# SUPPLEMENTARY COMPARISON OF NATIONAL STANDARD FACILITIES IN THE FIELD OF MEASURING THE POLARIZATION AND SPECIFIC TOTAL POWER LOSS IN SOFT MAGNETIC MATERIALS.

Registration number

## TECHNICAL PROTOCOL

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## 1 Introduction

At a meeting at the PTB in Braunschweig on the 5th and 6th of March 2014 between the representatives of UNIIM (Russia), PTB (Germany), CMI (Czech Republic), NPL (United Kingdom) the decision was made to carry out a supplementary comparison for the measurement of specific total power loss in soft magnetic materials. The measurements should be done in compliance to IEC 60404 part 3 on a defined set of magnetic materials supplied by UNIIM and NPL. Possible additional participant is INRIM (Italy).

Two work items have been defined:

- First: the results of the measurements shall demonstrate the degree of equivalence between the laboratories.
- Second: the capability of the test equipment shall be compared.

**CMC classification numbers:**

12.3.1 Specific total power loss: Epstein, ring and single sheet sample

## 1 Participants:

| № | NMI | Mail address | NMI acronym | Contact person | E-mail, phone fax |
|---|---|---|---|---|---|
| 1 | Ural Scientific Research Institute of Metrology | 620000, Russia, Yekaterinburg, ул. Krasnoarmeyskaya Str, 4 | "UNIIM" | Malygin Michael Aleksandrovich | E-mail: maligin@uniim.ru Tel/Fax (343)355-38-92 |
| 2 | Physikalisch-Technische Bundesanstalt | Bundesallee 100 38116 Braunschweig Germany | PTB | Dr.Martin Albrecht | Email: martin.albrecht@ptb.de |
| 3 | Czech Metrology Institute | Czech Republic, V Botanice 4, Praha 5 15072 | CMI | Josef Kupec Michal Ulvr | Email: jkupec@cmi.cz |
| 4 | Istituto Nazionale di Ricerca Metrologica | Strada delle Cacce 10135 Torino ITALY | INRIM | Carlo Appino | c.appino@inrim.it Phone: +39 011 3919 841 Fax: +39 011 3919 834, |

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|---|---|---|---|---|---|
| 5 | National Physical Laboratory | Hampton Road, Teddington5, Middlesex, TW11 0LW. | NPL | Dr Michael Hall | Email: michael.hall@npl.co.uk |

## 2 Organization of the comparisons

### 2.1 The samples

Four samples will be prepared for the comparison:

2 Epstein samples (UNIIM);
1 ring sample for comparison (UNIIM); and
1 ring sample for the comparison of the electrical measurements (NPL)

For the transfer standards provided by UNIIM three sets of each sample are prepared. Two sets stay at UNIIM and one set is distributed around the participants for the measurements of the comparison. Two sets are kept in reserve in case of damage to samples being circulated.

The transfer standards are samples of grain oriented and non-oriented electrical steel:

- one sample (No 1) of non-oriented steel in the form of strips with the dimensions (30×280) mm for Epstein frame measurements with a weight of approximately 0,5 kg and thickness of approximately 0,35 mm. The quantity of the strips in the sample must be a multiple of 4;
- one sample (No 2) of grain oriented steel in the form of strips with the dimensions (30×280) mm for Epstein frame measurements with a weight of approximately 0,5 kg, and thickness of approximately 0,23 mm. The quantity of the strips in the sample must be a multiple of 4;
- one ring sample made by a method of stamping of rings from grain oriented steel with the primary and secondary winding placed on the core and fixed firmly in position.
- one ring sample made of non-oriented steel with known characteristic supplied by NPL.

Samples are packed in wooden boxes for their safety during transportation. When received by a participant they should inform the laboratory that sent the transfer standards as well as the pilot laboratories that they have been received. Any damage to the box and/or transfer standards should be reported to the pilot laboratories immediately.

### 2.2 The organization of the comparison

The Comparison is carried out by a circulation scheme.

Standard samples are produced by UNIIM (Russia) by May 2014 and measured with ГЭТ 198-2011 by June 2014. When received, each participant should finish testing and shipping within one month. The participant report should be sent to the pilot laboratory performing the analyses within 2 months of completing their measurements.

After initial measurements at UNIIM one set of each sample and the single NPL ring core are sent to: 1. PTB, 2. CMI, 3. INRIM, 4. NPL, and after this back to UNIIM for final measurements to establish the stability (except NPL ring core). Use set labelled 01 as long as no damage has occurred.

After measurement the data should be sent to UNIIM for evaluation of the comparison results.

### 2.3 Epstein samples

#### 2.3.1 Preparation of the transfer samples for measurements

The Epstein pack from the set labelled 01 should be measured unless this has been replaced due to damage.

The sample in the form of strips with sizes 30x280 mm should be loaded into the Epstein frame in accordance with figure 1. On each strip an index showing the position within the pack and an arrow specifying position of the strip in the solenoids of the Epstein frame. The strips 1.1 and 3.1 are placed in solenoids 1 and 3 of the Epstein frame first. The solenoids 1 and 3 of the Epstein frame are parallel. The strips 2.1 and 4.1 are placed in the solenoids 2 and 4 of the Epstein frame. This sequence is repeated until all strips are loaded into the frame.

When loading the non-oriented steel, strips cut with the rolling direction should be loaded into two parallel solenoids with the strips cut against the rolling direction loaded into the other two solenoids.

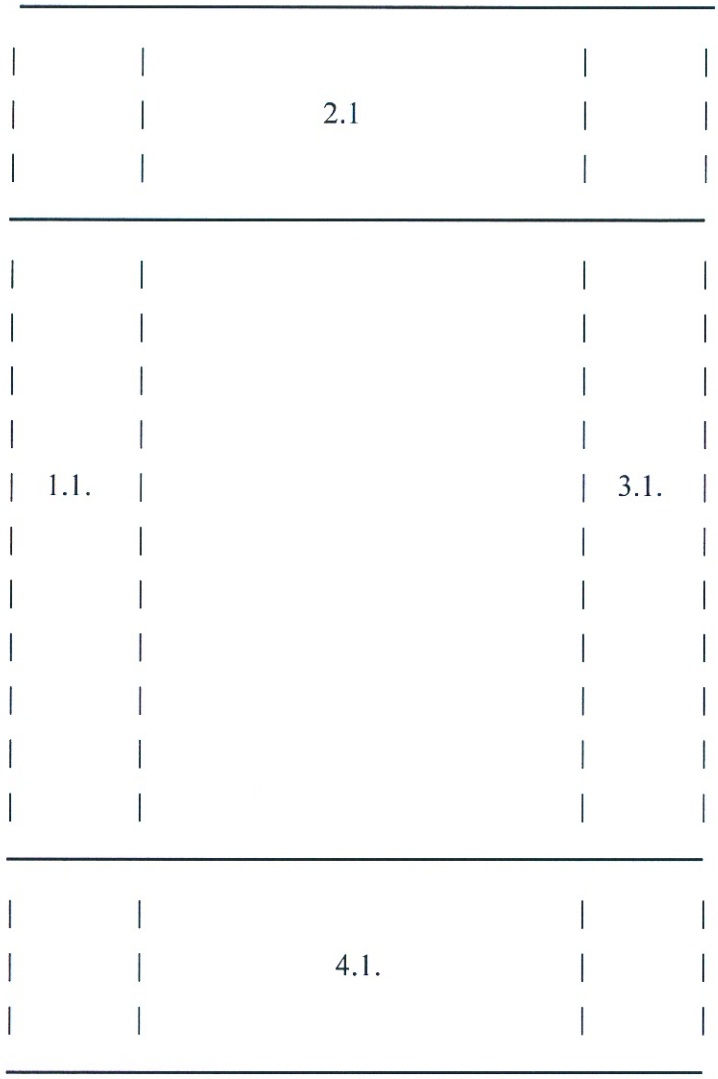


Figure 1 – Method of loading strips in the Epstein frame.

The sample is demagnetized by a variable magnetic field with a frequency of 50 Hz and with decreasing amplitude starting from a peak polarization larger than that used for measurements to a value as close as possible to zero. This should be not less than 1,8 T for an grain-oriented steel and not less than 1,6 T for an non-oriented steel. The time taken for the demagnetization should be not less than 40 s.

This demagnetization should be performed before each series of measurements.

### 2.3.2 Measurements of the Epstein samples

Each participant performs the following measurements using their standard equipment and measurement procedure:

The specific total loss and specific apparent power are measured stepwise from the lowest to the highest peak polarization value given below. At these values of peak magnetic polarization the values of the peak magnetic field strength are measured simultaneously (preferably).

Parameters for Epstein sample No 1(non-oriented):

Frequency 50 Hz, 60 Hz

Magnetizing curve $J_{max} = F(H_{max})$

$H_{max}$ = 100, 200, 500, 1000, 2500, A/m.

Specific loss $P = F(J_{max})$

at $J_{max}$ = 1.0; 1.1; 1.3; 1.5; 1.6 T.

Parameters for Epstein sample No 2 (grain oriented):

Frequency 50 Hz, 60 Hz

Magnetizing curve $J_{max} = F(H_{max})$

at $H_{max}$ = 30, 100, 500, 1000, 1500 A/m.

Specific loss $P = F(J_{max})$

at $J_{max}$ = 1.0; 1.3; 1.5; 1.7; 1.8 T

## 2.4 Ring samples

### 2.4.1 Preparation of the ring samples

The sample is connected to the measurement setup used for this comparison. The sample is demagnetized by a variable magnetic field with frequency 50 Hz and with decreasing amplitude starting from a peak polarization larger than that used for measurements to a value as close as possible to zero. This should be not less than 1,8 T for an grain-oriented steel and not less than 1,6 T for an non-oriented steel.. The time taken for the demagnetization should be not less than 40 s.

This demagnetization should be performed before each series of measurements.

### 2.4.2 Measurements on the ring samples

On the ring samples the specific total power loss and specific apparent power are measured stepwise from the lowest to the highest value given below. At the same values of the peak total magnetic flux density, B, the values of the peak magnetic field strength are measured simultaneously (preferably).

Parameter sets for the measurements on the grain oriented ring:

1. Frequency 50 Hz, 60 Hz
   Magnetizing curve $J_{max} = F(H_{max})$
   at $H_{max} = 30, 100, 500, 1000, 1500$ A/m.
   Specific loss $P = F(J_{max})$
   at $J_{max} = 1.0; 1.3; 1.5; 1.7; 1.8$ T
2. Frequency 400 Hz,
   Magnetizing curve $J_{max} = F(H_{max})$
   at $H_{max} = 30, 100, 500, 1000, 1300$ A/m.

   Specific loss $P = F(J_{max})$
   at $J_{max} = 1.0; 1.3; 1.5; (1.6; 1.7)$ T
3. Frequency 1000 Hz if possible,
   Magnetizing curve $J_{max} = F(H_{max})$
   at $H_{max} = 30, 100, 300, 500$ A/m.
   Specific loss $P = F(J_{max})$
   at $J_{max} = 0.5; 0.7; 1.0$ T

Parameters for the NPL ring core manufactured from non-oriented Transil grade steel:

1. Frequency 50 Hz, 60 Hz
   Magnetizing curve $J_{max} = F(H_{max})$
   $H_{max} = 100, 200, 500, 1000$ A/m.
   Specific loss $P = F(J_{max})$
   at $J_{max} = 1.0; 1.1, 1.3; 1.5; 1.6$ T.

## 3 Report of the results

3.1 Each participant shall send a report giving their results, a description of the measuring method and a statement of their traceability including if other National Standards are used.

3.2 The measurement uncertainties should be provided in the form of an uncertainty budget that list the uncertainty contributions:

| Standard uncertainty | A | B |
|---|---|---|
| Contribution due to | | |
| | | |
| | | |
| | | |
| Combined uncertainty (Quadratic summation) | | |
| Total combined standard uncertainty | | |
| Expanded uncertainty k=2 | | |
| Level of confidence | | |

3.3 The calculation of the expanded uncertainty is performed for a coverage factor of k = 2 that provides a confidence level of approximately 95%.

**4 Method estimation of the comparison results**

The estimation of the reference value with its uncertainty and the degree of equivalence of the NMIs participating in the comparison will be performed in accordance to the Guide of Uncertainty of Measurements (GUM).

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|---|---|---|
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| Physikalisch-Technische Bundesanstalt (PTB), Germany | Albrecht Martin | signature |
| Czech Metrology Institute (CMI), Czech Republic | Josef Kupec | signature |
| National ~~Physics~~ PHYSICAL Laboratory (NPL), United Kingdom | Michael Hall | signature |
| Istituto Nazionale di Ricerca Metrologica (INRIM), Italy | Carlo Appino | signature |