
British Standard

Magnetic materials

Part 10. Methods of measurement of magnetic properties of magnetic steel sheet and strip at medium frequencies

Matériaux magnétiques

Partie 10. Méthodes de mesure des propriétés magnétiques à fréquences moyennes des tôles et feuillards magnétiques en acier

Magnetische Werkstoffe

Teil 10. Verfahren zur Messung der magnetischen Eigenschaften von Elektroblech und -band bei mittleren Frequenzen

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National foreword

This Part of BS 6404 has been prepared under the direction of the Iron and Steel and Non-ferrous Metals Standards Policy Committees. It is identical with IEC 404-10 : 1988 'Methods of measurement of magnetic properties of magnetic steel sheet and strip at medium frequencies', published by the International Electrotechnical Commission (IEC).

This Part of BS 6404 is the tenth of a series of British Standards based on the IEC series 'Magnetic Materials'. The Part numbers of the British Standards follow the Parts of the IEC publication. The following Parts of the British Standard have been published or will shortly be published.

Part 1 Classification

Part 2 Methods of measurement of magnetic, electrical and physical properties of magnetic sheet and strip

Part 3 Methods of measurement of specific total losses of magnetic sheet and strip by means of a single sheet tester

Part 4 Methods of measurement of the d.c. magnetic properties of solid steels

Part 5 Methods of measurements of the magnetic properties of magnetically hard (permanent magnet) materials

Part 6 Methods of measurement of the magnetic properties of isotropic nickel-iron soft magnetic alloys, types E1, E2 and E4

Part 7 Method of measurement of the coercivity of magnetic materials in an open magnetic circuit

Part 8 Individual materials

Section 8.1 Specification for magnetically hard materials

Section 8.2 Specification for cold-rolled, magnetic, non-oriented, alloyed steel strip delivered in the semi-processed state

Section 8.3 Specification for cold-rolled, magnetic, non-oriented, non-alloyed steel strip delivered in the semi-processed state

Section 8.4 Specification for cold-rolled, non-oriented, magnetic steel sheet and strip delivered in the finally annealed state

*Section 8.5 Specification for steel sheet and strip with specified mechanical properties and magnetic permeability

Section 8.6 Specification for soft magnetic metallic materials

*Section 8.7 Specification for grain-oriented magnetic steel sheet and strip

Part 9 Methods for determination of the geometrical characteristics of magnetic steel sheet and strip

Additional Parts and Sections of IEC 404 will be published and are expected to provide a basis for additional Parts of BS 6404.

Cross-reference

The Technical Committee has reviewed the provisions of IEC 50 (901), to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

NOTE. For the purposes of this British Standard, any references to IEC page numbers in the text should be ignored.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

* In preparation.

MAGNETIC MATERIALS

Part 10: Methods of measurement of magnetic properties of magnetic steel sheet and strip at medium frequencies

INTRODUCTION

1. Field and scope of application

This standard is applicable to magnetic steel sheet and strip for the construction of magnetic circuits for use in the frequency range 400 Hz to 10 000 Hz.

Its object is to define the terminology and to specify the methods for the measurement of magnetic properties of magnetic steel sheet and strip.

2. Accuracy and reproducibility

The final accuracy of the test apparatus is a complex function dependent on the measuring instruments and other features of the measuring environment and equipment components; therefore it is not always possible to state the absolute accuracy which can be attained.

Moreover, experience in the use of a given method indicates the reproducibility which can be expected. Whenever the drafting Technical Committee has agreed upon reproducibility values, these have been given in this standard.

CHAPTER I: GENERAL CONDITIONS FOR A.C. MEASUREMENTS MADE WITH THE 25 CM EPSTEIN FRAME

3. Scope

This chapter specifies the general conditions for the determination of a.c. magnetic properties of magnetic steel sheet and strip by means of the 25 cm Epstein frame.

4. Field of application

The use of the 25 cm Epstein frame is applicable to flat strip specimens obtained from magnetic sheets and strips of any quality. The magnetic properties are determined for a sinusoidal induced voltage.

The measurements are made at an ambient temperature of 23 ± 5 °C on test specimens which have first been demagnetized.

5. Principle of the 25 cm Epstein frame method

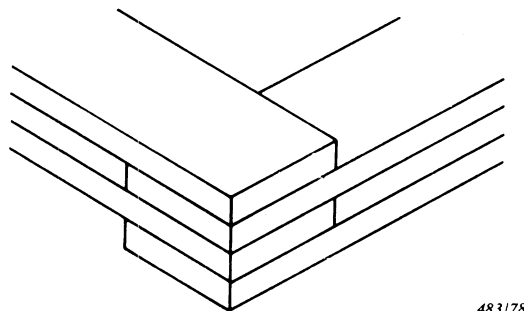
The 25 cm Epstein frame, which comprises a primary winding, a secondary winding and the specimen to be tested as a core, forms an unloaded transformer whose properties are measured by the methods described in the following chapters.

At the higher end of the frequency range a specially constructed Epstein frame (see Appendix A) may be required in which the interwinding capacitances are low and the material of the winding formers supporting the solenoids has a low dielectric loss.

A separate measuring system (for example a commercially available universal bridge capable of measuring resistance, capacitance and inductance) is required to determine the interwinding capacitance of the Epstein frame.

6. Test specimen

The magnetic circuit shall be made up of a core constructed with the strips to be tested, assembled in a square having double-lapped joints (see Figure 1) to form four branches of equal length and equal cross-sectional area.



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FIG. 1. – Double-lapped joints.

The strips shall be sampled in accordance with the product standard. They shall be cut by a method which will produce clean burr-free edges. They shall have the following dimensions:

- width $b = 30 \pm 0.2$ mm;
- length $280 \text{ mm} \leq l \leq 500 \text{ mm}$, the strips being of the same length within a tolerance of ± 0.5 mm.

For strips of length greater than 305 mm, care shall be taken to avoid bending the strips during the test.

When the strips are cut parallel or normal to the direction of rolling, the edge of the parent sheet shall be taken as the reference direction.

The following tolerances shall be allowed for the angle between the direction of rolling and that of cutting:

- $\pm 1^\circ$ for grain-oriented steel sheet;
- $\pm 5^\circ$ for non-oriented steel sheet.

Only flat strips shall be used. Measurements shall be made without additional insulation.

The number of strips forming a test specimen shall be not less than twelve and shall be a multiple of four. A force of 1 ± 0.1 N shall be applied to each corner, normal to the plane of the overlapping strips.

7. 25 cm Epstein frame

The 25 cm Epstein frame (hereafter referred to as the “Epstein frame”) shall consist of four solenoids into which the test specimen strips are introduced in such a manner that a closed magnetic circuit is formed (see Figure 2).

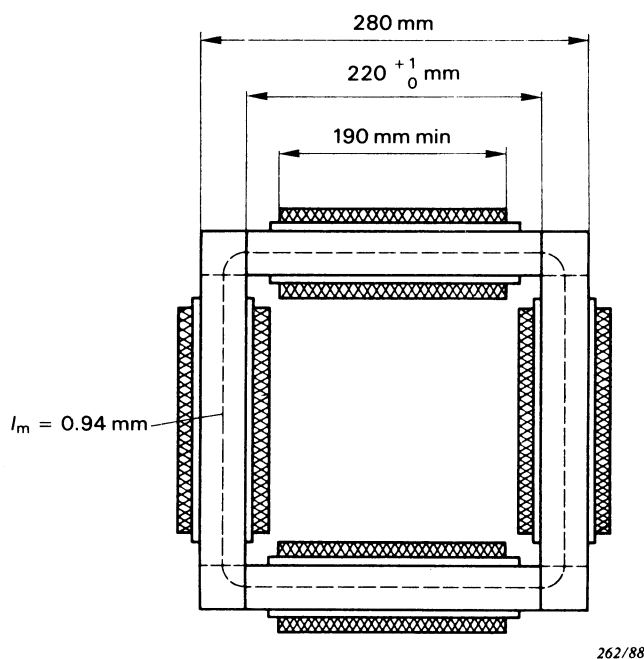


FIG. 2. – 25 cm Epstein frame.

If measurements are to be made under the conditions specified in Clause 8, a mutual inductor shall be provided for air flux compensation.

The winding formers supporting the solenoids shall be made of hard insulating material of low dielectric loss, such as polystyrene, and have a rectangular cross-section and an inner width of 32 mm. A height of about 5 mm will be sufficient and is recommended.

The solenoids shall be mounted on a non-conducting and non-magnetic base plate in a square arrangement. Each side of the inner square formed by the test specimen strip shall have a length of $220 \pm \frac{1}{2}$ mm (Figure 2).

In order to avoid undue wear of the winding formers and especially of their inner surfaces, winding formers of larger cross-section can be used into which replaceable liners of appropriate dimensions may be inserted.

Each solenoid comprises two windings:

- a primary winding (magnetizing winding);
- a secondary winding (voltage winding).

The windings on each solenoid shall be evenly distributed over a length of at least 190 mm, with each solenoid carrying one-fourth of the total number of turns. The individual primary windings of the four solenoids shall be connected in series, and the secondary individual windings shall be connected in a similar fashion.

At high frequencies, the loss due to the capacitance between the primary and secondary windings and also the self-capacitance of the secondary winding could be significant. The windings shall be spaced to minimize this loss.

The capacitance between the windings and the self-capacitance of the secondary winding shall be measured. If necessary, a correction shall be applied for the loss introduced.

The number of turns of the primary and secondary windings shall be chosen to suit the particular conditions of the power supply, instrumentation and measuring frequency.

A total of 200 turns for each of the primary and secondary windings is recommended and is commonly used for tests in the frequency range 400 Hz to 10 000 Hz.

The impedance of the windings shall be sufficiently small to avoid waveform distortion and minimize internal voltage drops.

The effective length l_m of the magnetic path in this test equipment is conventionally taken as 0.94 m. This value shall be used.

Consequently, the effective mass, i.e. the magnetically active mass of the test specimen, is given by the equation:

$$m_a = \frac{l_m}{4l} \cdot m \quad (1)$$

where:

m_a = effective mass of test specimen, in kilogrammes

m = mass of test specimen, in kilogrammes

l_m = conventional effective magnetic path length, in metres

l = length of a test specimen strip, in metres