

First edition
2005-11-15

Mechanical testing of metals — Symbols and definitions in published standards

*Essais mécaniques des métaux — Symboles et définitions figurant
dans les normes publiées*



PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

© ISO 2005

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

Foreword.....	v
Introduction	vi
1 Scope	1
2 Designation system	1
3 Definitions and symbols	3
3.1 Code 1.01 Metallic materials — Uninterrupted uniaxial creep testing in tension-method of test.....	4
3.1.1 Definitions	4
3.2 Code 1.02 Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines	6
3.3 Code 1.03 Metallic materials — Tensile testing at elevated temperature	7
3.3.1 Definitions	7
3.4 Code 1.04 Metallic materials — Tensile testing	9
3.4.1 Definitions	9
3.5 Code 1.05 Metallic materials — Verification of static uniaxial tensile testing machines	12
3.5.1 Definitions	12
3.6 Code 1.06 Metallic materials — Verification of static uniaxial testing machines — tension creep testing machines	13
3.7 Code 1.07 Metallic materials — Calibration of extensometers used in uniaxial testing	14
3.8 Code 1.08 Metallic materials — Tensile testing at low temperature.....	14
3.8.1 Definitions	14
3.9 Code 1.09 Metallic materials — Tensile testing in liquid helium	16
3.9.1 Definitions	16
3.10 Code 2.01 Metallic materials — Bend test.....	17
3.11 Code 2.02 Metallic materials — Sheet and strip 3 mm thick or less — Reverse bend test.....	18
3.12 Code 2.03 Metallic materials — Wire — Simple torsion test	18
3.13 Code 2.04 Metallic materials — Wire — Reverse bend test.....	18
3.14 Code 2.06 Metallic materials — Sheet and strip — Modified Erichsen cupping test.....	19
3.15 Code 2.07 Metallic materials — Tube (in full section) — Bend test.....	19
3.16 Code 2.08 Metallic materials — Tube — Flattening test	19
3.17 Code 2.09 Metallic materials — Tube — Drift expanding test.....	20
3.18 Code 2.10 Metallic materials — Tube — Flanging test	20
3.19 Code 2.11 Metallic materials — Tube — Ring expanding test	20
3.20 Code 2.13 — Metallic materials — Wire — Reverse torsion test	21
3.21 Code 2.14 Metallic materials — Sheet and strip — Determination of plastic strain ratio	21
3.21.1 Definitions	21
3.22 Code 2.15 Metallic materials — Sheet and strip — Determination of tensile strain hardening exponent.....	21
3.23 Code 2.16 Metallic materials — Earing test	22
3.24 Code 2.17 Metallic materials — Guidelines for the determination of forming-limit diagrams....	23
3.25 Code 2.18 Metallic materials — Tube ring hydraulic pressure test.....	23
3.26 Code 2.19 Metallic materials — Strain analysis report	23
3.27 Code 3.01 Metallic materials — Hardness test — Knoop test.....	24
3.28 Code 3.02 Metallic materials — Brinell hardness test — Part 1: Test method	24
3.29 Code 3.03 Hardness test — Vickers hardness test — Part 1: Test method.....	25
3.30 Code 3.04 Metallic materials — Rockwell Hardness test — Part 1: Test method (scales A-B-C-D-E-F-G-H-K-N-T).....	25
3.31 Code 3.06 Metallic materials — Instrumented indentation test for hardness and materials parameters — Part : Test method	26
3.32 Code 4.01 Charpy impact test (U-notch)	27

3.33	Code 4.01 Metallic materials — Charpy pendulum impact test — Part 1: Test method	27
3.33.1	Definitions	27
3.34	Code 4.01 Metallic materials — Charpy pendulum impact test — Part 2: Verification of test machines	28
3.34.1	Definitions	28
3.35	Code 4.01 Metallic materials — Charpy pendulum impact test — Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines	30
3.36	Code 4.03 — Metallic materials — Determination of the plane-strain fracture toughness	30
3.36.1	Definitions	30
3.37	Code 4.04 Steel — Charpy V-notch pendulum impact test — Instrumented test method	31
3.37.1	Definitions	31
3.38	Code 4.05 Metallic materials — Unified method of test for the determination of quasistatic fracture toughness	32
3.38.1	Definitions	32
3.39	Code 5.01 Metals — Axial load fatigue testing	35
3.40	Code 5.01 Metallic materials — Fatigue testing — Axial force controlled method	36
3.41	Code 5.02 Metals — Rotating bar bending fatigue testing	37
3.42	Code 5.03 Steel — Torsional stress fatigue testing	37
3.43	Code 5.04 Axial load fatigue machines — Dynamic force calibration — Strain gauge technique	37
3.44	Code 5.05 Metallic materials — Fatigue testing — Axial-strain-controlled method	38
3.44.1	Definitions	38
3.45	Code 5.06 Metallic materials — Fatigue testing — Statistical planning and analysis of data	40
3.45.1	Definitions	40
3.46	Code 5.07 Metallic materials — Fatigue testing — Fatigue crack growth method	40
3.46.1	Definitions	40
4	Concordance of Keywords Scope	43
5	Alphabetical listing of symbols	47
	Annex A Index	63

Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 25679 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*.

This first edition of ISO/TR 25679, together with ISO 23718¹⁾, *Metallic materials — Terms used in mechanical testing*, cancel and replace ISO/TR 12735-1:1996, *Mechanical testing of metals — Symbols used with their definitions — Part 1: Symbols and definitions in published standards*.

1) In preparation.

Introduction

This index of symbols and definitions in published standards has been prepared to provide an appropriate means for avoiding contradictions and misunderstandings and to standardize various kinds of symbols and their definitions generally used in this field. Wherever possible, the same symbol has been used to denote the same type of parameter in the different tests, but the differing types of test piece, product form and test have to be taken into account. This has not been universally possible and symbols should always be considered in the context of the specific method of test being used.

In the discussion of revising ISO/TR 12735-1:1996, common terms among the published standards were selected and a Draft International Standard covering terminology: ISO/DIS 23718, *Metallic materials — Terms used in mechanical testing*, was prepared. This Technical Report, which is an index of symbols and definitions, was separated from the terminology (ISO/DIS 23718) in order to be updated flexibly in future.

Mechanical testing of metals — Symbols and definitions in published standards

1 Scope

This Technical Report enumerates the symbols and definitions used in International Standards for specific methods of mechanical testing of metallic materials, which are the responsibility of ISO Technical Committee 164, *Mechanical testing of metals*. The data is indexed alphabetically and via a coding system. Annex A provides an additional cross-reference between the coding system and relevant International Standard numbers.

2 Designation system

To assist in indexing and cross-referencing symbols and definitions, a code number is used to identify test methods. The first digit of the code identifies the sub-committee of ISO/TC 164 that is responsible for preparing and reviewing International Standards for that test method. Subsequent digits are in ascending order of the ISO number for each International Standard or Draft International Standard.

International Standards that relate to a common test method and which all share the same set of symbols and definitions are given a single code number.

If there existed both a valid International Standard and a document designed to replace it that had reached the DIS stage, then both the International Standard and the DIS (Draft International Standard) or FDIS will have been assigned to the same code number.

Each test method for metallic materials is identified and designated as shown in Table 1. Annex A provides a rapid cross-reference to the coding system.

Table 1 — Identity and code of mechanical test

	Test Identity	Code	ISO standards
SC 1	Metallic materials — Uninterrupted uniaxial creep testing in tension — Method of test	1.01	204:1997 DIS 204:2005
	Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines	1.02	376:2004
	Metallic materials — Tensile testing at elevated temperature	1.03	783:1999
	Metallic materials — Tensile testing at ambient temperature	1.04	6892:1998
	Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system	1.05	7500-1:2004
	Metallic materials — Verification of static uniaxial testing machines — Part 2: Tension creep testing machines — Verification of the applied load	1.06	7500-2:1996 DIS 7500-2:2005
	Metallic materials — Calibration of extensometers used in uniaxial testing	1.07	9513:1999
	Metallic materials — Tensile testing at low temperature	1.08	15579:2000
	Metallic materials — Tensile testing in liquid helium	1.09	19819:2004

Table 1 (continued)

	Test Identity	Code	ISO standards
SC 2	Metallic materials — Bend test	2.01	7438:2005
	Metallic materials — Sheet and strip 3 mm thick or less — Reverse bend test	2.02	7799:1985
	Metallic materials — Wire — Simple torsion test	2.03	7800:2003
	Metallic materials — Wire — Reverse bend test	2.04	7801:1984
	*Metallic materials — Wire — Wrapping test	2.05	7802:1983
	Metallic materials — Sheet and strip — Erichsen cupping test	2.06	20482:2003
	Metallic materials — Tube (in full section) — Bend test	2.07	8491:1998
	Metallic materials — Tube — Flattening test	2.08	8492:1998
	Metallic materials — Tube — Drift-expanding test	2.09	8493:1998
	Metallic materials — Tube — Flanging test	2.10	8494:1998
	Metallic materials — Tube — Ring-expanding test	2.11	8495:1998
	*Metallic materials — Tube — Ring tensile test	2.12	8496:1998
	Metallic materials — Wire — Reverse torsion test	2.13	9649:1990
	Metallic materials — Sheet and strip — Determination of plastic strain ratio	2.14	10113:1991 DIS 10113:2005
	Metallic materials — Sheet and strip — Determination of tensile strain hardening exponent	2.15	10275:1993
	Metallic materials — Earing test	2.16	11531:1994
	Metallic materials — Guidelines for the determination of forming-limit diagrams	2.17	12004:1997
	Metallic materials — Tube ring hydraulic pressure test	2.18	15363:2000
	Metallic materials — Strain analysis report	2.19	TR 14936:1998
SC 3	Metallic materials — Hardness test — Knoop test	3.01	4545:1993 FDIS 4545-1 to 4545-4:2005
	*Metallic materials — Hardness test — Verification of Knoop hardness testing machines	3.01	4546:1993
	*Metallic materials — Hardness test — Calibration of standardized blocks to be used for Knoop hardness testing machines	3.01	4547:1993
	Metallic materials — Brinell hardness test — Part 1: Test method	3.02	6506-1:1999 FDIS 6506-1:2005
	*Metallic materials — Brinell hardness test — Part 2: Verification and calibration of testing machines	3.02	6506-2:1999 FDIS 6506-2:2005
	*Metallic materials — Brinell hardness test — Part 3: Calibration of reference blocks	3.02	6506-3:1999 FDIS 6506-3:2005
	Metallic materials — Vickers hardness test — Part 1: Test method	3.03	6507-1:1997 FDIS 6507-1:2005
	*Metallic materials — Vickers hardness test — Part 2: Verification of testing machines	3.03	6507-2:1997 FDIS 6507-2:2005
	*Metallic materials — Vickers hardness test — Part 3: Calibration of reference blocks	3.03	6507-3:1997 FDIS 6507-3:2005
	Metallic materials — Rockwell hardness test — Part 1: Test method (scales A, B, C, D, E, F, G, H, K, N, T)	3.04	6508-1:1999 FDIS 6508-1:2005

Table 1 (continued)

	Test Identity	Code	ISO standards
	*Metallic materials — Rockwell hardness test — Part 2: Verification and calibration of testing machines (scales A, B, C, D, E, F, G, H, K, N, T)	3.04	6508-2:1999 FDIS 6508-2:2005
	*Metallic materials — Rockwell hardness test — Part 3: Calibration of reference blocks (scales A, B, C, D, E, F, G, H, K, N, T)	3.04	6508-3:1999 FDIS 6508-3:2005
	*Metallic materials — Hardness testing — Tables of Knoop hardness values for use in tests made on flat surfaces	3.05	10250:1994
	Metallic materials — Instrumented indentation test for hardness and materials parameters — Part 1: Test method	3.06	14577-1:2002
	*Metallic materials — Instrumented indentation test for hardness and materials parameters — Part 2: Verification and calibration of testing machines	3.06	14577-2:2002
	*Metallic materials — Instrumented indentation test for hardness and materials parameters — Part 3: Calibration of reference blocks	3.06	14577-3:2002
	*Metallic materials — Conversion of hardness values	3.07	18265:2003
SC 4	Steel — Charpy impact test (U-notch)	4.01	83:1976
	*Steel — Charpy impact test (V-notch)	4.01	148:1983
	Metallic materials — Charpy pendulum impact test — Part 1: Test method	4.01	FDIS 148-1:2005
	Metallic materials — Charpy pendulum impact test — Part 2: Verification of test machines	4.01	148-2:1998
	Metallic materials — Charpy pendulum impact test — Part 3: Preparation and characterization of Charpy V reference test pieces for verification of test machines	4.01	148-3:1998
	*Steel — Designation of test piece axes	4.02	3785:1976 FDIS 3785:2005
	Metallic materials — Determination of plane-strain fracture toughness	4.03	12737:2005
	Steel — Charpy V-notch pendulum impact test — Instrumented test method	4.04	14556:2000
	Metallic materials — Unified method of test for the determination of quasistatic fracture toughness	4.05	12135:2002
SC 5	Metals — Axial load fatigue testing	5.01	1099:1975
	Metallic materials — Fatigue testing — Axial force controlled method	5.01	DIS 1099:2005
	Metals — Rotating bar bending fatigue testing	5.02	1143:1975
	Steel — Torsional stress fatigue testing	5.03	1352:1977
	Axial load fatigue testing machines — Dynamic force calibration — Strain gauge technique	5.04	4965:1979
	Metallic materials — Fatigue testing — Axial-strain-controlled method	5.05	12106:2003
	Metallic materials — Fatigue testing — Statistical planning and analysis of data	5.06	12107:2003
	Metallic materials — Fatigue testing — Fatigue crack growth method	5.07	12108:2002
* There are no symbols or definitions in the text of the standard.			

3 Definitions and symbols

Definitions and symbols employed in all of the International Standards and (Final) Draft International Standards prepared by ISO/TC 164, *Mechanical testing of metals* are classified under the codes listed in Table 1, *Identity and code of mechanical test*. If a standard has separate clauses for definitions and symbols, the definitions are listed first, followed by a table of symbols. Each table of symbols is re-arranged into a consistent alphabetical order. For clarity, notes, alternative definitions and conditions embodied within definitions, which are particular to the individual standard, are excluded.

3.1 Code 1.01 Metallic materials — Uninterrupted uniaxial creep testing in tension — Method of test

3.1.1 Definitions

reference length, L_r

base length used for the calculation of elongation

NOTE Examples of reference lengths for several types of test pieces are given.

original reference length, L_{r0}

reference length determined at ambient temperature before the test L_{r0} , not exceeding the parallel length L_c by more than 10 % L_c for circular test pieces, or by more than 15 % L_c for square or rectangular test pieces

final reference length, L_{ru}

reference length determined at ambient temperature after rupture, the two pieces having been carefully fitted back together so that their axes lie in a straight line

original gauge length, L_0

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

final gauge length after rupture, L_u

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

parallel length, L_c

length of the parallel reduced section of the test piece

extensometer gauge length, L_e

distance between the measuring points of the extensometer; as near as possible to the reference length

original cross-sectional area, S_0

cross-sectional area of the parallel length determined at ambient temperature prior to testing

minimum cross-sectional area after rupture, S_u

minimum cross-sectional area of the parallel length determined at ambient temperature after rupture, the two pieces having been carefully fitted back together so that their axes lie in a straight line

initial stress, σ_0

applied force divided by the original cross-sectional area S_0 of the test piece

elongation

increase of the reference length at any moment during the test

percentage creep elongation, A_f

at any given moment t during the test, the increase in the reference length between this moment and the zero moment (ΔL_{rt}) at a specified temperature, expressed as a percentage of the original reference length

$$A_f = \frac{\Delta L_{rt}}{L_{r0}} \times 100$$

NOTE 1 The symbol A_f may have as superscript the specified temperature T , in degrees Celsius, and as subscript the stress, in megapascals, and the time t , in hours.

NOTE 2 By convention, the zero moment (start of time) is the moment at which the initial stress (σ_0) is applied to the test piece. The origin of the elongation is the value of the reference length at the zero moment.

percentage elongation after creep rupture, A_{fu}

permanent elongation of the reference length after rupture ($L_{ru} - L_{ro}$), expressed as a percentage of the original reference length:

$$A_{fu} = \frac{L_{ru} - L_{ro}}{L_{ro}} \times 100$$

NOTE The symbol A_{fu} may have as superscript the specified temperature T , in degrees Celsius, and as subscript the stress, in megapascals.

percentage reduction of area after creep rupture, Z_u

maximum change in cross-sectional area measured after rupture ($S_o - S_u$), expressed as a percentage of the original cross-sectional area (S_o):

$$Z_u = \frac{S_o - S_u}{S_o} \times 100$$

NOTE The symbol Z_u may have as superscript the specified temperature T , in degrees Celsius, and as subscript the stress, in megapascals.

creep rupture time, t_u

time required for the test piece, maintained at the specified temperature T and strained by the specified tensile force, to rupture

NOTE The symbol t_u may have as superscript the specified temperature T , in degrees Celsius, and as subscript the stress, in megapascals.

simple machine

test machine that allows the straining of only one test piece at a time

multiple machine

test machine that allows simultaneous straining of more than one test piece at the same temperature

Table 2 — Symbols designated in the International Standard, Code 1.01

Symbol	Unit	Meaning
ΔL_{rt}	mm	Increase in the reference length between a moment t and the zero moment
σ_o	MPa	Initial stress
A_f	%	Percentage creep elongation
A_{fu}	%	Percentage elongation after creep rupture
b	mm	Width of the cross-section of the parallel length of a test piece of square or rectangular cross-section
d	mm	Diameter of the cross-section of the parallel length of a cylindrical test piece
L_c	mm	Parallel length
L_e	mm	Extensometer gauge length
L_o	mm	Original gauge length
L_r	mm	Reference length
L_{ro}	mm	Original reference length
L_{ru}	mm	Final reference length
L_u	mm	Final gauge length after rupture

Table 2 (continued)

Symbol	Unit	Meaning
r	mm	Transition radius
S_o	mm ²	Original cross-sectional area of the parallel length
S_u	mm ²	Minimum cross-sectional area after rupture
T	°C	Specified temperature
T_i	°C	Indicated temperature
t_u	h	Creep rupture time
Z_u	%	Percentage reduction of area after creep rupture

3.2 Code 1.02 Metallic materials — Calibration of force-proving instruments used for the verification of uniaxial testing machines

Table 3 — Symbols designated in the International Standard, Code 1.02

Symbol	Unit	Designation
b	%	Relative reproducibility error with rotation
b'	%	Relative repeatability without rotation
f_c	%	Relative interpolation error
F_f	N	Maximum capacity of the transducer
F_N	N	Maximum capacity of the measuring range
f_o	%	Relative zero error
i_f	—	Reading ^a on the indicator after removal of force
i_o	—	Reading ^a on the indicator before application of force
r	—	Resolution of the indicator
v	%	Relative reversibility error of the force proving instrument
X	—	Deflection with increasing test force
$\overline{X_r}$	—	Average value of the deflections with rotation
$\overline{X_{wr}}$	—	Average value of the deflections without rotation
X'	—	Deflection with decreasing test force
X_a	—	Computed value of deflection
X_{max}	—	Maximum deflection
X_{min}	—	Minimum deflection
X_N	—	Deflection corresponding to the maximum capacity
^a Reading value corresponding to the deflection.		

3.3 Code 1.03 Metallic materials — Tensile testing at elevated temperature

3.3.1 Definitions

gauge length

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

original gauge length, L_0

gauge length at ambient temperature before heating of the test piece and before application of force

final gauge length, L_u

gauge length after rupture, the two pieces having been carefully fitted back together so that their axes lie in a straight line, measured at ambient temperature

parallel length, L_c

parallel portion of the test piece

NOTE The concept of parallel length is replaced by the concept of distance between grips for non-machined test pieces.

extensometer gauge length, L_e

length of the parallel portion of the test piece used for the measurement of elongation by means of an extensometer

NOTE The length may differ from L_0 and could have a value greater than b , d , or D but less than L_c .

extension

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

elongation

increase in the original gauge length (L_0) under the action of the tensile force, at any moment during the test

percentage elongation

elongation expressed as a percentage of the original gauge length (L_0)

percentage permanent elongation

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

percentage elongation after fracture, A

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

percentage total elongation at fracture, A_t

total elongation (elastic elongation plus plastic elongation) of the gauge length at the moment of fracture, expressed as a percentage of the original gauge length (L_0)

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)

maximum force, F_m

greatest force which the test piece withstands during the test

stress

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

tensile strength, R_m stress corresponding to the maximum force (F_m)**yield strength**

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

upper yield strength, R_{eH}

value of stress at the moment when the first decrease in force is observed

lower yield strength, R_{eL}

lowest value of stress during plastic yielding, ignoring any transient effects

proof strength, non-proportional extension, R_p stress at which a non-proportional extension is equal to a specified proportion e of the extensometer gauge length (L_e)**Table 4 — Symbols designated in the International Standard, Code 1.03**

Symbol	Unit	Designation
θ_i	°C	Indicated temperature
θ	°C	Fixed temperature
a^a	mm	Thickness of a flat test piece or wall thickness of a tube
A^b	%	Percentage elongation after fracture: $\frac{L_u - L_o}{L_o} \times 100$
A_t	%	Percentage total elongation at fracture
b	mm	Width of the parallel length of a flat test piece or average width of a longitudinal strip from a tube or width of flat wire
d	mm	Diameter of the parallel length of a circular test piece or diameter of round wire or internal diameter of a tube
D	mm	External diameter of a tube
F_m	N	Maximum force
k	—	Coefficient of proportionality
L_c	mm	Parallel length
L_e	mm	Extensometer gauge length
L_o	mm	Original gauge length
L_t	mm	Total length of test piece
L_u	mm	Final gauge length after fracture
R_{eH}	N/mm ^{2 c}	Upper yield strength
R_{eL}	N/mm ²	Lower yield strength
R_m	N/mm ²	Tensile strength
R_p	N/mm ²	Proof strength, non-proportional extension
S_o	mm ²	Original cross-sectional area of the parallel length
S_u	mm ²	Minimum cross-sectional area after fracture

Table 4 (continued)

Symbol	Unit	Designation
Z	%	Percentage reduction of area: $\frac{S_o - S_u}{S_o} \times 100$
^a The symbol T is also used in steel-tube product standards. ^b In the case of proportional test pieces, only if the original gauge length is other than $5,65\sqrt{S_o}$, $5,65\sqrt{S_o} = 5\sqrt{\frac{4S_o}{\pi}}$, where S_o is the original cross-sectional area of the parallel length, shall the symbol A be supplemented by an index indicating the coefficient of proportionality used, e.g.: $A_{11,3}$ = percentage elongation of an original gauge length (L_o) of $11,3\sqrt{S_o}$. In the case of non-proportional test pieces, the symbol A shall be supplemented by a subscript designating the original gauge length used, expressed in millimetres, e.g.: A_{80} = percentage elongation of an original gauge length (L_o) of 80 mm. ^c 1 N/mm² = 1 MPa		

3.4 Code 1.04 Metallic materials — Tensile testing at ambient temperature

3.4.1 Definitions

gauge length, L

length of the cylindrical or prismatic portion of the test piece on which elongation shall be measured. In particular, a distinction is made between:

original gauge length, L_o

gauge length before application of force

final gauge length, L_u

gauge length after rupture of the test piece

parallel length, L_c

parallel portion of the reduced section of the test piece

NOTE The concept of parallel length is replaced by the concept of distance between grips for non-machined test pieces.

elongation

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

percentage elongation

elongation expressed as a percentage of the original gauge length (L_o)

percentage permanent elongation

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

percentage elongation after fracture, A

permanent elongation of the gauge length after fracture ($L_u - L_o$), expressed as a percentage of the original gauge length (L_o)

In the case of proportional test pieces, only if the original gauge length is other than $5,65\sqrt{S_o}$, where S_o is the original cross-sectional area of the parallel length, the symbol A shall be supplemented by an index indicating the coefficient of proportionality used, for example:

$$A_{11,3} = \text{percentage elongation of a gauge length } (L_o) \text{ of } 11,3\sqrt{S_o}$$

In the case of non-proportional test pieces, the symbol A shall be supplemented by an index indicating the original gauge length used, expressed in millimetres, for example:

$A_{80\text{ mm}}$ = percentage elongation of a gauge length (L_0) of 80 mm

percentage total elongation at fracture, A_t

total elongation (elastic elongation plus plastic elongation) of the gauge length at the moment of fracture, expressed as a percentage of the original gauge length (L_0)

percentage elongation at maximum force

increase in the gauge length of the test piece at maximum force, expressed as a percentage of the original gauge length (L_0). A distinction is made between the percentage total elongation at maximum force (A_{gt}) and the percentage non-proportional elongation at maximum force (A_g)

extensometer gauge length, L_e

length of the parallel portion of the test piece used for the measurement of extension by means of an extensometer

It is recommended that, for measurement of yield and proof strength parameter, $L_e \geq L_0/2$.

It is further recommended that, for measurement of parameters “at” or “after” maximum force, L_e be approximately equal to L_0 .

extension

increase in the extensometer gauge length (L_e) at a given moment of the test

percentage permanent extension

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

percentage yield point extension, A_e

in discontinuous yielding materials, the extension between the start of yielding and the start of uniform work hardening. It is expressed as a percentage of the extensometer gauge length (L_e)

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)

maximum force, F_m

greatest force that the test piece withstands during the test once the yield point has been passed

For materials without a yield point, it is the maximum value during the test

stress

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

tensile strength, R_m

stress corresponding to the maximum force (F_m)

yield strength

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

upper yield strength, R_{eH}

value of stress at the moment when the first decrease in force is observed

lower yield strength, R_{eL}

lowest value of stress during plastic yielding, ignoring any initial transient effects

proof strength, non-proportional extension, R_p

stress at which a non-proportional extension is equal to a specified percentage of the extensometer gauge length (L_e). The symbol used is followed by a suffix giving the prescribed percentage, for example: $R_{p0,2}$

proof strength, total extension, R_t

stress at which total extension (elastic extension plus plastic extension) is equal to a specified percentage of the extensometer gauge length (L_e). The symbol used is followed by a suffix giving the prescribed percentage, for example: $R_{t0,5}$

permanent set strength, R_r

stress at which, after removal of force, a specified permanent elongation or extension, expressed respectively as a percentage of original gauge length (L_o) or extensometer gauge length (L_e), has not been exceeded

The symbol used is followed by a suffix giving the specified percentage of the original gauge length (L_o) or of the extensometer gauge length (L_e), for example: $R_{r0,2}$

Table 5 — Symbols designated in the International Standard, Code 1.04

Symbol	Unit	Designation
a	mm	Thickness of a flat test piece or wall thickness of a tube
A	%	Percentage elongation after fracture: $\frac{L_u - L_o}{L_o} \times 100$
A_g	%	Percentage non-proportional elongation at maximum force F_m
A_e	%	Percentage yield point extension
A_{gt}	%	Percentage total elongation at maximum force F_m
A_t	%	Percentage total elongation at fracture
ΔL_m	mm	Extension at maximum force
b	mm	Width of the parallel length of a flat test piece or average width of a longitudinal strip from a tube or width of a flat wire
d	mm	Diameter of the parallel length of a circular test piece, or diameter of round wire or internal diameter of a tube
k	—	Coefficient of proportionality
D	mm	External diameter of a tube
E	N/mm ²	Modulus of elasticity
F_m	N	Maximum force
L_c	mm	Parallel length
L_e	mm	Extensometer gauge length
L_o	mm	Original gauge length
L'_o	mm	Initial gauge length for determination of A_g
L_t	mm	Total length of test piece
L_u	mm	Final gauge length
L'_u	mm	Final gauge length after fracture for determination of A_g
R_{eH}	N/mm ²	Upper yield strength
R_{eL}	N/mm ²	Lower yield strength
R_m	N/mm ²	Tensile strength
R_p	N/mm ²	Proof strength, non-proportional extension

Table 5 (continued)

Symbol	Unit	Designation
R_r	N/mm ²	Permanent set strength
R_t	N/mm ²	Proof strength, total extension
S_o	mm ²	Original cross-sectional area of the parallel length
S_u	mm ²	Minimum cross-sectional area, after fracture
Z	%	Percentage reduction of area: $\frac{S_o - S_u}{S_o} \times 100$

3.5 Code 1.05 Metallic materials — Verification of static uniaxial tensile testing machines

3.5.1 Definitions

calibration

set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards

NOTE 1 The result of a calibration permits either the assignment of values of measurands to the indications or the determination of corrections with respect to indications.

NOTE 2 A calibration may also determine other metrological properties, such as the effect of influence quantities.

NOTE 3 The result of a calibration may be recorded in a document, sometimes called a calibration certificate or a calibration report.

Table 6 — Symbols designated in the International Standard, Code 1.05

Symbol	Unit	Meaning
ρ_{air}	kg/m ³	Density of air
ρ_m	kg/m ³	Density of the dead weights
a	%	Relative resolution of the force indicator of the testing machine
b	%	Relative repeatability error of the force-measuring system of the testing machine
F	N	True force indicated by the force-proving instrument with increasing test force
F'	N	True force indicated by the force-proving instrument with decreasing test force
F_c	N	True force indicated by the force-proving instrument with increasing test force, for the complementary series of measurements for the smallest range which is used
$\bar{F}_i, \bar{F}$	N	Arithmetic mean of several measurements of F_i and F for the same discrete force
F'_i	N	Force indicated by the force indicator of the testing machine to be verified, with increasing test force
$F_{i \max}, F_{i \min}$ $F_{\max}, F_{\min}$	N	Highest or lowest value of F_i or F for the same discrete force
F_{ic}	N	Force reading on the force indicator of the testing machine to be verified, with increasing test force, for the complementary series of measurements for the smallest range which is used

Table 6 (continued)

Symbol	Unit	Meaning
F_{io}	N	Residual indication of the force indicator of the testing machine to be verified after removal of force
F_N	N	Maximum capacity of the measuring range of the force indicator of the testing machine
f_o	%	Relative zero error of the force-measuring system of the testing machine
g_n	m/s ²	Local acceleration due to gravity
q	%	Relative accuracy error of the force-measuring system of the testing machine
r	N	Resolution of the force indicator of the testing machine
ν	%	Relative reversibility error of the force-measuring system of the testing machine

3.6 Code 1.06 Metallic materials — Verification of static uniaxial testing machines — Tension creep testing machines

Table 7 — Symbols designated in the International Standard, Code 1.06

Symbol	Unit	Meaning
a	%	Relative discrimination threshold
b	%	Relative repeatability error of the testing machine
d	N	Discrimination threshold
d_1	N	Discrimination threshold corresponding to 20 % of the maximum force range (F_N)
F	N	True load indicated by the force proving instrument
$\bar{F}$	N	Arithmetic mean of several measurements of F for the same discrete load
F_i	N	Load applied by the testing machine to be verified — for deadweight machines: $F_i = mg^a$ — for lever-type machines: $F_i = mgR^a$ — for jockey weight machines, the value of F_i is indicated on the scale of the machine
F_M	N	Force exerted by the masses on the scale pan of the machine
$F_{\max}, F_{\min}$	N	Highest or lowest value of F for the same discrete load
F_N	N	Maximum capacity of the load range of the testing machine
F_v	N	Lower limit of the verified load range
q	%	Relative accuracy error of the testing machine
R	—	Lever ratio used for the verification

^a g = local acceleration due to gravity, in metres per second squared.

3.7 Code 1.07 Metallic materials — Calibration of extensometers used in uniaxial testing

Table 8 — Symbols used in the International Standard, Code 1.07

Symbols	Unit	Designation
$E_{\max}$	mm	Maximum limit of calibration range
$E_{\min}$	mm	Minimum limit of calibration range
L_e	mm	Nominal value of gauge length of extensometer
L'_e	mm	Measured value of gauge length of extensometer
l_i	μm	Displacement indicated by the extensometer
l_t	μm	True displacement given by the calibration apparatus
q	%	Relative bias error of the extensometer
q_{Le}	%	Relative gauge length error
r	μm	Resolution of extensometer

3.8 Code 1.08 Metallic materials — Tensile testing at low temperature

3.8.1 Definitions

gauge length, L

length of the cylindrical or prismatic portion of the test piece on which elongation shall be measured

original gauge length, L_o

gauge length before application of force measured at ambient temperature

final gauge length, L_u

gauge length after fracture of the test piece measured at ambient temperature

parallel length, L_c

length of the parallel portion of the reduced section of the test piece

extensometer gauge length, L_e

length of the parallel portion of the test piece used for the measurement of elongation by means of an extensometer

NOTE This length may differ from L_o and has a value greater than b or d but less than L_c .

elongation

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

percentage elongation

elongation expressed as a percentage of the original gauge length (L_o)

percentage permanent elongation

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

percentage elongation after fracture, A

permanent elongation of the original gauge length after fracture ($L_u - L_o$), expressed as a percentage of the original gauge length (L_o)

NOTE In the case of proportional test pieces, only if the original gauge length is other than $5,65\sqrt{S_0}$, where S_0 is the original cross-sectional area of the parallel length, should the symbol A be supplemented by an index indicating the coefficient of proportionality used, for example:

$A_{11,3}$ = percentage elongation of a gauge length (L_0) of $11,3\sqrt{S_0}$

In the case of non-proportional test pieces, the symbol A shall be supplemented by an index indicating the original gauge length used, expressed in millimetres, for example:

$A_{80\text{ mm}}$ = percentage elongation of a gauge length (L_0) of 80 mm.

percentage total elongation at fracture, A_t

total elongation (elastic elongation plus plastic elongation) of the gauge length at the moment of fracture, expressed as a percentage of the original gauge length (L_0)

extension

increase in the extensometer gauge length (L_e) at a given moment of the test

percentage permanent extension

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

percentage reduction of area, Z

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

maximum force, F_m

maximum force which the test piece withstands during the test after any yielding has taken place

NOTE For brittle materials, it is the maximum value during the test.

stress

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

tensile strength, R_m

stress corresponding to the maximum force (F_m)

yield strength

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

upper yield strength, R_{eH}

value of stress at which the first decrease in force is observed

lower yield strength, R_{eL}

lowest value of stress during plastic yielding, ignoring any transient effects

proof strength, non-proportional extension, R_p

stress at which the non-proportional extension is equal to a specified percentage of the extensometer gauge length (L_e)

NOTE The symbol used is followed by a suffix giving the prescribed percentage, for example: $R_{p0,2}$

Table 9 — Symbols and designations, Code 1.08

Symbol	Unit	Designation
θ	°C	Specified temperature
θ_i	°C	Indicated temperature
a	mm	Thickness of a flat test piece or wall thickness of a tube
A	%	Percentage elongation after fracture: $\frac{L_u - L_o}{L_o} \times 100$
A_t	%	Percentage total elongation at fracture
b	mm	Width of the parallel length of a flat test piece or average width of the longitudinal strip taken from a tube or width of flat wire
d	mm	Diameter of the parallel length of a cylindrical test piece or diameter of a circular wire
F_m	N	Maximum force
L_c	mm	Parallel length
L_e	mm	Extensometer gauge length
L_o	mm	Original gauge length
L_u	mm	Final gauge length after fracture
R_{eH}	N/mm ²	Upper yield strength
R_{eL}	N/mm ²	Lower yield strength
R_m	N/mm ²	Tensile strength
R_p	N/mm ²	Proof strength, non-proportional extension
S_o	mm ²	Original cross-sectional area of the parallel length
S_u	mm ²	Minimum cross-sectional area after fracture (final cross-sectional area)
Z	%	Percentage reduction of area: $\frac{S_o - S_u}{S_o} \times 100$

3.9 Code 1.09 Metallic materials — Tensile testing in liquid helium

3.9.1 Definitions

adiabatic heating

internal heating of a specimen resulting from deformation under conditions such that the heat generated by plastic work cannot be quickly dissipated to the surrounding cryogen

axial strain

average of the longitudinal strains measured at opposite or equally spaced surface locations on the sides of the longitudinal axis of symmetry of the specimen

NOTE The longitudinal strains are measured using two or more strain-sensing transducers located at the mid-length of the parallel length.

bending strain

difference between the strain at the surface of the specimen and the axial strain

NOTE The bending strain varies around the circumference and along the parallel length of the specimen

dewar

a vacuum-insulated container for cryogenic fluids