

Metallic materials — Instrumented indentation test for hardness and materials parameters —

Part 1: Test method

The European Standard EN ISO 14577-1:2002 has the status of a British Standard

ICS 77.040.10

National foreword

This British Standard is the official English language version of EN ISO 14577-1:2002. It is identical with ISO 14577-1:2002.

The UK participation in its preparation was entrusted by Technical Committee ISE/NFE/4, Mechanical testing of metals, to Subcommittee ISE/NFE/4/5, Indentation hardness testing, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Instrumented indentation testing is a developing test method which offers an opportunity to provide information about properties of the sample under test in addition to a measurement of its hardness.

Accordingly this standard has been prepared so that a unified approach may be made to the application and further development of this method.

This standard covers a wide range of indenter geometries and applied test forces, including those corresponding to all conventional hardness scales. In principle it is possible to compare the hardness values obtained to traditional scales and, for Vickers indenter geometries, the relationship of the test results to conventional hardness test values is given.

The aim of this standard is to provide tests that are not possible by conventional methods.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the *BSI Catalogue* under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the *BSI Electronic Catalogue* or of British Standards Online.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO foreword page, the ISO title page, pages ii to v, a blank page, pages 1 to 25, the Annex ZA page, an inside back cover and a back cover.

The BSI copyright date displayed in this document indicates when the document was last issued.

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English version

**Metallic materials - Instrumented indentation test for hardness
and materials parameters - Part 1: Test method (ISO 14577-
1:2002)**

Matériaux métalliques - Essai de pénétration instrumenté
pour la détermination de la dureté et de paramètres des
matériaux - Partie 1: Méthode d'essai (ISO 14577-1:2002)

Metallische Werkstoffe - Instrumentierte Eindringprüfung
zur Bestimmung der Härte und anderer Werkstoffparameter
- Teil 1: Prüfverfahren (ISO 14577-1:2002)

This European Standard was approved by CEN on 9 September 2002.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN ISO 14577-1:2002) has been prepared by Technical Committee ISO/TC 164 "Mechanical testing of metals" in collaboration with Technical Committee ECISS/TC 1 "Steel - Mechanical testing", the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2003, and conflicting national standards shall be withdrawn at the latest by April 2003.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of ISO 14577-1:2002 has been approved by CEN as EN ISO 14577-1:2002 without any modifications.

NOTE Normative references to International Standards are listed in Annex ZA (normative).

INTERNATIONAL STANDARD

ISO
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Metallic materials — Instrumented indentation test for hardness and materials parameters —

Part 1: Test method

*Matériaux métalliques — Essai de pénétration instrumenté pour la
détermination de la dureté et de paramètres des matériaux —*

Partie 1: Méthode d'essai



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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 3.

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.

Attention is drawn to the possibility that some of the elements of this part of ISO 14577 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 14577-1 was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

ISO 14577 consists of the following parts, under the general title *Metallic materials — Instrumented indentation test for hardness and materials parameters*:

- *Part 1: Test method*
- *Part 2: Verification and calibration of testing machines*
- *Part 3: Calibration of reference blocks*

Annexes A, C and E form a normative part of this part of ISO 14577. Annexes B, D and F are for information only.

Introduction

Hardness has typically been defined as the resistance of a material to permanent penetration by another harder material. The results obtained when performing Rockwell, Vickers and Brinell tests are determined after the test force has been removed. Therefore, the effect of elastic deformation under the indenter has been ignored.

ISO 14577 has been prepared to enable the user to evaluate the indentation of materials by considering both the force and displacement during plastic and elastic deformation. By monitoring the complete cycle of increasing and removal of the test force, hardness values equivalent to traditional hardness values can be determined. More significantly, additional properties of the material, such as its indentation modulus and elasto-plastic hardness, can also be determined. All these values can be calculated without the need to measure the indent optically.

ISO 14577 has been written to allow a wide variety of post test data analysis.

Metallic materials — Instrumented indentation test for hardness and materials parameters —

Part 1: Test method

1 Scope

This part of ISO 14577 specifies the method of instrumented indentation test for determination of hardness and other materials parameters for the three ranges given in Table 1.

Table 1 — Ranges of application

Macro range	Micro range	Nano range ^a
$2 \text{ N} \leq F \leq 30 \text{ kN}$	$2 \text{ N} > F; h > 0,2 \text{ }\mu\text{m}$	$h \leq 0,2 \text{ }\mu\text{m}$
^a For the nano range the mechanical deformation strongly depends on the real shape of indenter tip and the calculated materials parameters are significantly influenced by the contact area function of the indenter used in the testing machine. Therefore careful calibration of both instrument and indenter shape is required in order to achieve an acceptable reproducibility of the materials parameters determined with different machines.		

The macro and micro range are distinguished by the test forces in relation to the indentation depth.

Attention is drawn to the fact that the micro range has an upper limit given by the test force (2 N) and a lower limit given by the indentation depth of 0,2 μm .

The determination of hardness and other materials parameters is given in annex A.

At high contact pressures, damage to the indenter is possible. For this reason in the macro range, hardmetal indenters are often used. For test pieces with very high hardness and modulus of elasticity the influence of indenter deformation on the test result should be taken into account.

NOTE This test method can also be applied to thin metallic and non-metallic coatings and non-metallic materials. In this case the specifications in the relevant standards should be taken into account (see also 6.3).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 14577. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 14577 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 4287, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Terms, definitions and surface texture parameters*

ISO 14577-2:2002, *Metallic materials — Instrumented indentation test for hardness and materials parameters — Part 2: Verification and calibration of testing machines*

ISO Guide to the Expression of Uncertainty in Measurement (GUM)¹⁾

3 Symbols and designations

For the purposes of this International Standard, the symbols and designations in Table 2 shall be applied (see also Figure 1 and Figure 2).

Table 2 — Symbols and designations

Symbol	Designation	Unit
$A_p(h_c)$	Projected area of contact of the indenter at distance h_c from the tip	mm ²
$A_s(h)$	Surface area of the indenter at distance h from the tip	mm ²
C_{IT}	Indentation creep	%
E_{IT}	Indentation modulus	N/mm ²
F	Test force	N
F_{max}	Maximum test force	N
h	Indentation depth under applied test force	mm
h_c	Depth of the contact of the indenter with the test piece at F_{max}	mm
h_{max}	Maximum indentation depth at F_{max}	mm
h_p	Permanent indentation depth after removal of the test force	mm
h_r	Point of intersection of the tangent c to curve b at F_{max} with the indentation depth-axis (see Figure 1)	mm
H_{IT}	Indentation hardness	N/mm ²
HM	Martens hardness	N/mm ²
HM _s	Martens hardness, determined from the slope of the increasing force/indentation depth curve	N/mm ²
r	Radius of spherical indenter	mm
R_{IT}	Indentation relaxation	%
W_{elast}	Elastic reverse deformation work of indentation	N·m
W_{total}	Total mechanical work of indentation	N·m
α	Angle, specific to the shape of the pyramidal indenter	°
η_{IT}	Relation W_{elast}/W_{total}	%
NOTE 1 To avoid very long numbers the use of multiples or sub-multiples of the units is permitted.		
NOTE 2 1 N/mm ² = 1 MPa.		

1) Published in 1993; corrected and reprinted in 1995.