CASTNET

2012 Annual Report

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List of Acronyms and Abbreviations

% diff	percent difference
A/D	analog to digital converter
AQS	Air Quality System
ARS	Air Resource Specialists, Inc.
ASTM	American Society for Testing and Materials
CASTNET	Clean Air Status and Trends Network
DAS	data acquisition system
DC	direct current
deg	degree
DVM	digital voltmeter
EEMS	Environmental, Engineering & Measurement Services, Inc.
EPA	U.S. Environmental Protection Agency
ESC	Environmental Systems Corporation
FSAD	Field Site Audit Database
g-cm	gram centimeter
GPS	goblal positioning system
k	kilo (1000)
km	kilometer
lpm	liters per minute
MLM	Multilayer Model
m/s	meters per second
mv	millivolt
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
OAQPS	Office of Air Quality Planning and Standards
QAPP	Quality Assurance Project Plan
SOP	standard operating procedure
TEI	Thermo Environmental Instruments
USNO	United States Naval Observatory
V	volts
WRR	World Radiation Reference

1.0 Introduction

The Clean Air Status and Trends Network (CASTNET) is a national air monitoring program developed under mandate of the 1990 Clean Air Act Amendments. Each site in the network measures acidic gases and particles and other forms of atmospheric pollution using a continuous collection filter aggregated over a one week period. Hourly averages of surface ozone concentrations and selected meteorological variables are also measured.

Site measurements are used to estimate deposition rates of the various pollutants with the objective of determining relationships between emissions, air quality, deposition, and ecological effects. In conjunction with other national monitoring networks, CASTNET data are used to determine the effectiveness of national emissions control programs and to assess temporal trends and spatial deposition patterns in atmospheric pollutants. CASTNET data are also used for long-range transport model evaluations and effects research.

CASTNET pollutant flux estimates are calculated as the aggregate product of weekly measured chemical concentrations and model-estimated deposition velocities. Currently, the National Oceanic and Atmospheric Administration's multilayer inferential model (NOAA-MLM) described by Meyers et al. [1998] is used to derive deposition velocity estimates.

As of 2011, nearly all CASTNET ozone monitors adhere to the requirements of 40 CFR Parts 52, 53 and 58, and ozone concentration and quality assurance data are submitted to the Air Quality System (AQS) database.

As of January 2012, the network is comprised of 82 active rural sampling sites across the United States and Canada, cooperatively operated by the Environmental Protection Agency (EPA), the National Park Service (NPS), Environment Canada, and several independent partners. AMEC, Inc. is responsible for operating the EPA and Environment Canada sponsored sites, and Air Resource Specialists, Inc. (ARS) is responsible for operating the NPS sponsored sites.

All 82 sites collect filter samples for flux estimates. Ozone concentrations are measured at 79 of the 82 sites, and meteorological measurements continue at all NPS sites.

2.0 Project Objectives

The objectives of this project are to establish an independent and unbiased program of performance and systems audits for all CASTNET sampling sites. Ongoing Quality Assurance (QA) programs are an essential part of any long-term monitoring network.

Performance audits verify that all evaluated parameters are consistent with the accuracy goals as defined in the CASTNET Quality Assurance Project Plan (QAPP). The parameter specific accuracy goals are presented in Table 2.1.

Due to budgetary necessity, EPA discontinued meteorological measurements at all but 5 CASTNET sites. The meteorological sensors were audited on an as-directed basis.

Table 2.1 Performance Audit Challenge and Acceptance Criteria

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Precipitation	Response	10 manual tips	1 DAS count per tip
Precipitation	Accuracy	2 introductions of known amounts of water	≤ ±10.0% of input amount
Relative Humidity	Accuracy	Compared to reference instrument or standard solution	≤ ±10.0%
Solar Radiation	Accuracy	Compared to WRR traceable standard	≤ ±10.0% of daytime average
Surface Wetness	Response	Distilled water spray mist	Positive response
Surface Wetness	Sensitivity	1% decade resistance	N/A
Temperature	Accuracy	Comparison to 3 NIST measured baths (~ 0° C, ambient, ~ full-scale)	≤ ± 0.5° C
Delta Temperature	Accuracy	Comparison to temperature sensor at same test point	≤ ± 0.50° C

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Wind Direction	Orientation Accuracy	Parallel to alignment rod/crossarm, or sighted to distant point	≤ ±5° from degrees true
Wind Direction	Linearity	Eight cardinal points on test fixture	≤ ±5° mean absolute error
Wind Direction	Response Threshold	Starting torque tested with torque gauge	< 10 g-cm Climatronics; < 20 g-cm R. M. Young
Wind Speed	Accuracy	Shaft rotational speed generated and measured with certified synchronous motor	≤ ±0.5 mps below 5.0 mps input; ≤ ±5.0% of input at or above 5.0 mps
Wind Speed	Starting Threshold	Starting torque tested with torque gauge	< 0.5 g-cm
Mass Flow Controller	Flow Rate	Comparison with Primary Standard	≤ ± 5.0% of designated rate
Ozone	Slope	Linear regression of multi-point test gas concentration as measured with a certified transfer standard	0.9000 ≤ m ≤ 1.1000
	Intercept		-5.0 ppb ≤ b ≤ 5.0 ppb
	Correlation Coefficient		0.9950 ≤ r
	Percent Difference	Comparison with Standard Concentration	≤ ±10.0% of test gas concentration
DAS	Accuracy	Comparison with certified standard	≤ ± 0.003 VDC

In addition to the accuracy goals defined in the CASTNET QAPP the ozone monitors fall under the requirements of 40 CFR, Part 58 Appendix A, for quality assurance. To comply with Appendix A, the CASTNET audit program includes annual independent ozone performance evaluations (PE). The EEMS field scientists who conduct ozone PE maintain annual certification from the Office of Air Quality Planning and Standards (OAQPS). Methods and procedures used are compliant with the National Performance Audit Program (NPAP).

Performance audits are conducted using standards that are certified as currently traceable to the National Institute of Standards and Technology (NIST) or another authoritative organization. All standards are certified annually with the exception of ozone standards which are verified as level 2 standards at EPA regional labs at least twice per year.

Site systems audits are intended to provide a qualitative appraisal of the total measurement system. Site planning, organization, and operation are evaluated to ensure that good Quality Assurance/Quality Control (QA/QC) practices are being applied. At a minimum the following audit issues are addressed at each site systems audit:

- Site locations and configurations match those provided in the CASTNET QAPP.
- Meteorological instruments are in good physical and operational condition and are sited to meet EPA ambient monitoring guidelines (EPA-600/4-82-060).
- Sites are accessible, orderly, and if applicable, compliant with OSHA safety standards.
- Sampling lines are free of leaks, kinks, visible contamination, weathering, and moisture.
- Site shelters provide adequate temperature control.
- All ambient air quality instruments are functional, being operated in the appropriate range, and the zero air supply desiccant is unsaturated.
- All instruments are in current calibration.
- Site documentation (maintenance schedules, on-site SOPs, etc.) is current and log book records are complete.
- All maintenance and on-site SOPs are performed on schedule.
- Corrective actions are documented and appropriate for required maintenance/repair activity.
- Site operators demonstrate an adequate knowledge and ability to perform required site activities, including documentation and maintenance activities.

3.0 CASTNET Sites Visited in 2012

This report covers the CASTNET sites audited in 2012. Only those variables that were supported by the CASTNET program were audited. From February through November 2012, EEMS conducted field performance and systems audits at 38 monitoring sites. Twenty-seven of the sites visited are sponsored by the EPA and eleven sites are sponsored by the NPS. The final audit of the Howland ME site (HOW132) was performed as the site was being deactivated.

Initial audits were performed at the Howland ME Ameriflux site where EPA had installed 2 filter pack systems on a 30 m tower above and below the canopy. In addition to the filter pack system an ozone profile system consisting of an ozone analyzer with inlets at 8 heights and a transfer standard was installed at HOW191.

A total of 37 sites were visited. All but two of the 37 sites audited measured ozone. Catskills, NY (CAT175) and Everglades, FL (EVE419) do not have ozone analyzers. Five of the sites operated a full complement of meteorological sensors and all of the sites had temperature sensors even if they were not audited at the time. The locations and dates of the audits are presented in Table 3.1.

Table 3.1 Site Audits – 2012

Site ID	Sponsor Agency	Site Location	Audit dates
SUM156	EPA	Sumatra	16-Feb-12
EVE419	NPS	Everglades NP	21-Feb-12
IRL141	EPA	Indian River Lagoon	22-Feb-12
SND152	EPA	Sand Mountain	24-Feb-12
GAS153	EPA	Georgia Station	27-Feb-12
ESP127	EPA	Edgar Evins St. Park	04-Mar-12
SPD111	EPA	Speedwell	04-Mar-12
COW137	EPA	Coweeta	05-Mar-12
PNF126	EPA	Cranberry	06-Mar-12
CAN407	NPS	Canyonlands NP	02-Apr-12
MEV405	NPS	Mesa Verde NP	03-Apr-12
PET427	NPS	Petrified Forest NP	09-Apr-12

Site ID	Sponsor Agency	Site Location	Audit dates
CHA467	NPS	Chiricahua NM	11-Apr-12
JOT403	NPS	Joshua Tree NM	12-Apr-12
GRC474	NPS	Grand Canyon NP	17-Apr-12
GRB411	NPS	Great Basin NP	18-Apr-12
MOR409	NPS	Mount Rainier NP	25-Jun-12
DEN417	NPS	Denali NP	05-Jul-12
HOX148	EPA	Hoxeyville	07-Aug-12
UVL124	EPA	Unionville	08-Aug-12
ANA115	EPA	Ann Arbor	09-Aug-12
SAL133	EPA	Salamonie Reservoir	12-Aug-12
MKG113	EPA	M. K. Goddard St. Park	18-Sep-12
KEF112	EPA	Kane Experimental Forest	19-Sep-12
EGB181	EPA	Egbert, Ontario	25-Sep-12
CTH110	EPA	Connecticut Hill	26-Sep-12
HWF187	EPA	Huntington Wildlife Forest	27-Sep-12
ACA416	NPS	Acadia NP	09-Oct-12
HOW132	EPA	Howland	11-Oct-12
HOW191	EPA	Howland	11-Oct-12
HOW191-B	EPA	Howland	11-Oct-12
ASH135	EPA	Ashland	12-Oct-12
WST109	EPA	Woodstock	22-Oct-12
ABT147	EPA	Abington	23-Oct-12
CAT175	EPA	Claryville	24-Oct-12
ARE128	EPA	Arendtsville	30-Oct-12
PSU106	EPA	Penn State University	03-Nov-12
BEL116	EPA	Beltsville	20-Nov-12

In addition to the sites listed in Table 3.1 that were visited for complete systems and performance audits, the 42 sites listed in Table 3.2 were visited to conduct NPAP Through-The-Probe (TTP) ozone PE.

Table 3.2 Site Ozone PE Visits – 2012

Site ID	Sponsor Agency	Site Location	Audit dates
CAD150	EPA	Caddo Valley	28-Feb-12
CVL151	EPA	Coffeeville	28-Feb-12
CHE185	EPA	Cherokee Nation	29-Feb-12
CDZ171	EPA	Cadiz	01-Mar-12
MAC426	NPS	Mammoth Cave NP	02-Mar-12
MCK131	EPA	Mackville	03-Mar-12
MCK231	EPA	Mackville (precision site)	03-Mar-12
ALC188	EPA	Alabama-Coushatta	24-Mar-12
BBE401	NPS	Big Bend NP	26-Mar-12
PAL190	EPA	Palo Duro	27-Mar-12
QAK172	EPA	Quaker City	24-Apr-12
DCP114	EPA	Deer Creek St. Park	25-Apr-12
OXF122	EPA	Oxford	25-Apr-12
CKT136	EPA	Crockett	26-Apr-12
YOS404	NPS	Yosemite NP	04-May-12
ROM206	EPA	Rocky Mountain NP	09-May-12
ROM406	NPS	Rocky Mountain NP (NPS)	09-May-12
KNZ184	EPA	Konza Prairie	04-Jun-12
GTH161	EPA	Gothic	08-Jun-12
GLR468	NPS	Glacier NP	10-Jun-12
YEL408	NPS	Yellowstone NP	12-Jun-12
CNT169	EPA	Centennial	14-Jun-12

Site ID	Sponsor Agency	Site Location	Audit dates
STK138	EPA	Stockton	24-Jun-12
ALH157	EPA	Alhambra	26-Jun-12
VIN140	EPA	Vincennes	27-Jun-12
BVL130	EPA	Bondville	13-Aug-12
PRK134	EPA	Perkinstown	19-Aug-12
VOY413	NPS	Voyageurs NP	22-Aug-12
PED108	EPA	Prince Edward	28-Aug-12
THR422	NPS	Theodore Roosevelt NP	28-Aug-12
VPI120	EPA	Horton Station	29-Aug-12
WNC429	NPS	Wind Cave NP	29-Aug-12
PND165	EPA	Pinedale	02-Sep-12
WSP144	EPA	Washington Crossing St. Park	12-Sep-12
CDR119	EPA	Cedar Creek St. Park	23-Oct-12
PAR107	EPA	Parsons	24-Oct-12
LRL117	EPA	Laurel Hill St. Park	25-Oct-12
GRS420	NPS	Great Smoky Mountains NP	01-Nov-12
SHN418	NPS	Shenandoah NP - Big Meadows	13-Nov-12
BWR139	EPA	Blackwater NWR	17-Nov-12
CND125	EPA	Candor	29-Nov-12
BFT142	EPA	Beaufort	29-Nov-21

* In addition, HOW191 is an ozone profile site. The results for the profile audit are presented in Appendix 4.

4.0 Performance and Audit Results

Table 4.1 summarizes the number of test failures by variable tested. All test results are those recorded from the site's primary data logger. Since EEMS only audit meteorological sensors at 5 sites those parameters are not included in table 4.1

Performance audit results are discussed for each variable in the following sections. Tables are included to summarize the average and maximum error between the audit challenges and site results as recorded by the on-site Data Acquisition System (DAS). Linear regression and percent difference (% diff) calculation results are included where appropriate. Results that are outside the CASTNET QAPP acceptance criteria are shaded in the tables.

The errors presented in the tables in the following sections, are reported as the difference of the measurement recorded by the DAS and the audit standard. Where appropriate, negative values indicate readings that were lower than the standard, and positive values are readings that were above the standard value. With the exception of some flow rate audits (discussed in a later section), the errors appear to be random, and without bias. The results are also arranged by audit date. Viewing the results in this order helps to detect any errors that could have been caused by the degradation or drift of the audit standards during the year. The audit standards are transported and handled with care, and properly maintained to help prevent such occurrences. No known problems with the standards were apparent during the year. All standards were within specifications when re-certified at the end of the year.

Detailed reports of the field site audits, which contain all of the test points for each variable at each site, can be found in Appendix 1. The variable specific data forms included in Appendix 1 for each site contain the challenge input values, the output of the DAS, additional relevant information pertaining to the variable and equipment, and all available means of identification of the sensors and equipment.

Table 4.1 Performance Audit Results by Variable Tested

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Ozone	76	1	1.3
Flow Rate	38	1	2.6
Shelter Temperature	37	12	32.4
DAS Analog to Digital	34	0	0.0

4.1 Ozone

Seventy six ozone analyzers were audited during 2012. Each was challenged with ozone-free air and four up-scale concentrations. The ozone test gas concentrations were generated and measured with a NIST-traceable standard that was verified as a level 2 standard by USEPA. Of the 76 analyzers tested, all but one (KNZ184) met each of the acceptance criterion established in the CASTNET QAPP. The results of all ozone audits are presented in Table 4.2.

All ozone challenges were conducted to comply with the OAQPS Standard Operating Procedures (SOP) which can be found at www.epa.gov/ttn/amtic/. The results of the ozone audits were uploaded to the AQS database at the end of 2012 for all CASTNET sites that reported ozone data to AQS in 2012.

In February of 2011 OAQPS issued a memorandum providing guidance for low-level audits of pollutant gases. The list of audit concentrations was expanded to 10 levels, therefore beginning in 2012 EEMS conducted ozone audits using levels from the new expanded list, and in lower concentration ranges. Three consecutive audit levels were used.

4.2 Flow Rate

The dry deposition filter pack sampling system flow rates at all 38 sites visited were audited. A NIST-traceable dry-piston primary flow rate device was used for the tests. One site, or 2.6%, of the systems checked were outside the acceptance criterion of ± 5.0%.

4.3 Shelter Temperature

Shelter temperature was audited at all but one of the sites visited, CAT175, for a complete systems and performance audit. To meet the requirements in 40 CFR, shelter temperature at any site with an ozone analyzer must be maintained between 20 and 30 deg C. The method consisted of placing the audit standard in close proximity (in situ) to the shelter temperature sensor and recording either instantaneous observations of both sensors, or averages from both sensors. The audit sensors used are either a Resistive Temperature Detector (RTD) or a Thermocouple.

Most of the differences observed were due to the slow response of the site's shelter temperature sensors. Nearly all the site sensors lagged behind the audit sensor during the rapid changes in temperatures observed as the shelter air conditioning or shelter heating cycled. The shelter temperature sensors never reached the minimum or maximum temperature measured with the audit sensor. This is not likely to add a large error to the hourly averaged shelter temperature measurements. However, since the output of the shelter temperature sensors follow a sine wave curve but the actual shelter temperature does not change following a sine wave curve, if the

shelter temperature is set near the lower or higher allowable limits (20 to 30 degrees C) the actual hourly averages may be lower or higher than those measured by the site sensors.

The CASTNET QAPP does not make a distinction between shelter temperature and any other temperature sensor regarding accuracy criteria. However the sensors were evaluated using a 1 degree C acceptance criterion. This criterion better follows the EPA OAQPS guidelines.

The results are summarized in Table 4.2. Flow rate and shelter temperature data are reported only for the sites that were visited for complete systems and performance audits. Ozone results are included for all site visits.

Table 4.2 Performance Audit Results for Ozone, Shelter Temperature, and Flow Rate

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
SUM156	2.7	4.2	0.99133	-0.81721	0.99996	2.36	2.9	1.529	1.50	-1.88
EVE419						0.95	1.81	3.022	3.00	-0.72
IRL141	0.5	1.3	1.00768	-0.45907	1.00000	0.45	0.97	1.542	1.50	-2.71
SND152	0.7	1.6	1.00834	-0.13313	0.99999	0.25	0.43	1.564	1.50	-4.11
GAS153	0.9	1.6	1.00298	0.30623	0.99999	1.19	1.4	1.573	1.51	-4.20
CAD150	0.5	1.6	0.99834	0.26418	1.00000					
CVL151	3.3	6.7	0.99398	-1.18218	0.99994					
CHE185	0.9	1.6	0.9969	1.17661	0.99997					
CDZ171	0.9	1.7	0.99907	0.00993	0.99997					
MAC426	1.2	4.1	1.00654	-0.59285	0.99997					
MCK131	1.4	1.6	1.02123	-0.76342	0.99995					
MCK231	2.2	3.9	1.013	0.09628	1.00000					
ESP127	1.2	1.5	1.00961	-0.03351	0.99998	0.89	1.45	1.513	1.51	-0.29
SPD111	0.8	1.6	1.00302	-0.11333	0.99997	3.08	3.22	1.514	1.51	-0.22
COW137	2.8	4.5	1.02086	0.2746	0.99998	1.58	2.46	1.527	1.49	-2.39
PNF126	1.5	1.6	1.01298	0.09783	1.00000	2.07	2.52	1.529	1.50	-1.90
ALC188	2.3	3.6	1.01142	0.77262	0.99998					
BBE401	2.2	5.5	1.02031	-1.5986	0.99994					

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
PAL190	1.2	1.5	1.01478	-0.16824	1.00000					
CAN407	1.1	1.8	0.97943	0.68968	1.00000	0.76	0.89	3.039	3.01	-1.06
MEV405	1.9	2.8	0.98171	-0.31219	0.99998	0.22	0.4	3.064	3.00	-2.09
PET427	5.3	6.2	1.06523	-0.97317	0.99999	0.32	0.33	2.997	3.00	0.12
CHA467	2.7	4.2	1.01733	0.1084	0.99995	1.63	2.74	3.045	3.01	-1.13
JOT403	2.4	4.0	1.01051	0.67054	0.99997	2.19	3.39	3.027	2.99	-1.23
GRC474	0.7	1.8	0.99782	0.8637	0.99998	1.74	2.88	3.233	2.99	-7.52
GRB411	2.3	3.6	1.01411	0.54849	1.00000	0.79	1.25	3.025	3.00	-0.89
QAK172	1.6	2.2	1.01731	-0.01954	0.99999					
DCP114	0.6	1.5	1.01072	0.26653	1.00000					
OXF122	1.4	1.9	1.01534	-0.44294	0.99997					
CKT136	0.9	1.2	0.98732	0.22608	1.00000					
YOS404	1.3	3.2	0.95557	2.6644	0.99998					
ROM206	2.8	3.9	1.02898	-0.33312	0.99997					
ROM406	2.3	5.0	0.96708	2.38133	0.99998					
KNZ184	11.0	12.7	1.11907	-0.36313	0.99997					
GTH161	2.2	2.5	1.01898	0.43965	0.99998					
GLR468	1.5	2.0	1.02176	-0.38028	1.00000					
YEL408	0.7	1.4	1.00084	-0.09383	0.99999					
CNT169	1.9	2.9	1.01279	0.45572	1.00000					
STK138	3.1	3.3	1.02665	0.62493	0.99998					
MOR409	1.6	2.1	1.02496	-0.81061	0.99999	0.64	1.42	3.069	2.97	-3.21
ALH157	1.8	2.1	1.01474	0.27292	1.00000					
VIN140	0.9	2.0	1.0003	0.77447	0.99997					
DEN417	0.8	1.2	1.0083	-0.04508	0.99997	1.87	2.03	3.033	3.00	-1.08
HOX148	0.9	1.4	0.98798	0.68684	0.99994	0.89	1.12	1.547	1.50	-2.84
UVL124	2.5	3.8	1.01686	0.46476	0.99997	0.55	1.14	1.534	1.50	-2.24

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
ANA115	0.4	1.0	1.00401	-0.31467	1.00000	0.10	0.14	1.527	1.50	-2.01
SAL133	0.7	1.2	0.98615	0.58618	0.99999	0.42	0.63	1.508	1.50	-0.55
BVL130	2.2	2.5	0.97703	-0.1032	0.99999					
PRK134	1.1	2.3	0.99752	0.86078	1.00000					
VOY413	2.6	4.6	1.00367	1.45301	1.00000					
PED108	1.3	3.8	0.95831	1.68354	0.99989					
THR422	6.0	7.0	0.94654	-0.07908	0.99998					
VPI120	0.3	0.4	1.01168	0.43151	0.99996					
WNC429	2.0	3.8	0.99328	0.53115	1.00000					
PND165	1.2	1.7	1.00692	0.49433	0.99999					
WSP144	2.0	4.1	0.99239	1.64857	0.99999					
MKG113	0.8	1.1	0.9887	0.27575	1.00000	0.52	0.86	1.520	1.50	-1.33
KEF112	1.4	1.9	0.98461	0.051	0.99999	0.51	0.62	1.564	1.50	-4.07
EGB181						0.16	0.2	1.536	1.50	-2.37
CTH110	0.7	1.1	1.0134	-0.40286	1.00000	1.30	1.61	1.513	1.48	-2.19
HWF187	0.7	1.3	1.01419	-0.41459	1.00000	0.33	0.56	1.498	1.50	0.13
ACA416	3.2	4.3	0.96212	0.29896	0.99993	0.53	0.67	1.530	1.50	-1.96
HOW191	3.0	6.1	0.98987	0.57532	1.00000	0.26	0.4	1.514	1.51	-0.24
HOW191-B								1.504	1.50	-0.46
HOW132	1.5	2.6	0.98028	0.17489	0.99990	0.48	0.65	1.477	1.50	1.55
ASH135	1.4	1.5	1.01773	-0.34656	0.99999	0.55	0.84	1.510	1.51	0.02
WST109	0.2	0.5	0.99876	0.16956	1.00000	0.67	0.76	1.512	1.50	-0.82
ABT147	3.2	4.2	0.96006	0.29628	0.99995	1.23	3.4	1.501	1.50	-0.07
CAT175								1.462	1.50	2.63
CDR119	1.3	2.2	1.00905	0.3439	0.99999					
PAR107	1.4	2.6	1.00657	0.59606	0.99999					
LRL117	2.8	3.4	0.9666	0.56306	0.99999					

Site	Ozone average (% diff)	Ozone maximum (% diff)	Ozone slope	Ozone intercept	Ozone correlation	Shelter temp. average error (C)	Shelter temp. maximum error (C)	STP Flow observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
ARE128	0.8	1.9	0.99968	0.06764	0.99993	2.04	2.73	1.543	1.50	-2.79
GRS420	1.9	3.1	0.99614	1.25232	0.99994					
PSU106	0.8	2.1	0.99049	0.66213	0.99999	0.17	0.33	1.559	1.49	-4.43
SHN418	0.9	1.8	1.00815	-0.21303	0.99995					
BWR139	0.5	1.0	0.99669	0.06569	0.99992					
BEL116	1.6	2.1	0.97643	0.4792	0.99999	0.10	0.19	1.512	1.51	-0.11
CND125	1.9	2.3	1.01781	0.18162	0.99997					
BFT142	0.5	1.3	0.99133	-0.81721	0.99996					

4.4 Wind Speed

The wind speed sensors at three sites equipped for meteorological measurements were audited. All sites were found to be well within the acceptance limit. The results of the wind speed performance audits are presented in Table 4.3.

4.4.1 Wind Speed Starting Threshold

The condition of the wind speed bearings was evaluated as part of the performance audits. The data acceptance criterion for wind speed bearing torque is not defined in the QAPP. However, ***Appendix 1: CASTNET Field Standard Operating Procedures***, states that the wind speed bearing torque should be ≤ 0.2 g-cm. To establish the wind speed bearing torque criterion for audit purposes the rational described in the QAPP for data quality objectives (DQO) was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically field criteria are set at approximately one-half the DQO. Therefore, 0.5 g-cm was used for the acceptance limit for audit purposes. This value is within the manufacture's specifications for a properly maintained system. All sites were found to be within the acceptance limit.

4.5 Wind Direction

Two separate tests were performed to evaluate the accuracy of each wind direction sensor. A linearity test was performed to evaluate the ability of the sensor to function properly and accurately throughout the range from 1 to 360 degrees. This test evaluates the sensor independently of orientation and can be performed with the sensor mounted on a test fixture. A separate orientation test was used to determine if the sensor was aligned properly when installed

to measure wind direction accurately in degrees true. An audit standard compass was used to perform the orientation tests.

Using the average error of the orientation tests for each of the 5 sensors tested, all sites were within the acceptance criterion of ± 5 degrees. All sensors tested for average linearity, were within the acceptance limit. The results of the wind direction performance audits are presented in Table 4.3.

4.5.1 Wind Direction Starting Threshold

The condition of the wind direction bearings was evaluated as part of the performance audits. The data acceptance criterion for wind direction bearing torque is not defined in the QAPP. However, ***Appendix 1: CASTNET Field Standard Operating Procedures***, states that the wind direction bearing torque should be ≤ 10 g-cm for R. M. Young sensors. The manufacturer states that a properly maintained sensor will be accurate up to a starting threshold of 11 g-cm. To establish the wind direction bearing torque criterion for audit purposes the rational described in the QAPP for data quality objectives (DQO) was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically field criteria are set to approximately one-half the DQO. For audit purposes 20 g-cm was used for the acceptance limit for R. M. Young sensors. Climatronics sensors typically have a lower starting torque. For audit purposes a threshold of 10 g-cm was selected for Climatronics sensors. All of the wind direction starting thresholds were with acceptance limits. The test results are provided in Table 4.3.

Table 4.3 Performance Audit Results for Wind Sensors

	Wind Direction					Wind Speed				
	Orientation Error		Linearity Error		Starting Torque (g-cm)	Low Range Error		High Range Error		Starting Torque (g-cm)
Site	Ave (deg)	Max (deg)	Ave (deg)	Max (deg)		Ave (m/s)	Max (m/s)	Ave (% diff)	Max (% diff)	
GRB411	1.5	3	1.5	3	9	0.03	-0.06	0.00	0.01	0.20
MOR409	4	5	1.75	3	8	0.03	0.08	0.01	0.02	0.20
DEN417	4.6	5	1.25	3	0	0.01	0.02	0.00	0.00	0.25
ACA416	3.4	5	1.25	4	6	0.20	-0.22	0.01	-0.02	0.20
BEL116	2.25	3	1.25	2	15	0.05	-0.20	0.00	0.00	0.25

* Note: The wind systems acceptance criteria were applied to the average of the results. The data validation section of the CASTNET QAPP states that if any wind direction or wind speed challenge result is outside the acceptance criterion the variable is flagged. Maximum error values outside criteria and systems that fail for other reasons are denoted.

4.6 Temperature, Two Meter Temperature, and Delta Temperature

The temperature measurement systems, at the sites so equipped, consist of a temperature sensor mounted at 9 meters on the meteorological tower. A few sites also utilized a second sensor to measure temperature at approximately two meters from the ground (2-meter temperature). Delta temperature is calculated as part of the data logger program routine and is also recorded on-site.

All sites use shields to house the sensors that are designed to be mechanically aspirated with forced air blowers. In all cases the sensors were removed from the sensor shields, and placed in a uniform temperature bath with a precision NIST-traceable RTD, during the audit.

Results of the tests indicate that all sensors were within the acceptance criterion. The only 2-meter temperature sensor was within criterion. The average errors for all sensors are presented in Table 4.4.

4.6.1 Temperature Shield Blower Motors

All of the blower motors encountered during the site audits conducted during 2012 were found to be functioning.

4.7 Relative Humidity

The relative humidity systems at the sites were tested with a combination of primary standard salt solutions, and a certified transfer standard relative humidity probe. The results of the average and maximum errors throughout the entire measurement range of 0% - 100% are presented in Table 4.4.

The relative humidity measurement being made at each of the five sites equipped with relative humidity sensors is provided by a sensor supplied by any one of two different manufactures. At EPA sponsored sites with R. M. Young equipment, humidity sensors are operating in naturally aspirated shields. At EPA sponsored sites with Climatronics equipment, humidity sensors are operating in shields designed to be mechanically aspirated with forced-air blowers.

During audit tests with the primary standard salt solutions, the sensors were removed from the shields and placed in a temperature controlled enclosure. During audit tests with the transfer standard probe, the sensor and transfer were placed in the same ambient conditions. Therefore the audit tests do not account for differences in the operation of the sensors due to shield configurations.

All sensors were within the acceptance criterion. The results of the tests are included in Table 4.4.

Table 4.4 Performance Audit Results for Temperature and Humidity

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Delta Temperature Ave. Error (deg C)	Relative Humidity	
				Range 0 – 100%	
				Ave. Error (%)	Max. Error (%)
GRB411	0.06			2.84	-6.8
MOR409	0.11			2.51	4.8
DEN417	0.17			2.02	-3.1
HOX148	0.20				
UVL124	0.09				
ANA115	0.16				
SAL133	0.18				
MKG113	0.14				
KEF112	0.03				
EGB181	0.09				
CTH110	0.05				
HWF187	0.13				
ACA416	0.05		0.06	6.19	7.7
HOW191	0.26				
HOW191-B	0.08				
HOW132	0.14				
ASH135	0.06				
WST109	0.10				
ABT147	0.09				
CAT175	0.15				
ARE128	0.08				
PSU106	0.14				
BEL116	0.15	0.17		6.65	8.0

4.8 Solar Radiation

The ambient conditions encountered during the audit visits were suitable, with high enough light levels for accurate comparisons. A NIST-traceable Eppley PSP radiometer and translator were used as the audit standard system.

One of the sites (DEN417) had daytime average results that were outside the acceptance criterion. The results of the individual tests for each site are included in Table 4.5. The percent difference of the maximum solar radiation value observed during each site audit is also reported in Table 4.5 although this criterion is not part of the CASTNET data quality indicators. Those values greater than ±10% are bold.

4.9 Precipitation

All sites audited used a tipping bucket rain gauge for the obtaining precipitation measurement data. The audit challenges consisted of entering multiple amounts of a known volume of water into the tipping bucket funnel at a rate equal to approximately 2 inches of rain per hour. Equivalent amounts of water entered were compared to the amount recorded by the DAS. The rain gauge at one site, Acadia National Park, ME (ACA416) was outside of the acceptable criterion. The results are summarized in Tables 4.5.

4.10 Surface Wetness

The acceptance criteria established for the surface wetness sensors used at the CASTNET sites requires the sensor to have a positive response from a condition of dry to a condition of wet. All of the sensors tested exhibited a positive response to a wet condition.

Table 4.5 Performance Audit Results for Solar Radiation, Precipitation, and Surface Wetness

Site	Solar Radiation Error				Precipitation Ave. Error (% diff)	Wetness Sensor (On when wet?)
	Daytime Ave. (% diff)	Max. Value (w/m2)	Max. Observed (w/m2)	Max. Value (% diff)		
GRB411	7.52	957	1018	6.0	8.0	Yes
MOR409	0.13	442	429	-3.0	5.0	Yes
DEN417	18.14	798	645	-23.7	1.0	Yes
ACA416	2.91	689	671	-2.7	19.0	Yes
BEL116	6.35	299	318	6.0	5.0	Yes

4.11 Data Acquisition Systems (DAS)

All of the NPS sponsored sites visited utilized an ESC logger as the primary and only DAS. All EPA sites visited operated Campbell loggers as their only DAS. The results presented in tables 4.1 and 4.6 include the tests performed on the primary logger at each site.

4.11.1 Analog Test

The accuracy of each primary logger was tested on two different channels (if two channels were available to be used) with a NIST-traceable Fluke digital voltmeter. At some of the EPA sponsored sites the channels above analog channel 8 could not be tested since there were no empty channels available to test. All data loggers were within the acceptance criterion of ± 0.003 volts.

4.11.2 Functionality Tests

Other performance tests used to evaluate the DAS included the verification of the date and time, and operation of the battery backup system used to save the DAS date, time, and configuration during a power outage. All DAS were set to the correct date and within ±5 minutes per the acceptance criterion for time.

Table 4.6 Performance Audit Results for Data Acquisition Systems

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
	Low Channel		High Channel			
	Average	Maximum	Average	Maximum		
SUM156	0.0001	0.0002			Y	0.07
EVE419	0.0001	0.0002	0.0001	0.0002	Y	1.17
IRL141	0.0001	0.0001			Y	0.23
SND152	0.0000	-0.0001			Y	0.07
GAS153	0.0000	-0.0001			Y	0.00
CAD150					Y	0.00
CVL151					Y	0.00
CHE185					Y	0.00
CDZ171					Y	0.00
MAC426					Y	0.00
MCK131					Y	0.00

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
	Low Channel		High Channel			
	Average	Maximum	Average	Maximum		
MCK231					Y	0.00
ESP127	0.0000	0.0000			Y	0.05
SPD111	0.0001	-0.0002			Y	0.03
COW137	0.0000	0.0001			Y	0.03
PNF126	0.0000	0.0001			Y	0.02
ALC188					Y	0.00
BBE401					Y	0.00
PAL190					Y	0.00
CAN407	0.0001	-0.0002	0.0001	-0.0002	Y	1.42
MEV405	0.0001	-0.0002	0.0001	-0.0001	Y	0.17
PET427	0.0001	-0.0001	0.0002	-0.0003	Y	0.33
CHA467	0.0001	-0.0003	0.0001	-0.0003	Y	0.55
JOT403	0.0000	-0.0001	0.0001	0.0001	Y	0.67
GRC474	0.0002	-0.0003	0.0001	-0.0001	Y	0.70
GRB411	0.0001	0.0002	0.0000	-0.0001	Y	0.43
QAK172					Y	0.00
DCP114					Y	0.00
OXF122					Y	0.00
CKT136					Y	0.00
YOS404					Y	0.00
ROM206					Y	0.00
ROM406					Y	0.00
KNZ184					Y	0.00
GTH161					Y	0.00
GLR468					Y	0.00
YEL408					Y	0.00

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
	Low Channel		High Channel			
	Average	Maximum	Average	Maximum		
CNT169					Y	0.00
STK138					Y	0.00
MOR409	0.0002	-0.0004	0.0001	0.0003	Y	0.23
ALH157					Y	0.00
VIN140					Y	0.00
DEN417	0.0001	0.0003	0.0001	-0.0003	Y	1.27
HOX148	0.0000	0.0001			Y	0.28
UVL124	0.0001	0.0001			Y	0.27
ANA115	0.0001	0.0001			Y	0.18
SAL133	0.0001	0.0002			Y	0.17
BVL130					Y	0.00
PRK134					Y	0.00
VOY413					Y	0.00
PED108					Y	0.00
THR422					Y	0.00
VPI120					Y	0.00
WNC429					Y	0.00
PND165					Y	0.00
WSP144					Y	0.00
MKG113	0.0001	0.0003			Y	0.03
KEF112	0.0000	0.0000			Y	0.02
EGB181	0.0001	0.0002			Y	0.02
CTH110	0.0001	0.0002			Y	0.02
HWF187	0.0001	0.0002			Y	0.55
ACA416	0.0003	0.0007			Y	0.40
HOW132	0.0000	0.0001			Y	0.00

Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
	Low Channel		High Channel			
	Average	Maximum	Average	Maximum		
HOW191					Y	0.00
HOW191-B					Y	0.00
ASH135	0.0000	-0.0001			Y	0.00
WST109	0.0001	0.0002			Y	0.02
ABT147	0.0001	0.0002			Y	0.02
CDR119					Y	0.00
CAT175	0.0001	0.0002			Y	0.03
PAR107					Y	0.00
LRL117					Y	0.00
ARE128	0.0001	0.0002			Y	0.07
GRS420					Y	0.00
PSU106	0.0001	-0.0002			Y	0.02
SHN418					Y	0.00
BWR139					Y	0.00
BEL116	0.0000	0.0001			Y	0.02
CND125					Y	0.00
BFT142					Y	0.07

5.0 Systems Audit Results

The following sections summarize the site systems audit findings and provide information observed regarding the measurement processes at the sites. Conditions that directly affect data accuracy have been reported in the previous sections. Other conditions that affect data quality and improvements to some measurement systems or procedures are suggested in the following sections.

5.1 Siting Criteria

All of the sites that were visited have undergone changes during the period of site operation which include population growth, road construction, and foresting activities. Of the changes noted, none were determined to have a significant impact.

Some sites that are located in state and national parks are not in open areas, and have trees within the 50 meter criterion established in the QAPP. Given the land use and aesthetic concerns, these sites are acceptable and represent an adequate compromise with regard to siting criteria and the goal of long-term monitoring.

5.2 Sample Inlets

With consideration given to the siting criteria compromises described in the previous section, the sites visited this year have analyzer sample trains that are sited properly and in accordance with the CASTNET QAPP. The filter packs and ozone inlets are designed to sample from 10 meters. Teflon tubing of adequate diameter is used for the ozone inlets. Most of the filter pack sample lines are also Teflon. Inline filters are present in the sample trains. The ozone zero, span, and precision calibration test gases are introduced at the ozone sample inlet, through all filters and the entire sample train. All sample trains contain only Teflon fittings and materials.

5.3 Infrastructure

Sites continue to be improved by repairing the site shelters which had deteriorated throughout the years of operation. The installation and upgrade of the data loggers, many of which had degrading signal cables, was especially helpful. A few of the site shelters are still in need of repair, but overall the condition of the sites has improved again during the past year. The shelters at sites ESP127, GRB411, MKG113, and SAL133 showed signs of leaky roofs and rot in some areas.

5.4 Site Operators

Generally the site operators are very conscientious and eager to complete the site activities correctly. They are willing to, and have performed sensor replacements and repairs at the sites with support provided by the AMEC and ARS field operations centers. In some cases, where replacements or repairs were made, documentation of the activities was not complete, and did not include serial numbers of the removed and installed equipment.

Many of the CASTNET site operators also perform site operator duties for the National Atmospheric Deposition Program (NADP). Many of the NPS site operators also perform other air, or environmental quality functions within their park. All are a valuable resource for the program. Some of the site operators mentioned that the CASTNET features in the NPS "Monitor" are informative, helpful, and appreciated.

Still many of the site operators have not been formally trained to perform the CASTNET duties by either AMEC or ARS. They had been given instructions by the previous site operators and over the phone instructions from the field operation centers at AMEC and ARS, and in some instances official training documentation is not readily available.

5.5 Documentation

There were some documentation problems regarding the dry deposition filter pack flow rate section of the Site Status Report Forms (SSRF) completed by the site operators each week during the regular site visits. Common errors included improper reporting of "initial flow", "final flow", and "leak check" values. A few operators do not use the required "chain-of-custody" label.

The NPS site operator procedures are well developed and readily accessible at all of the NPS sites visited. There is an electronic interface, "DataView 2", available to view, analyze, and print site data. There are electronic "checklists" for the site operator to complete during the site visits; however, all of the CASTNET filter pack procedures are not included in the "checklists". Flow rates and leak check results are not recorded electronically.

An electronic logbook is included in the interface software. This system permits easy access to site documentation data. Complete calibration reports have been added to the system and accessible through the site computer.

5.6 Site Sensor and FSAD Identification

Continued improvement has also been made in the area of documentation of sensors and systems used at the sites. It is important to maintain proper sensor identification for the purposes of site

inventory and to properly identify operational sensors for data validation procedures. Many sensors have had new numbers affixed for proper identification.

Where possible the identification numbers assigned (serial numbers and barcodes) are used within the field site audit database for all the sensors encountered during the site audits. The records are used for both the performance and systems audits. If a sensor is not assigned a serial number by the manufacturer, that field is entered as "none". If it is unknown whether an additional client ID number is assigned to a sensor, and a number is not found, the client ID is also entered as "none". If it is typical for a manufacturer and/or client ID number to be assigned to a sensor, and that number is not present, the field is entered as "missing". If either the serial number or the client ID numbers cannot be read, the field is entered as "illegible". An auto-number field is assigned to each sensor in the database in order to make the records unique.

6.0 Summary and Recommendations

The CASTNET Site Audit Program has been successful in evaluating the field operations of the sites for several years allowing EEMS to look at trends in overall site performance and equipment function. The results of performance and systems audits are recorded and archived in a relational database, the Field Site Audit Database (FSAD). CASTNET site operations are generally acceptable and continue to improve. Some differences between actual site operations and operations described in the QAPP have been identified and described. Procedural differences between EPA and NPS sponsored sites have also been described.

As discussed previously the shelters have received some much needed attention. It was also observed that improvements were made to the shelter temperature control systems. As a requirement in 40 CFR Part 58 for ozone monitoring, shelter temperature must be maintained within a certain range. Additional improvement could be made to accurately measure and report shelter temperature.

The previous paragraphs and sections included some recommendations for improving the field operations systems. One recommendation for improving the audit program is presented in the following section; this recommendation was also included in the previous annual report.

6.1 Follow-up visits

It is recommended that some of the conditions encountered during the audits be addressed during the next scheduled site maintenance and calibration visit. In order to determine if the needed actions occurred, a follow-up procedure should be established. This procedure need not be another audit and could be achieved by a follow up after the 6-month calibration trip performed by AMEC or ARS.

Additional data validation audits could be conducted to determine if polled data are scaled correctly. Review of the polled data and site documentation should be performed routinely to ascertain and correct these types of problems.

6.2 In Situ Comparisons

An improvement to the audit procedures designed to evaluate the differences in measurement technique would be to develop an “In Situ” audit measurement system. This would require a suite of sensors that would be collocated with the site sensors. Ideally the audit sensors would address the inconsistent sensor installations observed throughout the network. By deploying a suite of certified NIST traceable sensors installed and operating as recommended by the manufacturer and to EPA guidelines, subtle differences in the operation of the existing CASTNET measurement systems could be evaluated. The “In Situ” sensors would be operated at

each site for a 24 hour period and the measurements would be compared to the CASTNET measurements.

7.0 References

Office of Air Quality and Planning Standards AMTIC website, SOP and guidance documents: www.epa.gov/ttn/amtic/

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II - Ambient Air Specific Methods – EPA.

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements – EPA.

Clean Air Status and Trends Network (CASTNET) Quality Assurance Project Plan (2003) – EPA.

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume I: - A Field Guide To Environmental Quality Assurance – EPA.

Quality Assurance Handbook for Air Pollution Measurement Systems: Volume II: Part1 Ambient Air Quality Monitoring Program Quality System Development – EPA.

Sensitivity of the National Oceanic and Atmospheric Administration multilayer model to instrument error and parameterization uncertainty: Journal of Geophysical Research, Vol. 105. No. D5, March 16, 2000.

Wind System Calibration, Recommended Calibration Interval, Procedure, and Test Equipment: November 1999, R. M. Young Company

APPENDIX 1

Audit Standards Certifications

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Science and Ecosystem Support Division
Enforcement and Investigations Branch
Superfund and Air Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	USEPA R4	EEMS
Contact:	Mike Crowe	Eric Hebert
Make:	NIST	TEI
Model:	SRP	49C analyzer
S/N:	10	49C-73104-373
Guest Test Status:		**PASS**
Guest Known Offset:		0

SESD Project #:
Test #: 1

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0129	-0.0470	0.9999992	488	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Date Start	Time Start	Date End	Time End	File	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
01/23/12	11:23 AM	01/23/12	12:30 PM	c0123001.xls	1.0127	-0.0930	0.9999992	487	0.15
01/23/12	12:31 PM	01/23/12	1:36 PM	c0123002.xls	1.0127	0.0541	0.9999994	488	-0.20
01/23/12	1:36 PM	01/23/12	2:42 PM	c0123003.xls	1.0132	-0.1020	0.9999989	488	-0.11

Comments: Instrument within tolerance.
No adjustments made.
Ozone calibration factors at time of test: O3 BKG = 0.2 O3 COEF = 1.027

Verification Expires on: **January 23, 2013**

Mike Crowe Date

New 6-day averages:

slope = 1.01297

int = 0.09498

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Science and Ecosystem Support Division
Enforcement and Investigations Branch
Superfund and Air Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	USEPA R4	EEMS
Contact:	Mike Crowe	Eric Hebert
Make:	NIST	Environics
Model:	SRP	6103
S/N:	10	3874
Guest Test Status:		**PASS**
Guest Known Offset:		0

SESD Project #:
Test #: 1

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0001	-1.6786	0.999997	488	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Date Start	Time Start	Date End	Time End	File	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
01/23/12	11:23 AM	01/23/12	12:30 PM	c0123001.xls	0.9967	-1.5435	0.9999984	487	0.15
01/23/12	12:31 PM	01/23/12	1:36 PM	c0123002.xls	1.0011	-1.6945	0.9999967	488	-0.20
01/23/12	1:36 PM	01/23/12	2:42 PM	c0123003.xls	1.0026	-1.7979	0.9999959	488	-0.11

Comments: Instrument within tolerance.
No adjustments made.
Ozone calibration factors at time of test: BKG = 2.50 GAIN =1.110

Verification Expires on: **January 23, 2013**

Mike Crowe _____ Date _____

new 6-day averages:

slope = 1.00817
int = 0.12695

Warren-Knight Instrument Company
2045 Bennett Road
Philadelphia, PA 19116
Phone: 215-464-9300; Fax: 215-464-9303
Web: http://www.warrenind.com

CERTIFICATION OF CALIBRATION AND CONFORMANCE

We hereby certify that the equipment below has been manufactured and/or inspected by standards traceable to NIST. Calibration of the specified instrument has been performed in compliance with ANSI Z540-1 requirements. It is warranted that the equipment has been calibrated to be in full conformance with the drawings and specifications of the instrument. Calibration tests were performed on the material specified below and were in accordance with all applicable quality assurance requirements with data on file at our facility.

Customer Name:	EE & MS
Purchase Order #:	
Instrument:	S-25 Tracon Surveying Compass
Serial Number:	190037
Quantity:	1
Calibration Due:	1/2013

EEMS # 01265

Declination functional

John Noga

John Noga, Quality Control

January 30, 2012

Measurement Standards:
Theodolite: Wild T-3 S/N 18801/CAL 5/14/97 NIST# 738/229329-83 738/223398
Optical Wedge: K&E 71-7020 S/N 5167/CAL 4/19/01 NIST# 731/244084-89

Warren-Knight Instrument Company
2045 Bennett Road
Philadelphia, PA 19116
Phone: 215-464-9300; Fax: 215-464-9303
Web: http://www.warrenind.com

CERTIFICATION OF CALIBRATION AND CONFORMANCE

We hereby certify that the equipment below has been manufactured and/or inspected by standards traceable to NIST. Calibration of the specified instrument has been performed in compliance with ANSI Z540-1 requirements. It is warranted that the equipment has been calibrated to be in full conformance with the drawings and specifications of the instrument. Calibration tests were performed on the material specified below and were in accordance with all applicable quality assurance requirements with data on file at our facility.

Customer Name:	EE & MS
Purchase Order #:	
Instrument:	S-25 Tracon Surveying Compass
Serial Number:	192034
Quantity:	1
Calibration Due:	1/2013

EEMS # 01270

Declination Not Functional

John Noga

John Noga, Quality Control

January 30, 2012

Measurement Standards:
Theodolite: Wild T-3 S/N 18801/CAL 5/14/97 NIST# 738/229329-83 738/223398
Optical Wedge: K&E 71-7020 S/N 5167/CAL 4/19/01 NIST# 731/244084-89

Warren-Knight Instrument Company
2045 Bennett Road
Philadelphia, PA 19116
Phone: 215-464-9300; Fax: 215-464-9303
Web: http://www.warrenind.com

CERTIFICATION OF CALIBRATION AND CONFORMANCE

We hereby certify that the equipment below has been manufactured and/or inspected by standards traceable to NIST. Calibration of the specified instrument has been performed in compliance with ANSI Z540-1 requirements. It is warranted that the equipment has been calibrated to be in full conformance with the drawings and specifications of the instrument. Calibration tests were performed on the material specified below and were in accordance with all applicable quality assurance requirements with data on file at our facility.

Customer Name:	EE & MS
Purchase Order #:	
Instrument:	S-25 Tracon Surveying Compass
Serial Number:	191832
Quantity:	1
Calibration Due:	1/2013

EEMS # 01272

Declination functional (EL)

John Noga, Quality Control

January 30, 2012

Measurement Standards:
Theodolite: Wild T-3 S/N 18801/CAL 5/14/97 NIST# 738/229329-83 738/223398
Optical Wedge: K&E 71-7020 S/N 5167/CAL 4/19/01 NIST# 731/244084-89

NVLAP®
NVLAP Lab Code 200661

Bios
Driving a Higher Standard in Flow Measurement℠

Calibration Certificate

Certificate No.	5012054	**Sold to:**	Environmental Engineering & Measurement Services, Inc - Gainesville
Product	Definer 220 High Flow		1128 NW 39th Drive
Serial No.	122974		Gainesville, FL 32605
Cal. Date	2/6/2012		USA

All calibrations are performed in accordance with ISO 17025 at Bios International Corporation, 10 Park Place, Butler, NJ, 07405, 800-663-4977, an ISO 17025:2005 – accredited laboratory through NVLAP. This report shall not be reproduced except in full without the written approval of the laboratory. Results only relate to the items calibrated. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

All units tested in accordance with Bios International Corporation test number PR18-13 using high-purity bottled nitrogen or dry filtered laboratory air.

As Received Calibration Data

Technician Sonia Otero

Lab. Pressure 738 mmHg
Lab. Temperature 22.4 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
502.25 sccm	501.705 sccm	0.11%	1.00%	In Tolerance
4994.7 sccm	5002.85 sccm	-0.16%	1.00%	In Tolerance
29957 sccm	30079 sccm	-0.41%	1.00%	In Tolerance
22 °C	22.1 °C	-0.1°C	±0.8°C	In Tolerance
738 mmHg	738 mmHg	0 mmHg	±3.5mmHg	In Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	103521	11/15/2011	11/14/2012
Precision Thermometer	305460	8/15/2011	8/14/2012
Precision Barometer	2981392	5/27/2011	5/26/2012

EEMS # 01416

Bios

Driving a Higher Standard in Flow Measurement℠

As Shipped Calibration Data

Certificate No. 5012054
Technician Sonia Otero

Lab. Pressure 763 mmHg
Lab. Temperature 22.5 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
503.91 sccm	500.715 sccm	0.64%	1.00%	In Tolerance
5023.9 sccm	5005.95 sccm	0.36%	1.00%	In Tolerance
30171 sccm	30007 sccm	0.55%	1.00%	In Tolerance
22.4 °C	22.4 °C	-	±0.8°C	In Tolerance
763 mmHg	763 mmHg	-	±3.5mmHg	In Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	103521	11/15/2011	11/14/2012
Precision Thermometer	305460	8/15/2011	8/14/2012
Precision Barometer	2981392	5/27/2011	5/26/2012

Calibration Notes

Bios is an ISO 17025-accredited metrology laboratory. Each Bios primary gas flow standard is dynamically verified by comparing it to one of our laboratory standards, which is a Proven DryCal® Technology volumetric piston prover of much higher accuracy but of similar operating principles. For this purpose, a flow generator of ±0.03% stability is used. Our laboratory standards are qualified by direct measurement of their dimensions (diameter, length and time) using NIST-traceable precision gauges and instruments, such as depth micrometers and laser micrometers. NIST numbers for these gauges and instruments are available upon request. Rigorous analyses of our laboratory standards' uncertainties have been performed, in accordance with The Guide to the Expression of Uncertainty in Measurement (the GUM), assuring their traceable accuracy. Flow readings in sccm performed at STP of 21.1°C and 760 mmHg.

Technician Notes:

EEMS # 01416

Harvey Padden, President and Chief Metrologist

NVLAP Lab Code 200661

Bios
Driving a Higher Standard in Flow Measurement℠

Calibration Certificate

Certificate No.	5012053	**Sold to:**	Environmental Engineering & Measurement Services, Inc - Gainesville
Product	Definer 220 Low Flow		1128 NW 39th Drive
Serial No.	120910		Gainesville, FL 32605
Cal. Date	2/6/2012		USA

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All units tested in accordance with Bios International Corporation test number PR18-13 using high-purity bottled nitrogen or dry filtered laboratory air.

As Received Calibration Data

Technician Sonia Otero

Lab. Pressure 738 mmHg
Lab. Temperature 22.4 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
30.248 sccm	30.111 sccm	0.45%	1.00%	In Tolerance
100.68 sccm	100.115 sccm	0.56%	1.00%	In Tolerance
500 sccm	501.14 sccm	-0.23%	1.00%	In Tolerance
22.1 °C	22 °C	0.1°C	±0.8°C	In Tolerance
737 mmHg	738 mmHg	-1 mmHg	±3.5mmHg	In Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-10	105329	10/27/2011	10/26/2012
Precision Thermometer	305460	8/15/2011	8/14/2012
Precision Barometer	2981392	5/27/2011	5/26/2012

EEMS # 01415

Bios

Driving a Higher Standard in Flow Measurement℠

As Shipped Calibration Data

Certificate No. 5012053
Technician Sonia Otero

Lab. Pressure 763 mmHg
Lab. Temperature 22.4 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
30.124 sccm	30.026 sccm	0.33%	1.00%	In Tolerance
101.03 sccm	100.595 sccm	0.43%	1.00%	In Tolerance
502.94 sccm	499.735 sccm	0.64%	1.00%	In Tolerance
22.3 °C	22.3 °C	-	±0.8°C	In Tolerance
763 mmHg	763 mmHg	-	±3.5mmHg	In Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-10	105329	10/27/2011	10/26/2012
Precision Thermometer	305460	8/15/2011	8/14/2012
Precision Barometer	2981392	5/27/2011	5/26/2012

Calibration Notes

Bios is an ISO 17025-accredited metrology laboratory. Each Bios primary gas flow standard is dynamically verified by comparing it to one of our laboratory standards, which is a Proven DryCal® Technology volumetric piston prover of much higher accuracy but of similar operating principles. For this purpose, a flow generator of ±0.03% stability is used. Our laboratory standards are qualified by direct measurement of their dimensions (diameter, length and time) using NIST-traceable precision gauges and instruments, such as depth micrometers and laser micrometers. NIST numbers for these gauges and instruments are available upon request. Rigorous analyses of our laboratory standards' uncertainties have been performed, in accordance with The Guide to the Expression of Uncertainty in Measurement (the GUM), assuring their traceable accuracy. Flow readings in sccm performed at STP of 21.1°C and 760 mmHg.

Technician Notes:

EEMS # 01415

Harvey Padden, President and Chief Metrologist

Certificate Number
A1061518

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32505
FEDEX

P.O. Number: HOLD

ID Number: 01310
EMS #

Description:	TRUE RMS MULTIMETER	Calibration Date:	2/9/2012
Manufacturer:	FLUKE	Calibration Due:	2/9/2013
Model Number:	187	Procedure:	METCAL FLUKE 187
Serial Number:	86590148	Rev:	
Technician:	CHRISTIAN CRUZ	Temperature:	75 °F
		Humidity:	37 % RH
		As Found Condition:	**IN TOLERANCE**
		Calibration Results:	**IN TOLERANCE**

On-Site Calibration: ☐
Comments:

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. Either the measurement standard TUR to the item being calibrated is 4:1 or measurement uncertainties are reported. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

TMI's Quality System is accredited to ISO 17025 and ANSI/NCSL Z540-1 by A2LA and complies with the requirements of ANSI/NCSL Z540.3, 10 CFR 50 Appendix B and 10 CFR Part 21. ISO17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements.

Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

TONY ROGERS, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
1566901	FLUKE	5522A	1/7/2012	1/7/2013

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Certificate Number
A1061517

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32505
FEDEX

P.O. Number: HOLD

EMS #
ID Number: 01311

Description:	TRUE RMS MULTIMETER	Calibration Date:	2/9/2012
Manufacturer:	FLUKE	Calibration Due:	2/9/2013
Model Number:	287	Procedure:	METCAL FLUKE 287
Serial Number:	95740135		Rev:
Technician:	CHRISTIAN CRUZ	Temperature:	75 °F
		Humidity:	37 % RH
On-Site Calibration: ☐		**As Found Condition:**	**IN TOLERANCE**
Comments:		**Calibration Results:**	**IN TOLERANCE**

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. Either the measurement standard TUR to the item being calibrated is 4:1 or measurement uncertainties are reported. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

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TONY ROGERS, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
1566901	FLUKE	5522A	1/7/2013	1/7/2013

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Certificate Number
A1061516

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32505
FEDEX

P.O. Number: HOLD

ID Number: 01312
EEMS #

Description:	TRUE RMS MULTIMETER	Calibration Date:	2/9/2012
Manufacturer:	FLUKE	Calibration Due:	2/9/2013
Model Number:	287	Procedure:	METCAL FLUKE 287
Serial Number:	95740243	Rev:	
Technician:	CHRISTIAN CRUZ	Temperature:	75 °F
		Humidity:	37 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments:

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. Either the measurement standard TUR to the item being calibrated is 4:1 or measurement uncertainties are reported. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

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Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

TONY ROGERS, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
1566901	FLUKE	5522A	1/7/2012	1/7/2013

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Certificate Number
A1061705

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32505
FEDEX

P.O. Number: HOLD

ID Number: 01230

Description:	TEMPERATURE INDICATOR	Calibration Date:	2/10/2012
Manufacturer:	EUTECHNICS	Calibration Due:	2/10/2013
Model Number:	4600-1.2.5	Procedure:	TMI- M-THERMO
Serial Number:	01D102193	Rev:	
Technician:	ANTHONY MOORE	Temperature:	68 °F
On-Site Calibration: ☐		Humidity:	49 % RH
Comments:		**As Found Condition:**	**IN TOLERANCE**
		Calibration Results:	**IN TOLERANCE**

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. Either the measurement standard TUR to the item being calibrated is 4:1 or measurement uncertainties are reported. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

TMI's Quality System is accredited to ISO 17025 and ANSI/NCSL Z540-1 by A2LA and complies with the requirements of ANSI/NCSL Z540.3, 10 CFR 50 Appendix B and 10 CFR Part 21. ISO17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements.

Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

TONY ROGERS, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
A06118	HART SCIENTIFIC	9103	10/10/2011	10/10/2012

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

INSTRUMENT DATA SHEET

Serial/Asset Number: 01230 Customer: EE & MS
Date Tested: 02/10/12

Parameter Tested	Nominal Value In °C	Tolerance ±.13 °C	Lower Limit	Upper Limit	As Found	Pass/Fail	As Left
Temperature Accuracy							
	0.000	0.130	-0.130	0.130	0.05	PASS	AS FOUND
	10.000	0.130	9.870	10.130	9.98	PASS	AS FOUND
	20.000	0.130	19.870	20.130	19.95	PASS	AS FOUND
	30.000	0.130	29.870	30.130	29.95	PASS	AS FOUND
	40.000	0.130	39.870	40.130	40.08	PASS	AS FOUND
	50.000	0.130	49.870	50.130	50.10	PASS	AS FOUND

Slope = 1.001571

int = -0.02095

r = 0.999995

Certificate Number
A1061721

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32505
FEDEX

P.O. Number: HOLD

ID Number: 01231

Description:	TEMPERATURE PROBE	Calibration Date:	2/10/2012
Manufacturer:	UNKNOWN	Calibration Due:	2/10/2013
Model Number:	SP034-39	Procedure:	TMI- M-THERMO
Serial Number:	01H0060	Rev:	
Technician:	ANTHONY MOORE	Temperature:	68 °F
On-Site Calibration: ☐		Humidity:	49 % RH
Comments:		**As Found Condition:**	**IN TOLERANCE**
		Calibration Results:	**IN TOLERANCE**

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. Either the measurement standard TUR to the item being calibrated is 4:1 or measurement uncertainties are reported. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

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TONY ROGERS, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
A06118	HART SCIENTIFIC	9103	10/10/2011	10/10/2012

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

INSTRUMENT DATA SHEET

Serial/Asset Number: 01231 Customer: EE & MS
Date Tested: 02/10/12

Parameter Tested	Nominal Value In °C	Tolerance ±.13 °C	Lower Limit	Upper Limit	As Found	Pass/Fail	As Left
Temperature Accuracy							
	0.000	0.130	-0.130	0.130	0.05	PASS	AS FOUND
	10.000	0.130	9.870	10.130	9.98	PASS	AS FOUND
	20.000	0.130	19.870	20.130	19.95	PASS	AS FOUND
	30.000	0.130	29.870	30.130	29.95	PASS	AS FOUND
	40.000	0.130	39.870	40.130	40.08	PASS	AS FOUND
	50.000	0.130	49.870	50.130	50.10	PASS	AS FOUND

Certificate Number
A1062784

Certificate of Calibration

Customer: EE & MS
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number: HOLD

ID Number: 45656048/124432

EEMS # 01225

Description:	TEMP/HUM PROBE	Calibration Date:	2/13/2012
Manufacturer:	ROTRONIC	Calibration Due:	2/13/2013
Model Number:	HYGROCLIP	Procedure:	TMI-M-THERMOHUM Rev: 4/30/2011
Serial Number:	45656 048/124432	Temperature:	72 °F
Technician:	BRIAN WINGROVE	Humidity:	41 % RH
On-Site Calibration: ☐		**As Found Condition:**	**IN TOLERANCE**
Comments:		**Calibration Results:**	**IN TOLERANCE**

Limiting Attribute:

This instrument has been calibrated using standards traceable to the National Institute of Standards and Technology, derived from natural physical constants, ratio measurements or compared to consensus standards. Unless otherwise noted, the method of calibration is direct comparison to a known standard.

Reported uncertainties and "test uncertainty ratios" (TUR's) are expressed as expanded uncertainty values at approximately 95% confidence level using a coverage factor of K=2. Either the measurement standard TUR to the item being calibrated is 4:1 or measurement uncertainties are reported. Statements of compliance are based on test results falling within specified limits with no reduction by the uncertainty of the measurement.

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Results contained in this document relate only to the item calibrated. Calibration due dates appearing on the certificate or label are determined by the client for administrative purposes and do not imply continued conformance to specifications.

TONY ROGERS, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
9304027	THUNDER SCIENTIFIC	2500	1/28/2010	4/10/2012

TMI Technical Maintenance, Inc.
12530 TELECOM DRIVE, TEMPLE TERRACE, FL 33637
Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Technical Maintenance, Inc.

INSTRUMENT DATA SHEET

Rotronic
Model Hygropalm
Thermo Hygrometer

Asset Number: 01225 Customer: EE & MS
Date Tested: 2/13/12

Parameter Tested	Nominal Value	Tolerance	Lower Limit	Upper Limit	As Found	Pass/Fail	As Left
Temperature Accuracy							
	20degC	±0.2 °C	19.8	20.2	20.1	Pass	As Found
	30degC	±0.2 °C	29.8	30.2	29.9	Pass	As Found
	50degC	±0.2 °C	49.8	50.2	49.9	Pass	As Found
Humidity Accuracy							
	20	±1.5%	18.5	21.5	20.0	Pass	As Found
	50	±1.5%	48.5	51.5	50.3	Pass	As Found
	75	±1.5%	73.5	76.5	75.4	Pass	As Found

CERTIFICATE OF CALIBRATION AND TESTING

R. M. Young Company certifies that the equipment listed below was inspected and calibrated prior to shipment in accordance with established manufacturing and testing procedures. Standards established by R.M. Young Company for calibrating the measuring and test equipment used in controlling product quality are traceable to the National Institute of Standards and Technology.

MODEL: ☒ **18802** / ☒ **18811** SERIAL NUMBER: CAO2777
(18802 Comprised of Models 18820A Control Unit & 18830A Motor Assembly)
(18811 Comprised of Models 18820A Control Unit & 18831A Motor Assembly)

Nominal Motor RPM	27106D Output Frequency (Hz) - (1)	Calculated Rpm (1)	Indicated Rpm (2)
18802		-	☒ CW / CCW rotation verified
300	50	300	300
2700	450	2700	2700
5100	850	5100	5100
7500	1250	7500	7500
10,200	1700	10200	10200
12,600	2100	12600	12600
15,000	2500	15000	15000
18811		-	☒ CW / CCW rotation verified
30.0	5	30.0	30.0
150.0	25	150.0	150.0
300.0	50	300.0	300.0
450.0	75	450.0	450.0
600.0	100	600.0	600.0
750.0	125	750.0	750.0
990.0	165	990.0	990.0

(1) Measured frequency output of RM Young Model 27106D standard anemometer attached to motor shaft - 27106D produces 10 pulses per revolution of the anemometer shaft.
(2) Indicated on the Control Unit LCD display.
* Indicates out of tolerance

☐ No Calibration Adjustments Required ☐ As Found ☒ As Left

Traceable frequency meter used in calibration Model: DPS740 SN: 4863

Date of inspection 5-7-12
Inspection Interval One Year

Tested By RP

EPLAB

THE EPPLEY LABORATORY, INC.

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 34341F3

Resistance: 699 Ω at 23°C
Temperature Compensation Range: -20° to +40°C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter^{-2} (roughly one half a solar constant).

As a result of a series of comparisons, it has been found to have a sensitivity of:

9.45×10^{-6} volts/watts meter^{-2}

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter^{-2}. This radiometer is linear to within ± 0.5% up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Eleventh International Pyrheliometric Comparisons (IPC XI) at Davos, Switzerland in September-October 2010.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Useful conversion facts: 1 cal cm^{-2} min^{-1} = 697.3 watts meter^{-2}
1 BTU/ft^2-hr^{-1} = 3.153 watts meter^{-2}

Shipped to: EEMS
Gainesville, FL

S.O. Number: 63457
Date: May 23, 2012

Date of Test: May 22, 2012

In Charge of Test: Debra L. Hegarty

Reviewed by: Thomas J. Kurtz

Remarks: Used with amplifier # 10765

NVLAP®
NVLAP Lab Code 200661

Bios
Driving a Higher Standard in Flow Measurement℠

Calibration Certificate

Certificate No. 5015962
Product DryCal Nexus NS
Serial No. 103471
Cal. Date 6/13/2012

Sold to: Environmental Engineering & Measurement Services, Inc - Gainesville
1128 NW 39th Drive
Gainesville, FL 32605
USA

All calibrations are performed in accordance with ISO 17025 at Bios International Corporation, 10 Park Place, Butler, NJ, 07405, 800-663-4977, an ISO 17025:2005 – accredited laboratory through NVLAP. This report shall not be reproduced except in full without the written approval of the laboratory. Results only relate to the items calibrated. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

Temperature and pressure are tested in accordance with Bios International Corporation PR06-02.
Expanded uncertainty of measurement: temperature ±0.035°C and pressure ±8Pa at two times coverage.

As Received Calibration Data

Technician Brian Roberts

Lab. Pressure 751 mmHg
Lab. Temperature 22.8 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	Condition
24.5°C	22.8°C	1.7°C	±0.6°C	Out of Tolerance
753mmHg	751mmHg	2mmHg	±1.8mmHg	Out of Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
Precision Thermometer	305460	8/15/2011	8/14/2012
Precision Barometer	2981392	6/4/2012	6/4/2013

EEMS # 01420

Bios

Driving a Higher Standard in Flow Measurement℠

As Shipped Calibration Data

Certificate No. 5015962
Technician Brian Roberts

Lab. Pressure 751 mmHg
Lab. Temperature 22.5 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	Condition
22.5°C	22.5°C	-	±0.6°C	In Tolerance
751mmHg	751mmHg	-	±1.8mmHg	In Tolerance

Bios International Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
Precision Thermometer	305460	8/15/2011	8/14/2012
Precision Barometer	2981392	6/4/2012	6/4/2013

DryCal Nexus Temperature and Pressure Certification

The Drycal DCLite is a true primary volumetric flow standard. Temperature and pressure corrections are applied by the Nexus NS to obtain standardized flow readings. The temperature and pressure transducers are calibrated against NIST traceable standards.

Calibration Notes

Bios is an ISO 17025-accredited metrology laboratory. Calibration Certificates for gauges and instruments used for calibration are available upon request. Rigorous analyses of our laboratory standards' uncertainties have been performed, in accordance with The Guide to the Expression of Uncertainty in Measurement (the GUM), assuring their traceable accuracy.

Technician Notes: _____

DWW

David W. Wilson, Chief Metrologist

FEMS # 01420
Nexus
6/13/2012

Bios International • 10 Park Place Butler, NJ 07405 • 800.663.4977 • www.biosint.com

BGI INCORPORATED 58 GUINAN STREET WALTHAM, MA 02451
NIST Traceable Calibration Facility, ISO 9001:2008 Registered

deltaCal

CERTIFICATE OF CALIBRATION - NIST TRACEBILITY

(Refer to instruction manual for further details of calibration)

deltaCal Serial Number: 001196 DATE: 22-Aug-12

Calibration Operator: YI TIAN

Critical Venturi Flow Meter: Max Uncertainty = 0.346%
Serial Number: 1A *CEESI NVLAP NIST Data File 07BGI-0001*
Serial Number: 2A *CEESI NVLAP NIST Data File 07BGI-0003*
Serial Number: 3A *CEESI NVLAP NIST Data File 07BGI-0004*
Serial Number: 4A *CEESI NVLAP NIST Data File 07BGI-0002*

Room Temperature : Uncertainty = 0.071% Room Temperature: 20.7 C
Brand: *Accu-Safe* Serial Number: 254881
NIST Traceability No. 516837
deltaCal:
Ambient Temperature (set): 20.7 C
Aux (filter) Temperature (set): 20.7 C

Barometric Pressure and Absolute Pressure
Vaisala Model PTB330(50-1100) Digital Accuracy: 0.03371%
S/N DH0850001
NIST Traceable (Princo Primary Standard Model 453 S/N W12537) Certificate No. P-7485
deltaCal:
Barometric Pressure (set): 764 mm of Hg

Results of Venturi Calibration

Flow Rate (Q) vs. Pressure Drop (ΔP). Where: Q=Lpm, ΔP= Cm of H_2O

Q= 3.83007 ΔP ^ 0.52155

Overall Uncertainty: 0.35%

Date Placed In Service 9/20/2012
(To be filled in by operator upon receipt)

Recommended Recalibration Date 9/20/2013
(12 months from date placed in service)

Revised: March 2012