

Calibration certificate no. 01/2019

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Leveling staff (type, no.):

GPCL3,, no. 32316

Calibration range [the order of the scale division]:

9-682

Comparator:

Horizontal comparator

Contract:

[REDACTED]

Date:

13.12.2018

Laboratory of metrology of short lengths

Slovak University of Technology in Bratislava

Faculty of Civil Engineering

Department of Surveying

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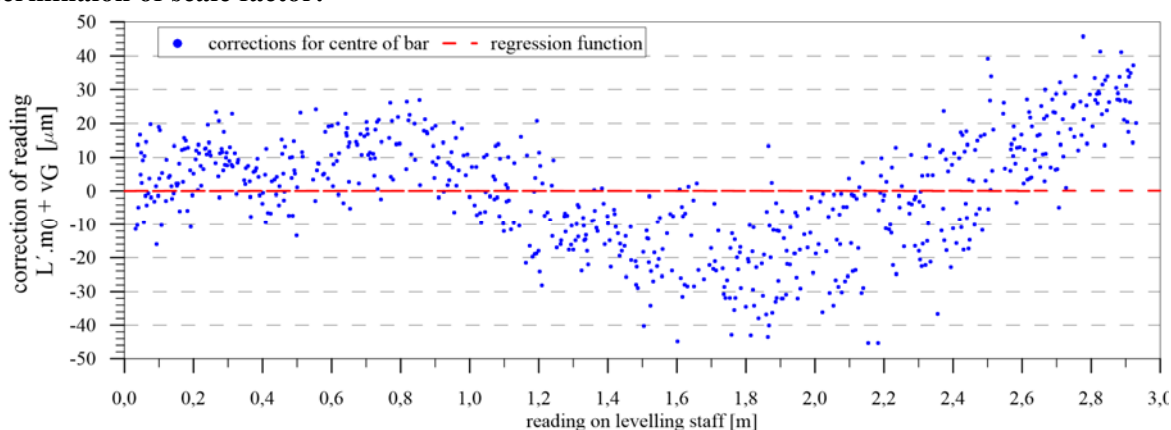
Coefficient of expansion (standardized value):

$$\alpha_{TN} = 0,50 \text{ ppm} \cdot ^\circ\text{C}^{-1}$$

Position of the leveling staff during calibration:

horizontal

Determination of scale factor:



Scale factor:

$$m_0 = -0.04 \pm 0,02 \text{ ppm}$$

$$T_0 = 20,2^\circ\text{C}$$

$$v_G = -34 \cdot 10^{-6} \text{ m}$$

Reading on the levelling staff after correction:

$$L = L' \cdot [1 + m_0 + \alpha_T \cdot (T - T_0) \cdot 10^{-6}] + v_G$$

L' [m]

measured value

m_0

scale factor

T [°C]

temperature during measurement

α_T [ppm · °C⁻¹]

coefficient of expansion

T_0 [°C]

temperature during calibration

v_G [m]

index correction

Determination of scale factor:

1st measurement:

scale factor:

$$0.0341 \text{ ppm} \pm 0,020 \text{ ppm}$$

Average temperature

20,4 °C

Average atmospheric pressure:

1003.9 hPa

Average deviation of measurements:

± 5.83 μm

2nd measurement:

scale factor:

$$0.0417 \text{ ppm} \pm 0,036 \text{ ppm}$$

Average temperature

20,0 °C

Average atmospheric pressure:

1005,7 hPa

Average deviation of measurements:

± 5,75 μm

Average from both measurement:

scale factor:

$$0.0379 \text{ ppm} \pm 0,028 \text{ ppm}$$

Average temperature

20,2 °C

Average atmospheric pressure:

1004.8 hPa

Average deviation of measurements:

± 5.79 μm

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Corrections for the centre of the division of the leveling staff scale [μm]:

	0	1	2	3	4	5	6	7	8	9
0										-11.44
10	-10.19	13.77	-4.88	16.66	4.83	11.38	2.32	9.17	-9.47	10.45
20	-1.41	14.61	-4.10	-0.72	3.64	19.77	-1.81	-3.10	1.35	-15.95
30	-1.35	18.92	3.71	17.93	-10.18	5.41	-2.84	9.24	3.99	4.59
40	1.48	-2.21	-0.66	13.31	2.16	1.51	2.19	8.12	-5.99	12.28
50	2.66	15.63	12.63	14.79	-5.85	12.86	6.11	-10.81	-1.19	5.19
60	9.37	12.13	0.30	13.72	11.28	7.54	1.60	6.44	12.63	12.74
70	10.87	19.55	14.39	11.68	10.59	8.26	23.36	4.31	20.72	-1.80
80	11.20	12.57	11.54	6.10	17.53	7.80	9.89	11.35	7.60	9.03
90	13.07	7.85	22.86	7.37	11.31	-0.85	8.54	9.26	3.16	2.12
100	6.86	7.45	2.85	-1.77	-7.62	5.61	6.06	6.76	9.53	4.17
110	-1.15	-3.73	-0.54	4.88	-9.35	12.52	-6.52	-6.59	2.94	3.40
120	-1.06	4.24	-4.24	1.33	15.16	11.13	5.24	-2.71	-0.18	13.26
130	-7.31	9.99	3.83	10.17	-7.23	14.69	6.23	5.14	-13.30	1.13
140	23.26	11.57	10.19	3.45	-2.90	24.14	6.14	8.35	8.07	4.91
150	5.12	17.44	3.78	19.09	10.70	19.25	1.37	7.93	9.00	20.01
160	-1.08	11.33	-3.56	22.84	17.09	16.31	18.58	13.24	2.70	14.37
170	-5.24	14.51	13.76	2.24	16.86	10.69	16.22	20.38	18.36	16.87
180	10.70	11.46	9.63	11.01	4.58	9.71	18.19	20.46	0.65	21.18
190	-2.43	14.51	15.66	26.16	4.12	20.73	3.34	13.96	21.91	13.99
200	6.43	26.46	20.95	22.56	10.87	20.02	9.29	27.07	1.76	17.77
210	21.22	17.51	17.05	18.45	8.58	13.35	3.93	19.24	7.87	9.89
220	-1.90	14.42	-0.20	1.79	8.42	3.27	7.86	11.65	6.94	20.30
230	-6.30	15.73	1.60	6.19	18.54	10.64	4.76	10.89	-1.75	7.08
240	-4.23	7.07	-7.12	-6.39	-9.55	10.18	-6.21	-0.43	10.75	-1.61
250	4.35	-2.35	3.35	13.36	-1.93	13.95	-7.39	9.67	-9.68	-12.01
260	1.92	-3.07	0.86	10.12	-2.72	-11.61	-9.66	8.31	-10.45	16.01
270	-21.64	10.64	-16.54	-5.99	-19.75	-0.19	-18.88	3.89	-18.79	20.69
280	-17.99	11.46	-24.21	7.54	-28.11	2.28	-7.33	-6.28	-8.55	1.50
290	-13.47	9.16	-17.00	-16.00	-14.84	-7.38	-6.60	-12.17	-7.28	-17.64
300	-16.11	-10.34	-17.67	-14.80	-9.97	-4.05	-13.73	-4.68	-23.95	-8.00
310	-10.40	-14.85	-14.48	-13.13	-17.88	-22.12	-8.85	-8.78	0.21	-5.87
320	-11.08	-11.99	0.79	-3.74	-16.02	-7.53	-9.82	-14.79	-22.77	-5.56
330	-6.78	-10.71	-12.76	-19.51	-15.83	-17.92	-16.49	-13.55	-25.67	-10.67
340	-20.83	-21.01	-27.97	-22.71	-28.99	-18.21	-40.22	-11.84	-14.13	-14.31
350	-21.32	-1.52	-34.23	-24.02	-26.96	-18.38	-22.54	-9.18	-20.46	-7.95

Technical specialist: Ing. Pavol Kajánek, PhD.

Bratislava, 13.12.2018

Laboratory director: doc. Ing. Ján Erdélyi, PhD.

Institute director: prof. Ing. Alojz Kopáček, PhD.

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	0	1	2	3	4	5	6	7	8	9
360	-25.51	-17.40	-12.75	-6.83	-23.92	-7.46	-44.85	0.37	-25.96	-4.70
370	-31.62	-7.52	-28.00	-6.61	-28.51	1.29	-13.42	-2.72	-28.46	2.15
380	-23.63	-26.29	-22.25	-17.15	-23.36	-3.63	-21.07	-23.86	-11.87	-23.21
390	-30.83	-28.55	-31.92	-26.60	-31.92	-17.08	-42.89	-12.64	-35.47	-14.44
400	-31.95	-19.88	-23.49	-18.41	-16.83	-29.00	-34.56	-20.35	-21.16	-10.31
410	-43.01	-18.19	-29.42	-10.95	-34.15	-22.88	-37.96	-21.74	-31.19	-19.08
420	-36.78	-6.12	-43.48	13.31	-40.16	-10.33	-19.91	2.36	-36.30	-11.79
430	-33.02	-3.58	-31.94	-11.89	-26.85	-12.13	-32.01	-5.91	-32.11	-14.11
440	-30.99	-18.01	-21.95	-22.11	-10.84	-18.78	-18.80	-6.36	-25.87	-7.22
450	-32.07	-17.66	-29.14	-13.09	-17.04	-5.13	-12.50	-1.90	-24.48	-18.80
460	-16.05	-3.01	-36.14	-0.93	-18.11	-7.58	-30.41	-5.39	-34.12	-1.12
470	-26.62	-14.65	-28.64	-6.90	-16.00	-0.91	-30.20	-4.71	-26.99	-4.62
480	-25.45	3.68	-15.66	-0.98	-24.02	-1.31	-23.66	-2.22	-17.18	1.13
490	-30.41	8.48	-28.92	-1.13	-45.34	-45.34	-5.65	-0.59	4.51	9.77
500	-2.63	-1.29	-11.18	2.71	-11.55	-10.06	-12.52	6.93	-22.24	12.83
510	-24.87	-1.37	-4.88	1.36	-16.66	-3.56	-6.60	10.72	-3.92	-2.33
520	-16.50	-1.71	-18.00	-3.08	-20.65	-0.27	-22.59	4.58	-15.90	-4.28
530	-22.30	9.87	-14.99	4.69	-9.80	13.51	-21.27	4.65	-36.73	11.54
540	-11.87	12.23	-5.10	23.75	-14.88	9.41	-17.85	5.90	-22.91	7.85
550	-11.19	11.20	-15.61	9.85	-8.42	17.39	-10.94	16.53	-17.63	11.70
560	-3.70	17.63	-7.96	13.63	-17.23	3.38	-14.61	2.95	-10.02	12.30
570	-6.83	14.79	-5.13	16.24	-11.75	16.61	3.08	39.20	-5.39	26.82
580	0.30	33.83	6.01	18.22	22.97	26.24	6.65	5.94	12.42	13.83
590	10.40	19.21	15.35	8.18	-3.39	12.84	12.99	16.69	2.29	12.47
600	6.48	27.21	3.41	23.41	3.67	21.70	4.02	19.20	9.21	12.09
610	16.32	16.67	7.19	25.24	10.90	21.41	2.94	29.94	11.03	22.16
620	7.02	27.22	23.44	23.15	6.39	28.89	6.45	17.16	-4.89	32.11
630	13.77	21.27	10.19	28.94	0.90	18.24	24.86	25.59	15.98	33.88
640	12.05	26.59	16.43	45.67	21.26	25.29	14.00	28.66	19.13	33.38
650	27.05	28.75	26.09	29.32	28.92	41.21	22.80	31.43	13.58	32.77
660	23.81	33.95	26.36	30.46	27.18	28.97	27.14	33.79	26.90	41.14
670	21.08	26.93	26.63	31.03	20.36	35.68	17.52	33.76	26.42	34.95
680	14.38	37.24	20.11							

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