CASTNET
2016 Annual Report

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Prepared by:

environmental engineering
& measurement services, inc.

1128 NW 39th Drive
Gainesville, FL 32605

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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
BLM	Bureau of Land Management
BLM-WY	Wyoming's Bureau of Land Management
CASTNET	Clean Air Status and Trends Network
CFR	Code of Federal Regulation
CMAQ	Community Multi-scale Air Quality
DAS	data acquisition system
DC	direct current
DEP	Department of Environmental Protection
deg	degree
DQO	data quality objectives
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
NADP	National Atmospheric Deposition Program
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NPAP	National Performance Audit Program
NPS	National Park Service
OAQPS	Office of Air Quality Planning and Standards
PE	Performance Evaluation
ppb	parts per billion
QA	quality assurance
QA/QC	quality assurance/quality control

QAPP	Quality Assurance Project Plan
RH	relative humidity
RTD	Resistance Temperature Detector
SJRWMD	Saint John's Water Management District
SOP	standard operating procedure
SRP	standard reference photometer
SSRF	Site Status Report Forms
TEI	Thermo Environmental Instruments
TTP	Through The Probe
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USNO	United States Naval Observatory
V	volts
VDC	volts direct current
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 using a continuous collection filter aggregated over a one week period and/or other forms of atmospheric pollution. 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.

Historically, CASTNET pollutant flux measurements have been reported as the aggregate product of weekly measured concentrations and model-estimated deposition velocities. The Multi-layer Model (MLM) was used to derive deposition velocity estimates from on-site meteorological parameters, land use types, and site characteristics. In 2011, EPA discontinued meteorological measurements at most EPA-sponsored CASTNET sites. Currently, average historical deposition velocities are used to estimate dry deposition fluxes (Bowker et al 2011). Deposition velocity estimations are currently being derived using the Community Multi-scale Air Quality (CMAQ) Model.

As of 2011, nearly all CASTNET ozone monitors adhere to the requirements of 40 CFR Part 58, and ozone concentration and quality assurance data are submitted to the Air Quality System (AQS) database. Currently 80 sites at 78 distinct locations measure ground-level ozone concentrations.

As of January 2017, the network is comprised of 95 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, Wyoming's Bureau of Land Management (BLM-WY), and several independent partners. AMEC Foster Wheeler is responsible for operating the EPA and Environment Canada sponsored sites, and Air Resource Specialists, Inc. (ARS) is responsible for operating the NPS and Bureau of Land Management (BLM) sponsored sites. All sites collect filter samples for flux estimates.

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 acceptance criteria have changed over the years and EEMS relies on the CASTNET contractor to provide updates to the acceptance criteria. The current criteria are included in Table 2-1.

Due to budgetary necessity, the meteorological measurements were shifted to operating on an as-funded basis. 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
Shelter Temperature			2 °C
Temperature	Accuracy	Comparison to 3 NIST measured baths (~ 0° C, ambient, ~ full-scale)	≤ ± 0.5° C

Sensor	Parameter	Audit Challenge	Acceptance Criteria
Delta Temperature	Accuracy	Comparison to temperature sensor at same test point	≤ ± 0.50° C
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	$0.9000 \le m \le 1.1000$
	Intercept		$-5.0 \text{ ppb} \le b \le 5.0 \text{ ppb}$
	Correlation Coefficient		$0.9950 \le r$
	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 2016

This report covers the CASTNET sites audited in 2016. Only those variables that were supported by the CASTNET program were audited. From February through December 2016, EEMS conducted field performance and systems audits at 37 monitoring sites. Meteorological sensors at two of the sites (FOR605 and BEL116) were also audited. The locations, sponsor agency and dates of the audits along with states and EPA Regions are presented in Table 3-1.

Table 3-1. Site Audits

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
IRL141	EPA/SJRWMD	Indian River Lagoon	FL / R4	2/15/2016
SUM156	EPA/USFS	Sumatra	FL / R4	3/1/2016
GAS153	EPA	Georgia Station	GA / R4	3/8/2016
SND152	EPA	Sand Mountain	AL / R4	3/9/2016
SPD111	EPA	Speedwell	TN / R4	3/12/2016
JOT403	NPS	Joshua Tree NM	CA / R9	3/29/2016
COW137	EPA/USFS	Coweeta	NC / R4	4/13/2016
ESP127	EPA	Edgar Evins St. Park	TN / R4	4/14/2016
CHA467	NPS	Chiricahua NM	AZ / R9	4/19/2016
GRC474	NPS	Grand Canyon NP	AZ / R9	4/20/2016
PET427	NPS	Petrified Forest NP	AZ / R9	4/21/2016
MEV405	NPS	Mesa Verde NP	CO / R8	5/31/2016
CAN407	NPS	Canyonlands NP	UT / R8	6/1/2016
GRB411	NPS	Great Basin NP	NV / R9	6/3/2016
FOR605	BLM/EPA	Fortification Creek	WY / R8	6/22/2016
DEN417	NPS	Denali NP	AK / R10	7/7/2016
SAL133	EPA	Salamonie Reservoir	IN / R5	7/19/2016
ANA115	EPA	Ann Arbor	MI / R5	8/15/2016
MKG113	EPA	M. K. Goddard St. Park	PA / R3	8/15/2016

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
UVL124	EPA	Unionville	MI / R5	8/16/2016
KEF112	EPA	Kane Experimental Forest	PA / R3	8/17/2016
HOX148	EPA	Hoxeyville	MI / R5	8/18/2016
PSU106	EPA	Penn State University	PA / R3	8/22/2016
RED004	EPA	Red Lake Nation	MN / R5	8/30/2016
WST109	EPA	Woodstock	NH / R1	9/15/2016
ABT147	EPA	Abington	CT / R1	9/17/2016
HWF187	EPA	Huntington Wildlife Forest	NY / R2	10/1/2016
ACA416	NPS/Maine DEP	Acadia NP	ME / R1	10/5/2016
HOW191	EPA	Howland AmeriFlux	ME / R1	10/10/2016
ASH135	EPA	Ashland	ME / R1	10/11/2016
CAT175	EPA	Claryville	NY / R2	10/14/2016
CTH110	EPA	Connecticut Hill	NY / R2	10/15/2016
ARE128	EPA	Arendtsville	PA / R3	10/16/2016
NPT006	EPA	Nez Perce	ID / R10	10/20/2016
DIN431	NPS	Dinosaur NM	UT / R8	10/25/2016
BEL116	EPA	Beltsville	MD / R3	11/14/2016
PNF126	EPA	Cranberry	NC / R4	11/26/2016

In addition to the sites listed in Table 3-1 that were visited for complete systems and performance audits, the 41 sites listed in Table 3-2 were visited to conduct NPAP Through-The-Probe (TTP) ozone Performance Evaluations (PE). Two sites (GRB411 and ARE128) were visited for both full systems and performance audits, and ozone PE audits.

Table 3-2. Site Ozone PE Visits

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
CAD150	EPA	Caddo Valley	AR / R6	2/19/2016
CVL151	EPA	Coffeeville	MS / R4	2/19/2016
ALC188	EPA	Alabama-Coushatta	TX / R6	3/5/2016
PAL190	EPA	Palo Duro	TX / R6	3/7/2016
BBE401	NPS	Big Bend NP	TX / R6	3/8/2016
MCK131	EPA	Mackville	KY / R4	3/11/2016
MCK231	EPA	Mackville (precision site)	KY / R4	3/11/2016
MAC426	NPS	Mammoth Cave NP	KY / R4	3/14/2016
CKT136	EPA	Crockett	KY / R4	3/29/2016
CDZ171	EPA	Cadiz	KY / R4	3/30/2016
CHE185	EPA	Cherokee Nation	OK / R6	4/1/2016
PIN414	NPS	Pinnacles NM	CA / R9	4/4/2016
DCP114	EPA	Deer Creek St. Park	OH / R5	4/16/2016
OXF122	EPA	Oxford	OH / R5	4/16/2016
QAK172	EPA	Quaker City	OH / R5	4/17/2016
PND165	EPA	Pinedale	WY / R8	6/17/2016
BAS601	EPA	Basin	WY / R8	6/21/2016
STK138	EPA	Stockton	IL / R5	7/20/2016
ALH157	EPA	Alhambra	IL / R5	7/21/2016
VIN140	EPA	Vincennes	IN / R5	7/22/2016
CNT169	EPA	Centennial	WY / R8	8/18/2016
LRL117	EPA	Laurel Hill St. Park	PA / R3	8/23/2016
NEC602	EPA	Newcastle	WY / R8	8/24/2016
VOY413	NPS	Voyageurs NP	MN / R5	8/29/2016
PRK134	EPA	Perkinstown	WI / R5	9/1/2016
SAN189	EPA	Santee Sioux	NE / R7	9/9/2016
GRB411	NPS	Great Basin NP	NV / R9	9/18/2016

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
BVL130	EPA	Bondville	IL / R5	9/24/2016
GLR468	NPS	Glacier NP	MT / R8	9/26/2016
CND125	EPA	Candor	NC / R4	10/17/2016
VPI120	EPA	Horton Station	VA / R3	10/17/2016
CDR119	EPA	Cedar Creek St. Park	WV / R3	10/18/2016
PAR107	EPA/USFS	Parsons	WV / R3	10/18/2016
ARE128	EPA	Arendtsville	PA / R3	10/19/2016
PED108	EPA	Prince Edward	VA / R3	10/21/2016
SHN418	NPS	Shenandoah NP - Big Meadows	VA / R3	10/21/2016
GRS420	NPS	Great Smoky Mountains NP	TN / R4	10/27/2016
WSP144	EPA	Washington Crossing St. Park	NJ / R2	11/7/2016
BWR139	EPA	Blackwater NWR	MD / R3	11/8/2016
YEL408	NPS	Yellowstone NP	WY / R8	11/8/2016
BFT142	EPA	Beaufort	NC / R4	11/10/2016

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 logger.

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 the ozone data, which will be discussed in more detail in the following 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 the Appendices of each 2016 Quarterly report. The variable specific data forms included in Appendix A of each quarter's report 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 for each site.

Table 4-1. Performance Audit Results by Variable Tested

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Ozone	75	2	1.3
Flow Rate	37	3	8.1
Shelter Temperature (average)	34	17	50
Wind Direction Orientation Average Error	2	1	50

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Orientation Maximum Error	2	1	50
Wind Direction Linearity Average Error	1	0	0.0
Linearity Maximum Error	1	0	0.0
Wind Direction Starting Torque	2	1	50
Wind Speed Low Range Average Error	2	0	0.0
Low Range Maximum Error	2	0	0.0
Wind Speed High Range Average Error	2	0	0.0
High Range Maximum Error	2	0	0.0
Wind Speed Starting Torque	2	0	0.0
Temperature	30	1	3.3
2 Meter Temperature	7	1	14
Relative Humidity	3	0	0.0
Solar Radiation	3	0	0.0
Precipitation	2	0	0.0
DAS Analog to Digital	32	0	0.0

4.1 Ozone

Seventy five ozone monitor audits were performed in 2016, with two monitors (GRB411 and ARE128) audited twice. All ozone challenges were conducted to comply with the OAQPS NPAP-TTP Standard Operating Procedures (SOP) which can be found at https://www3.epa.gov/ttn/amtic/npapsop.html. The results of the ozone audits were uploaded to the AQS database at the end of each quarter. 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 photometer that was verified as a level 2 standard by USEPA.

Two monitors tested failed the annual PE (GRB411 and ASH135). The ASH135 monitor had a known problem and was scheduled to be repaired soon after the audit. The GRB411 monitor was audited a second time approximately three months later and found to be within acceptance criteria. Results of all ozone audits performed are included in Table 4-2.

Table 4-2. Performance Audit Results for Ozone

	Ozone Average (% diff)	Ozone Maximum (% diff)	Ozone Slope	Ozone Intercept	Ozone Correlation
IRL141	-2.1	-4.6	1.00836	-1.47647	0.99997
CAD150	-3.2	-4.4	0.99138	-1.23118	0.99999
CVL151	-3.8	-4.9	0.97364	-0.61837	1
SUM156	-4.2	-5.5	0.97127	-0.54639	0.99993
ALC188	-2.7	-3.3	0.97778	-0.37153	0.99997
PAL190	-5.1	-5.9	0.95475	-0.34953	0.99996
BBE401	-4.6	-5.9	0.96345	-0.33495	0.99998
GAS153	-2.8	-3.5	0.97306	-0.03198	0.99999
SND152	-3.7	-4.3	0.97031	-0.34373	1
MCK131	-3.1	-5.1	0.98866	-0.87496	0.99997
MCK231	-3.9	-5.1	0.97274	-0.57623	1
SPD111	-3.1	-4.2	0.98108	-0.58564	0.99999
MAC426	-2.5	-2.8	0.97892	-0.1997	1
CKT136	-2.7	-3.2	0.97821	-0.23864	1
JOT403	-4.9	-5.3	0.95798	-0.39801	0.99999
CDZ171	-3.5	-4.8	0.97287	-0.32319	0.99999
CHE185	0.7	6.2	0.97361	1.6448	0.99973
PIN414	2.1	3.3	1.03331	-0.71228	0.9999
COW137	-1.0	-1.4	0.99229	0.03487	0.99998
ESP127	-1.3	-2.1	0.975	0.63082	0.99999
DCP114	-1.7	-2.1	0.97443	0.55974	0.99999

	Ozone Average (% diff)	Ozone Maximum (% diff)	Ozone Slope	Ozone Intercept	Ozone Correlation
OXF122	-1.4	-1.6	0.98772	-0.26958	0.99998
QAK172	-1.3	-2.1	0.96998	0.98659	1
CHA467	-4.8	-6.7	0.97534	-0.8701	0.9999
GRC474	-4.4	-5.7	0.96775	-0.55396	0.99999
PET427	-3.5	-3.8	0.97261	-0.41686	0.99999
MEV405	-3.4	-6.3	1.01172	-1.62584	0.99817
CAN407	-1.6	-2.6	0.99509	-0.50561	0.99997
GRB411	-9.7	-14.2	0.95038	-1.97991	0.99957
PND165	-4.3	-8.7	0.97932	-0.7121	0.9998
BAS601	-4.4	-5.4	0.95939	0.02332	0.99996
DEN417	4.7	6.1	1.06973	-1.0724	0.99999
SAL133	-0.7	-1.5	0.98516	0.28944	0.99998
STK138	-1.4	-2.4	0.97109	0.68618	0.99999
ALH157	-1.6	-2.5	0.97394	0.53928	0.99998
VIN140	-2.5	-4.4	0.98104	-0.18851	0.99996
ANA115	0.6	1.2	0.99502	0.55491	1
MKG113	-1.0	-2.0	1.00272	-0.79901	0.99998
UVL124	-1.1	-2.9	1	-0.57786	0.99996
KEF112	-1.3	-2.2	0.98447	0.27377	0.99995
CNT169	6.4	6.8	1.07153	-0.45958	0.99999
HOX148	-0.8	-0.9	0.98573	0.47845	0.99998
PSU106	-1.0	-1.2	0.98609	0.18438	1
LRL117	-1.2	-2.0	0.9773	0.56697	0.99998
NEC602	-1.7	-2.3	0.97977	0.1879	0.99995
VOY413	-1.1	-2.2	0.97748	0.57243	0.99994
PRK134	-4.2	-4.7	0.95671	-0.02669	0.99997
SAN189	-2.8	-4.0	0.99074	-0.92556	0.99994
WST109	0.1	0.3	0.99396	0.48937	0.99999
ABT147	-1.9	-2.3	0.97593	0.31758	0.99999
GRB411	-6.5	-8.7	0.94866	-0.61043	0.99996

	Ozone Average (% diff)	Ozone Maximum (% diff)	Ozone Slope	Ozone Intercept	Ozone Correlation
BVL130	-1.8	-2.5	0.99046	-0.34535	0.99999
GLR468	7.7	8.1	1.0788	-0.12526	0.99998
HWF187	-1.4	-1.8	0.98859	-0.21053	0.99999
ACA416	3.2	3.6	1.02779	0.30046	0.99999
HOW191	-3.0	-5.3	0.9895	-0.77461	0.99995
ASH135	-19.3	-23.2	0.84488	-1.88979	0.99996
CTH110	-2.7	-4.1	0.98214	-0.50545	0.99997
ARE128	-1.9	-3.3	0.99462	-0.67845	0.99999
CND125	-2.1	-2.3	0.98222	-0.21269	0.99999
VPI120	-1.7	-2.4	0.98939	-0.26083	0.99999
CDR119	-3.7	-4.7	0.97008	-0.20393	0.99996
PAR107	-1.5	-2.0	0.98764	-0.36289	0.99995
ARE128	-2.6	-3.8	0.9828	-0.27955	0.99998
NPT006	-3.2	-4.3	0.9830	-0.77941	0.99999
PED108	-1.3	-2.2	0.99524	-0.38233	1
SHN418	-0.7	-1.5	0.98889	0.10568	0.99993
DIN431	-1.4	-2.4	0.9929	-0.30017	1
GRS420	1.4	5.7	0.98817	0.69307	0.99999
WSP144	-3.8	-4.3	0.96686	-0.67538	0.99988
BWR139	-0.9	-1.5	0.99546	-0.32609	0.99998
YEL408	-0.2	0.2	0.9910	0.49905	0.99998
BFT142	-2.0	-2.4	0.98367	-0.03766	0.99998
BEL116	-5.1	-8.0	0.97281	-0.80589	0.99999
PNF126	3.3	5.3	1.0435	-0.27084	0.99971

4.1.1 Ozone Bias

Figure 4-1 presents the average percent difference of each site ozone PE for 2016. The results indicate that there may be a slight negative bias. This could be due to the correction factors used to correct the level 2 standard photometer when performing audits. EEMS follows the EPA ***Technical Assistance Document*** "**Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone**" ***October 2013*** which can be found at the AMTIC website:

https://www3.epa.gov/ttn/amtic/files/ambient/qaqc/OzoneTransferStandardGuidance.pdf. The document provides the rationale for standard photometer designation and the procedures required to ensure photometer stability. The process involves comparisons to a higher level standard (in this case a regional EPA level 1 standard) and also multiple comparisons on separate days, known as "6x6 verification". As described in the document, once the transfer standard comparison relationship with the level 1 standard has been established and the stability requirements are met, the actual ozone concentration is calculated by:

$$Std. O_3\ conc. = \frac{1}{\bar{m}}\ (Indicated\ O_3\ conc. - \bar{I})$$

Where:
$\bar{m}$ = average slope
$\bar{I}$ = average intercept

EEMS uses this equation with the running 6x6 average slope and intercept to correct level 2 standard photometer measurements back to the regional EPA level 1 standard reference photometer (SRP).

Since the technical assistance document also states that if any adjustments are made to the transfer standard a new 6x6 verification is required, EEMS does not adjust the physical settings (background and span) of the level 2 standards unless the photometer does not meet the criteria (+/- 3 %) comparison to the level 1 standard. This procedure could be introducing a bias to the standard since the level 2 standards are only compared to the level 1 SRP two or three times per year. The running 6x6 slope and intercept averages may not reflect the current relationship between the level 2 and the level 1 standards.

To further investigate this hypothesis EEMS began correcting the level 2 standard photometer using the most recent verification results rather than the running 6x6 results starting in 2017. Preliminary data are presented in Figure 4-2 which shows the average percent differences of the ozone PE audits performed to date in 2017. The data appear to indicate little if any bias.

Figure 4-1. 2016 Ozone PE Average % Difference

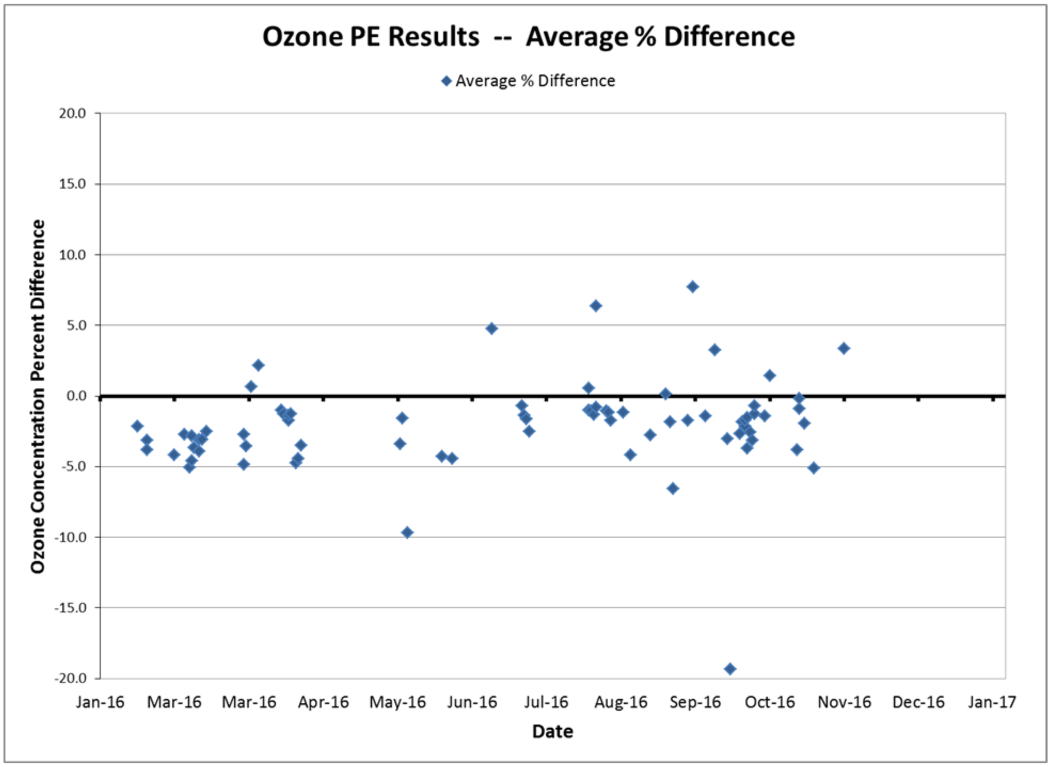
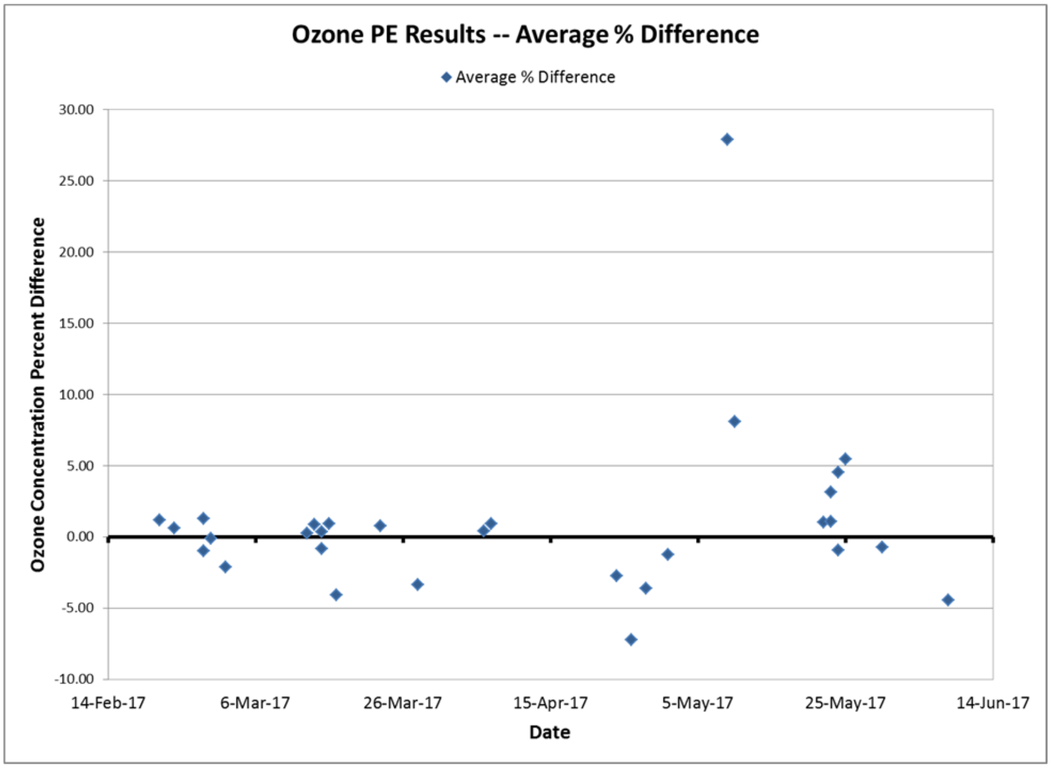


Figure 4-2. 2017 Ozone PE Average % Difference



4.2 Flow Rate

The dry deposition filter pack sampling system flow rates at 37 sites were audited. A NIST-traceable dry-piston primary flow rate device was used for the tests. Two sites were outside the acceptance criterion of ± 5.0%.

4.3 Shelter Temperature

At each site reporting ozone concentrations to AQS, the hourly average shelter temperature must be between 20 and 30 degrees C, or the hourly ozone data may be invalidated. Shelter temperature was audited at 34 of the sites visited. 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 Resistance 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 on and off. 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 2 degree C acceptance criterion. This criterion better follows the EPA OAQPS guidelines.

The results are summarized in Table 4-3. Flow rate and shelter temperature data are reported only for the sites that were visited for complete systems and performance audits.

Table 4-3. Performance Audit Results Shelter Temperature, and Flow Rate

	Shelter Temp. Average Error (C)	Shelter Temp. Maximum Error (C)	STP Flow Observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
IRL141	2.2	2.8	1.48	1.51	1.99
SUM156	-0.2	-0.7	1.48	1.50	1.33
GAS153	1.0	1.8	1.45	1.50	3.11

	Shelter Temp. Average Error (C)	Shelter Temp. Maximum Error (C)	STP Flow Observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
SND152	0.2	1.6	1.48	1.51	1.77
SPD111	-0.6	-1.2	1.48	1.50	1.33
JOT403	-3.9	-5.3	3.00	3.00	-0.11
COW137	-1.3	-2.1	1.48	1.50	1.55
ESP127	3.0	4.5	1.63	1.51	-7.95
CHA467	2.6	5.3	2.98	3.00	0.67
GRC474	2.8	3.2	2.96	2.99	1.00
PET427	1.0	2.6	3.00	3.03	1.10
MEV405	-0.9	-1.7	3.23	3.00	-7.67
CAN407	3.5	4.2	2.95	3.02	2.32
GRB411	2.7	3.3	3.01	3.00	-0.33
FOR605			3.28	3.37	2.87
DEN417	6.4	14.1	2.98	3.00	0.67
SAL133	1.7	3.1	1.53	1.50	-1.78
ANA115	1.8	4.4	1.49	1.50	0.44
MKG113	-0.1	-0.5	1.50	1.50	0.22
UVL124	2.2	2.3	1.50	1.50	0.00
KEF112	0.8	3.2	1.52	1.50	-1.56
HOX148	2.2	3.8	1.50	1.50	0.00
PSU106	1.4	2.1	1.51	1.50	-0.67
RED004			3.01	3.01	0.00
WST109	0.3	4.1	1.47	1.50	1.78
ABT147	0.1	-1.5	1.51	1.50	-0.44
HWF187	1.3	3.4	1.48	1.50	1.11
ACA416	-2.2	-4.2	1.50	1.38	-8.70
HOW191	2.8	4.5	1.49	1.50	0.67
ASH135	3.6	3.7	1.48	1.50	1.33
CAT175			1.49	1.51	1.11
CTH110	0.1	0.8	1.48	1.50	1.33
ARE128	5.4	6.8	1.52	1.50	-0.89

	Shelter Temp. Average Error (C)	Shelter Temp. Maximum Error (C)	STP Flow Observed (lpm)	Flow DAS (lpm)	Flow Error (% diff)
NPT006	1.1	2.7	3.02	3.00	-0.67
DIN431	3.7	8.9	2.98	3.01	0.89
BEL116	3.9	10.9	1.50	1.50	-0.22
PNF126	-3.8	-4.8	1.52	1.50	-1.33

4.4 Wind Speed

The wind speed sensors at two sites equipped for meteorological measurements were audited. Wind speed data accuracy results at 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 were 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. Both systems 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.
- An 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 both sensors tested, one site was outside the acceptance criterion of ± 5 degrees. 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 were 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. One of the sensors tested was outside of acceptance limits for wind direction starting threshold. The test results are provided in Table 4-4.

Table 4-4. 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)	
BEL116	2.0	3.0	1.5	4.0	22.5	0.05	0.180	0.001	0.002	0.35
FOR605	12.5	13.0			0.5	0.09	0.310	0.008	0.019	0.45

* 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.

4.6 Temperature and Two-Meter Temperature

The EPA sponsored site temperature measurement systems consist of a temperature sensor mounted at approximately 9 meters above ground-level on a tower. One site (BEL116) also utilized a second sensor to measure temperature at approximately two meters from the ground (2-meter temperature). Sites operated by the Park Service have recently moved the temperature sensors to two meters from the ground (2 meter temperature).

Temperature sensors utilized by the BLM are not the same type as those at other CASTNET sites. The BLM temperature sensors are combined relative humidity and temperature sensors and not standalone RTD or encased thermistor temperature sensors. Due to the design of the RH/Temperature sensor, it cannot be submerged in water baths in order to challenge the sensor at different temperature audit levels. For that reason the combination RH/Temperature sensors were audited by placing the sensor in a watertight chamber (RH salt chamber) and then placing the chamber in an ice-water bath, ambient bath, and hot water bath. Therefore the audit results are not directly comparable to audit results of RTD or encased thermistor sensors.

All sites use shields to house the sensors that are either mechanically aspirated with forced air, or naturally aspirated. 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 but one (ABT147) of the 29 sensors (10-meter) tested were within the acceptance criterion.

Only seven 2-meter temperature sensors were tested, with one (FOR605) above acceptance criterion. It should be noted that FOR605 is sponsored by the BLM and operates a combination RH/Temperature sensor as described above. The average errors for all sensors are presented in Table 4-5.

4.6.1 Temperature Shield Blower Motors

All of the temperature sensor shield blower motors encountered during the site audits conducted during 2016 were found to be functioning. All 2-meter temperature sensor shield blowers were functioning properly.

4.7 Relative Humidity

The three relative humidity systems that were audited 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 measurement range of approximately 30% to 95% are presented in Table 4-5.

As in previous years, operation of humidity sensors with respect to natural or forced-air aspiration can vary between sites. At most EPA sponsored sites humidity sensors are operating in naturally aspirated shields. At most NPS sponsored sites 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 the different shield configurations.

All sensors tested were within the acceptance criterion. The results of the tests are included in Table 4-5.

Table 4-5. Performance Audit Results for Temperature and Relative Humidity

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Relative Humidity Range 0 – 100%	
			Ave. Error	Max. Error
IRL141	0.19			
SUM156	0.00			
GAS153	0.12			
SND152	0.11			
SPD111	0.06			
COW137	0.02			
ESP127	-0.20			
CHA467	0.04			
GRC474	0.09			
PET427	-0.22			
MEV405		0.31		
CAN407		-0.03		
GRB411		0.07		
FOR605		1.28	0.82	1.30
DEN417		-0.09		
SAL133	0.06			
ANA115	0.08			
MKG113	0.01			
UVL124	-0.06			
KEF112	-0.04			

Site	Temperature Ave. Error (deg C)	2 Meter Temperature Ave. Error (deg C)	Relative Humidity Range 0 – 100%	
			Ave. Error	Max. Error
HOX148	0.12			
PSU106	0.28			
RED004	-0.03			
WST109	0.12			
ABT147	-0.81			
HWF187	-0.08			
ACA416		-0.03	-1.83	-6.40
HOW191	-0.02			
ASH135	0.02			
CAT175	0.05			
CTH110	0.11			
ARE128	-0.05			
NPT006	-0.34			
DIN431	-0.05			
BEL116	0.03	0.19	1.00	3.30
PNF126	0.23			

4.8 Solar Radiation

The ambient conditions encountered during the audit visits were suitable (high enough light levels) for accurate comparisons of solar radiation measurements. A World Radiation Reference (WRR) traceable Eppley PSP radiometer and translator were used as the audit standard system.

Three sites were tested. All sites had daytime average results that were within the acceptance criterion. The results of the individual tests for each site are included in Table 4-6. The percent difference of the maximum single-hour average solar radiation value observed during each site audit is also reported in Table 4-6 although this criterion is not part of the CASTNET data quality indicators. Those values greater than ±10% are bold.

4.9 Precipitation

The two 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 results are summarized in Tables 4-6.

The FOR605 site is solar powered and the tipping bucket is not heated. The tipping bucket heater was found to be functioning properly at the BEL116 site.

Table 4-6. Performance Audit Results for Solar Radiation and Precipitation

	Site	Solar Radiation Error				Precipitation Ave. Error (% diff)
		Daytime Ave. (% diff)	Std. Max. Value (w/m2)	Site Max. Observed (w/m2)	Max. Value (% diff)	
10/5/2016	ACA416	-8.55	662	602	-9.46	
11/14/2016	BEL116	8.53	531	573	9.0	4
6/22/2016	FOR605	0.14	948	951	0.4	1.9

4.10 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 table 4-7 include the tests performed on the primary logger at each site.

4.10.1 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 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.

4.10.2 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 4-7. 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		
2/15/2016	IRL141	0.0001	0.0001			Y	0.00
3/1/2016	SUM156	0.0003	0.0006			Y	0.00
3/8/2016	GAS153	0.0003	0.0007			Y	0.02
3/9/2016	SND152	0.0003	0.0005			Y	0.47
3/12/2016	SPD111	0.0003	0.0005			Y	0.05
3/29/2016	JOT403	0.0002	0.0004			Y	0.00
4/13/2016	COW137	0.0003	0.0004			Y	0.65
4/14/2016	ESP127	0.0003	0.0005			Y	0.68
4/19/2016	CHA467			0.0004	0.0010	Y	2.17
4/20/2016	GRC474			0.0003	0.0005	Y	0.18
4/21/2016	PET427			0.0007	0.0011	Y	2.12
5/31/2016	MEV405	0.0003	0.0007			Y	3.00
6/1/2016	CAN407			0.0002	0.0006	Y	0.33
6/3/2016	GRB411					Y	0.00
6/22/2016	FOR605	0.0000	0.0000			Y	1.68
7/7/2016	DEN417	0.0004	0.0006			Y	0.00
7/19/2016	SAL133	0.0003	0.0004			Y	0.00
8/15/2016	ANA115	0.0001	0.0002			Y	0.00
8/15/2016	MKG113	0.0003	0.0004			Y	0.00
8/16/2016	UVL124	0.0001	0.0001			Y	0.02
8/17/2016	KEF112	0.0003	0.0006			Y	0.07
8/18/2016	HOX148	0.0000	0.0000			Y	0.03
8/22/2016	PSU106	0.0003	0.0005			Y	0.08
8/30/2016	RED004					Y	0.00
9/15/2016	WST109	0.0004	0.0007			Y	0.00

	Site	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
		Low Channel		High Channel			
		Average	Maximum	Average	Maximum		
9/17/2016	ABT147	0.0003	0.0005			Y	0.00
10/1/2016	HWF187	0.0000	0.0000			Y	0.33
10/5/2016	ACA416					Y	0.00
10/10/2016	HOW191					Y	0.22
10/11/2016	ASH135	0.0000	0.0001			Y	0.08
10/14/2016	CAT175	0.0001	0.0002			Y	0.08
10/15/2016	CTH110	0.0000	0.0000			Y	0.20
10/16/2016	ARE128	0.0001	0.0002			Y	0.08
10/25/2016	DIN431			0.0003	0.0007	Y	2.00
11/14/2016	BEL116	0.0001	0.0001			Y	0.00
11/26/2016	PNF126	0.0000	0.0001			Y	0.00

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. None of those changes were determined to have a significant impact on the siting criteria that did not exist when the site was initially established.

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, all but one site (LAV410) visited in 2016 have ozone monitor sample trains that are sited properly and in accordance with the CASTNET QAPP. All ozone sample inlets are currently being evaluated with respect to obstructions above the inlet. The acceptance criterion requires that there should be no obstructions (including trees) within a 22.5 degree angle (object distance must be at least two times the height) above the ozone inlet. There are trees that violate the 22.5 degree sample inlet requirement at the LAV410 site.

Ozone sample inlets are between 3 and 15 meters. With the exception of one site (WNC429) Teflon tubing of the proper diameter is used for the ozone inlets. The ozone sample train at WNC429 is primarily glass with an exhaust fan downstream of the ozone sample port. The ozone analyzer at WNC429 (South Dakota) is operated by the State.

With the exception of WNC429, 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 are comprised of only Teflon fittings and materials. Sample inlet particulate filters of 5 micron are present at most sites.

The dry deposition filter packs are designed to sample from 10 meters. Most of the filter pack sample lines are also Teflon. Inline filters are present in the sample trains to prevent moisture and particulates from damaging the flow rate controller.

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 and replacement of degrading signal cables, has been very beneficial to the network. 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.

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.

5.5 Documentation

There were some documentation problems with 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.

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, however the reports available on-site are not up to date.

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. 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 is an important variable. 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 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. A portable system of meteorological sensors would be beneficial for meteorological measurement evaluations particularly at BLM sponsored sites.

7.0 References

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

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Bowker, G.E., Schwede, D.B.; Lear, G.G.; Warren-Hicks, W.J., and Finkelstein, P.L., 2011. Quality assurance decisions with air models: a case study of imputation of missing input data using EPA's multi-layer model. Water, Air, and Soil Pollution 222, 391e402.

APPENDIX 1

Audit Standards Certifications

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cells

	Date	**1/20/2016**
m_1	1/20/2016	0.996283
m_2	1/19/2016	0.99735
m_3	1/18/2016	0.99700
m_4	9/21/2015	1.01937
m_5	1/7/2015	1.01820
m_6	1/8/2014	1.00420
I_1	1/20/2016	-0.201849
I_2	1/19/2016	-0.46253
I_3	1/18/2016	-0.21412
I_4	9/21/2015	0.02326
I_5	1/7/2015	-0.41020
I_6	1/8/2014	0.35220
Average m	1/20/2016	1.00540
Avarage I	1/20/2016	-0.15221
$s_{m\,(\%)}$	1/20/2016	1.07
$s_{I\,(ppb)}$	1/20/2016	0.3
Test s_m	1/20/2016	PASS
Test s_I	1/20/2016	PASS

EEMS # 01110
At EEMS s/n: 49CPS 70008-364
1/20/2016
BKG = 0.0
COEF = 1.018

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cells

	Date	**1/21/2016**
m_1	1/21/2016	0.995048
m_2	1/20/2016	0.99628
m_3	1/19/2016	0.99735
m_4	1/18/2016	0.99700
m_5	9/21/2015	1.01937
m_6	1/7/2015	1.01820
I_1	1/21/2016	-0.212226
I_2	1/20/2016	-0.20185
I_3	1/19/2016	-0.46253
I_4	1/18/2016	-0.21412
I_5	9/21/2015	0.02326
I_6	1/7/2015	-0.41020
Average m	1/21/2016	1.00387
Avarage I	1/21/2016	-0.24628
$s_{m\,(\%)}$	1/21/2016	1.15
$s_{I\,(ppb)}$	1/21/2016	0.2
Test s_m	1/21/2016	PASS
Test s_I	1/21/2016	PASS

EEMS # 01110
At EEMS s/n: 49CPS 70008-364
1/21/2016
BKG = 0.0
COEF = 1.018

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cells

	Date	**1/22/2016**
m_1	1/22/2016	0.996080
m_2	1/21/2016	0.99505
m_3	1/20/2016	0.99628
m_4	1/19/2016	0.99735
m_5	1/18/2016	0.99700
m_6	9/21/2015	1.01937
I_1	1/22/2016	-0.281123
I_2	1/21/2016	-0.21223
I_3	1/20/2016	-0.20185
I_4	1/19/2016	-0.46253
I_5	1/18/2016	-0.21412
I_6	9/21/2015	0.02326
Average m	1/22/2016	1.00019
Avarage I	1/22/2016	-0.22477
$s_{m\,(\%)}$	1/22/2016	0.94
$s_{I\,(ppb)}$	1/22/2016	0.2
Test s_m	1/22/2016	PASS
Test s_I	1/22/2016	PASS

EEMS # 01110
At EEMS s/n: 49CPS 70008-364
1/22/2016
BKG = 0.0
COEF = 1.018

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cells

	Date	**1/23/2016**
m_1	1/23/2016	0.998330
m_2	1/22/2016	0.99608
m_3	1/21/2016	0.99505
m_4	1/20/2016	0.99628
m_5	1/19/2016	0.99735
m_6	1/18/2016	0.99700
I_1	1/23/2016	-0.334816
I_2	1/22/2016	-0.28112
I_3	1/21/2016	-0.21223
I_4	1/20/2016	-0.20185
I_5	1/19/2016	-0.46253
I_6	1/18/2016	-0.21412
Average m	1/23/2016	0.99668
Avarage I	1/23/2016	-0.28444
$s_{m\,(\%)}$	1/23/2016	0.11
$s_{I\,(ppb)}$	1/23/2016	0.1
Test s_m	1/23/2016	PASS
Test s_I	1/23/2016	PASS

EEMS # 01110
At EEMS s/n: 49CPS 70008-364
1/23/2016 6-day
BKG = 0.0
COEF = 1.018

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cells

	Date	**1/29/2016**
m_1	1/29/2016	1.00680
m_2	1/23/2016	0.99833
m_3	1/22/2016	0.99608
m_4	1/21/2016	0.99505
m_5	1/20/2016	0.99628
m_6	1/19/2016	0.99735
I_1	1/29/2016	-0.09460
I_2	1/23/2016	-0.33482
I_3	1/22/2016	-0.28112
I_4	1/21/2016	-0.21223
I_5	1/20/2016	-0.20185
I_6	1/19/2016	-0.46253
Average m	1/29/2016	0.99832
Avarage I	1/29/2016	-0.26452
$s_{m\,(\%)}$	1/29/2016	0.43
$s_{I\,(ppb)}$	1/29/2016	0.1
Test s_m	1/29/2016	PASS
Test s_I	1/29/2016	PASS

EEMS # 01110
At EPA R-4 s/n: 49CPS 70008-364
1/29/2016 Verification
BKG = 0.0
COEF = 1.018

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cells

	Date	**9/12/2016**
m_1	9/12/2016	1.00466
m_2	1/29/2016	1.00680
m_3	1/23/2016	0.99833
m_4	1/22/2016	0.99608
m_5	1/21/2016	0.99505
m_6	1/20/2016	0.99628
I_1	9/12/2016	0.01298
I_2	1/29/2016	-0.09460
I_3	1/23/2016	-0.33482
I_4	1/22/2016	-0.28112
I_5	1/21/2016	-0.21223
I_6	1/20/2016	-0.20185
Average m	9/12/2016	0.99953
Avarage I	9/12/2016	-0.18527
$s_{m\,(\%)}$	9/12/2016	0.50
$s_{I\,(ppb)}$	9/12/2016	0.1
Test s_m	9/12/2016	PASS
Test s_I	9/12/2016	PASS

EEMS # 01110
At EPA R-7 s/n: 49CPS 70008-364
9/12/2016 Verification
BKG = 0.0
COEF = 1.018

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cell:

	Date	**1/21/2016**
	S/N=	**0517112175**
m_1	1/21/2016	0.991499
m_2	1/20/2016	0.99565
m_3	1/19/2016	0.99975
m_4	1/18/2016	0.99722
m_5	1/7/2015	1.01540
m_6	1/3/2015	0.99307
I_1	1/21/2016	-0.844393
I_2	1/20/2016	-0.23545
I_3	1/19/2016	-0.73832
I_4	1/18/2016	-0.43380
I_5	1/7/2015	-0.09100
I_6	1/3/2015	0.13058
Average m	1/21/2016	0.99876
Avarage I	1/21/2016	-0.36873
$s_{m\,(\%)}$	1/21/2016	0.87
$s_{I\,(ppb)}$	1/21/2016	0.4
Test s_m	1/21/2016	PASS
Test s_I	1/21/2016	PASS

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cell:

	Date	**1/22/2016**
	S/N=	**0517112175**
m_1	1/22/2016	0.993072
m_2	1/21/2016	0.99150
m_3	1/20/2016	0.99565
m_4	1/19/2016	0.99975
m_5	1/18/2016	0.99722
m_6	1/7/2015	1.01540
I_1	1/22/2016	-0.398185
I_2	1/21/2016	-0.84439
I_3	1/20/2016	-0.23545
I_4	1/19/2016	-0.73832
I_5	1/18/2016	-0.43380
I_6	1/7/2015	-0.09100
Average m	1/22/2016	0.99876
Avarage I	1/22/2016	-0.45686
$s_{m\,(\%)}$	1/22/2016	0.87
$s_{I\,(ppb)}$	1/22/2016	0.3
Test s_m	1/22/2016	PASS
Test s_I	1/22/2016	PASS

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cell:

	Date	**1/23/2016**
	S/N=	**0517112175**
m_1	1/23/2016	0.994291
m_2	1/22/2016	0.99307
m_3	1/21/2016	0.99150
m_4	1/20/2016	0.99565
m_5	1/19/2016	0.99975
m_6	1/18/2016	0.99722
I_1	1/23/2016	-0.686363
I_2	1/22/2016	-0.39819
I_3	1/21/2016	-0.84439
I_4	1/20/2016	-0.23545
I_5	1/19/2016	-0.73832
I_6	1/18/2016	-0.43380
Average m	1/23/2016	0.99525
Avarage I	1/23/2016	-0.55609
$s_{m\,(\%)}$	1/23/2016	0.30
$s_{I\,(ppb)}$	1/23/2016	0.2
Test s_m	1/23/2016	PASS
Test s_I	1/23/2016	PASS

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cell:

	Date	**1/29/2016**
	S/N	**0517112175**
m_1	1/29/2016	1.00100
m_2	1/23/2016	0.99429
m_3	1/22/2016	0.99307
m_4	1/21/2016	0.99150
m_5	1/20/2016	0.99565
m_6	1/19/2016	0.99975
I_1	1/29/2016	0.25770
I_2	1/23/2016	-0.68636
I_3	1/22/2016	-0.39819
I_4	1/21/2016	-0.84439
I_5	1/20/2016	-0.23545
I_6	1/19/2016	-0.73832
Average m	1/29/2016	0.99588
Avarage I	1/29/2016	-0.44084
$s_{m\,(\%)}$	1/29/2016	0.38
$s_{I\,(ppb)}$	1/29/2016	0.4
Test s_m	1/29/2016	PASS
Test s_I	1/29/2016	PASS

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cell:

	Date	**2/8/2017**
	S/N	**0517112175**
m_1	2/8/2017	1.008785
m_2	1/29/2016	1.00100
m_3	1/23/2016	0.99429
m_4	1/22/2016	0.99307
m_5	1/21/2016	0.99150
m_6	1/20/2016	0.99565
I_1	2/8/2017	0.363823
I_2	1/29/2016	0.25770
I_3	1/23/2016	-0.68636
I_4	1/22/2016	-0.39819
I_5	1/21/2016	-0.84439
I_6	1/20/2016	-0.23545
Average m	2/8/2017	0.99738
Avarage I	2/8/2017	-0.25715
$s_{m\,(\%)}$	2/8/2017	0.65
$s_{I\,(ppb)}$	2/8/2017	0.5
Test s_m	2/8/2017	PASS
Test s_I	2/8/2017	PASS

Enter date in yellow highlighted cell next to "Date". Place cursor next to m_1 and type ctrl+a.
Enter new slope and intercept in yellow highlighted cell:

	Date	**3/21/2017**
	S/N=	**0517112175**
m_1	3/21/2017	1.002500
m_2	2/8/2017	1.00879
m_3	1/29/2016	1.00100
m_4	1/23/2016	0.99429
m_5	1/22/2016	0.99307
m_6	1/21/2016	0.99150
I_1	3/21/2017	0.458700
I_2	2/8/2017	0.36382
I_3	1/29/2016	0.25770
I_4	1/23/2016	-0.68636
I_5	1/22/2016	-0.39819
I_6	1/21/2016	-0.84439
Average m	3/21/2017	0.99852
Avarage I	3/21/2017	-0.14145
$s_{m\,(\%)}$	3/21/2017	0.67
$s_{I\,(ppb)}$	3/21/2017	0.6
Test s_m	3/21/2017	PASS
Test s_I	3/21/2017	PASS

$$\left[\sum_{i=1}^{6} (m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i \right)^2 \right]$$

$$\left[\sum_{i=1}^{6} (I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i \right)^2 \right]$$

$$S_m = \frac{100}{\bar{m}} \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6} (m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i \right)^2 \right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6} (I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i \right)^2 \right]}$$

$$S_m = \frac{100}{\bar{m}} \sqrt{\ldots}$$

$$S_I = \sqrt{\frac{1}{5}\ldots}$$

EEMS 01111
6-day calibration
At EEMS **1/21/2016**
BKG = -0.6
COEF = 1.020

EEMS 01111
6-day calibration
At EEMS **1/22/2016**
BKG = -0.6
COEF = 1.020

EEMS 01111
6-day calibration
At EEMS **1/23/2016**
BKG = -0.6
COEF = 1.020

EEMS 01111
Verification
At EPA R-4 **1/29/2016**
BKG = -0.6
COEF = 1.020

EEMS 01111
Verification
At EEMS **2/8/2017**
BKG = -0.6
COEF = 1.020

EEMS 01111
6-day calibration
At EPA R4 **3/21/2017**
BKG = -0.6
COEF = 1.020

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	3/4/2015
m_1	3/4/2015	0.992773
m_2	3/3/2015	0.99785
m_3	1/7/2015	1.02480
m_4	1/8/2014	1.01870
m_5	1/4/2014	1.00565
m_6	1/3/2014	1.00489
I_1	3/4/2015	-0.445048
I_2	3/3/2015	-0.29464
I_3	1/7/2015	0.57470
I_4	1/8/2014	0.40360
I_5	1/4/2014	0.39663
I_6	1/3/2014	0.12097
Average m	3/4/2015	1.00744
Avarage I	3/4/2015	0.12603
$s_{m\,(\%)}$	3/4/2015	1.21
$s_{I\,(ppb)}$	3/4/2015	0.4
Test s_m	3/4/2015	PASS
Test s_I	3/4/2015	PASS

EEMS # 01112

At EEMS

offset = -0.2

span = 1.017

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	3/5/2015
m_1	3/5/2015	0.99532
m_2	3/4/2015	0.99277
m_3	3/3/2015	0.99785
m_4	1/7/2015	1.02480
m_5	1/8/2014	1.01870
m_6	1/4/2014	1.00565
I_1	3/5/2015	-0.49499
I_2	3/4/2015	-0.44505
I_3	3/3/2015	-0.29464
I_4	1/7/2015	0.57470
I_5	1/8/2014	0.40360
I_6	1/4/2014	0.39663
Average m	3/5/2015	1.00585
Avarage I	3/5/2015	0.02337
$s_{m\,(\%)}$	3/5/2015	1.31
$s_{I\,(ppb)}$	3/5/2015	0.5
Test s_m	3/5/2015	PASS
Test s_I	3/5/2015	PASS

EEMS # 01112

At EEMS

offset = -0.2

span = 1.017

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	3/7/2015
m_1	3/7/2015	0.99124
m_2	3/5/2015	0.99532
m_3	3/4/2015	0.99277
m_4	3/3/2015	0.99785
m_5	1/7/2015	1.02480
m_6	1/8/2014	1.01870
I_1	3/7/2015	-0.46416
I_2	3/5/2015	-0.49499
I_3	3/4/2015	-0.44505
I_4	3/3/2015	-0.29464
I_5	1/7/2015	0.57470
I_6	1/8/2014	0.40360
Average m	3/7/2015	1.00345
Avarage I	3/7/2015	-0.12009
$s_{m\,(\%)}$	3/7/2015	1.44
$s_{I\,(ppb)}$	3/7/2015	0.5
Test s_m	3/7/2015	PASS
Test s_I	3/7/2015	PASS

EEMS # 01112

At EEMS

offset = -0.2

span = 1.017

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	3/8/2015
m_1	3/8/2015	0.99208
m_2	3/7/2015	0.99124
m_3	3/5/2015	0.99532
m_4	3/4/2015	0.99277
m_5	3/3/2015	0.99785
m_6	1/7/2015	1.02480
I_1	3/8/2015	-0.33284
I_2	3/7/2015	-0.46416
I_3	3/5/2015	-0.49499
I_4	3/4/2015	-0.44505
I_5	3/3/2015	-0.29464
I_6	1/7/2015	0.57470
Average m	3/8/2015	0.99901
Avarage I	3/8/2015	-0.24283
$s_{m\,(\%)}$	3/8/2015	1.29
$s_{I\,(ppb)}$	3/8/2015	0.4
Test s_m	3/8/2015	PASS
Test s_I	3/8/2015	PASS

EEMS # 01112

At EEMS

offset = -0.2

span = 1.017

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	3/9/2015
m_1	3/9/2015	0.99502
m_2	3/8/2015	0.99208
m_3	3/7/2015	0.99124
m_4	3/5/2015	0.99532
m_5	3/4/2015	0.99277
m_6	3/3/2015	0.99785
I_1	3/9/2015	-0.53651
I_2	3/8/2015	-0.33284
I_3	3/7/2015	-0.46416
I_4	3/5/2015	-0.49499
I_5	3/4/2015	-0.44505
I_6	3/3/2015	-0.29464
Average m	3/9/2015	0.99405
Avarage I	3/9/2015	-0.42803
$s_{m\,(\%)}$	3/9/2015	0.25
$s_{I\,(ppb)}$	3/9/2015	0.1
Test s_m	3/9/2015	PASS
Test s_I	3/9/2015	PASS

EEMS # 01112

At EEMS

offset = -0.2

span = 1.017

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	6/25/2015
m_1	6/25/2015	0.99659
m_2	3/9/2015	0.99502
m_3	3/8/2015	0.99208
m_4	3/7/2015	0.99124
m_5	3/5/2015	0.99532
m_6	3/4/2015	0.99277
I_1	6/25/2015	-0.18324
I_2	3/9/2015	-0.53651
I_3	3/8/2015	-0.33284
I_4	3/7/2015	-0.46416
I_5	3/5/2015	-0.49499
I_6	3/4/2015	-0.44505
Average m	6/25/2015	0.99384
Avarage I	6/25/2015	-0.40946
$s_{m\,(\%)}$	6/25/2015	0.21
$s_{I\,(ppb)}$	6/25/2015	0.1
Test s_m	6/25/2015	PASS
Test s_I	6/25/2015	PASS

EEMS # 01112

At EPA R-7

Verification

offset = -0.2

span = 1.017

S/N = 0419606966

Enter new slope and intercept in yellow highlighted cells

	Date	1/28/2016
m_1	1/28/2016	1.00120
m_2	6/25/2015	0.99659
m_3	3/9/2015	0.99502
m_4	3/8/2015	0.99208
m_5	3/7/2015	0.99124
m_6	3/5/2015	0.99532
I_1	1/28/2016	0.02750
I_2	6/25/2015	-0.18324
I_3	3/9/2015	-0.53651
I_4	3/8/2015	-0.33284
I_5	3/7/2015	-0.46416
I_6	3/5/2015	-0.49499
Average m	1/28/2016	0.99524
Avarage I	1/28/2016	-0.33070
$s_{m\,(\%)}$	1/28/2016	0.36
$s_{I\,(ppb)}$	1/28/2016	0.2
Test s_m	1/28/2016	PASS
Test s_I	1/28/2016	PASS

EEMS # 01112

At EPA R-4

Verification

offset = -0.2

span = 1.017

$$\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]$$

$$\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]}$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\right.}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\right.}$$

Enter date in yellow highlighted cell next to "Date".

S/N = 0517112167

Enter new slope and intercept in yellow highlighted cells

	Date	**1/21/2016**
m_1	1/21/2016	0.996503
m_2	1/20/2016	0.99993
m_3	1/19/2016	1.00076
m_4	1/18/2016	0.99819
m_5	9/21/2015	1.02307
m_6	4/29/2015	1.02260
I_1	1/21/2016	-0.323250
I_2	1/20/2016	-0.41890
I_3	1/19/2016	-0.49351
I_4	1/18/2016	-0.27641
I_5	9/21/2015	-0.26399
I_6	4/29/2015	-0.20400
Average m	1/21/2016	1.00684
Avarage I	1/21/2016	-0.33001
$S_{m\,(\%)}$	1/21/2016	1.24
$S_{I\,(ppb)}$	1/21/2016	0.1
Test S_m	1/21/2016	PASS
Test S_I	1/21/2016	PASS

Enter date in yellow highlighted cell next to "Date".

S/N = 0517112167

Enter new slope and intercept in yellow highlighted cells

	Date	**1/22/2016**
m_1	1/22/2016	0.998195
m_2	1/21/2016	0.99650
m_3	1/20/2016	0.99993
m_4	1/19/2016	1.00076
m_5	1/18/2016	0.99819
m_6	9/21/2015	1.02307
I_1	1/22/2016	-0.384025
I_2	1/21/2016	-0.32325
I_3	1/20/2016	-0.41890
I_4	1/19/2016	-0.49351
I_5	1/18/2016	-0.27641
I_6	9/21/2015	-0.26399
Average m	1/22/2016	1.00278
Avarage I	1/22/2016	-0.36001
$S_{m\,(\%)}$	1/22/2016	1.00
$S_{I\,(ppb)}$	1/22/2016	0.1
Test S_m	1/22/2016	PASS
Test S_I	1/22/2016	PASS

Enter date in yellow highlighted cell next to "Date".

S/N = 0517112167

Enter new slope and intercept in yellow highlighted cells

	Date	**1/23/2016**
m_1	1/23/2016	0.999917
m_2	1/22/2016	0.99820
m_3	1/21/2016	0.99650
m_4	1/20/2016	0.99993
m_5	1/19/2016	1.00076
m_6	1/18/2016	0.99819
I_1	1/23/2016	-0.335463
I_2	1/22/2016	-0.38403
I_3	1/21/2016	-0.32325
I_4	1/20/2016	-0.41890
I_5	1/19/2016	-0.49351
I_6	1/18/2016	-0.27641
Average m	1/23/2016	0.99892
Avarage I	1/23/2016	-0.37193
$S_{m\,(\%)}$	1/23/2016	0.16
$S_{I\,(ppb)}$	1/23/2016	0.1
Test S_m	1/23/2016	PASS
Test S_I	1/23/2016	PASS

Enter date in yellow highlighted cell next to "Date".

S/N = 0517112167

Enter new slope and intercept in yellow highlighted cells

	Date	**1/28/2016**
m_1	1/28/2016	1.00770
m_2	1/23/2016	0.99992
m_3	1/22/2016	0.99820
m_4	1/21/2016	0.99650
m_5	1/20/2016	0.99993
m_6	1/19/2016	1.00076
I_1	1/28/2016	0.22470
I_2	1/23/2016	-0.33546
I_3	1/22/2016	-0.38403
I_4	1/21/2016	-0.32325
I_5	1/20/2016	-0.41890
I_6	1/19/2016	-0.49351
Average m	1/28/2016	1.00050
Avarage I	1/28/2016	-0.28841
$S_{m\,(\%)}$	1/28/2016	0.38
$S_{I\,(ppb)}$	1/28/2016	0.3
Test S_m	1/28/2016	PASS
Test S_I	1/28/2016	PASS

Enter date in yellow highlighted cell next to "Date".

S/N = 0517112167

Enter new slope and intercept in yellow highlighted cells

	Date	**9/14/2016**
m_1	9/14/2016	1.01342
m_2	1/28/2016	1.00770
m_3	1/23/2016	0.99992
m_4	1/22/2016	0.99820
m_5	1/21/2016	0.99650
m_6	1/20/2016	0.99993
I_1	9/14/2016	0.32479
I_2	1/28/2016	0.22470
I_3	1/23/2016	-0.33546
I_4	1/22/2016	-0.38403
I_5	1/21/2016	-0.32325
I_6	1/20/2016	-0.41890
Average m	9/14/2016	1.00261
Avarage I	9/14/2016	-0.15202
$S_{m\,(\%)}$	9/14/2016	0.65
$S_{I\,(ppb)}$	9/14/2016	0.3
Test S_m	9/14/2016	PASS
Test S_I	9/14/2016	PASS

Enter date in yellow highlighted cell next to "Date".

Enter new slope and intercept in yellow highlighted cells

	Date	**3/21/2017**
m_1	3/21/2017	1.00560
m_2	9/14/2016	1.01342
m_3	1/28/2016	1.00770
m_4	1/23/2016	0.99992
m_5	1/22/2016	0.99820
m_6	1/21/2016	0.99650
I_1	3/21/2017	0.06720
I_2	9/14/2016	0.32479
I_3	1/28/2016	0.22470
I_4	1/23/2016	-0.33546
I_5	1/22/2016	-0.38403
I_6	1/21/2016	-0.32325
Average m	3/21/2017	1.00356
Avarage I	3/21/2017	-0.07101
$S_{m\,(\%)}$	3/21/2017	0.65
$S_{I\,(ppb)}$	3/21/2017	0.3
Test S_m	3/21/2017	PASS
Test S_I	3/21/2017	PASS

$$\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]$$

$$\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]$$

$$S_m = \frac{100}{\bar{m}}\sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(m_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} m_i\right)^2\right]}$$

$$S_I = \sqrt{\frac{1}{5}\left[\sum_{i=1}^{6}(I_i)^2 - \frac{1}{6}\left(\sum_{i=1}^{6} I_i\right)^2\right]}$$

$$S_m = \frac{100}{\bar{m}}$$

$$S_I =$$

EEMS # 01113
6-day calibration
At EEMS 1/21/2016
offset = -0.2
span = 1.015

EEMS # 01113
6-day calibration
At EEMS 1/22/2016
offset = -0.2
span = 1.015

EEMS # 01113
6-day calibration
At EEMS 1/23/2016
offset = -0.2
span = 1.015

EEMS # 01113
Verification
At EPA R4 1/28/2016
offset = -0.2
span = 1.015

EEMS # 01113
Verification
At EPA R7 9/14/2016
offset = -0.2
span = 1.015

EEMS # 01113
Verification
At EPA R4 3/21/2017
offset = -0.2
span = 1.015

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:	EPA Region 4	EEMS
Contact:	Keith Harris	Eric Hebert
Make:	NIST	49CPS
Model:	SRP-10	TEI
S/N:	10	49CPS-0419606966
Guest Test Status:		**PASS**
Guest Known Offset:		0

SESD Project #:
Test #: #1 "as found"

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0012	0.0275	0.9999978	482	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)
01/27/16	1:09 PM	01/27/16	2:59 PM	c0127001.xls	1.0007	0.0686	0.9999974	482	-0.14
01/27/16	2:59 PM	01/27/16	5:00 PM	c0127002.xls	1.0013	-0.0355	0.9999983	482	0.00
01/27/16	5:00 PM	01/27/16	6:49 PM	c0127003.xls	1.0015	0.0285	0.9999986	481	-0.15
01/27/16	6:49 PM	01/27/16	8:34 PM	c0127004.xls	1.0006	0.1371	0.9999988	482	-0.27
01/27/16	8:35 PM	01/27/16	10:27 PM	c0127005.xls	1.0023	-0.1237	0.9999993	482	0.03
01/27/16	10:27 PM	01/28/16	12:13 AM	c0127006.xls	1.0009	0.0036	0.9999941	483	0.50
01/28/16	12:13 AM	01/28/16	1:58 AM	c0127007.xls	1.0012	0.1138	0.9999984	482	-0.03

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: -0.2 ppb O3 COEF: 1.017

EEMS # 0112

New 6-day
m = 0.99524
b = -0.33070

Verification Expires on: **January 28, 2017**

Keith Harris [signature] Date 01/28/16

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:	EPA Region 4	EEMS
Contact:	Keith Harris	Eric Hebert
Make:	NIST	TEI
Model:	SRP-10	49CPS
S/N:	10	517112167
Guest Test Status:		**PASS**
Guest Known Offset:		0

SESD Project #:
Test #: # "as found"

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0077	0.2247	0.999997	482	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)
01/27/16	1:09 PM	01/27/16	2:59 PM	c0127001.xls	1.0074	0.2954	0.9999975	482	-0.14
01/27/16	2:59 PM	01/27/16	5:00 PM	c0127002.xls	1.0079	0.1305	0.9999968	482	0.00
01/27/16	5:00 PM	01/27/16	6:49 PM	c0127003.xls	1.0083	0.1883	0.9999984	481	-0.15
01/27/16	6:49 PM	01/27/16	8:34 PM	c0127004.xls	1.0071	0.3510	0.9999959	482	-0.27
01/27/16	8:35 PM	01/27/16	10:27 PM	c0127005.xls	1.0086	0.0725	0.9999992	482	0.03
01/27/16	10:27 PM	01/28/16	12:13 AM	c0127006.xls	1.0072	0.2073	0.9999928	483	0.50
01/28/16	12:13 AM	01/28/16	1:58 AM	c0127007.xls	1.0073	0.3276	0.9999978	482	-0.03

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: ~~0.0~~ -0.2 ppb O3 COEF: ~~0.000~~ 1.015

EEms# 01113

New Avg 6-day
m = 1.00050
b = -0.28841

Verification Expires on: **January 28, 2017**

Keith Harris [signature] Date 01/28/16

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:	EPA Region 4	EEMS
Contact:	Keith Harris	Eric Hebert
Make:	NIST	TEI
Model:	SRP-10	49CPS
S/N:	10	49CPS-70008-364
Guest Test Status:		PASS
Guest Known Offset:		0

SESD Project #:
Test #: #1 "as found"

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0068	-0.0946	0.999997	481	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)
01/29/16	9:25 AM	01/29/16	11:10 AM	c0129001.xls	1.0066	-0.0851	0.9999976	480	0.08
01/29/16	11:10 AM	01/29/16	12:55 PM	c0129002.xls	1.0070	-0.0748	0.9999978	481	-0.21
01/29/16	12:55 PM	01/29/16	2:50 PM	c0129003.xls	1.0069	-0.1239	0.9999969	481	-0.14

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: 0.0 ppb O3 COEF: 1.018

EEMS# 01110

New 6-day:
m = 0.99832
b = -0.26452

Verification Expires on: **January 29, 2017**

Keith Harris [signature] Date 01/29/16

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:	EPA Region 4	EEMS
Contact:	Keith Harris	Eric Hebert
Make:	NIST	49CPS
Model:	SRP-10	TEI
S/N:	10	517112175
Guest Test Status:		PASS
Guest Known Offset:		0

SESD Project #:
Test #: # "as found"

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0010	0.2577	0.9999987	481	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)
01/29/16	9:25 AM	01/29/16	11:10 AM	c0129001.xls	1.0000	0.2740	0.9999982	480	0.08
01/29/16	11:10 AM	01/29/16	12:55 PM	c0129002.xls	1.0015	0.2235	0.9999986	481	-0.21
01/29/16	12:55 PM	01/29/16	2:50 PM	c0129003.xls	1.0014	0.2757	0.9999992	481	-0.14

Comments:

Instrument tested as found.
Ozone calibration factors at time of test: O3 BKG: -0.6 ppb O3 COEF: 1.020

EEMS # 0111

New 6-day
m = 0.99588
b = -0.44084

Verification Expires on: **January 29, 2017**

Keith Harris [signature] Date 01/29/16

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
Science and Technology Center
300 Minnesota Avenue
Kansas City, Kansas 66101

September 15, 2016

Mr. Eric Hebert
EEMS

Dear Mr. Hebert:

Enclosed is a summary of the annual ozone photometer verifications conducted on units 49CPS-70008-364 and 0517112167. These verifications were performed on September 12 and 14, 2016. Each verification consisted of three challenges against Standard Reference Photometer (SRP) #7. The average slope and intercept from these three challenges, is used to determine if the photometer is operating in an acceptable manner. Please find enclosed 3 data sheets which identify this process has been completed and the unit has been deemed acceptable.

Photometer verifications/certifications are evaluated according to the criteria stated in the "Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone," technical assistance document. These criteria state that Level 2 transfer standards must have a slope in the range of 0.97 to 1.03, and an intercept in the range of -3.0 to +3.0. Based on these criteria, unit number 233-S is acceptable as level 2 transfer standards. Please review the technical assistance document to establish an average and correction factor based on these results. These results are not to be used for any physical adjustment to the instrument.

If you have any questions concerning the results of these photometer verifications, please call me at (913) 551-5063.

Sincerely,

James N. Regehr
Environmental Scientist
Monitoring & Environmental Sampling Branch

Enclosures

VA ∂ 2

Standard Reference Photometer
Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	12-Sep-16
Operator:	J. Regehr / T. Bui	**Start Time:**	10:26
Instrument:	SRP-07 Cell Length=89.73	**End Time:**	11:37
Comment:	Certification of EEMS TEI49cPS 70008364 SRP Gene	**Filename:**	c0912001.xls

Calibrated Instrument:	EEMS	**Calibration Results**	**Value**	**Standard Uncertainty**
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	1.00463	0.00025
Make:	TEI	**Intercept**	0.02891	0.06659
Model:	49c-PS	**Covariance**		-1.7900E-08
Serial Number:	70008-364	**Res Std Dev**	0.09516	

EEMS # 01110

Calibration Parameters: Raw Saved;Dark Count On (5)
Air Flow Rate: 7.0 l/min
Lamp Intensity Range: 0.0 to 85.0 %
Number Conc. Points: 7 **Points/Concentration:** 10
Conditioning: 45.0 % for 5 minutes

Calibration	SRP-07		EEMS		EEMS	
Data Points	Result	Std. Dev	Result	Std. Dev	Predicted	Residual
Dark Count 1	17					
Dark Count 2	16					
1	471.5	0.7	473.6	0.6	473.68	-0.12
2	382.9	0.4	384.9	0.4	384.73	0.14
3	287.7	0.3	289.0	0.2	289.08	-0.04
4	199.1	0.1	200.1	0.2	200.05	0.09
5	103.8	0.2	104.3	0.2	104.27	0.04
6	74.9	0.2	75.2	0.2	75.26	-0.09
7	0.0	0.2	0.0	0.1	-0.01	-0.02

Bkg = 0.0
Coef = 1.018

3 run Avg:
m = 1.00466
b = 0.01298

6 day avg m = 0.99953
b = -0.18527

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 7
Science and Technology Center
300 Minnesota Avenue
Kansas City, Kansas 66101

September 15, 2016

Mr. Eric Hebert
EEMS

Dear Mr. Hebert:

Enclosed is a summary of the annual ozone photometer verifications conducted on units 49CPS-70008-364 and 0517112167. These verifications were performed on September 12 and 14, 2016. Each verification consisted of three challenges against Standard Reference Photometer (SRP) #7. The average slope and intercept from these three challenges, is used to determine if the photometer is operating in an acceptable manner. Please find enclosed 3 data sheets which identify this process has been completed and the unit has been deemed acceptable.

Photometer verifications/certifications are evaluated according to the criteria stated in the "Transfer Standards for Calibration of Air Monitoring Analyzers for Ozone," technical assistance document. These criteria state that Level 2 transfer standards must have a slope in the range of 0.97 to 1.03, and an intercept in the range of -3.0 to +3.0. Based on these criteria, unit number 233-S is acceptable as level 2 transfer standards. Please review the technical assistance document to establish an average and correction factor based on these results. These results are not to be used for any physical adjustment to the instrument.

If you have any questions concerning the results of these photometer verifications, please call me at (913) 551-5063.

Sincerely,

James N. Regehr
Environmental Scientist
Monitoring & Environmental Sampling Branch

Enclosures

VAN 1

Standard Reference Photometer

Calibration Report

Calibrating Institute:	EPA Region 7	**Date:**	14-Sep-16
Operator:	J. Regehr / T. Bui	**Start Time:**	14:01
Instrument:	SRP-07 Cell Length=89.73	**End Time:**	15:16
Comment:	Certification of EEMS TEI49cPS 0517112167 SRP Gene	**Filename:**	c0914001.xls

EEMS # 01113

Calibrated Instrument:	EEMS	**Calibration Results**	**Value**	**Standard Uncertainty**
Owner:	EEMS			
Contact:	Eric Hebert	**Slope**	1.01229	0.00065
Make:	TEI	**Intercept**	0.75420	0.17940
Model:	49c-PS	**Covariance**		-9.5237E-08
Serial Number:	517112167	**Res Std Dev**	0.26086	

Calibration Parameters: Raw Saved;Dark Count On (5)
Air Flow Rate: 7.0 l/min
Lamp Intensity Range: 0.0 to 45.0 %
Number Conc. Points: 7 **Points/Concentration:** 10
Conditioning: 45.0 % for 2 minutes

Calibration Data Points	SRP-07 Result	SRP-07 Std. Dev	EEMS Result	EEMS Std. Dev	EEMS Predicted	EEMS Residual
Dark Count 1	16					
Dark Count 2	17					
1	486.4	0.3	493.0	0.9	493.17	-0.22
2	408.7	0.2	414.4	0.8	414.48	-0.12
3	290.2	0.2	295.1	1.0	294.54	0.53
4	194.0	0.2	197.2	0.7	197.18	0.04
5	97.5	0.2	99.6	1.0	99.48	0.10
6	76.7	0.2	78.2	0.5	78.41	-0.18
7	0.1	0.2	0.7	1.0	0.85	-0.14

BKG = -0.2
COEFF = 1.015

3 RUN AVG
M = 1.01342
b = 0.32479

Nav 6day

M = ~~1.00315~~ 1.00261
b = ~~-0.09865~~ -0.15202

SCOTT-MARRIN, INC.
6531 BOX SPRINGS BLVD. • RIVERSIDE, CA 92507
(951) 653-6780 • FAX (951) 653-2430 • WWW.SCOTTMARRIN.COM

PGVP Vendor
ID: H12013

Report Of Analysis
EPA Protocol Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64679-01
REPORT DATE: April 7, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER SIZE: 50A (52 std cu ft)
CYLINDER NUMBER: **JB03523**
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA	
Carbon monoxide	1490 ± 16 ppm	GMIS	SRM 1681b	Carle Insts Model 8000	3/17/2014	3/24/2014
			Samp#: 1-K-33	Serial # 8249	1489 ppm	1492 ppm
		Cyl#: AAL7017	Cyl#: CAL016258	Methanation/FID	1491 ppm	1483 ppm
		1125 ± 12 ppm	983.5 ± 3 ppmv	Gas Chromatography	1490 ppm	1492 ppm
		Exp: 11/29/2020	Exp: 4/1/2015	LAST CAL DATE: 3/3/2014	$\bar{x}$: 1490 ppm	1489 ppm
Nitric oxide	15.42 ± 0.11 ppm	GMIS	SRM 1683b	TECO Model 42C	3/17/2014	4/1/2014
NOx	15.42 ppm		Samp#: 45-V-106	Serial # 57458-333	15.42 ppm	15.43 ppm
Nitrogen dioxide	< 0.08 ppm	Cyl#: CC114770	Cyl#: CAL017973	Continuous	15.41 ppm	15.46 ppm
		20.58 ± 0.15 ppm	48.79 ± 0.34 ppm	Chemiluminescence	15.39 ppm	15.43 ppm
		Exp: 2/25/2017	Exp: 3/25/2019	LAST CAL DATE: 3/14/2014	$\bar{x}$: 15.41 ppm	15.44 ppm
Sulfur dioxide	15.06 ± 0.16 ppm	GMIS	SRM 1689	Bovar/W Res Model 922M	3/14/2014	3/21/2014
			Samp#: 98-A-33	Serial # 9228379-1	15.04 ppm	15.05 ppm
		Cyl#: CA03167	Cyl#: FF40537	Continuous	15.08 ppm	15.06 ppm
		10.13 ± 0.11 ppm	4.813 ± 0.05 ppm	UV Photometry	15.05 ppm	15.08 ppm
		Exp: 6/12/2017	Exp: 1/8/2017	LAST CAL DATE: 2/27/2014	$\bar{x}$: 15.06 ppm	15.06 ppm
O2-free Nitrogen	Balance					

CERTIFICATION DATE: March 21, 2014 **EPA EXPIRATION DATE:** March 22, 2017

ppm = µmole/mole % = mole-% $\bar{x}$ = EPA weighted mean

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: *[signature]* M.J.Monson APPROVED: *[signature]* J. T. Marrin

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

SCOTT-MARRIN, INC.
6531 BOX SPRINGS BLVD. • RIVERSIDE, CA 92507
(951) 653-6780 • FAX (951) 653-2430 • WWW.SCOTTMARRIN.COM

PGVP Vendor
ID: H12013

Report Of Analysis
EPA Protocol Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64465-01
REPORT DATE: February 18, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER SIZE: 50A (52 std cu ft)
CYLINDER NUMBER: **JB03389**
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA	
Carbon monoxide	1402 ± 17 ppm	GMIS	SRM 2637a	Carle Insts Model 8000	2/6/2014	2/13/2014
			Samp#: 56-F-35	Serial # 8249	1398 ppm	1397 ppm
		Cyl#: AAL17294	Cyl#: CAL017149	Methanation/FID	1398 ppm	1404 ppm
		2603 ± 26 ppm	2438 ± 5.1 ppmv	Gas Chromatography	1406 ppm	1407 ppm
		Exp: 6/27/2020	Exp: 11/9/2015	**LAST CAL DATE:** 1/30/2014	x̄ : 1401 ppm	1403 ppm
Nitric oxide	14.10 ± 0.10 ppm	GMIS	SRM 1683b	TECO Model 42C	2/6/2014	2/14/2014
NOx	14.10 ppm		Samp#: 45-V-106	Serial # 57458-333	14.09 ppm	14.12 ppm
Nitrogen dioxide	< 0.07 ppm	Cyl#: CC114770	Cyl#: CAL017973	Continuous	14.08 ppm	14.09 ppm
		20.49 ± 0.15 ppm	48.79 ± 0.34 ppm	Chemiluminescence	14.07 ppm	14.08 ppm
		Exp: 9/20/2021	Exp: 3/25/2019	**LAST CAL DATE:** 2/14/2014	x̄ : 14.08 ppm	14.10 ppm
Sulfur dioxide	14.27 ± 0.16 ppm	GMIS	SRM 1689	Bovar/W Res Model 922M	2/5/2014	2/12/2014
			Samp#: 98-A-33	Serial # 9228379-1	14.30 ppm	14.30 ppm
		Cyl#: CA03167	Cyl#: FF40537	Continuous	14.29 ppm	14.18 ppm
		10.13 ± 0.11 ppm	4.813 ± 0.05 ppm	UV Photometry	14.28 ppm	14.18 ppm
		Exp: 6/12/2017	Exp: 1/8/2017	**LAST CAL DATE:** 1/27/2014	x̄ : 14.29 ppm	14.22 ppm
O2-free Nitrogen	Balance					

CERTIFICATION DATE: February 12, 2014 **EPA EXPIRATION DATE:** February 13, 2017

ppm = µmole/mole % = mole-% $\overline{x}$ = EPA weighted mean

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: [signature] M.J.Monson APPROVED: [signature] J. T. Marrin

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

SCOTT-MARRIN, INC.
6531 BOX SPRINGS BLVD. • RIVERSIDE, CA 92507
(951) 653-6780 • FAX (951) 653-2430 • WWW.SCOTTMARRIN.COM

Report Of Analysis
NIST-Traceable Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64465-05
REPORT DATE: February 18, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER NUMBER: JB03440

COMPONENT	CONCENTRATION (v/v)	NIST TRACEABLE REFERENCE STANDARD
Carbon monoxide	0.590 ± 0.012 ppmv	SRM 2612a
Ultrapure Air	Balance	

Cylinder Size: 50A (52 std cu ft)
Cylinder Pressure: 2000 psig
Shelf Life: 24 months

ppm = umole/mole % = mole-%

The above analyses are traceable to the National Institute of Standards and Technology by intercomparison with the reference standard listed herein. Where indicated, volumetric and gravimetric reference standards are traceable thru use of our analytical balance. NIST Certificate Numbers 822/272801-6 and 822/274081-06.

ANALYST: M.J.Monson APPROVED: J. T. Marrin

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Report Of Analysis
NIST-Traceable Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64465-05
REPORT DATE: February 18, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER NUMBER: JB03443

COMPONENT	CONCENTRATION (v/v)	NIST TRACEABLE REFERENCE STANDARD
Carbon monoxide	0.591 ± 0.012 ppmv	SRM 2612a
Ultrapure Air	Balance	

Cylinder Size: 50A (52 std cu ft)
Cylinder Pressure: 2000 psig
Shelf Life: 24 months

ppm = umole/mole   % = mole-%

The above analyses are traceable to the National Institute of Standards and Technology by intercomparison with the reference standard listed herein. Where indicated, volumetric and gravimetric reference standards are traceable thru use of our analytical balance. NIST Certificate Numbers 822/272801-6 and 822/274081-06.

ANALYST: [signature] M.J.Monson   APPROVED: [signature] J. T. Marrin

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PGVP Vendor
ID: H12013

Report Of Analysis
EPA Protocol Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64679-03
REPORT DATE: April 7, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER SIZE: 50A (52 std cu ft)
CYLINDER NUMBER: **JB03465**
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA	
Carbon monoxide	4.48 ± 0.07 ppm	GMIS	SRM 2613a	Carle Insts Model 8000	3/13/2014	3/20/2014
			Samp#: 22-16-E	Serial # 8249	4.50 ppm	4.47 ppm
		Cyl#: CC101213	Cyl#: CLM09661	Methanation/FID	4.50 ppm	4.47 ppm
		11.07 ± 0.14 ppm	19.72 ± 0.25 ppm	Gas Chromatography	4.48 ppm	4.50 ppm
		Exp: 10/15/2021	Exp: 8/1/2017	**LAST CAL DATE:** 3/3/2014	$\bar{x}$: 4.49 ppm	4.48 ppm
Ultrapure Air	Balance					

CERTIFICATION DATE: March 20, 2014 **EPA EXPIRATION DATE:** March 21, 2022

ppm = µmole/mole **% = mole-%** **$\bar{x}$ = EPA weighted mean**

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: Mark Monson APPROVED: [signature]

M.J.Monson J. T. Marrin

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

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PGVP Vendor
ID: H12013

Report Of Analysis
EPA Protocol Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64465-03
REPORT DATE: February 18, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER SIZE: 50A (52 std cu ft)
CYLINDER NUMBER: **JB03174**
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA	
Carbon monoxide	4.60 ± 0.07 ppm	GMIS	SRM 2613a	Carle Insts Model 8000	1/24/2014	1/31/2014
			Samp#: 22-16-E	Serial # 8249	4.60 ppm	4.58 ppm
		Cyl#: CC101213	Cyl#: CLM09661	Methanation/FID	4.56 ppm	4.61 ppm
		11.07 ± 0.14 ppm	19.72 ± 0.25 ppm	Gas Chromatography	4.60 ppm	4.60 ppm
		Exp: 10/15/2021	Exp: 8/1/2017	LAST CAL DATE: 1/30/2014	$\bar{x}$: 4.59 ppm	4.60 ppm
Ultrapure Air	Balance					

CERTIFICATION DATE: January 31, 2014 **EPA EXPIRATION DATE:** February 1, 2022

ppm = µmole/mole % = mole-% $\bar{x}$ = EPA weighted mean

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: *[signature]* M.J.Monson APPROVED: *[signature]* J. T. Marrin

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

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PGVP Vendor
ID: H12013

Report Of Analysis
EPA Protocol Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64679-02
REPORT DATE: April 7, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER SIZE: 50A (52 std cu ft)
CYLINDER NUMBER: **JB03450**
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION	REPLICATE ANALYSIS DATA	
Carbon monoxide	42.9 ± 0.3 ppm	GMIS	SRM 1678c	Carle Insts Model 8000	3/14/2014	3/21/2014
			Samp#: 4-6-I	Serial # 8249	42.9 ppm	42.8 ppm
		Cyl#: ALM021434	Cyl#: CLM009356	Methanation/FID	42.6 ppm	42.8 ppm
		56.2 ± 0.4 ppm	49.8 ± 0.35 ppmv	Gas Chromatography	43.1 ppm	42.9 ppm
		Exp: 1/10/2021	Exp: 6/21/2015	**LAST CAL DATE:** 3/3/2014	$\bar{x}$: 42.9 ppm	42.8 ppm
Ultrapure Air	Balance					

CERTIFICATION DATE: March 21, 2014 **EPA EXPIRATION DATE:** March 22, 2022

ppm = µmole/mole **% = mole-%** **$\bar{x}$ = EPA weighted mean**

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: Mark Monson
M.J.Monson

APPROVED: [signature]
J. T. Marrin

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

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PGVP Vendor
ID: H12013

Report Of Analysis
EPA Protocol Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64465-02
REPORT DATE: February 18, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER NUMBER: **JB03170**

CYLINDER SIZE: 50A (52 std cu ft)
CYLINDER PRESSURE: 2000 psig

COMPONENT	CONCENTRATION (v/v) ± EPA UNCERTAINTY	REFERENCE STANDARD		ANALYZER MAKE, MODEL, S/N, DETECTION		REPLICATE ANALYSIS DATA	
Carbon monoxide	46.4 ± 0.3 ppm	GMIS	SRM 1678c	Carle Insts Model 8000		1/24/2014	1/31/2014
			Samp#: 4-6-I	Serial # 8249		46.4 ppm	46.3 ppm
		Cyl#: ALM021434	Cyl#: CLM009356	Methanation/FID		46.3 ppm	46.6 ppm
		56.2 ± 0.4 ppm	49.8 ± 0.35 ppmv	Gas Chromatography		46.2 ppm	46.5 ppm
		Exp: 1/10/2021	Exp: 6/21/2015	LAST CAL DATE: 1/30/2014	$\bar{x}$:	46.3 ppm	46.5 ppm
Ultrapure Air	Balance						

CERTIFICATION DATE: January 31, 2014 **EPA EXPIRATION DATE:** February 1, 2022

ppm = µmole/mole % = mole-% $\bar{x}$ = EPA weighted mean

The above analyses were performed in accordance with Procedure G1 of the EPA Traceability Protocol, Report Number EPA600/R-12/531, dated May 2012.

The above analyses should not be used if the cylinder pressure is less than 100 psig.

ANALYST: Mark Monson
M.J.Monson

APPROVED: [signature]
J. T. Marrin

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

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(951) 653-6780 • FAX (951) 653-2430 • WWW.SCOTTMARRIN.COM

Report Of Analysis
NIST-Traceable Gas Mixtures

EEMS01
TO: Env'l, Engineering & Measurement Svcs
Attn: Eric Hebert
8010 Southwest 17th Place
Gainesville, FL 32607
(352) 262-0802

REPORT NO: 64715-01
REPORT DATE: April 14, 2014
CUSTOMER PO NO: E HEBERT

CYLINDER NUMBER: **FB03896**

COMPONENT	CONCENTRATION (v/v)	NIST TRACEABLE REFERENCE STANDARD
n-Propylnitrate	5.02 ± 0.25 ppmv	SRM 2627a
Nitrogen	Balance	

Cylinder Size: 30A (28 std cu ft)
Cylinder Pressure: 2000 psig
Shelf Life: 12 months

ppm = umole/mole **% = mole-%**

The above analyses are traceable to the National Institute of Standards and Technology by intercomparison with the reference standard listed herein. Where indicated, volumetric and gravimetric reference standards are traceable thru use of our analytical balance. NIST Certificate Numbers 822/272801-6 and 822/274081-06.

ANALYST: D.C. M[signature] — D.C.Marrin **APPROVED:** [signature] — J. T. Marrin

The only liability of this company for gas which fails to comply with this analysis shall be replacement or reanalysis thereof by the company without extra cost.

STANDARD CALIBRATION GASES IN ALUMINUM CYLINDERS

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-2

Site Name: EPA R-7 | Audit Date: 9/12/2016

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Absolute Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Ozone Audit Point #1					N/A	
Ozone Audit Point #2					N/A	
Ozone Audit Point #3					N/A	
Ozone Audit Point #4					N/A	
Ozone Audit Point #5					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	0.005	-0.0026		-0.0076	Pass	
CO Audit level 7	21.216	20.865	-1.7	-0.3510	Pass	
CO Audit level 6	12.149	12.021	-1.1	-0.1280	Pass	
CO Audit level 5	7.136	7.120	-0.2	-0.0160	Pass	
CO Audit level					N/A	
CO Audit level					N/A	
Post Zero	0.004	0.0065		0.0025	Pass	
Oxides of Nitrogen						
Pre Zero	0.0001	0.0000		-0.0001	Pass	
NO Audit Point #1	0.2134	0.2071	-3.0	-0.0063	Pass	
NO Audit Point #2	0.1222	0.1192	-2.5	-0.0030	Pass	
NO Audit Point #3	0.0718	0.0700	-2.5	-0.0018	Pass	
NO Audit Point #4					N/A	
NO Audit Point #5					N/A	
Post Zero	0	-0.0001		0.0	Pass	
Pre Zero	0.0001	0.0000		-0.0001	Pass	
NOx Audit Point #1	0.2134	0.2069	-3.0	-0.0065	Pass	
NOx Audit Point #2	0.1222	0.1191	-2.5	-0.0031	Pass	
NOx Audit Point #3	0.0718	0.0701	-2.4	-0.0017	Pass	
NOx Audit Point #4					N/A	
NOx Audit Point #5					N/A	
Post Zero	0.0000	0.0000		0.0	Pass	
Pre Zero	0.0000	0.0000		0		
NO2 Audit level 7	0.1290	0.1253	-2.9	-0.0037	Pass	
NO2 Audit level 6	0.0750	0.0726	-3.2	-0.0024	Pass	
NO2 Audit level 5	0.0390	0.0373	-4.4	-0.0017	Pass	
NO2 Audit level					N/A	
Post Zero	0.0000	0.0001		0.0		
Converter Efficiency NO2 level 7	99.9%				Pass	
Converter Efficiency NO2 level 6	99.7%				Pass	
Converter Efficiency NO2 level 5	99.2%				Pass	
Converter Efficiency NO2 level					N/A	
Sulfur Dioxide						
Pre Zero	0.0001	-0.0001		-0.0002	Pass	
SO2 Audit level 8	0.2159	0.2152	-0.3	-0.0007	Pass	
SO2 Audit level 7	0.1237	0.1239	0.2	0.0002	Pass	
SO2 Audit level 6	0.0726	0.0728	0.3	0.0002	Pass	
SO2 Audit level					N/A	
SO2 Audit level					N/A	
Post Zero	0.0000	-0.0001		-0.0001	Pass	

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-2

Site Name: EPA R-7 | Audit Date: 9/12/2016

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Absolute Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Ozone Audit Point #1					N/A	
Ozone Audit Point #2					N/A	
Ozone Audit Point #3					N/A	
Ozone Audit Point #4					N/A	
Ozone Audit Point #5					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	0.023	0.0009		-0.0221	Pass	
CO Audit level 5	3.523	3.542	0.5	0.0191	Pass	
CO Audit level 4	1.872	1.906	1.8	0.0340	Pass	
CO Audit level 3	0.741	0.783	5.7	0.0420	Pass	
CO Audit level 3	0.408	0.460	12.7	0.0517	Pass	Warning
CO Audit level 2	0.126	0.171	35.7	0.0450	Pass	Warning
Post Zero	-0.045	-0.002		0.0430	Pass	
Oxides of Nitrogen						
Pre Zero	0.0002	-0.0001		-0.0003	Pass	
NO Audit Point #1	0.0354	0.0352	-0.6	-0.0002	Pass	
NO Audit Point #2	0.0188	0.0187	-0.5	-0.0001	Pass	
NO Audit Point #3	0.0075	0.0075	0.0	0.0000	Pass	
NO Audit Point #4	0.0041	0.0044	7.3	0.0003	Pass	
NO Audit Point #5	0.0013	0.0015	15.4	0.0002	Pass	
Post Zero	-0.0005	-0.0001		0.0004	Pass	
Pre Zero	0.0002	-0.0001		-0.0003	Pass	
NOx Audit Point #1	0.0354	0.0350	-1.1	-0.0004	Pass	
NOx Audit Point #2	0.0188	0.0186	-1.1	-0.0002	Pass	
NOx Audit Point #3	0.0075	0.0075	0.0	0.0000	Pass	
NOx Audit Point #4	0.0041	0.0043	4.9	0.0002	Pass	
NOx Audit Point #5	0.0013	0.0015	15.4	0.0002	Pass	
Post Zero	-0.0005	-0.0001		0.0004	Pass	
Pre Zero	0.0000	0.0000		0.0000		
NO2 Audit level 4	0.0180	0.0171	-5.0	-0.0009	Pass	
NO2 Audit level 3	0.0070	0.0064	-8.6	-0.0006	Pass	
NO2 Audit level 2	0.0030	0.0034	13.3	0.0004	Pass	
NO2 Audit level 1	0.0020	0.0017	-15.0	-0.0003	Pass	
Post Zero	0.0000	0.0000		0.0000		
Converter Efficiency NO2 level 4	99.4%				Pass	
Converter Efficiency NO2 level 3	100.0%				Pass	
Converter Efficiency NO2 level 2	100.0%				Pass	
Converter Efficiency NO2 level 1	100.0%				Pass	
Sulfur Dioxide						
Pre Zero	0.0002	0.0000		-0.0002	Pass	
SO2 Audit level 5	0.0359	0.0344	-4.2	-0.0015	Pass	
SO2 Audit level 4	0.0191	0.0183	-4.2	-0.0008	Pass	
SO2 Audit level 3	0.0075	0.0070	-6.7	-0.0005	Pass	
SO2 Audit level 2	0.0042	0.0040	-4.8	-0.0002	Pass	
SO2 Audit level 1	0.0013	0.0012	-7.7	-0.0001	Pass	
Post Zero	-0.0005	-0.0001		0.0004	Pass	

FINAL SUMMARY AUDIT REPORT FLOW BASED
EEMS Van-2

Site Name: EPA R-7

Audit Date: 9/12/2016

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Absolute Differenc e (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero			[redacted]			
Ozone Audit Point #1					**N/A**	
Ozone Audit Point #2					**N/A**	
Ozone Audit Point #3					**N/A**	
Ozone Audit Point #4					**N/A**	
Ozone Audit Point #5					**N/A**	
Post Zero			[redacted]			
Carbon Monoxide						
Pre Zero	0.000	-0.0026	[redacted]	-0.0026	**Pass**	
CO Audit level 7	21.194	20.865	-1.6	-0.3291	**Pass**	
CO Audit level 6	12.148	12.021	-1.0	-0.1270	**Pass**	
CO Audit level 5	7.103	7.120	0.2	0.0173	**Pass**	
CO Audit level					**N/A**	
CO Audit level					**N/A**	
Post Zero	0.000	0.0065	[redacted]	0.0065	**Pass**	
Oxides of Nitrogen						
Pre Zero	0.0000	0.0000	[redacted]	0	**Pass**	
NO Audit Point #1	0.2132	0.2071	-2.9	-0.0061	**Pass**	
NO Audit Point #2	0.1222	0.1192	-2.5	-0.0030	**Pass**	
NO Audit Point #3	0.0714	0.0700	-2.0	-0.0014	**Pass**	
NO Audit Point #4					**N/A**	
NO Audit Point #5					**N/A**	
Post Zero	0.0000	-0.0001	[redacted]	0.0	**Pass**	
Pre Zero	0.0000	0.0000	[redacted]	0	**Pass**	
NOx Audit Point #1	0.2132	0.2069	-3.0	-0.0063	**Pass**	
NOx Audit Point #2	0.1222	0.1191	-2.5	-0.0031	**Pass**	
NOx Audit Point #3	0.0714	0.0701	-1.8	-0.0013	**Pass**	
NOx Audit Point #4					**N/A**	
NOx Audit Point #5					**N/A**	
Post Zero	0.0000	0.0000	[redacted]	0.0	**Pass**	
Pre Zero	0.0000	0.0000	[redacted]	0		
NO2 Audit level 7	0.1290	0.1253	-2.9	-0.0037	**Pass**	
NO2 Audit level 6	0.0750	0.0726	-3.2	-0.0024	**Pass**	
NO2 Audit level 5	0.0390	0.0373	-4.4	-0.0017	**Pass**	
NO2 Audit level					**N/A**	
Post Zero	0.0000	0.0000	[redacted]	0.0		
Converter Efficiency NO2 level 7	99.9%				**Pass**	
Converter Efficiency NO2 level 6	99.7%				**Pass**	
Converter Efficiency NO2 level 5	99.2%				**Pass**	
Converter Efficiency NO2 level					**N/A**	
Sulfur Dioxide						
Pre Zero	0.0000	-0.0001	[redacted]	-0.0001	**Pass**	
SO2 Audit level 8	0.2157	0.2152	-0.2	-0.0005	**Pass**	
SO2 Audit level 7	0.1236	0.1239	0.2	0.0003	**Pass**	
SO2 Audit level 6	0.0723	0.0728	0.7	0.0005	**Pass**	
SO2 Audit level					**N/A**	
SO2 Audit level					**N/A**	
Post Zero	0.0000	-0.0001	[redacted]	-0.0001	**Pass**	

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-2

Site Name: EPA R-7 | Audit Date: 9/12/2016

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Absolute Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Ozone Audit Point #1					N/A	
Ozone Audit Point #2					N/A	
Ozone Audit Point #3					N/A	
Ozone Audit Point #4					N/A	
Ozone Audit Point #5					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	0.023	0.0009		-0.0221	Pass	
CO Audit level 5	3.523	3.542	0.5	0.0191	Pass	
CO Audit level 4	1.872	1.906	1.8	0.0340	Pass	
CO Audit level 3	0.741	0.783	5.7	0.0420	Pass	
CO Audit level 3	0.408	0.460	12.7	0.0517	Pass	Warning
CO Audit level 2	0.126	0.171	35.7	0.0450	Pass	Warning
Post Zero	-0.045	-0.002		0.0430	Pass	
Oxides of Nitrogen						
Pre Zero	0.0002	-0.0001		-0.0003	Pass	
NO Audit Point #1	0.0354	0.0352	-0.6	-0.0002	Pass	
NO Audit Point #2	0.0188	0.0187	-0.5	-0.0001	Pass	
NO Audit Point #3	0.0075	0.0075	0.0	0.0000	Pass	
NO Audit Point #4	0.0041	0.0044	7.3	0.0003	Pass	
NO Audit Point #5	0.0013	0.0015	15.4	0.0002	Pass	
Post Zero	-0.0005	-0.0001		0.0004	Pass	
Pre Zero	0.0002	-0.0001		-0.0003	Pass	
NOx Audit Point #1	0.0354	0.0350	-1.1	-0.0004	Pass	
NOx Audit Point #2	0.0188	0.0186	-1.1	-0.0002	Pass	
NOx Audit Point #3	0.0075	0.0075	0.0	0.0000	Pass	
NOx Audit Point #4	0.0041	0.0043	4.9	0.0002	Pass	
NOx Audit Point #5	0.0013	0.0015	15.4	0.0002	Pass	
Post Zero	-0.0005	-0.0001		0.0004	Pass	
Pre Zero	0.0000	0.0000		0.0000		
NO2 Audit level 4	0.0180	0.0171	-5.0	-0.0009	Pass	
NO2 Audit level 3	0.0070	0.0064	-8.6	-0.0006	Pass	
NO2 Audit level 2	0.0030	0.0034	13.3	0.0004	Pass	
NO2 Audit level 1	0.0020	0.0017	-15.0	-0.0003	Pass	
Post Zero	0.0000	0.0000		0.0000		
Converter Efficiency NO2 level 4	99.4%				Pass	
Converter Efficiency NO2 level 3	100.0%				Pass	
Converter Efficiency NO2 level 2	100.0%				Pass	
Converter Efficiency NO2 level 1	100.0%				Pass	
Sulfur Dioxide						
Pre Zero	0.0002	0.0000		-0.0002	Pass	
SO2 Audit level 5	0.0359	0.0344	-4.2	-0.0015	Pass	
SO2 Audit level 4	0.0191	0.0183	-4.2	-0.0008	Pass	
SO2 Audit level 3	0.0075	0.0070	-6.7	-0.0005	Pass	
SO2 Audit level 2	0.0042	0.0040	-4.8	-0.0002	Pass	
SO2 Audit level 1	0.0013	0.0012	-7.7	-0.0001	Pass	
Post Zero	-0.0005	-0.0001		0.0004	Pass	

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-1

Site Name: EPA R-7 | Audit Date: 9/14/2016

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Absolute Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Ozone Audit Point #1					N/A	
Ozone Audit Point #2					N/A	
Ozone Audit Point #3					N/A	
Ozone Audit Point #4					N/A	
Ozone Audit Point #5					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	0.011					
CO Audit level 5	4.339				N/A	
CO Audit level 4	1.725				N/A	
CO Audit level 3	0.719				N/A	
CO Audit level 3	0.482				N/A	
CO Audit level 2	0.192				N/A	
Post Zero	-0.072					
Oxides of Nitrogen						
Pre Zero	0.0001	0.0000		-0.0001	Pass	
NO Audit Point #1	0.0449	0.0461	2.7	0.0012	Pass	
NO Audit Point #2	0.0178	0.0179	0.6	0.0001	Pass	
NO Audit Point #3	0.0074	0.0077	4.1	0.0003	Pass	
NO Audit Point #4	0.0050	0.0055	10.0	0.0005	Pass	
NO Audit Point #5	0.0020	0.0027	35.0	0.0007	Pass	
Post Zero	-0.0007	0.0000		0.0007	Pass	
Pre Zero	0.0001	0.0000		-0.0001	Pass	
NOx Audit Point #1	0.0449	0.0461	2.7	0.0012	Pass	
NOx Audit Point #2	0.0178	0.0179	0.6	0.0001	Pass	
NOx Audit Point #3	0.0074	0.0078	5.4	0.0004	Pass	
NOx Audit Point #4	0.0050	0.0056	12.0	0.0006	Pass	
NOx Audit Point #5	0.0020	0.0027	35.0	0.0007	Pass	
Post Zero	-0.0007	0.0001		0.0008	Pass	
Pre Zero	0.0000	0.0001		0.0001		
NO2 Audit level 4	0.0110	0.0107	-2.7	-0.0003	Pass	
NO2 Audit level 3	0.0070	0.0072	2.9	0.0002	Pass	
NO2 Audit level 2	0.0030	0.0031	3.3	0.0001	Pass	
NO2 Audit level 1	0.0010	0.0016	60.0	0.0006	Pass	
Post Zero	0.0000	0.0000		0.0000		
Converter Efficiency NO2 level 4	98.2%				Pass	
Converter Efficiency NO2 level 3	101.3%				Pass	
Converter Efficiency NO2 level 2	100.0%				Pass	
Converter Efficiency NO2 level 1	100.0%				Pass	
Sulfur Dioxide						
Pre Zero	0.0001					
SO2 Audit level 5	0.0439				N/A	
SO2 Audit level 4	0.0174				N/A	
SO2 Audit level 3	0.0073				N/A	
SO2 Audit level 2	0.0049				N/A	
SO2 Audit level 1	0.0019				N/A	
Post Zero	-0.0007					

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-1

Site Name: EPA R-7

Audit Date: 9/15/2016

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Absolute Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Ozone Audit Point #1					N/A	
Ozone Audit Point #2					N/A	
Ozone Audit Point #3					N/A	
Ozone Audit Point #4					N/A	
Ozone Audit Point #5					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	0.005	0.0045		-0.0005	Pass	
CO Audit level 5	4.324	4.343	0.4	0.0190	Pass	
CO Audit level 4	1.703	1.734	1.8	0.0310	Pass	
CO Audit level 3	0.648	0.676	4.3	0.0280	Pass	
CO Audit level 3	0.428	0.445	4.0	0.0170	Pass	
CO Audit level 2	0.163	0.180	10.4	0.0170	Pass	
Post Zero	-0.015	0.019		0.0340	Pass	
Oxides of Nitrogen						
Pre Zero	0.0001					
NO Audit Point #1	0.0447				N/A	
NO Audit Point #2	0.0176				N/A	
NO Audit Point #3	0.0067				N/A	
NO Audit Point #4	0.0044				N/A	
NO Audit Point #5	0.0017				N/A	
Post Zero	-0.0002					
Pre Zero	0.0001					
NOx Audit Point #1	0.0447				N/A	
NOx Audit Point #2	0.0176				N/A	
NOx Audit Point #3	0.0067				N/A	
NOx Audit Point #4	0.0044				N/A	
NOx Audit Point #5	0.0017				N/A	
Post Zero	-0.0002					
Pre Zero	0.0000					
NO2 Audit level 4					N/A	
NO2 Audit level 3					N/A	
NO2 Audit level 2					N/A	
NO2 Audit level 1					N/A	
Post Zero	0.0000					
Converter Efficiency NO2 level 4					N/A	
Converter Efficiency NO2 level 3					N/A	
Converter Efficiency NO2 level 2					N/A	
Converter Efficiency NO2 level 1					N/A	
Sulfur Dioxide						
Pre Zero	0.0001	0.0000		-0.0001	Pass	
SO2 Audit level 5	0.0437	0.0415	-5.0	-0.0022	Pass	
SO2 Audit level 4	0.0172	0.0162	-5.8	-0.0010	Pass	
SO2 Audit level 3	0.0066	0.0050	-24.2	-0.0016	Pass	Warning
SO2 Audit level 2	0.0043	0.0032	-25.6	-0.0011	Pass	
SO2 Audit level 1	0.0016	0.0011	-31.3	-0.0005	Pass	
Post Zero	-0.0001	-0.0001		0.0000	Pass	

MesaLabs

Pg 1 of 2

NVLAP

NVLAP Lab Code 200661-0

Calibration Certificate

CertificateNo.	65904	**Sold To:**	Environmental Engineering & Measurement Services
Product	200-220H Definer 220 High Flow		8010 SW 17th Place
Serial No.	131818		Gainesville, FL 32607
Cal. Date	17-Dec-2015		US

EEMS #01417

All calibrations are performed at Mesa Laboratories, Inc., 10 Park Place, Butler, NJ, 07405, an ISO 17025:2005 accredited laboratory through NVLAP of NIST. 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.

As Received Calibration Data

Technician Lilianna Malinowska

Lab. Pressure 751 mmHg
Lab. Temperature 22.6 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
25183 sccm	25056 sccm	0.51%	1.00%	In Tolerance
5004.9 sccm	5000.7 sccm	0.08%	1.00%	In Tolerance
1500.2 sccm	1500.45 sccm	-0.02%	1.00%	In tolerance
22.1 °C	22.5 °C	-	± 0.8°C	In Tolerance
751 mmHg	751 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	29-Nov-2015	28-Nov-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

Slope = 1.005649
int = -0.01577
r^2 = 1.00000

MesaLabs

EE MS
01417
Pg 2 of 2

NVLAP Lab Code 200661-0

As Shipped Calibration Data

Certificate No 65904
Technician Lilianna Malinowska

Lab. Pressure 747 mmHg
Lab. Temperature 22.6 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
25234 sccm	25101.5sccm	0.53%	1.00%	In Tolerance
5030.7 sccm	5001.2 sccm	0.59%	1.00%	In Tolerance
1510.4 sccm	1501.6 sccm	0.59%	1.00%	In Tolerance
22.6 °C	22.6 °C	-	± 0.8°C	In Tolerance
747 mmHg	747 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	29-Nov-2015	28-Nov-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

Louis Guido, Chief Metrologist

MesaLabs

NVLAP

NVLAP Lab Code 200661-0

Calibration Certificate

CertificateNo. 76160

Product 200-220H Definer 220 High Flow

Serial No. 122974

Cal. Date 10-Feb-2016

Pg 1 of 2

Sold To: Environmental Engineering & Measurement Services
8010 SW 17th Place
Gainesville, FL 32607
US

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As Received Calibration Data

Technician

Lab. Pressure mmHg
Lab. Temperature 21.8 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
sccm	sccm		1.00%	
sccm	sccm		1.00%	
sccm	sccm		1.00%	
°C	°C	-	± 0.8°C	In Tolerance
mmHg	mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
Percision Thermometer			
Precision Barometer			

EEMS #01416

MesaLabs

EEMS # 01416
2/10/2016

NVLAP Lab Code 200661-0

Pg 2 of 2

As Shipped Calibration Data

Certificate No	76160	**Lab. Pressure**	748 mmHg
Technician	Lilianna Malinowska	**Lab. Temperature**	21.8 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
25171 sccm	25186.5sccm	-0.06%	1.00%	In Tolerance
5012.3 sccm	5000.3 sccm	0.24%	1.00%	In Tolerance
1507.6 sccm	1501.95 sccm	0.38%	1.00%	In Tolerance
21.8 °C	21.8 °C	-	± 0.8°C	In Tolerance
748 mmHg	748 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	29-Nov-2015	28-Nov-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

Lou Guido

Louis Guido, Chief Metrologist

MesaLabs

NVLAP Lab Code 200661-0

Calibration Certificate

CertificateNo. 76161

Product 200-220L Definer 220 Low Flow

Serial No. 120910

Cal. Date 10-Feb-2016

Pg 1 of 2

EEMS# 01415

Sold To: Environmental Engineering & Measurement Services
8010 SW 17th Place
Gainesville, FL 32607
US

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As Received Calibration Data

Technician Lilianna Malinowska

Lab. Pressure 747 mmHg
Lab. Temperature 21.5 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
484.74 sccm	480.43 sccm	0.9%	1.00%	In Tolerance
108.09 sccm	107.98 sccm	0.1%	1.00%	In Tolerance
33.41 sccm	33.18 sccm	0.69%	1.00%	In tolerance
20.2 °C	20.5 °C	-	± 0.8°C	In Tolerance
746 mmHg	760 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-10	103743	07-Apr-2015	06-Apr-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

MesaLabs

FEMS #
01415
2/10/2016
Pg 2 of 2

NVLAP Lab Code 200661-0

As Shipped Calibration Data

Certificate No 76161
Technician Lilianna Malinowska

Lab. Pressure 748 mmHg
Lab. Temperature 21.5 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
451.16 sccm	450.215sccm	0.21%	1.00%	In Tolerance
100.37 sccm	100.415 sccm	-0.04%	1.00%	In Tolerance
30.741 sccm	30.6215 sccm	0.39%	1.00%	In Tolerance
21.5 °C	21.5 °C	-	± 0.8°C	In Tolerance
748 mmHg	748 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-10	103743	07-Apr-2015	06-Apr-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

Lou Guido

Louis Guido, Chief Metrologist

Mesa Laboratories Inc. 10 Park Place Butler, NJ 07405 USA
(973) 492-8400 FAX (973) 492-8270 www.mesalabs.com Symbol "MLAB" on the NAS

Project:	**Bios NEXUS EEMS # 01420/01410 Certification**	Flow Rate Standard:	**BIOS Definer 220-H**
Project #:		EEMS #	**01416**
Contact Name:		Certification Date:	**2/10/2016**
Contact Phone #:		Certification #:	**76160**
Contact Address:		**slope =**	0.998946
		inter =	0.011852

environmental, engineering & measurement services

Date:

2/28/2016 Flow rates are corrected to STP of one atmosphere and 25.0 degrees C. were plumbed together in series.
All tests were conducted with dry air. Nexus #1420, Definer 220-H EEMS# 01416

UNADJUSTED:

BIOS Nexus, EEMS # 01420 / 01410

Flow Rate Standard--Definer 220-H

01420 / 01410	
Slope =	**0.990909**
Intercept =	**0.031721**
Correl =	**0.99988**

	Temp deg C	Press mmHg
Definer	21.2	765
NEXUS	20.5	764

SL/m: standard liters per minute

Definer 220-H	9100	NEXUS / DC-LITE		
STP SL/M Corrected X	Flow SL/m	reading SL/m Y	Diff Y - X	% Diff (Y - X)/X
0.921		0.935	0.014	1.6%
1.117		1.131	0.014	1.2%
1.41		1.43	0.024	1.7%
1.92		1.96	0.036	1.9%
2.93		2.93	0.000	0.0%
3.43		3.43	-0.005	-0.1%

Average Error (SL/m) = 0.014

NEXUS / DC_LITE Corrected Values (using slope and intercept)		
SL/m	Diff	% Diff
0.911	-0.009	-1.0%
1.109	-0.008	-0.7%
1.414	0.005	0.4%
1.945	0.022	1.1%
2.926	-0.005	-0.2%
3.429	-0.005	-0.2%

Average Error (Sl/m) 0.001

Raw Readings (Each set for 10 reading sets)

<u>Target</u>	<u>Definer</u>	<u>Nexus</u>
1	0.932	0.936
	0.931	0.936
	0.932	0.935
	0.931	0.933
	<u>Definer</u>	<u>Nexus</u>
1.2	1.131	1.128
	1.130	1.122
	1.122	1.138
	1.127	1.134
	<u>Definer</u>	<u>Nexus</u>
1.5	1.418	1.438
	1.419	1.432
	1.418	1.430
	1.424	1.432
	<u>Definer</u>	<u>Nexus</u>
2	1.933	1.963
	1.934	1.948
	1.932	1.964
	1.933	1.961
	<u>Definer</u>	<u>Nexus</u>
3	2.9373	2.929
	2.9429	2.931
	2.9354	2.936
	2.9424	2.928
	<u>Definer</u>	<u>Nexus</u>
3.5	3.447	3.425
	3.436	3.433
	3.441	3.433
	3.447	3.427

Confirmation			
Test at 1.60 set point using			
NEXUS / DC-LITE only (Y)		Definer only (X)	
R1	R2	R1	R2
1.530	1.528	1.52	1.522
Average	1.529	Average	1.5210
Nexus corrected Value	1.511	corr =	1.511
Diff from Definer value (X)	0.02%		
Test at 3.00 set point using			
NEXUS / DC-LITE only (Y)		Definer only (X)	
R1	R2	R1	R2
2.93	2.925	2.9317	2.9296
Average	2.928	Average	2.9307
Nexus corrected Value	2.922	corr =	2.922
Diff from Definer value (X)	0.02%		

EEMS #01417

MesaLabs

NVLAP

NVLAP Lab Code 200661-0

Calibration Certificate

CertificateNo. 89109

Product 200-220H Definer 220 High Flow

Serial No. 131818

Cal. Date 20-Apr-2016

Sold To: Environmental Engineering & Measurement Services
8010 SW 17th Place
Gainesville, FL 32607
US

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As Received Calibration Data

Technician Lilianna Malinowska

Lab. Pressure 752 mmHg
Lab. Temperature 22.2 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Received
27096.2 sccm	26484.73 sccm	2.31%	1.00%	Out of Tolerance
5424.64 sccm	5312.97 sccm	2.1%	1.00%	Out of Tolerance
1658.26 sccm	1622.86 sccm	2.18%	1.00%	Out of Tolerance
21.3 °C	22.5 °C	-	± 0.8°C	Out of Tolerance
752 mmHg	751 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	103521	24-Jun-2015	23-Jun-2016
Percision Thermometer	305460	22-Sep-2015	21-Sep-2016
Precision Barometer	2981392	29-Jun-2015	28-Jun-2016

MesaLabs

NVLAP Lab Code 200661-0

As Shipped Calibration Data

Certificate No	89109	**Lab. Pressure**	756 mmHg
Technician	Lilianna Malinowska	**Lab. Temperature**	22.2 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
26532.5 sccm	26441.5sccm	0.34%	1.00%	In Tolerance
5325.16 sccm	5307.04 sccm	0.34%	1.00%	In Tolerance
1632.29 sccm	1623.96 sccm	0.51%	1.00%	In Tolerance
21.7 °C	21.7 °C	-	± 0.8°C	In Tolerance
756 mmHg	756 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML-800-44	101897	29-Nov-2015	28-Nov-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

Louis Guido, Chief Metrologist

EEMS
#01421

MesaLabs

NVLAP

NVLAP Lab Code 200661-0

Calibration Certificate

CertificateNo.	85366	**Sold To:**	Environmental Engineering & Measurement Services
Product	200-220H Definer 220 High Flow		8010 SW 17th Place
Serial No.	148613		Gainesville, FL 32607
Cal. Date	16-Mar-2016		US
Sales Date	21-Apr-2016 *Calibration interval commences on sale date.*		

All calibrations are performed at Mesa Laboratories, Inc., 10 Park Place, Butler, NJ, 07405, an ISO 17025:2005 accredited laboratory through NVLAP of NIST. 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.

Calibration Data

Certificate No	85366	**Lab. Pressure**	748 mmHg
Technician	Zenaida Ortiz	**Lab. Temperature**	22.6 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
26540.9 ccm	26461.27 ccm	0.3%	1.00%	In Tolerance
5325.13 ccm	5312.46 ccm	0.24%	1.00%	In Tolerance
1628.87 ccm	1624.94 ccm	0.24%	1.00%	In Tolerance
22 °C	22 °C	-	± 0.8°C	In Tolerance
748 mmHg	748 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML_800_10	103743	07-Apr-2015	06-Apr-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

MesaLabs

EEMS
01419

NVLAP®
NVLAP Lab Code 200661-0

Calibration Certificate

CertificateNo. 87566

Product 200-220L Definer 220 Low Flow

Serial No. 148737

Cal. Date 22-Mar-2016

Sales Date 21-Apr-2016 *Calibration interval commences on sale date.*

Sold To:
Environmental Engineering & Measurement Services
8010 SW 17th Place
Gainesville, FL 32607
US

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Calibration Data

Certificate No 87566
Technician Lilianna Malinowska
Lab. Pressure 751 mmHg
Lab. Temperature 21.9 °C

Instrument Reading	Lab Standard Reading	Deviation	Allowable Deviation	As Shipped
480.14 ccm	480.12 ccm	0.0%	1.00%	In Tolerance
107.89 ccm	107.98 ccm	-0.08%	1.00%	In Tolerance
33.13 ccm	33.2 ccm	-0.21%	1.00%	In Tolerance
21.5 °C	21.5 °C	-	± 0.8°C	In Tolerance
749 mmHg	749 mmHg	-	± 3.5 mmHg	In Tolerance

Mesa Laboratories Standards Used

Description	Standard Serial Number	Calibration Date	Calibration Due Date
ML_800_10	103743	07-Apr-2015	06-Apr-2016
Percision Thermometer	305460	21-Sep-2015	20-Sep-2016
Precision Barometer	2981392	28-Jun-2015	27-Jun-2016

MesaLabs

NVLAP Lab Code 200661-0

Calibration Notes

The expanded uncertainty of flow, temperature, and pressure measurements all have a coverage factor of k = 2 for a confidence interval of approximately 95%.

Flow testing is in accordance with our test number PR18-13 with an expanded uncertainty of 0.18% using high-purity nitrogen or filtered laboratory air. Flow readings in sccm are performed at STP of 21.1°C and 760 mmHg.

Pressure testing is in accordance with our test number PR18-11 with an expanded uncertainty of 0.16 mmHg.

Temperature testing is in accordance with our test number PR18-12 with an expanded uncertainty of 0.04 °C.

Traceability to the International System of Units (SI) is verified by accreditation to ISO/IEC 17025 by NVLAP under NVLAP Code 200661-0.

Technician Notes:

Louis Guido, Chief Metrologist

4/21/2016	01421	**DATA FROM MESA LABS**		test raw	test corr	% diff
		220	**std**			01421-01417
		1.62887	1.62494	4.0839	4.07	-0.83%
		5.32513	5.31246	6.0814	6.06	-0.59%
		26.5409	26.46127	9.1051	9.08	-0.60%
				12.089	12.05	-0.66%
	slope	1.003088				
	inter	-0.00231				

4/20/2016	01417	**DATA FROM MESA LABS**		test raw	test corr
		220	**std**		
		1.63229	1.62396	4.1229	4.11
		5.32516	5.30704	6.1229	6.10
		26.5325	26.4415	9.1659	9.13
				12.176	12.13
	slope	1.003371			
	inter	0.001647			

NVLAP Lab Code 200348-0

FLUKE® Calibration

Certificate of Calibration
Fluke Calibration, American Fork
Primary Temperature Laboratory

EEMS # 01229

Description:	Digital Thermometer with Probe	**Certificate Number:**	B5C18007
Manufacturer:	Fluke	**Date of Calibration:**	09 Dec 2015
Model:	1551A	**Date Due:**	
Serial Number:	3275143	**Temperature:**	21.0 to 25.0 °C
Status:	As-Found: New As-Left: In Tolerance	**Relative Humidity:**	15 to 60 %RH
Calibration:	Full	**Pressure:**	83.5 to 88.5 kPa
Procedure:	AFC124 - 001	**Issue Date:**	18 Dec 2015

page 1 of 2

Customer:	FOTRONIC CORPORATION MELROSE MA
PO Number:	0203284

This calibration is traceable to the SI through recognized national measurement institutes, ratiometric techniques, or natural physical constants and is in compliance with ISO17025:2005 and ANSI/NCSL Z540.1. The calibration has been completed in accordance with the Fluke Calibration Quality System document QSD 111.0. Calibration certificates without signatures are not valid. This certificate applies to only the item identified and shall not be reproduced other than in full, without the specific written approval by Fluke Corporation. This certificate shall not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government.

This calibration certificate may contain data that is not covered by the Scope of Accreditation. The unaccredited test points, where applicable, are indicated by an asterisk (*), or confined to clearly marked sections. Functional tests are not accredited.

Measurement uncertainties at the time of test are given where applicable. They are calculated in accordance with the method described in the ISO Guide to the Expression of Uncertainty in Measurement. The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k such that the coverage probability corresponds to approximately 95 %.

Comments:

Cert: B5C18007
Due:
S/N: 3275143

Electronically signed by
Approved Signatory
Michael Coleman
Metrologist

Certificate of Calibration

Model: 1551A
Serial No.: 3275143
Certificate No: B5C18007

Page 2 of 2

As Found Data

No As Found Data Required

EEMS # 01229

slope = 1.0000112
int = -0.001926

12/9/2015

As Left Data

Data ID: B5343072143703

Calibration Constants	
R0	100.003539
A	3.917265E-03
B	-6.408775E-07
C	-1.292775E-11
MINOP	-60
MAXOP	170

Nominal (°C)	Actual (°C)	Measured (°C)	Error (°C)	Tolerance (°C)	Uncertainty	Pass/Fail
-50	-49.9886	-49.9898	-0.0012	±0.0500	±0.0080	P
-25	-25.0848	-25.0911	-0.0063	±0.0500	±0.0080	P
0	-0.0078	-0.0070	0.0008	±0.0500	±0.0080	P
100	100.0117	100.0118	0.0001	±0.0500	±0.0080	P
157	156.9983	156.9973	-0.0010	±0.0500	±0.0080	P

Name	Reference	Offset
Device Calibration Constants		
DEVICE CAL 1	50.0080	0.0882
DEVICE CAL 2	100.0020	0.0760
DEVICE CAL 3	150.0070	0.0652
DEVICE CAL 4	200.0000	0.0598
User Calibration Constants		
USER CAL 1	-50.0000	0.0000
USER CAL 2	0.0000	0.0000
USER CAL 3	157.0000	0.0000

Certificate Number
A2062999
Issue Date: 12/23/15

Certificate of Calibration

EEMS #

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01226

Description: DIGITAL STIK THERMOMETER
Manufacturer: FLUKE
Model Number: 1551A EX
Serial Number: 2085085
Technician: JEFF BAHMANN
On-Site Calibration: ☐
Comments:

Calibration Date: 12/23/2015
Calibration Due: 12/23/2016
Procedure: FLUKE 1551A EX,52A EX Rev: 11/1/2010
Temperature: 70 F
Humidity: 40 % RH
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. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. 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/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1 and TMI's Quality Manual, QM-1.

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.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
30946	FLUKE	5616	9/8/2014	2/25/2016
A06118	HART SCIENTIFIC	9103	1/13/2015	5/13/2016
A11967	HART SCIENTIFIC	9140	10/29/2014	6/27/2016
A88072	FLUKE/HART	1502A	11/23/2015	3/5/2016

Certificate Number
A2062999
Issue Date: 12/23/15

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	-25.00	-25.05	-24.95	-25.02	-25.02	°C	
Temperature Accuracy	0.00	-0.05	0.05	0.05	0.05	°C	
Temperature Accuracy	100.00	99.95	100.05	99.96	99.96	°C	
Temperature Accuracy	150.00	149.95	150.05	149.95	149.95	°C	

12/23/2015

Slope = 0.9996275 EEMS # 01226

int = 0.0059542

r^2 = 0.999999

Date

1/19/2016 - - Calibration and verification of three RTD meters with most recent certification of EEMS RTD

TMI Data -- 12/23/2015

	TMI STD	EEMS RTD 01226	diff	(van 2) corrected
cert date=	12/23/2015			
	-25.00	-25.02	0.020	-25.035
	0.00	0.05	-0.050	0.044
	100.00	99.96	0.040	99.991
	150.00	149.95	0.050	150.000
			0.000	-0.006
			0.000	-0.006

RTD 01226

2016 correction:	slope=	0.9996275
	intercept=	0.0059542
	0.9999999	

1/19/2016

	At EEMS	**Date 1/19/2016** RTD 01226	**RTD 01230 / 01231** EEMS AER		**RTD 01227** EEMS SEG		**RTD 01228** EEMS van1		**RTD 01229** EEMS van1	
	raw	corrected	raw	corrected	raw	corrected	raw	corrected	raw	corrected
	0.02	0.01	0.03	0.00	0.02	0.00		#DIV/0!	0.01	0.04
	15.51	15.51	15.53	15.52	15.59	15.53		#DIV/0!	15.51	15.54
	28.73	28.73	28.75	28.75	28.85	28.75		#DIV/0!	28.73	28.76
	41.44	41.45	41.44	41.45	41.58	41.44		#DIV/0!	41.44	41.48
	51.08	51.09	51.06	51.08	51.25	51.09		#DIV/0!	51.08	51.12
slope =			**0.999048**		**1.00279**		**#DIV/0!**		**0.9998**	
intercept =			**0.027816**		**0.021429**		**#DIV/0!**		**-0.0284**	
correlation =			**1.0000**		**1.0000**		**#DIV/0!**		**1.0000**	

Date

1/10/2016 - - Calibration and verification of three thermocouples and fluke meters with most recent certification of EEMS RTD

TMI Data -- 12/23/2015

	TMI STD	EEMS RTD 01226	diff	corrected
cert date=	12/23/2015			
	-25.000	-25.02	0.020	-25.035
	0.000	0.05	-0.050	0.044
	100.000	99.96	0.040	99.991
	150.000	149.95	0.050	150.000
			0.000	-0.006
			0.000	-0.006

RTD 01230/01231

2016 correction:	slope=	0.99962748
	intercept=	0.0059542
	0.9999999	

1/10/2016

At EEMS RTD 01226 raw	Date 1/10/2016 corrected		fluke = 01311 EEMS SEG thermo = 01236 raw	corrected	fluke = 01312 EEMS van 2 thermo = 01237 raw	corrected	fluke = 01310 EEMS van 1 thermo = 01238 raw	corrected
0.02	0.01		0.1	0.09	0.1	0.12	0.1	0.07
15.62	15.62		15.6	15.58	15.6	15.60	15.7	15.65
31.79	31.80		31.8	31.77	31.7	31.69	31.8	31.72
50.64	50.65		50.6	50.56	50.6	50.58	50.7	50.59
68.69	68.71		68.8	68.75	68.8	68.76	68.9	68.76
89.91	89.90		90.0	89.94	90.0	89.95	90.2	90.03
80.46	80.45		80.5	80.45	80.5	80.45	80.5	80.34
	-0.01			-0.01		0.02		-0.03
Thermocouple offset =			-0.2		-0.6		0.4	
POST CALIBRATION CHECK								
23.63	23.63		23.7	23.68	23.6	23.60	23.6	23.53
		slope =	**1.000533**		**1.0007715**		**1.00161**	
		intercept =	**0.009986**		**-0.015795**		**0.02947**	
		correlation =	**1.0000**		**1.0000**		**1.0000**	

Standard Practice for Maintaining Constant Relative Humidity by Means of Aqueous Solutions[1]

This standard is issued under the fixed designation E 104; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice describes two methods for generating constant relative humidity (rh) environments in relatively small containers.

1.2 This practice is applicable for obtaining constant relative humidities ranging from dryness to near saturation at temperatures spanning from 0 to 50°C.

1.3 This practice is applicable for closed systems such as environmental conditioning containers and for the calibration of hygrometers.

1.4 This practice is not recommended for the generation of continuous (flowing) streams of constant humidity unless precautionary criteria are followed to ensure source stability. (See Section 9.)

1.5 **Caution**—Both saturated salt solutions and sulfuric acid-water solutions are extremely corrosive, and care should be taken in their preparation and handling.

1.6 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* (For more specific safety precautionary information see 1.5 and 10.1.)

2. Referenced Documents

2.1 *ASTM Standards:*

D 1193 Specification for Reagent Water[2]

D 4023 Definitions of Terms Relating to Humidity Measurements[3]

E 126 Test Method for Inspection and Verification of Hydrometers[4]

2.2 *Other Document:*

DIN50008 "Konstantklimate uber waBerigen Losungen" (Constant Climates Over Aqueous Solutions).
Part 1: Saturated Salt and Glycerol Solutions.
Part 2: Sulfuric Acid Solutions. (1981)[5]

3. Definitions

3.1 *non-hygroscopic material*—material which neither absorbs nor retains water vapor.

3.2 For definitions of other terms used in this practice refer to Definitions D 4023.

4. Summary of Practice

4.1 Standard value relative humidity environments are generated using selected aqueous saturated salt solutions or various strength sulfuric acid-water systems.

5. Significance and Use

5.1 Standard value relative humidity environments are important for conditioning materials in shelf-life studies or in the testing of mechanical properties such as dimensional stability and strength. Relative humidity is also an important operating variable for the calibration of many species of measuring instruments.

6. Interferences

6.1 Temperature regulation of any solution-head space environment to ±0.1°C is essential for realizing generated relative humidity values within ±0.5 % (expected).

6.2 *Sulfuric Acid*—Water systems are strongly hygroscopic and can substantially change value by absorption and desorption if stored in an open container. Only freshly prepared solutions, or solutions which values have been independently tested for strength should be used.

6.3 Some aqueous saturated salt solutions change composition following preparation by hydrolysis or by reaction with environmental components (for example, carbon dioxide absorption by alkaline materials). These solutions should be freshly prepared on each occasion of use.

7. Apparatus

7.1 *Container*—The container, including a cover or lid which can be secured airtight, should be made of corrosion resistant, non-hygroscopic material such as glass. A metal or plastic container is acceptable if the solution is retained in a dish or tray made of appropriate material. Refer also to 9.2 for size restrictions.

7.2 *Hydrometers*—One or more hydrometers may be used to test sulfuric acid solution densities for the range of humidities concerned. The hydrometer(s) should have a minimum scale division of 0.001 gm/cm^3. (Refer to Test Method E 126.)

---

[1] This practice is under the jurisdiction of ASTM Committee D-22 on Sampling and Analysis of Atmospheres and is the direct responsibility of Subcommittee D22.11 on Meteorology.

Current edition approved Feb. 22, 1985. Published June 1985.

[2] *Annual Book of ASTM Standards*, Vol 11.01.

[3] *Annual Book of ASTM Standards*, Vol 11.03.

[4] *Annual Book of ASTM Standards*, Vol 14.03.

[5] Published by Deutsches Institut für Normung, 4-10 Burggrzfenstrasse Postfach 1107, D-1000 Berlin, Federal Republic of Germany. Also available from ANSI Publication Office, New York, NY.

8. Reagents and Materials

8.1 *Purity of Reagents*—Reagent grade chemicals shall be used for preparation of all standard solutions. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.[6] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

8.1.1 Saturated salt solutions may be prepared using either amorphous or hydrated reagents (that is, reagents containing water of crystallization). Hydrated reagents are often preferred to amorphous forms for their solvating characteristics.

8.2 *Purity of Water*—Reagent water produced by distillation, or by ion exchange, or reverse osmosis followed by distillation shall be used. See Specification D 1193.

9. Technical Precautions

9.1 Although a container capable of airtight closure is described in Section 7, it may be desirable to have a vent under certain conditions of test or with some kinds of containers (changes in pressure may produce undesirable cracks in some types of containers). The vent should be as small as practical to minimize loss of desired equilibrium conditions when in use.

9.2 The container should be small to minimize the influence of any temperature variations acting upon the container and contents. A maximum proportion of 25 cm^3 volume/cm^2 of solution surface area is suggested, and overall container headspace volume should be no larger than necessary to confine a stored item.

9.3 Measurement accuracy is strongly dependent on the ability to achieve and maintain temperature stability during actual use of any solution system. Temperature instability of ±0.1°C can cause corresponding instabilities in generated values of relative humidity of ±0.5 %.

9.4 The compatibility of any constant relative humidity system used for instrument calibration testing should be confirmed by reference to the instrument manufacturer's instructions.

9.5 Important considerations leading to stability should include (but are not necessarily limited to) the following:

9.5.1 Elimination of leakage paths.

9.5.2 Elimination of heat sources or heat sinks, or both, for temperature stability.

9.5.3 Limiting flow rate to preclude source carry-over.

10. Preparations of Aqueous Solutions

10.1 Caution—Saturated salt-water systems and sulfuric acid solutions should be regarded as hazardous materials. Refer to 1.6 for guidelines.

10.2 *Saturated Salt-Water Systems:*

10.2.1 Select a salt of characteristic value from Annex A1.

NOTE —The reference document by Greenspan[7] contains information on many other saturated salt solutions which may be used. These additional systems, however, are less accurately or less completely defined in value. Also, some may only be used when freshly prepared (to limit the influence of chemical instability such as hydrolysis or acid gas absorption). The salts listed in Annex A1 can be used for a year or more.

10.2.2 Place a quantity of the selected salt in the bottom of a container or an insert tray to a depth of about 4 cm for low rh salts, or to a depth of about 1.5 cm for high rh salts.

10.2.3 Add water in about 2-mL increments, stirring well after each addition, until the salt can absorb no more water as evidenced by free liquid. Although a saturated solution system is defined when any excess quantity of undissolved solute is present, it is preferred to keep the excess liquid present to a minimum for ease in handling and for minimal impact on stability should temperature variations occur.

10.2.4 Close the container and allow 1 h for temperature stabilization.

10.2.5 The container may be used as a reservoir from which quantities of slush can be transferred for use, or the entire container may be used for conditioning tests.

10.3 *Sulfuric Acid-Water Solutions:*

10.3.1 Determine the acid concentration corresponding to the desired relative humidity value from Annex A2, interpolating as necessary.

10.3.2 Measure sufficient working quantities of sulfuric acid reagent and reagent water so that, when mixed in proper proportion, a sufficient depth of liquid is available for proper floatation of a test hydrometer. (See Section 9.)

10.3.3 Measure solution density after the sulfuric acid-water solution has cooled following mixing. Refer to Annex A2 for desired values.

10.3.4 Store the prepared mixture in a container with a tight-fitting lid. Check solution density before each occasion of use.

11. Precision and Bias

11.1 Under ideal conditions, the bias (accuracy) of the sources generated by this practice are equal to the uncertainty figures associated with each source value, as stated in the Annex tables. In actual use, lack of temperature equilibrium (±0.5°C) and other functional losses can reduce the bias statement to ±2.5 %. Precision is ±0.5 % rh.

---

[6] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, NY, and the "United States Pharmacopeia."

[7] Greenspan, L., "Humidity Fixed Points of Binary Saturated Aqueous Solutions," *Journal of Research*, National Institute of Standards and Technology, Vol. 81A, 1977, pp. 89–96.

ANNEXES

(Mandatory Information)

A1.1 EQUILIBRIUM RELATIVE HUMIDITY VALUES FOR SELECTED SATURATED AQUEOUS SALT SOLUTIONS

Temperature (°C)	Lithium Chloride[A] LiCl, %	Potassium Acetate[A] CH_3COOK	Magnesium Chloride[A] $MgCl_2 \cdot 6H_2O$, %	Potassium Carbonate[A] K_2CO_3, %	Magnesium Nitrate[A] $Mg(NO_3)_2 \cdot 6H_2O$, %	Sodium Chloride[A] NaCl, %	Potassium Chloride[A] KCl, %	Barium Chloride[B] $BaCl_2 \cdot H_2O$, %	Potassium Nitrate[A] KNO_3, %	Potassium Sulfate[A] K_2SO_4, %
0	11.2 ± 0.5	...	33.7 ± 0.3	43.1 ± 0.7	60.4 ± 0.6	75.5 ± 0.3	88.6 ± 0.5	...	96.3 ± 2.9	98.8 ± 2.1
5	11.3 ± 0.5	...	33.6 ± 0.3	43.1 ± 0.5	58.9 ± 0.4	75.7 ± 0.3	87.7 ± 0.5	93 ± 2	96.3 ± 2.1	98.5 ± 0.9
10	11.3 ± 0.4	23.4 ± 0.5	33.5 ± 0.2	43.1 ± 0.4	57.4 ± 0.3	75.7 ± 0.2	86.8 ± 0.4	93 ± 2	96.0 ± 1.4	98.2 ± 0.8
15	11.3 ± 0.4	23.4 ± 0.3	33.3 ± 0.2	43.2 ± 0.3	55.9 ± 0.3	75.6 ± 0.2	85.9 ± 0.3	92 ± 2	95.4 ± 1.0	97.9 ± 0.6
20	11.3 ± 0.3	23.1 ± 0.3	33.1 ± 0.2	43.2 ± 0.3	54.4 ± 0.2	75.5 ± 0.1	85.1 ± 0.3	91 ± 2	94.6 ± 0.7	97.6 ± 0.5
25	11.3 ± 0.3	22.5 ± 0.3	32.8 ± 0.2	43.2 ± 0.4	52.9 ± 0.2	75.3 ± 0.1	84.3 ± 0.3	90 ± 2	93.6 ± 0.6	97.3 ± 0.5
30	11.3 ± 0.2	21.6 ± 0.5	32.4 ± 0.1	43.2 ± 0.5	51.4 ± 0.2	75.1 ± 0.1	83.6 ± 0.3	89 ± 2	92.3 ± 0.6	97.0 ± 0.4
35	11.3 ± 0.2	...	32.1 ± 0.1	...	49.9 ± 0.3	74.9 ± 0.1	83.0 ± 0.3	88 ± 2	90.8 ± 0.8	96.7 ± 0.4
40	11.2 ± 0.2	...	31.6 ± 0.1	...	48.4 ± 0.4	74.7 ± 0.1	82.3 ± 0.3	87 ± 2	89.0 ± 1.2	96.4 ± 0.4
45	11.2 ± 0.2	...	31.1 ± 0.1	...	46.9 ± 0.5	74.5 ± 0.2	81.7 ± 0.3	...	87.0 ± 1.8	96.1 ± 0.4
50	11.1 ± 0.2	...	30.5 ± 0.1	...	45.4 ± 0.6	74.4 ± 0.2	81.2 ± 0.3	...	84.8 ± 2.5	95.8 ± 0.5

[A] See "Humidity Fixed Points of Binary Saturated Aqueous Solutions," by L. Greenspan. Published in the *Journal of Research* by the National Institute of Standards and Technology, Vol 81A, 1977, pp. 89–96.

[B] See the German standard, DIN 50008, Constant Climates Over Aqueous Solutions, (referenced in 2.2).

A2. EQUILIBRIUM RELATIVE HUMIDITY VALUES FOR SULFURIC ACID-WATER SOLUTIONS

NOTE—The values shown in this table are stated with an uncertainty of ±1 % rh

Weight % H_2SO_4	Density, g/mL at 20°C	Density, g/mL at 23°C	Density, g/mL at 25 %	Equilibrium Relative Humidity in % at t°C			
				5°C	23°C	25°C	50°C
5	10 317	10 307	10 300	98	98	98	98
10	10 661	10 648	10 640	96	96	96	96
15	11 020	11 005	10 994	92	92	92	93
20	11 394	11 376	11 365	88	88	88	89
25	11 783	11 764	11 760	82	82	82	83
30	12 185	12 164	12 150	74	75	75	77
35	12 599	12 577	12 563	65	66	67	69
40	13 028	13 005	12 991	54	56	57	59
45	13 476	13 452	13 437	43	46	46	49
50	13 591	13 972	13 911	32	35	35	38
55	14 453	14 428	14 412	23	25	25	28
60	14 983	14 957	14 940	14	16	16	19
65	15 533	15 507	15 490	8	9	9	11
70	16 105	16 077	16 059	4	4	5	6

Date

1/23/2016 - - Calculation of correction factor for RH standard with most recent certification of EEMS Hygropalm

TMI - Certification date = 12/24/2015

	TMI STD	EEMS Hygropalm 01225	diff	corrected
cert date=	4/11/2015			
	33.000	33.40	-0.400	33.279
	50.000	49.30	0.700	49.532
	75.000	74.40	0.600	75.189

Rotronic 01225

2016 correction:	slope=	0.9783
for RH	intercept=	0.8446
	0.9998137	

At EEMS raw	**Date 1/23/2016** Hygropalm 01225 corrected	**salt**	EEMS to 01225 ID = 01220 raw	corrected	EEMS to salt 01220 raw	corrected	EEMS to salt 01225 raw	corrected
33.2	33.07	**32.8**	33.9	32.69	33.9	34.51	33.2	35.01
53.7	54.03	**52.9**	54.5	53.61	54.5	56.58	53.7	57.19
70.9	71.61	**75.3**	74.1	73.50	74.1	77.58	70.9	75.80
90.7	91.85	**93.6**	91.1	90.76	91.1	95.79	90.7	97.22
	-0.86			-1.72		-1.81		-0.91
	-0.86			-1.72		-1.81		-0.91
	-0.86			-1.72		-1.81		-0.91
	-0.86			-1.72		-1.81		-0.91

POST CALIBRATION CHECK

	EEMS to 01225 (01220)	EEMS to salt (01220)	EEMS to salt (01225)
slope =	**0.985069**	**0.9333384**	**0.92426**
intercept =	**1.693537**	**1.6935374**	**0.84459**
correlation =	**0.9987**	**0.9987**	**1.0000**

Certificate Number
A2063482
Issue Date: 12/24/15

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

EEMS#

P.O. Number:
ID Number: 01225

Description: THERMO HYGROMETER
Manufacturer: ROTRONIC
Model Number: HYGROPALM
Serial Number: 40861 002/124431
Technician: SEAN LEWIS
On-Site Calibration: ☐
Comments:

Limiting Attribute:

Calibration Date: 12/24/2015
Calibration Due: 12/24/2016
Procedure: TMI-M-HYGROTHERMOGRAPHS Rev: 2/22/2011
Temperature: 70 F
Humidity: 43 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

RH: m = 0.9783
b = 0.8446 r^2 = 0.9998

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. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. 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/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1 and TMI's Quality Manual, QM-1.

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.

FRANK BAHMANN, BRANCH MANAGER

Jack Shuler
JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
9304027	THUNDER SCIENTIFIC	2500	4/11/2015	4/11/2016

Temp: m = 0.97865
b = 1.56232 °F
r^2 = 0.99996

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

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	61.7	61.3	62.1	62.0	62.0	°F	
Temperature Accuracy	68.9	68.5	69.3	68.9	68.9	°F	
Temperature Accuracy	79.6	79.2	80.0	79.5	79.5	°F	
Relative Humidity Accuracy	33.0	32.0	34.0	33.4	33.4	%RH	
Relative Humidity Accuracy	50.0	48.8	51.3	49.3	49.3	%RH	
Relative Humidity Accuracy	75.0	73.5	76.6	74.4	74.4	%RH	

Certificate Number
A2063483
Issue Date: 12/24/15

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 45656048/124432

Description: TEMP/HUM PROBE
Manufacturer: ROTRONIC
Model Number: HYGROCLIP
Serial Number: 45656 048/124432
Technician: SEAN LEWIS
On-Site Calibration: ☐
Comments:

Calibration Date: 12/24/2015
Calibration Due: 12/24/2016
Procedure: TMI-M-HYGROTHERMOGRAPHS Rev: 2/22/2011
Temperature: 70 F
Humidity: 43 % RH
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. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. 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/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1 and TMI's Quality Manual, QM-1.

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.

FABA

FRANK BAHMANN, BRANCH MANAGER

Jack Shuler

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
9304027	THUNDER SCIENTIFIC	2500	4/11/2015	4/11/2016

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	61.7	61.3	62.1	62.0	62.0	°F	
Temperature Accuracy	68.9	68.5	69.3	68.9	68.9	°F	
Temperature Accuracy	79.6	79.2	80.0	79.5	79.5	°F	
Relative Humidity Accuracy	33.0	32.0	34.0	33.4	33.4	%RH	
Relative Humidity Accuracy	50.0	48.8	51.3	49.3	49.3	%RH	
Relative Humidity Accuracy	75.0	73.5	76.6	74.4	74.4	%RH	

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:	Environmental Engineering & Measurement Services, Inc.	
Purchase Order #:		
Instrument:	Ushikata Tracon S-25 Compass	
Serial Number:	191832	BEC (SEG)
Quantity:	1	
Calibration Due:	12/2016	12/9/2015

Page 1 of 2

John Noga, Quality Control

January 14, 2016

Measurement Standards
Theodolite Wild T-3 S/N 18801 Calibration 02/06/15 Due 02/06/16 NIST Number 738/229329-83 738/223398
Optical Wedge K&E 71-7020 S/N 5167 Calibration 02/12/14 Due 02/12/19 731/244084-89 731/2216117

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

Calibration Data Record			Temperature:	Humidity:
Customer Name	GE & MS	Item Name	USHIKATA	
Manufacturer	BEC	Model		
Serial Number	191832	Calibration Date	12-9-15	
Calibration Frequency		Job Card Number	S-23060	
Customer Reference Number		Date of Certification	12-9-15	

Measurement Standards

Theodolite Wild T-3 S/N 18801 Calibration 02/12/15 Due 02/12/16 NIST Number 738/229329-83 738/223398

Optical Wedge K&E 71-7020 S/N 5167 Calibration; 02/12/14 Due 2/12/19, NIST Number 731/244084-89 731/221617

Initial Report

Vanes		Direction (Degree)	Tolerance (Minute)	Compass Needle Error (Minute)
Pivot in line with Circle/Sights	☐ Pass ☐ Fail	0	+/- 30	
Needle		45	+/- 30	
Pivot Sharpness	☐ Pass ☐ Fail	90	+/- 30	
Straightness (+/-15 Minutes)	☐ Pass ☐ Fail	135	+/- 30	
Balance	☐ Pass ☐ Fail	180	+/- 30	
Lifter Function	☐ Pass ☐ Fail	225	+/- 30	
Azimuth Ring		270	+/- 30	
Control Knob Function	☐ Pass ☐ Fail	315	+/- 30	
Pinion Gear	☐ Pass ☐ Fail			
Graduation Clarity	☐ Pass ☐ Fail			
Graduation less than 1 minute in any position	☐ Pass ☐ Fail			
Level Bubble				
Bubble in Level	☐ Pass ☐ Fail			
Physical Condition	☐ Pass ☐ Fail			

Pass/Repair/Replace

Pass	N/A	Replace	Repair	
☐	☐	☐	☐	Needle ☐ Sharpen ☐ Magnetize
☐	☐	☐	☐	Cap with Jewel
☐	☐	☐	☐	Pivot ☐ Sharpen
☐	☐	☐	☐	Level ☐ Remount
☐	☐	☐	☐	North Sight
☐	☐	☐	☐	North Sight Block
☐	☐	☐	☐	South Sight
☐	☐	☐	☐	South Sight Block
☐	☐	☐	☐	Vane Spring
☐	☐	☐	☐	Drive
☐	☐	☐	☐	Control Knob Assembly
☐	☐	☐	☐	Cover Glass
☐	☐	☐	☐	Cover Glass Gasket
☐	☐	☐	☐	Clamp Screw
☐	☐	☐	☐	Pinion Gear
☐	☐	☐	☐	Compass Ring

Final Report

Vanes		Direction (Degree)	Tolerance (Minute)	Compass Needle Error (Minute)
Pivot in line with Circle/Sights	☑ Pass ☐ Fail	0	+/- 30	< 30
Needle		45	+/- 30	< 30
Pivot Sharpness	☑ Pass ☐ Fail	90	+/- 30	< 30
Straightness (+/-15 Minutes)	☑ Pass ☐ Fail	135	+/- 30	< 30
Balance	☑ Pass ☐ Fail	180	+/- 30	< 30
Lifter Function	☑ Pass ☐ Fail	225	+/- 30	< 30
Azimuth Ring		270	+/- 30	< 30
Control Knob Function	☑ Pass ☐ Fail	315	+/- 30	< 30
Pinion Gear	☑ Pass ☐ Fail			
Graduation Clarity	☑ Pass ☐ Fail			
Graduation less than 1 minute in any position	☑ Pass ☐ Fail			
Level Bubble				
Bubble in Level	☑ Pass ☐ Fail			
Physical Condition	☑ Pass ☐ Fail			

Certification

Joseph Paslogyi	
Repair Technician	John Noga, Quality Assurance

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:	Environmental Engineering & Measurement Services, Inc.
Purchase Order #:	Van # 1
Instrument:	Ushikata Tracon S-25 Compass
Serial Number:	190037 EEMS # 01265
Quantity:	1
Calibration Due:	~~12/2016~~ 12/9/2015

Page 1 of 2

John Noga, Quality Control

January 14, 2016

Measurement Standards
Theodolite Wild T-3 S/N 18801 Calibration 02/06/15 Due 02/06/16 NIST Number 738/229329-83 738/223398
Optical Wedge K&E 71-7020 S/N 5167 Calibration 02/12/14 Due 02/12/19 731/244084-89 731/2216117

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

Calibration Data Record			Temperature:	Humidity:
Customer Name	EEVMS	Item Name	USHIKATA	
Manufacturer	01265	Model		
Serial Number	190037	Calibration Date	12-9-15	
Calibration Frequency		Job Card Number	S-23058	
Customer Reference Number		Date of Certification	12-9-15	

Measurement Standards

Theodolite Wild T-3 S/N 18801 Calibration 02/12/15 Due 02/12/16 NIST Number 738/229329-83 738/223398

Optical Wedge K&E 71-7020 S/N 5167 Calibration; 02/12/14 Due 2/12/19, NIST Number 731/244084-89 731/221617

Initial Report

Vanes	
Pivot in line with Circle/Sights	☐ Pass ☐ Fail
Needle	
Pivot Sharpness	☐ Pass ☐ Fail
Straightness (+/-15 Minutes)	☐ Pass ☐ Fail
Balance	☐ Pass ☐ Fail
Lifter Function	☐ Pass ☐ Fail
Azimuth Ring	
Control Knob Function	☐ Pass ☐ Fail
Pinion Gear	☐ Pass ☐ Fail
Graduation Clarity	☐ Pass ☐ Fail
Graduation less than 1 minute in any position	☐ Pass ☐ Fail
Level Bubble	
Bubble in Level	☐ Pass ☐ Fail
Physical Condition	☐ Pass ☐ Fail

Direction (Degree)	Tolerance (Minute)	Compass Needle Error (Minute)
0	+/-30	
45	+/-30	
90	+/-30	
135	+/-30	
180	+/-30	
225	+/-30	
270	+/-30	
315	+/-30	

Pass/Repair/Replace

Pass	N/A	Replace	Repair	
☐	☐	☐	☐	Needle ☐ Sharpen ☐ Magnetize
☐	☐	☐	☐	Cap with Jewel
☐	☐	☐	☐	Pivot ☐ Sharpen
☐	☐	☐	☐	Level ☐ Remount
☐	☐	☐	☐	North Sight
☐	☐	☐	☐	North Sight Block
☐	☐	☐	☐	South Sight
☐	☐	☐	☐	South Sight Block
☐	☐	☐	☐	Vane Spring
☐	☐	☐	☐	Drive
☐	☐	☐	☐	Control Knob Assembly
☐	☐	☐	☐	Cover Glass
☐	☐	☐	☐	Cover Glass Gasket
☐	☐	☐	☐	Clamp Screw
☐	☐	☐	☐	Pinion Gear
☐	☐	☐	☐	Compass Ring

Final Report

Vanes	
Pivot in line with Circle/Sights	☑ Pass ☐ Fail
Needle	
Pivot Sharpness	☑ Pass ☐ Fail
Straightness (+/-15 Minutes)	☑ Pass ☐ Fail
Balance	☑ Pass ☐ Fail
Lifter Function	☑ Pass ☐ Fail
Azimuth Ring	
Control Knob Function	☑ Pass ☐ Fail
Pinion Gear	☑ Pass ☐ Fail
Graduation Clarity	☑ Pass ☐ Fail
Graduation less than 1 minute in any position	☑ Pass ☐ Fail
Level Bubble	
Bubble in Level	☑ Pass ☐ Fail
Physical Condition	☑ Pass ☐ Fail

Direction (Degree)	Tolerance (Minute)	Compass Needle Error (Minute)
0	+/-30	<30
45	+/-30	<30
90	+/-30	<30
135	+/-30	<30
180	+/-30	<30
225	+/-30	<30
270	+/-30	<30
315	+/-30	<30

Certification

Joseph Paolozzi	
Repair Technician	John Noga, Quality Assurance

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:	Environmental Engineering & Measurement Services, Inc.
Purchase Order #:	
Instrument:	Ushikata Tracon S-25 Compass
Serial Number:	199578 EEMS # 01272
Quantity:	1
Calibration Due:	~~12/2016~~ 12/9/2015

Page 1 of 2

John Noga, Quality Control

January 14, 2016

Measurement Standards
Theodolite Wild T-3 S/N 18801 Calibration 02/06/15 Due 02/06/16 NIST Number 738/229329-83 738/223398
Optical Wedge K&E 71-7020 S/N 5167 Calibration 02/12/14 Due 02/12/19 731/244084-89 731/2216117

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

Calibration Data Record			Temperature:	Humidity:
Customer Name	GE 4/45	Item Name	USHIKATA	
Manufacturer	01272	Model		
Serial Number	199578	Calibration Date	12-9-15	
Calibration Frequency		Job Card Number	S-23059	
Customer Reference Number		Date of Certification	12-9-15	

Measurement Standards

Theodolite Wild T-3 S/N 18801 Calibration 02/12/15 Due 02/12/16 NIST Number 738/229329-83 738/223398

Optical Wedge K&E 71-7020 S/N 5167 Calibration; 02/12/14 Due 2/12/19, NIST Number 731/244084-89 731/221617

Initial Report

Vanes	
Pivot in line with Circle/Sights	☐ Pass ☐ Fail
Needle	
Pivot Sharpness	☐ Pass ☐ Fail
Straightness (+/-15 Minutes)	☐ Pass ☐ Fail
Balance	☐ Pass ☐ Fail
Lifter Function	☐ Pass ☐ Fail
Azimuth Ring	
Control Knob Function	☐ Pass ☐ Fail
Pinion Gear	☐ Pass ☐ Fail
Graduation Clarity	☐ Pass ☐ Fail
Graduation less than 1 minute in any position	☐ Pass ☐ Fail
Level Bubble	
Bubble in Level	☐ Pass ☐ Fail
Physical Condition	☐ Pass ☐ Fail

Direction (Degree)	Tolerance (Minute)	Compass Needle Error (Minute)
0	+/- 30	
45	+/- 30	
90	+/- 30	
135	+/- 30	
180	+/- 30	
225	+/- 30	
270	+/- 30	
315	+/- 30	

Pass/Repair/Replace

Pass	N/A	Replace	Repair	
☐	☐	☐	☐	Needle ☐ Sharpen ☐ Magnetize
☐	☐	☐	☐	Cap with Jewel
☐	☐	☐	☐	Pivot ☐ Sharpen
☐	☐	☐	☐	Level ☐ Remount
☐	☐	☐	☐	North Sight
☐	☐	☐	☐	North Sight Block
☐	☐	☐	☐	South Sight
☐	☐	☐	☐	South Sight Block
☐	☐	☐	☐	Vane Spring
☐	☐	☐	☐	Drive
☐	☐	☐	☐	Control Knob Assembly
☐	☐	☐	☐	Cover Glass
☐	☐	☐	☐	Cover Glass Gasket
☐	☐	☐	☐	Clamp Screw
☐	☐	☐	☐	Pinion Gear
☐	☐	☐	☐	Compass Ring

Final Report

Vanes	
Pivot in line with Circle/Sights	☑ Pass ☐ Fail
Needle	
Pivot Sharpness	☑ Pass ☐ Fail
Straightness (+/-15 Minutes)	☑ Pass ☐ Fail
Balance	☑ Pass ☐ Fail
Lifter Function	☑ Pass ☐ Fail
Azimuth Ring	
Control Knob Function	☑ Pass ☐ Fail
Pinion Gear	☑ Pass ☐ Fail
Graduation Clarity	☑ Pass ☐ Fail
Graduation less than 1 minute in any position	☑ Pass ☐ Fail
Level Bubble	
Bubble in Level	☑ Pass ☐ Fail
Physical Condition	☑ Pass ☐ Fail

Direction (Degree)	Tolerance (Minute)	Compass Needle Error (Minute)
0	+/- 30	<30
45	+/- 30	<30
90	+/- 30	<30
135	+/- 30	<30
180	+/- 30	<30
225	+/- 30	<30
270	+/- 30	<30
315	+/- 30	<30

Certification

(signature) Repair Technician	John Noga, Quality Assurance

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: CA02777
(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

☐ New Unit(s)	☒ Service / Repair Unit ☒ No Calibration Adjustments Required	☐ As Found ☐ As Left

Traceable frequency meter used in calibration Model: DP5740 SN: 4863

Date of inspection 11 Dec 15
Inspection Interval One Year

EEMS # 01260 / 01261 / 01262

Tested By EC

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: CA04013
(18802 Comprised of Models 18820A Control Unit & 18830A Motor Assembly)
(18811 Comprised of Models 18820A Control Unit & 18831A Motor Assembly)

EEMS #s 01253 01254 01255

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	10,200	10,200
12,600	2100	12,600	12,600
15,000	2500	15,000	15,000
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

☐ New Unit(s)	☒ Service / Repair Unit ☒ No Calibration Adjustments Required	☐ As Found ☐ As Left

Traceable frequency meter used in calibration Model: DP5740 SN: 4863

Date of inspection 11 Feb 2016
Inspection Interval One Year

Tested By EC

EEMS #'s 01457 & 01456

R.M. Young Company
2801 Aero Park Drive
Traverse City, Michigan 49686 USA

Certificate of Calibration and Testing

Test Unit:		
Model:	18802	Serial Number: CA4353
Description:	Anemometer Drive - 200 to 15,000 Rpm - Comprised of Models 18820A Control Unit & 18830A Motor Assembly	

R.M. Young Company certifies that the above equipment has been inspected and calibrated using standards whose accuracies are traceable to the National Institute of Standards and Technologies (NIST).

Nominal Motor Rpm	27106D Output Frequency Hz (1)	Calculated Rpm (2)	Indicated Rpm (3)
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
☒ Clockwise and Counterclockwise rotation verified			

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

*Indicates out of tolerance

Traceable frequency meter used in calibration BK 1823

Date of inspection 3/7/16

Tested By [signature]

Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

Environics®

nqa. ISO 9001 Registered · ANAB Accredited

Series 9100

System SN 6496

EE/ms
01152

FLOW CALIBRATION/CERTIFICATION REPORT

MFC # 1 Size: 20 SLPM

SERIAL # 0115330001

This flow controller was calibrated using a NIST-traceable Flow Standard. This calibration was performed with AIR at a standard reference temperature of 77°F and a pressure of 29.92 in. Hg. This is not performance data. This data is used by the system operating modes to improve the flow accuracy.

	Set Flow	True Flow
5 %	1.0 SLPM	1.017 SLPM
10 %	2.0 SLPM	2.019 SLPM
20 %	4.0 SLPM	4.029 SLPM
30 %	6.0 SLPM	6.039 SLPM
40 %	8.0 SLPM	8.057 SLPM
50 %	10.0 SLPM	10.060 SLPM
60 %	12.0 SLPM	12.082 SLPM
70 %	14.0 SLPM	14.110 SLPM
80 %	16.0 SLPM	16.147 SLPM
90 %	18.0 SLPM	18.209 SLPM
100 %	20.0 SLPM	20.323 SLPM

Slope 1.0131
Intercept -0.0330

Verified by: Fennie Lundmark Date: 2-15-16

Computerized Gas Mixing / Dilution / Calibration Systems

Environics Inc. • 69 Industrial Park Road East • Tolland, CT 06084 • (860) 872-1111 • Fax: (860) 870-9333
World Wide Web: http://www.environics.com E-mail: info@environics.com

EEMS
01152

Series 9100

System SN 6496

FLOW CALIBRATION/CERTIFICATION REPORT

MFC # 2 Size: 100 SCCM

SERIAL # 0106722025

This flow controller was calibrated using a NIST-traceable Flow Standard. This calibration was performed with AIR at a standard reference temperature of 77°F and a pressure of 29.92 in. Hg. This is not performance data. This data is used by the system operating modes to improve the flow accuracy.

	Set Flow	True Flow
5 %	5.0 SCCM	5.303 SCCM
10 %	10.0 SCCM	10.409 SCCM
20 %	20.0 SCCM	20.683 SCCM
30 %	30.0 SCCM	30.839 SCCM
40 %	40.0 SCCM	40.997 SCCM
50 %	50.0 SCCM	51.149 SCCM
60 %	60.0 SCCM	61.482 SCCM
70 %	70.0 SCCM	71.545 SCCM
80 %	80.0 SCCM	81.693 SCCM
90 %	90.0 SCCM	92.085 SCCM
100 %	100.0 SCCM	102.610 SCCM

Slope 1.0216
Intercept 0.1661

Verified by: Terrie Lundmark Date: 2-15-16

EEMS
01152

Series 9100

System SN 6496

FLOW CALIBRATION/CERTIFICATION REPORT

MFC # 3 Size: 10 SCCM

SERIAL # 0009449001

This flow controller was calibrated using a NIST-traceable Flow Standard. This calibration was performed with AIR at a standard reference temperature of 77°F and a pressure of 29.92 in. Hg. This is not performance data. This data is used by the system operating modes to improve the flow accuracy.

	Set Flow	True Flow
5 %	0.5 SCCM	0.525 SCCM
10 %	1.0 SCCM	1.053 SCCM
20 %	2.0 SCCM	2.089 SCCM
30 %	3.0 SCCM	3.122 SCCM
40 %	4.0 SCCM	4.137 SCCM
50 %	5.0 SCCM	5.160 SCCM
60 %	6.0 SCCM	6.163 SCCM
70 %	7.0 SCCM	7.151 SCCM
80 %	8.0 SCCM	8.148 SCCM
90 %	9.0 SCCM	9.194 SCCM
100 %	10.0 SCCM	10.199 SCCM

Slope 1.0156
Intercept 0.0523

Verified by: Terrie Lundmark Date: 2-15-16

Environics Inc. • 69 Industrial Park Road East • Tolland, CT 06084 • (860) 872-1111 • Fax: (860) 870-9333
World Wide Web: http://www.environics.com E-mail: info@environics.com

Certificate Number
A2062909
Issue Date: 12/23/15

Certificate of Calibration

EEMS #

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01310

Description: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 187
Serial Number: 86590148
Technician: MIKE CASOLI
On-Site Calibration: ☐
Comments:

Calibration Date: 12/23/2015
Calibration Due: 12/23/2016
Procedure: METCAL FLUKE 187 Rev: 6/15/2015
Temperature: 68 F
Humidity: 42 % RH
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. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. 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/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1 and TMI's Quality Manual, QM-1.

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.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
1727902	FLUKE	5522A/SC1100	10/14/2015	10/14/2016

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 187
Multimeter

Instrument Data Sheet

ID Number: 01310
Serial Number: 85690148

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
DISPLAY OPERATIONAL VERIFICATION							
Display Test						Pass	
BACKLIGHT OPERATIONAL VERIFICATION							
Backlight Test						Pass	
INPUT ALERT OPERATIONAL VERIFICATION							
Alert Function / Non-Current Functions						Pass	
Alert Function OHMS / mA Input						Pass	
No Alert Function mAmps / mA Input						Pass	
KEYPAD OPERATIONAL VERIFICATION							
Keypad Buttons Operational						Pass	
AC VOLTAGE VERIFICATION TEST							
4.5000 V @ 20 Hz		4.4758	4.4020	4.5980	V	Pass	
4.5000 V @ 45 Hz		4.4957	4.4780	4.5220	V	Pass	
4.5000 V @ 1 kHz		4.5027	4.4780	4.5220	V	Pass	
4.5000 V @ 10 kHz		4.4997	4.4780	4.5220	V	Pass	
4.5000 V @ 20 kHz		4.4961	4.4285	4.5715	V	Pass	
4.5000 V @ 100 kHz		4.4467	4.1360	4.8640	V	Pass	
45.000 V @ 45 Hz		44.955	44.780	45.220	V	Pass	
45.000 V @ 1 kHz		45.026	44.780	45.220	V	Pass	
45.000 V @ 10 kHz		45.094	44.780	45.220	V	Pass	
45.000 V @ 20 kHz		45.284	44.285	45.715	V	Pass	
450.00 V @ 45 Hz		449.51	447.80	452.20	V	Pass	
450.00 V @ 1 kHz		450.27	447.80	452.20	V	Pass	
450.00 V @ 10 kHz		451.15	447.80	452.20	V	Pass	
900.0 V @ 45 Hz		898.6	892.4	907.6	V	Pass	
900.0 V @ 1 kHz		900.0	892.4	907.6	V	Pass	
900.0 V @ 10 kHz		902.8	892.4	907.6	V	Pass	
45.0000 mV @ 20 Hz		44.8540	44.0200	45.9800	mV	Pass	
45.000 mV @ 45 Hz		45.049	44.780	45.220	mV	Pass	
45.000 mV @ 1 kHz		44.940	44.780	45.220	mV	Pass	
45.000 mV @ 10 kHz		43.556	42.710	47.290	mV	Pass	
45.000 mV @ 20 kHz		43.399	42.485	47.515	mV	Pass	
45.000 mV @ 100 kHz		41.001	38.210	51.790	mV	Pass	
450.00 mV @ 20 Hz		447.61	440.20	459.80	mV	Pass	
450.00 mV @ 45 Hz		450.53	447.80	452.20	mV	Pass	
450.00 mV @ 1 kHz		449.27	447.80	452.20	mV	Pass	
450.00 mV @ 10 kHz		434.50	427.10	472.90	mV	Pass	
450.00 mV @ 20 kHz		433.60	424.85	475.15	mV	Pass	
450.00 mV @ 100 kHz		431.88	413.60	486.40	mV	Pass	
2900.0 mV @ 20 Hz		2876.7	2834.0	2966.0	mV	Pass	

Instrument Data Sheet

ID Number: 01310
Serial Number: 85690148

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
2900.0 mV @ 45 Hz		2891.9	2884.4	2915.6	mV	Pass	
2900.0 mV @ 1 kHz		2901.8	2884.4	2915.6	mV	Pass	
2900.0 mV @ 10 kHz		2898.6	2884.4	2915.6	mV	Pass	
2900.0 mV @ 20 kHz		2895.6	2852.5	2947.5	mV	Pass	
2900.0 mV @ 100 kHz		2962.6	2664.0	3136.0	mV	Pass	

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FREQUENCY ACCURACY VERIFICATION TEST

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20.000 kHz @ 150 mV		20.000	19.998	20.002	kHz	Pass

===

DC VOLTAGE VERIFICATION TEST

===

5.0000 V		4.9995	4.9977	5.0023	V	Pass
4.0000 V		3.9996	3.9980	4.0020	V	Pass
3.0000 V		2.9997	2.9982	3.0018	V	Pass
2.0000 V		1.9998	1.9985	2.0015	V	Pass
1.0000 V		0.9998	0.9987	1.0013	V	Pass
-5.0000 V		-4.9993	-5.0023	-4.9977	V	Pass
50.000 V		49.994	49.982	50.018	V	Pass
-50.000 V		-49.993	-50.018	-49.982	V	Pass
500.00 V		499.95	499.48	500.52	V	Pass
-500.00 V		-499.93	-500.52	-499.48	V	Pass
1000.0 V		999.8	998.8	1001.2	V	Pass
-1000.0 V		-999.7	-1001.2	-998.8	V	Pass

==

DCV + ACV MEASUREMENT ACCURACY VERIFICATION

==

4.5000 V @ 1 kHz		4.5031	4.4735	4.5265	V	Pass
45.000 V @ 1 kHz		45.031	44.735	45.265	V	Pass
450.00 V @ 1 kHz		450.34	447.35	452.65	V	Pass
900.0 V @ 1 kHz		901.8	891.5	908.5	V	Pass

==

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50.000 mV		50.003	49.930	50.070	mV	Pass
-50.000 mV		-49.991	-50.070	-49.930	mV	Pass
500.00 mV		499.99	499.83	500.17	mV	Pass
-500.00 mV		-499.96	-500.17	-499.83	mV	Pass
2900.0 mV		2900.0	2898.8	2901.2	mV	Pass
-2900.0 mV		-2899.9	-2901.2	-2898.8	mV	Pass

==

DCmV+ACmV MEASUREMENT ACCURACY VERIFICATION

==

45.000 mV @ 1 kHz		44.925	42.350	47.650	mV	Pass
450.00 mV @ 1 kHz		449.18	447.35	452.65	mV	Pass
2900.0 mV @ 1 kHz		2902.9	2891.5	2908.5	mV	Pass

===

RESISTANCE VERIFICATION TEST

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 187
Multimeter

Instrument Data Sheet

ID Number: 01310
Serial Number: 85690148

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
190.00 Ohm		190.04	189.80	190.20	Ω	Pass	
1.9000 kOhm		1.9000	1.8988	1.9012	kΩ	Pass	
19.000 kOhm		19.000	18.988	19.012	kΩ	Pass	
190.00 kOhm		190.00	189.88	190.12	kΩ	Pass	
1.9000 MOhm		1.8997	1.8967	1.9033	MΩ	Pass	
19.000 MOhm		19.003	18.806	19.194	MΩ	Pass	
100.0 MOhm		99.8	96.8	103.2	MΩ	Pass	
CONDUCTANCE VERIFICATION TEST							
10.00 nS		10.02	9.80	10.20	nS	Pass	
AC CURRENT TEST VERIFICATION							
45.000 mA @ 1 kHz		45.047	44.642	45.358	mA	Pass	
350.00 mA @ 1 kHz		350.39	347.32	352.68	mA	Pass	
450.00 µA @ 1 kHz		450.32	446.42	453.58	µA	Pass	
4500.0 µA @ 1 kHz		4502.9	4465.7	4534.3	µA	Pass	
DC CURRENT VERIFICATION TEST							
45.000 mA		45.011	44.922	45.078	mA	Pass	
350.00 mA		350.15	349.45	350.55	mA	Pass	
450.00 µA		450.01	448.67	451.33	µA	Pass	
4500.0 µA		4500.0	4488.5	4511.5	µA	Pass	
AC CURRENT VERIFICATION TEST (cont.)							
4.5000 A @ 1 kHz		4.5039	4.4305	4.5695	A	Pass	
10.000 A @ 1 kHz		10.007	9.845	10.155	A	Pass	
DC CURRENT VERIFICATION TEST (cont.)							
4.5000 A		4.5003	4.4765	4.5235	A	Pass	
10.000 A		10.000	9.948	10.052	A	Pass	
CAPACITANCE VERIFICATION TESTS							
0.900 nF		0.897	0.877	0.923	nF	Pass	1.59
9.10 nF		9.19	8.96	9.24	nF	Pass	
90.1 nF		90.1	88.7	91.5	nF	Pass	
1.000 µF		1.000	0.985	1.015	µF	Pass	

PROCEDURE NAME: FLUKE:187:VOLTMETER DIGITAL:5520A:1.01:06/15/2015

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 187
Multimeter

Instrument Data Sheet

ID Number: 01310
Serial Number: 85690148

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
TEMPERATURE ACCURACY VERIFICATION							
-10.0 °C		-9.9	-11.1	-8.9	°C	Pass	
0.0 °C		0.0	-1.0	1.0	°C	Pass	
100.0 °C		100.1	98.0	102.0	°C	Pass	
350.0 °C		350.2	345.5	354.5	°C	Pass	

***** End of Certificate *****

Certificate Number
A2062914
Issue Date: 12/23/15

Certificate of Calibration

EEMS

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01311

Description: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 287
Serial Number: 95740135
Technician: MIKE CASOLI
On-Site Calibration: ☐
Comments:

Calibration Date: 12/23/2015
Calibration Due: 12/23/2016
Procedure: METCAL FLUKE 287 Rev: 6/15/2015
Temperature: 68 F
Humidity: 42 % RH
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. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. 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/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1 and TMI's Quality Manual, QM-1.

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.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
1727902	FLUKE	5522A/SC1100	10/14/2015	10/14/2016

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

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 287
Multimeter

Instrument Data Sheet

ID Number: 01311
Serial Number: 95740135

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
IDENTIFICATION & FIRMWARE REVISION							
Manufacturer: FLUKE							
Model: 287							
Serial Number: 95740135							
Firmware Level: V1.00							
TONE WARNING VERIFICATION							
Tone Warning Functional						Pass	
DCmV MEASUREMENT ACCURACY VERIFICATION							
0.000 mV		0.001	-0.020	0.020	mV	Pass	
0.025 mV		0.025	0.005	0.045	mV	Pass	
-0.025 mV		-0.025	-0.045	-0.005	mV	Pass	
50.000 mV		50.001	49.955	50.045	mV	Pass	
500.00 mV		500.00	499.86	500.14	mV	Pass	
-250.00 mV		-249.99	-250.08	-249.92	mV	Pass	
50.00 mV		50.00	49.97	50.03	mV	Pass	
DCmV + ACmV MEASUREMENT ACCURACY VERIFICATION							
250.00 mV @ 35 kHz		248.48	237.10	262.90	mV	Pass	
RESISTANCE MEASUREMENT ACCURACY VERIFICATION							
0.00 Ohm		0.01	-0.10	0.10	Ωs	Pass	
1.000 Ohm		0.990	0.899	1.101	Ωs	Pass	
190.00 Ohm		190.02	189.81	190.19	Ωs	Pass	
1.90000 kOhm		1.90019	1.89885	1.90115	kΩs	Pass	
19.000 kOhm		19.005	18.988	19.012	kΩs	Pass	
190.000 kOhm	190.0100	190.000	189.895	190.125	kΩs	Pass	
1.9000 MOhm		1.9009	1.8967	1.9032	MΩs	Pass	
10.000 MOhm		10.007	9.846	10.154	MΩs	Pass	
100.00 MOhm	100.300	100.00	92.08	108.52	MΩs	Pass	
ACmV MEASUREMENT ACCURACY VERIFICATION							
5.000 mV @ 20 Hz		5.001	4.865	5.135	mV	Pass	
50.000 mV @ 65 kHz		48.623	48.210	51.790	mV	Pass	
50.00 mV @ 100 kHz		49.06	47.85	52.15	mV	Pass	
250.00 mV @ 65 kHz		246.61	240.85	259.15	mV	Pass	
500.00 mV @ 45 Hz		499.63	498.25	501.75	mV	Pass	

PROCEDURE NAME: FLUKE:287:VOLTMETER DIGITAL:5520A:1.01:06/15/2015

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 287
Multimeter

Instrument Data Sheet

ID Number: 01311
Serial Number: 95740135

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
FREQUENCY MEASUREMENT ACCURACY VERIFICATION							
45.000 Hz @ 500 mV		45.000	44.986	45.014	Hz	Pass	
950.00 kHz @ 600 mV		950.00	949.90	950.10	kHz	Pass	
ACV MEASUREMENT ACCURACY VERIFICATION							
0.1000 V @ 60 Hz		0.1010	0.0952	0.1048	V	Pass	
0.5000 V @ 10 kHz		0.4974	0.4945	0.5055	V	Pass	
3.0000 V @ 100 kHz		3.0469	2.8160	3.1840	V	Pass	
15.000 V @ 100 kHz		15.000	14.435	15.565	V	Pass	
500.00 V @ 10 kHz		499.41	497.75	502.25	V	Pass	
1000.0 V @ 10 kHz		999.4	993.5	1006.5	V	Pass	
DCV MEASUREMENT ACCURACY VERIFICATION							
4.0000 V		4.0000	3.9988	4.0012	V	Pass	
-40.000 V		-40.000	-40.012	-39.988	V	Pass	
400.00 V		399.99	399.86	400.14	V	Pass	
600.0 V		600.0	599.6	600.4	V	Pass	
DCV + ACV MEASUREMENT ACCURACY VERIFICATION							
0.2000 V		0.2001	0.1978	0.2023	V	Pass	
2.0000 V @ 5 kHz		2.0047	1.9660	2.0340	V	Pass	
DIODE MEASUREMENT ACCURACY VERIFICATION							
1.0000 V		1.0020	0.9880	1.0120	V	Pass	
Beeper is Operational						Pass	
ACIuA MEASUREMENT ACCURACY VERIFICATION							
500.00 µA @ 60 Hz		500.18	496.80	503.20	µA	Pass	
500.00 µA @ 10 kHz		500.25	496.80	503.20	µA	Pass	1.14
5000.0 µA @ 10 kHz		5003.1	4969.0	5031.0	µA	Pass	2.38
DCIuA MEASUREMENT ACCURACY VERIFICATION							
500.00 µA		499.96	499.43	500.57	µA	Pass	
5000.0 µA		4999.8	4996.1	5003.9	µA	Pass	
ACImA MEASUREMENT ACCURACY VERIFICATION							

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 287
Multimeter

Instrument Data Sheet

ID Number: 01311
Serial Number: 95740135

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
4.000 mA @ 20 Hz		3.989	3.940	4.060	mA	Pass	
30.000 mA @ 10 kHz		30.029	29.800	30.200	mA	Pass	3.17
300.00 mA @ 10 kHz		300.37	284.60	315.40	mA	Pass	
400.00 mA @ 60 Hz		400.06	397.55	402.45	mA	Pass	
DCImA MEASUREMENT ACCURACY VERIFICATION							
0.100 mA		0.102	0.090	0.110	mA	Pass	
50.000 mA		49.991	49.965	50.035	mA	Pass	
400.00 mA		399.92	399.38	400.62	mA	Pass	
ACI MEASUREMENT ACCURACY VERIFICATION							
5.0000 A @ 1 kHz		5.0034	4.9580	5.0420	A	Pass	
5.000 A @ 1 kHz		5.001	4.955	5.045	A	Pass	
DCI MEASUREMENT ACCURACY VERIFICATION							
5.0000 A		5.0002	4.9840	5.0160	A	Pass	
10.000 A		10.001	9.968	10.032	A	Pass	
TEMPERATURE MEASUREMENT ACCURACY VERIFICATION							
0.0 °C		-0.1	-1.0	1.0	°C	Pass	
100.0 °C		99.9	98.0	102.0	°C	Pass	
1000.0 °C		1000.0	989.0	1011.0	°C	Pass	
CAPACITANCE MEASUREMENT ACCURACY VERIFICATION							
0.900 nF		0.899	0.886	0.914	nF	Pass	0.97
9.10 nF		9.09	8.96	9.24	nF	Pass	
90.1 nF		89.9	88.7	91.5	nF	Pass	
1.000 µF		1.000	0.985	1.015	µF	Pass	
1.00 µF		1.00	0.94	1.06	µF	Pass	

***** End of Certificate *****

Certificate Number
A2062915
Issue Date: 12/23/15

Certificate of Calibration

EEMS #

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
1128 NW 39TH DRIVE
GAINESVILLE, FL 32605
FEDEX

P.O. Number:
ID Number: 01312

Description: DIGITAL MULTIMETER
Manufacturer: FLUKE
Model Number: 287
Serial Number: 95740243
Technician: MIKE CASOLI
On-Site Calibration: ☐
Comments:

Calibration Date: 12/23/2015
Calibration Due: 12/23/2016
Procedure: METCAL FLUKE 287 Rev: 6/15/2015
Temperature: 68 F
Humidity: 42 % RH
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. A TUR of 4:1 is routinely observed unless otherwise noted on the certificate. 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/IEC 17025 and ANSI/NCSL Z540-1 by A2LA. ISO/IEC 17025 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. The instrument listed on this certificate has been calibrated to the requirements of ANSI/NCSL Z540-1 and TMI's Quality Manual, QM-1.

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.

FRANK BAHMANN, BRANCH MANAGER

JACK SHULER, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
1727902	FLUKE	5522A/SC1100	10/14/2015	10/14/2016

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

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 287
Multimeter

Instrument Data Sheet

ID Number: 01312
Serial Number: 95740243

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
IDENTIFICATION & FIRMWARE REVISION							
Manufacturer: FLUKE							
Model: 287							
Serial Number: 95740243							
Firmware Level: V1.00							
TONE WARNING VERIFICATION							
Tone Warning Functional						Pass	
DCmV MEASUREMENT ACCURACY VERIFICATION							
0.000 mV		0.000	-0.020	0.020	mV	Pass	
0.025 mV		0.024	0.005	0.045	mV	Pass	
-0.025 mV		-0.025	-0.045	-0.005	mV	Pass	
50.000 mV		50.000	49.955	50.045	mV	Pass	
500.00 mV		500.01	499.86	500.14	mV	Pass	
-250.00 mV		-249.98	-250.08	-249.92	mV	Pass	
50.00 mV		50.02	49.97	50.03	mV	Pass	
DCmV + ACmV MEASUREMENT ACCURACY VERIFICATION							
250.00 mV @ 35 kHz		248.23	237.10	262.90	mV	Pass	
RESISTANCE MEASUREMENT ACCURACY VERIFICATION							
0.00 Ohm		0.01	-0.10	0.10	Ωs	Pass	
1.000 Ohm		0.990	0.899	1.101	Ωs	Pass	
190.00 Ohm		190.02	189.81	190.19	Ωs	Pass	
1.90000 kOhm		1.89989	1.89885	1.90115	kΩs	Pass	
19.000 kOhm		19.002	18.988	19.012	kΩs	Pass	
190.000 kOhm	189.9700	190.000	189.855	190.085	kΩs	Pass	
1.9000 MOhm		1.8994	1.8967	1.9032	MΩs	Pass	
10.000 MOhm		9.999	9.846	10.154	MΩs	Pass	
100.00 MOhm	99.700	100.00	91.52	107.88	MΩs	Pass	
ACmV MEASUREMENT ACCURACY VERIFICATION							
5.000 mV @ 20 Hz		4.990	4.865	5.135	mV	Pass	
50.000 mV @ 65 kHz		48.859	48.210	51.790	mV	Pass	
50.00 mV @ 100 kHz		49.05	47.85	52.15	mV	Pass	
250.00 mV @ 65 kHz		246.75	240.85	259.15	mV	Pass	
500.00 mV @ 45 Hz		499.54	498.25	501.75	mV	Pass	

PROCEDURE NAME: FLUKE:287:VOLTMETER DIGITAL:5520A:1.01:06/15/2015

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 287
Multimeter

Instrument Data Sheet

ID Number: 01312
Serial Number: 95740243

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
FREQUENCY MEASUREMENT ACCURACY VERIFICATION							
45.000 Hz @ 500 mV		45.000	44.986	45.014	Hz	Pass	
950.00 kHz @ 600 mV		950.00	949.90	950.10	kHz	Pass	
ACV MEASUREMENT ACCURACY VERIFICATION							
0.1000 V @ 60 Hz		0.0976	0.0952	0.1048	V	Pass	
0.5000 V @ 10 kHz		0.4956	0.4945	0.5055	V	Pass	
3.0000 V @ 100 kHz		3.1735	2.8160	3.1840	V	Pass	
15.000 V @ 100 kHz		14.974	14.435	15.565	V	Pass	
500.00 V @ 10 kHz		499.32	497.75	502.25	V	Pass	
1000.0 V @ 10 kHz		999.1	993.5	1006.5	V	Pass	
DCV MEASUREMENT ACCURACY VERIFICATION							
4.0000 V		4.0001	3.9988	4.0012	V	Pass	
-40.000 V		-40.001	-40.012	-39.988	V	Pass	
400.00 V		400.00	399.86	400.14	V	Pass	
600.0 V		600.0	599.6	600.4	V	Pass	
DCV + ACV MEASUREMENT ACCURACY VERIFICATION							
0.2000 V		0.1999	0.1978	0.2023	V	Pass	
2.0000 V @ 5 kHz		2.0038	1.9660	2.0340	V	Pass	
DIODE MEASUREMENT ACCURACY VERIFICATION							
1.0000 V		1.0081	0.9880	1.0120	V	Pass	
Beeper is Operational						Pass	
ACIuA MEASUREMENT ACCURACY VERIFICATION							
500.00 µA @ 60 Hz		499.95	496.80	503.20	µA	Pass	
500.00 µA @ 10 kHz		500.12	496.80	503.20	µA	Pass	1.14
5000.0 µA @ 10 kHz		5001.6	4969.0	5031.0	µA	Pass	2.38
DCIuA MEASUREMENT ACCURACY VERIFICATION							
500.00 µA		500.00	499.43	500.57	µA	Pass	
5000.0 µA		5000.0	4996.1	5003.9	µA	Pass	
ACImA MEASUREMENT ACCURACY VERIFICATION							

Technical Maintenance, Inc.
12530 Telecom Drive
Tampa, FL 33637

Fluke
Model: 287
Multimeter

Instrument Data Sheet

ID Number: 01312
Serial Number: 95740243

Test Run: FOUND-LEFT
Date Tested: 23 December 2015

Test Results

Test Description	True Value	Test Result	Lower limit	Upper limit	Units	Result	TUR
4.000 mA @ 20 Hz		3.973	3.940	4.060	mA	Pass	
30.000 mA @ 10 kHz		30.019	29.800	30.200	mA	Pass	3.17
300.00 mA @ 10 kHz		300.29	284.60	315.40	mA	Pass	
400.00 mA @ 60 Hz		399.99	397.55	402.45	mA	Pass	
DCImA MEASUREMENT ACCURACY VERIFICATION							
0.100 mA		0.110	0.090	0.110	mA	Pass	
50.000 mA		49.993	49.965	50.035	mA	Pass	
400.00 mA		399.99	399.38	400.62	mA	Pass	
ACI MEASUREMENT ACCURACY VERIFICATION							
5.0000 A @ 1 kHz		5.0030	4.9580	5.0420	A	Pass	
5.000 A @ 1 kHz		4.998	4.955	5.045	A	Pass	
DCI MEASUREMENT ACCURACY VERIFICATION							
5.0000 A		5.0014	4.9840	5.0160	A	Pass	
10.000 A		10.003	9.968	10.032	A	Pass	
TEMPERATURE MEASUREMENT ACCURACY VERIFICATION							
0.0 °C		0.0	-1.0	1.0	°C	Pass	
100.0 °C		100.0	98.0	102.0	°C	Pass	
1000.0 °C		1000.1	989.0	1011.0	°C	Pass	
CAPACITANCE MEASUREMENT ACCURACY VERIFICATION							
0.900 nF		0.886	0.886	0.914	nF	Pass	0.97
9.10 nF		9.08	8.96	9.24	nF	Pass	
90.1 nF		90.1	88.7	91.5	nF	Pass	
1.000 µF		1.001	0.985	1.015	µF	Pass	
1.00 µF		1.00	0.94	1.06	µF	Pass	

***** End of Certificate *****

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

Calibration Certificate

Instrument: Precision Spectral Pyranometer, Model PSP, Serial Number 34341F3

Procedure: This pyranometer was compared in Eppley's Integrating Hemisphere according to procedures described in ***ISO 9847 Section 5.3.1*** and Technical Procedure, TP01 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.

Transfer Standard: Eppley Precision Spectral Pyranometer, Model PSP, Serial Number 21231F3

Results:
Sensitivity: **$S = 9.41\ \mu V / Wm^{-2}$**
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2)
Resistance: 699 Ω at 23°C
Date of Test: December 29, 2015

EEMS # 01245
01246

Traceability: This calibration is traceable to the World Radiation Reference (WRR) through comparisons with Eppley's AHF standard self-calibrating cavity pyrheliometers which participated in the Eleventh International Pyrheliometric Comparisons (IPC XI) at Davos, Switzerland in September-October 2010. Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".

Due Date: Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.

Customer: EEMS
Gainesville, FL

Signatures: Debra L. Hunty / M. VIEIRA Thomas D. Kirk
In Charge of Test: Reviewed by:

Eppley SO: 64603

Date of Certificate: January 5, 2016

Remarks: With Amplifier # 10765 Gain = 75.91 So 1 Volt Out = 1400 Wm^{-2}

End of Report

PACKING LIST

The Eppley Laboratory, Inc.
12 Sheffield Ave.,P.O. Box 419

Phone # 401-847-1020 Fed. ID No. 05-0136490

S.O. No. **64603**

12/30/2015

EEMS #
01245 / 01246

12/29/2015

Page 2 of 2

Name / Address	Ship To
EEMS Att: Erik Hebert 1128 NW 39th Drive Gainesville, FL 32605	EEMS Att: Eric Hebert 1128 NW 39th Drive Gainesville, FL 32605

P.O... Verbal Ship Date 1/12/2016 Ship Via UPS COLLECT

	Ordered	Amount
Reset Amplifier # 10765	[redacted]	
Recalibration of Model PSP # 34341F3 w/ Case, shield + Cable		

Set Gain so $1V = 1400\ Wm^{-2}$

$1400 \times S = V_{Full}$

$S = 9.41$

$V_{Full} = 13174$

$\mu V = 0.013174$

$$Gain = \frac{1V}{V_{Full}\ (\mu V)} = 75.91$$

Made in USA

Terms Credit Card

FOB Newport, RI USA

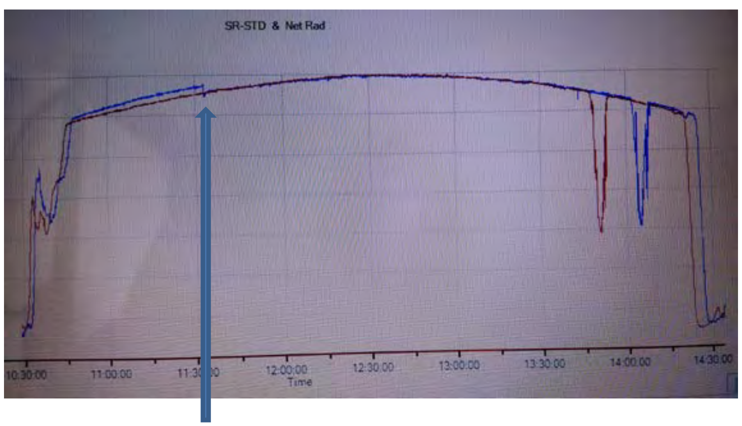
Site EEMS MOBILE LAB 2

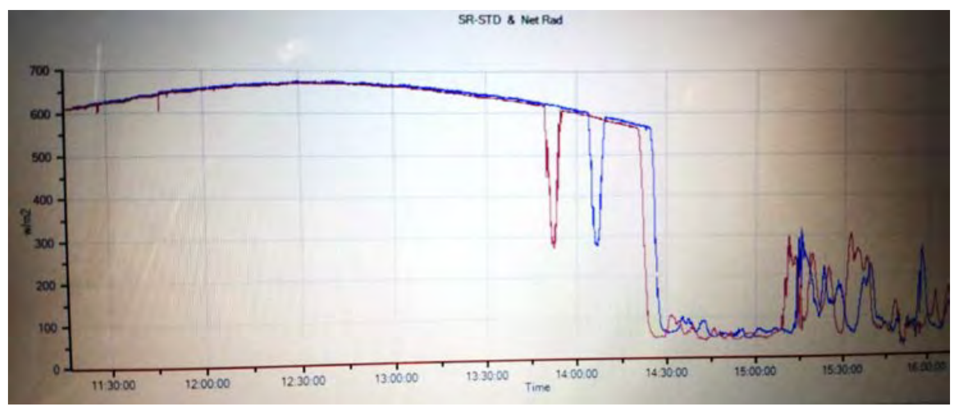
Sensor # PY48645/Translator # EEMS 01240

Date&Time	SR-RMY Field Std	Eppley Std	SR-RMY Field corrected = (x-b)/m	Uncorrected error		Corrected error	
	W/M2	W/M2	W/M2	W/M2	% diff	W/M2	% diff
11/01/2016 11:00	658.71	649.5	656.9	9.21	1.4%	7.4	1.1%
11/01/2016 12:00	691.75	693.4	689.6	-1.65	-0.2%	-3.8	-0.5%
11/01/2016 15:00	112.92	119.5	115.1	-6.58	-5.5%	-4.4	-3.7%
11/01/2016 16:00	51.14	49.2	53.8	1.94	3.9%	4.6	9.3%
12/01/2016 03:00	1.4	-2.4	4.4	3.8		6.8	
12/01/2016 08:00	40.84	39.8	43.6	1.04	2.6%	3.8	9.5%
12/01/2016 09:00	59.8	67.2	62.4	-7.4	-11.0%	-4.8	-7.2%
12/01/2016 10:00	297.2	302.5	298.0	-5.3	-1.8%	-4.5	-1.5%
12/01/2016 11:00	624.7	623.2	623.1	1.5	0.2%	-0.1	0.0%
12/01/2016 12:00	669.29	666.7	667.4	2.59	0.4%	0.7	0.1%
12/01/2016 15:00	116.84	124.7	119.0	-7.86	-6.3%	-5.7	-4.6%
			Average =	-0.79	-1.6%	0.00	0.00

slope = **1.00748**

intercept = **-3.05909**





Adjusted

	EEMS# =	01245	01244	
Site:AuditVan1		Eppley	Licor	
Date	Time	SR Std : Value		% diff
15/09/2016	10:19	497.7	499.5	0.4%
15/09/2016	10:20	512.3	514.9	0.5%
15/09/2016	10:21	511.0	525.3	2.8%
15/09/2016	10:22	413.9	441.2	6.6%
15/09/2016	10:23	279.5	287.7	2.9%
15/09/2016	10:24	264.8	260.9	-1.5%
15/09/2016	10:25	310.1	300.1	-3.2%
15/09/2016	10:26	295.2	301.1	2.0%
15/09/2016	10:27	258.9	261.7	1.1%
15/09/2016	10:28	252.7	250.2	-1.0%
15/09/2016	10:29	272.1	263.4	-3.2%
15/09/2016	10:30	272.5	273.1	0.2%
15/09/2016	10:31	279.4	274.4	-1.8%
15/09/2016	10:32	284.9	285.9	0.4%
15/09/2016	10:33	291.8	284.0	-2.7%
15/09/2016	10:34	369.8	348.3	-5.8%
15/09/2016	10:35	451.3	468.0	3.7%
15/09/2016	10:36	306.4	317.5	3.6%
15/09/2016	10:37	306.0	297.5	-2.8%
15/09/2016	10:38	325.4	325.8	0.1%
15/09/2016	10:39	317.2	316.6	-0.2%
15/09/2016	10:40	318.6	314.1	-1.4%
15/09/2016	10:41	351.4	355.3	1.1%
15/09/2016	10:42	274.9	284.5	3.5%
15/09/2016	10:43	255.5	255.0	-0.2%
15/09/2016	10:44	255.5	252.0	-1.4%
15/09/2016	10:45	262.9	258.0	-1.8%
15/09/2016	10:46	274.6	268.7	-2.2%
15/09/2016	10:47	284.6	279.0	-1.9%
15/09/2016	10:48	294.2	289.4	-1.7%
15/09/2016	10:49	292.4	289.9	-0.8%
15/09/2016	10:50	282.9	281.0	-0.7%
15/09/2016	10:51	272.5	269.8	-1.0%
15/09/2016	10:52	266.0	261.7	-1.6%
15/09/2016	10:53	271.0	266.0	-1.9%
15/09/2016	10:54	258.0	253.1	-1.9%
15/09/2016	10:55	255.0	249.6	-2.1%
15/09/2016	10:56	253.5	247.4	-2.4%
15/09/2016	10:57	256.7	249.6	-2.8%
15/09/2016	10:58	264.6	255.6	-3.4%
15/09/2016	11:09	345.7	332.6	-3.8%
15/09/2016	11:10	391.1	375.3	-4.0%

15/09/2016	11:11	394.2	395.3	0.3%
15/09/2016	11:12	360.3	354.7	-1.6%
15/09/2016	11:13	371.7	361.9	-2.6%
15/09/2016	11:14	369.6	362.6	-1.9%
15/09/2016	11:15	363.7	359.6	-1.1%
15/09/2016	11:16	355.8	350.1	-1.6%
15/09/2016	11:17	337.1	331.2	-1.7%
15/09/2016	11:18	339.2	328.4	-3.2%
15/09/2016	11:19	343.8	336.2	-2.2%
15/09/2016	11:20	341.6	333.6	-2.3%
15/09/2016	11:21	343.5	334.3	-2.7%
15/09/2016	11:22	341.6	333.6	-2.3%
15/09/2016	11:23	331.0	320.3	-3.2%
15/09/2016	11:24	327.1	317.0	-3.1%
15/09/2016	11:25	325.4	313.1	-3.8%
15/09/2016	11:26	356.2	324.6	-8.9%
15/09/2016	11:27	470.4	462.2	-1.7%
15/09/2016	11:28	483.0	445.8	-7.7%
15/09/2016	11:29	440.4	476.5	8.2%
15/09/2016	11:30	334.0	321.0	-3.9%
15/09/2016	11:31	457.3	413.7	-9.5%
15/09/2016	11:32	487.2	457.7	-6.1%
15/09/2016	11:33	522.9	512.9	-1.9%
15/09/2016	11:34	457.1	447.2	-2.2%
15/09/2016	11:35	562.2	549.5	-2.3%
15/09/2016	11:36	586.4	558.9	-4.7%
15/09/2016	11:37	627.7	624.0	-0.6%
15/09/2016	11:38	629.2	622.9	-1.0%
15/09/2016	11:39	599.4	589.9	-1.6%
15/09/2016	11:40	615.9	607.9	-1.3%
15/09/2016	11:41	616.6	607.6	-1.5%
15/09/2016	11:42	617.8	608.9	-1.4%
15/09/2016	11:43	618.2	610.2	-1.3%
15/09/2016	11:44	619.7	611.4	-1.3%
15/09/2016	11:45	620.9	612.3	-1.4%
15/09/2016	11:46	624.2	616.0	-1.3%
15/09/2016	11:47	626.6	619.0	-1.2%
15/09/2016	11:48	630.9	623.1	-1.2%
15/09/2016	11:49	637.8	629.8	-1.3%
15/09/2016	11:50	648.3	639.5	-1.4%
15/09/2016	11:51	656.8	648.6	-1.3%
15/09/2016	11:52	666.1	658.2	-1.2%
15/09/2016	11:53	670.6	663.6	-1.0%
15/09/2016	11:54	676.6	670.0	-1.0%
15/09/2016	11:55	645.6	644.0	-0.3%
15/09/2016	11:56	674.6	662.9	-1.7%
15/09/2016	11:57	683.3	677.0	-0.9%

15/09/2016	11:58	680.8	681.0	0.0%
15/09/2016	12:01	675.0	660.8	-2.1%
15/09/2016	12:02	693.8	687.4	-0.9%
15/09/2016	12:03	660.6	683.8	3.5%
15/09/2016	12:04	484.8	470.5	-2.9%
15/09/2016	12:05	501.0	476.4	-4.9%
15/09/2016	12:06	641.8	627.0	-2.3%
15/09/2016	12:07	660.9	650.4	-1.6%
15/09/2016	12:08	660.8	654.1	-1.0%
15/09/2016	12:09	662.7	655.7	-1.1%
15/09/2016	12:10	662.3	655.8	-1.0%
15/09/2016	12:11	662.8	657.2	-0.8%
15/09/2016	12:12	661.6	654.9	-1.0%
			average =	-1.4%

slope (m) = 0.99140

intercept (b) = -2.3