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Mass Comparison:

2 kg, 100 g, 20 g, 2 g and 100 mg weights

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Abstract

A comparison M5 of 2 kg, 100 g, 20 g, 2 g and 100 mg weights was carried out in May and June 2004 by the Centre for Metrology and Accreditation (MIKES). Three accredited calibration laboratories from Finland took part to the comparison. The reference laboratory was MIKES.

The comparison was made with OIML class E₂ weights. The participants calibrated the weights according to their own measurement procedures. Measurement results of the laboratories were taken from calibration certificates.

All results were in agreement with the results of MIKES.

Tiivistelmä

Mittatekniikan keskus (MIKES) järjesti touko- ja kesäkuussa 2004 punnusten vertailumittauksen M5. Vertailu tehtiin 2 kg, 100 g, 20 g, 2 g ja 100 mg punnuksilla. Vertailumittaukseen osallistui kolme akkreditoitua kalibrointilaboratoriota Suomesta. Vertailun referenssilaboratoriona oli MIKES.

Vertailu tehtiin punnuksilla, jotka kuuluivat OIML luokkaan E₂. Vertailuun osallistuneet laboratoriot tekivät mittaukset omien mittausten menetelmiensä mukaisesti. Mittaustulokset on otettu laboratorioden antamista kalibrointitodistuksista.

Kaikki mittaustulokset olivat mittausepävarmuuksien sisällä samoja kuin MIKESin tulokset.

1 Introduction

A mass comparison was arranged in May and June 2004 co-ordinated by the Centre for Metrology and Accreditation (MIKES). The comparison was made with 2 kg, 200 g, 20 g, 2 g and 100 mg weights.

The aim of the comparison was to compare measurement results between the participants and the reference laboratory. Also uncertainty calculations were analysed. No detailed calibration instructions were given to the laboratories.

Three accredited calibration laboratories from Finland participated in the comparison. One of the laboratories is not accredited for calibration of weights but only for calibration of balances.

2 Transfer standards

The transfer standards (2 kg, 100 g, 20 g, 2 g and 100 mg) were stainless steel weights of OIML class E2. The 100 mg weight was a wire weight. The other weights were knob weights. The transfer standards are more than 5 years old and they have been calibrated several times.

The transfer standards were calibrated at MIKES before the comparison and the calibration was checked after the comparison. The calibration results and the mass changes during the comparison are given in Table 1.

ID	Conventional mass (m)	$U(m)$	Density (ρ)	$U(\rho)$	Mass change
P18 2kg	1999998,37 mg	$\pm 0,30$ mg	7964,4 kg/m ³	$\pm 0,3$ kg/m ³	-0,04 mg
P13 100g	100000,025 mg	$\pm 0,015$ mg	7958,0 kg/m ³	$\pm 1,3$ kg/m ³	0,002 mg
P13 20g	20000,036 mg	$\pm 0,008$ mg	7956,1 kg/m ³	$\pm 1,3$ kg/m ³	-0,001 mg
P13 2g	2000,010 mg	$\pm 0,004$ mg	7933,4 kg/m ³	$\pm 6,3$ kg/m ³	0,001 mg
P13 100mg	100,0027 mg	± 0.0015 mg	7937 kg/m ³	± 50 kg/m ³	0,0000 mg

Table 1. The masses and densities of the transfer standards and their expanded uncertainties U with $k = 2$. The last column gives the mass change during the comparison.

At MIKES the weights 100 mg, 2 g and 20 g were calibrated by subdivision. The 2 kg and 100 g weights were calibrated by comparison. The density of weights (2 g - 2 kg) have been determined by hydrostatic weighing in water. The mass changes during the comparison were smaller than measurement uncertainties. Their contribution to mass or its uncertainty is insignificant.

The traceability of mass at MIKES comes from BIPM. In Table 1 only the conventional mass is given. The uncertainty of mass is the same as the uncertainty in the CMC tables of MIKES.

3 Participants

The following laboratories participated to the comparison:

Inspecta Oy, K004, Helsinki,
Raute Precision Oy, K019, Lahti,
Teopal Oy, K037, Espoo,

The laboratories made the measurements between 10.5.2004 and 13.6.2004.

4 Measurement instructions

The following information about the transfer standards was given to the participants in advance: Nominal masses, OIML-class, densities and their uncertainties. Also instruction how to handle, store and transport the weights were given. For each laboratory the measurement time was one week. The participants were asked to send their results as calibration certificates to MIKES in two weeks after the return of the weights.

5 Results

Two laboratories presented their results as calibration certificates. One laboratory which was not accredited for calibration of weights gave only a measurement report. The uncertainties of the laboratories have been estimated according to EA-4/02.

Following the EA intercomparison practice the laboratories were given letter codes (A-C). The order is not necessarily the same as in section 3.

Results from the laboratories are given in Table 2. The conventional mass is denoted by m . The uncertainties U are expanded uncertainties corresponding to a coverage probability of 95 %. In all cases the coverage factor is two ($k = 2$). Laboratory A did not measure the 2 kg weights. This was agreed in advance.

A tool often used in analysing the results from interlaboratory comparisons is the normalised error En , which takes into account both the result and its uncertainty. The normalised error En is given as:

$$E_n = \frac{m_{lab} - m_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}} .$$

here the subscript lab refers to the calibration laboratory and ref refers to MIKES. In Table 3 mass differences between the laboratories and the reference laboratory $\Delta m = m_{lab} - m_{ref}$ and the corresponding uncertainties $U = \sqrt{U_{lab}^2 + U_{ref}^2}$ are given.

LAB	MIKES	MIKES	A	A	B	B	C	C
Weight	m (mg)	$U(m)$ (mg)	m (mg)	$U(m)$ (mg)	m (mg)	$U(m)$ (mg)	m (mg)	$U(m)$ (mg)
2 kg	1999998,37	0,30			1999998,3	1,0	1999998	3
100 g	100000,025	0,015	100000,02	0,13	100000,02	0,05	100000,06	0,05
20 g	20000,036	0,008	20000,042	0,028	20000,036	0,027	20000,036	0,025
2 g	2000,010	0,004	2000,011	0,027	2000,011	0,013	2000,007	0,012
100 mg	100,0027	0,0015	100,000	0,027	100,003	0,005	100,000	0,005

Table 2. Results from the comparison, m = conventional mass and $U(m)$ = expanded uncertainty.

LAB	A	A	B	B	C	C
Weight	Δm (mg)	U (mg)	Δm (mg)	U (mg)	Δm (mg)	U (mg)
2 kg			-0,070	1,044	-0,370	3,015
100 g	-0,005	0,131	-0,005	0,052	0,035	0,052
20 g	0,006	0,029	0,000	0,028	0,000	0,026
2 g	0,001	0,027	0,001	0,014	-0,003	0,013
100 mg	-0,003	0,027	0,000	0,005	-0,003	0,005

Table 3. Mass differences Δm and their expanded uncertainties U .

Calculated E_n -values of the results are shown in Table 4,

LAB	A	B	C
Weight	E_n	E_n	E_n
2 kg		-0,067	-0,123
100 g	-0,038	-0,096	0,670
20 g	0,206	0,000	0,000
2 g	0,037	0,074	-0,237
100 mg	-0,100	0,057	-0,517

Table 4. E_n values for the comparison.

A result of the comparison is considered acceptable if the absolute value of the normalised error E_n is less than 1. In this comparison all $|E_n|$ values are below 1.

6 Measurement procedures and contents of certificates

The laboratories calibrated the transfer weights by comparing them with their reference weights. Laboratory B used two reference weight in each calibration. In all laboratories the reference weights are traceable to MIKES.

According to the certificates all laboratories included the following uncertainty components: the reference weight(s), the mass comparator and variation of weighing results. One laboratory did not make any air buoyancy correction. Two laboratories did not include air buoyancy correction in their uncertainty calculations.

The uncertainties of the accredited weight calibration laboratories were equal to their best measurement capabilities.

The certificates of two accredited weight calibration laboratories were in accordance with the requirements of ISO/IEC 17025.

7 Conclusions

Three accredited mass calibration laboratories participated in a comparison of 100 mg - 2 kg weights.

All results of the participating laboratories were in agreement with the reference values of MIKES (E_n values smaller than one).

The weights were stable during the comparison.

8 References

- [1] EA-4/02: Expression of the Uncertainty of Measurement in Calibration.
- [2] SO/IEC 17025: General requirements for the testing and calibration laboratories.
- [3] Weights of Classes E1, E2, F1, F2, M1, M1-2, M2, M2-3, M3 , OIML R111, draft 2004.

Figures on results

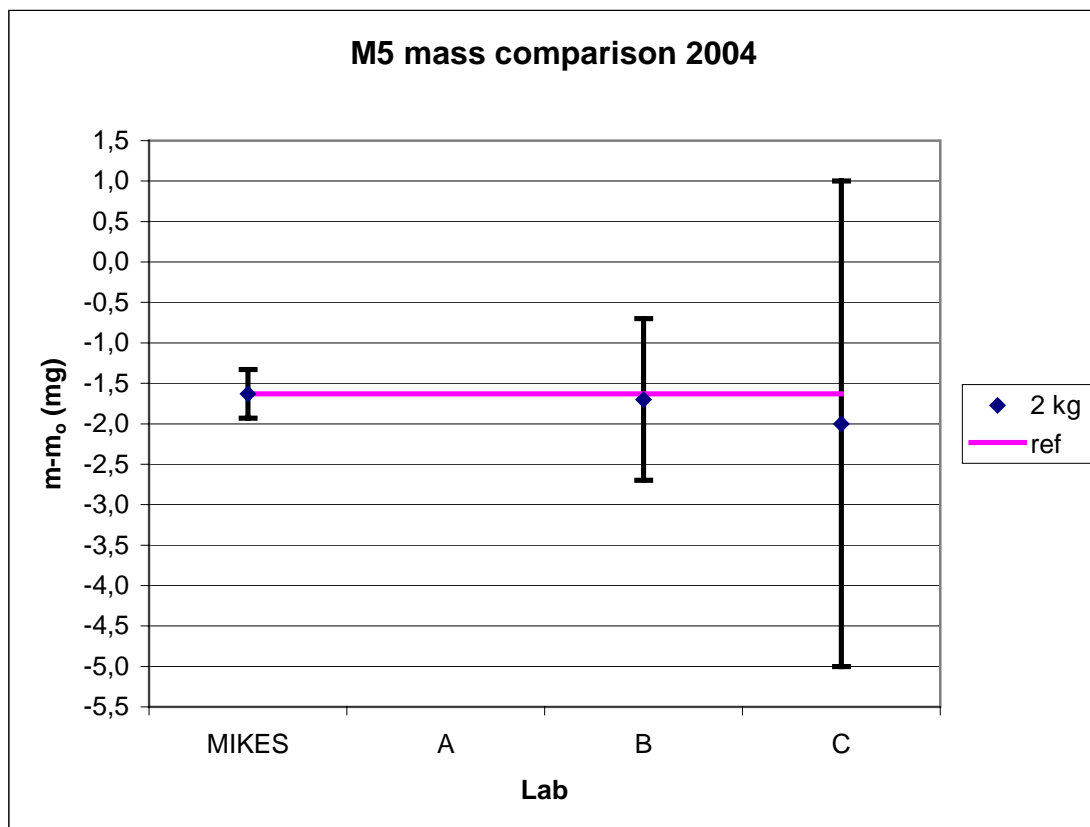


Figure 1. Measurement results for the 2 kg weight. The uncertainties are expanded uncertainties.

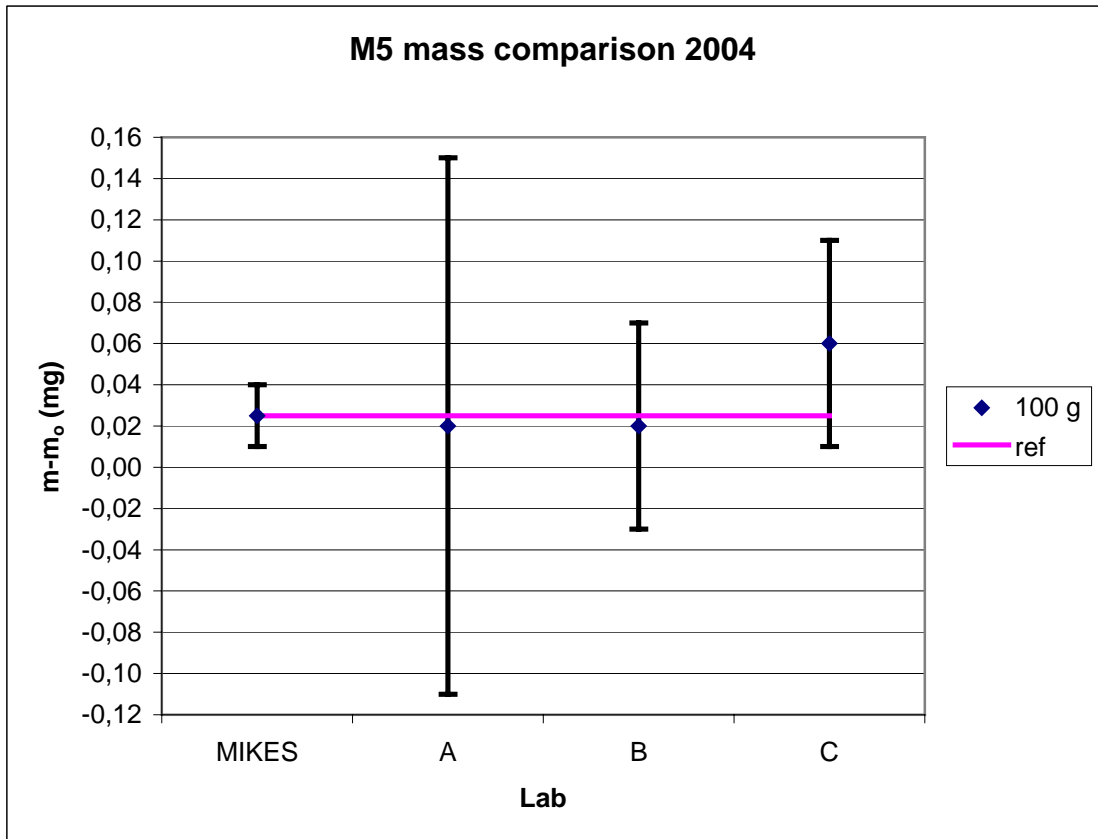


Figure 2. Measurement results for the 100 g weight.

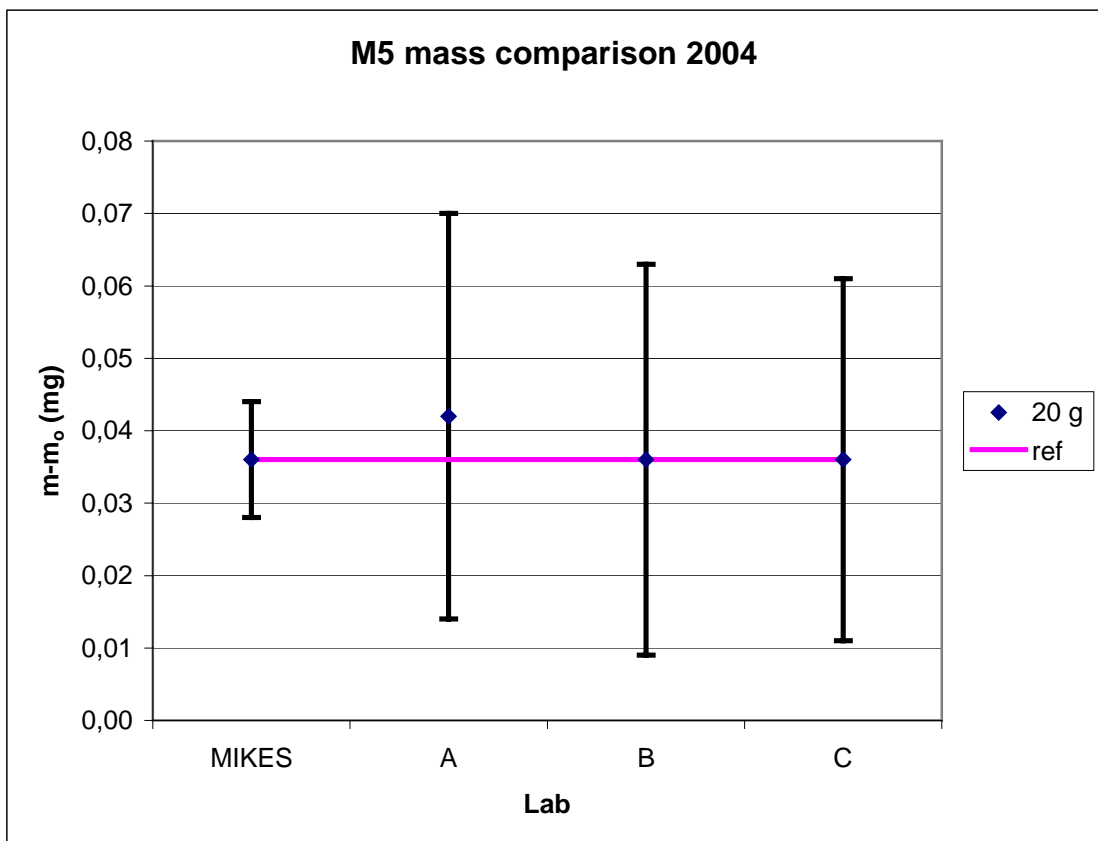


Figure 3. Measurement results for the 20 g weight.

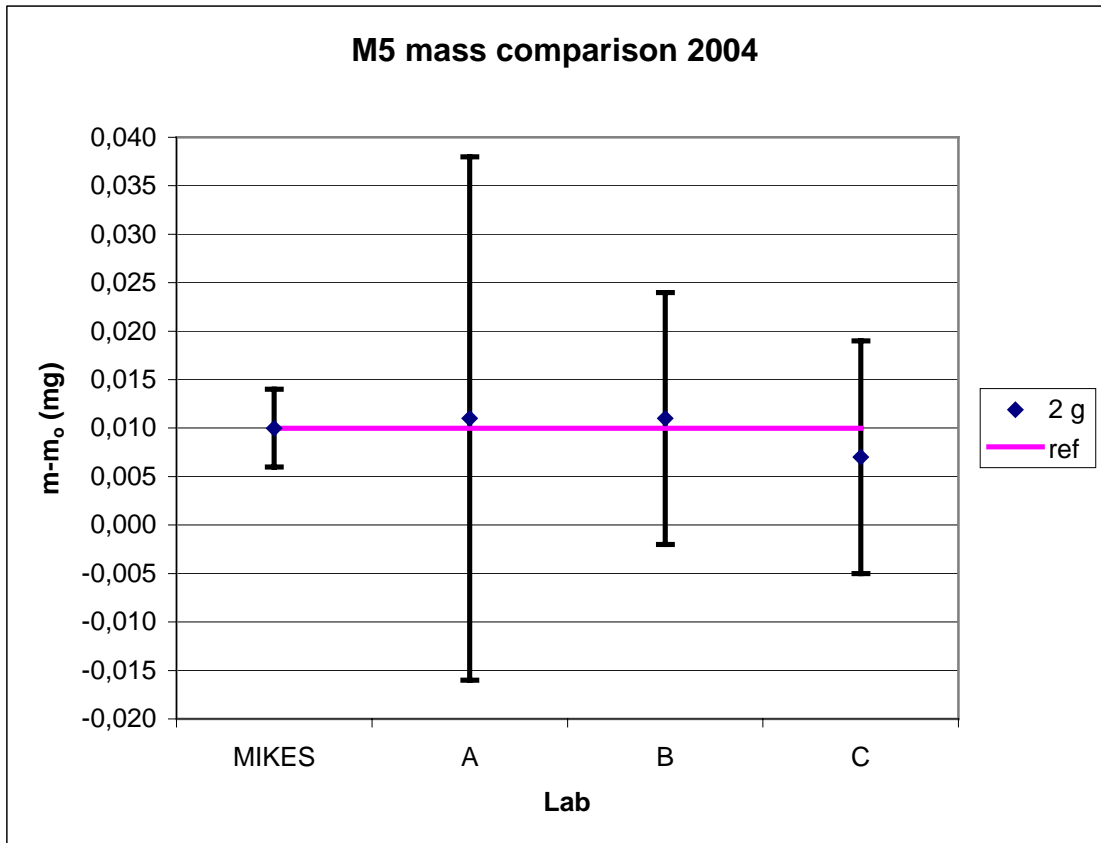


Figure 4. Measurement results for the 2 g weight.

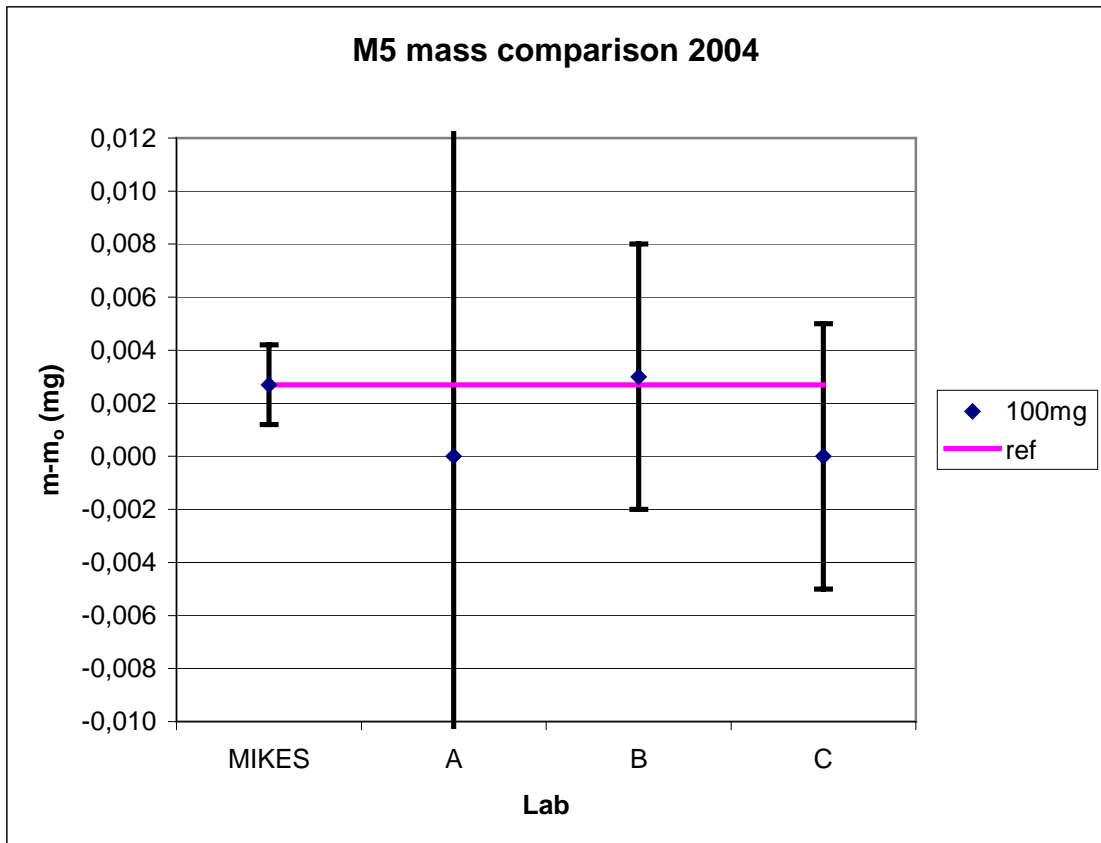


Figure 5. Measurement results for the 100 mg weight.

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- J1/2002 T. Weckström, *Lämpötilan mittaus*
- J2/2002 J. Järvinen, M. Heinonen and A. Lassila (Eds.), *Annual Report 2001*
- J3/2002 S.I. Niemelä, *Uncertainty of quantitative determinations derived by cultivation of microorganisms*
- J4/2002 A. Lassila, *Calibration of gauge blocks by mechanical comparison. Final Report*
- J5/2002 V. König, A. Pitkäkoski, M. Rantanen and S. Semenoja, *Comparison of spinning rotor vacuum gauges between MIKES, SP and Vaisala Oyj*
- J6/2002 M. Rantanen and S. Semenoja, *Calibration of a 130 Pa CDG: Comparison of the results from MIKES PTB and MKS Deutschland*
- J1/2003 J. Järvinen, M. Heinonen and A. Lassila (Eds.), *Annual Report 2002*
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- J8/2003 J. Järvinen (Toim.), *Kansallinen mittanormaalitoiminta ja sen kehittäminen 2003 - 2007*
- J1/2004 J. Järvinen et al. (Eds.) *Annual Report 2003*
- J2/2004 S. Semenoja, M. Rantanen, J. Leskinen and A. Pitkäkoski, *Comparison in the absolute pressure range 100 kPa to 2100 kPa between MIKES and Vaisala Oyj*
- J3/2004 V. Esala, *Pituuden vertailumittaus D6, loppuraportti*
- J4/2004 J. Halttunen, *Coriolis-mittarin vertailumittaus, syksy 2002. Interlaboratory comparison of a Coriolis flowmeter, Autumn 2002*
- J5/2004 L. Uusipaikka, *Suhteellisen kosteuden kalibrointien vertailu, loppuraportti.*

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