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DIN SPEC 91411: A standardized representation of magnetic scales

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***Abstract* – When it comes to scales for magnetic length and angle measurement systems, there has been no uniform terminology, no common drawing rules - neither for the mechanical nor for the magnetic parameters - and this has often led to misunderstandings or even errors in de-sign drawings. This primarily affects manufacturers of magnets, magnetic scales and sen-sors as well as machine or device manufacturers. A consortium consisting of a total of 13 companies and research institutions, mainly members of the Innovation Platform for Mag-netic Microsystems INNOMAG e. V., has now developed a DIN SPEC standard for the uni-form representation of magnetic measuring scales.**

I. INTRODUCTION

Magnetic measuring systems are becoming increasingly widespread for the safe detection of movements or positions. The robust, wear-free measuring principle offers numerous advantages over other measuring principles [1 to 6]. Magnetic measuring systems often consist of a field-generating permanent magnet in the form of a measurement scale and a sensor that converts the changes in the magnetic field (strength and/or direction) into electrical output signals via the magnetic scale (Fig. 1). The sensors used are typically based on a magneto resistive or Hall effect [7 to 9].

Measurement scales, in the form of rotary or linear scales, are necessary to realise magnetic measuring systems in combination with one or more sensors (Fig. 2). For the production of magnetic measuring scales, the blanks can be magnetically encoded using different processes (Fig. 3). The material and geometry of the measurement scales are selected according to the requirements of the later place of use and the magnetic coding to be applied.

The magnetic encodings range from simple dipole permanent magnets, to single-track incremental magnetisations in which the measurement scale is described alternately with north and south poles, as well as complex, multi-track magnetisation patterns. The documentation describing the respective measurement scales can there-fore also be correspondingly complex.

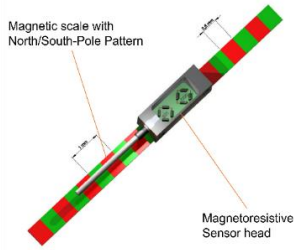

Fig. 1. Magnetic length measuring system consisting of sensor head and scale (Image source: ITK Dr. Kassen GmbH).

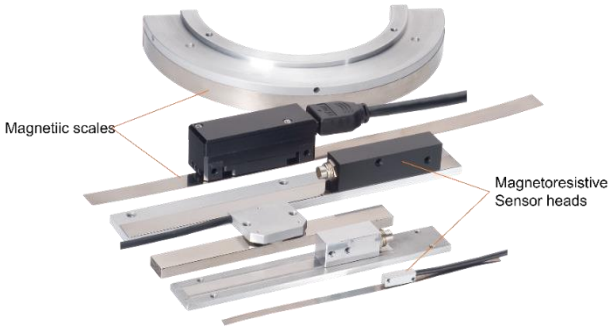

Fig. 2. Magnetic length and angle measuring systems (Image source: ITK Dr. Kassen GmbH).

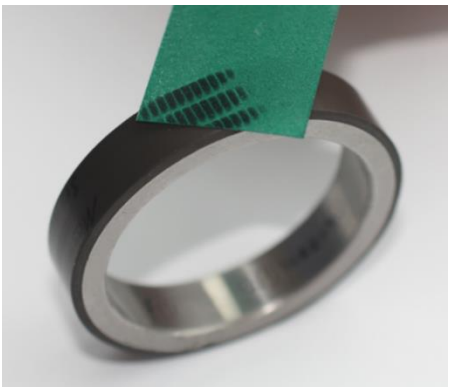

Fig. 3. Magnetisation pattern on a pole ring (Image source: Sensitec GmbH).

II. PROBLEM DEFINITION

There is currently no common terminology or standardised rules for design drawings for the representation of the mechanical and magnetic parameters of magnetic measurement scales (Fig. 4).

Fig. 4. Magnetic measurement scales: Scales (left) and pole rings (right) (Image source: Sensitec GmbH)

The individual steps in the value chain (Fig. 5) are often undertaken by different players and there is usually a need for coordination regarding the mechanical and magnetic properties of the dimensional scale. Incomplete information and different designations lead to misunderstandings and errors that result in lost time and increased costs in the development and application of magnetic measurement systems.

III. SOLUTION APPROACH: DIN SPEC

The creation of a document by means of DIN SPEC is considered to be the shortest way to establish standards on the market directly from research.

DIN SPEC PAS (PAS = "Publicly Available Specification") is a consortium standard that is developed within a few months in small agile working groups and is not subject to outside consensus. The German standards organization DIN ensures that a DIN SPEC does not contradict any existing norms or standards. The standards can also be published internationally and also be the basis for a subsequent “full” DIN standard (Fig. 6).

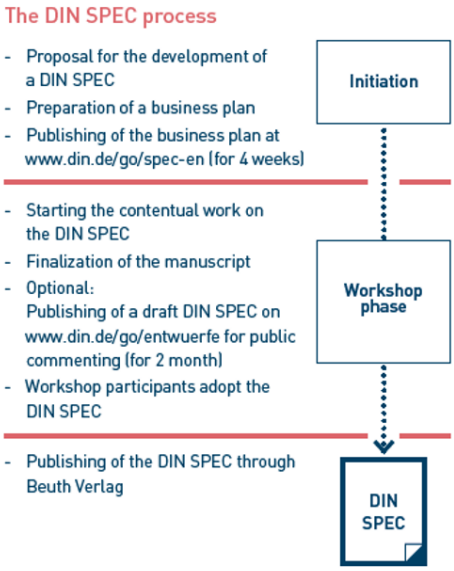

Fig. 6. Creation of a DIN SPEC (Image source: DIN)

DIN currently has more than 150 ongoing and published DIN SPEC according to the PAS procedure. The range of topics includes, for example, terminology, classification, measurement, testing, process and interface standards, guides or reference architecture models on the various innovative topics. The initiators of the standards come from the manufacturing industry, the service sector or from science; they include large companies as well as start-ups and SMEs.

The consortium for DIN SPEC 91411 "Requirements for the technical representation of magnetic dimensional standards in design drawings" consisted of participants (Table 1) covering all stages in the value chain (Fig. 5):

- Magnet manufacturers
- Sensor manufacturers
- Encoder manufacturers
- Research institutions

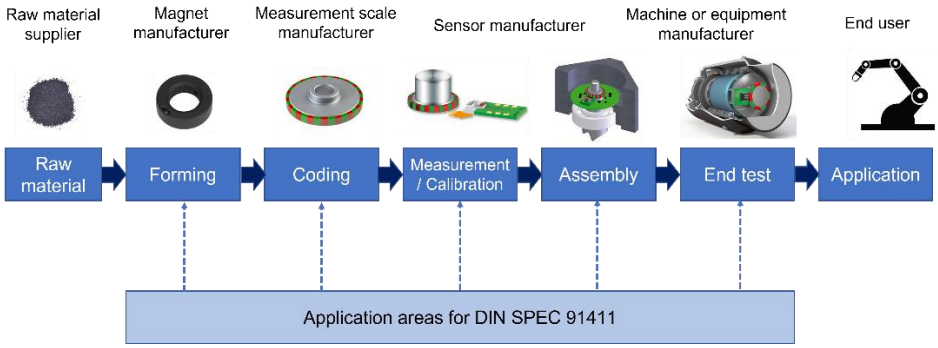

Fig. 5. Areas of application for DIN SPEC 91411

The participants were almost exclusively members of the Innovation Platform for Magnetic Microsystems INNOMAG e. V. (www.innomag.org). This network brings together the interests and potentials of manufacturers, service providers and users as a network. Founded in February 2007, the network is based in Kaiserslautern, Rhineland-Palatinate, and currently has over 40 members.

Table 1. Companies involved in the consortium.

Company	Location
Balluff GmbH	Neuhausen a.d. Fildern
Baumer Hübner GmbH	Berlin
Bundesanstalt für Materialforschung und -prüfung (BAM)	Berlin
Bogen Electronic GmbH	Berlin
Elsoma GmbH	Schwerte
Festo SE & Co. KG	Esslingen
ITK Dr. Kassen GmbH	Lahnau
INNOVENT e. V.	Jena
Fritz Kübler GmbH	Villingen-Schwenningen
Magnetfabrik Bonn GmbH	Bonn
Matesy GmbH	Jena
Sensitec GmbH	Wetzlar
TE Connectivity Sensors Germany GmbH	Dortmund

For the members of INNOMAG e. V., there were five main reasons for creating a DIN SPEC to standard-ise the representation of magnetic dimensional scales:

- Network: The DIN SPEC process promotes exchange with relevant market participants. This leads to further networks with key players: the requirements of manufacturers and customers flow into the common standard.
- Recognised: Well established worldwide, the DIN brand ensures maximum trust in the market. The innovation thus enjoys acceptance among potential users and investors.
- Plug & Play: The DIN SPEC process aligns the innovation with the current state of the art. Users can thus work with the innovation without hurdles.
- Simple: DIN organises the entire DIN SPEC project. This saves time to focus on content and networking
- Fast: DIN SPEC can be created and published within a few months. DIN SPEC prepared ac-cording to the PAS procedure are made available free of charge as a download at www.beuth.de.

IV. RESULTS

The consortium has developed a DIN SPEC standard for the uniform representation of magnetic dimensional standards. A total of 20 employees from 13 companies - mainly members of the Innovation Plat-form of Magnetic Microsystems INNOMAG e.V. - have finally presented a solution to this long-known problem with DIN SPEC 91411 "Requirements for the technical representation of magnetic dimensional standards in design drawings" after almost three years of cooperation.

The creation of DIN SPEC 91411 began in June 2019 at a kick-off meeting in Berlin and originally the document was to be completed by June 2020. Due to the onset of the COVID crisis, there was a significant delay in implementation as it was very difficult at times to organise the necessary project meetings. The draft publication took place in December 2021, after which there was a two-month period during which other interested parties could make additions to complete the document. The final publication of the German-language main document [10] took place in August 2022. The English language translation was published in January 2023.

The new standard has different contents that help to specify the description of magnetic dimensional standards. To set a framework for the DIN SPEC, a new taxonomy of magnetic dimensional standards was developed (Fig. 7).

This taxonomy describes all common dimensional standards and offers designations for an unambiguous assignment of a scale or pole ring and the associated magnetic tracks according to the following parameters:

- Type of measuring standard
- Form
- Track alignment
- Magnetisation
- Track type
- Track length

Subsequently, a glossary or dictionary was created with corresponding symbols, equations, units and auxiliary graphics (Fig. 8) for mechanical and magnetic parameters in relation to dimensional standards (pole rings, scales). The aim was to develop a main document based on this, in which the specification for dimensional standards is defined more precisely and presented more clearly, so that errors and misunderstandings can be avoided in the future.

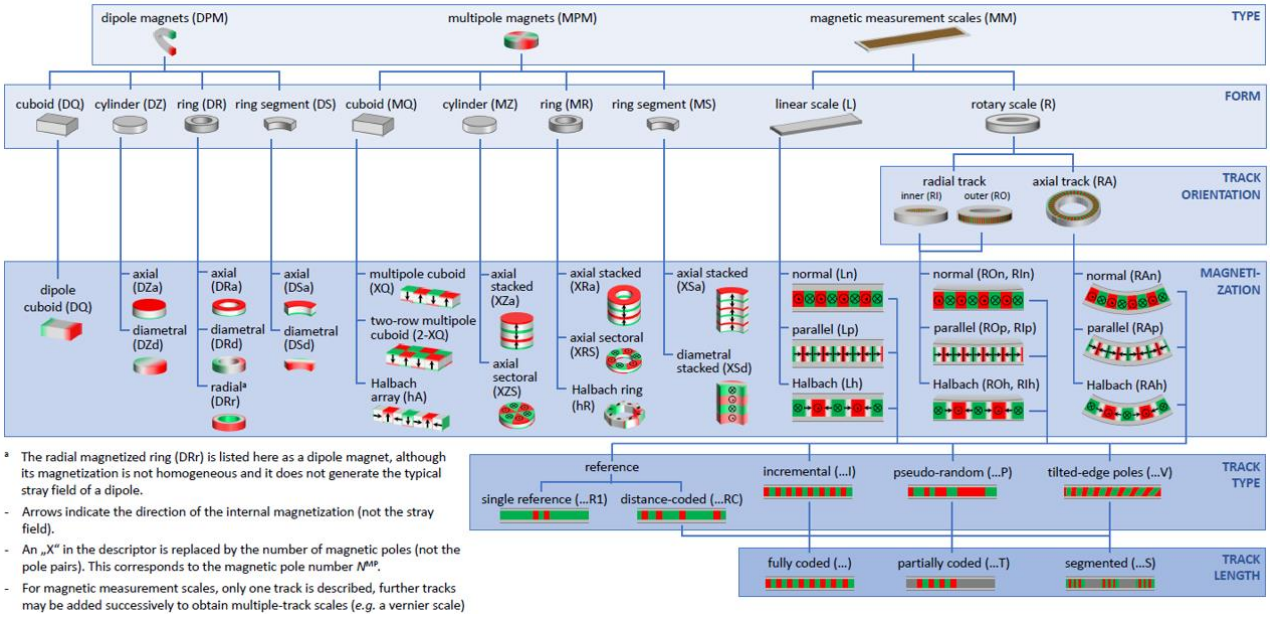

Fig. 7. Taxonomy of magnetic measurement scales (Image source: INNOMAG e.V.)

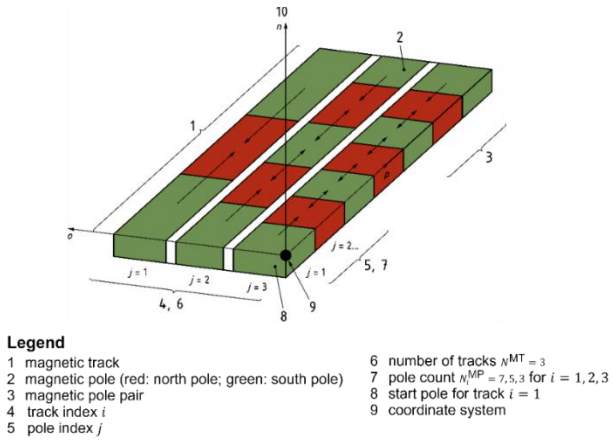

Fig. 8. Auxiliary graphic: Terminology linear scales

To support the practical implementation, the main document was supplemented by several example drawings (Fig. 9). Different types of dimensional standards were shown with the required track, pole and sensor data. Furthermore, the drawings were provided with DIN-compliant form and position tolerances to provide assistance in the mechanical description of the dimensional scale.

V. SUMMARY AND OUTLOOK

Magnetic measuring systems are increasingly used in numerous fields of application. However, there was a lack of standardisation of the representation of magnetic measurement scales. In the creation of DIN SPEC 91411 "Requirements for the technical representation of magnetic measurement scales in construction drawings", a taxonomy, glossary and example drawings were created. DIN SPEC 91411 was successfully published in August 2022 and already actively used by several consortium members. The English version is also now available. The new DIN SPEC standard helps to avoid unnecessary errors in the selection, design and procurement of magnetic measurement scales. The way is the goal: The consortium work not only had the new standard as a result, but also provided a very effective forum for knowledge ex-change between the consortium members. Another DIN SPEC project was started under the auspices of INNOM-AG e. V. as a logical follow-up to DIN SPEC 91411. DIN SPEC 91479 deals with the characterisation of magnetic measurement scales. The aim is to establish a common terminology and define standardised rules for test conditions, measuring equipment and measuring procedures. DIN SPEC 91479 is scheduled for completion during 2023.

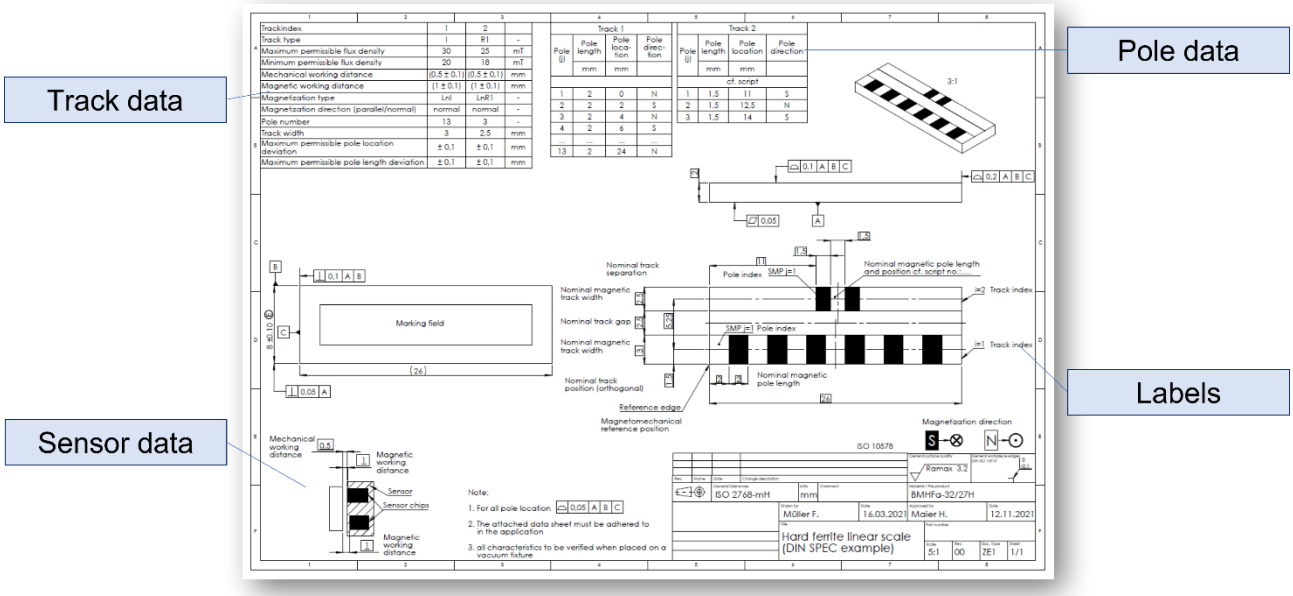

Fig. 9. Example drawing with additional data and labels

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