Designation: B887 – 12

Standard Test Method for Determination of Coercivity (Hcs) of Cemented Carbides[1]

This standard is issued under the fixed designation B887; 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 magnetization coercivity (Hcs) of cemented carbide materials and products using coercive force instrumentation. It is patterned after ISO 3326.

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

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

B243 Terminology of Powder Metallurgy

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

2.2 *ISO Standard:Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.*

ISO 3326 Hardmetals - Determination of (the Magnetization) Coercivity

3. Terminology

3.1 *Definitions:*

3.1.1 For definition of terms used in this procedure refer to Terminology A340 and Terminology B243.

3.1.2 *dc*—direct current.

4. Summary of Test Method

4.1 A test sample is positioned in the dc magnetic field of the test apparatus and magnetized to technical saturation. The magnetic field polarity is then reversed and the test sample is demagnetized by increasing the energy of the reversed magnetic field until the test sample reaches zero magnetism. The coercive force (Hc) is the magnetizing force required to return the saturated magnetic induction to zero.

5. Significance and Use

5.1 Measurement of coercivity provides a relative comparison of carbide grain size, binder content, and possibly carbon deficiency for a given graded carbide material or product, and may be employed as a non-destructive measurement indicating deviation from a specified norm.

5.2 This test method allows the non-destructive estimate of average carbide grain size in sintered cemented carbide hardmetals. It is appropriate for a wide range of compositions and tungsten carbide (WC) WC grain sizes, and can be used for acceptance of material or product to specification.

6. Interferences

6.1 Hcs measurement is a non-destructive “bulk” measurement that is averaged over the specimen volume. Bi-modal grain size distributions will give approximately the same Hc value as would be obtained from a normal grain size distribution about the same mean value.

6.2 Large test specimens must be sized to fit within the magnetic field coil spacing available for the apparatus employed.

6.3 Small test specimens may be immeasurable if their size prohibits detection by the magnetic field coils for the apparatus employed.

6.4 Specimen shape, that is, symmetry and aspect ratio, influence Hc measurement values and repeatability of results. Test specimens should be positioned with their long axis in the direction of the magnetic field. Asymmetrically shaped test specimens should be tested in several positions, the measurement values recorded, and the average value reported.

[1] This test method is under the jurisdiction of ASTM Committee B09 on Metal Powders and Metal Powder Products and is the direct responsibility of Subcommittee B09.06 on Cemented Carbides.

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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.

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7. Apparatus

7.1 Instrumentation capable of the dc magnetization of appropriately sized test samples to technical saturation and accurate measurement of the energy required to restore the magnetic induction to zero.

8. Procedure

8.1 For commercial instrumentation, refer to the equipment operators manual and follow the manufacturer's operating instructions.

8.2 Position the test sample in the center of the magnetic field. The test sample should be positioned with its long axis in the direction of the magnetic field (see 6.4).

8.3 Magnetize the test sample to technical saturation.

8.4 Reverse the magnetic field polarity and demagnetize the test sample to zero.

8.5 Record the Hc measurement, that is, energy required to demagnetize the test sample.

8.6 Replicate measurement of the same test sample shall be made, reversing the polarity of the saturation and demagnetizing magnet fields, where possible.

8.7 For asymmetric sample shapes, repeat measurements shall be made by repositioning the specimen in the dc magnetic field of the instrumentation with consideration being given to the shape, that is, symmetry of the test sample, and to its aspect ratio, that is, length versus width.

9. Report

9.1 Report the following information:

9.1.1 Test sample identification,

9.1.2 Average Hcs coercivity (amp per metre (A/m) or oersteds), and

9.1.3 Range of measured Hc values, especially for replicate measurements of asymmetric sample shapes.

10. Precision and Bias

10.1 The precision of this test method is based on an interlaboratory study of ASTM B887- Standard Test Method for Determination of Coercivity (Hcs) of Cemented Carbides, conducted in 2010. Three laboratories participated in this study, recording the coercivity on three specimens each, of ten different materials. This procedure was performed three times on each material in order to determine the precision of the test method. Every "test result" represents an individual observation. Except for the limited number of participating laboratories, Practice E691 was followed for the design and analysis of the data.[4]

10.1.1 *Repeatability limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "r" value for that material; "r" is the interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

10.1.1.1 Repeatability limits are listed in Table 1 below.

10.1.2 *Reproducibility limit (R)*—Two test results shall be judged not equivalent if they differ by more than the "R" value for that material; "R" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

10.1.2.1 Reproducibility limits are listed in Table 1 below.

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

10.1.4 Any judgment in accordance with statement 9.1.1 and 9.1.2 would normally have an approximate 95% probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting results guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95% probability limit would imply. Consider the precision limits as general guides, and the associated probability of 95% as only a rough indicator of what can be expected.

10.2 *Bias*—Measurement of coercive force is a relative comparison against well characterized reference materials (see Section 8). No statement about bias can be made due to the effects of test specimen shape, variations in the binder content that are within material or product specification, and the presence of carbon deficiency.

10.3 The precision statement was determined through statistical examination of 90 results, from three laboratories, on the materials described in the table below.

Material	Description
1	6.7%Ni, 0.12% VC, balance WC
2	25%Co, 1.5%TaC, 1.5%NbC, balance WC
3	8%Co, 0.32%VC, balance WC
4	6.25%Co, 1.5%TaC, 1.5%NbC, balance WC
5	8.5%Co,8%TiC, 6.8%TaC, 3%NbC, balance WC
6	10%Co, 0.25%VC, balance WC
7	12.25%Co, balance WC
8	25%Co, 0.3%VC, balance WC
9	4.5%Co, 1%Ni, 0.5%VC, 0.4%Cr3C2, balance WC
10	16%Co, balance WC

10.4 No certified cemented carbide standards are available for coercive force measurement. Most common practice is the development of (internal) reference materials representative of the product(s) being evaluated.

TABLE 1 Coercivity (Oe)

MATERIAL	Average[A]	sr	sR	r	R
10	56.0	0.0	0.0	0.0	0.0
5	78.0	0.0	0.0	0.0	0.0
2	128.6	0.5	0.5	1.3	1.5
7	154.2	0.5	0.5	1.3	1.3
4	221.3	0.5	0.5	1.3	1.4
6	238.3	0.6	0.6	1.6	1.6
3	297.0	0.7	0.7	2.1	2.1
1	322.6	28.4	28.4	79.4	79.4
8	442.0	15.9	15.9	44.7	44.7
9	563.1	1.0	2.2	2.8	6.1

[A]The average of labortories' calculated averages

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B09-1018.

11. Keywords

11.1 cemented carbide; coercive force; coercivity; magnetization

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