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Metallic materials — Torsion test at room temperature

Matériaux métalliques — Essai de torsion à température ambiante

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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 procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 2, *Ductility testing*.

This second edition cancels and replaces the first edition (ISO 18338:2015), of which it constitutes a minor revision. The changes are as follows:

— the duplicated part of Formula (A.4) has been deleted;

— minor editorial changes.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Metallic materials — Torsion test at room temperature

1 Scope

This document specifies the method for torsion test at room temperature of metallic materials. The tests are conducted at room temperature to determine torsional properties.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing*

ISO 9513, *Metallic materials — Calibration of extensometer systems used in uniaxial testing*

ASTM E2624, *Standard Practice for Torque Calibration of Testing Machines and Devices*

DIN 51309, *Materials testing machines — Calibration of static torque measuring devices*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
troptometer gauge length
L_e
length of the parallel reduced section of the test piece for measurement of angle of twist by means of a troptometer

3.2
torque
T
moment of couple that generates or tends to generate rotation or torsion

3.3
maximum torque
T_m
for materials displaying discontinuous yielding, highest torque that the test piece withstands during the test after the yielding period, or for materials displaying no discontinuous yielding, highest torque that the test piece withstands during the test

3.4
angle of twist
ϕ
angle of relative rotation measured between two planes normal to the test-piece's longitudinal axial over the gauge length

Note 1 to entry: See Figure 1.

3.5
shear angle
ψ
angle due to shearing displacement at surface of test piece along the gauge length

Note 1 to entry: See Figure 1.

3.6
shear stress
τ
any moment during the test, torque, T, divided by the original polar section modulus, W_p

3.7
shearing displacement
ΔL
arc length swept out by the cylinder or major tube radius moving through the angle of twist, also being equivalent to the gauge length sweeping through the shear angle

Note 1 to entry: See Figure 1.

3.8
shear strain
γ
based on the gauge length, the increase of the shearing displacement, ΔL, at any moment during the test, expressed as a percentage of the gauge length L_e, or is equal to the tangent of the shear angle, ψ

3.9
slope
m_G
slope of the linear, elastic portion of the shear stress-shear strain curve

3.10
torsional proof strength, plastic torsion
τ_p
shear stress at which the plastic component of shear strain, due to torsion at the test piece outer surface, is equal to a specified percentage

Note 1 to entry: A suffix is added to the subscript to indicate the prescribed percentage, e.g. $\tau_{p0,35}$.

3.11
torsional yield strength
when the metallic material exhibits a yield phenomenon, shear stress corresponding to the point reached during the torsion test at which plastic deformation occurs without any increase in the torque

3.11.1
upper torsional yield strength
$\tau_{e,H}$
maximum value of shear stress prior to the first decrease in torque when the discontinuous yielding occurs

3.11.2
lower torsional yield strength
$\tau_{e,L}$
lowest value of shear stress during discontinuous yielding, ignoring any initial transient effects

3.12
torsional strength
τ_m
shear stress corresponding to the maximum torque, T_m

3.13
maximum plastic shear strain
γ_{max}
maximum plastic shear strain component at the outer surface when total separation of the test piece occurs

3.14
reference torsional proof strength, plastic torsion
$\tau_{r,p}$
shear stress at the outer surface of a test piece, calculated according to Nadai's expression, when cross-section of the test piece is in partly plastic torsion and attained the proof plastic shear strain

Note 1 to entry: A suffix is added to the subscript to indicate the prescribed percentage, e.g. $\tau_{r,p0,35}$.

3.15
reference torsional strength
$\tau_{r,m}$
maximum shear stress is calculated according to the Nadai's expression for fractured test piece

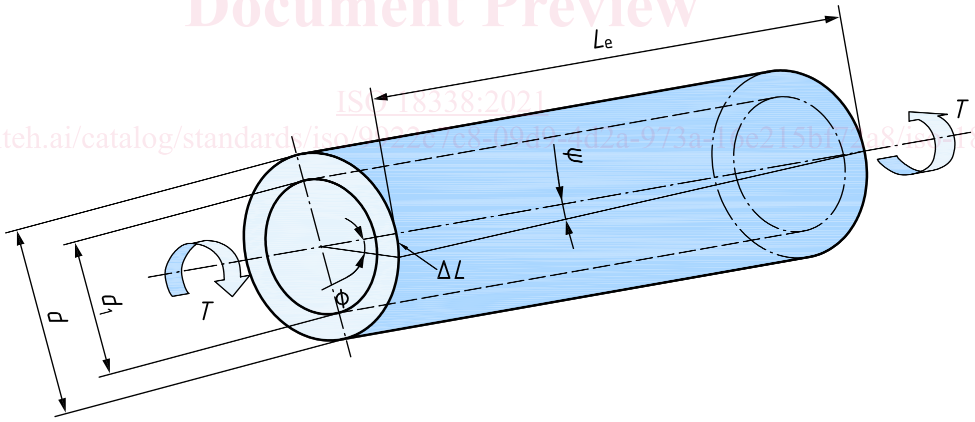


Figure 1 — Basic symbols for torsion test

4 Symbols and designations

Symbols and corresponding designations are given in Table 1 and Figure 1 or elsewhere in this document where they appear.

Table 1 — Symbols and designations

Symbol	Designation	Unit
	Test piece	
d	original external diameter of a tube or a cylinder test piece parallel length portion	mm
d_i	original internal diameter of the parallel length of a tube test piece	mm
L_c	parallel length	mm
L_e	troptometer gauge length	mm
L_t	total length of the test piece	mm
W_p	original polar section modulus [see Formulae (2) and (3)]	mm^3
	Torque	
T	Torque	N·mm
	Angle of twist – shearing displacement	
ϕ	angle of twist	rad
Ψ	shear angle	rad
ΔL	shearing displacement	mm
	Shear stress – shear strain	
τ	shear stress	MPa[a]
$\Delta\tau$	increment in shear stress	MPa
γ	shear strain	%
$\Delta\gamma$	Increment in shear strain	%
γ_p	specified plastic shear strain	%
γ_{max}	maximum plastic shear strain	%
	Yield strength – proof strength – torsional strength	
m_G	slope of elastic portion of the shear stress-shear strain curve[b]	MPa
$\tau_{e,H}$	upper torsional yield strength	MPa
$\tau_{e,L}$	lower torsional yield strength	MPa
τ_p	torsional proof strength, plastic torsion	MPa
τ_m	torsional strength	MPa
$\tau_{r,p}$	reference torsional proof strength, plastic torsion	MPa
$\tau_{r,m}$	reference torsional strength	MPa

a 1 MPa = 1 Nmm^{-2}.

b In the elastic portion of the shear stress-shear strain curve, the value of slope may not necessarily represent the shear modulus of elasticity. The value can closely agree with the value of shear modulus of elasticity if optimal conditions (high resolution of troptometer, high accuracy of torque measuring system, perfect alignment of the test piece, etc.) are used.

5 Principle of test

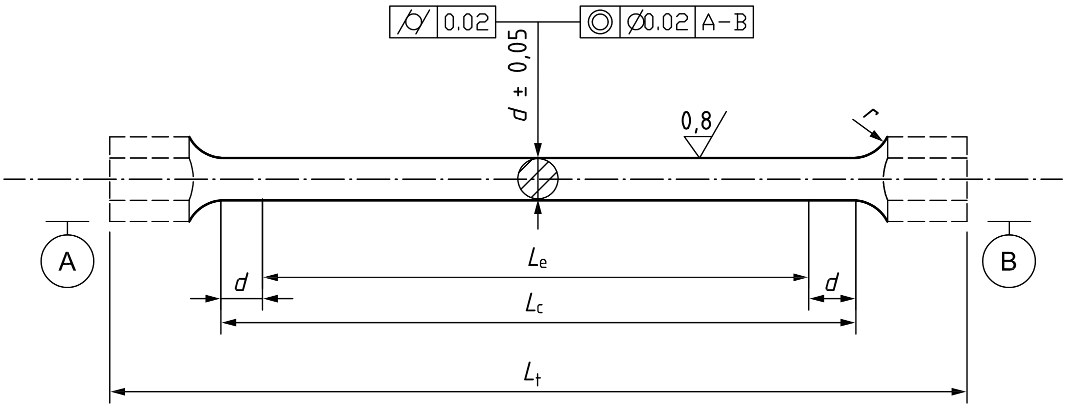
The test piece is subjected to continuously increasing angle of twist, generally to fracture, for the determination of one or more of the mechanical properties such as elastic slope, torsional proof strength, torsional yield strength, torsional strength and maximum plastic shear strain.

6 Test piece

6.1 Shape and dimensions of test pieces

6.1.1 Cylinder test pieces

The shape and dimensions for cylinder test pieces are shown in Figure 2. The shape and size for two ends of the test piece should be in coincidence with the testing machine gripping part. It is recommended that the test pieces be 10 mm diameter, 50 mm or 100 mm gauge length, and 70 mm or 120 mm parallel length. If other test pieces are used, the parallel length should be the sum of gauge length and two times diameter.



Key

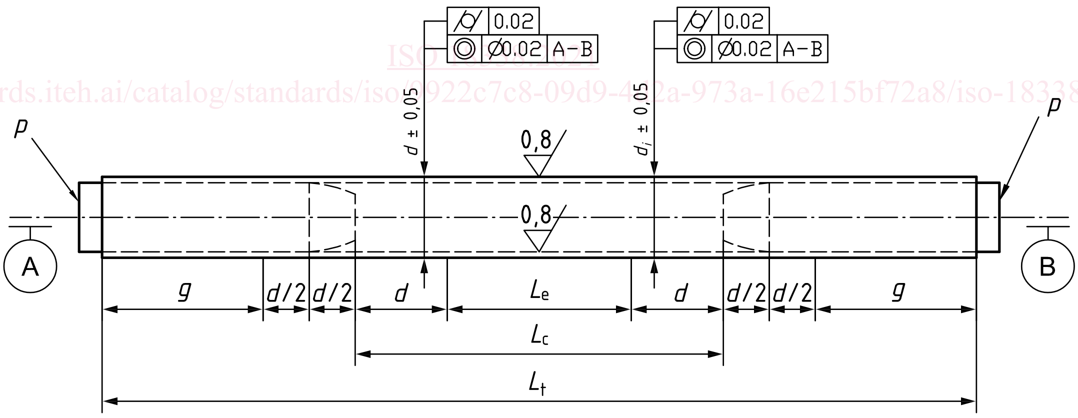
r transition radius

NOTE The shape of the test-piece heads is only given as a guide.

Figure 2 — Cylinder test piece

6.1.2 Tube test pieces

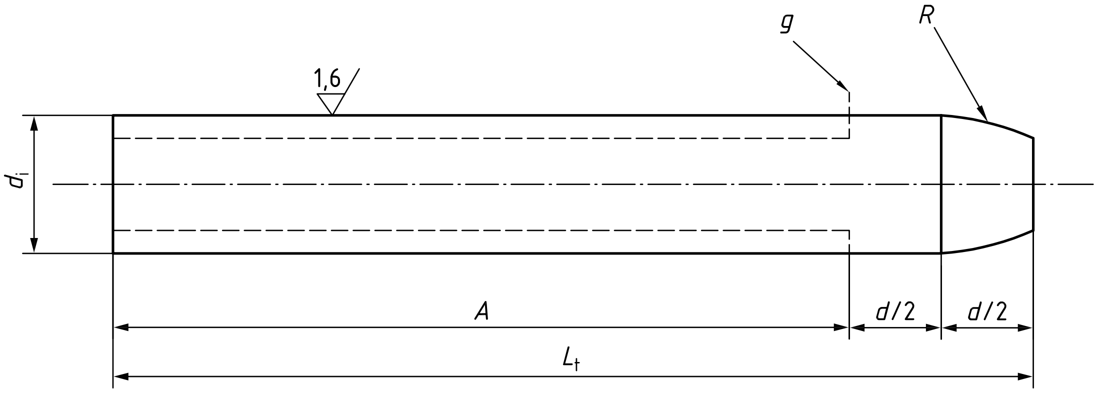
The shape and dimensions for tube test pieces are shown in Figure 3. The parallel length for tube test pieces should be the sum of gauge length and two times external diameter. Tube test pieces should be straight and round, plugged at both ends. The plugged two ends should not be in the parallel length part of tube test pieces. The shape and size for plugs are shown in Figure 4.



Key

g	gripped end	*p*	plug
d	original external diameter	d_i	original internal diameter

Figure 3 — Tube test piece



Key

g gripped end

R plug transition radius

A parallel and straight part of the plug, here $A \geq 40$ mm

The diameter of the plug shall have a slight taper from the grip limiting line to the curved section.

Figure 4 — Plugs for tube test pieces

6.1.3 Preparation of test pieces

The test pieces shall be taken and prepared in accordance with the requirement of the relevant International Standards for the different materials. If applicable, the test pieces shall meet the requirement of tensile test pieces specified in ISO 377.

7 Determination of original cross-sectional dimensions

7.1 Cylinder test pieces

The external diameter of the cylinder test piece should be measured at sufficient cross-sections perpendicular to the longitudinal axis in the central region of the parallel length of the test piece. The measuring error of diameter should not exceed ± 0,5 %. A minimum of three cross-sections is recommended. The average diameter measured will be used for the calculation of the original polar section modulus, W_p.

7.2 Tube test pieces

The external diameter and internal diameter for tube test pieces should be measured at two ends and on two directions perpendicular to each other, respectively. The measuring error of external diameter and internal diameter should not exceed ± 0,5 %. The average external diameter and internal diameter measured will be used for the calculation of the original polar section modulus, W_p.

8 Accuracy of the testing apparatus

8.1 Testing machine

8.1.1 Either one of the gripping parts of the testing machine can freely move along the axial direction during torsion test and the two gripping parts should be in good alignment.

8.1.2 The angle of twist shall be applied continuously on the test piece without shock and vibration.

