Eidgenössische Materialprüfungs- und Forschungsanstalt
Laboratoire fédéral d'essai des matériaux et de recherche
Laboratorio federale di prova dei materiali e di ricerca
Institut federal da controlla da material e da retschertgas
Swiss Federal Laboratories for Materials Testing and Research

Empa
Überlandstrasse 129
CH-8600 Dübendorf
Tel. +41 58 7651111
Fax +41 58 7651122

Empa
Materials Science and Technology

Laboratory Air Pollution / Environmental Technology

Calibration Laboratory accredited by the Swiss Accreditation Service
The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Certificate-No. 5214015421-O3-2

Date: 2017-05-12

Pages: 11

Client: ISAC-CNR
Via Gobetti 101
I-40129 Bologna

Order-No. 5214015421
Contact person: Dr. Paolo Cristofanelli

Calibration Certificate

Test object:	Ozone calibrator	Type: TEI 49i-PS S/N 1404860524
	Calibration settings (initial)	COEF 1.023, BKG -0.3
	Calibration settings (final)	COEF 1.000, BKG -0.3
Primary standard:	Ozone primary standard	type SRP
	NIST, Gaithersburg	S/N 15
Measurement Conditions:	Date of the calibration:	2017-03-29/30 and 2017-04-04/05
	Location:	Empa Dübendorf Air-conditioned laboratory (LA 028)
	Environmental conditions:	Temperature: 22.5 ± 1.0 °C Pressure: 970.1 – 977.4 hPa
	Absorption coefficient (α):	308.32 $cm^{-1}atm^{-1}$ (Base e, 1013hPa, 273.15K, 253.7nm)
	Warm-up time:	>24 hours
	Conditioning:	>2 hours at 380 $nmolmol^{-1}$ ozone
	Zero air / ozone generator:	The zero air unit and the ozone generator of the SRP were used.
Measurement program:	A measurement cycle consisted of ozone measurements at 11 mole fractions, ranging between 0 – 250 $nmolmol^{-1}$. 12 (initial settings) and 14 (final settings) measurement cycles were made.	
Measurement uncertainty:	The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to a coverage probability of approx. 95%.	

This certificate documents the traceability to national standards, which realize the physical unit of measurements (SI).

The measurements, the uncertainty with confidence probability and calibration methods are given on the following pages and are part of the certificate.

The following table shows the results with the initial calibration settings (COEF 1.023, BKG -0.3):

Results:

No.	Reference		TEI 49i-PS #1404860524			
	SRP#15	s_d		s_d	deviation to reference	
	nmolmol^{-1}	nmolmol^{-1}	nmolmol^{-1}	nmolmol^{-1}	nmolmol^{-1}	%
1	173.88	0.28	179.11	0.15	5.23	3.01
2	50.36	0.40	51.81	0.12	1.45	2.89
3	99.28	0.15	102.17	0.10	2.89	2.91
4	147.92	0.28	152.11	0.13	4.19	2.83
5	217.58	0.21	223.73	0.18	6.14	2.82
6	12.89	0.26	13.30	0.11	0.41	3.17
7	78.57	0.13	80.76	0.13	2.19	2.79
8	-0.02	0.18	0.21	0.10	0.23	NA
9	199.24	0.38	204.73	0.20	5.49	2.75
10	124.78	0.25	128.38	0.07	3.60	2.88
11	244.47	0.31	251.43	0.11	6.96	2.85
12	124.51	0.23	128.01	0.17	3.50	2.81
13	173.45	0.12	178.22	0.06	4.77	2.75
14	147.45	0.15	151.65	0.08	4.20	2.85
15	217.10	0.19	223.18	0.13	6.08	2.80
16	98.60	0.17	101.35	0.09	2.75	2.78
17	198.16	0.17	203.57	0.11	5.41	2.73
18	77.81	0.24	80.04	0.09	2.23	2.86
19	50.33	0.20	51.67	0.07	1.34	2.67
20	12.92	0.13	13.38	0.07	0.46	3.56
21	0.33	0.21	0.26	0.12	-0.07	NA
22	245.03	0.42	251.99	0.60	6.96	2.84
23	173.15	0.22	178.37	0.11	5.22	3.01
24	198.24	0.17	203.77	0.09	5.53	2.79
25	216.77	0.43	222.88	0.19	6.11	2.82
26	49.92	0.25	51.44	0.09	1.52	3.05
27	98.78	0.21	101.77	0.09	2.99	3.03
28	124.42	0.21	127.83	0.12	3.42	2.75
29	77.77	0.18	80.17	0.13	2.41	3.09
30	-0.25	0.14	0.24	0.10	0.50	NA
31	12.93	0.28	13.55	0.04	0.61	4.74
32	148.21	0.31	152.36	0.20	4.15	2.80
33	244.22	0.45	251.07	0.33	6.85	2.81
34	198.10	0.20	203.66	0.14	5.56	2.81
35	98.59	0.38	101.54	0.08	2.95	2.99
36	172.87	0.16	177.82	0.17	4.95	2.86
37	77.65	0.18	80.15	0.14	2.50	3.22
38	124.61	0.33	127.88	0.08	3.27	2.62
39	216.73	0.24	222.93	0.17	6.20	2.86
40	49.74	0.32	51.50	0.12	1.76	3.54
41	-0.04	0.12	0.24	0.06	0.28	- NA
42	12.96	0.19	13.54	0.11	0.59	4.54
43	148.12	0.27	152.37	0.19	4.24	2.87
44	244.09	0.24	251.18	0.29	7.09	2.90
45	50.11	0.29	51.67	0.13	1.56	3.12
46	217.07	0.27	223.21	0.11	6.14	2.83
47	147.66	0.23	151.56	0.11	3.89	2.64
48	197.77	0.22	203.24	0.16	5.47	2.77
49	12.81	0.16	13.32	0.06	0.51	3.99
50	78.28	0.20	80.54	0.07	2.26	2.88
51	-0.15	0.23	0.16	0.14	0.31	- NA

52	125.55	0.22	128.94	0.12	3.39	2.70
53	99.40	0.17	102.11	0.10	2.71	2.73
54	173.65	0.19	178.61	0.12	4.96	2.86
55	244.24	0.33	250.97	0.22	6.72	2.75
56	147.48	0.21	151.65	0.14	4.17	2.83
57	98.90	0.29	101.63	0.09	2.73	2.76
58	197.95	0.19	203.61	0.17	5.66	2.86
59	12.87	0.33	13.38	0.11	0.51	3.96
60	124.91	0.31	128.44	0.19	3.54	2.83
61	78.37	0.20	80.56	0.10	2.19	2.79
62	217.61	0.17	223.75	0.07	6.14	2.82
63	50.13	0.29	51.59	0.10	1.46	2.92
64	173.64	0.31	178.60	0.15	4.96	2.86
65	0.19	0.31	0.26	0.09	0.07	NA
66	245.13	0.40	252.11	0.55	6.99	2.85
67	12.96	0.41	13.41	0.08	0.46	3.52
68	148.26	0.20	152.45	0.27	4.19	2.82
69	173.76	0.15	178.76	0.06	5.00	2.88
70	78.19	0.13	80.54	0.10	2.35	3.01
71	50.29	0.27	51.95	0.07	1.67	3.31
72	198.87	0.31	204.40	0.10	5.53	2.78
73	99.00	0.29	101.83	0.06	2.83	2.86
74	217.51	0.17	223.67	0.18	6.16	2.83
75	124.19	0.24	127.71	0.15	3.52	2.84
76	0.04	0.22	0.22	0.06	0.18	NA
77	245.26	0.52	252.41	0.47	7.15	2.92
78	124.97	0.29	128.46	0.10	3.50	2.80
79	78.39	0.24	80.46	0.05	2.07	2.64
80	217.62	0.30	223.88	0.07	6.26	2.88
81	99.00	0.20	101.72	0.08	2.72	2.75
82	12.70	0.46	13.48	0.07	0.78	6.16
83	199.35	0.43	204.99	0.45	5.64	2.83
84	50.42	0.33	51.71	0.09	1.30	2.58
85	-0.38	0.44	0.25	0.08	0.63	NA
86	175.35	0.50	180.47	0.33	5.11	2.92
87	148.01	0.29	152.34	0.05	4.32	2.92
88	244.68	0.28	251.75	0.13	7.07	2.89
89	217.57	0.30	223.81	0.15	6.24	2.87
90	78.04	0.20	80.30	0.11	2.26	2.89
91	50.54	0.32	51.79	0.05	1.25	2.47
92	199.01	0.35	204.68	0.16	5.67	2.85
93	12.86	0.15	13.41	0.13	0.55	4.28
94	124.97	0.34	128.76	0.15	3.79	3.03
95	-0.08	0.29	0.18	0.09	0.27	NA
96	175.27	0.47	180.45	0.44	5.18	2.96
97	148.15	0.24	152.33	0.08	4.18	2.82
98	99.65	0.36	102.31	0.07	2.65	2.66
99	244.62	0.32	251.57	0.10	6.95	2.84
100	98.95	0.37	101.93	0.07	2.98	3.01
101	198.47	0.24	204.12	0.20	5.65	2.85
102	78.04	0.15	80.31	0.16	2.28	2.92
103	50.29	0.33	51.81	0.09	1.52	3.02
104	0.32	0.26	0.26	0.12	-0.07	NA
105	175.49	0.56	180.52	0.39	5.03	2.87
106	218.04	0.40	224.27	0.22	6.24	2.86
107	124.51	0.31	128.30	0.14	3.79	3.05
108	13.01	0.27	13.48	0.11	0.46	3.57
109	148.02	0.49	152.35	0.30	4.33	2.92

110	244.50	0.10	251.45	0.09	6.95	2.84
111	124.59	0.37	128.31	0.12	3.73	2.99
112	-0.15	0.28	0.27	0.09	0.42	NA
113	218.06	0.48	224.37	0.27	6.30	2.89
114	173.62	0.32	178.63	0.12	5.01	2.89
115	50.20	0.21	51.61	0.14	1.40	2.80
116	99.32	0.23	102.20	0.10	2.88	2.90
117	78.15	0.14	80.48	0.11	2.33	2.98
118	198.50	0.35	204.21	0.09	5.71	2.88
119	12.84	0.21	13.43	0.13	0.59	4.63
120	148.10	0.27	152.31	0.31	4.21	2.85
121	244.26	0.23	251.37	0.19	7.10	2.91
122	78.08	0.29	80.39	0.05	2.31	2.96
123	99.44	0.25	101.92	0.12	2.48	2.50
124	198.10	0.20	203.96	0.22	5.86	2.96
125	12.78	0.20	13.34	0.11	0.56	4.39
126	148.05	0.32	152.39	0.33	4.34	2.93
127	173.58	0.24	178.60	0.06	5.02	2.89
128	217.21	0.32	223.51	0.12	6.29	2.90
129	-0.05	0.32	0.26	0.05	0.30	NA
130	50.45	0.15	51.99	0.04	1.55	3.06
131	125.16	0.26	128.97	0.15	3.81	3.04
132	244.83	0.29	251.75	0.28	6.92	2.83

s_d: standard deviation (n = 10 measurement values)
NA: not applicable

Calibration function: The following calibration function for the initial calibration of the TEI 49i-PS #1404860524 (COEF 1.023, BKG -0.3) for the range of 0-250 nmolmol^{-1} was determined from the comparison on 2017-03-29/30 at a temperature of 22.5±1°C and a pressure of 974.7 – 977.4 hPa.

Reference value (SRP#15) = 0.9731 x TEI 49i-PS #1404860524 - 0.14) nmolmol^{-1}
(valid for calibration settings COEF 1.023, BKG -0.3)

Measurement uncertainty: of the calibration

reference value (SRP#15)	value (TEI 49i-PS)	± uncertainty
0 nmolmol^{-1}	0.2	± 1.0 nmolmol^{-1}
25 nmolmol^{-1}	25.8	± 1.1 nmolmol^{-1}
50 nmolmol^{-1}	51.3	± 1.5 nmolmol^{-1}
75 nmolmol^{-1}	77.2	± 2.0 nmolmol^{-1}
100 nmolmol^{-1}	102.9	± 2.5 nmolmol^{-1}
125 nmolmol^{-1}	128.6	± 3.0 nmolmol^{-1}
150 nmolmol^{-1}	154.3	± 3.6 nmolmol^{-1}
175 nmolmol^{-1}	180.0	± 4.1 nmolmol^{-1}
200 nmolmol^{-1}	205.7	± 4.7 nmolmol^{-1}
225 nmolmol^{-1}	231.4	± 5.2 nmolmol^{-1}
250 nmolmol^{-1}	257.1	± 5.8 nmolmol^{-1}

Figure 1 shows the linear regression of the difference (TEI 49i-PS #1404860524 - SRP#15) versus SRP#15, including the prediction interval (95%) with the initial calibration settings. The

measurement values of the inter-comparison are within the range of the prediction interval with a probability of 95%. The prediction interval is a measure of the uncertainty of the calibration function.

Figure 2 shows the regression residuals versus the run index (time dependence) and the mole fraction. The absence of a temporal trend indicates stable instrument conditions. The absence of mole fraction dependence in the residuals indicates linearity of the instrument.

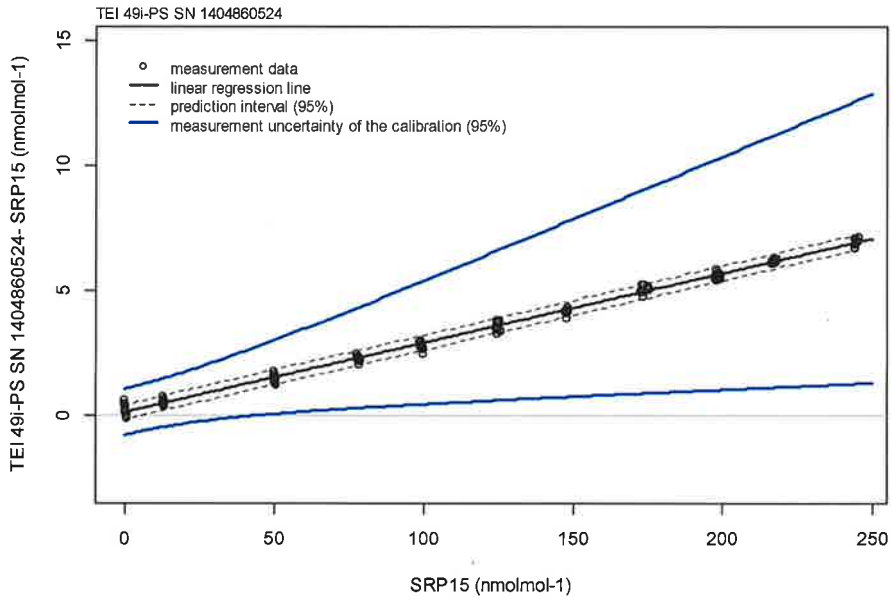

Figure 1: Linear regression of the difference (TEI 49i-PS #1404860524- SRP#15) vs. SRP#15 for the initial calibration settings.

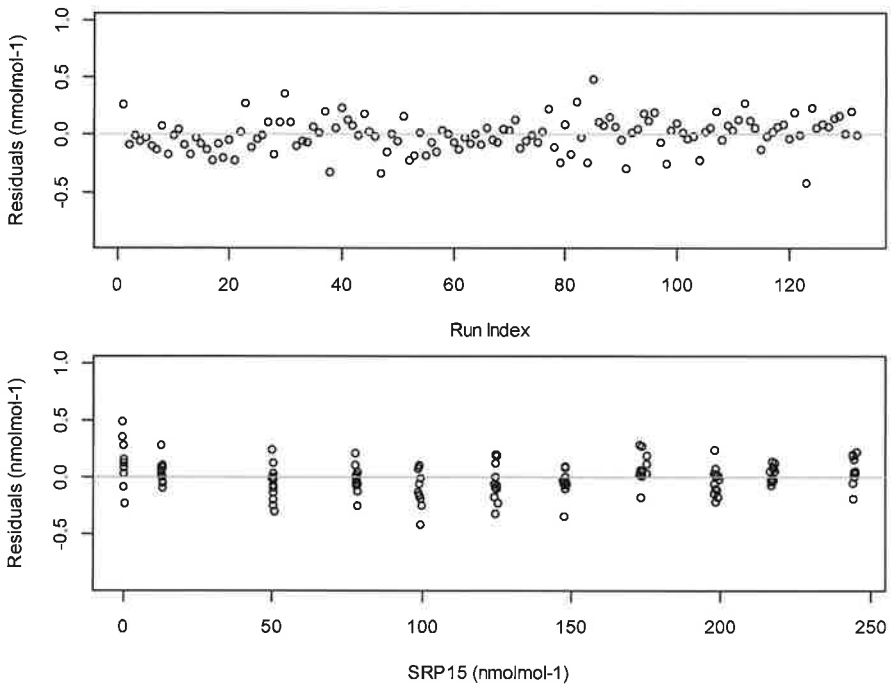

Figure 2: Regression residuals of the ozone inter-comparison as a function of run index (upper panel) and mole fraction (lower panel) for the initial calibration settings.

The following table shows the results with the final calibration settings (COEF 1.000, BKG -0.3):

Results:

No.	Reference		TEI 49i-PS #1404860524			
	SRP#15	s_d		s_d	deviation to reference	
	nmolmol^{-1}	nmolmol^{-1}	nmolmol^{-1}	nmolmol^{-1}	nmolmol^{-1}	%
1	0.09	0.31	0.30	0.10	0.21	NA
2	77.42	0.25	77.60	0.00	0.18	0.23
3	49.72	0.23	49.80	0.10	0.08	0.15
4	12.79	0.28	13.00	0.10	0.21	1.62
5	146.32	0.20	146.50	0.10	0.18	0.12
6	98.18	0.42	98.30	0.10	0.12	0.12
7	197.22	0.28	197.10	0.10	-0.12	-0.06
8	172.11	0.20	172.30	0.20	0.19	0.11
9	123.36	0.29	123.60	0.10	0.24	0.19
10	215.92	0.25	216.10	0.10	0.18	0.08
11	242.33	0.30	242.80	0.20	0.47	0.19
12	77.52	0.17	77.70	0.10	0.18	0.24
13	98.10	0.27	98.30	0.10	0.20	0.20
14	49.75	0.33	49.90	0.20	0.15	0.29
15	196.65	0.29	196.70	0.10	0.05	0.03
16	0.08	0.10	0.30	0.10	0.22	NA
17	124.38	0.42	124.40	0.10	0.02	0.02
18	215.74	0.23	216.00	0.10	0.26	0.12
19	172.15	0.18	172.30	0.10	0.15	0.09
20	146.47	0.12	146.70	0.00	0.23	0.16
21	13.03	0.21	13.10	0.10	0.07	0.51
22	242.17	0.23	242.40	0.10	0.23	0.10
23	171.96	0.18	172.20	0.10	0.24	0.14
24	98.23	0.26	98.60	0.10	0.37	0.38
25	77.63	0.31	77.90	0.10	0.27	0.34
26	49.72	0.53	50.00	0.10	0.28	0.56
27	215.76	0.27	216.10	0.10	0.34	0.16
28	-0.23	0.16	0.30	0.10	0.53	NA
29	196.99	0.09	197.40	0.00	0.41	0.21
30	123.55	0.24	124.00	0.10	0.45	0.36
31	146.82	0.38	146.90	0.20	0.08	0.06
32	12.81	0.27	13.10	0.10	0.29	2.27
33	242.82	0.24	243.00	0.20	0.18	0.07
34	196.96	0.28	197.20	0.10	0.24	0.12
35	0.19	0.26	0.30	0.00	0.11	NA
36	50.24	0.22	50.30	0.00	0.06	0.12
37	124.38	0.29	124.50	0.10	0.12	0.09
38	98.65	0.14	98.80	0.20	0.15	0.15
39	172.36	0.21	172.70	0.10	0.34	0.20
40	13.05	0.41	13.10	0.10	0.05	0.41
41	147.01	0.41	147.20	0.30	0.19	0.13
42	215.82	0.34	216.20	0.20	0.38	0.18
43	77.64	0.18	78.00	0.10	0.36	0.46
44	242.69	0.35	242.80	0.20	0.11	0.05
45	98.59	0.34	98.90	0.10	0.31	0.31
46	77.84	0.25	78.00	0.20	0.16	0.21
47	197.07	0.39	197.50	0.20	0.43	0.22
48	216.17	0.25	216.10	0.10	-0.07	-0.03
49	50.21	0.28	50.20	0.10	-0.01	-0.03
50	12.90	0.29	13.00	0.10	0.10	0.74
51	124.37	0.28	124.40	0.30	0.03	0.02
52	172.77	0.22	173.00	0.00	0.23	0.13
53	147.11	0.24	147.20	0.10	0.09	0.06
54	-0.09	0.13	0.30	0.10	0.39	NA

55	243.63	0.61	244.20	0.70	0.57	0.23
56	12.83	0.30	13.10	0.10	0.27	2.14
57	172.86	0.27	173.20	0.40	0.34	0.20
58	123.82	0.12	124.20	0.10	0.38	0.31
59	0.15	0.27	0.30	0.10	0.15	NA
60	147.85	0.21	148.20	0.10	0.35	0.24
61	78.07	0.16	78.30	0.10	0.23	0.30
62	216.29	0.22	216.70	0.10	0.41	0.19
63	98.62	0.21	98.70	0.10	0.08	0.08
64	197.12	0.27	197.50	0.20	0.38	0.19
65	49.91	0.17	50.00	0.10	0.09	0.18
66	243.07	0.31	243.30	0.20	0.23	0.10
67	172.48	0.25	172.60	0.10	0.12	0.07
68	0.30	0.34	0.30	0.10	0.00	-0.44
69	147.98	0.27	148.30	0.20	0.32	0.22
70	50.21	0.34	50.30	0.10	0.09	0.18
71	98.88	0.31	99.10	0.10	0.22	0.22
72	13.01	0.31	13.20	0.20	0.19	1.45
73	216.77	0.45	217.20	0.70	0.43	0.20
74	124.27	0.27	124.30	0.10	0.03	0.02
75	197.55	0.40	197.70	0.10	0.15	0.08
76	77.45	0.37	77.80	0.10	0.35	0.45
77	242.97	0.29	243.20	0.30	0.23	0.10
78	98.40	0.36	98.50	0.20	0.10	0.10
79	77.76	0.23	77.80	0.10	0.04	0.05
80	216.35	0.37	216.50	0.10	0.15	0.07
81	-0.12	0.21	0.30	0.10	0.42	NA
82	174.12	0.56	174.40	0.40	0.28	0.16
83	123.90	0.26	124.30	0.10	0.40	0.32
84	12.94	0.13	13.00	0.10	0.06	0.45
85	50.16	0.28	50.40	0.10	0.24	0.48
86	197.69	0.27	197.80	0.10	0.11	0.06
87	146.65	0.24	147.10	0.10	0.45	0.30
88	242.60	0.41	242.90	0.30	0.30	0.12
89	77.54	0.33	77.80	0.10	0.26	0.33
90	0.09	0.26	0.30	0.10	0.21	NA
91	216.67	0.27	217.00	0.50	0.33	0.15
92	123.81	0.32	124.20	0.10	0.39	0.32
93	172.40	0.23	172.60	0.10	0.20	0.11
94	196.81	0.17	197.00	0.20	0.19	0.09
95	12.81	0.30	13.00	0.10	0.19	1.45
96	50.22	0.18	50.30	0.10	0.08	0.17
97	98.58	0.12	98.90	0.10	0.32	0.33
98	147.06	0.22	147.10	0.10	0.04	0.03
99	242.62	0.37	243.00	0.20	0.38	0.16
100	77.59	0.35	77.80	0.00	0.21	0.27
101	172.32	0.15	172.60	0.10	0.28	0.16
102	12.83	0.37	13.00	0.10	0.17	1.34
103	98.96	0.47	99.20	0.10	0.24	0.24
104	216.27	0.37	216.50	0.20	0.23	0.10
105	146.66	0.20	147.00	0.10	0.34	0.23
106	49.95	0.26	50.00	0.10	0.05	0.10
107	-0.08	0.23	0.30	0.10	0.38	NA
108	197.80	0.31	198.00	0.20	0.20	0.10
109	123.84	0.30	124.20	0.10	0.36	0.29
110	242.76	0.18	243.10	0.20	0.34	0.14
111	123.61	0.32	124.00	0.10	0.39	0.31
112	49.84	0.29	50.10	0.10	0.26	0.51
113	216.21	0.38	216.60	0.10	0.39	0.18
114	196.88	0.15	196.90	0.10	0.02	0.01
115	77.64	0.21	77.50	0.10	-0.14	-0.18

116	12.80	0.29	13.10	0.10	0.30	2.35
117	99.11	0.24	99.20	0.10	0.09	0.09
118	172.85	0.25	173.10	0.10	0.25	0.14
119	-0.06	0.26	0.30	0.10	0.36	NA
120	148.05	0.28	148.30	0.20	0.25	0.17
121	243.40	0.32	243.80	0.20	0.40	0.16
122	77.80	0.18	78.00	0.10	0.20	0.26
123	172.69	0.34	172.90	0.10	0.21	0.12
124	123.62	0.26	123.90	0.20	0.28	0.23
125	146.74	0.18	147.00	0.10	0.26	0.17
126	197.07	0.18	197.30	0.10	0.23	0.12
127	12.72	0.15	13.00	0.10	0.28	2.18
128	216.56	0.40	217.00	0.70	0.44	0.20
129	49.75	0.21	50.00	0.10	0.25	0.50
130	0.00	0.18	0.30	0.20	0.30	NA
131	99.11	0.35	99.50	0.10	0.39	0.39
132	243.38	0.48	244.10	0.40	0.72	0.30
133	0.07	0.19	0.30	0.10	0.23	NA
134	78.18	0.24	78.30	0.10	0.12	0.16
135	124.09	0.19	124.60	0.10	0.51	0.41
136	49.98	0.30	50.30	0.10	0.32	0.64
137	197.28	0.33	197.50	0.10	0.22	0.11
138	216.14	0.30	216.40	0.20	0.26	0.12
139	12.77	0.17	13.00	0.10	0.23	1.80
140	147.06	0.39	147.40	0.10	0.34	0.23
141	98.45	0.20	98.80	0.10	0.35	0.36
142	172.29	0.19	172.60	0.10	0.31	0.18
143	242.51	0.38	242.90	0.10	0.39	0.16
144	77.59	0.30	77.70	0.10	0.11	0.14
145	146.63	0.25	146.90	0.10	0.27	0.18
146	12.72	0.19	12.90	0.10	0.18	1.41
147	197.57	0.39	198.10	0.40	0.53	0.27
148	172.52	0.18	172.80	0.20	0.28	0.16
149	98.31	0.33	98.40	0.20	0.09	0.09
150	49.72	0.26	50.00	0.00	0.28	0.56
151	-0.04	0.33	0.30	0.10	0.34	NA
152	124.80	0.46	125.00	0.00	0.20	0.16
153	216.68	0.32	217.00	0.30	0.32	0.15
154	242.41	0.33	243.10	0.20	0.69	0.28

s_d: standard deviation (n = 10 measurement values)
NA: not applicable

Calibration function: The following calibration function for the final calibration of the TEI 49i-PS #1404860524 (COEF 1.000, BKG -0.3) for the range of 0-250 nmolmol^{-1} was determined from the comparison on 2017-04-04/05 at a temperature of 22.5±1°C and a pressure of 970.1 – 972.2 hPa.

Reference value (SRP#15) = 0.9995 x TEI 49i-PS #1404860524 - 0.19) nmolmol^{-1}
(valid for calibration settings COEF 1.000, BKG -0.3)

Measurement uncertainty: of the calibration

reference value (SRP#15)	value (TEI 49i-PS)	± uncertainty
0 nmolmol^{-1}	0.2	± 1.0 nmolmol^{-1}
25 nmolmol^{-1}	25.2	± 1.1 nmolmol^{-1}
50 nmolmol^{-1}	50.2	± 1.5 nmolmol^{-1}
75 nmolmol^{-1}	75.2	± 2.0 nmolmol^{-1}
100 nmolmol^{-1}	100.2	± 2.5 nmolmol^{-1}
125 nmolmol^{-1}	125.2	± 3.0 nmolmol^{-1}
150 nmolmol^{-1}	150.3	± 3.6 nmolmol^{-1}
175 nmolmol^{-1}	175.3	± 4.1 nmolmol^{-1}
200 nmolmol^{-1}	200.3	± 4.7 nmolmol^{-1}
225 nmolmol^{-1}	225.3	± 5.2 nmolmol^{-1}
250 nmolmol^{-1}	250.3	± 5.8 nmolmol^{-1}

Figure 3 shows the linear regression of the difference (TEI 49i-PS #1404860524 - SRP#15) versus SRP#15, including the prediction interval (95%) with the final calibration settings. The measurement values of the inter-comparison are within the range of the prediction interval with a probability of 95%. The prediction interval is a measure of the uncertainty of the calibration function.

Figure 4 shows the regression residuals versus the run index (time dependence) and the mole fraction. The absence of a temporal trend indicates stable instrument conditions. The absence of mole fraction dependence in the residuals indicates linearity of the instrument.

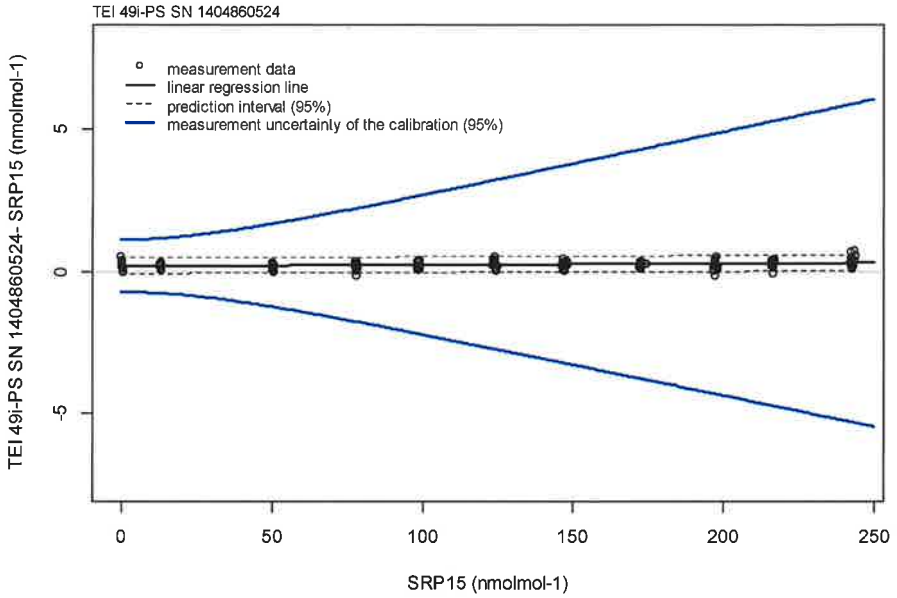

Figure 3: Linear regression of the difference (TEI 49i-PS #1404860524- SRP#15) vs. SRP#15 for the final calibration settings.

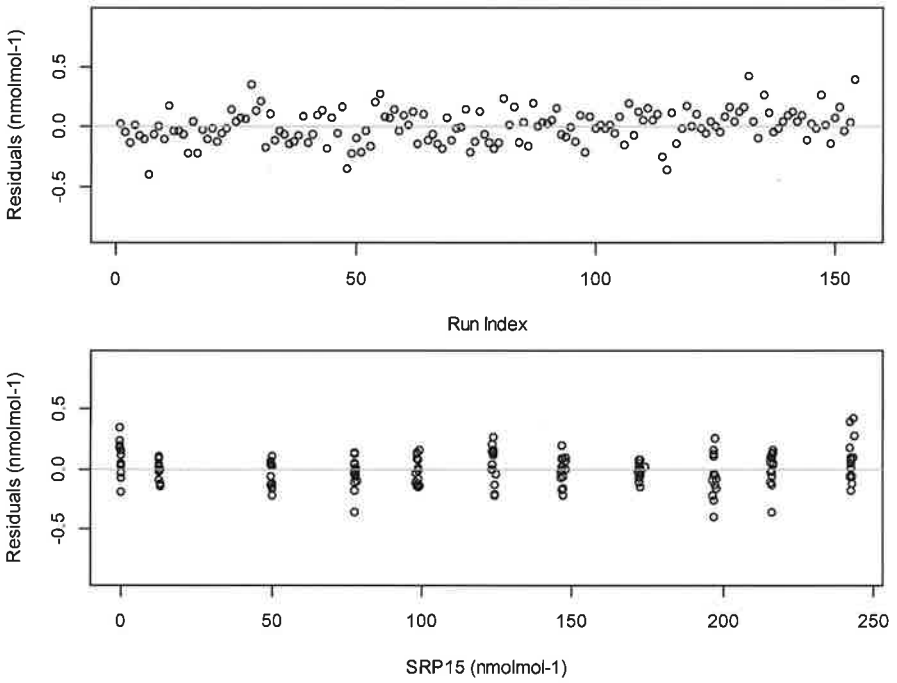

Figure 4: Regression residuals of the ozone inter-comparison as a function of run index (upper panel) and mole fraction (lower panel) for the final calibration settings.

Pressure sensor: The pressure sensor of the TEI 49i-PS #1404860524 was compared to the reference barometer (GB-1, meteolabor AG) at ambient pressure. For the initial calibration (COEF 1.023, BKG -0.3), the pressure sensor reading of the TEI 49i-PS (968.7 hPa) was not adjusted to the reference pressure (972.4 hPa). The pressure sensor reading of the TEI 49i-PS #1404860524 (965.9 hPa) was adjusted to the reference pressure (971.2 hPa) for the calibration with the final settings (COEF 1.000, BKG -0.3) on 4. April 2017.

Calibration settings: The calibration settings of the TEI 49i-PS #1404860524 were not changed for the initial calibration (COEF 1.023, BKG -0.3). In agreement with the cusutomer, a second calibration with adjusted calibration settings (COEF 1.000, BKG -0.3) was made.

Uncertainty: The measurement uncertainties given above were determined in the Empa calibration laboratory under well known, ideal conditions. It reflects the minimal uncertainty, which can be guaranteed for the actual state of the tested instrument. To estimate the complete uncertainty budget of a specific instrument, additional parameters such as long-term drift, temperature and pressure variability, maintenance and competence of the staff have to be considered. Thus, a careful evaluation of the uncertainty budget is indicated considering customer specific circumstances.

Dübendorf, 12. May 2017

Empa Dübendorf,
Laboratory Air Pollution/Environmental Technology

Head of the calibration service

Dr. C. Zellweger

Head of the Laboratory

i.V. Dr. L. Emmenegger