

U.S. Department of Commerce
National Institute of Standards and Technology
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REPORT OF ANALYSIS

October 15, 2007

Calibration of OREC Model DM100, serial numbers 748, 318, and 757 Ozone Monitors

Submitted to:

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Job No.: 8017

The OREC Model DM100, serial numbers 748 (OREC748), 318 (OREC318), and 757 (OREC757) Ozone Monitors, owned by Corporate Consulting Service, Inc., were calibrated by comparison with the NIST Standard Reference Photometer serial # 2 (NIST SRP 2). The comparisons were conducted at NIST in Gaithersburg, MD over the period October 10 – 11, 2007. 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 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 2 ppbv¹ (absolute) in the 0 ppbv to 100 ppbv range and 2 % (relative) in the 100 ppbv to 1000 ppbv range. NIST does not make any claims as to the future performance of the OREC ozone monitors, but is merely reporting the data obtained while operated at NIST.

Calibration Parameters for all three OREC Ozone Monitors:

Powered on: October 10, 2007, 10:00 AM.
Conditioning: 3 – 4 hours around 920 ppbv prior to calibration.
Configuration: Drawing Sample Gas from NIST SRP Sample Manifold.
Drawing Reference Gas from NIST SRP Reference Manifold.
Data Connection: Analog.

¹ The unit parts per billion by volume (ppbv), which is equivalent to nmol/mol, is most commonly used in ozone calibration work and hereafter will be exclusively used in this report.

The OREC748, OREC318, and OREC757 ozone monitors were initially set up and powered up on October 10, 2007, at 10:00 AM, and connected to the SRP control system via analog signal connection. The sample and reference inlets of all three OREC ozone monitors were connected to the SRP sample/reference manifold using approximately 1 meter of Teflon tubing for each. They were then allowed to sample approximately 920 ppbv over a 3 – 4 hour period before beginning the official calibration runs. After the span values were set by CCSI personnel, a set of 7 – comparison runs were performed overnight starting on October 10, 2007, up to a maximum ozone concentration of 970 ppbv. The results of the comparison runs performed in this report are given below. A graphical representation of the data presented in this report can be found in Appendix I. The individual 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 for the OREC DM100, serial # 748 from the set of 8 – comparison runs.

$$C_{\text{OREC748}} = [(1.00480 \times C_{\text{SRP2}}) - 3.8] \text{ ppbv}$$

Where, C_{OREC748} = ozone concentration (ppbv) determined by the OREC DM100, serial # 748.

C_{SRP2} = ozone concentration (ppbv) determined by the NIST SRP 2.

Data summary from individual calibration runs:

FileName	Date/Time	Max conc.	OREC748 Slope	OREC748 u-slope	OREC748 Intercept	OREC748 u-intercept	OREC748 RSD
c1010001.xls	10/10/2007 17:43	970.6	1.00473	0.00281	-3.99868	1.36195	2.97343
c1010002.xls	10/10/2007 20:14	969.3	1.00811	0.00213	-6.38694	1.03019	2.24843
c1010003.xls	10/10/2007 22:34	971.0	1.00285	0.00292	-3.00606	1.41687	3.09400
c1010004.xls	10/11/2007 0:45	971.4	1.00424	0.00143	-2.38108	0.69564	1.51881
c1010005.xls	10/11/2007 3:01	970.1	1.00065	0.00399	-1.29192	1.93458	4.22308
c1010006.xls	10/11/2007 5:30	971.1	1.00497	0.00248	-4.24700	1.20490	2.63024
c1010007.xls	10/11/2007 7:51	970.1	1.00802	0.00179	-5.56048	0.86713	1.89311
Average:		970.5	1.00480	0.00251	-3.83888	1.21589	2.65444
Std. Dev.:		0.7	0.00267	0.00084	1.77738	0.40930	0.89352

u = uncertainty, RSD = residual standard deviation.

The following average linear regression equation was obtained for the OREC DM100, serial # 318 from the set of 8-comparison runs.

$$C_{\text{OREC318}} = [(0.98597 \times C_{\text{SRP2}}) - 0.42] \text{ ppbv}$$

Where, C_{OREC318} = ozone concentration (ppbv) determined by the OREC DM100, serial # 318.

C_{SRP2} = ozone concentration (ppbv) determined by the NIST SRP 2.

Data summary from individual calibration runs:

FileName	Date/Time	Max conc.	OREC318 Slope	OREC318 u-slope	OREC318 Intercept	OREC318 u-intercept	OREC318 RSD
c1010001.xls	10/10/2007 17:43	970.6	0.98279	0.00132	-0.16487	0.64134	1.40020
c1010002.xls	10/10/2007 20:14	969.3	0.98497	0.00120	-1.05363	0.58324	1.27294
c1010003.xls	10/10/2007 22:34	971.0	0.98684	0.00129	-0.72583	0.62677	1.36867
c1010004.xls	10/11/2007 0:45	971.4	0.98740	0.00097	0.06692	0.47058	1.02743
c1010005.xls	10/11/2007 3:01	970.1	0.98723	0.00113	-0.47963	0.54726	1.19464
c1010006.xls	10/11/2007 5:30	971.1	0.98578	0.00188	-0.46532	0.90920	1.98475
c1010007.xls	10/11/2007 7:51	970.1	0.98679	0.00117	-0.09794	0.56834	1.24078
Average:		970.5	0.98597	0.00128	-0.41719	0.62096	1.35563
Std. Dev.:		0.7	0.00164	0.00029	0.38869	0.13891	0.30321

u = uncertainty, RSD = residual standard deviation.

The following average linear regression equation was obtained for the OREC DM100, serial # 757 from the set of 8-comparison runs.

$$C_{\text{OREC757}} = [(1.02152 \times C_{\text{SRP2}}) - 5.1] \text{ ppbv}$$

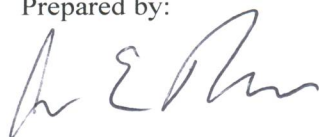
Where, C_{OREC757} = ozone concentration (ppbv) determined by the OREC DM100, serial # 757.
 C_{SRP2} = ozone concentration (ppbv) determined by the NIST SRP 2.

Data summary from individual calibration runs:

FileName	Date/Time	Max conc.	OREC757 Slope	OREC757 u-slope	OREC757 Intercept	OREC757 u-intercept	OREC757 RSD
c1010001.xls	10/10/2007 17:43	970.6	1.01819	0.00130	-4.51997	0.62932	1.37395
c1010002.xls	10/10/2007 20:14	969.3	1.01982	0.00115	-4.76121	0.55873	1.21946
c1010003.xls	10/10/2007 22:34	971.0	1.02035	0.00093	-4.38780	0.44861	0.97964
c1010004.xls	10/11/2007 0:45	971.4	1.02272	0.00113	-5.44934	0.54626	1.19267
c1010005.xls	10/11/2007 3:01	970.1	1.02115	0.00144	-4.68605	0.69634	1.52008
c1010006.xls	10/11/2007 5:30	971.1	1.02404	0.00131	-6.17205	0.63508	1.38635
c1010007.xls	10/11/2007 7:51	970.1	1.02435	0.00078	-5.39849	0.38045	0.83059
Average:		970.5	1.02152	0.00115	-5.05356	0.55640	1.21468
Std. Dev.:		0.7	0.00228	0.00023	0.64228	0.11089	0.24200

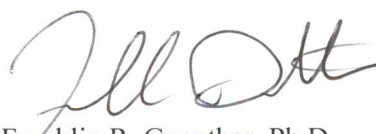
u = uncertainty, RSD = residual standard deviation.

Prepared by:



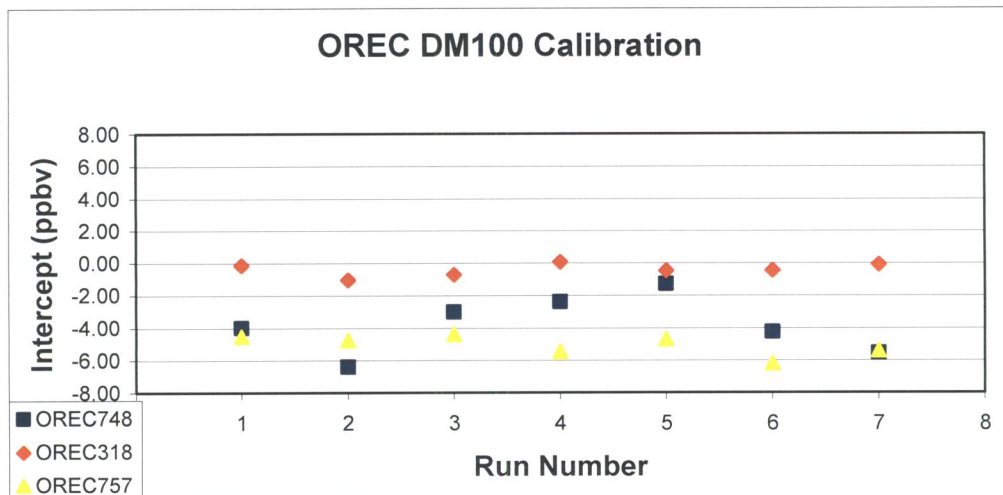
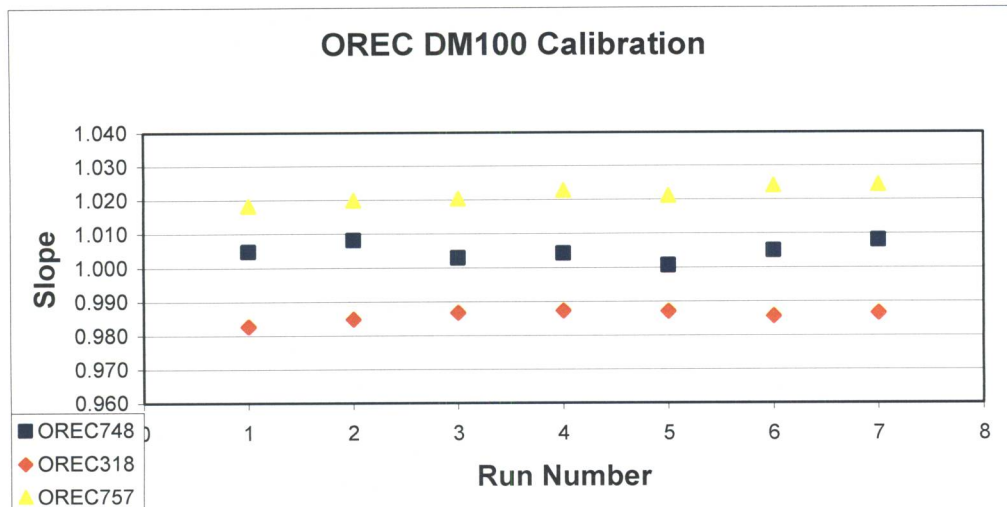
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Appendix I. Graphical summary of calibration data.



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).