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Mechanical testing of metals — Symbols and definitions in published standards

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

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Foreword

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

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is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.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 23718[1)], *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 Sandard.

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 Sandard) 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_{ro}
reference length determined at ambient temperature before the test L_{ro}, 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_o
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_o
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_o
applied force divided by the original cross-sectional area S_o 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

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

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_o) 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_o
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_o 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_o) 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_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)

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_o)

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

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_o) 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/mm^2 = 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:

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