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Standard Test Method for Leeb Hardness Testing of Steel Products[1]

This standard is issued under the fixed designation A956/A956M; 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 the Leeb hardness of steel, cast steel, and cast iron (Part A), including the methods for the verification of Leeb hardness testing instruments (Part B), and the calibration of standardized test blocks (Part C).

NOTE 1—The original title of this standard was "Standard Test Method for Equotip Hardness Testing of Steel Products."[1]

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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]

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

3.1 *Definitions:*

3.1.1 *calibration*—determination of the values of the significant operating parameters of the instrument by comparison with values indicated by a reference instrument or by a set of reference standards.

3.1.2 *Leeb hardness number*—a number equal to the ratio of the rebound velocity to the impact velocity of a 0.118 in. [3 mm] or 0.197 in. [5 mm] (based on the type of impact device) diameter spherically shaped tungsten carbide, silicon nitride, or diamond tipped impact body, multiplied by 1000.

$$L = \frac{\text{Rebound Velocity}}{\text{Impact Velocity}} \times 1000$$

The Leeb hardness number is followed by the symbol *HL* with one or more suffix characters representing the type of impact device.

3.1.3 *Leeb hardness test*—a dynamic hardness test method using a calibrated instrument that impacts a spherically shaped tungsten carbide, silicon nitride, or diamond tipped body with a fixed velocity (generated by a spring force) onto a surface of the material under test. The ratio of the rebound velocity to the impact velocity of the impact body is a measure of the hardness of the material under test.

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

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

4. Summary of Test Method

4.1 During a hardness test, an impact body with a spherically shaped tungsten carbide, silicon nitride, or diamond tip impacts, after being propelled to the specified velocity, the test surface from which it rebounds. The impact and rebound velocities are measured when the impact body is approximately 0.039 in. [1 mm] from the test surface. This is accomplished by means of a permanent magnet mounted in the impact body

[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.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. 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**

which, during the test, moves through a coil in the impact device and induces an electric voltage on both the impact and rebound movements. These induced voltages are proportional to the respective impact and rebound velocities. The quotient of these measured voltage values derived from the impact and rebound velocities, multiplied by the factor 1000 produces a number which constitutes the Leeb hardness value.

5. Significance and Use

5.1 Hardness of a material is a poorly defined term that may have many meanings depending on the type of test performed and the expectations of the person involved. The Leeb hardness test is of the dynamic or rebound type, which primarily depends both on the plastic and on the elastic properties of the material being tested. The results obtained are indicative of the strength and dependent on the heat treatment of the material tested.

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

A. GENERAL DESCRIPTION OF INSTRUMENTS AND TEST PROCEDURE FOR LEEB HARDNESS TEST

6. Apparatus

6.1 The instrument used for Leeb hardness testing consists of (*1*) an impact device that is equipped with a spherically shaped tungsten carbide, silicon nitride, or synthetic diamond tipped impact body, an induction coil velocity measuring assembly, and a support ring, and (*2*) an electronic digital display hardness indicating device.

6.2 *Impact Devices*—There are eight types of impact devices used in Leeb hardness testing. These are the *D, DC, D*+15, *DL*, *G, C, S*, and the *E* impact units. Brief descriptions of the types of devices and their common applications are given in Appendix X1. Table 1 provides the specifications for the Leeb scales according to impact device type.

6.3 See 8.1.1 when using replacement machine components.

7. Test Piece

7.1 *Form*—The Leeb hardness test is acceptable for steel, cast steel, and cast iron with varying shapes and sizes.

7.2 *Thickness and Weight*—The thickness and weight of the test piece shall be considered when selecting the impact device to be employed. The following guidelines are offered as minimum weights and sizes of test pieces for selecting the proper test equipment. Test pieces of weights less than the minimum or pieces of any weight with sections less than the minimum thickness require rigid support and coupling to a thick, heavier non-yielding surface to resist the impact of the device. Failure to provide adequate support and coupling will produce test results lower than the true hardness value.

Impact Device	Minimum Mass without Rigid Support	Minimum Mass with Rigid Support	Minimum Thickness (Uncoupled)	Minimum Thickness (Coupled)
D, DC, D+15, *DL, S, E*	11.0 lb [5 kg]	4.4 lb [2 kg]	0.984 in. [25 mm]	0.118 in. [3 mm]
G	33.1 lb [15 kg]	11.0 lb [5 kg]	2.756 in. [70 mm]	0.394 in. [10 mm]
C	3.3 lb [1.5 kg]	0.3 lb [0.5 kg]	0.394 in. [10 mm]	0.039 in. [1 mm]

7.3 *Curvature*—Test pieces with curved surfaces may be tested on either the convex or concave surfaces providing that this radius of curvature of the specimens is matched to the size of the support ring and is not less than 1.969 in. [50 mm] for the *G* impact device or 1.181 in. [30 mm] for other impact devices.

7.4 *Surface Finish/Preparation*—The test surface shall be carefully prepared to avoid any alterations in hardness caused by heating during grinding or by work hardening during machining. Any paint, scale, pits, or other surface coatings shall be completely removed. The surfaces to be tested shall be smooth. Failure to provide adequate surface finish will produce questionable test results. Coarse finishes will tend to lower the measured value. It is recommended that the test surface be machined or ground and polished to the following finishes. (The grinding wheel grit size shown for each finish is offered for guidance in achieving the finish noted.)

TABLE 1 Specifications of Standard Leeb Hardness Testing Devices

Property	Symbol	Unit	*D/DC*	*S*	*E*	*D*+15	*DL*	*C*	*G*
Impact velocity[A]	V_A	ft/s [m/s]	6.73 [2.05] ± 5 %	6.73 [2.05] ± 5 %	6.73 [2.05] ± 5 %	5.58 [1.7] ± 5 %	5.97 [1.82] ± 5 %	4.56 [1.39] ± 5 %	9.78 [2.98] ± 5 %
Impact body, mass	M	oz [g]	0.192 ± 0.002 [5.45 ± 0.05]	0.190 ± 0.002 [5.40 ± 0.05]	0.192 ± 0.002 [5.45 ± 0.05]	0.273 ± 0.002 [7.75 ± 0.05]	0.256 ± 0.002 [7.25 ± 0.05]	0.109 ± 0.002 [3.1 ± 0.05]	0.705 ± 0.002 [20.00 ± 0.05]
Indenter, radius	R	in. [mm]	0.059 [1.5]	0.059 [1.5]	0.059 [1.5]	0.059 [1.5]	0.055 [1.39]	0.059 [1.5]	0.098 [2.5]
material			TC[B]	Si_3N_4	PCD[C]	TC	TC	TC	TC
hardness	h	HV2	1600 ± 100	1600 ± 100	≥4500[D]	1600 ± 100	1600 ± 100	1600 ± 100	1600 ± 100
Maximum distance of ball indenter from the test piece surface when measuring velocity	H	in. [mm]	0.079 [2.0]	0.079 [2.0]	0.079 [2.0]	0.079 [2.0]	0.079 [2.0]	0.079 [2.0]	0.118 [3.0]

[A] Impact direction: vertical down, in the direction of gravity.
[B] TC = tungsten carbide.
[C] PCD = polycrystaline diamond.
[D] The hardness of the impact body E indenter is informational, not required to be verified.