No. 12 test piece

### E.2.3 Bar-form test piece

The sampling method of test piece shall be in accordance with the product standards.

### E.3 Determination of original cross-sectional area $S_0$ .

The original cross-sectional area of the tube-form test piece may be obtained from the mass of test piece, length of test piece measured and density of the material according to equation (E.1).

NOTE : ISO 6892-1 specifies that the error in determining the original cross-sectional area shall not exceed  $\pm 1\%$ .

$$S_0 = \frac{1000 \times m}{\rho \times L_c} \dots \dots \dots (E.1)$$

where,  $m$  : mass of test piece (g)  
 $L_c$  : total length of test piece (mm)  
 $\rho$  : density of material of test piece ( $\text{g} \cdot \text{cm}^{-3}$ )

The original cross-sectional area of longitudinal strip-form test piece should be calculated according to equation (E.2).

If  $b_0/D_0 < 0.25$

$$S_0 = a_0 b_0 \left[ 1 + \frac{b_0^2}{6D_0(D_0 - 2a_0)} \right] \dots \dots \dots (E.2)$$

where,  $a_0$  : wall thickness of tube  
 $b_0$  : average width of test piece  
 $D_0$  : outside diameter of tube

Or equation (E.3) may be used.

$$S_o = a_o(D_o - a_o) \sin^{-1} \frac{b_o}{D_o - a_o} \dots\dots\dots (E.3)$$

NOTE 1 **ISO 6892-1** specifies that the calculation shall be carried out according to the following equation.

$$S_o = \frac{b_o}{4} (D_o^2 - b_o^2)^{1/2} \cdot \frac{D_o^2}{4} \arcsin \left( \frac{b_o}{D_o} \right) - \frac{b_o}{4} [(D_o - 2a_o)^2 - b_o^2]^{1/2} - \left( \frac{D_o - 2a_o}{2} \right)^2 \arcsin \left( \frac{2}{D_o - 2a_o} \right)$$

NOTE 2 **ISO 6892-1** permits the use of equation  $S_o = a_o b_o$ , if  $b_o/D_o < 0.1$ .

For the tube-form test piece, the original cross-sectional area shall be obtained according to equation (E.4).

$$S_o = \pi a_o (D_o - a_o) \dots\dots\dots (E.4)$$

**Annex F (informative)**

**Estimation of crosshead separation rate in consideration of stiffness of testing machine**

Equation (JB.1) in **JB.1** does not consider any elastic deformation of the testing equipment (frame, load cell, grips, etc.). This means that the deformation can be separated into the elastic deformation of the testing equipment and the elastic deformation of the test piece. Only a part of the crosshead separation rate is transferred to the test piece. The resulting strain rate at the test piece  $\dot{\epsilon}_m$  per second is given by equation (F.1).

$$\dot{\epsilon}_m = v_c / \left( \frac{m \times S_0}{C_M} + L_c \right) \dots\dots\dots (F.1)$$

- where,  $C_M$  : stiffness of testing equipment (N/mm)  
 (around the point of interest such as  $R_{p0.2}$ , if stiffness is not linear, e.g., when using wedge grips)  
 $L_c$  : parallel length of test piece (mm)  
 $m$  : slope of stress-percentage extension curve at a given moment of test (MPa)  
 (around the point of interest such as  $R_{p0.2}$ )  
 $S_0$  : original cross-sectional area (mm<sup>2</sup>)  
 $v_c$  : crosshead separation rate (mm · s<sup>-1</sup>)

NOTE : The values of  $m$  and  $C_M$  derived from the linear portion of the stress-strain curve cannot be used.

Equation (JB.1) does not compensate for the effects of stiffness of testing equipment (see **JB.1**). A better approximation of the crosshead separation rate  $v_c$  (mm · s<sup>-1</sup>) necessary to produce a resulting strain rate at the test piece  $\dot{\epsilon}_m$  around the point of interest, can be obtained from equation (F.2).

$$v_c = \dot{\epsilon}_m \left( \frac{m \times S_0}{C_M} + L_c \right) \dots\dots\dots (F.2)$$

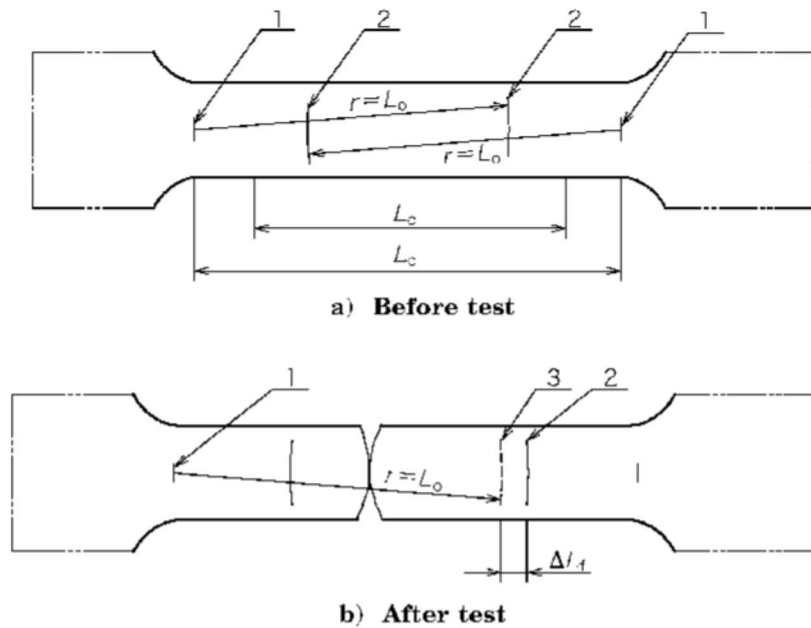
**Annex G (informative)**  
**Measurement method of percentage elongation after  
fracture if specified value is less than 5 %**

Precautions should be taken when measuring the percentage elongation after fracture of the product, if the specified value thereof is less than 5 %.

One of the recommended methods is as follows (see figure G.1).

Prior to the test, a very small mark should be made on each end of the parallel portion. Using a pair of needle-pointed dividers set at the original gauge length, an arc is scribed with the mark as a centre. After fracture, the fractured parts of the test piece should be placed in a fixture and axial compressive force applied, preferably by means of a screw, sufficient to firmly hold the pieces together during measurement. A second arc of the same radius should then be scribed from the original centre closest to the fracture, and the distance between the two scratches measured by means of a measuring microscope or other suitable instrument. In order to render the fine scratches more easily visible, a suitable dye film may be applied to the test piece before testing.

**NOTE :** Another measuring method is described in **20.2** (measuring method of the extension at fracture using an extensometer).



- $L_0$  : original gauge length
- $L_c$  : parallel length
- $\Delta L$  : elongation at fracture
- $r$  : radius of arc scribed from mark at end of parallel portion ( $r = L_0$ )
- 1 : mark made at end of parallel portion
- 2 : arc scribed by a pair of needle-pointed dividers by making mark at end of parallel portion as the base point and setting to original gauge length
- 3 : arc scribed by a pair of needle-pointed dividers by making mark at end of parallel portion as the base point and setting to original gauge length after fracture

**Figure G.1 Example of measuring method of percentage elongation after fracture if specified value is less than 5 %**



## Annex H (informative)

### Measurement method of percentage elongation after fracture based on subdivision of original gauge length

To avoid having to reject test pieces where the fracture location does not comply with **20.1**, the following method may be applied upon the agreement between the parties concerned with delivery.

- a) Before the test, the original gauge length is divided into  $N$  equal lengths of 5 mm (recommended) to 10 mm.
- b) After the test, the gauge mark on the shorter part of the fractured test piece is made as X and the gauge mark on the longer part of the fractured test piece which is at the same distance from the fracture as X is made as Y.

If  $n$  is the number of intervals between X and Y, the elongation after fracture is obtained as follows.

- 1) If  $N-n$  is an even number [see figure H.1 a)], the distance between X and Y,  $l_{XY}$  and the distance from Y to the graduation Z,  $l_{YZ}$ , which is located at  $(N-n)/2$  are measured.

The percentage elongation after fracture is obtained according to equation (H.1).

$$A = \frac{l_{XY} + 2l_{YZ} - L_0}{L_0} \times 100 \dots\dots\dots (H.1)$$

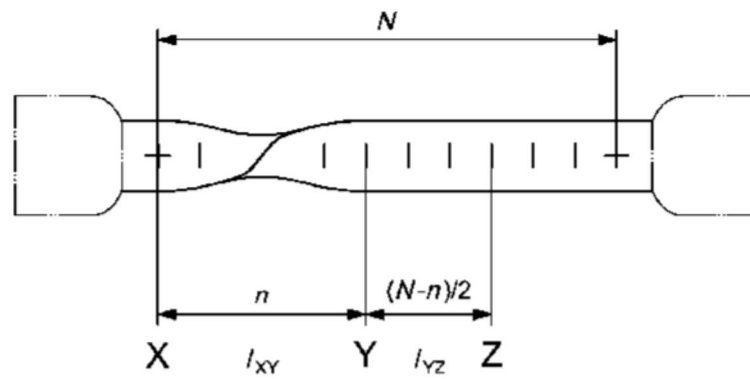
- 2) If  $N-n$  is an odd number [see figure H.1 b)], the distance between X and Y,  $l_{XY}$ , the distance from Y to the graduation Z',  $l_{YZ'}$ , and the distance from Y to the graduation Z'',  $l_{YZ''}$  are measured. The location of Z' and Z'' are as follows.

The graduation Z' is located at  $(N-n-1)/2$

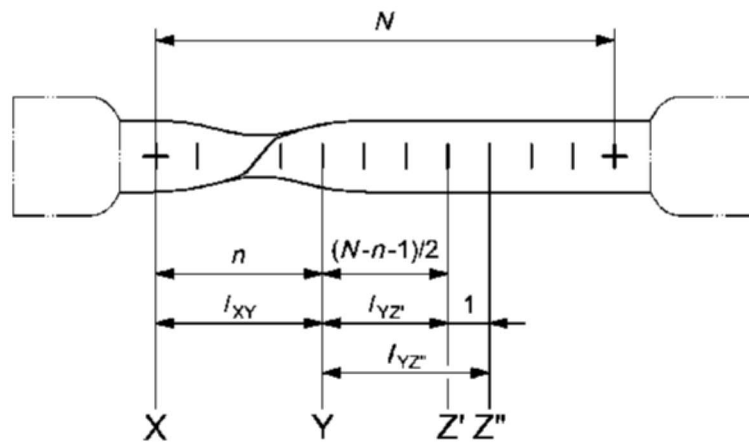
The graduation Z'' is located at  $(N-n+1)/2$

The percentage elongation after fracture is obtained according to equation (H.2).

$$A = \frac{l_{XY} + l_{YZ'} + l_{YZ''} - L_0}{L_0} \times 100 \dots\dots\dots (H.2)$$



a) If  $N-n$  is even number



b) If  $N-n$  is odd number

- $n$  : number of graduations between  $X$  and  $Y$
- $N$  : number of equal lengths
- $X$  : gauge mark on shorter part of test piece
- $Y$  : gauge mark on longer part of test piece
- $Z, Z', Z''$  : gauge marks

NOTE : The shape of gripped ends is only given as guide.

**Figure H.1 Example of measurement method of percentage elongation after fracture**

## Annex I (informative)

### Measurement of percentage plastic elongation without necking for bar, wire rod and wire

This method is to be carried out on the longer part of a fractured test piece.

Before the test, equidistant marks are made between the gauge marks so that the distance between two successive marks becomes equal to a fraction of the initial gauge length  $L'_0$ . The marking of the initial gauge length  $L'_0$  should be accurate to within  $\pm 0.5$  mm. The measurement of the final gauge length after fracture  $L'_u$  is made on the longer fractured part of the test piece, and should be accurate to within  $\pm 0.5$  mm.

In order for the measurement to be valid, the following two conditions should be met.

- a) The measuring zone should be located at least  $5d_0$  from the fracture and at least  $2.5d_0$  from the grip.
- b) The final gauge length measured should be at least equal to the value specified in the product standard.

The percentage plastic elongation without necking is calculated according to equation (I.1).

$$A_{wn} = \frac{L'_u - L'_0}{L'_0} \times 100 \dots\dots\dots (I.1)$$

NOTE : For many metallic materials, the maximum force occurs in the range where necking starts. This means the forces for  $A_g$  and  $A_{wn}$  for these materials will be nearly equal. Large differences will be found in highly cold deformed material such as double reduced tin plate, irradiated structural steel and tests carried out at elevated temperatures.

## Annex JA (informative)

### Number of measuring points required for calculation of cross-sectional area of test piece

#### JA.1 Obtaining method of original cross-sectional area of parallel portion of test piece

It is specified so that the cross-sectional area of parallel portion of test piece is obtained by the measured values at sufficient positions on the central part. Generally, it is obtained from the average of 3 positions at both ends of gauge length and the central part. However, for the tube-form test piece specified in Annex E, it is obtained from the measurements at the end of the test piece.

#### JA.2 Concept where dimensional measurement is made to one point

For the case of the parallel portion of the test piece and the unmachined test piece, it is considered acceptable that the position of dimensional measurement in longitudinal direction is one point, if it is sufficiently managed that the cross-sectional area between gripped ends are even over the whole length and the cross-sectional area change (maximum value - minimum value) is within 0.5 %. For respective dimensions, the position of dimensional measurement in longitudinal direction may be made to one point, if the tolerances in table JA.1 to table JA.3 are sufficiently managed so as not to exceed.

**Table JA.1 Dimensional tolerances of test piece (test piece with circular cross section)**

Unit: mm

Nominal diameter	Tolerances
10 or over to and excl. 12	0.025
12 or over to and excl. 16	0.03
16 or over	0.04

**Table JA.2 Dimensional tolerances of test piece (test piece of under 6 mm in thickness with rectangular cross section)**

Unit: mm		Unit: mm	
Nominal thickness	Tolerances	Nominal width	Tolerances
0.6 or over to and excl. 1.2	0.002	12.5 or over to and excl. 25	0.02
1.2 or over to and excl. 2.5	0.004	25 or over	0.04
2.5 or over to and excl. 6	0.01		

**Table JA.3 Dimensional tolerances of test piece (test piece of 6 mm or over in thickness with rectangular cross section)**

Unit: mm		Unit: mm	
Nominal thickness	Tolerances	Nominal width	Tolerances
6 or over to and excl. 12	0.02	25 or over to and excl. 40	0.05
12 or over to and excl. 20	0.04	40 or over	0.10
20 or over	0.05		

## Annex JB (informative)

### Testing rate based on strain rate control (method A)

In this Annex, the test method in which the testing rate in the elastic part is controlled by the strain rate is specified as method A in **ISO 6892-1**. This is listed in view of the spread of this method in Japan for the future.

#### JB.1 General

Method A is intended to minimize the variation of the testing rates during the moment when the strain rate sensitive parameters are measured and to minimize the measurement uncertainty of the test results.

Two different types of strain rate control are described in this section. The first is the control of the strain rate itself  $\dot{\epsilon}_{t_c}$ , that is based on the feedback obtained from an extensometer. The second is the control of the estimated strain rate over the parallel portion  $\dot{\epsilon}_{L_c}$  which is achieved by controlling the crosshead separation rate at a velocity equal to the desired strain rate calculated from the parallel length.

If a material shows homogeneous deformation behaviour and the force remains nominally constant, the strain rate  $\dot{\epsilon}_{L_c}$  and the estimated strain rate over the parallel portion  $\dot{\epsilon}_{t_c}$  are approximately equal. Differences exist if the material exhibits discontinuous or serrated yielding (e.g., some steels and AlMg alloys in the yield point elongation range, or materials which show serrated yielding like the Portevin-Le Chatelier effect), or if necking occurs. If the force is increasing, the estimated strain rate of the parallel portion may be substantially below the target strain rate due to the compliance of the testing machine.

The testing rate conforms to the following requirements.

- a) In the range up to and including the measurement of  $R_{eH}$ ,  $R_p$  or  $R_t$ , the specified strain rate  $\dot{\epsilon}_{t_c}$  (see **3.7.1**) is applied. In this range, to eliminate the influence of the compliance of the tensile testing machine, the use of an extensometer clamped on the test piece is necessary to have accurate control over the strain rate. (For testing machines unable to control by strain rate, a procedure using the estimated strain rate over the parallel portion  $\dot{\epsilon}_{L_c}$  may be used.)
- b) During discontinuous yielding, the estimated strain rate over the parallel portion  $\dot{\epsilon}_{L_c}$  (see **3.7.2**) should be applied. In this range, it is impossible to control the strain rate using the extensometer clamped on to the test piece because local yielding can occur outside the extensometer gauge length. The required estimated strain rate over the parallel portion may be maintained in this range sufficiently accurately using a constant crosshead separation rate,  $v_c$  (see **3.7.3**).

$$v_c = L_c \times \dot{\epsilon}_{L_c} \dots\dots\dots \text{(JB.1)}$$

where,  $\dot{\epsilon}_{L_c}$  : estimated strain rate over parallel portion

$L_c$  : parallel length of test piece

- c) In the range following  $R_p$  or  $R_t$  or end of yielding (see **3.7.2**),  $\dot{\epsilon}_{L_c}$  or  $\dot{\epsilon}_{t_c}$  may be used. The use of  $\dot{\epsilon}_{t_c}$  is recommended to avoid any control problems which may arise if necking occurs outside the extensometer gauge length.

The strain rates specified in **JB.2** to **JB.4** is maintained during the measurement of the relevant material property (see also figure JB.1).

During switching to another strain rate or to another control mode, no discontinuities in the stress-strain curve should be introduced which distort the values of  $R_m$ ,  $A_g$  or  $A_{gt}$  (see figure 10). This effect can be reduced by a suitable gradual switch between the rates.

The shape of the stress-strain curve in the workhardening range can also be influenced by the strain rate. The testing rate applied should be documented.

### **JB.2 Measurement of upper yield strength $R_{eH}$ or proof strength $R_p$ and $R_t$**

The strain rate  $\dot{\epsilon}_{Lc}$  is kept as constant as possible up to and including the measurement of  $R_{eH}$ ,  $R_p$  and  $R_t$ . During the measurement of these material properties, the strain rate  $\dot{\epsilon}_{Lc}$  is in one of the two following specified ranges (see figure JB.1).

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

Range 2:  $(0.000\ 25 \pm 0.000\ 005)\ s^{-1}$  (recommended unless otherwise specified)

If the testing machine is not able to control the strain rate directly, the estimated strain rate over the parallel portion  $\dot{\epsilon}_{Lc}$ , i.e., constant crosshead separation rate, is used. This rate is calculated using equation (JB.1).

The resulting strain rate on the test piece will be lower than the specified strain rate because the compliance of the testing machine is not considered. An explanation thereof is given in Annex F.

### **JB.3 Lower yield strength $R_{eL}$ or percentage yield point extension $A_e$**

Following the detection of the upper yield strength, the estimated strain rate over the parallel portion  $\dot{\epsilon}_{Lc}$  shall be maintained in one of the following two specified ranges until discontinuous yielding has ended (see figure JB.1).

Range 2:  $(0.000\ 25 \pm 0.000\ 05)\ s^{-1}$  (recommended when  $R_{eL}$  is measured)

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

### **JB.4 Tensile strength $R_m$ , percentage elongation after fracture $A$ , percentage total extension at the maximum force $A_{gt}$ , percentage plastic extension at maximum force $A_g$ and percentage reduction of area $Z$**

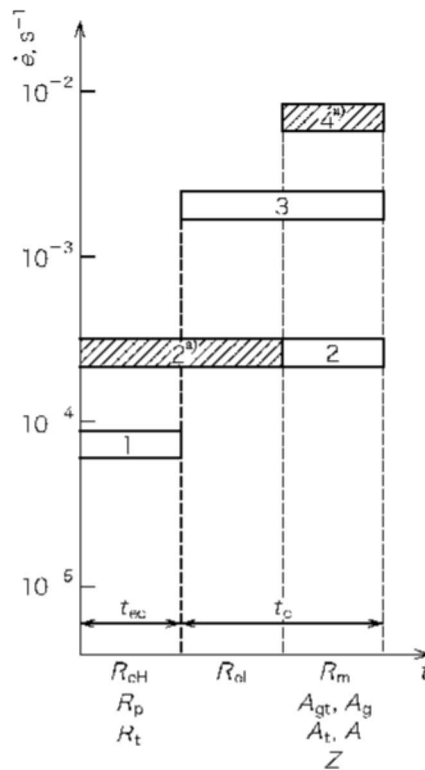
After measurement of the required yield/proof strength properties, the estimated strain rate over the parallel portion  $\dot{\epsilon}_{Lc}$  is changed to one of the following specified ranges.

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

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

Range 4:  $(0.006\ 7 \pm 0.001\ 33)\ s^{-1}$  [ $(0.4 \pm 0.08)\ \text{min}^{-1}$ ] (recommended unless otherwise specified)

If the purpose of the tensile test is only to measure the tensile strength, then an estimated strain rate over the parallel portion of the test piece according to range 3 or range 4 may be applied throughout the entire test.



- $\dot{\epsilon}$  : strain rate  
 $t$  : time progress of tensile test  
 $t_{ec}$  : time range controlled by extensometer or crosshead separation rate  
 $t_c$  : time range controlled by crosshead separation rate  
 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 ± 0.08) min<sup>-1</sup>]

Note <sup>a)</sup> Recommended

**Figure JB.1** Illustration of strain rate to be used during test if  $R_{eH}$ ,  $R_{eL}$ ,  $R_p$ ,  $R_t$ ,  $R_m$ ,  $A_g$ ,  $A_{gt}$ ,  $A_t$ ,  $A$ ,  $A_l$  and  $Z$  are measured

### Bibliography

JIS G 0416 *Steel and steel products—Location and preparation of samples and test pieces for mechanical testing*

NOTE : Corresponding International Standard: ISO 377:1997 *Steel and steel products—Location and preparation of samples and test pieces for mechanical testing (MOD)*

ISO 2566-1 *Steel—Conversion of elongation values—Part 1: Carbon and low alloy steels*

ISO 2566-2 *Steel—Conversion of elongation values—Part 2: Austenitic steels*

ASTM E 1012 *Standard Practice for verification of Test Frame and Specimen Alignment Under Tensile and Compressive Axial Force Application*

**Annex JC (informative)**  
**Comparison table between JIS and corresponding International Standard**

<b>JIS Z 2241 : 2011 Metallic materials—Tensile testing—Method of test at room temperature</b>		<b>ISO 6892-1 : 2009 Metallic materials—Tensile testing—Part 1: Method of test at room temperature</b>		<b>(V) Justification for the technical deviation and future measures</b>											
<b>(I) Requirements in JIS</b>		<b>(IV) Classification and details of technical deviation between JIS and the International Standard by clause</b>													
<b>No. and title of clause</b>	<b>Content</b>	<b>(II) International Standard number</b>	<b>(III) Requirements in International Standard</b>	<b>Classification by clause</b>	<b>Detail of technical deviation</b>										
		<b>No. of clause</b>	<b>Content</b>	<b>Identical</b>											
1	Scope Tensile test method at room temperature (10 °C to 35 °C) is specified.		In NOTE, it is stated that the computer-controlled tensile testing machines are described in Annex A.	Identical											
2	Normative references														
3	Terms and definitions			Alteration	The following term numbers in ISO Standard are altered in JIS. <table style="margin-left: 20px;"> <tr> <td style="text-align: right;">JIS</td> <td style="text-align: right;">ISO Standard</td> </tr> <tr> <td style="text-align: right;">3.4.3</td> <td style="text-align: right;">3.6.6</td> </tr> <tr> <td style="text-align: right;">3.4.4</td> <td style="text-align: right;">3.6.4</td> </tr> <tr> <td style="text-align: right;">3.4.5</td> <td style="text-align: right;">3.6.5</td> </tr> <tr> <td style="text-align: right;">3.4.6</td> <td style="text-align: right;">3.6.3</td> </tr> </table> For 3.9 (maximum force) JIS specifies that if required, the agreement between the parties concerned with delivery is necessary. The term "yield point" is added in 3.10.2.	JIS	ISO Standard	3.4.3	3.6.6	3.4.4	3.6.4	3.4.5	3.6.5	3.4.6	3.6.3
JIS	ISO Standard														
3.4.3	3.6.6														
3.4.4	3.6.4														
3.4.5	3.6.5														
3.4.6	3.6.3														
				Addition											



(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause	(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content		
4 Symbols and designations			4	<p>Deletion</p> <p>In <b>JIS</b>, the symbol "t" of wall thickness (symbol used in product standards of steel tubes) is deleted.</p> <p>Alteration</p> <p>The position of figures are moved to clause 4 in <b>JIS</b>. The description on strain rate control in figure 9 is moved to Annex JB.</p>	<p>There is no technical deviation.</p> <p>The strain rate control is moved to Annex (informative). The incorporation to the text will be studied according to the actual situation in Japan at the next revision of <b>JIS</b>.</p>	
5 Principle			5	Identical		
6 Test piece	6.1.1 General		6	<p>6.1.1</p> <p>Identical</p> <p>In <b>ISO</b> Standard, other applicable test pieces of <b>ISO, API, ASTM, DIN, IACS</b> and <b>JIS</b> are described specifically. In <b>JIS</b>, it is expressed as "otherwise specified in other standards".</p> <p>Addition</p> <p>In <b>JIS</b>, note on straightness of the test piece is added in <b>6.1.1</b>.</p> <p>Addition</p> <p>The description that the test piece may be tapered is added in <b>6.1.2</b>.</p> <p>Addition</p> <p>Types of test pieces of <b>JIS</b> are added in <b>6.2</b>.</p>	<p>Technical deviation is slight.</p>	
	6.1.2 Machined test pieces					
	6.2 Types of test pieces					

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
7 Measurement of original cross-sectional area	Measuring accuracy of test piece is at least to the nearest 0.5 % of numerical value, provided that dimensions of not more than 2 mm may be to the nearest 0.01 mm.		7	It is determined by measuring accuracy of cross-sectional area, and specified in respective Annexes according to shapes of test pieces.	Alteration	Conventionally JIS adopts severer specification than that of ISO Standard. Consideration on lapped test pieces is added.	Proposal to ISO will be studied as necessary.
8 Marking of original gauge length			8		Addition	JIS describes that scribed lines on coating are permissible. JIS describes that the extensometer gauge length may be used as the original gauge length when error to extensometer gauge length is within $\pm 1.0\%$ .	There is no technical deviation.
9 Accuracy of testing machine	9.1 Testing machine 9.2 Extensometer		9		Identical Alteration	In JIS, the extensometer to be used is that of Class 2 or better.	Specification of ISO Standard will be adopted at the future revision according to the actual situation in Japan.
10 Conditions of testing	10.1 Setting of zero point of force 10.2 Method of gripping		10.1 10.2		Identical Identical		

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
10 Conditions of testing (concluded)	10.3 Testing rate	10.3	Testing rate based on strain rate control (method A)	Deletion	In <b>JIS, 10.3</b> (method A) of <b>ISO Standard</b> is moved to Annex JB (informative).	Will be studied at the next revision according to actual situation in future of application in strain rate control in Japan.	
	10.3.2.2 Lower yield strength $R_{eL}$	10.4	Testing rate based on stress rate control (method B)	Alteration	The stress rate of table 3 is conventional $3 \text{ MPa} \cdot \text{s}^{-1}$ to $30 \text{ MPa} \cdot \text{s}^{-1}$ in <b>JIS</b> , and $6 \text{ MPa} \cdot \text{s}^{-1}$ to $60 \text{ MPa} \cdot \text{s}^{-1}$ in <b>ISO Standard</b> .	Adoption will be continuously studied on the confirmation of the compatibility of data, etc.	
	10.3.2.6 Tensile strength $R_m$ , percentage elongation after fracture $A$ , percentage total extension at maximum force $A_{gt}$ , percentage plastic extension at maximum force $A_g$ and percentage reduction of area $Z$			Alteration	In <b>JIS</b> , when only lower yield strength of <b>10.3.2.2</b> is measured, the range of stress rate in table 3 is conformed in the elastic part.		
				Addition	In <b>JIS</b> , when only tensile strength of <b>10.3.2.6</b> is measured, the minimum rate is specified. Also, the maximum rate may be exceeded, if it is specified in the product standard.	Proposal to <b>ISO Standard</b> will be studied.	
11 Measurement of upper yield strength $R_{eU}$		11		Identical	The calculation equation is listed and made comprehensive.		

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
12 Measurement of lower yield strength $R_{eL}$			12		Identical	The calculation equation is listed and made comprehensive.	
13 Proof strength (plastic extension) $R_p$			13		Deletion	The plastic extension method (figure 6) is moved to NOTE.	Adoption will be studied at the revision from next time according to the actual situation of usage in Japan.
14 Proof strength (total extension) $R_t$			14		Identical		
15 Method of verification of permanent set strength $R_r$			15		Identical		
16 Measurement of percentage yield point extension $A_e$			16		Addition	Other method than that specified in ISO Standard is made applicable according to actual situation in Japan.	Adoption to ISO Standard will be studied at the revision from next time according to the actual situation of usage in Japan.
17 Measurement of percentage plastic extension at maximum force $A_g$			17		Identical		

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
18	Measurement of percentage total extension at maximum force $A_{gt}$	18		18	Identical		
19	Measurement of percentage total extension at fracture $A_1$	19		19	Identical		
20	Measurement of percentage elongation after fracture $A$	20	20.1	20	Alteration	In JIS, the fractured position 1/4 or more of original gauge length inside the gauge mark is effective. In ISO Standard, that 1/3 or more is effective.	JIS is severer than ISO Standard. Proposal to ISO will be studied.
			20.2		Addition	In NOTE, fracture definitions of A, B and C are added.	
			20.3		Addition	The description that extensometer gauge length and original gauge length are made same when measuring the elongation after fracture with extensometer, and the accuracy of measurement are added.	
			20.3		Identical		

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
21	Measurement of percentage reduction of area Z		21		Identical Deletion	ISO Standard describes that the measuring accuracy of minimum cross-sectional area after fracture is $\pm 2\%$ ; however, it is deleted in JIS.	
22	Test report		22		Alteration  Addition	Omission of items in test report is made possible upon the agreement between the parties concerned with delivery.  Accuracy of rounding of elongation after fracture "1%" is added.	
Annex A (informative)			Annex A		Deletion		Modification to conform to the actual situation of computer-controlled tensile testing machine in Japan will be proposed to ISO.

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex B (normative)	Test pieces used for thin products less than 3 mm in thickness		Annex B	Test pieces used for thin products less than 3 mm in thickness	Alteration	Tolerances on nominal dimensions severer than those in ISO Standard are applied in JIS (table B.1). Severer values than those in ISO Standard are applied in JIS for finishing accuracy of test piece whose nominal dimensions can be used without measurement (table B.2). Specifications of measuring accuracy ( $\pm 2\%$ ) of original cross-sectional area and measuring accuracy of width ( $\pm 0.2\%$ ) are made NOTE.	Values in JIS are severer than those of ISO Standard, and proposal to ISO will be studied in future.
Annex C (normative)	Test pieces used for wires and bars with diameter or traverse of less than 4 mm		Annex C	Test pieces used for wires and bars with diameter or traverse of less than 4 mm	Alteration	Measuring accuracy ( $\pm 1\%$ ) of original cross-sectional area is deleted. The measuring accuracy in the text is substituted. Specification of the distance between grips is altered, which is severer in JIS.	Values in JIS are severer than those of ISO Standard, and proposal to ISO will be studied in future.

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex D (normative)	Test pieces of sheet of 3 mm or more in thickness, and wires and bars of 4 mm or more in diameter or width across flats		Annex D	Test pieces of sheet of 3 mm or more in thickness, and wire sand bars of 4 mm or more in diameter or width across flats	Alteration	D.2.1 In case of dispute on parallel length, the length is modified so that the specified length should be applied. Permissible range of diameters of test pieces is added in table D.1. Machining tolerances on nominal dimensions in table D.4 which are severer than those in ISO Standard are adopted in JIS.	Adoption of and conformance to ISO Standard are planned continuously according to the actual situation of application in Japan. Proposal on test pieces of JIS to ISO will be studied.
					Addition	Type of test pieces of JIS are added.	
					Deletion	Non-proportional test piece in ISO Standard whose original gauge length is 80 mm is deleted. Measuring accuracy is equal to the specification in the text (0.5 %) of JIS.	



(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex E (normative)	Test pieces used for tubes		Annex E	<p>Types of test pieces of JIS are added.</p> <p>Equation with higher accuracy (E.2) and <math>S_v = d_0 b_0</math> among simplified equation (E.3) used for the calculation of original cross-sectional area are moved to NOTE.</p> <p>Also, equation conventionally used in JIS is added.</p>	<p>Technical deviation is slight.</p> <p>Proposal on the equation conventionally used in JIS to ISO will be studied.</p>		
Annex F (informative)			Annex F	Identical			
Annex G (informative)			Annex G	Identical			
Annex H (informative)			Annex H	Identical			
Annex I (informative)			Annex I	Identical			
Annex JA (informative)	Number of measuring points required for calculation of cross-sectional area of test piece			Addition	In ISO Standard, the specification on number of measuring points required is not clear. The concept on this is described and made to be applicable for the judgement reference.	Proposal to ISO Standard will be studied in future.	

(I) Requirements in <b>JIS</b>		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between <b>JIS</b> and the International Standard by clause		(V) Justification for the technical deviation and future measures
No. and title of clause	Content		No. of clause	Content	Classification by clause	Detail of technical deviation	
Annex JB (informative)	Testing rate based on strain rate control (method A)				Alteration	In ISO Standard, it is described in the text; in <b>JIS</b> , it is described in Annex (informative).	Adoption to <b>JIS</b> will be studied according to actual situation of application in Japan.

Overall degree of correspondence between **JIS** and International Standard (ISO 6892-1:2009): MOD

NOTE 1 Symbols in sub-columns of classification by clause in the above table indicate as follows:

- Identical: Identical in technical contents.
- Deletion: Deletes the specification item(s) or content(s) of International Standard.
- Addition: Adds the specification item(s) or content(s) which are not included in International Standard.
- Alteration: Alters the specification content(s) which are included in International Standard.

NOTE 2 Symbol in column of overall degree of correspondence between **JIS** and International Standard in the above table indicates as follows:

- MOD: Modifies International Standard.

Errata for JIS (English edition) are printed in *Standardization and Quality Control*, published monthly by the Japanese Standards Association, and also provided to subscribers of JIS (English edition) in *Monthly Information*.

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**Standards Publishing Department, Japanese Standards Association**  
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN  
TEL. 03-3583-8002 FAX. 03-3583-0462