

U.S. Department of Commerce
National Institute of Standards and Technology
Material Measurement Laboratory
Analytical Chemistry Division
Gaithersburg, MD 20899-8393

REPORT OF ANALYSIS

October 12, 2011

Calibration of TEI 49i PS, serial # 0726724741 Ozone Calibrator

Submitted to:

Mr. Peter Andersen
2B Technologies, Inc.
2100 Central Ave., Suite 105
Boulder, CO 80301

Job No.: 2015
Folder No.: 281543-12

The Thermo Electron, Inc., serial number 0726724741 (TEI2B) Ozone Calibrator, owned by 2B Technologies, Inc. was calibrated by comparison with the National Institute of Standards and Technology (NIST) Standard Reference Photometer (SRP) serial # 0 (SRP 0). The comparisons were conducted at NIST in Gaithersburg, MD, over the period October 11-12, 2011. Each calibration consisted of measurements of ten different concentration levels and two measurements of zero concentration. The measurements of the ten concentration levels were randomly ordered, while the measurements of zero concentration were obtained at the beginning and end of each comparison run. The TEI2B was calibrated in accordance with the Gas Metrology Group Quality Manual (QM-III-839.03), following TP 839.0312A (calibration of ozone instrumentation).

The results obtained by NIST standard reference photometers are based on a molecular absorption coefficient of $308.32 \text{ cm}^{-1} \times \text{atm}^{-1}$ (natural logarithm base) [1] referenced to 273.15 K and 101.3 kPa for ozone at 253.7 nm. The uncertainty with which the SRP assays ozone is fundamentally dependent on the uncertainty of the value of the ozone absorption coefficient at 253.7 nm. The estimated expanded standard uncertainties [2] of the SRP ozone concentration measurements are defined by the following equations:

$$u(x) = \sqrt{(0.28)^2 + (1.1 \times 10^{-2} x)^2} \text{ nmol/mol}$$

$$U_{95}^+ = 2 \times u(x) \text{ nmol/mol}, U_{95}^- = (-2 \times u(x) - 0.001 \times x) \text{ nmol/mol}$$

NIST does not make any claims as to the future performance of the TEI2B, but is merely reporting the data obtained while operated at NIST.

Calibration Parameters for the TEI2B Ozone Calibrator:

Powered on: October 11, 2011, 10:30 a.m.

Conditioning: Zero air, then 60 minutes at 1000 ppbv prior to calibration.

Configuration: SRP 0 and TEI2B drawing sample from TEI2B sample manifold.
SRP 0 drawing reference from SRP reference manifold.
TEI2B drawing reference from TEI2B internal reference manifold.

Data Connection: RS-232.

The TEI2B ozone calibrator parameters were left in their original state during all calibration runs; range: 1000 PPB, averaging time: 10 sec., O3 BKG: 0.0 PPB, O3 COEF: 1.000. The SRP 0 1-meter Teflon sample inlet line was connected to the TEI2B sample manifold and the SRP 0 1-meter Teflon reference inlet line remained connected to the SRP reference manifold. The TEI2B sample inlet is connected to the TEI2B sample manifold internally and the TEI2B reference is drawn from its own internal manifold.

A set of 11-comparison runs were performed overnight starting on October 11, 2011, up to a maximum ozone concentration of 1000.5 ppbv as measured by SRP 0.

The results of the comparison runs performed in this report are given below. The individual Excel calibration report files and an Excel spreadsheet summary are provided on a CD with this report.

Results

The following average linear regression equation was obtained from the 11-calibration runs of the TEI 49i PS, serial # 0726724741:

$$\text{TEI2B} = [(0.98968 \times \text{SRP 0}) - 0.204] \text{ ppbv}$$

Where, TEI2B = ozone concentration (ppbv) determined by the TEI2B.
SRP 0 = ozone concentration (ppbv) determined by the SRP 0.

Data summary from individual calibration runs:

FileName	Date	Max conc.	TEI2B Slope	TEI2B u-slope	TEI2B Intercept	TEI2B u-intercept	TEI2B SER
c1011001.xls	10/11/2011 12:30	1000.7	0.98976	0.00014	-0.36271	0.07080	0.15674
c1011002.xls	10/11/2011 15:24	1000.3	0.98958	0.00015	-0.17823	0.07545	0.16708
c1011003.xls	10/11/2011 17:17	1000.6	0.98963	0.00014	-0.14409	0.07355	0.16288
c1011004.xls	10/11/2011 19:12	1000.7	0.98947	0.00016	-0.17653	0.08409	0.18621
c1011005.xls	10/11/2011 21:05	1000.0	0.98984	0.00015	-0.21698	0.07495	0.16596
c1011006.xls	10/11/2011 22:59	1000.3	0.98968	0.00013	-0.14869	0.06552	0.14509
c1011007.xls	10/12/2011 0:53	1000.3	0.98973	0.00015	-0.27126	0.07591	0.16809
c1011008.xls	10/12/2011 2:47	1001.1	0.98963	0.00015	-0.19277	0.07691	0.17031
c1011009.xls	10/12/2011 4:41	1000.6	0.98973	0.00010	-0.21876	0.05311	0.11760
c1011010.xls	10/12/2011 6:35	1000.6	0.98965	0.00012	-0.24643	0.06013	0.13314
c1011011.xls	10/12/2011 8:28	1000.0	0.98982	0.00020	-0.08870	0.10460	0.23161
Average:		1000.5	0.98968	0.00014	-0.20410	0.07409	0.16406
Median:		1000.6	0.98968	0.00015	-0.19277	0.07495	0.16596
Std. Dev.:		0.3	0.00011	0.00003	0.07307	0.01328	0.02941
SD (mean):		0.0	0.00001	0.00000	0.00664	0.00121	0.00267

u = uncertainty, SER = standard error of the regression.

Prepared by:



James E. Norris
Electronics Technician

Reviewed by:



Franklin R. Guenther, Ph.D.
Group Leader
Gas Metrology Group

References:

1. Paur, R.J., and McElroy, F.F., "Technical Assistance Document for the Calibration of Ambient Ozone Monitors," pp. 3-9, *U.S. Environmental Protection Agency Research Report, EPA- 600/4-79-057*, September 1979.
2. Taylor, B.N., and Kuyatt, C.E., "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results," *National Institute of Standards and Technology Technical Note 1297*, 1994 Edition (U.S. Government Printing Office, Washington, D.C., September 1994).