

Measurements and magnets are everywhere: advanced magnetic testing methods as requisites for physical understanding, progress in standards and materials, and improved applications

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Measurements mean knowledge. No scientific and technological activity can be rationally pursued without resorting to some kind of well-defined and reproducible measurement. This is especially true for magnetic materials, where advances in the physical understanding of their properties and in the variety and efficiency of their applications hang on the development of solid and innovative measurement techniques. These must relate, in any case, to the rigorous framework provided by the coherent SI system of units, to which they can be traced through an unbroken chain of calibrations, ultimately linked to the activity of the National Metrological Institutes. The appearance of novel physical phenomena and new or improved materials, and the development of increasingly fast digital methods in measurement control and data acquisition and handling have brought about new challenges and opportunities in magnetic measurements. Enhanced measurement methodologies, developed either for basic investigations or for keeping abreast of new advances in materials and applications, eventually call for an evolution of the Standards, the tool by which the novel achievements in measuring methods are transferred to industry, in order to cover, under strict reproducibility requisites, the broadening demands of the market.

In this communication we shall highlight the physical principles underlying the modern methodologies employed in the characterization of hard and soft magnetic materials, by considering both standard measuring approaches to materials of present-day industrial interest and some recent developments and results ensuing from novel and improved techniques, namely concerning the investigation of the magnetization process and the magnetocaloric effect.

The talk will develop, in particular, around the following main topics:

- The landscape of present-day IEC standards in magnetic measurements.
- Epstein versus Single Sheet Tester method: the results of a recent IEC-TC68 broad intercomparison.
- Two-dimensional measurements in magnetic sheets up to saturation. Fieldmetric versus thermometric measurements.
- Measurements of permanent magnets: the VSM and the Pulsed Field Magnetometer methods versus the closed-circuit hysteresisgraph method.
- Measurement of magnetic losses in soft magnetic materials from DC to the GHz range. Fast stroboscopic techniques elucidate the evolution of the domain wall dynamics versus frequency.
- Calorimetric techniques for the characterization of the magnetocaloric effect on low Curie temperature materials, for perspective use in magnetic refrigeration.

We shall look, in particular, at the physical insight gained by the application of these techniques, besides highlighting their technical features and perspectives. While not pretending to provide a description of the present state of the art in magnetic measurements, the selected examples are chosen to convey trends and ideas lying behind advances in experimental methods, an indispensable step on the road to improved materials and applications.