TECHNICAL REPORT

ISO TR 14577

First edition
1995-12-15

Metallic materials — Hardness test — Universal test

Matériaux métalliques — Essai de dureté — Essai universel

Reference number
ISO/TR 14577:1995(E)

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 Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.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 14577, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 3, *Hardness testing*.

This document is being issued in the Technical Report (type 2) series of publications (according to subclause G.3.2.2 of part 1 of the ISO/IEC Directives, 1995) as a "prospective standard for provisional application" in the field of hardness testing because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

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Printed in Switzerland

This document is not to be regarded as an "International Standard". It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this Technical Report (type 2) will be carried out not later than three years after its publication with the options of: extension for another three years; conversion into an International Standard; or withdrawal.

For hardness measurements, in practice several different methods are standardized.

Each of them more or less covers only one material. The reason is that no method fulfills the definition of hardness as being the resistance of a material against the indentation of a body made from a harder material. Additionally the methods of Brinell and Vickers have the disadvantage of needing observers to record the length measurements. The consequences are increased costs and inconsistencies due to different aptitudes in different observers.

Rockwell methods are free from this aspect but the resolution of hardness is low and decreases with increasing hardness of the material tested.

Progress in depth measurement makes it possible to create a new method of hardness measurement, which is suitable for all materials. Therefore the name universal hardness has been chosen. This method is able to give a lot more information about the material tested than simply hardness value, without recourse to additional measurement.

This Technical Report describes this new method of taking measurements of hardness as normally carried out in several standards. The method and the most important data pertaining to the apparatus are given.

Annexes A, B and C of this Technical Report are for information only.

Introduction

The hardness test is termed a universal test, because this test is suitable for hardness testing of all materials. The reason is that the hardness value comes from the indentation depth under working test force. The geometry of the indenter makes the result theoretically independent from the test force chosen.

Metallic materials — Hardness test — Universal test

1 Scope

This Technical Report specifies the method of universal hardness test for metallic materials using indentation depths $\geqslant 3$ µm. The hardness value can be influenced by unknown changes in the surface of the specimen and by the real geometry of the top of the indenter. In this case a modified method is helpful (see annex A). In the case of an indentation depth > 10 µm this effect does not often occur. The same test method can also be used for all other materials.

2 Principle

Forcing a diamond indenter in the form of any upright pyramid with a square base and with a specified angle between opposite faces at the vertex into the surface of a test piece and measuring the indentation depth under working test force F (see figure 1).

The universal hardness is given by the quotient obtained by dividing the test force by the idealized sloping area of the indentation under working test force where the indenter and indentation under working test force exhibit the same geometric data.

3 Symbols and designations

3.1 See table 1 and figures 1 and 2.

3.2 The universal hardness is written as the calculated value completed by

a) the test force used;

b) the duration of loading, in seconds, if different from time specified in 6.4.

EXAMPLES

— HU 10 = 6 400

Universal hardness value 6 400 N/mm^2 is measured with the test force 10 N

— HU 50/20 = 6 400

Universal hardness value 6 400 N/mm^2 is measured with the test force 50 N with the test force applied for 20 s

Table 1 — Symbols and designation

Symbol	Designation
α	Angle between the opposite faces at the vertex of the pyramidal indenter (136°)
F	Test force, in newtons
h	Indentation depth, in millimetres, under working test force
HU	universal hardness, in newtons per square millimetre

NOTE

$$HU = \frac{\text{Test Force}}{\text{Surface area of indentation under working test force}}$$

$$= \frac{F}{4\,h^2 \times \dfrac{\sin\left(\frac{136°}{2}\right)}{\cos^2\left(\frac{136°}{2}\right)}} = \frac{F}{26{,}43\,h^2}$$

4 Apparatus

4.1 Testing machine, capable of applying a predetermined test force in the range between 0,01 N and 1 000 N with an uncertainty of ± 1 %.

4.2 Indenter, a diamond in the shape of an upright pyramid with a square base.

4.2.1 The angle between to opposite faces at the vertex of the diamond pyramid shall be 136 ± 0,1° (see figure 1).

4.2.2 The inclination of the axis of the diamond pyramid to the axis of the indenter holder (normal to the seating surface) shall be within 0,5°. The four faces shall meet at a point, any line of junction between opposite faces being less than 0,5 µm (see figure 2).

The part of the plunger under stress from the test force shall be made from hardmetal. The diamond shall be plain-mounted on the hardmetal (see figure 3).

4.3 Measuring device, according to the conditions laid down in table 2.

If there is any additional error due to the definition of the zero point for depth measurement, this error can be compensated by smaller errors of test force and/or the measuring device.

Table 2 — Estimation capability and maximum permissible error as a function of the indentation depth

Indentation depth, h µm	Estimation capability
$3 \leqslant h < 15$	± 1 % of h
$15 \leqslant h < 30$	± 0,15 µm
$h \geqslant 30$	± 0,5 % of h
	Maximum permissible error
$3 \leqslant h < 6$	± 0,06 µm
$6 \leqslant h < 15$	1 % of h
$15 \leqslant h < 30$	± 0,15 µm
$h \geqslant 30$	± 0,5 % of h

5 Test piece

5.1 The test shall be carried out on a surface which is smooth and even, free from oxide scale, foreign matter and, in particular, free from lubricants.

5.2 Preparation shall be carried out in such a way that any alteration of the surface hardness, due to heat or cold-working, for example, is minimized.

NOTE 1 In case of doubt about the influence of preparation on the hardness value, the modified procedure, given in annex A, may be of use.

5.3 The thickness of the test piece or of the layer under test shall be at least 10 times the indentation depth. No deformation shall be visible at the back of the test piece after the test.

5.4 For test pieces of small cross-section or of irregular shape, it may be necessary to provide some form of additional support.

6 Procedure

6.1 Carry out the test at ambient temperature between 10 °C and 35 °C, unless otherwise specified. Tests carried out under controlled conditions shall be made at a temperature of 23 °C ± 5 °C.

6.2 The test force shall be within the range of 0,01 N to 1 000 N (figures A.1 and B.1 show the increments in test force).

6.3 Place the test piece on a rigid support. The contact surfaces shall be clean from foreign matter (scale, oil, dirt, etc.). It is important that the test piece lie firmly on the support so that displacement cannot occur during the test.

6.4 Bring the indenter into contact with the test surface. Apply the test force in a direction perpendicular to the surface without shock and vibration, until the applied test force attains the specified values. The time from the initial application of the force until the full force is reached shall be 2 s to 3 s and may not exceed 10 s. The duration of test force shall be 2 s to 3 s. For particular materials a longer time is provided; this time shall be applied with a tolerance of ± 1 s.

6.5 Throughout the test, the apparatus shall be protected from shock and vibration.

6.6 The distance between the centre of any indentation and the edge of the test piece shall be at least 20 times the indentation depth. The distance between the centres of two adjacent indentations shall be at least 20 times the indentation depth in the case of steel, copper and copper alloys and at least 40 times of the indentation depth in the case of light metals, lead, tin and their alloys.

6.7 Measure the Indentation depth under working test force. The reading shall be taken for the calculation of the universal hardness value.

7 Test report

The test report shall include the following information:

a) reference to this Technical Report;

b) all information necessary for identification of the test sample;

c) the result abtained;

d) all operations not specified in this Technical Report or regarded as optional;

e) details of any occurrence which may have influenced the results.

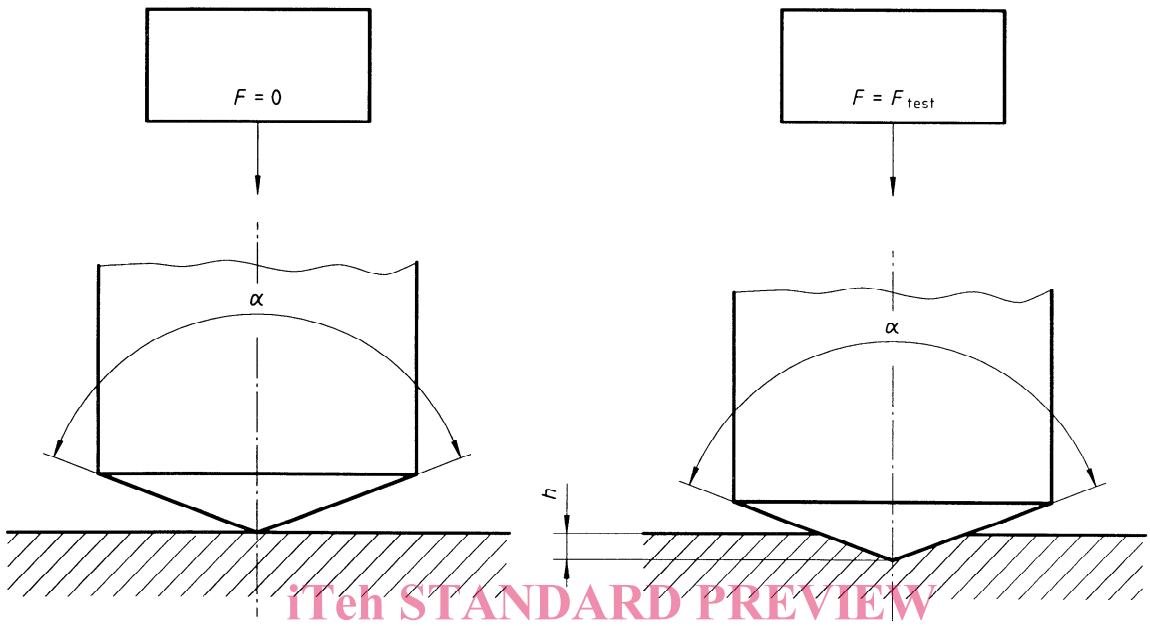

Figure 1 — Indenter and universal hardness indentation

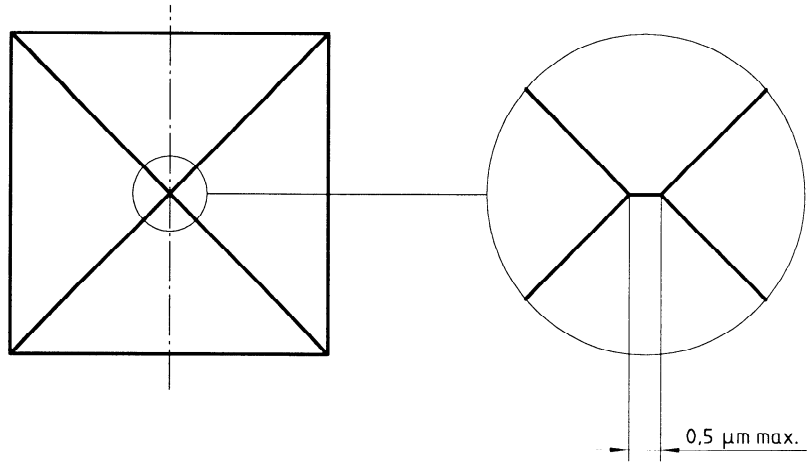

Figure 2 — Indenter (see 4.2.2)

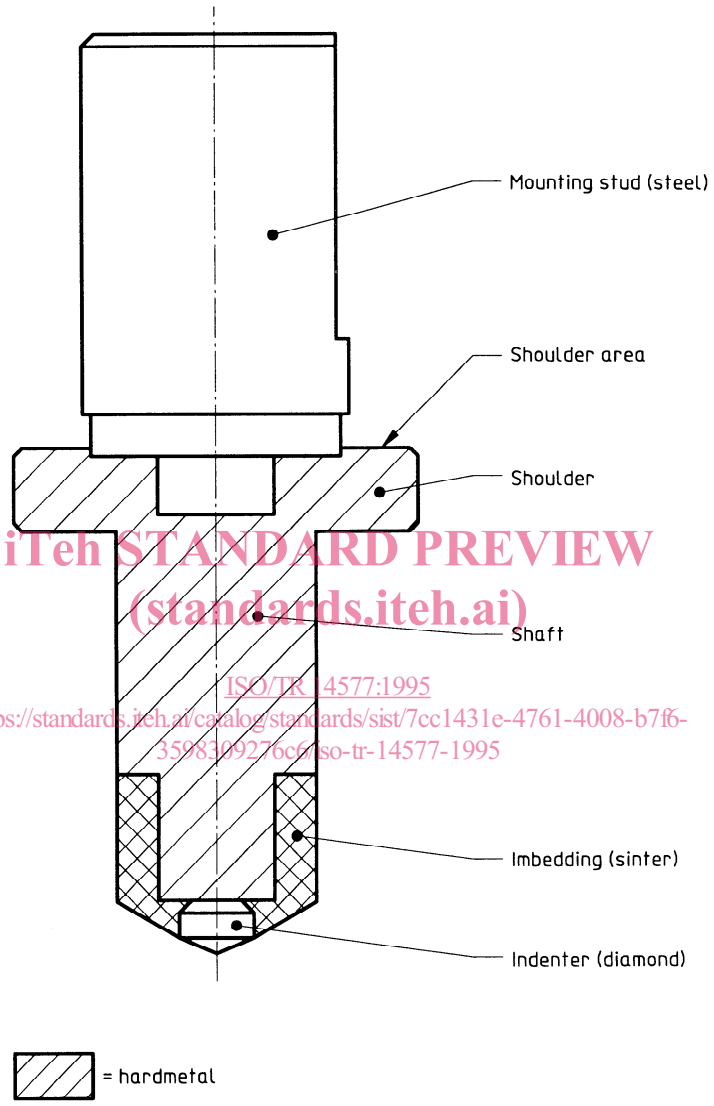

Figure 3 — Indentation assembly (see 4.2.2)