Designation: B886 – 19

Standard Test Method for Determination of Magnetic Saturation (Ms) of Cemented Carbides[1]

This standard is issued under the fixed designation B886; 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 magnetic saturation (Ms) of cemented carbide powder materials and sintered products using magnetic saturation induction test instrumentation.

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, 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]

A340 Terminology of Symbols and Definitions Relating to Magnetic Testing

A977/A977M Test Method for Magnetic Properties of High-Coercivity Permanent Magnet Materials Using Hysteresigraphs

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

E1316 Terminology for Nondestructive Examinations

3. Terminology

3.1 *Definitions:*

3.1.1 For definition of terms used in this procedure refer to Terminology A340, Terminology B243, and Terminology E1316.

3.1.2 *dc*—direct current.

4. Summary of Test Method

4.1 *For Permanent Magnet Instrument*—A test specimen is statically positioned with the long axis perpendicular to the magnetic field generated by a permanent magnet and sensing coils of the test apparatus. The specimen is magnetized to induction saturation by the field and translated linearly that the intrinsic magnetic moment of the specimen's binder phase induces a dc current to flow in the sensing coils of the test apparatus. The induced current is proportional to the amount of magnetic binder phase present in the test specimen. Measurement of the induced current permits calculation of the intrinsic magnetic saturation of the test sample.

4.2 *For Electromagnet Instrument*—A test specimen is placed into a holder housing the Hall probe and sensing coils which has been positioned between the poles of the electromagnet. The magnetic field is increased while the sensing coils measure the magnetic flux of the specimen. The magnetic flux can be related to the intrinsic magnetic saturation of the test specimen.

5. Significance and Use

5.1 This test method allows the nondestructive measurement of the magnetic fraction of the binder phase in cemented carbide powder materials and sintered product, and may be used as an indirect measure of the carbon level in the material or product.

5.2 Measurement of magnetic saturation provides a comparison of the relative fraction of magnetic binder phase, that is, cobalt, nickel, or iron, present in the material and can be used for acceptance of product to specification.

5.3 Measurement of magnetic saturation can be used as a measure of the quality of powder material.

[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.

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

6. Interferences

6.1 No direct absolute measurement of magnetic saturation can be made. The measurement is a relative comparison of standard reference materials.

6.2 Measurement of magnetic saturation is a nondestructive "bulk" measurement which is averaged over the test specimen volume. The technique cannot be used to infer anything regarding the relative distribution of the binder phase within the test sample.

6.3 Measurement of magnetic saturation is affected by test sample size and shape, especially aspect ratio, and the composition of the binder phase, that is, a mixture of ferromagnetic elements of varying intrinsic magnetic moments.

6.4 Small test samples or test samples containing relatively low concentrations of the binder phase may be immeasurable in that the low concentration prohibits detection by the field sensing coils of the specific apparatus employed.

7. Apparatus

7.1 *Instrumentation,* capable of inducing magnetic saturation and then sensing the inherent intrinsic magnetic moment of the magnetic fraction of the binder phase.

7.2 *Balance,* having a capacity of 200 g and a sensitivity of 0.001 g.

8. Standards

8.1 No certified cemented carbide standards, powder materials or sintered product, are available for magnetic saturation measurement. Most common practice is the development of (internal) reference materials representative of the test samples being evaluated.

8.2 Pure ferromagnetic materials such as nickel (Ni) or iron (Fe) with known magnetic moments are recommended for calibration of the instrumentation.

9. Test Specimen

9.1 Test specimens may be in the form of sintered solids, unsintered powder compacts, or encapsulated powders of a size suitable to fit into the specimen holder of the apparatus.

10. Procedure

10.1 For commercial instrumentation, refer to the equipment manufacturers operating manual and follow operating instructions.

10.2 Read and record the value of the intrinsic magnetic saturation from the test apparatus. Measurement units are Tesla-m^3 per kilogram (emu per gram (csg)).

10.3 Relative percent of magnetic saturation of the test sample may be calculated and reported. Consideration must be given to the composition of the binder phase with respect to ferromagnetic components, and the presence of other metallic constituents, for example, chromium (Cr) in the powder material or sintered product, that would affect the binder phase composition or magnetic moment of the constituents.

10.4 Repeat measurements can be made to obtain an average value and range of values for test specimens of asymmetric shape. Orientation of the test sample should be changed within the test apparatus sample chamber for each repeat measurement.

11. Report

11.1 Report magnetic saturation as Tesla-m^3 per kilogram (emu per gram), or as relative percent (that is, magnetic portion of the binder phase/total mass of binder phase in test sample).

12. Precision and Bias

12.1 *Precision*—The precision of this test method is based on an interlaboratory study of Test Method B886 conducted in 2010. Three laboratories participated in this study, recording the magnetic saturation 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.[3]

12.1.1 *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.

12.1.1.1 Repeatability limits are listed in Table 1 below.

TABLE 1 Magnetic Saturation (T-m^3/kg)

Material	Average[A]	sr	sR	r	R
1	0.00130	0.00	0.00	0.00	0.00
9	0.08690	0.00	0.00	0.00	0.00
4	0.10290	0.00	0.00	0.00	0.00
3	0.14478	0.00043	0.00075	0.00121	0.00210
5	0.16140	0.00	0.00	0.00	0.00
6	0.19340	0.00	0.00	0.00	0.00
7	0.22274	0.00043	0.00043	0.00121	0.00121
10	0.31539	0.00053	0.00053	0.00149	0.00149
8	0.43313	0.00066	0.00071	0.00185	0.00200
2	0.44962	0.00088	0.00133	0.00247	0.00373

[A] The average of laboratories' calculated averages.

12.1.2 *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.

12.1.2.1 Reproducibility limits are listed in Table 1.

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

12.1.4 Any judgment in accordance with statement 12.1.1 and 12.1.2 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

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:B09-1017. Contact ASTM Customer Service at service@astm.org.

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.

12.2 *Bias*—Measurement of magnetic saturation is a relative comparison against well characterized reference materials of similar composition and mass (see 8.1). No statement about bias can be made due to the affects of test specimen size and shape, variations in the binder phase composition that are within material or product specification, and the affect of variations of the carbon content of the test samples (see 6.3).

12.3 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, 0.15 % 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

13. Keywords

13.1 cemented carbide; magnetic saturation (Ms)

SUMMARY OF CHANGES

Committee B09 has identified the location of selected changes to this standard since the last issue (B886 – 12) that may impact the use of this standard.

(1) Added A977/A977M to 2.1.
(2) Added 4.2 to include electromagnetic instruments and new sample positioning information.
(3) Removed references to ferromagnetic materials in 8.2, and replaced with nickel and iron.
(4) Removed last sentence from 9.1.
(5) Deleted the previous versions of 10.2 to 10.5 and renumbered Section 10 accordingly.

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