Extended comparisons of total power loss measurements performed by Epstein frame using revised procedures at room temperature

Extended final report

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Table of contents

1 Introduction

Two experimental setups are currently used for the measurement of power losses in magnetic steels – the Epstein frame and the Single Sheet Tester (SST). To date, a number of intercomparisons, promoted by EURAMET and the IEC TC 68 have confirmed good reproducibility for both the Epstein and SST methods, with an uncertainty around 1 % for the power loss measurement. These comparisons, however, were only focused on measurements at 50 Hz and room temperature [1].

Within the HEFMAG project a new reference round robin comparison was performed between Epstein frames and SST at 50 Hz and 100 Hz using non-oriented and grain-oriented samples. In addition, a new Epstein round robin comparison up to higher frequencies of 10 kHz using non-oriented and $Fe_{50}Co_{50}$ sheets was performed.

As an output of the round robin test a number of documents will be drafted in parallel to the conductance of the measurements. At all stages of the round robin test these documents shall reflect the current state of knowledge:

1. Report of measurement results: This document contains the results of measurements and their accuracy for each method and each laboratory and a discussion of the findings during the round robin comparison. This report will be shared through a report to IEC TC 68 and made available to the stakeholders.
2. A Good practice guide on the measurement of power losses in non-oriented steels and grain-oriented materials using standard measurement setups at room temperature will be developed for end users This document will provide the basis for discussions on CMC revisions and updates of some of the IEC 60404 standards within the IEC TC 68.

2 Reference samples

The aim of this task is to evaluate and reduce the uncertainty of Epstein frame power loss measurements for low and high frequencies from 50 Hz to 10 kHz at room temperature according to IEC 60404-2 (or if necessary IEC 60404-10).

Six Epstein samples were prepared for the comparison. The transfer standards are samples of grain-oriented (GO) and non-oriented (NO) electrical steel:

- two samples of NO steel in the form of strips for Epstein frame measurements with a weight of at least 240 g for the 700 turns Epstein (according to IEC 60404-2) and no less than 12 strips for the 100 turns or 200 turns Epstein (according to IEC 60404-10). The quantity of the strips in the sample must be a multiple of 4 and rolling direction must be considered. Thickness will be approximately 0.2 mm (NO 0.2) and 0.3 mm (NO 0.3).
- three samples of GO steel in the form of strips for Epstein frame measurements with a weight of at least 240 g for the 700 turns Epstein (according to IEC 60404-2) and no less than 12 strips for the 100 turns or 200 turns Epstein (according to IEC 60404-10). The quantity of the strips in the sample must be a multiple of 4 and rolling direction must be considered. Thickness will be approximately 0.18 mm (GO 0.18), 0.2 mm (Laser scribed 0.2) and 0.3 mm (GO 0.3).
- sample of $Fe_{50}Co_{50}$ steel sheets in the form of Epstein strips (minimum 12) and thickness of approximately 0.2 mm (FeCo 0.2). The quantity of the strips in the sample must be a multiple of 4. The sample will be used for measurement at frequencies up to 10 kHz.

All samples were demagnetized prior to measurement.

3 Measurements to be made

3.1 *Quantity to be measured*

Measurements of specific total power loss P_s (W/kg) of the Epstein samples were performed according to the standard IEC 60404-2 (up to 400 Hz) and IEC 60404-10 (above 400 Hz) using optimized experimental Epstein setups for power loss measurements under standard conditions.

The magnetic polarization J_m was measured at H_m = 800 A/m in the GO strips and at H_m = 2500 A/m in the NO strips. A frequency of 50 Hz was used for both GO and NO strips.

4 Organisation

4.1 *Pilot Laboratory*

Pilot laboratory:

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4.2 *Participants*

The following national metrology institutes (NMIs) and stakeholders participated in the comparison:

Acronym	Laboratory	Country	Contact
INRIM	Istituto Nazionale di Ricerca Metrologica	Italy	Massimo Pasquale m.pasquale@inrim.it Carlo Appino c.appino@inrim.it
PTB	Physikalisch-Technische Bundesanstalt	Germany	Franziska Weickert franziska.weickert@ptb.de Korbinian Pfnuer korbinian.pfnuer@ptb.de

CMI	Czech Metrology Institute	Czech Republic	Michal Ulvr mulvr@cmi.cz
NPL	National Physical Laboratory	United Kingdom	Stuart Harmon stuart.harmon@npl.co.uk Daniel Brunt daniel.brunt@npl.co.uk
UNOTT	University of Nottingham	United Kingdom	Gaurang Vakil Gaurang.Vakil@nottingham.ac.uk Ram Ramanathan Mathavan Jeyabalan Ram.Ramanathan@nottingham.ac.uk
NIM	National Institute of Metrology	China	Wenjie Gong wjgong@nim.ac.cn
×	Baosteel	China	ZHOU Xing ZHOUXH@tunkia.com shenjie170498@baosteel.com
M-P	Magnet-Physik	Germany	Robert Hiergeist robert.hiergeist@magnet-physik.de
TK	ThyssenKrupp	Germany, France	Christian Hecht christian.hecht@thyssenkrupp.com

4.3 *Comparison schedule*

The comparison was carried out by a circulation scheme. The organization of the comparison follows: 1. INRIM, 2. PTB, 3. CMI, 4. NPL, 5. UNOTT and then the samples was returned to INRIM.
After this round the samples were sent to NIM China and stakeholders Baosteel, Magnet-Physik and ThyssenKrupp.

It was expected that each participant covers the freight charges from his location to the next on the list. Each participant was responsible for insurance of the samples from arrival in their laboratory until arrival in the subsequent laboratory.

The transport of the travelling standards was arranged by door-to-door parcel service.

5 Measurement instructions

5.1 *Measurements of the samples*

Each participant performed the following measurements using their standard equipment and measurement procedure. The specific total losses were measured stepwise from the lowest to the highest peak polarization value J_m given below at given frequencies. The measuring temperature was 23 ± 1 °C. If not, an appropriate correcting of the coefficient was applied.

Parameters for the Epstein sample NO 0.2	
frequency (Hz)	**specific total power loss at J_m**
50	1 T, 1.4 T, 1.5 T
100	1 T, 1.4 T, 1.5 T
200	1 T, 1.4 T
400	1 T, 1.4 T

Parameters for the Epstein sample NO 0.3	
frequency (Hz)	**specific total power loss at J_m**
50	1 T, 1.25 T, 1.5 T
100	1 T, 1.25 T, 1.5 T
200	1 T, 1.25 T, 1.5 T
400	1 T, 1.25 T
1000	0.5 T, 1 T, 1.25 T
2000	0.5 T
5000	0.1 T,0.2 T, 0.35 T
10000	0.1 T, 0.15 T

Parameters for the Epstein GO samples	
frequency (Hz)	**specific total power loss at J_m**
50	1 T, 1.5 T, 1.7 T, 1.8 T
100	1 T, 1.5 T, 1.7 T, 1.8 T
200	1 T, 1.5 T, 1.7 T, 1.8 T
400	1 T, 1.5 T, 1.7 T, 1.8 T
1000	0.5 T, 1 T, 1.5 T, 1.7 T, 1.8 T

Parameters for the Epstein sample FeCo 0.2	
frequency (Hz)	**specific total power loss at J_m**
50	0.5 T, 1 T, 1.5 T, 1.7 T, 2 T
100	0.5 T, 1 T, 1.5 T, 1.7 T, 2 T
200	0.5 T, 1 T, 1.5 T, 1.7 T, 2 T
400	0.5 T, 1 T, 1.5 T, 1.7 T, 2 T
1000	0.5 T, 1 T, 1.5 T, 1.7 T
2000	0.5 T
10000	0.1 T, 0.15 T

6 Measurement results

6.1 *Calculation of the reference value and its uncertainty*

For all measurements of total losses and $J_m(H_m)$ measurements, the evaluation of this comparison was performed following procedure B in [2]. The Mandel-Paule (M-P) mean [3] was chosen for the analysis of the data. On its basis the following characteristics were calculated:

- the modified reduced observed chi-squared value by the formula:

$$\tilde{\chi}_{obs} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\frac{(x_i - x_{ref})^2}{u_i^2 + s^2}} \quad (1)$$

where N is the number of participants, x_i is the results of the total losses of the i-th participant of the comparisons and u_i is the declared standard uncertainty of the i-th participant of the comparison for coverage factor k = 1 (68%). The value of the unexplained variance s^2 is chosen such that chi-squared value < 1.

- the reference value of total losses x_{ref} by the formula:

$$x_{ref} = u^2(x_{ref})\sum_{i=1}^{N}\frac{x_i}{u_i^2 + s^2} \quad (2)$$

- standard uncertainty of the reference value of total losses $u(x_{ref})$ by the formula:

$$u(x_{ref}) = \left[\sum_{i=1}^{N}\frac{1}{u_i^2 + s^2}\right]^{-1/2} \quad (3)$$

- the degree of equivalence of the measurement standard d_i by the formula (4) with a corresponding uncertainty by the formulas (5), (6):

$$d_i = x_i - x_{ref} \quad (4)$$

$$u(d_i) = \sqrt{u^2(x_i) + u^2(x_{ref})} \quad (5)$$

$$E_n = \frac{|d_i|}{2u(d_i)}, \quad (6)$$

where d_i is degree of equivalence and $u(d_i)$ is the standard uncertainty of the degree of equivalence.

The declared uncertainties are judged as confirmed if equation $E_n < 1$ is satisfied, that is a confirmation of the relevant rows from CMC.

The maximal value of the expanded uncertainty of the reference value $U(x_{ref})$ ($k = 2$) was chosen as 3 % for frequencies up to 400 Hz and 5 % for frequencies above 400 Hz except FeCo sample, where the maximal value of the expanded uncertainty of the reference value was chosen as 5 % for all frequencies

6.2 *Evaluation of comparison results*

Results of NMIs are marked as Lab1, Lab2, etc. and stakeholders results are marked as Stkh1, Stkh2, etc.
Analysis of the GO 0.18 sample measurement is divided into two parts, one with the results of the NMIs only and the second with the results of stakeholders only, because two different samples were used and the two sets of results could not be directly compared without a large increase of the overall uncertainty.

Parameters of measured samples:

Sample	Density (kg/m^3)	Cross section ($\times 10^{-5}\ m^2$)	Weight (kg)	Number of strips, N_s (-)	Nominal length (m)
Laser scribed GO 0.2	7650	3.3105 2.2073 1.6545	0.30924 0.20618 0.15455	24 16 12	0.305
GO 0.18	7650	2.61590 2.09280	0.25640 0.20504	20 16	0.320
NO 0.3	7600	2.64974	0.24140	12	0.300
GO 0.3	7650	4.2840	0.39331	20	0.300
NO 0.2	7650	2.89547 1.73397	0.26576 0.15917	20 12	0.300
FeCo 0.2	8120	3.5662 1.7834	0.34755 0.1736	24 12	0.300

6.2.1 Total losses results

Results of the NO 0.3 sample

N_s	Losses	Lab1		Lab2		Lab3		Lab4		Lab5		Lab6		Stkh1		Stkh2		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-12	$P_{1.0/50}$	0.903	0.25	0.904	0.18	0.903	0.70	0.904	0.325	0.904	0.35	0.901	0.5	0.9028	0.14	0.903	0.5	0.9032	0.0008
	$P_{1.4/50}$	1.826	0.25	1.837	0.24	1.830	0.90	1.839	0.375	1.850	0.4	1.833	0.5	1.8328	0.17	1.818	0.5	1.8338	0.0037
	$P_{1.5/50}$	2.158	0.40	2.173	0.27	2.160	0.90	2.174	0.375	2.172	0.4	2.162	0.5	2.1607	0.16	2.141	0.5	2.1636	0.0047
	$P_{1.0/100}$	2.099	0.25	2.112	0.18	2.090	0.70	2.107	0.325	2.109	0.35	2.102	0.5	2.1047	0.16	2.100	0.5	2.1046	0.0038
	$P_{1.4/100}$	4.219	0.25	4.283	0.26	4.230	0.90	4.285	0.375	4.302	0.35	4.266	0.5	4.2622	0.17	4.229	0.5	4.261	0.019
	$P_{1.5/100}$	4.964	0.25	5.075	0.26	4.990	0.90	5.068	0.375	5.033	0.4	5.028	0.5	5.0150	0.17	4.980	0.5	5.020	0.026
	$P_{1.0/200}$	5.232	0.30	5.272	0.18	5.220	0.70	5.235	0.20	5.277	0.35	5.249	0.5	5.2627	0.33	5.246	0.5	5.252	0.010
	$P_{1.4/200}$	10.552	0.60	10.72	0.24	10.530	0.90	10.56	0.30	10.753	0.40	10.650	0.5	10.6594	0.28	10.586	0.5	10.630	0.056
	$P_{1.0/400}$	13.959	0.65	14.17	0.20	14.100	0.90	14.09	0.20	14.217	0.3	14.160	0.75	14.2037	0.3	14.158	0.5	14.145	0.033
	$P_{1.4/400}$	28.462	0.65	×	×	28.88	0.9	28.83	0.28	×	×	29.110	0.75	29.2582	0.33	29.039	0.5	28.94	0.18

N_s	Losses	d_i								$u(d_i)$							
		Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2
1-12	$P_{1.0/50}$	-0.0002	0.0008	-0.0006	0.0008	0.0008	-0.0022	-0.0004	-0.0006	0.002	0.002	0.006	0.003	0.003	0.005	0.002	0.005
	$P_{1.4/50}$	-0.0078	0.0034	-0.0038	0.0052	0.0162	-0.0008	-0.0010	-0.0153	0.006	0.006	0.017	0.008	0.008	0.010	0.005	0.010
	$P_{1.5/50}$	-0.0056	0.0095	-0.0036	0.0104	0.0084	-0.0016	-0.0029	-0.0229	0.010	0.008	0.020	0.009	0.010	0.012	0.006	0.012
	$P_{1.0/100}$	-0.0056	0.0073	-0.0146	0.0024	0.0044	-0.0026	0.0001	-0.0046	0.006	0.005	0.015	0.008	0.008	0.011	0.005	0.011
	$P_{1.4/100}$	-0.0418	0.0222	-0.0308	0.0242	0.0412	0.0052	0.0014	-0.0319	0.022	0.022	0.042	0.025	0.024	0.028	0.020	0.028
	$P_{1.5/100}$	-0.0562	0.0548	-0.0302	0.0478	0.0128	0.0078	-0.0052	-0.0399	0.029	0.029	0.052	0.032	0.033	0.036	0.027	0.036
	$P_{1.0/200}$	-0.0199	0.0201	-0.0319	-0.0169	0.0251	-0.0029	0.0108	-0.0058	0.018	0.014	0.038	0.014	0.021	0.028	0.020	0.028
	$P_{1.4/200}$	-0.0784	0.0896	-0.1004	-0.0704	0.1226	0.0196	0.0290	-0.0449	0.085	0.062	0.110	0.064	0.071	0.077	0.064	0.077
	$P_{1.0/400}$	-0.1859	0.0241	-0.0449	-0.0549	0.0721	0.0151	0.0588	0.0130	0.096	0.043	0.131	0.043	0.054	0.111	0.054	0.078
	$P_{1.4/400}$	-0.4736	×	-0.0556	-0.1056	×	0.1744	0.3226	0.1038	0.256	×	0.315	0.194	×	0.281	0.202	0.229

N_s	Losses	E_n							
		Lab1	**Lab2**	**Lab3**	**Lab4**	**Lab5**	**Lab6**	**Stkh1**	**Stkh2**
1-12	$P_{1.0/50}$	**0.045**	**0.212**	**0.046**	**0.129**	**0.120**	**0.242**	**0.138**	**0.064**
	$P_{1.4/50}$	**0.657**	**0.298**	**0.111**	**0.334**	**0.979**	**0.038**	**0.098**	**0.780**
	$P_{1.5/50}$	**0.287**	**0.629**	**0.091**	**0.550**	**0.423**	**0.070**	**0.252**	**0.977**
	$P_{1.0/100}$	**0.430**	**0.682**	**0.482**	**0.155**	**0.267**	**0.115**	**0.012**	**0.205**
	$P_{1.4/100}$	**0.968**	**0.507**	**0.363**	**0.488**	**0.854**	**0.091**	**0.034**	**0.563**
	$P_{1.5/100}$	**0.975**	**0.941**	**0.291**	**0.743**	**0.195**	**0.108**	**0.094**	**0.554**
	$P_{1.0/200}$	**0.540**	**0.743**	**0.422**	**0.593**	**0.602**	**0.052**	**0.272**	**0.104**
	$P_{1.4/200}$	**0.464**	**0.726**	**0.456**	**0.547**	**0.867**	**0.127**	**0.228**	**0.291**
	$P_{1.0/400}$	**0.964**	**0.278**	**0.171**	**0.636**	**0.671**	**0.068**	**0.547**	**0.083**
	$P_{1.4/400}$	**0.924**	×	**0.088**	**0.272**	×	**0.310**	**0.799**	**0.227**

Results of the GO 0.18 sample

N_s	Losses	Lab1		Lab2		Lab3		Lab4		Lab5		Lab6		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-20	$P_{1.0/50}$	0.256	0.25	0.2369	0.21	0.237	0.50	0.244	0.33	×	×	0.244	0.5	0.2395	0.0023
	$P_{1.5/50}$	×	×	0.5322	0.21	0.527	0.50	0.540	0.33	×	×	0.542	0.5	0.5354	0.0041
	$P_{1.7/50}$	×	×	0.7243	0.28	0.712	0.70	0.732	0.38	×	×	0.746	0.5	0.7288	0.0082
	$P_{1.8/50}$	0.929	0.25	0.928	0.55	×	×	0.931	0.55	×	×	0.968	0.5	0.9291	0.0020
	$P_{1.0/100}$	×	×	0.6473	0.20	0.644	0.50	0.676	0.33	0.6741	0.35	0.668	0.5	0.6620	0.0086
	$P_{1.5/100}$	×	×	1.4672	0.20	×	×	1.500	0.33	1.5164	0.4	1.491	0.5	1.494	0.015

	$P_{1.7/100}$	×	×	1.969	0.26	1.935	0.70	1.993	0.35	×	×	2.008	0.5	1.977	0.021
	$P_{1.8/100}$	2.452	0.25	2.470	0.52	2.411	1.00	2.470	0.50	×	×	2.534	0.5	2.468	0.032
	$P_{1.0/200}$	1.896	0.25	1.889	0.20	1.887	0.50	1.940	0.33	1.9120	0.35	1.944	0.5	1.911	0.015
	$P_{1.5/200}$	4.315	0.25	4.307	0.20	4.309	0.50	4.312	0.23	4.3940	0.35	4.362	0.5	4.333	0.025
	$P_{1.7/200}$	5.637	0.25	5.667	0.23	5.639	0.70	5.640	0.23	5.8130	0.4	5.747	0.5	5.690	0.062
	$P_{1.8/200}$	6.741	0.25	6.811	0.42	6.700	1.00	6.74	0.38	×	×	6.967	0.5	6.85	0.071
1-16	$P_{1.0/400}$	5.857	0.30	5.839	0.20	5.902	0.50	5.997	0.20	5.8790	0.35	5.935	0.75	5.901	0.050
	$P_{1.5/400}$	13.384	0.30	13.40	0.18	13.438	0.50	13.30	0.20	13.5930	0.4	13.260	0.75	13.397	0.085
	$P_{1.7/400}$	17.039	0.30	17.11	0.21	17.131	0.70	16.99	0.20	17.3390	0.4	17.020	0.75	17.11	0.11
	$P_{1.8/400}$	19.463	0.30	19.54	0.26	19.537	1.00	19.41	0.28	20.1700	0.4	19.790	0.75	19.65	0.27
	$P_{1.0/1000}$	27.105	0.50	27.13	0.21	27.445	0.50	27.30	0.20	27.1500	0.45	27.160	1.00	27.218	0.054

N_s	Losses	d_i						$u(d_i)$						E_n					
		Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	**Lab1**	**Lab2**	**Lab3**	**Lab4**	**Lab5**	**Lab6**
1-20	$P_{1.0/50}$	-0.0035	-0.0027	-0.0026	0.0045	×	0.0045	0.002	0.002	0.003	0.002	×	0.003	**0.750**	**0.574**	**0.510**	**0.930**	×	**0.868**
	$P_{1.5/50}$	×	-0.0032	-0.0079	0.0046	0.0165	0.0066	×	0.004	0.005	0.004	0.005	0.005	×	**0.374**	**0.806**	**0.510**	×	**0.666**
	$P_{1.7/50}$	×	-0.0045	-0.0164	0.0032	0.0251	0.0172	×	0.008	0.010	0.009	0.009	0.009	×	**0.268**	**0.855**	**0.184**	×	**0.955**
	$P_{1.8/50}$	-0.0001	-0.0011	×	0.0019	×	0.0389	0.003	0.005	×	0.005	×	0.005	**0.024**	**0.105**	×	**0.169**	×	×
	$P_{1.0/100}$	×	-0.0147	-0.0175	0.0140	0.0121	0.0060	×	0.009	0.009	0.009	0.009	0.009	×	**0.846**	**0.956**	**0.792**	**0.674**	**0.327**
	$P_{1.5/100}$	×	-0.0263	×	0.0065	0.0229	-0.0025	×	0.016	×	0.016	0.016	0.017	×	**0.846**	×	**0.204**	**0.698**	**0.073**
	$P_{1.7/100}$	×	-0.0077	-0.0422	0.0163	0.0571	0.0313	×	0.021	0.025	0.022	0.022	0.023	×	**0.181**	**0.857**	**0.377**	×	**0.685**
	$P_{1.8/100}$	-0.0163	0.0017	-0.0569	0.0017	0.1615	0.0657	0.033	0.034	0.040	0.034	0.034	0.034	**0.250**	**0.025**	**0.710**	**0.025**	×	**0.955**
	$P_{1.0/200}$	-0.0151	-0.0221	-0.0243	0.0289	0.0009	0.0329	0.015	0.015	0.017	0.016	0.016	0.018	**0.493**	**0.735**	**0.698**	**0.909**	**0.027**	**0.938**
	$P_{1.5/200}$	-0.0176	-0.0256	-0.0239	-0.0206	0.0614	0.0294	0.027	0.027	0.033	0.027	0.032	0.033	**0.321**	**0.480**	**0.360**	**0.381**	**0.956**	**0.440**
	$P_{1.7/200}$	-0.0534	-0.0234	-0.0512	-0.0504	0.1226	0.0566	0.064	0.063	0.074	0.063	0.065	0.068	**0.420**	**0.185**	**0.348**	**0.399**	**0.939**	**0.414**
	$P_{1.8/200}$	-0.1095	-0.0395	-0.1500	-0.1105	x	0.1165	0.073	0.077	0.098	0.075	x	0.079	**0.750**	**0.258**	**0.768**	**0.733**	**x**	**0.737**

1-16	$P_{1.0/400}$	-0.0440	-0.0620	0.0011	0.0960	-0.0220	0.0340	0.053	0.051	0.058	0.051	0.055	0.067	**0.415**	**0.604**	**0.010**	**0.933**	**0.199**	**0.254**
	$P_{1.5/400}$	-0.0133	-0.0003	0.0409	-0.0973	0.1957	-0.1373	0.094	0.088	0.108	0.089	0.105	0.131	**0.071**	**0.002**	**0.189**	**0.548**	**0.936**	**0.525**
	$P_{1.7/400}$	-0.0661	0.0059	0.0256	-0.1151	0.2339	-0.0851	0.119	0.113	0.161	0.112	0.123	0.167	**0.278**	**0.026**	**0.080**	**0.512**	**0.951**	**0.255**
	$P_{1.8/400}$	-0.1883	-0.1123	-0.1140	-0.2413	0.5187	0.1387	0.275	0.274	0.333	0.274	0.281	0.307	**0.342**	**0.205**	**0.171**	**0.440**	**0.923**	**0.226**
	$P_{1.0/1000}$	-0.1126	-0.0906	0.2279	0.0824	-0.0676	-0.0576	0.146	0.078	0.147	0.076	0.121	0.277	**0.386**	**0.580**	**0.774**	**0.539**	**0.279**	**0.104**

N_s	Losses	Stkh1		Stkh2		Stkh3		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %		
1-20	$P_{1.0/50}$	0.2448	0.31	0.248	0.5	0.243	0.5	0.2452	0.0016
	$P_{1.5/50}$	0.5468	0.25	0.542	0.5	0.539	0.5	0.5430	0.0027
	$P_{1.7/50}$	0.7532	0.32	0.741	0.5	0.736	0.5	0.7436	0.0061
	$P_{1.8/50}$	0.9780	0.29	0.948	0.5	0.949	0.5	0.959	0.011
	$P_{1.0/100}$	0.6767	0.2	0.676	0.5	0.675	0.5	0.6764	0.0012
	$P_{1.5/100}$	1.5115	0.24	1.501	0.5	1.493	0.5	1.5033	0.0058
	$P_{1.7/100}$	2.0339	0.27	2.004	0.5	1.990	0.5	2.010	0.015
	$P_{1.8/100}$	2.5650	0.27	2.496	0.5	2.496	0.5	2.520	0.024
	$P_{1.0/200}$	1.9696	0.32	1.951	0.5	1.965	0.5	1.9636	0.0056
	$P_{1.5/200}$	4.4096	0.23	4.357	0.5	4.352	0.5	4.377	0.020
	$P_{1.7/200}$	5.8188	0.43	5.727	0.5	5.711	0.5	5.753	0.038
	$P_{1.8/200}$	7.0842	0.20	6.867	0.5	6.902	0.5	6.954	0.071
1-16	$P_{1.0/400}$	6.0200	0.33	5.874	0.75	5.937	0.75	5.951	0.046
	$P_{1.5/400}$	13.6664	0.25	13.144	0.75	13.204	0.75	13.35	0.18
	$P_{1.7/400}$	17.5586	0.23	16.987	0.75	16.987	0.75	17.19	0.21
	$P_{1.8/400}$	20.1936	0.33	19.789	0.75	19.841	0.75	19.97	0.14

N_s	Losses	d_i			$u(d_i)$			E_n		
		Stkh1	Stkh2	Stkh3	Stkh1	Stkh2	Stkh3	**Stkh1**	**Stkh2**	**Stkh3**
1-20	$P_{1.0/50}$	-0.0004	0.0028	-0.0022	-0.0004	0.002	0.002	**0.002**	**0.126**	**0.689**
	$P_{1.5/50}$	0.0038	-0.0010	-0.0040	0.0038	0.003	0.004	**0.004**	**0.639**	**0.130**
	$P_{1.7/50}$	0.0096	-0.0026	-0.0076	0.0096	0.007	0.007	**0.007**	**0.731**	**0.185**
	$P_{1.8/50}$	0.0194	-0.0106	-0.0096	0.0194	0.011	0.012	**0.012**	**0.878**	**0.455**
	$P_{1.0/100}$	0.0003	-0.0004	-0.0014	0.0003	0.002	0.004	**0.004**	**0.081**	**0.057**
	$P_{1.5/100}$	0.0082	-0.0023	-0.0103	0.0082	0.007	0.009	**0.009**	**0.596**	**0.123**
	$P_{1.7/100}$	0.0238	-0.0061	-0.0201	0.0238	0.016	0.018	**0.018**	**0.732**	**0.168**
	$P_{1.8/100}$	0.0450	-0.0240	-0.0240	0.0450	0.025	0.027	**0.027**	**0.903**	**0.444**
	$P_{1.0/200}$	0.0060	-0.0126	0.0014	0.0060	0.008	0.011	**0.011**	**0.357**	**0.559**
	$P_{1.5/200}$	0.0327	-0.0199	-0.0249	0.0327	0.023	0.030	**0.030**	**0.724**	**0.335**
	$P_{1.7/200}$	0.0655	-0.0263	-0.0423	0.0655	0.046	0.048	**0.048**	**0.719**	**0.275**
	$P_{1.8/200}$	0.1302	-0.0870	-0.0520	0.1302	0.073	0.079	**0.079**	**0.896**	**0.550**
1-16	$P_{1.0/400}$	0.0695	-0.0765	-0.0135	0.0695	0.050	0.063	**0.064**	**0.699**	**0.603**
	$P_{1.5/400}$	0.3183	-0.2041	-0.1441	0.3183	0.183	0.205	**0.205**	**0.871**	**0.498**
	$P_{1.7/400}$	0.3667	-0.2049	-0.2049	0.3667	0.215	0.246	**0.246**	**0.854**	**0.416**
	$P_{1.8/400}$	0.2229	-0.1817	-0.1297	0.2229	0.151	0.201	**0.201**	**0.739**	**0.452**

Results of the GO 0.3 sample

N_s	Losses	Lab1		Lab2		Lab3		Lab4		Lab5		Lab6		Stkh1		Stkh2		Stkh3		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-20	$P_{1.0/50}$	0.343	0.50	0.338	0.20	0.338	0.50	0.3419	0.33	0.345	0.3	0.336	0.5	0.3355	0.32	0.336	0.5	0.336	0.5	0.3388	0.0027
	$P_{1.5/50}$	0.747	0.25	0.752	0.20	0.749	0.50	0.747	0.33	×	×	0.745	0.5	0.7418	0.33	0.756	0.5	0.748	0.5	0.7481	0.0020
	$P_{1.7/50}$	1.011	0.40	1.004	0.24	0.997	0.70	0.994	0.35	×	×	0.991	0.5	0.9818	0.34	1.004	0.5	0.989	0.5	0.9964	0.0073
	$P_{1.8/50}$	1.230	0.40	1.234	0.44	1.231	1.00	1.227	0.48	×	×	1.227	0.5	×	×	1.224	0.5	1.202	0.5	1.2288	0.0025
	$P_{1.0/100}$	1.013	0.25	1.021	0.19	1.006	0.50	1.008	0.20	1.017	0.5	1.000	0.5	1.0002	0.27	1.026	0.5	0.991	0.5	1.0091	0.0084
	$P_{1.5/100}$	2.232	0.25	2.259	0.20	2.239	0.50	2.240	0.20	2.275	0.35	2.250	0.5	2.2480	0.31	2.277	0.5	2.234	0.5	2.250	0.010
	$P_{1.7/100}$	2.935	0.25	2.940	0.22	2.907	0.70	2.909	0.23	×	×	2.928	0.5	2.9147	0.34	2.955	0.5	2.896	0.5	2.9241	0.0067
	$P_{1.8/100}$	3.430	0.25	3.466	0.36	3.439	1.00	3.434	0.33	×	×	3.434	0.5	3.3983	0.29	3.443	0.5	3.393	0.5	3.429	0.015
	$P_{1.0/200}$	3.100	0.25	3.103	0.19	3.122	0.50	3.119	0.20	3.127	0.4	3.089	0.5	3.0990	0.36	3.124	0.5	3.07	0.5	3.106	0.011
	$P_{1.5/200}$	6.852	0.25	6.838	0.22	6.857	0.50	6.835	0.20	6.927	0.4	6.873	0.5	6.8621	0.34	6.907	0.5	6.822	0.5	6.862	0.019
	$P_{1.7/200}$	8.897	0.25	8.948	0.23	8.879	0.70	8.90	0.23	×	×	8.994	0.5	8.9178	0.320	8.997	0.5	8.882	0.5	8.924	0.014
	$P_{1.8/200}$	10.356	0.25	10.46	0.32	10.393	1.00	10.40	0.30	×	×	10.410	0.5	10.3474	0.300	10.481	0.5	10.358	0.5	10.397	0.019
	$P_{1.0/400}$	9.623	1.00	9.827	0.20	9.786	0.50	9.78	0.20	9.812	0.35	9.803	0.75	9.8812	0.380	9.691	0.750	9.742	0.75	9.793	0.023
	$P_{1.5/400}$	21.694	0.75	21.95	0.20	21.969	0.50	21.82	0.20	×	×	21.980	0.75	22.1264	0.290	21.911	0.750	21.996	0.75	21.934	0.098
	$P_{1.7/400}$	29.030	0.50	29.44	0.24	29.330	0.70	29.23	0.23	×	×	29.420	0.75	29.2222	0.320	29.277	0.750	29.334	0.75	29.280	0.070
	$P_{1.8/400}$	34.262	0.50	34.69	0.32	34.417	1.00	34.42	0.28	×	×	34.710	0.75	34.4120	0.330	34.359	0.750	34.514	0.75	34.474	0.079
	$P_{0.5/1000}$	12.984	0.80	12.71	0.22	12.576	0.80	12.97	0.20	12.797	0.50	12.790	1.00	12.4830	0.260	×	×	×	×	12.75	0.14
	$P_{1.0/1000}$	45.120	0.60	45.34	0.22	45.398	0.80	45.29	0.20	45.830	0.40	45.570	1.00	45.8624	0.350	45.985	1.00	45.543	1.00	45.51	0.10

N_s	Losses	d_i									$u(d_i)$								
		Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	Stkh3	Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	Stkh3
1-20	$P_{1.0/50}$	0.0042	-0.0009	-0.0004	0.0031	0.0057	-0.0028	-0.0033	-0.0028	-0.0028	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
	$P_{1.5/50}$	-0.0011	0.0039	0.0009	-0.0011	×	-0.0031	-0.0063	0.0079	-0.0001	0.003	0.003	0.004	0.003	×	0.004	0.003	0.004	0.004
	$P_{1.7/50}$	0.0146	0.0074	0.0002	-0.0024	×	-0.0054	-0.0146	0.0076	-0.0074	0.008	0.008	0.010	0.008	×	0.009	0.008	0.009	0.009
	$P_{1.8/50}$	0.0012	0.0048	0.0024	-0.0018	×	-0.0018	×	-0.0048	×	0.006	0.006	0.013	0.006	×	0.007	×	0.007	×
	$P_{1.0/100}$	0.0034	0.0122	-0.0033	-0.0011	0.0079	-0.0091	-0.0089	0.0169	-0.0181	0.009	0.009	0.010	0.009	0.010	0.010	0.009	0.010	0.010
	$P_{1.5/100}$	-0.0184	0.0089	-0.0113	-0.0104	0.0246	-0.0004	-0.0024	0.0266	-0.0164	0.012	0.011	0.015	0.011	0.013	0.015	0.013	0.015	0.015
	$P_{1.7/100}$	0.0109	0.0160	-0.0176	-0.0151	×	0.0039	-0.0094	0.0309	-0.0281	0.010	0.009	0.021	0.009	×	0.016	0.012	0.016	0.016
	$P_{1.8/100}$	0.0008	0.0368	0.0097	0.0048	×	0.0048	-0.0309	0.0138	-0.0362	0.018	0.020	0.038	0.019	×	0.023	0.018	0.023	0.023
	$P_{1.0/200}$	-0.0061	-0.0029	0.0157	0.0129	0.0209	-0.0171	-0.0071	0.0179	-0.0361	0.013	0.012	0.019	0.012	0.017	0.019	0.016	0.019	0.019
	$P_{1.5/200}$	-0.0101	-0.0241	-0.0054	-0.0271	0.0649	0.0109	0.0000	0.0449	-0.0401	0.025	0.024	0.039	0.023	0.034	0.039	0.030	0.039	0.039
	$P_{1.7/200}$	-0.0268	0.0242	-0.0446	-0.0238	×	0.0702	-0.0060	0.0732	-0.0418	0.026	0.025	0.064	0.025	×	0.047	0.032	0.047	0.047
	$P_{1.8/200}$	-0.0406	0.0654	-0.0037	0.0034	×	0.0134	-0.0492	0.0844	-0.0386	0.032	0.039	0.106	0.037	×	0.055	0.037	0.056	0.055
	$P_{1.0/400}$	-0.1704	0.0336	-0.0073	-0.0134	0.0186	0.0096	0.0878	-0.1024	-0.0514	0.099	0.030	0.054	0.030	0.041	0.077	0.044	0.076	0.077
	$P_{1.5/400}$	-0.2403	0.0117	0.0351	-0.1143	×	0.0457	0.1921	-0.0233	0.0617	0.190	0.107	0.147	0.107	×	0.192	0.117	0.191	0.192
	$P_{1.7/400}$	-0.2496	0.1624	0.0507	-0.0496	×	0.1404	-0.0574	-0.0026	0.0544	0.161	0.100	0.217	0.096	×	0.232	0.117	0.231	0.231
	$P_{1.8/400}$	-0.2123	0.2157	-0.0570	-0.0543	×	0.2357	-0.0623	-0.1153	0.0397	0.189	0.136	0.353	0.123	×	0.272	0.138	0.270	0.271
	$P_{0.5/1000}$	0.2332	-0.0388	-0.1749	0.2192	0.0462	0.0392	-0.2678	×	×	0.170	0.137	0.168	0.137	0.149	0.186	0.138	×	×
	$P_{1.0/1000}$	-0.3891	-0.1691	-0.1110	-0.2191	0.3209	0.0609	0.3533	0.4759	0.0339	0.289	0.143	0.377	0.136	0.210	0.467	0.190	0.471	0.467

N_s	Losses	E_n								
		Lab1	**Lab2**	**Lab3**	**Lab4**	**Lab5**	**Lab6**	**Stkh1**	**Stkh2**	**Stkh3**
1-20	$P_{1.0/50}$	**0.654**	**0.161**	**0.070**	**0.528**	**0.982**	**0.441**	**0.568**	**0.441**	**0.441**
	$P_{1.5/50}$	**0.204**	**0.762**	**0.102**	**0.178**	×	**0.368**	**0.992**	**0.915**	**0.015**
	$P_{1.7/50}$	**0.878**	**0.483**	**0.012**	**0.150**	×	**0.308**	**0.915**	**0.430**	**0.422**
	$P_{1.8/50}$	**0.109**	**0.403**	**0.096**	**0.142**	×	**0.136**	×	**0.364**	×
	$P_{1.0/100}$	**0.192**	**0.703**	**0.166**	**0.064**	**0.400**	**0.464**	**0.503**	**0.855**	**0.925**
	$P_{1.5/100}$	**0.779**	**0.392**	**0.370**	**0.459**	**0.939**	**0.013**	**0.096**	**0.862**	**0.537**
	$P_{1.7/100}$	**0.550**	**0.862**	**0.410**	**0.809**	×	**0.121**	**0.394**	**0.953**	**0.882**
	$P_{1.8/100}$	**0.022**	**0.932**	**0.130**	**0.126**	×	**0.104**	**0.851**	**0.299**	**0.793**
	$P_{1.0/200}$	**0.228**	**0.116**	**0.413**	**0.520**	**0.634**	**0.453**	**0.228**	**0.473**	**0.961**
	$P_{1.5/200}$	**0.199**	**0.500**	**0.069**	**0.582**	**0.968**	**0.139**	**0.000**	**0.571**	**0.515**
	$P_{1.7/200}$	**0.506**	**0.483**	**0.350**	**0.483**	×	**0.744**	**0.094**	**0.776**	**0.448**
	$P_{1.8/200}$	**0.630**	**0.847**	**0.018**	**0.046**	×	**0.121**	**0.674**	**0.756**	**0.349**
	$P_{1.0/400}$	**0.861**	**0.555**	**0.068**	**0.222**	**0.225**	**0.062**	**0.997**	**0.672**	**0.336**
	$P_{1.5/400}$	**0.633**	**0.055**	**0.119**	**0.533**	×	**0.119**	**0.820**	**0.061**	**0.161**
	$P_{1.7/400}$	**0.774**	**0.815**	**0.117**	**0.258**	×	**0.303**	**0.246**	**0.006**	**0.118**
	$P_{1.8/400}$	**0.562**	**0.791**	**0.081**	**0.220**	×	**0.433**	**0.225**	**0.214**	**0.073**
	$P_{0.5/1000}$	**0.686**	**0.141**	**0.520**	**0.800**	**0.155**	**0.106**	**0.967**	×	×
	$P_{1.0/1000}$	**0.672**	**0.593**	**0.147**	**0.803**	**0.765**	**0.065**	**0.929**	**0.505**	**0.036**

Results of the NO 0.2 sample

N_s	Losses	Lab1		Lab2		Lab3		Lab4		Lab5		Lab6		Stkh1		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-20	$P_{1.0/50}$	0.961	0.25	0.961	0.17	0.962	0.70	0.959	0.35	0.965	0.35	0.945	0.5	0.9368	0.11	0.9556	0.0096
	$P_{1.25/50}$	1.469	0.25	1.475	0.22	1.474	0.70	1.471	0.38	1.489	0.45	1.458	0.5	1.4387	0.23	1.468	0.015
	$P_{1.5/50}$	2.237	0.25	2.268	0.27	2.251	0.90	2.247	0.38	2.287	0.45	2.251	0.5	2.2152	0.19	2.251	0.018
	$P_{1.0/100}$	2.098	0.25	2.102	0.19	2.099	0.70	2.092	0.35	1.906	0.35	2.065	0.5	2.0500	0.26	2.084	0.017
	$P_{1.25/100}$	3.195	0.25	3.226	0.22	3.223	0.70	3.205	0.35	3.256	0.35	3.182	0.5	3.1469	0.23	3.205	0.031
	$P_{1.5/100}$	4.854	0.25	4.978	0.27	4.911	0.90	4.909	0.38	4.979	0.4	4.905	0.5	4.8385	0.26	4.910	0.035
	$P_{1.0/200}$	4.791	0.30	4.829	0.19	4.809	0.70	4.814	0.33	4.863	0.5	4.753	0.5	4.7190	0.26	4.797	0.039
	$P_{1.25/200}$	7.303	0.50	7.407	0.22	7.371	0.70	7.40	0.35	7.484	0.4	7.317	0.5	7.2330	0.20	7.359	0.062
	$P_{1.5/200}$	11.065	0.80	11.48	0.27	11.248	0.90	11.39	0.35	11.425	0.4	11.260	0.5	11.1043	0.23	11.285	0.094
1-12	$P_{1.0/400}$	11.43	0.4	11.71	1.09	11.635	0.7	11.70	0.325	11.661	0.5	11.630	0.75	11.5485	0.22	11.611	0.080
	$P_{1.25/400}$	17.52	0.4	18.19	4.1	17.912	0.7	17.92	0.325	17.996	0.40	17.910	0.75	17.6800	0.18	17.83	0.15
	$P_{0.5/1000}$	12.089	0.6	12.35	0.64	12.205	0.7	12.22	0.20	12.287	0.40	12.320	1	12.5886	0.11	12.30	0.15
	$P_{1.0/1000}$	41.33	0.8	42.67	0.71	42.343	0.8	41.92	0.20	42.530	0.40	42.690	1.00	42.3032	0.13	42.38	0.23
	$P_{1.25/1000}$	63.98	0.8	67.2	3.39	65.865	0.9	65.01	0.20	66.200	0.40	66.420	1.00	×	×	65.82	0.40
	$P_{0.5/2000}$	33.1	0.8	×	×	33.920	0.7	33.68	0.20	33.908	0.40	34.090	1.50	×	×	33.72	0.17
1-12	$P_{0.1/5000}$	×	×	×	×	6.603	0.9	6.884	0.20	6.539	0.45	6.894	2.00	×	×	6.72	0.10
	$P_{0.2/5000}$	×	×	×	×	25.628	0.9	26.06	0.20	25.620	0.50	26.300	2.00	×	×	25.84	0.14
	$P_{0.35/5000}$	×	×	×	×	72.046	0.9	71.75	0.20	72.620	0.50	73.070	2.00	×	×	72.07	0.25
	$P_{0.1/10000}$	×	×	×	×	20.931	1	21.68	0.20	20.920	0.45	21.720	2.00	×	×	21.27	0.22
	$P_{0.15/10000}$	×	×	×	×	45.383	1	46.19	0.20	45.810	0.50	46.930	2.00	×	×	45.98	0.22

N_s	Losses	d_i							$u(d_i)$						
		Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1
1-20	$P_{1.0/50}$	0.0054	0.0054	0.0060	0.0034	0.0094	-0.0106	-0.0188	0.010	0.010	0.012	0.010	0.010	0.011	0.010
	$P_{1.25/50}$	0.0014	0.0071	0.0060	0.0034	0.0214	-0.0096	-0.0289	0.015	0.015	0.018	0.016	0.016	0.016	0.015
	$P_{1.5/50}$	-0.0137	0.0170	0.0006	-0.0037	0.0363	0.0003	-0.0355	0.019	0.019	0.027	0.020	0.021	0.021	0.018
	$P_{1.0/100}$	0.0137	0.0179	0.0148	0.0077	×	-0.0193	-0.0343	0.017	0.017	0.022	0.018	×	0.020	0.018
	$P_{1.25/100}$	-0.0096	0.0215	0.0179	0.0004	0.0514	-0.0226	-0.0577	0.032	0.031	0.038	0.033	0.033	0.035	0.031
	$P_{1.5/100}$	-0.0563	0.0677	0.0004	-0.0013	0.0687	-0.0053	-0.0718	0.037	0.038	0.056	0.040	0.040	0.043	0.037
	$P_{1.0/200}$	-0.0056	0.0323	0.0129	0.0174	0.0664	-0.0436	-0.0776	0.041	0.040	0.051	0.042	0.046	0.045	0.040
	$P_{1.25/200}$	-0.0561	0.0479	0.0115	0.0409	0.1249	-0.0421	-0.1261	0.072	0.064	0.080	0.067	0.069	0.072	0.063
	$P_{1.5/200}$	-0.2204	0.1956	-0.0375	0.1046	0.1396	-0.0254	-0.1811	0.129	0.099	0.138	0.102	0.104	0.109	0.097
1-12	$P_{1.0/400}$	-0.1819	0.0981	0.0235	0.0881	0.0491	0.0181	-0.0634	0.092	0.151	0.114	0.089	0.099	0.118	0.084
	$P_{1.25/400}$	-0.3113	0.3587	0.0810	0.0887	0.1647	0.0787	-0.1513	0.161	0.760	0.192	0.156	0.162	0.198	0.148
	$P_{0.5/1000}$	-0.2058	0.0522	-0.0893	-0.0748	-0.0078	0.0252	0.2938	0.170	0.173	0.176	0.156	0.161	0.197	0.154
	$P_{1.0/1000}$	×	0.2947	-0.0323	-0.4553	0.1547	0.3147	-0.0721	×	0.379	0.408	0.242	0.284	0.483	0.234
	$P_{1.25/1000}$	×	1.3766	0.0416	-0.8134	0.3766	0.5966	×	×	2.313	0.716	0.422	0.481	0.776	×
	$P_{0.5/2000}$	-0.6160	×	0.2040	-0.0360	0.1920	0.3740	×	0.313	×	0.290	0.180	0.215	0.538	×
1-12	$P_{0.1/5000}$	×	×	-0.1144	0.1666	-0.1784	0.1766	×	×	×	0.113	0.097	0.101	0.168	×
	$P_{0.2/5000}$	×	×	-0.2170	0.2150	-0.2250	0.4550	×	×	×	0.272	0.154	0.193	0.545	×
	$P_{0.35/5000}$	×	×	-0.0232	-0.3192	0.5508	1.0008	×	×	×	0.695	0.289	0.441	1.483	×
	$P_{0.1/10000}$	×	×	-0.3434	0.4056	-0.3544	0.4456	×	×	×	0.307	0.228	0.243	0.489	×
	$P_{0.15/10000}$	×	×	-0.5924	0.2147	-0.1653	0.9547	×	×	×	0.502	0.234	0.314	0.963	×

N_s	Losses	E_n						
		Lab1	**Lab2**	**Lab3**	**Lab4**	**Lab5**	**Lab6**	**Stkh1**
1-20	$P_{1.0/50}$	**0.275**	**0.280**	**0.256**	**0.169**	**0.465**	**0.496**	**0.977**
	$P_{1.25/50}$	**0.046**	**0.237**	**0.168**	**0.108**	**0.667**	**0.296**	**0.969**
	$P_{1.5/50}$	**0.366**	**0.452**	**0.011**	**0.093**	**0.883**	**0.008**	**0.968**
	$P_{1.0/100}$	**0.392**	**0.522**	**0.334**	**0.212**	×	**0.491**	**0.978**
	$P_{1.25/100}$	**0.152**	**0.341**	**0.235**	**0.006**	**0.786**	**0.328**	**0.917**
	$P_{1.5/100}$	**0.759**	**0.901**	**0.003**	**0.017**	**0.852**	**0.062**	**0.964**
	$P_{1.0/200}$	**0.068**	**0.407**	**0.126**	**0.209**	**0.728**	**0.481**	**0.959**
	$P_{1.25/200}$	**0.391**	**0.375**	**0.072**	**0.306**	**0.911**	**0.294**	**0.995**
	$P_{1.5/200}$	**0.856**	**0.993**	**0.136**	**0.515**	**0.671**	**0.116**	**0.934**
1-12	$P_{1.0/400}$	**0.986**	**0.325**	**0.103**	**0.497**	**0.248**	**0.076**	**0.377**
	$P_{1.25/400}$	**0.966**	**0.236**	**0.211**	**0.284**	**0.509**	**0.199**	**0.510**
	$P_{0.5/1000}$	**0.606**	**0.151**	**0.254**	**0.240**	**0.024**	**0.064**	**0.953**
	$P_{1.0/1000}$	×	**0.389**	**0.040**	**0.941**	**0.273**	**0.325**	**0.154**
	$P_{1.25/1000}$	×	**0.298**	**0.029**	**0.963**	**0.391**	**0.384**	×
	$P_{0.5/2000}$	**0.983**	×	**0.351**	**0.100**	**0.446**	**0.348**	×
1-12	$P_{0.1/5000}$	×	×	**0.506**	**0.857**	**0.887**	**0.525**	×
	$P_{0.2/5000}$	×	×	**0.399**	**0.700**	**0.583**	**0.417**	×
	$P_{0.35/5000}$	×	×	**0.017**	**0.553**	**0.624**	**0.337**	×
	$P_{0.1/10000}$	×	×	**0.560**	**0.888**	**0.728**	**0.456**	×
	$P_{0.15/10000}$	×	×	**0.590**	**0.458**	**0.263**	**0.496**	×

Results of the Laser scribed GO 0.2 sample

N_s	Losses	Lab1		Lab2		Lab3		Lab4		Lab5		Lab6		Stkh1		Stkh2		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-24	$P_{1.0/50}$	0.267	0.40	0.2636	0.22	0.267	0.50	0.2659	0.33	×	×	0.2660	0.5	0.2677	0.17	0.266	0.5	0.2661	0.0016
	$P_{1.5/50}$	0.578	0.25	0.5785	0.21	0.583	0.50	0.580	0.33	×	×	0.584	0.5	0.5847	0.23	0.584	0.5	0.5814	0.0014
	$P_{1.7/50}$	0.791	0.25	0.7885	0.30	0.795	0.70	0.789	0.38	×	×	0.811	0.5	0.8107	0.26	0.812	0.5	0.7995	0.0058
	$P_{1.8/50}$	1.027	0.25	1.016	0.60	1.029	1.00	1.015	0.55	×	×	1.075	0.5	1.0678	0.13	1.073	0.5	1.043	0.015
	$P_{1.0/100}$	0.726	0.25	0.7258	0.29	0.739	0.50	0.739	0.33	0.7405	0.45	0.744	0.5	0.7486	0.24	0.737	0.5	0.7374	0.0071
	$P_{1.5/100}$	1.602	0.25	1.605	0.20	1.611	0.50	1.618	0.33	×	×	1.635	0.5	1.6424	0.17	1.622	0.5	1.619	0.012
	$P_{1.7/100}$	2.126	0.25	2.153	0.26	2.139	0.70	2.151	0.35	×	×	2.207	0.5	2.2103	0.25	2.204	0.5	2.170	0.023
	$P_{1.8/100}$	2.710	0.40	2.705	0.55	2.682	1.00	2.693	0.50	×	×	2.846	0.5	2.8292	0.11	2.843	0.5	2.759	0.041
1-16	$P_{1.0/200}$	2.150	0.25	×	×	2.150	0.50	2.167	0.33	2.1686	0.3	2.185	0.5	2.1959	0.13	2.129	0.5	2.164	0.021
	$P_{1.5/200}$	4.878	0.25	×	×	4.779	0.50	4.789	0.33	4.8395	0.3	4.845	0.5	4.8731	0.19	4.797	0.5	4.830	0.027
	$P_{1.7/200}$	6.232	0.25	×	×	6.237	0.70	6.256	0.33	×	×	6.368	0.5	6.3821	0.22	6.348	0.5	6.304	0.050
	$P_{1.8/200}$	7.442	0.25	×	×	7.470	1.00	7.52	0.45	×	×	7.775	0.5	7.7785	0.28	7.787	0.5	7.63	0.12
1-12	$P_{1.0/400}$	6.642	0.30	×	×	6.664	0.50	6.636	0.20	6.632	0.40	6.770	0.75	6.7393	0.32	6.770	0.75	6.691	0.054
	$P_{1.5/400}$	14.953	0.30	×	×	14.869	0.50	14.81	0.20	14.890	0.40	15.03	0.75	14.9595	0.14	15.059	0.75	14.933	0.080
	$P_{1.7/400}$	18.985	0.30	×	×	18.961	0.70	18.98	0.20	19.150	0.40	19.30	0.75	19.2229	0.12	19.268	0.75	19.12	0.12
	$P_{1.8/400}$	21.890	0.30	×	×	21.954	1.00	21.96	0.28	×	×	22.59	0.75	22.5111	0.20	22.575	0.75	22.25	0.25
	$P_{1.0/1000}$	30.178	0.5	×	×	30.602	0.50	30.38	0.20	30.410	0.35	30.94	1.00	30.9019	0.15	30.693	1.00	30.58	0.26
	$P_{1.5/1000}$	65.28	0.5	×	×	66.280	0.50	65.81	0.20	66.400	0.35	67.05	1.00	×	×	67.425	1.00	66.32	0.56
	$P_{1.7/1000}$	85.25	0.5	×	×	85.512	0.70	85.3	0.20	86.970	0.40	87.08	1.00	×	×	87.359	1.00	86.20	0.73
	$P_{1.8/1000}$	98.88	0.5	×	×	99.246	1.00	98.9	0.28	×	×	101.7	1.00	×	×	101.490	1.00	100.0	1.1

N_s	Losses	d_i								$u(d_i)$								E_n							
		Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	Lab1	Lab2	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	**Lab1**	**Lab2**	**Lab3**	**Lab4**	**Lab5**	**Lab6**	**Stkh1**	**Stkh2**
1-24	$P_{1.0/50}$	0.0009	-0.0025	0.0006	-0.0002	×	-0.0001	0.0016	-0.0002	0.002	0.002	0.002	0.002	×	0.002	0.002	0.002	**0.235**	**0.750**	**0.149**	**0.059**	×	**0.027**	**0.489**	**0.055**
	$P_{1.5/50}$	-0.0032	-0.0029	0.0014	-0.0014	×	0.0026	0.0033	0.0026	0.002	0.002	0.003	0.002	×	0.003	0.002	0.003	**0.807**	**0.796**	**0.221**	**0.304**	×	**0.400**	**0.853**	**0.408**
	$P_{1.7/50}$	-0.0087	-0.0110	-0.0045	-0.0105	×	0.0115	0.0112	0.0124	0.006	0.006	0.008	0.007	×	0.007	0.006	0.007	**0.707**	**0.874**	**0.279**	**0.803**	×	**0.812**	**0.906**	**0.875**
	$P_{1.8/50}$	-0.0164	-0.0271	-0.0143	-0.0284	×	0.0316	0.0244	0.0295	0.015	0.016	0.018	0.016	×	0.016	0.015	0.016	**0.531**	**0.825**	**0.390**	**0.875**	×	**0.974**	**0.794**	**0.911**
	$P_{1.0/100}$	-0.0114	-0.0116	0.0015	0.0016	0.0031	0.0066	0.0112	-0.0007	0.007	0.007	0.008	0.008	0.008	0.008	0.007	0.008	**0.774**	**0.780**	**0.094**	**0.105**	**0.196**	**0.409**	**0.759**	**0.043**
	$P_{1.5/100}$	-0.0175	-0.0144	-0.0079	-0.0014	×	0.0156	0.0230	0.0029	0.012	0.012	0.014	0.013	×	0.014	0.012	0.014	**0.713**	**0.598**	**0.282**	**0.053**	×	**0.552**	**0.968**	**0.101**
	$P_{1.7/100}$	-0.0444	-0.0171	-0.0307	-0.0190	×	0.0370	0.0403	0.0339	0.024	0.024	0.027	0.024	×	0.025	0.024	0.025	**0.942**	**0.362**	**0.559**	**0.393**	×	**0.727**	**0.854**	**0.666**
	$P_{1.8/100}$	-0.0489	-0.0536	-0.0771	-0.0659	×	0.0871	0.0703	0.0842	0.043	0.044	0.049	0.043	×	0.044	0.041	0.044	**0.574**	**0.612**	**0.784**	**0.760**	×	**0.998**	**0.850**	**0.966**
1-16	$P_{1.0/200}$	-0.0137	×	-0.0139	0.0032	0.0048	0.0212	0.0321	-0.0344	0.022	×	0.024	0.022	0.022	0.024	0.021	0.024	**0.317**	×	**0.294**	**0.071**	**0.108**	**0.447**	**0.756**	**0.730**
	$P_{1.5/200}$	0.0483	×	-0.0503	-0.0407	0.0098	0.0153	0.0434	-0.0323	0.030	×	0.036	0.031	0.031	0.037	0.029	0.036	**0.807**	×	**0.692**	**0.646**	**0.159**	**0.210**	**0.752**	**0.444**
	$P_{1.7/200}$	-0.0722	×	-0.0674	-0.0482	×	0.0638	0.0779	0.0438	0.053	×	0.067	0.054	×	0.060	0.052	0.059	**0.686**	×	**0.506**	**0.444**	×	**0.536**	**0.746**	**0.368**
	$P_{1.8/200}$	-0.1878	×	-0.1596	-0.1098	×	0.1452	0.1487	0.1571	0.119	×	0.139	0.122	×	0.124	0.120	0.124	**0.789**	×	**0.573**	**0.449**	×	**0.586**	**0.622**	**0.634**
1-12	$P_{1.0/400}$	-0.0495	×	-0.0269	-0.0553	-0.0593	0.0787	0.0480	0.0787	0.058	×	0.064	0.056	0.061	0.074	0.059	0.074	**0.427**	×	**0.211**	**0.494**	**0.490**	**0.529**	**0.410**	**0.529**
	$P_{1.5/400}$	0.0203	×	-0.0637	-0.1227	-0.0427	0.0973	0.0268	0.1261	0.092	×	0.109	0.085	0.100	0.138	0.083	0.138	**0.110**	×	**0.291**	**0.718**	**0.214**	**0.352**	**0.162**	**0.455**
	$P_{1.7/400}$	-0.1342	×	-0.1587	-0.1392	0.0308	0.1808	0.1037	0.1487	0.132	×	0.178	0.125	0.142	0.187	0.121	0.187	**0.508**	×	**0.445**	**0.557**	**0.109**	**0.482**	**0.427**	**0.397**
	$P_{1.8/400}$	-0.3551	×	-0.2908	-0.2851	×	0.3449	0.2660	0.3300	0.260	×	0.334	0.258	x	0.303	0.255	0.303	**0.684**	×	**0.436**	**0.552**	×	**0.569**	**0.521**	**0.545**
	$P_{1.0/1000}$	-0.3991	×	0.0244	-0.1971	-0.1671	0.3629	0.3248	0.1157	0.296	×	0.298	0.262	0.276	0.401	0.259	0.399	**0.673**	×	**0.041**	**0.376**	**0.302**	**0.452**	**0.626**	**0.145**
	$P_{1.5/1000}$	-1.0408	×	-0.0405	-0.5108	0.0792	0.7292	×	1.1040	0.647	×	0.649	0.574	0.605	0.873	×	0.876	**0.804**	×	**0.031**	**0.445**	**0.065**	**0.418**	×	**0.630**
	$P_{1.7/1000}$	-0.9419	×	-0.6798	-0.8919	0.7781	0.8881	×	1.1676	0.849	×	0.947	0.754	0.812	1.139	×	1.141	**0.555**	×	**0.359**	**0.592**	**0.479**	**0.390**	×	**0.512**
	$P_{1.8/1000}$	-1.0928	×	-0.7269	-1.0728	×	1.7272	×	1.5174	1.196	×	1.474	1.124	x	1.490	×	1.489	**0.457**	×	**0.247**	**0.477**	×	**0.579**	×	**0.510**

Additional results of the Laser scribed GO 0.2 sample (200 Hz – 1000 Hz) with Lab2 measurements

N_s	Losses	Lab1		Lab2*		Lab3		Lab4		Lab5		Lab6		Stkh1		Stkh2		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-16	$P_{1.0/200}$	2.150	0.25	2.149	0.13	2.150	0.50	2.167	0.33	2.1686	0.3	2.185	0.5	2.1959	0.13	2.129	0.5	2.162	0.018
	$P_{1.5/200}$	4.878	0.25	4.795	0.18	4.779	0.50	4.789	0.33	4.8395	0.3	4.845	0.5	4.8731	0.19	4.797	0.5	4.825	0.026
	$P_{1.7/200}$	6.232	0.25	6.288	0.16	6.237	0.70	6.256	0.33	×	×	6.368	0.5	6.3821	0.22	6.348	0.5	6.302	0.039
	$P_{1.8/200}$	7.442	0.25	7.538	0.28	7.470	1.00	7.52	0.45	×	×	7.775	0.5	7.7785	0.28	7.787	0.5	7.617	0.092
1-12	$P_{1.0/400}$	6.642	0.30	6.661	0.13	6.664	0.50	6.636	0.20	6.632	0.40	6.770	0.75	6.7393	0.32	6.770	0.75	6.682	0.024
	$P_{1.5/400}$	14.953	0.30	14.77	0.14	14.869	0.50	14.81	0.20	14.890	0.40	15.030	0.75	14.9595	0.14	15.059	0.75	14.909	0.068
	$P_{1.7/400}$	18.985	0.30	18.9	0.13	18.961	0.70	18.98	0.20	19.150	0.40	19.300	0.75	19.2229	0.12	19.268	0.75	19.087	0.094
	$P_{1.8/400}$	21.890	0.30	21.82	0.21	21.954	1.00	21.96	0.28	×	×	22.590	0.75	22.5111	0.20	22.575	0.75	22.18	0.18
	$P_{1.0/1000}$	30.178	0.5	30.08	0.14	30.602	0.50	30.38	0.20	30.410	0.35	30.94	1.00	30.9019	0.15	30.693	1.00	30.51	0.21
	$P_{1.5/1000}$	65.28	0.5	65.74	0.17	66.280	0.50	65.81	0.20	66.400	0.35	67.05	1.00	×	×	67.425	1.00	66.15	0.30
	$P_{1.7/1000}$	85.25	0.5	85.22	0.36	85.512	0.70	85.3	0.20	86.970	0.40	87.08	1.00	×	×	87.359	1.00	85.96	0.39
	$P_{1.8/1000}$	98.88	0.5	99.3	1.06	99.246	1.00	98.9	0.28	×	×	101.7	1.00	×	×	101.490	1.00	99.71	0.52

*****Lab2 measured the Laser Scribed GO 0.2 sample with N1-24 in the frequency range of 200 Hz to 1000 Hz

N_s	Losses	d_i								$u(d_i)$								E_n							
		Lab1	Lab2*	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	Lab1	Lab2*	Lab3	Lab4	Lab5	Lab6	Stkh1	Stkh2	**Lab1**	**Lab2***	**Lab3**	**Lab4**	**Lab5**	**Lab6**	**Stkh1**	**Stkh2**
1-16	$P_{1.0/200}$	-0.0118	-0.0131	-0.0120	0.0051	0.0067	0.0231	0.0340	-0.0325	0.019	0.018	0.021	0.019	0.019	0.021	0.018	0.021	**0.317**	**0.363**	**0.287**	**0.132**	**0.175**	**0.550**	**0.937**	**0.781**
	$P_{1.5/200}$	0.0529	-0.0301	-0.0458	-0.0361	0.0144	0.0199	0.0480	-0.0278	0.028	0.027	0.035	0.030	0.029	0.035	0.027	0.035	**0.935**	**0.561**	**0.655**	**0.605**	**0.245**	**0.282**	**0.884**	**0.396**
	$P_{1.7/200}$	-0.0699	-0.0139	-0.0651	-0.0459	×	0.0661	0.0802	0.0461	0.042	0.040	0.059	0.044	×	0.050	0.041	0.050	**0.831**	**0.172**	**0.556**	**0.521**	×	**0.656**	**0.967**	**0.459**
	$P_{1.8/200}$	-0.1748	-0.0788	-0.1465	-0.0968	×	0.1582	0.1617	0.1702	0.094	0.094	0.118	0.098	×	0.100	0.094	0.100	**0.932**	**0.418**	**0.619**	**0.494**	×	**0.793**	**0.856**	**0.852**
1-12	$P_{1.0/400}$	-0.0398	-0.0206	-0.0172	-0.0456	-0.0496	0.0884	0.0577	0.0884	0.031	0.025	0.041	0.027	0.035	0.056	0.032	0.056	**0.645**	**0.411**	**0.211**	**0.843**	**0.699**	**0.790**	**0.904**	**0.789**
	$P_{1.5/400}$	0.0436	-0.1374	-0.0403	-0.0994	-0.0194	0.1206	0.0501	0.1494	0.081	0.071	0.101	0.074	0.090	0.131	0.071	0.132	**0.269**	**0.974**	**0.201**	**0.673**	**0.108**	**0.459**	**0.354**	**0.568**
	$P_{1.7/400}$	-0.1023	-0.1873	-0.1268	-0.1073	0.0627	0.2127	0.1356	0.1807	0.110	0.097	0.163	0.101	0.121	0.172	0.097	0.172	**0.466**	**0.963**	**0.390**	**0.530**	**0.259**	**0.617**	**0.702**	**0.524**
	$P_{1.8/400}$	-0.2887	-0.3617	-0.2243	-0.2187	×	0.4113	0.3324	0.3965	0.188	0.183	0.282	0.187	×	0.245	0.182	0.245	**0.767**	**0.991**	**0.398**	**0.586**	×	**0.841**	**0.912**	**0.810**
	$P_{1.0/1000}$	-0.3307	-0.4267	0.0928	-0.1287	-0.0987	0.4313	0.3932	0.1841	0.261	0.218	0.263	0.222	0.239	0.376	0.219	0.374	**0.632**	**0.981**	**0.177**	**0.290**	**0.207**	**0.574**	**0.900**	**0.246**
	$P_{1.5/1000}$	-0.8735	-0.4135	0.1269	-0.3435	0.2465	0.8965	×	1.2714	0.442	0.318	0.446	0.326	0.378	0.734	×	0.737	**0.988**	**0.651**	**0.142**	**0.527**	**0.326**	**0.611**	×	**0.862**
	$P_{1.7/1000}$	-0.7074	-0.7374	-0.4453	-0.6574	1.0126	1.1226	×	1.4021	0.579	0.497	0.715	0.427	0.524	0.955	×	0.957	**0.611**	**0.742**	**0.311**	**0.769**	**0.966**	**0.588**	×	**0.732**
	$P_{1.8/1000}$	-0.8319	-0.4119	-0.4660	-0.8119	×	1.9881	×	1.7783	0.718	1.172	1.121	0.589	×	1.142	×	1.140	**0.580**	**0.176**	**0.208**	**0.689**	×	**0.870**	×	**0.780**

*****Lab2 measured the Laser Scribed GO 0.2 sample with N1-24 in the frequency range of 200 Hz to 1000 Hz

Results of the FeCo 0.2 sample

N_s	Losses	Lab1		Lab2		Lab3		Lab4		Lab5		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
1-24	$P_{0.5/50}$	0.324	0.50	0.3226	1.56	0.324	1.5	0.3095	0.55	0.3299	0.4	0.3219	0.0064
	$P_{1.0/50}$	0.853	0.50	0.8611	0.71	0.871	1.50	0.833	0.50	0.8726	0.4	0.8577	0.0120
	$P_{1.5/50}$	1.525	0.50	1.5625	0.43	1.565	1.00	1.519	0.65	1.5754	0.45	1.5492	0.0237
	$P_{1.7/50}$	1.896	0.50	1.9121	0.43	1.909	1.00	1.863	0.55	1.9010	0.45	1.8961	0.0273
	$P_{2.0/50}$	2.365	0.50	2.385	0.40	2.375	1.00	2.324	0.60	2.352	0.45	2.3603	0.0364
	$P_{0.5/100}$	0.688	0.50	0.6916	1.56	0.709	1.5	0.6738	0.80	0.703	0.35	0.6929	0.0138
	$P_{1.0/100}$	1.857	0.50	1.905	0.70	1.914	1.50	1.842	0.50	1.917	0.35	1.8857	0.0233
	$P_{1.5/100}$	3.353	0.50	3.445	0.41	3.434	1.00	3.36	0.50	3.452	0.35	3.4085	0.0369
	$P_{1.7/100}$	4.186	0.50	4.241	0.43	4.230	1.00	4.137	0.70	4.235	0.45	4.2058	0.0638
	$P_{2.0/100}$	5.255	0.50	5.327	0.40	5.294	1.00	5.186	0.70	5.269	0.45	5.2663	0.0819
	$P_{0.5/200}$	1.517	0.50	1.531	1.39	1.606	1.5	1.508	0.325	1.540	0.4	1.5388	0.0276
	$P_{1.0/200}$	4.320	0.50	4.378	0.67	4.407	1.50	4.256	0.33	4.372	0.40	4.3429	0.0513
	$P_{1.5/200}$	7.714	0.50	8.057	0.43	8.034	1.00	7.84	0.33	8.052	0.45	7.9379	0.1137
	$P_{1.7/200}$	9.563	0.50	9.841	0.44	9.750	1.00	9.52	0.33	9.842	0.45	9.7017	0.1102
	$P_{2.0/200}$	12.188	0.50	12.54	0.40	12.510	1.00	12.12	0.35	12.434	0.45	12.3541	0.1205
	$P_{0.5/400}$	3.467	0.50	3.714	1.56	3.561	2.00	3.504	0.40	3.532	0.35	3.5513	0.0695
1-12	$P_{1.0/400}$	9.724	0.50	×	×	9.952	2.00	9.85	0.40	10.008	0.35	9.8714	0.0691
	$P_{1.5/400}$	19.050	0.50	×	×	19.711	1.00	19.75	0.40	19.967	0.45	19.6185	0.2763
	$P_{1.7/400}$	24.321	0.50	×	×	24.772	1.00	24.78	0.40	24.919	0.45	24.6962	0.1650
	$P_{2.0/400}$	32.026	0.50	×	×	32.606	1	32.75	0.40	32.567	0.40	32.4880	0.2004
1-12	$P_{0.5/1000}$	10.462	0.5	×	×	10.950	1.5	10.92	0.40	10.819	0.40	10.78	0.16

	$P_{1.0/1000}$	33.519	0.5	×	×	35.239	1.5	35.30	0.40	34.913	0.45	34.7208	0.5181
	$P_{1.5/1000}$	73.6	0.5	×	×	77.002	1	78.9	0.45	77.430	0.45	77.9139	0.5800
	$P_{1.7/1000}$	99.1	0.5	×	×	103.504	1	103.9	0.45	103.710	0.35	103.8304	0.1960
	$P_{0.5/2000}$	×	×	×	×	×	×	28.83	0.40	28.300	0.45	28.5751	0.2911
	$P_{0.1/10000}$	×	×	×	×	×	×	19.13	0.60	18.720	0.45	18.9311	0.2170
	$P_{0.15/10000}$	×	×	×	×	×	×	40.56	0.60	39.620	0.42	40.0998	0.5034

N_s	Losses	d_i					$u(d_i)$					E_n				
		Lab1	Lab2	Lab3	Lab4	Lab5	Lab1	Lab2	Lab3	Lab4	Lab5	**Lab1**	**Lab2**	**Lab3**	**Lab4**	**Lab5**
1-24	$P_{0.5/50}$	0.0021	0.0007	0.0020	-0.0124	0.0080	0.007	0.008	0.008	0.007	0.007	**0.155**	**0.040**	**0.124**	**0.936**	**0.606**
	$P_{1.0/50}$	-0.0047	0.0034	0.0135	-0.0247	0.0149	0.013	0.013	0.018	0.013	0.013	**0.184**	**0.126**	**0.380**	**0.970**	**0.595**
	$P_{1.5/50}$	-0.0242	0.0133	0.0153	-0.0302	0.0262	0.025	0.025	0.028	0.026	0.025	**0.487**	**0.270**	**0.270**	**0.589**	**0.530**
	$P_{1.7/50}$	-0.0001	0.0160	0.0129	-0.0331	0.0049	0.029	0.029	0.033	0.029	0.029	**0.002**	**0.280**	**0.194**	**0.567**	**0.086**
	$P_{2.0/50}$	0.0047	0.0247	0.0151	-0.0363	-0.0079	0.038	0.038	0.043	0.039	0.038	**0.062**	**0.329**	**0.174**	**0.466**	**0.104**
	$P_{0.5/100}$	-0.0049	-0.0013	0.0163	-0.0191	0.0099	0.014	0.018	0.017	0.015	0.014	**0.171**	**0.036**	**0.468**	**0.643**	**0.355**
	$P_{1.0/100}$	-0.0287	0.0194	0.0281	-0.0437	0.0313	0.025	0.027	0.037	0.025	0.024	**0.572**	**0.361**	**0.379**	**0.872**	**0.645**
	$P_{1.5/100}$	-0.0555	0.0368	0.0252	-0.0485	0.0435	0.041	0.039	0.050	0.041	0.039	**0.685**	**0.467**	**0.250**	**0.598**	**0.561**
	$P_{1.7/100}$	-0.0198	0.0351	0.0241	-0.0688	0.0292	0.067	0.066	0.077	0.070	0.067	**0.147**	**0.265**	**0.157**	**0.491**	**0.220**
	$P_{2.0/100}$	-0.0113	0.0606	0.0276	-0.0803	0.0030	0.086	0.085	0.098	0.090	0.085	**0.065**	**0.358**	**0.141**	**0.448**	**0.018**
	$P_{0.5/200}$	-0.0218	-0.0074	0.0668	-0.0308	0.0012	0.029	0.035	0.037	0.028	0.028	**0.381**	**0.106**	**0.911**	**0.549**	**0.021**
	$P_{1.0/200}$	-0.0229	0.0346	0.0638	-0.0869	0.0291	0.056	0.059	0.084	0.053	0.054	**0.206**	**0.293**	**0.381**	**0.817**	**0.268**
	$P_{1.5/200}$	-0.2239	0.1191	0.0962	-0.0979	0.1141	0.120	0.119	0.139	0.117	0.119	**0.933**	**0.501**	**0.345**	**0.420**	**0.478**
	$P_{1.7/200}$	-0.1387	0.1393	0.0486	-0.1817	0.1403	0.120	0.118	0.147	0.115	0.119	**0.577**	**0.588**	**0.165**	**0.794**	**0.590**
	$P_{2.0/200}$	-0.1661	0.1889	0.1563	-0.2341	0.0799	0.135	0.131	0.174	0.128	0.133	**0.615**	**0.724**	**0.450**	**0.916**	**0.301**
	$P_{0.5/400}$	-0.0843	0.1626	0.0096	-0.0473	-0.0193	0.072	0.090	0.100	0.071	0.071	**0.588**	**0.898**	**0.048**	**0.334**	**0.137**

1-12	$P_{1.0/400}$	-0.1474	×	0.0806	-0.0214	0.1366	0.085	×	0.211	0.073	0.078	**0.872**	×	**0.191**	**0.147**	**0.881**
	$P_{1.5/400}$	-0.5685	×	0.0924	0.1315	0.3485	0.292	×	0.339	0.279	0.291	**0.973**	×	**0.136**	**0.236**	**0.600**
	$P_{1.7/400}$	-0.3752	×	0.0758	0.0838	0.2228	0.205	×	0.298	0.172	0.200	**0.915**	×	**0.127**	**0.243**	**0.558**
	$P_{2.0/400}$	×	×	0.1180	0.2620	0.0790	×	×	0.383	0.214	0.239	×	×	**0.154**	**0.612**	**0.165**
1-12	$P_{0.5/1000}$	-0.3179	×	0.1699	0.1401	0.0391	0.164	×	0.226	0.157	0.162	**0.968**	×	**0.375**	**0.446**	**0.121**
	$P_{1.0/1000}$	×	×	0.5184	0.5792	0.1922	×	×	0.740	0.523	0.541	×	×	**0.350**	**0.554**	**0.177**
	$P_{1.5/1000}$	×	×	-0.9123	0.9861	-0.4839	×	×	0.964	0.608	0.677	×	×	**0.473**	**0.811**	**0.358**
	$P_{1.7/1000}$	×	×	-0.3267	0.0696	-0.1204	×	×	1.053	0.309	0.413	×	×	**0.155**	**0.113**	**0.146**
	$P_{0.5/2000}$	×	×	×	0.2549	-0.2751	×	×	×	0.297	0.318	×	×	×	**0.429**	**0.433**
	$P_{0.1/10000}$	×	×	×	0.1989	-0.2111	×	×	×	0.220	0.233	×	×	×	**0.451**	**0.453**
	$P_{0.15/10000}$	×	×	×	0.4602	-0.4798	×	×	×	0.510	0.530	×	×	×	**0.451**	**0.452**

Additional results of the FeCo sample (400 Hz – 1000 Hz) with Lab2 measurements

N_s	Losses	Lab1		Lab2*		Lab3		Lab4		Lab5		x_{ref} (W/kg)	$u(x_{ref})$ (W/kg)
		X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %		
N1-12	$P_{1.0/400}$	9.724	0.50	10.40	0.10	9.952	2.00	9.85	0.40	10.008	0.35	9.8714	0.0691
	$P_{1.5/400}$	19.050	0.50	19.49	0.10	19.711	1.00	19.75	0.40	19.967	0.45	19.6185	0.2763
	$P_{1.7/400}$	24.321	0.50	25.13	0.10	24.772	1.00	24.78	0.40	24.919	0.45	24.6962	0.1650
	$P_{2.0/400}$	32.026	0.50	33.01	0.10	32.606	1	32.75	0.40	32.567	0.40	32.4880	0.2004
	$P_{1.0/1000}$	33.519	0.5	35.79	0.32	35.239	1.5	35.30	0.40	34.913	0.45	34.7208	0.5181

*****Lab2 measured FeCo sample with N1-24 in the frequency range of 400 Hz to 1000 Hz

N_s	Losses	d_i					$u(d_i)$					E_n				
		Lab1	Lab2*	Lab3	Lab4	Lab5	Lab1	Lab2*	Lab3	Lab4	Lab5	**Lab1**	**Lab2***	**Lab3**	**Lab4**	**Lab5**
N1-12	$P_{1.0/400}$	-0.2643	0.4097	-0.0363	-0.1383	0.0197	0.215	0.210	0.289	0.213	0.212	**0.614**	**0.976**	**0.063**	**0.324**	**0.046**
	$P_{1.5/400}$	-0.5412	-0.1032	0.1197	0.1588	0.3758	0.281	0.265	0.329	0.276	0.279	**0.964**	**0.195**	**0.182**	**0.288**	**0.674**
	$P_{1.7/400}$	-0.4696	0.3424	-0.0187	-0.0106	0.1284	0.243	0.212	0.325	0.232	0.238	**0.968**	**0.809**	**0.029**	**0.023**	**0.270**
	$P_{2.0/400}$	×	0.2230	-0.1840	-0.0400	-0.2230	×	0.118	0.345	0.173	0.173	×	**0.941**	**0.266**	**0.115**	**0.645**
	$P_{1.0/1000}$	×	0.4549	-0.0958	-0.0351	-0.4221	×	0.236	0.567	0.249	0.259	×	**0.966**	**0.084**	**0.070**	**0.816**

*****Lab2 measured FeCo sample with N1-24 in the frequency range of 400 Hz to 1000 Hz

6.2.2 $J_m(H_m)$ curve results at 50 Hz

H_m (A/m)	Lab1		Lab2		Lab3		Lab4		x_{ref} (T)	$u(x_{ref})$ (T)	d_i				$u(d_i)$				E_n			
	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %			CMI	PTB	INRIM	NPL	CMI	PTB	INRIM	NPL	**CMI**	**PTB**	**INRIM**	**NPL**
2500	1.536	0.25	1.5424	0.062	1.546	0.50	1.542	0.28	1.5411	0.0032	-0.005	0.001	0.005	0.001	0.010	0.007	0.017	0.011	0.256	0.097	0.146	0.042

Results of the NO 0.3 sample

H_m (A/m)	Lab1		Lab2		Lab3		Lab4		x_{ref} (T)	$u(x_{ref})$ (T)	d_i				$u(d_i)$				E_n			
	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %			CMI	PTB	INRIM	NPL	CMI	PTB	INRIM	NPL	**CMI**	**PTB**	**INRIM**	**NPL**
800	1.900	0.25	1.9054	0.06	1.912	0.50	1.898	0.25	1.9034	0.0024	-0.003	0.002	0.009	-0.005	0.011	0.005	0.020	0.011	0.160	0.186	0.218	0.254

Results of the GO 0.3 sample

H_m (A/m)	Lab1		Lab2		Lab3		Lab4		x_{ref} (T)	$u(x_{ref})$ (T)	d_i				$u(d_i)$				E_n			
	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %			CMI	PTB	INRIM	NPL	CMI	PTB	INRIM	NPL	**CMI**	**PTB**	**INRIM**	**NPL**
2500	1.560	0.25	1.5537	0.06	1.570	0.50	1.553	0.25	1.5570	0.0032	0.003	-0.003	0.013	-0.004	0.010	0.007	0.017	0.010	0.151	0.248	0.385	0.198

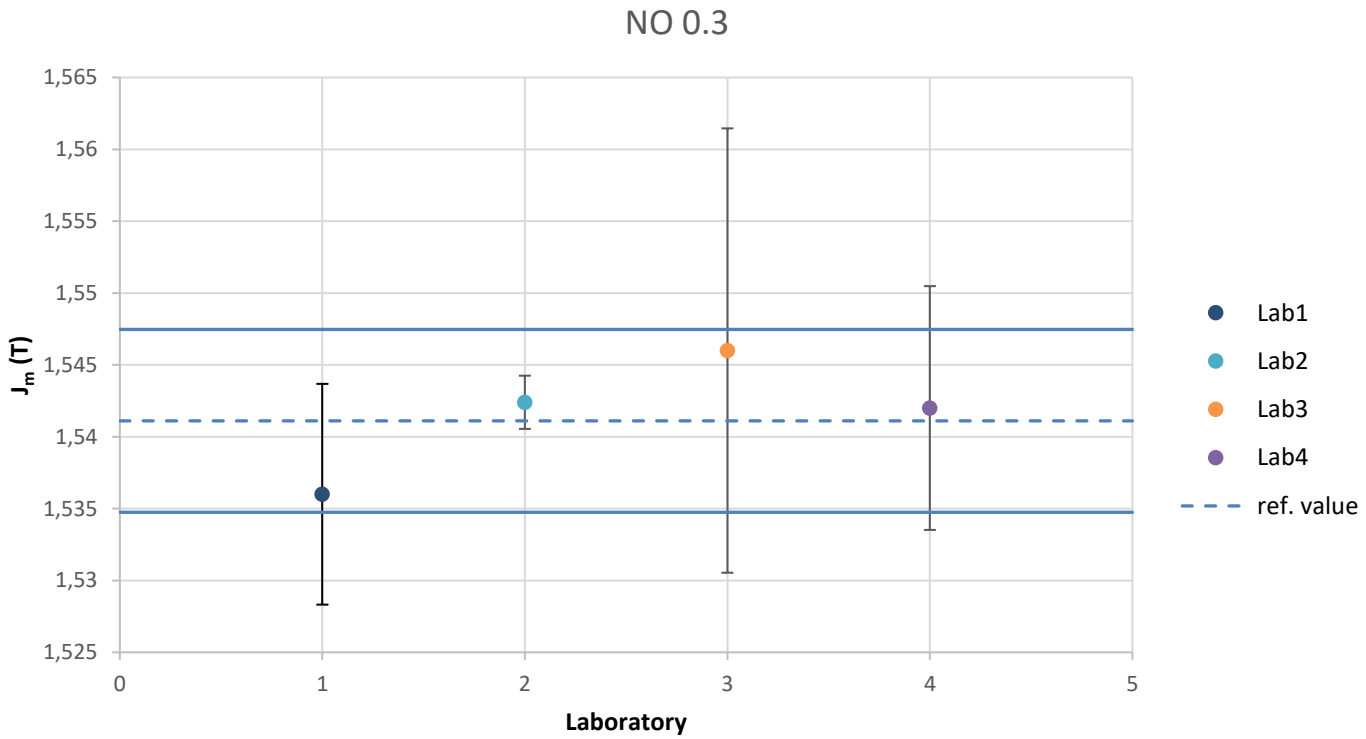
Results of the NO 0.2 sample

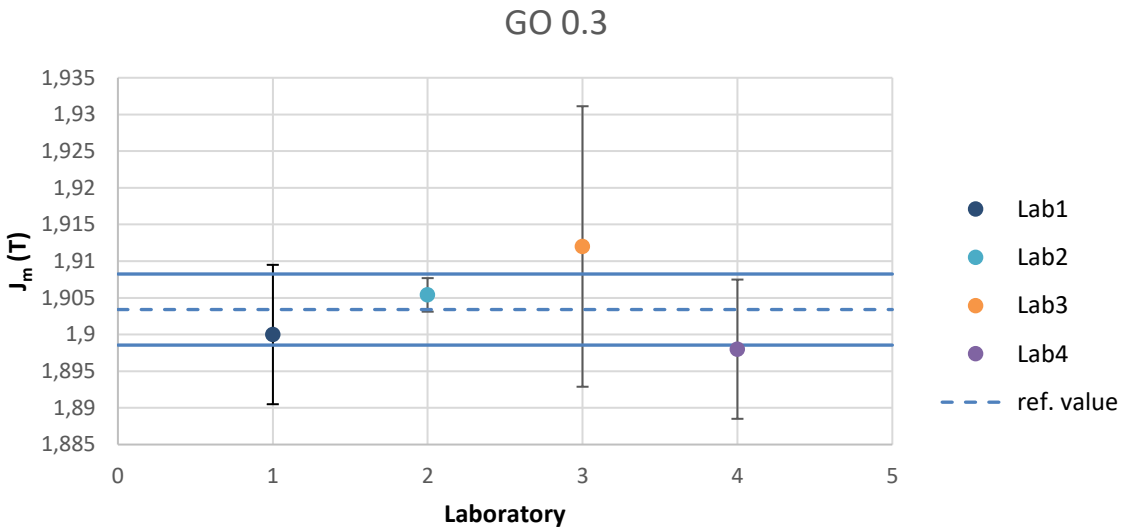
H_m (A/m)	Lab1		Lab2		Lab3		Lab4		x_{ref} (T)	$u(x_{ref})$ (T)	x_{ref} (T)				$u(d_i)$				E_n			
	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %			CMI	PTB	INRIM	NPL	CMI	PTB	INRIM	NPL	**CMI**	**PTB**	**INRIM**	**NPL**
800	1.901	0.40	1.9161	0.06	1.913	0.50	1.908	0.25	1.9113	0.0035	-0.010	0.005	0.002	-0.003	0.017	0.007	0.020	0.012	0.308	0.319	0.041	0.141

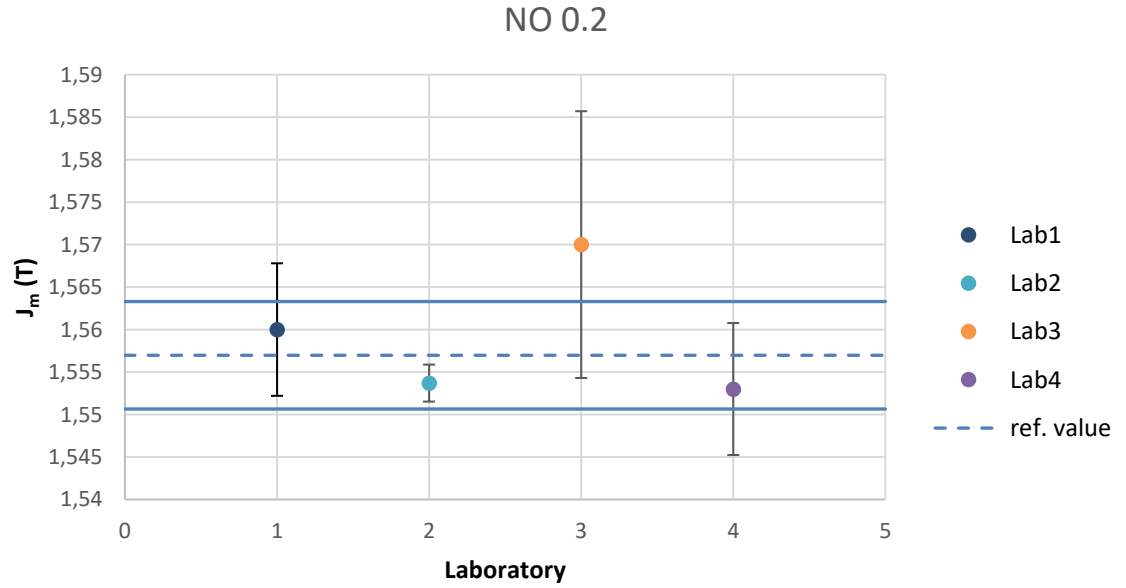
Results of the GO 0.18 sample

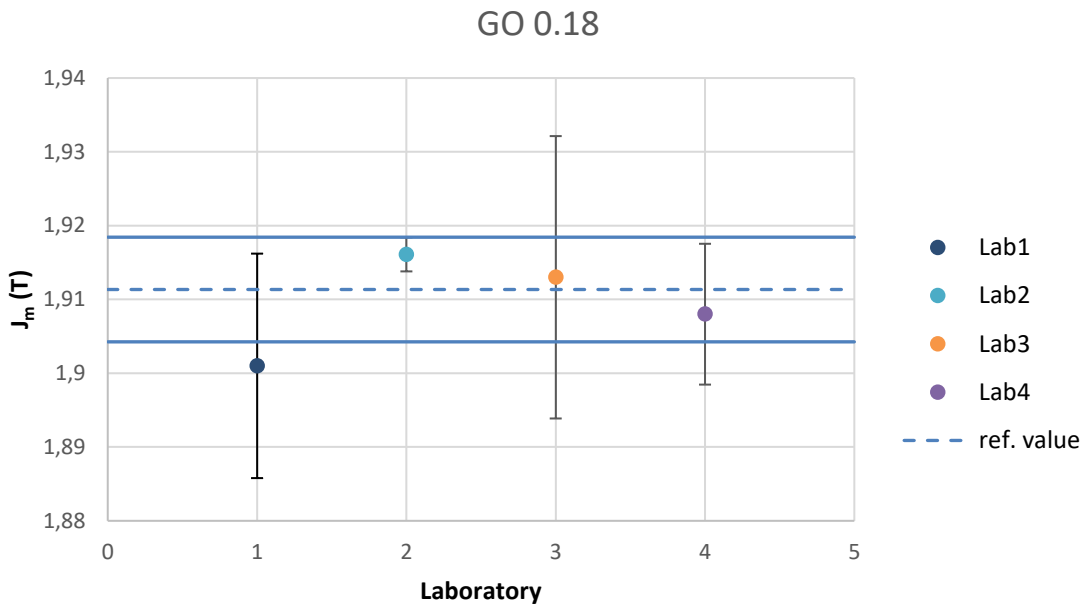
H_m (A/m)	Lab1		Lab2		Lab3		Lab4		x_{ref} (T)	$u(x_{ref})$ (T)	d_i				$u(d_i)$				E_n			
	X	u_x, %	X	u_x, %	X	u_x, %	X	u_x, %			CMI	PTB	INRIM	NPL	CMI	PTB	INRIM	NPL	**CMI**	**PTB**	**INRIM**	**NPL**
800	1.922	0.30	1.9118	0.06	1.912052	0.50	1.904	0.25	1.9120	0.0037	0.010	0.000	0.000	-0.008	0.014	0.008	0.020	0.012	0.366	0.013	0.000	0.333

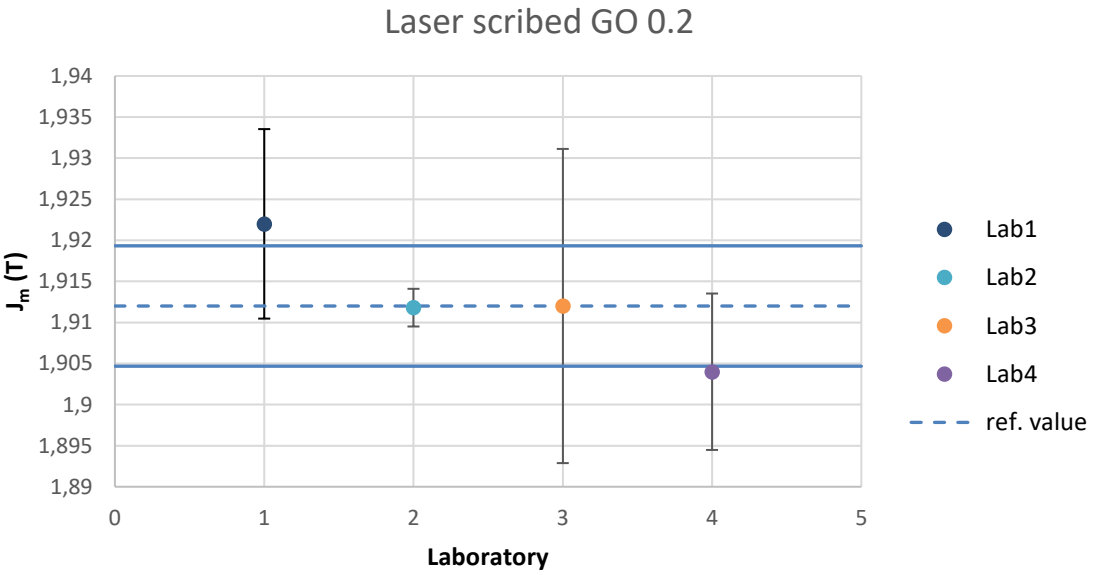
Results of the Laser scribed GO 0.2 sample




GO 0.3
1,935
1,93
1,925
1,92
1,915
1,91
1,905
1,9
1,895
1,89
1,885
J_m (T)
0
1
2
3
4
5
Laboratory
Lab1
Lab2
Lab3
Lab4
ref. value


NO 0.2
1,59
1,585
1,58
1,575
1,57
1,565
1,56
1,555
1,55
1,545
1,54
J_m (T)
0
1
2
3
4
5
Laboratory
Lab1
Lab2
Lab3
Lab4
ref. value


GO 0.18
1,94
1,93
1,92
1,91
1,9
1,89
1,88
J_m (T)
0
1
2
3
4
5
Laboratory
Lab1
Lab2
Lab3
Lab4
ref. value


Laser scribed GO 0.2
1,94
1,935
1,93
1,925
1,92
1,915
1,91
1,905
1,9
1,895
1,89
J_m (T)
0
1
2
3
4
5
Laboratory
Lab1
Lab2
Lab3
Lab4
ref. value

7 Summary and conclusions

After the evaluation of the data in agreement with the rules of EURAMET the agreement of the comparison is very good, because E_n values smaller 1 are obtained for all data points. This report also confirms that the results are consistent with the declared uncertainty of each individual laboratory.

8 References

[1] C. Appino et al.: “International Comparison on SST and Epstein Measurements in Grain-oriented Fe-Si Sheet Steel”, International Journal of Applied Electromagnetics and Mechanics 48, pp. 123 – 133, 2015.

[2] M. G. Cox: “The evaluation of key comparison data”, Metrologia, vol. 39, no. 6, 2002.

[3] S. Pommé and J. Keightley: “Determination of a reference value and its uncertainty through a power-moderated mean”, Metrologia, vol. 52, no. 3, 2015, pp. S200–S212.