TECHNICAL REPORT

ISO/TR 12735-1

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Mechanical testing of metals — Symbols used with their definitions —

Part 1:
Symbols and definitions in published standards

Essais mécaniques des métaux — Symboles utilisés et leurs définitions —
Partie 1: Symboles et définitions figurant dans les normes publiées

Reference number
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Foreword

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

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, 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).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 12735-1, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*.

ISO/TR 12735 consists of the following parts, under the general title *Mechanical testing of metals — Symbols used with their definitions*:

— *Part 1: Symbols and definitions in published standards*

International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

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— *Part 2: Recommendations for the development of symbols and definitions*

Annex A of this part of ISO/TR 12735 is for information only.

Introduction

This part of ISO/TR 12735 has been prepared to provide the appropriate means of 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.

Mechanical testing of metals — Symbols used with their definitions —

Part 1:
Symbols and definitions in published standards

1 Scope

This part of ISO/TR 12735 is entirely informative. In it are enumerated the symbols and definitions used in ISO international standards for specific methods of mechanical testing of metallic materials which are the responsibility of ISO Technical Committee 164. The data are indexed alphabetically and via a coding system. Annex A provides an additional cross-reference between the coding system and relevant ISO 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, at the time of publication of this part of ISO/TR 12735, there existed both a valid International Standard and a document designed to replace it that had reached DIS stage, then both the international standard and the draft international standard 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 STANDARD
Creep test (Non-interrupted)	1.01	204:—
Calibration of force proving devices	1.02	376:1987
Elevated temperature tensile test	1.03	783:1989
Tensile test	1.04	6892:—
Verification of the tensile testing machine	1.05	7500-1:1986
Verification of the uniaxial tensile creep testing machine	1.06	7500-2:—
Verification of extensometers	1.07	9513:—
Bend test	2.01	7438:1985
Reverse bend test on sheets and strips	2.02	7799:1985
Torsion testing on wire	2.03	7800:1984
Reverse bend testing of wire	2.04	7801:1984
Wire wrapping test	2.05	7802:1983
Modified Erichsen cupping test	2.06	8490:1986
Bend testing of tube	2.07	8491:1986
Flattening test on tubes	2.08	8492:1986
Drift expanding test on tubes	2.09	8493:1986

Table 1. Identity and code of mechanical test

TEST IDENTITY	CODE	ISO STANDARD
Flanging test on tubes	2.10	8494:1986
Ring expansion test on tubes	2.11	8495:1986
Ring tensile test on tube	2.12	8496:1986
Reverse torsion testing of wire	2.13	9649:1990
r value test	2.14	10113:1991
n value test	2.15	10275:1993
Earing test	2.16	11531:1994
Brinell hardness test	3.01	6506:1981
Tables of Brinell hardness values	3.01	410:1982
Verification of Brinell testing machine	3.01	156:1982
Calibration of Brinell standardized blocks	3.01	726:1982
Vickers hardness test, HV 5 - HV 100	3.02	6507-1:—
Vickers hardness test, HV 0.2 - HV 5	3.02	6507-2:—
Vickers microhardness test, < HV 0.2	3.02	6507-3:—
Tables of Vickers hardness values, HV 5 - HV 100	3.02	6507-1:—
Tables of Vickers hardness values, HV 0,2 - HV 5	3.02	6507-1:—
Tables of Vickers hardness values, less than HV 0.2	3.02	6507-1:—
Verification of Vickers testing machine: HV 0,2 - HV 100	3.02	6507-2:—
Verification of Vickers testing machine: less than HV 0,2	3.02	6507-2:—
Calibration of Vickers standardized blocks: HV 0,2 - HV 100	3.02	6507-3:—
Calibration of Vickers standardized blocks : less than HV 0,2	3.02	6507-3:—
Rockwell hardness test	3.03	6508:1986
Verification of Rockwell testing machine	3.03	716:1986
Calibration of Rockwell standardized blocks	3.03	674:1988
Rockwell superficial hardness test	3.04	1024:1989

Table 1. Identity and code of mechanical test		
TEST IDENTITY	CODE	ISO STANDARD
Verification of superficial Rockwell testing machines	3.04	1079:1989
Calibration of superficial Rockwell standardized blocks	3.04	1355:1989
Knoop hardness test	3.05	4545:1993
Verification of Knoop hardness testing machines	3.05	4546:1993
Calibration of Knoop standardized blocks	3.05	4547:1993
Tables of Knoop hardness values	3.05	10250:1994
Macro Rockwell hardness test	3.06	11700-1:—
Verification of Macro Rockwell hardness testing machines	3.06	11700-2:—
Calibration of Macro Rockwell standardized blocks	3.06	11700-3:—
Impact test - Steel, Charpy U-notch	4.01	83:1976
Impact test - Steel, Charpy V-notch	4.02	148:1983
Verification of impact testing machines	4.03	148-2:— and 148-3:—
Steel - designation of test piece axes	4.04	3785:—
Determination of the plane strain fracture toughness	4.05	12737:—
Axial fatigue test	5.01	1099:1975
Rotating bend fatigue test	5.02	1143:1975
Torsional fatigue test	5.03	1352:1977
Dynamic calibration (axial load)	5.04	4965:1979

3. DEFINITIONS AND SYMBOLS

Definitions and symbols employed in all of the international standards and draft international standards prepared by ISO TC 164 are here classified under the codes listed in Table 1. 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 – *Uninterrupted uniaxial creep testing in tension*

3.1.1 *Definitions.*

Reference length (L_r). Base length used for the calculation of elongation.

Original reference length (L_{ro}). Reference length determined at ambient temperature before the test.

Final reference length (L_{ru}). Reference length determined at ambient temperature after rupture, the two straight pieces having been carefully fitted back together so that their axes lie in a straight line.

Original gauge length (L_o). Length between gauge marks on the testpiece measured at ambient temperature before the test.

Final gauge length after rupture (L_u). Length between gauge marks on the testpiece 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. The extensometer gauge length shall be 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 pices 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 t and the zero moment (ΔL_{rt}) at the specified temperature expressed as a percentage of the original gauge length.

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.

Percentage reduction of area after creep rupture (Z_f). Maximum change in cross-sectional area occuring during the test (S_o – S_u) expressed as a percentage of the original cross-sectional area (S_o).

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.

Table 2. Symbols designated in the international standard, Code 1.01

Symbol	Units	Definition
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 stress 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 testpiece
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
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_f	%	Percentage reduction in area after creep rupture

3.2 Code 1.02 – *Calibration of force proving devices used for the verification of uniaxial testing machines.*

Table 3. Symbols designated in the international standard, Code 1.02

Symbol	Unit	Definition
b	%	Relative repeatability error of the force proving instrument
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
r	–	Resolution of the indicator
u	%	Relative reversibility error of the force proving instrument
X	–	Reading on the indicator with increasing test force
X'	–	Reading on the indicator with decreasing test force
$\bar{X}$	–	Average value of the readings on the indicator
X_a	–	Computed value of deflection
X_{if}	–	Reading on the indicator after removal of force
X_{io}	–	Reading on the indicator before application of force
X_{max}	–	Maximum reading on the indicator
X_{min}	–	Minimum reading on the indicator
X_N	–	Reading on the indicator, corresponding to the maximum capacity

3.3 Code 1.03 –*Metallic materials – Tensile testing at elevated temperature*

3.3.1 *Definitions.*

Gauge length. Length of the parallel-sided 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. This length is measured at ambient temperature.

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.

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: Difference between final gauge length and original gauge length, $L_u - L_o$, expressed as a percentage of the original gauge length, L_o.

Percentage total elongation at fracture, A_t: Increase in the original gauge length of test piece 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 which has occurred during the test, $S_o - S_u$, expressed as a percentage of the original cross-sectional area, S_o.

Maximum force (F_m): The maximum force which the testpiece 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 stress: 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 stress, R_{eH}: Value of stress at the moment when the first decrease in force is observed.

Lower yield stress, R_{eL}: Lowest value of stress during plastic yielding, ignoring any transient effects.

Proof stress of non-proportional elongation, R_p: Stress at which a non-proportional elongation is equal to a specified percentage of the original gauge length, L_o.

Table 4. Symbols designated in the international standard, Code 1.03

Symbol	Unit	Definition
θ_i	°C	Indicated temperature
a	mm	Thickness of a flat testpiece 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-sided portion 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-sided portion 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
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	Upper yield stress
R_{eL}	N/mm^2	Lower yield stress
R_m	N/mm^2	Tensile strength
R_p	N/mm^2	Proof stress (non-proportional elongation)
S_o	mm^2	Original cross-sectional area of the parallel sided portion
S_u	mm^2	Minimum cross-sectional area after fracture
Z	%	Percentage reduction of area: $\frac{S_o - S_u}{S_o} \times 100$

3.4 Code 1.04 – *Metallic materials – Tensile testing*

3.4.1 *Definitions.*

Gauge length: Length of the cylindrical or prismatic portion of the test piece on which elongation is measured at any moment during the test.

Original gauge length(L_o): Gauge length 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.

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.

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).

Percentage total elongation at fracture (A_t): Increase in the original gauge length of test piece at the moment of fracture, expressed as a percentage of the original gauge length (L_o).

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_o).

Percentage yield point elongation: Elongation between the start of yielding and the start of work-hardening ... expressed as a percentage of the original gauge length (L_o).

Percentage reduction of area (Z): Maximum change in cross-sectional area which has occurred during the test (S_o - S_u) expressed as a percentage of the original cross-sectional area (S_o).

Maximum force (F_m): The greatest force which the testpiece 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 stress: 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 stress (R_{eH}): Value of stress at the moment when the first decrease in force is observed.

Lower yield stress (R_{eL}): Lowest value of stress during plastic yielding, ignoring any transient effects.

Proof stress of non-proportional elongation (R_p): Stress at which a non-proportional elongation is equal to a specified percentage of the original gauge length (L_o).

Proof stress, total elongation (R_t): Stress at which total elongation (elastic elongation plus plastic elongation) is equal to a specified percentage of the original gauge length (L_o).

Permanent set stress (R_r): Stress at which, after removal of force, a specified permanent elongation, expressed as a percentage of original gauge length (L_o), occurs.

Table 5. Symbols designated in the international standard, Code 1.04

Symbol	Unit	Definition
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_{gt}	%	Percentage total elongation at maximum force F_m
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 the 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
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_t	mm	Total length of testpiece
L_u	mm	Final gauge length after fracture
R_{eH}	N/mm^2	Upper yield stress
R_{eL}	N/mm^2	Lower yield stress
R_m	N/mm^2	Tensile strength