Designation: A1038 – 26

Standard Test Method for Portable Hardness Testing by the Ultrasonic Contact Impedance Method[1]

This standard is issued under the fixed designation A1038; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method covers the determination of comparative hardness values by applying the ultrasonic contact impedance method (UCI method).

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 *Exception*—Informational inch-pound units are provided in Note 1 and ksi is used in 12.1.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A370 Test Methods and Definitions for Mechanical Testing of Steel Products

E10 Test Method for Brinell Hardness of Metallic Materials

E18 Test Methods for Rockwell Hardness of Metallic Materials

E92 Test Methods for Vickers Hardness and Knoop Hardness of Metallic Materials

E140 Hardness Conversion Tables for Metals Relationship Among Brinell Hardness, Vickers Hardness, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology and Equations

3.1 *Definitions:*

3.1.1 *calibration, n*—determination of the specific values of the significant operating parameters of the UCI instrument by comparison with values indicated by a standardized workbench hardness tester or by a set of certified reference test pieces.

3.1.2 *surface finish, n*—all references to surface finish in this test method are defined as surface roughness (that is, *Ra* = average roughness value).

3.1.3 *UCI hardness test, n*—a hardness testing method using a calibrated instrument by pressing a resonating rod with a defined indenter, for example, a Vickers diamond, with a fixed force against the surface of the part to be tested.

3.1.4 *UCI method, n*—ultrasonic contact impedance, a hardness testing method developed by Dr. Claus Kleesattel in 1961 based on the measurement of the frequency shift of a resonating rod caused by the essentially elastic nature of the finite area of contact between the indenter and the test piece during the penetration.

3.1.5 *verification, n*—checking or testing the UCI instrument to ensure conformance with this test method.

3.2 *Equations:*

3.2.1 The *average* $\bar{x}$ of a set of n measurements $x_1, x_2, ..., x_n$ is calculated as:

$$\bar{x} = \frac{x_1 + x_2 + ... + x_n}{n} \quad (1)$$

where each of the individual measurements $x_1, x_2, ..., x_n$ is the result from a single indentation.

3.2.2 The *error E* in the performance of an ultrasonic contact impedance hardness testing instrument at each hardness level, relative to a standardized reference value, is calculated as an absolute percent error determined as:

[1] This test method is under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and is the direct responsibility of Subcommittee A01.13 on Mechanical and Chemical Testing and Processing Methods of Steel Products and Processes.

Current edition approved Feb. 15, 2026. Published March 2026. Originally approved in 2005. Last previous edition approved in 2019 as A1038 – 19. DOI: 10.1520/A1038-26.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

$$E = \left| 100 \times \left(\frac{\bar{x} - x_{ref}}{x_{ref}} \right) \right| \quad (2)$$

where:

$\bar{x}$ = the *average* (see 3.2.1) of *n* measurements made on a standard reference block as part of a performance verification, and

x_{ref} = the certified reference hardness reported for the standard reference block.

3.2.3 The *repeatability* R_v in the performance of an ultrasonic contact impedance testing instrument at each hardness level, relative to a standardized reference value, is calculated as percent, defined as:

$$R_v = \left(\frac{x_{max} - x_{min}}{x_{ref}} \right) \times 100 \quad (3)$$

where:

x_{max} = highest hardness value, and

x_{min} = lowest hardness value.

4. Significance and Use

4.1 The hardness of a material is a defined quantity having many scales and being dependent on the way the test is performed. In order to avoid the creation of a new method involving a new hardness scale, the UCI method converts into common hardness values, for example, HV, HRC, etc.

4.2 The UCI hardness test is a superficial determination, only measuring the hardness condition of the surface contacted. The results generated at a specific location do not represent the part at any other surface location and yield no information about the material at subsurface locations.

4.3 The UCI hardness test may be used on large or small components at various locations. It can be used to make hardness measurements on positions difficult to access, such as tooth flanks or roots of gears.

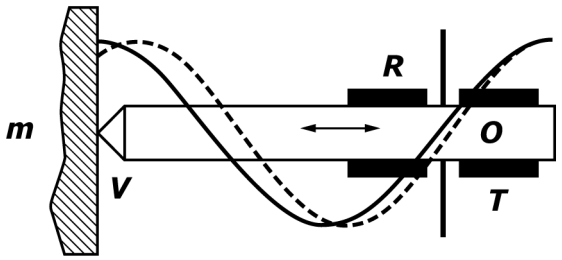
A. GENERAL DESCRIPTION OF INSTRUMENTS AND TEST PROCEDURE FOR UCI HARDNESS TESTING

5. Apparatus

5.1 Instruments used for UCI hardness testing generally consist of *(1)* a probe containing a rod with a defined indenter, for example, a Vickers diamond, attached to the contacting end in accordance with Test Methods E92 (see Fig. 1), *(2)* vibration generating means, *(3)* vibration detecting means, *(4)* electronic means for the numerical evaluation, and *(5)* a digital display, indicating the measured hardness number.

5.2 *UCI Probes*—There are different probes available for UCI hardness testing. They typically cover static loads ranging from 1 N to 98 N. See also Appendix X1. They also come in different sizes with longer and shorter sensor rods for specials applications. And they are developed in two versions, that is, manually operated or equipped with a servo-motor for automatic testing.

5.3 *Summary of Test Method*—In conventional workbench hardness testing like Brinell or Vickers testing according to Test Methods E10 and E92, the hardness value is determined optically by the size of the indentation in the material generated by a certain test load, after the indenter has been removed. In the mobile hardness test under applied load according to the UCI method, however, the size of the produced indents are not determined optically. Instead the contact area is derived from the electronically measured shift of an ultrasonic resonance frequency. To carry out the UCI test, a probe containing the rod with the indenter is excited into a longitudinal ultrasonic oscillation of about 70 kHz by piezoelectric ceramics—the so-called zero frequency, which occurs when the indenter is vibrating in air.



longitudinal amplitudes (no contact)

longitudinal amplitudes (in contact)

Legend:

T = Piezo transducer,
R = receiver,
O = oscillating rod,
V = indenter, for example, Vickers diamond, and
m = test material.

FIG. 1 Schematic Description of the UCI Probe

5.3.1 The probe regulates the specified test load. The vibrating tip penetrates into the material creating an elastic contact, which results in a positive frequency shift of the resonating rod. This shift is related to the size of the indent area (contact area of the indenter with the material). The size, in turn, is a measure for the hardness of the test material at a given modulus of elasticity, for example, HV(UCI) according to Eq 4.

5.3.2 Therefore, the frequency shift is relatively small for hard materials, because the indenter penetrates not very deep into the test material leaving only a small indent.

5.3.3 The frequency shift becomes larger if the indenter penetrates deeper into the material, indicating medium hardness, in accordance with the larger test indentations. Analogously, the frequency shift becomes largest when soft materials are tested (see Fig. 2).

5.3.4 The instrument constantly monitors the resonance frequency, calculates the frequency shift when the specified test load has been reached either after the probe mechanism has triggered the corresponding measurement frequency or after a specific dwell time has been elapsed. The instrument carries out the evaluation and calculations, and displays instantaneously the hardness value, for example, HV(UCI).