BALANCE COMPARISON FOR FINNISH ACCREDITED LABORATORIES: 600 G AND 10 KG BALANCES

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Abstract: VTT MIKES arranged a balance calibration comparison for Finnish laboratories accredited for balance calibration. The calibrated balances were 600 g ja 10 kg balances. Four accredited laboratories and seven persons carrying out the measurements participated in the comparison. All the results were in agreement with the reference value of the comparison. The largest normalized error $|E_n|$ was 0.64.

Keywords: Accredited laboratory, balance, comparison

1. INTRODUCTION

VTT MIKES arranged a balance calibration comparison for Finnish accredited laboratories in May - June 2016. The comparison was carried out in the laboratory premises and with the balances of VTT MIKES. The aim of the comparison was to compare the calibration results of the participants. Seven persons from four accredited laboratories participated in the comparison. The participant laboratories were: Oy G.W. Berg & Co Ab, Inspecta Tarkastus Oy, Lahti Precision Oy, and Teo-Pal Oy. The measurements were carried out using the weights owned by each accredited laboratory. The accredited laboratories reported their measurement results in the form of calibration certificates. The reference value of the comparison was calculated as the weighted average of the results of the participants.

2. BALANCES

The comparison included two balances: Sartorius MSA10202S, number 29307916, max = 10200 g, d = 0,01 g, and Sartorius ME614S, number 17010129, max = 610 g, d = 0,1 mg. Both balances were equipped with internal adjustment weights. The balances were internally adjusted before each comparison measurement.

The stability of the balances was monitored with the following weights:

  - MSA10202S: 2kg, 5 kg and 10kg
  - ME614S: 200g and 500g

The stability monitoring measurements were carried out before and after each comparison measurement. The uncertainty due to instability is the standard deviation of the reading with each load.

The loading points were the following:

  - Sartorius ME614: Loading with 0 g, 50 g, 100 g, 150 g, 200 g, 250 g, 300 g, 350 g, 400 g, 450 g, 500 g and 600 g.

  - Sartorius MSA10202S: Loading with 0 g, 1000 g, 2000 g, 3000 g, 4000 g, 5000 g, 6000 g, 7000 g, 8000 g, 9000 g, 10000 g and 10200 g.

It was not mandatory to measure at all loading points.

3. RESULTS

The results of the persons carrying out the calibrations are presented with randomly given letters A to G. In the Tables 1a and 1b give the results with associated uncertainties. Only the loading points with measurements carried out by more than one accredited laboratory are included in the Tables. According to the calibration certificates, all the laboratories estimated their measurement uncertainties according to EA-4/02 [1]. All of the accredited laboratories included up- and downloading in the calibration. The uncertainty components due to repeatability and eccentricity were determined and included in the uncertainty as well. Uncertainty due to air buoyancy, weights used in the calibration and resolution of the balance display were also included. The laboratories used weights of OIML classes E_2 and F_1 [3]. The participants measured the environmental conditions with their own devices. The measurement procedures were according to [4].

The reference value of the comparison, *y,* and its associated standard uncertainty $u(y)$ was calculated according to [2]:

$$y = \frac{\sum_{i=1}^{n} x_i/u^2(x_i)}{\sum_{i=1}^{n} 1/u^2(x_i)} \quad (n=7) \tag{1}$$

$$u(y) = \sqrt{\sum_{i=1}^{n} 1/u^2(x_i)}, \tag{2}$$

where x_i is the result of the measurer i and $u(x_i) = U(x_i)/k$ is the standard uncertainty of that measurement.

The consistency of the results was studied with χ^2 test (probability 5 %, $n-1$ = 6 degrees of freedom, tabulated value 12.6). If the χ^2 value is below the tabulated value, the

weighted average of the measurement results can be used as the reference value of the comparison.

$$\chi^2 = \sum \frac{(x_i - y)^2}{u^2(x_i)} \qquad (3)$$

In this comparison, all the χ^2 values were smaller than the tabulated value.

The reference values of the comparison and their uncertainties are given in Tables 2a and 2b.

Table 1a. Results for balance ME614. E = error of the reading, $\underline{U}$ = expanded uncertainty (k=2). The values are given in milligrams (mg).

load (g)	A		B		C		D		E		F		G	
	E	U	E	U	E	U	E	U	E	U	E	U	E	U
0	0	0.29	0	0.3	0	0.37	0	0.1			0	0.1	0	0.1
1			0	0.3	0	0.37	-0.1	0.1			-0.1	0.1		
5			0	0.3	0	0.38	-0.1	0.1			-0.2	0.1		
10			0	0.31	-0.1	0.38	-0.1	0.1			-0.3	0.2		
50	-0.1	0.29	-0.1	0.32	0	0.39	-0.1	0.2			-0.2	0.2	-0.1	0.3
100	-0.1	0.3	0.1	0.34	0	0.41	-0.1	0.2			-0.1	0.2	-0.3	0.3
150	0	0.32											-0.4	0.5
200	-0.1	0.37	-0.1	0.41	-0.3	0.47	-0.3	0.3			-0.2	0.3		
300	-0.1	0.43					-0.2	0.4			-0.3	0.4		
400	0	0.5	-0.2	0.57	-0.3	0.64	-0.4	0.6			-0.3	0.6	-0.5	0.9
600	0.5	0.65	0	0.79	-0.4	0.85	0	0.9			0.2	0.9	-0.1	1.3

Table 1b. Results for balance MSA10202. E = error of the reading, $\underline{U}$ = expanded uncertainty (k=2). The values are given in grams (g).

load (g)	A		B		C		D		E		F		G	
	E	U	E	U	E	U	E	U	E	U	E	U	E	U
0	0	0.02	0	0.019	0	0.019	0	0.01	0	0.01	0	0.01	0.01	0.01
500			0	0.019	0	0.019	0	0.01	-0.01	0.02	-0.01	0.01		
1000	0	0.02	-0.01	0.019	-0.01	0.019	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01	0.02
2000	-0.02	0.02											-0.02	0.02
3000			-0.02	0.019	-0.04	0.019	-0.02	0.01	-0.03	0.02	-0.04	0.02	-0.03	0.03
4000	-0.05	0.021											-0.04	0.03
5000			-0.06	0.02	-0.05	0.02	-0.05	0.01	-0.06	0.02	-0.07	0.02	-0.06	0.04
6000	-0.08	0.023											-0.07	0.05
8000	-0.1	0.026											-0.09	0.06
10000	-0.1	0.029	-0.09	0.024	-0.09	0.024							-0.08	0.07

The differences between the measurement results and the comparison reference value

$$d_i = x_i - y \qquad (4)$$

with the associated uncertainties $u(d_i)$ are presented in Tables 3a and 3b. The uncertainty $u(d_i)$ is calculated as

$$u^2(d_i) = u^2(x_i) + u^2_{stab} - u^2(y) \qquad (5)$$

where u^2_{stab} is the uncertainty due to stability of the balance.

The normalized errors E_n are calculated as

$$E_n = \frac{d_i}{U(d_i)} \qquad (6)$$

where $U(d_i) = 2u(d_i)$. If the absolute value of the normalized error $|E_n|$ is below 1, the result is considered acceptable. In this comparison, the largest $|E_n|$ value was 0.64. The E_n values of the comparison are presented in Tables 4a and 4b.

Table 2a. The reference value of the comparison and its uncertainty, ME614.

load (g)	y (mg)	$u(y)$ (mg)
0	0.0	0.03
1	-0.1	0.03
5	-0.1	0.03
10	-0.1	0.04
50	-0.1	0.05
100	-0.1	0.05
150	-0.1	0.13
200	-0.2	0.08
300	-0.2	0.12
400	-0.2	0.12
600	0.1	0.17

Table 2b. The reference value of the comparison and its uncertainty, MSA10202.

load (g)	y(g)	$u(y)$ (g)
0	0.00	0.003
500	0.00	0.003
1000	-0.01	0.003
2000	-0.02	0.007
3000	-0.03	0.004
4000	-0.05	0.009
5000	-0.06	0.004
6000	-0.08	0.010
8000	-0.10	0.012
10000	-0.09	0.007

Table 3a. Measurement result - reference value with associated uncertainty, ME614

load (g)	A		B		C		D		E		F		G	
	d	u(d)	d	u(d)	d	u(d)	d	u(d)	d	u(d)	d	u(d)	d	u(d)
0	0.0	0.2	0.0	0.2	0.0	0.2	0.0	0.1			0.0	0.1	0.0	0.1
1			0.1	0.2	0.1	0.2	0.0	0.1			0.0	0.1		
5			0.1	0.2	0.1	0.2	0.0	0.1			-0.1	0.1		
10			0.1	0.2	0.0	0.2	0.0	0.1			-0.2	0.2		
50	0.0	0.2	0.0	0.2	0.1	0.2	0.0	0.2			-0.1	0.2	0.0	0.2
100	0.0	0.2	0.2	0.2	0.1	0.2	0.0	0.2			0.0	0.2	-0.2	0.2
150	0.1	0.2											-0.3	0.3
200	0.1	0.2	0.1	0.2	-0.1	0.3	-0.1	0.2			0.0	0.2		
300	0.1	0.3					0.0	0.3			-0.1	0.3		
400	0.2	0.3	0.0	0.3	-0.1	0.4	-0.2	0.4			-0.1	0.4	-0.3	0.5
600	0.4	0.4	-0.1	0.4	-0.5	0.5	-0.1	0.5			0.1	0.5	-0.2	0.7

Table 3b. Measurement result - reference value with associated uncertainty, MSA10202

load (g)	A		B		C		D		E		F		G	
	d	u(d)	d	u(d)	d	u(d)	d	u(d)	d	u(d)	d	u(d)	d	u(d)
0	0.00	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.01	0.01	0.01
500			0.00	0.02	0.00	0.02	0.00	0.01	-0.01	0.02	-0.01	0.01		
1000	0.01	0.02	0.00	0.02	0.00	0.02	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.02
2000	0.00	0.01											0.00	0.01
3000			0.01	0.02	-0.01	0.02	0.01	0.01	0.00	0.02	-0.01	0.02	0.00	0.02
4000	0.00	0.01											0.01	0.02
5000			0.00	0.02	0.01	0.02	0.01	0.01	0.00	0.02	-0.01	0.02	0.00	0.02
6000	0.00	0.03											0.01	0.04
8000	0.00	0.03											0.01	0.04
10000	-0.01	0.04	0.00	0.03	0.00	0.03							0.01	0.05

Table 4a. E_n values of the comparison, ME614

	A	B	C	D	E	F	G
1		0.26	0.22	-0.04		-0.04	
5		0.39	0.32	0.18		-0.29	
10		0.36	0.07	0.13		-0.64	
50	0.06	0.06	0.28	0.08		-0.30	0.06
100	0.00	0.52	0.22	0.00		0.00	-0.58
150	0.44						-0.61
200	0.27	0.25	-0.19	-0.29		0.02	
300	0.19						
400	0.41	0.06	-0.08	-0.24		-0.09	-0.27
600	0.59	-0.12	-0.57	-0.11		0.11	-0.15

Table 4b. E_n values of the comparison, MSA10202

	A	B	C	D	E	F	G
500		0.17	0.17	0.21	-0.20	-0.26	
1000	0.34	-0.02	-0.02	-0.03	-0.03	-0.03	-0.02
2000	0.00						0.00
3000		0.25	-0.51	0.31	-0.13	-0.49	-0.10
4000	-0.14						0.21
5000		-0.18	0.19	0.24	-0.18	-0.54	-0.11
6000	-0.03						0.11
8000	-0.03						0.10
10000	-0.12	0.03	0.03				0.13

5. CONCLUSIONS

Four Finnish laboratories accredited for balance calibration participated in the calibration comparison of 600 g ja 10 kg balances. All the results were in agreement with the reference value of the comparison. The largest normalized error $|E_n|$ was 0.64.

6. REFERENCES

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