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.

Designation: A956/A956M – 22

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 pageon 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.

Impact Device	Surface Finish—Ra (max)	Grit Size (Approx.)
D, DC, D+15*, DL, S, E*	78.7 µin. [2 µm]	200
G	275.6 µin. [7 µm]	65
C	15.7 µin. [0.4 µm]	500

7.5 *Magnetic Fields*—Performance of the Leeb hardness test on parts with a residual magnetic field may affect the results. It is recommended that any residual magnetic field be less than 4 G.

7.6 *Vibration*—Vibration of the test specimen may affect the results of the Leeb hardness test. It is recommended that this test be performed with the test piece at rest.

7.7 *Temperature*—The temperature of the test piece may affect the results of the test. In addition, this effect may be different for different materials. Testing to this procedure shall be performed with the temperature of the test piece between 39 °F [4 °C] and 100 °F [38 °C]. At temperatures outside this range, the user shall develop a temperature correction for the specific material being tested.

8. Verification of Apparatus

8.1 *Verification Method*—Prior to each shift, work period, or use, and following a period of extended continuous use (1000 impacts), the instrument shall be verified as specified in Part B. Any instrument not meeting the requirements of Part B shall not be employed for the acceptance testing of product.

8.1.1 Cautionary note: When replacement parts are used in a Leeb hardness tester it is important that they be fully compatible with the original equipment, otherwise incorrect hardness readings may be obtained. Calibration using a single standard test block may indicate acceptable results, but additional calibration tests using blocks of differing hardness may yield unacceptable results. If replacement, non-original equipment parts are used, multiple block calibration verification is strongly advised. Specifically, one calibration block of a hardness equal to or lower than the minimum expected hardness of the material being tested, one calibration block of a hardness equal to or greater than the maximum expected hardness of the material being tested, and one calibration block near the middle of the range should be used.

9. Procedure

9.1 To perform a hardness test, the impact device is connected to the user interface device and powered on.

9.1.1 The impact device is readied for impact.

9.1.1.1 *Mechanically Charged Device*—Some impact devices are charged mechanically by pulling the impact body against a spring or other mechanism that propels the impact body at the prescribed velocity. The impact device, while not in contact with the test piece, is held firmly with one hand while the charging mechanism is activated with the other hand. Once the impact body is in the charged position the charging mechanism is allowed to slowly return to its resting position.

9.1.1.2 *Otherwise Charged Device*—Devices that are not charged mechanically may use gravity or other force application method to propel the impact body at the prescribed velocity. Charging of these devices should be conducted according to manufacturer's instructions.

9.1.2 After placing the readied (loaded) impact device on the test surface, trigger the impact by actuating the release mechanism according to manufacturer's instructions.

9.1.3 The Leeb hardness value is displayed or otherwise used by a user interface device after the impact.

NOTE 2—The user interface device may take the form of a computer or PLC that does not display the hardness value directly to the user. Such a user interface device may use the hardness value to operate an automatic sorting machine or simply log the value in a database.

9.2 *Alignment*—To prevent errors resulting from misalignment, the base support ring of the impact device shall be held snugly and perpendicular to the surface of the test piece.

9.3 *Impact Direction*—The impact device is calibrated for the down vertical impact direction (perpendicular to a horizontal surface). For other impact directions such as 45° from the horizontal plane or from underneath, the measured hardness values will require adjustment (see 10.2). Some newer models automatically compensate for test direction.

9.4 *Spacing Indentations*—The distance between any two impact points shall not be less than two diameters edge-to-edge. The distance between the impact point and a specimen edge shall not be less than three diameters edge-to-edge. No point shall be impacted more than once.

9.5 *Reading the Leeb Instrument*—Hardness values in Leeb units are read directly on the electronic display of the indicator device. The indicated value is automatically replaced with the next test impact result.

9.6 *Number of Impacts*—Five impacts in an area of approximately 1 in.^{2} [645 mm^2] shall constitute a test. If the material being tested is considered to be nonhomogeneous (for example, cast iron) ten impacts in an area shall be made to constitute a test.

10. Calculation of Hardness Result

10.1 The hardness test result shall be the arithmetic average of the five individual impact readings in the measuring area.

10.2 *Compensation for Test Direction*—When using a Leeb instrument without automatic compensation for test direction, the compensation value for direction of test impact is to be subtracted from the average value determined for the measuring area. This compensation value can be determined in accordance with Tables 2-9.

11. Conversion to Other Hardness Scales or Tensile Strength Values

11.1 There is no direct correlation between the Leeb hardness test principle and other hardness methods or a tensile strength test. All such conversions are, at best, approximations and therefore conversions should be avoided except for special cases where a reliable basis for the approximate conversion and the accuracy of the conversion has been obtained by comparison testing. No conversions shall be employed without specific agreement between the party specifying this test method and the party performing the hardness test.

TABLE 2 Compensation Values for Other Impact Directions: Device D

L_D				
300				
	-6	-12	-20	-29
350				
	-6	-12	-19	-27
400				
	-5	-11	-18	-25
450				
	-5	-10	-17	-24
500				
	-5	-10	-16	-22
550				
	-4	-9	-15	-20
600				
	-4	-8	-14	-19
650				
	-4	-8	-13	-18
700				
	-3	-7	-12	-17
750				
	-3	-6	-11	-16
800				
	-3	-6	-10	-15
850				
	-2	-5	-9	-14
900				

TABLE 4 Compensation Values for Other Impact Directions: Device E

L_E				
300				
	-5	-9	-18	-26
350				
	-4	-9	-17	-24
400				
	-4	-9	-16	-22
450				
	-4	-8	-15	-21
500				
	-4	-8	-14	-20
550				
	-4	-8	-13	-18
600				
	-3	-7	-12	-17
650				
	-3	-7	-12	-16
700				
	-3	-6	-11	-15
750				
	-3	-6	-10	-14
800				
	-3	-5	-9	-13
850				
	-2	-5	-8	-12
900				

TABLE 3 Compensation Values for Other Impact Directions: Device D + 15

L_{D+15}				
300				
	-7	-14	-26	-38
350				
	-7	-13	-25	-36
400				
	-6	-12	-23	-34
450				
	-6	-12	-22	-32
500				
	-6	-11	-21	-30
550				
	-6	-11	-20	-28
600				
	-5	-10	-19	-27
650				
	-5	-10	-18	-25
700				
	-5	-9	-17	-24
750				
	-4	-9	-16	-22
800				
	-4	-8	-15	-21
850				
	-4	-8	-14	-20
900				

TABLE 5 Compensation Values for Other Impact Directions: Device C

L_C				
350				
	-7	-15	^{A}	^{A}
400				
	-7	-14		
450				
	-7	-13		
500				
	-6	-13		
550				
	-6	-12		
600				
	-6	-11		
650				
	-5	-10		
700				
	-5	-10		
750				
	-4	-9		
800				
	-4	-8		
850				
	-4	-7		
900				
	-3	-6		
950				

^{A} Not permitted.

12. Report

12.1 Report the following information:

12.1.1 The average Leeb hardness number for each test area with the impact device indicated (for example, xxx *HLD* or xxx *HLD*+15).

12.1.2 When hardness values converted from the Leeb number are reported, the instrument used shall be reported in parentheses, for example, *HB* (*HLG*).

13. Precision and Bias[3]

13.1 The precision of this test method is based on an interlaboratory study of E140, Standard Hardness Conversion

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:E28-1044. Contact ASTM Customer Service at service@astm.org.

TABLE 6 Compensation Values for Other Impact Directions: Device G (Steel)

L_G				
300				
	. . .	. . .	-12	-18
350				
	. . .	. . .	-11	-17
400				
	. . .	. . .	-11	-16
450				
	-2	-5	-10	-15
500				
	. . .	. . .	-9	-14
550				
	. . .	. . .	-9	-13
600				
	. . .	. . .	-8	-12
650				
	. . .	. . .	-8	-11
700				
	. . .	. . .	-7	-10
750				

TABLE 7 Compensation Values for Other Impact Directions: Device G (Grey Cast Iron)

L_G				
350				
	. . .	. . .	-11	-17
400				
	. . .	. . .	-11	-16
450				
	-2	-5	-10	-15
500				
	. . .	. . .	-9	-14
550				
	. . .	. . .	-9	-13
600				

TABLE 8 Compensation Values for Other Impact Directions: Device DL

L_{DL}				
550				
	-3	-6	-11	-16
600				
	-3	-5	-9	-14
650				
	-2	-5	-8	-13
700				
	-2	-4	-7	-11
750				
	-2	-3	-6	-10
800				
	-1	-3	-5	-9
850				
	-1	-2	-4	-7
900				
	-1	-2	-3	-6
950				

TABLE 9 Compensation Values for Other Impact Directions: Device S

L_S				
400				
	-4	-9	-16	-23
450				
	-4	-8	-15	-22
500				
	-4	-8	-14	-21
550				
	-4	-7	-13	-19
600				
	-3	-7	-12	-18
650				
	-3	-7	-12	-16
700				
	-3	-6	-11	-15
750				
	-3	-6	-10	-14
800				
	-3	-5	-9	-12
850				
	-2	-5	-8	-11
900				
	-2	-5	-7	-10
950				

Tables for Metals Relationship Among Brinell Hardenss, Vickers Hardenss, Rockwell Hardness, Superficial Hardness, Knoop Hardness, Scleroscope Hardness, and Leeb Hardness, conducted in 2006. Six laboratories tested five unique blocks at varying hardness levels. Every "test result" represents an individual determination and nine replicate test results were reported by each lab for each level. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report RR:E28-1044.

13.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

13.1.1.1 Repeatability can be interpreted as maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.1.2 Repeatability limits are listed in Table 10.

13.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in 1 case in 20.

13.1.2.1 Reproducibility can be interpreted as maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

13.1.2.2 Reproducibility limits are listed in Table 10.

13.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

13.1.4 Any judgment in accordance with statements 13.1.1 and 13.1.2 would have an approximate 95 % probability of being correct.

TABLE 10 Hardness

Material	Average[A] $\bar{x}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Blocks 0521, 0520, and 0519 – Level 1 hardness	795.7	3.4	6.5	9.5	18.1
Blocks 0518, 0517, and 0516 – Level 2 hardness[A]	728.9	4.1	5.9	11.6	16.6
Blocks 0515, 0514, and 0513 – Level 3 hardness	674.7	2.7	4.4	7.5	12.4
Blocks 0512, 0511, and 0510 – Level 4 hardness	595.9	2.4	5.1	6.8	14.4
Blocks 059, 058, and 057 – Level 5 hardness[A]	512.8	3.0	8.0	8.5	22.5

[A] Data from only five laboratories used.

13.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

13.3 The precision statement was determined through statistical examination of 252 results, from 6 laboratories, on blocks representing 5 levels of hardness. These five levels have been described as the following:

Level 1: 800 HLD
Level 2: 720 HLD
Level 3: 670 HLD
Level 4: 600 HLD
Level 5: 520 HLD

13.3.1 To judge the equivalency of two test results, it is recommended to choose the level closest in characteristics to the test level.

B. VERIFICATION OF LEEB HARDNESS INSTRUMENTS

14. Scope

14.1 Part B covers the procedure for verification of Leeb hardness instruments by a standardized block method.

15. General Requirements

15.1 Before a Leeb hardness instrument is verified, the instrument shall be examined to ensure that:

15.1.1 The batteries in the indicating device are not discharged, and faulty batteries are replaced as required.

15.1.2 The impact device is clean, and the spherical tip of the impact body is free from all foreign matter (for example, dust, dirt, grease, scale, etc.).

15.1.3 The tip of the impact body is free from cracks or deformed areas.

15.1.4 The test block is placed on a clean, level, firmly supported base.

16. Verification by Standardized Test Blocks

16.1 Check the Leeb hardness instrument by making five impacts uniformly distributed across a calibrated test surface of a standardized test block.

16.2 The Leeb hardness instrument shall be considered verified if the arithmetic average of the five individual impact readings fall within ±6 HL units of the reference value of the calibrated surface. Any instrument not verified shall not be used for testing without repair and re-verification.

C. CALIBRATION OF STANDARDIZED HARDNESS TEST BLOCKS FOR LEEB HARDNESS INSTRUMENTS

17. Scope

17.1 Part C covers the calibration of standardized hardness test blocks used for the verification of Leeb hardness instruments.

18. Manufacture

18.1 Each test block shall be made of steel with dimensions not less than 3.543 in. [90 mm] in diameter by 2.126 in. [54 mm] thick for impact devices *D, DC, D*+15, *DL*, *C*, *S*, and *E* and 4.724 in. [120 mm] in diameter by 2.756 in. [70 mm] thick for impact device *G*. The two opposite end plane surfaces shall be parallel.

18.2 Each block shall be specifically prepared and heat treated to give a specific hardness and the necessary homogeneity and stability of structure.

18.3 Each steel block shall be demagnetized by the manufacturer and maintained demagnetized by the user.

18.4 A non-test surface of the test block shall have a fine ground finish of 276 µin. [7 µm] maximum.

18.5 The test surface(s) shall be polished or fine ground and free of scratches and other discontinuities which would influence the rebound characteristics of the test block.

18.6 The surface finish of the test surface(s) shall not exceed 16 µin. [0.4 µm] maximum.

18.7 To ensure that no material is subsequently removed from the test surface(s) of the standardized test block, an official mark or the thickness to an accuracy of ±0.001 in. [±0.025 mm] at the time of calibration shall be marked on the test surface(s).

19. Standardizing Procedure

19.1 The standardizing hardness test blocks shall be calibrated with a Leeb instrument for which the operational characteristics have been certified by the manufacturer and which has been verified in accordance with the requirements of Part B.

19.2 Make ten uniformly distributed hardness impacts on the test surface of the test block.

19.3 Take the arithmetic mean of all of the readings as the mean hardness of the calibrated test block surface.

19.4 Leeb test blocks may be calibrated on one or both of the opposite end plane surfaces.

20. Uniformity of Hardness

20.1 Unless the difference between the largest and the smallest of the ten readings is less than 13 Leeb units, the block cannot be regarded as sufficiently uniform for standardization purposes.

21. Marking

21.1 Each block shall be marked with:

21.1.1 Arithmetic mean of the hardness values found in the standardization test suffixed by the scale designation letter (for example, *HLD*).

21.1.2 The name or mark of the supplier.

21.1.3 The thickness of the test block.

22. Keywords

22.1 dynamic hardness test; Equotip; Equotip hardness test; Leeb; rebound hardness test

APPENDIXES

(Nonmandatory Information)

X1. STANDARD SINGLE COIL REBOUND HARDNESS TESTERS ACCORDING TO THE LEEB PRINCIPLE

X1.1 General Description

X1.1.1 There are eight established types of impact devices for rebound hardness testers according to the Leeb principle: *D*, *DC*, *E*, *D*+15, *DL*, *C*, *S*, and *G*. The impact devices *D* and *E* have become industry standards for general purpose applications since the first introduction of the *D*-device in 1975. The other types have been added with the time for applications with special requirements. For more details, see X1.4.

X1.1.2 It is well known that the *L*-readings for a given specimen differ significantly, depending on the impact device type used. The main reasons for this are:

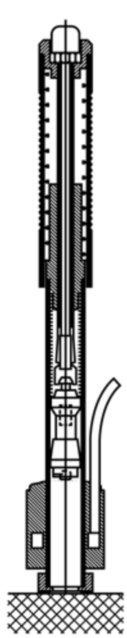

FIG. X1.1 Impact Device D

X1.1.2.1 Different impact energies;

X1.1.2.2 Different sizes and materials of the indenter; and

X1.1.2.3 Different stiffnesses of the impact bodies.

X1.1.3 One important advantage of the Leeb testing method is, that it can be used for any direction. The results are, however, not completely independent on the impact angle. Each of the standard probes has its own characteristic direction dependency, which is determined by:

X1.1.3.1 The combination of the impact velocity and the free flight length of the impact body; and

X1.1.3.2 The shape of the induction voltage signal, which is determined by the velocity versus time curve on the one hand and by the characteristics of the sensor coil and the permanent magnet on the other hand.

X1.1.4 For the standard single coil rebound hardness testing devices, a typical induction voltage curve is sketched in Fig. X1.2 where the shape of this curve is unique for all impact devices of this type. The impact and rebound velocities are assumed to be proportional to the extreme values *A* and *B* of the signal curve, which is a good approximation, if the device is constructed so, that the extremes are near the signal step caused by the impact. If they are too near, however, the reproducibility of the measurement suffers, because the signal is often disturbed short after the impact. The width of the signal curve has some influence on the result, because it determines, how good the proportionality between minimum value *B* and rebound velocity is.

X1.1.5 Another parameter of paramount importance determining the actual *L* value for a material of a given hardness is the impact energy, which follows from the impact velocity, the mass of the impact body, and its stiffness (which determines how much energy the impact body absorbs). In order to reproduce the standard direction dependency, it is necessary to