2020 Clean Air Status and Trends Network Site Audit Program Annual Report

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U.S. Environmental Protection Agency
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Prepared by:

4475E NW 6th Street, Ext
Gainesville, FL 32609

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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-WSO	Bureau of Land Management-Wyoming State Office
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
ECCC	Environment and Climate Change Canada
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	global 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
ppm	parts per million

PSD	Prevention of Significant Deterioration
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
SLAMS	State or Local Air Monitoring Stations
SOP	standard operating procedure
SRP	standard reference photometer
SSRF	Site Status Report Forms
STP	standard temperature and pressure
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
Wood	Wood Environment and Infrastructure Solutions
WRR	World Radiation Reference

1.0 Introduction

The Clean Air Status and Trends Network (CASTNET) is a national air monitoring program established in 1988 by the US EPA. Nearly all CASTNET sites measure weekly concentrations of acidic gases and particles to provide accountability for EPA's emission reduction programs. Most sites measure ground-level ozone as well as supplemental measurements such as meteorology and/or other trace gas concentrations.

Ambient concentrations 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 critical loads 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, CASTNET pollutant flux estimates are calculated as the aggregate product of weekly measured chemical concentrations and gridded model-estimated deposition velocities. Total deposition is assessed using the NADP's Total Deposition Hybrid Method (TDEP; EPA, 2015c; Schwede and Lear, 2014), which combines data from established ambient monitoring networks and chemical-transport models. To estimate dry deposition, ambient measurement data from CASTNET were merged with dry deposition rates and flux output from the Community Multiscale Air Quality (CMAQ) modeling system. The dry deposition surface is then merged with wet deposition grids from NADP and the Parameter-elevation Regressions on Independent Slopes Model (PRISM) to estimate total deposition.

Since 2011 nearly all CASTNET ozone monitors have adhered to the requirements for State or Local Air Monitoring Stations (SLAMS) as specified by the EPA in 40 CFR Part 58. As such, the ozone data collected must meet the requirements in 40 CFR Part 58 Appendix A, which defines the quality assurance (QA) requirements for gaseous pollutant ambient air monitoring. The audits performed by EEMS under this contract fulfill the requirement for annual performance evaluation (PE) audits of pollutant monitors in the network. The QA requirements can be found at: https://www3.epa.gov/ttn/amtic/files/ambient/pm25/qa/APP_D%20validation%20template%20version%2003_2017_for%20AMTIC%20Rev_1.pdf

Currently 87 sites at 85 distinct locations measure ground-level ozone concentrations. Annual PE audit QA data are submitted to the Air Quality System (AQS) database.

As of December 2020, the network is comprised of 97 active rural sampling sites across the United States and Canada, cooperatively operated by the Environmental Protection Agency (EPA), the National Park Service (NPS), Bureau of Land Management – Wyoming State Office (BLM-WSO) and several independent partners. Wood Environment and Infrastructure Solutions (Wood) is responsible for operating the EPA sponsored sites and Air Resource Specialist, Inc. (ARS) is responsible for operating the NPS and BLM-WSO sponsored sites.

2.0 Project Objectives

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

Performance audits verify that all reported 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	Average Difference	Comparison to RTD at 3 observed points	2 °C
Temperature	Accuracy	Comparison to 3 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 ≤ m ≤ 1.1000
	Intercept		-5.0 ppb ≤ b ≤ 5.0 ppb
	Correlation Coefficient		0.9950 ≤ r
	Percent Difference	Comparison with Standard Concentration	Audit levels 3 through 10: ≤ ±15.1% of test gas concentration Audit levels 1 and 2: ≤ ± 1.5 ppb actual difference or ≤ ±15.1%
DAS	Accuracy	Comparison with certified standard	≤ ± 0.003 VDC

The accuracy goals defined for ozone monitors in the CASTNET QAPP Table 4-12 are the same as those of 40 CFR, Part 58 Appendix A, for quality assurance for CASTNET site. To comply with Appendix A, the CASTNET audit program includes annual independent ozone PE. The EEMS

field scientists who conduct ozone PE maintain annual certification from the Office of Air Quality Planning and Standards (OAQPS) through the annual National Performance Audit Program (NPAP) training which EEMS attended in October 2019 (see end of Appendix for NPAP training certifications). EEMS personnel performed the Through-The-Probe (TTP) pollutant monitor audits following EPA's Quality Assurance Guidance Document – Method Compendium – Field Standard Operating Procedures (SOP) for the Federal $PM_{2.5}$ Performance Evaluation Program and NPAP-TTP Audit Standard Operating Procedures (SOP). All procedures and guidance documents used to perform these audits can be found at the EPA OAQPS website:
https://www3.epa.gov/ttn/amtic/npepqa.html

The NPAP is a QA program implemented by the OAQPS to conduct audits of gaseous air pollutant monitors by standard methods throughout each region of the U.S. The method includes introduction of National Institute of Standards and Traceability (NIST) traceable audit gases to the station monitors through the ambient sample inlet, including all filters and fittings. This method evaluates measurement system accuracy including the entire sample train. The audit gas concentrations are also measured and verified with an audit analyzer on-site. For gases other than ozone the audit analyzer is calibrated at the time of the audit.

Performance evaluations (PE) are conducted using standards that are certified as currently traceable to the 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 2020

This report covers the CASTNET sites audited in 2020. Only those variables that were supported by the CASTNET program were audited. From February through December 2020, EEMS conducted PE and field systems audits at 34 monitoring sites. Meteorological sensors at one of the sites 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. Systems and Performance Site Audits

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
ABT147	EPA	Abington	CT / R1	9/28/2020
ANA115	EPA	Ann Arbor	MI / R5	10/7/2020
ARE128	EPA	Arendtsville	PA / R3	7/29/2020
ASH135	EPA	Ashland	ME / R1	9/27/2020
BEL116	EPA	Beltsville	MD / R3	9/22/2020
CAN407	NPS	Canyonlands NP	UT / R8	8/27/2020
CAT175	EPA	Claryville	NY / R2	10/20/2020
CAV436	NPS	Carlsbad Caverns	NM / R6	9/29/2020
CHA467	NPS	Chiricahua NM	AZ / R9	9/28/2020
COW137	EPA	Coweeta	NC / R4	5/30/2020
CTH110	EPA	Connecticut Hill	NY / R2	7/20/2020
DEN417	NPS	Denali NP	AK / R10	10/7/2020
DEV412	NPS	Death Valley NM	CA / R9	11/14/2020
DIN431	NPS	Dinosaur NM	UT / R8	8/28/2020
ESP127	EPA	Edgar Evans St. Park	TN / R4	10/16/2020
FOR605	EPA	Fortification Creek	WY / R8	6/3/2020
GAS153	EPA	Georgia Station	GA / R4	6/1/2020
GRB411	NPS	Great Basin NP	NV / R9	6/24/2020
GRC474	NPS	Grand Canyon NP	AZ / R9	9/25/2020
GRT434	NPS	Grand Teton NP	WY / R8	8/10/2020

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
HOX148	EPA	Hoxeyville	MI / R5	10/3/2020
HWF187	EPA	Huntington Wildlife Forest	NY / R2	7/13/2020
IRL141	EPA	Indian River Lagoon	FL / R4	5/22/2020
JOT403	NPS	Joshua Tree NM	CA / R9	11/13/2020
KEF112	EPA	Kane Experimental Forest	PA / R3	7/22/2020
MKG113	EPA	M. K. Goddard St. Park	PA / R3	7/21/2020
NPT006	EPA	Nez Perce Tribe	ID / R10	7/8/2020
PET427	NPS	Petrified Forest NP	AZ / R9	9/24/2020
PNF126	EPA	Cranberry	NC / R4	11/15/2020
PSU106	EPA	Penn State University	PA / R3	7/27/2020
RED004	EPA	Red Lake Nation	MN / R5	9/29/2020
SAL133	EPA	Salamonie Reservoir	IN / R5	11/4/2020
SND152	EPA	Sand Mountain	AL / R4	5/31/2020
SPD111	EPA	Speedwell	TN / R4	10/12/2020
SUM156	EPA	Sumatra	FL / R4	3/3/2020
UMA009	EPA	Umatilla Indian Reservation	WA / R10	11/23/2020
UVL124	EPA	Unionville	MI / R5	10/6/2020
WST109	EPA	Woodstock	NH / R1	9/25/2020

In addition to the sites listed in Table 3-1 that were visited for complete systems and performance audits, the 40 sites listed in Table 3-2 were visited to conduct TTP ozone and other pollutant gas PE.

Table 3-2. Site Ozone PE Visits

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
ALC188	EPA	Alabama-Coushatta	TX / R6	2/17/2020
ALH157	EPA	Alhambra	IL / R5	12/7/2020
BAS601	EPA	Basin	WY / R8	6/2/2020
BBE401	NPS	Big Bend NP	TX / R6	2/19/2020
BFT142	EPA	Beaufort	NC /R4	12/16/2020
BVL130	EPA	Bondville	IL / R5	11/6/2020
BWR139	EPA	Blackwater NWR	MD / R3	11/15/2020
CAD150	EPA	Caddo Valley	AR / R6	8/22/2020
CDR119	EPA	Cedar Creek St. Park	WV / R3	11/13/2020
CDZ171	EPA	Cadiz	KY / R4	12/8/2020
CHC432	NPS	Chaco NHP	NM / R6	8/24/2020
CHE185	EPA	Cherokee Nation	OK / R6	8/21/2020
CKT136	EPA	Crockett	KY / R4	11/8/2020
CND125	EPA	Candor	NC / R4	12/12/2020
CNT169	EPA	Centennial	WY / R8	7/15/2020
CRM435	NPS	Craters of the Moon	ID / R10	7/6/2020
CVL151	EPA	Coffeeville	MS / R4	8/23/2020
DCP114	EPA	Deer Creek St. Park	OH / R5	8/29/2020
GLR468	NPS	Glacier NP	MT / R8	8/13/2020
GRS420	NPS	Great Smoky Mountains NP	TN / R4	10/14/2020
LRL117	EPA	Laurel Hill St. Park	PA / R3	6/17/2020
MAC426	NPS	Mammoth Cave NP	KY / R4	8/19/2020
MCK131	EPA	Mackville	KY / R4	11/7/2020

Site ID	Sponsor Agency	Site Location	State and EPA Region	Audit dates
MCK231	EPA	Mackville (precision site)	KY / R4	11/7/2020
NEC602	EPA	Newcastle	WY / R8	6/3/2020
OXF122	EPA	Oxford	OH / R5	11/2/2020
PAL190	EPA	Palo Duro	TX / R6	2/20/2020
PAR107	EPA	Parsons	WV / R3	11/12/2020
PED108	EPA	Prince Edward	VA / R3	12/6/2020
PND165	EPA	Pinedale	WY / R8	8/8/2020
PRK134	EPA	Perkinstown	WI / R5	6/23/2020
QAK172	EPA	Quaker City	OH / R5	11/9/2020
SAN189	EPA	Santee Sioux	NE / R7	10/22/2020
SHN418	NPS	Shenandoah NP - Big Meadows	VA / R3	6/16/2020
STK138	EPA	Stockton	IL / R5	11/18/2020
VIN140	EPA	Vincennes	IN / R5	12/4/2020
VOY413	NPS	Voyageurs NP	MN / R5	9/30/2020
VPI120	EPA	Horton Station	VA / R3	11/10/2020
WSP144	EPA	Washington Crossing St. Park	NJ / R2	7/30/2020
YEL408	NPS	Yellowstone NP	WY / R8	8/11/2020

4.0 Performance Audit Results

This section provides the summarized performance evaluation (audit) results of each variable challenged at each station visited except for trace gas audit results. CASTNET operates trace gas monitors at several sites including three sites that are part of the NCORE Network (GRS420, MAC426, and BVL130). Performance evaluation audits of the CASTNET trace gas monitors were performed at BVL130, ROM206, PND165, HWF187, GRS420, MAC426, and PNF126 in 2020. Results of the NO_y, CO, and SO_2 monitor audits for those sites have been uploaded to the EPA AQS database and are not included in this report. All PE results for all monitors were within acceptance limits.

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 indicate readings that were above the standard value. The results are 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. Errors for all parameters other than ozone appear to be random and without bias.

Ozone audit results in general indicate a slight negative bias which will be discussed in the following section.

Detailed reports of the field site audits, which contain all test points for each variable at each site, can be found in the Appendices of each of the 2020 Quarterly reports. 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 summarizes the number of test failures by variable tested. All station data are recorded from the station’s primary datalogger.

Table 4-1. Performance Audit Results by Variable Tested

Variable Tested	Number of Tests	Number of tests Failed	% Failed
Ozone	74	2	2.7
Flow Rate	35	1	2.9
Shelter Temperature (average)	35	1	2.9
Wind Direction Orientation Average Error	1	0	0
Orientation Maximum Error	1	0	0
Wind Direction Linearity Average Error	1	0	0
Linearity Maximum Error	1	0	0
Wind Direction Starting Torque	1	0	0
Wind Speed Low Range Average Error	1	0	0
Low Range Maximum Error	1	0	0
Wind Speed High Range Average Error	1	0	0
High Range Maximum Error	1	0	0
Wind Speed Starting Torque	1	0	0
All Temperature Sensors	33	2	6.1
Relative Humidity	1	0	0
Solar Radiation	1	0	0
Precipitation	0	0	0
DAS Analog to Digital	32	0	0

4.1 Ozone

Seventy-four ozone performance evaluation audits were performed in 2020. All ozone challenges were conducted to comply with the OAQPS NPAP-TTP Standard Operating Procedures (SOP) which can be found at https://www.epa.gov/amtic/national-performance-audit-program-npap-gaseous-monitoring. Each ozone monitor was challenged with ozone-free air and four up-scale concentrations. The ozone test gas concentrations were measured with a NIST-traceable photometer that was verified as a level 2 standard by USEPA. The results of the ozone audits were uploaded to the AQS database at the end of each quarter.

Results of all ozone audits performed are included in Table 4-2. Two monitors tested failed the annual PE with a level 2 test point difference above ± 1.5 ppb. These monitors, UVL124 and PRK134 are highlighted in the table below. It was determined that the monitor at UVL124 required maintenance. The monitors at THR422, ACA416 and WNC429 are operated by state agencies.

Table 4-2. Performance Audit Results for Ozone

Site ID	Actual Difference for Level 2	Average (% diff) for Levels 3, 4 and 6	Maximum (% diff) for Levels 3, 4 and 6	Ozone Slope	Ozone Intercept	Ozone Correlation	EEMS Standard Number	Date
ABT147	0.06	-0.3	-0.4	0.99571	0.08449	1.00000	1114	9/28/2020
ALC188	-0.57	-1.6	-1.9	0.99031	-0.30602	1.00000	1110	2/17/2020
ALH157	-0.71	-1.6	-2.1	0.99253	-0.41390	0.99999	1110	12/7/2020
ANA115	0.26	2.1	2.2	1.02018	0.02164	1.00000	1115	10/7/2020
ARE128	-1.26	-3.8	-5.2	0.97883	-0.78681	0.99998	1114	7/29/2020
ASH135	-0.93	-2.5	-3.7	0.98793	-0.62522	0.99999	1114	9/27/2020
BAS601	-0.16	-0.3	-0.6	1.00369	-0.20488	0.99998	1110	6/2/2020
BBE401	-0.30	-0.1	-0.6	1.00051	-0.07487	0.99999	1110	2/19/2020
BEL116	0.32	0.0	0.9	0.98550	0.77873	0.99999	1115	9/22/2020
BFT142	-0.57	-1.1	-2.0	1.00390	-0.77559	1.00000	1114	12/16/2020
BVL130	-0.85	-4.2	-4.8	0.96538	-0.39174	1.00000	1114	11/6/2020
BWR139	-0.36	-1.5	-1.8	0.98884	-0.14904	1.00000	1114	11/15/2020
CAD150	0.65	-3.3	-3.8	0.94902	1.27959	0.99997	1115	8/22/2020
CAN407	-0.32	-1.8	-2.5	0.98565	-0.03337	0.99997	1110	8/27/2020
CAVE	0.94	1.3	3.4	0.98485	1.54690	0.99997	1110	9/29/2020
CDR119	-0.37	-1.9	-2.2	0.98394	-0.09674	1.00000	1114	11/13/2020

Site ID	Actual Difference for Level 2	Average (% diff) for Levels 3, 4 and 6	Maximum (% diff) for Levels 3, 4 and 6	Ozone Slope	Ozone Intercept	Ozone Correlation	EEMS Standard Number	Date
CDZ171	-0.02	-0.3	-0.7	0.99764	0.01650	0.99999	1110	12/8/2020
CHA467	-0.29	-1.1	-2.0	0.99093	-0.07257	0.99996	1110	9/28/2020
CHC432	0.08	-0.6	-0.7	0.99221	0.22496	1.00000	1110	8/24/2020
CHE185	-0.52	-5.0	-5.7	0.94897	0.11020	0.99997	1115	8/21/2020
CKT136	-0.66	-2.2	-2.8	0.98431	-0.25993	0.99999	1114	11/8/2020
CND125	-0.39	0.1	0.6	1.01001	-0.50766	1.00000	1114	12/12/2020
CNT169	-0.26	0.0	-0.4	0.99445	0.28335	0.99997	1110	7/15/2020
COW137	-1.46	-3.7	-5.6	0.98820	-1.43148	0.99999	1114	5/30/2020
CRM435	-0.57	-2.7	-2.8	0.97287	0.04425	0.99999	1110	7/6/2020
CTH110	-1.00	-5.4	-6.0	0.95439	-0.44109	1.00000	1114	7/20/2020
CVL151	0.44	1.2	1.9	0.99856	0.72172	0.99999	1115	8/23/2020
DCP114	0.18	0.3	0.5	0.99947	0.26606	0.99999	1114	8/29/2020
DEN417	0.55	0.0	1.0	0.98810	0.66287	0.99999	1110	10/7/2020
DEV412	-0.52	-2.0	-2.5	0.98540	-0.23248	1.00000	1110	11/14/2020
DIN431	-1.02	-2.0	-3.1	0.98984	-0.43922	0.99996	1110	8/28/2020
ESP127	-0.26	-2.9	-3.4	0.96253	0.43361	1.00000	1115	10/16/2020
GAS153	-1.34	-5.2	-7.0	0.96464	-0.73163	0.99997	1114	6/1/2020
GLR468	-1.42	-2.4	-4.5	0.99774	-0.83009	0.99984	1110	8/13/2020
GRB411	-1.10	-3.9	-5.0	0.97888	-0.67707	0.99986	1110	6/24/2020
GRC474	-0.56	-2.7	-2.9	0.97316	-0.01397	1.00000	1110	9/25/2020
GRS420	-0.29	-3.0	-3.3	0.97265	-0.03298	1.00000	1115	10/14/2020
GRT434	0.24	2.5	2.6	1.02367	0.11388	0.99999	1110	8/10/2020
HOX148	-0.12	-1.3	-1.4	0.98482	0.16381	1.00000	1115	10/3/2020
HWF187	-0.51	-1.5	-2.1	0.99352	-0.48948	1.00000	1114	7/13/2020
IRL141	-0.28	-0.1	-0.9	0.99475	0.20607	0.99996	1114	5/22/2020
JOT403	-0.01	-1.1	-1.5	0.98833	0.15462	0.99999	1110	11/13/2020
KEF112	-0.47	-2.5	-2.6	0.97185	0.24380	0.99998	1114	7/22/2020

Site ID	Actual Difference for Level 2	Average (% diff) for Levels 3, 4 and 6	Maximum (% diff) for Levels 3, 4 and 6	Ozone Slope	Ozone Intercept	Ozone Correlation	EEMS Standard Number	Date
LRL117	-0.56	-2.1	-2.5	0.98615	-0.35395	1.00000	1114	6/17/2020
MAC426	-0.22	-1.7	-1.8	0.98289	0.10760	0.99999	1114	8/19/2020
MCK131	-0.78	-3.4	-4.6	0.97873	-0.57646	0.99999	1114	11/7/2020
MCK231	-0.53	-1.5	-2.5	0.99707	-0.65291	1.00000	1114	11/7/2020
MKG113	-0.40	-1.2	-1.5	0.99187	-0.09786	0.99998	1114	7/21/2020
NEC602	-1.39	-2.9	-3.9	0.98551	-0.60777	0.99989	1110	6/3/2020
NPT006	-0.42	1.8	3.2	1.03208	-0.55726	0.99990	1110	7/8/2020
OXF122	-0.41	-0.9	-1.7	0.99756	-0.36609	1.00000	1114	11/2/2020
PAL190	-0.11	-1.0	-1.4	0.99309	-0.13399	0.99999	1110	2/20/2020
PAR107	-1.02	-2.9	-3.5	0.98329	-0.77807	1.00000	1114	11/12/2020
PED108	-0.38	-2.4	-2.5	0.97700	-0.03784	1.00000	1114	12/6/2020
PET427	-0.72	-1.9	-2.1	0.98244	-0.04845	0.99997	1110	9/24/2020
PND165	-1.48	-4.1	-5.2	0.97310	-0.76266	0.99997	1110	8/8/2020
PNF126	0.00	0.4	1.0	1.00058	0.08738	0.99999	1115	11/15/2020
PRK134	-2.00	-6.4	-7.9	0.96157	-1.39677	0.99999	1114	6/23/2020
PSU106	-0.68	-1.6	-2.2	0.99347	-0.54192	1.00000	1114	7/27/2020
QAK172	-0.63	-2.7	-3.0	0.97826	-0.27934	1.00000	1114	11/9/2020
SAL133	-0.45	-0.6	-1.0	0.99920	-0.32976	1.00000	1114	11/4/2020
SAN189	0.41	0.6	0.8	1.00548	0.03634	0.99999	1110	10/22/2020
SHN418	-0.66	-3.6	-3.8	0.96769	-0.13372	1.00000	1114	6/16/2020
SND152	0.29	1.0	2.3	0.99969	0.42217	0.99999	1114	5/31/2020
SPD111	-1.46	-3.2	-3.9	0.98127	-0.93412	0.99999	1115	10/12/2020
STK138	-0.57	-1.4	-2.4	0.99445	-0.39568	0.99999	1114	11/18/2020
SUM156	-0.33	1.2	2.9	1.03563	-1.04683	0.99997	1114	3/3/2020
UMA009	0.28	1.2	1.3	1.01124	0.04290	1.00000	1110	11/23/2020
UVL124	-3.53	-10.2	-14.1	0.95010	-2.66192	0.99997	1115	10/6/2020
VIN140	0.08	0.0	-0.3	1.00141	-0.00927	0.99999	1114	12/4/2020

Site ID	Actual Difference for Level 2	Average (% diff) for Levels 3, 4 and 6	Maximum (% diff) for Levels 3, 4 and 6	Ozone Slope	Ozone Intercept	Ozone Correlation	EEMS Standard Number	Date
VOY413	-0.43	-1.9	-2.4	0.98621	-0.03828	0.99994	1115	9/30/2020
VPI120	-0.84	-4.3	-5.0	0.96927	-0.54355	0.99998	1114	11/10/2020
WSP144	-0.88	-3.2	-4.2	0.97793	-0.48678	0.99999	1114	7/30/2020
WST109	-0.35	-0.3	-0.6	1.00016	-0.21124	1.00000	1114	9/25/2020
YEL408	-0.57	-2.0	-2.6	0.98725	-0.28452	0.99999	1110	8/11/2020
ZIO433	-1.11	-0.7	-1.6	1.01491	-1.38144	0.99999	1110	8/26/2020

4.1.1 Ozone Bias

EEMS is aware of 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://www.epa.gov/sites/default/files/2020-09/documents/ozonetransferstandardguidance.pdf. EEMS is also aware of the document revisions that are currently in the review process prior to approval and publishing. The discussion below references the currently approved and published document.

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 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 used this equation prior to 2017 with a rolling 6x6 average slope and intercept to correct level 2 standard photometer measurements back to the regional EPA level 1 standard reference photometer (SRP) for ozone PE audits. Since the technical assistance document also states that if any adjustments are made to the transfer standard a new 6x6 verification is required, EEMS did not adjust the physical settings (background and span) of the level 2 standards unless the photometer did not meet the criteria (+/- 3 %) comparison to the level 1 standard. Thereby only mathematical corrections were applied to the level 2 standard photometers.

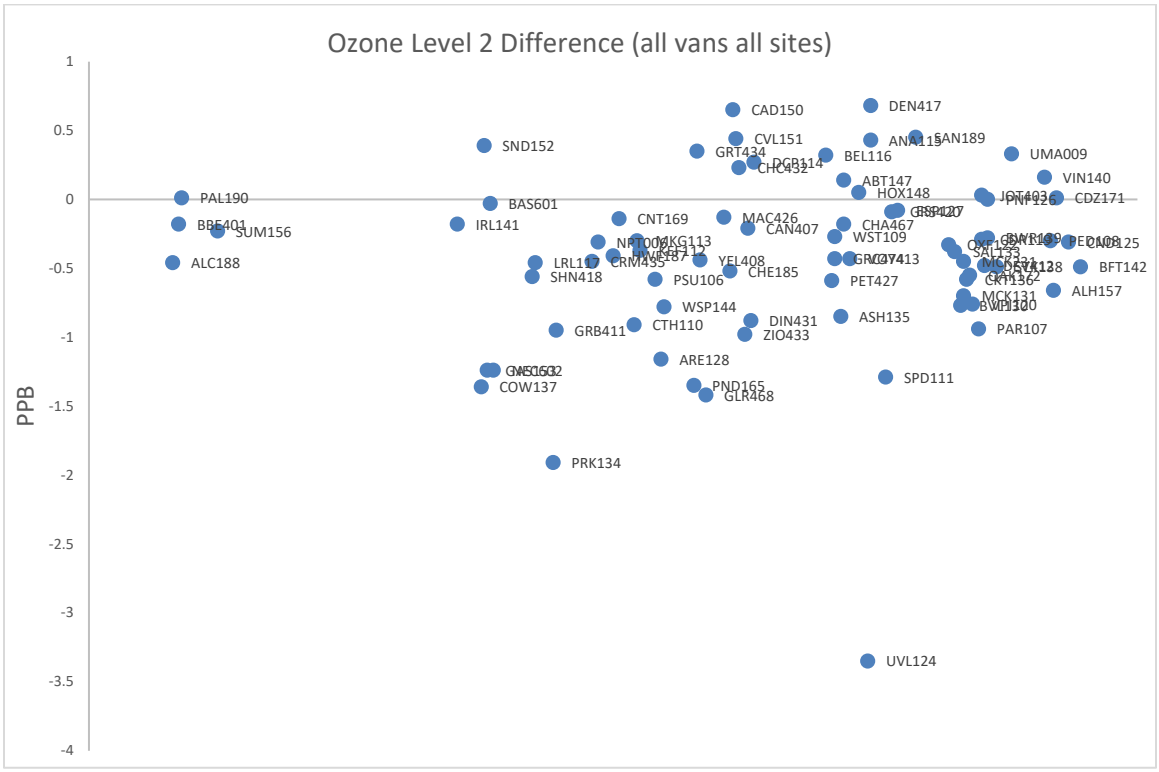
Review of data prior to 2017 indicated that this procedure may have introduced a bias to the standard since the level 2 standards are only compared to the level 1 SRP two or three times per year. The rolling 6x6 slope and intercept averages may not have reflected the current relationship between the level 2 and the level 1 standards. This bias was observed in the data from the 2016 ozone PE audits.

In 2017, EEMS elected to deviate from the EPA Technical Assistance Document and began correcting the level 2 standard photometer using the most recent verification results rather than the rolling 6x6 results. All ozone audit standard measurements have been corrected back to the EPA level 1 standard using most recent slope and intercept relationship to the SRP since 2017.

The remainder of this section will focus on only Level 2 audit results available in AQS. Station monitor response to ozone-free (zero-air) audit gas are not available in AQS. Since EEMS frequently observes negative responses to zero-air from station monitors, it is likely that the lowest audit concentrations are impacted. Level 2 audit results provide the lowest concentration data with enough data points for a cursory comparison, therefore only level 2 audit data are compared.

Figures 4-1 presents annual PE ozone results for Level 2 concentrations performed by EEMS in 2020. As in previous years, the results indicate that there may be a negative bias. Data presented in previous year's reports indicate that the negative bias is not observed in results of PE performed at sites other than CASTNET. Those data are not presented in this report which will focus only on CASTNET PE and EEMS standards.

Figure 4-1. Ozone PE Actual Difference Level 2 Audits Performed by EEMS

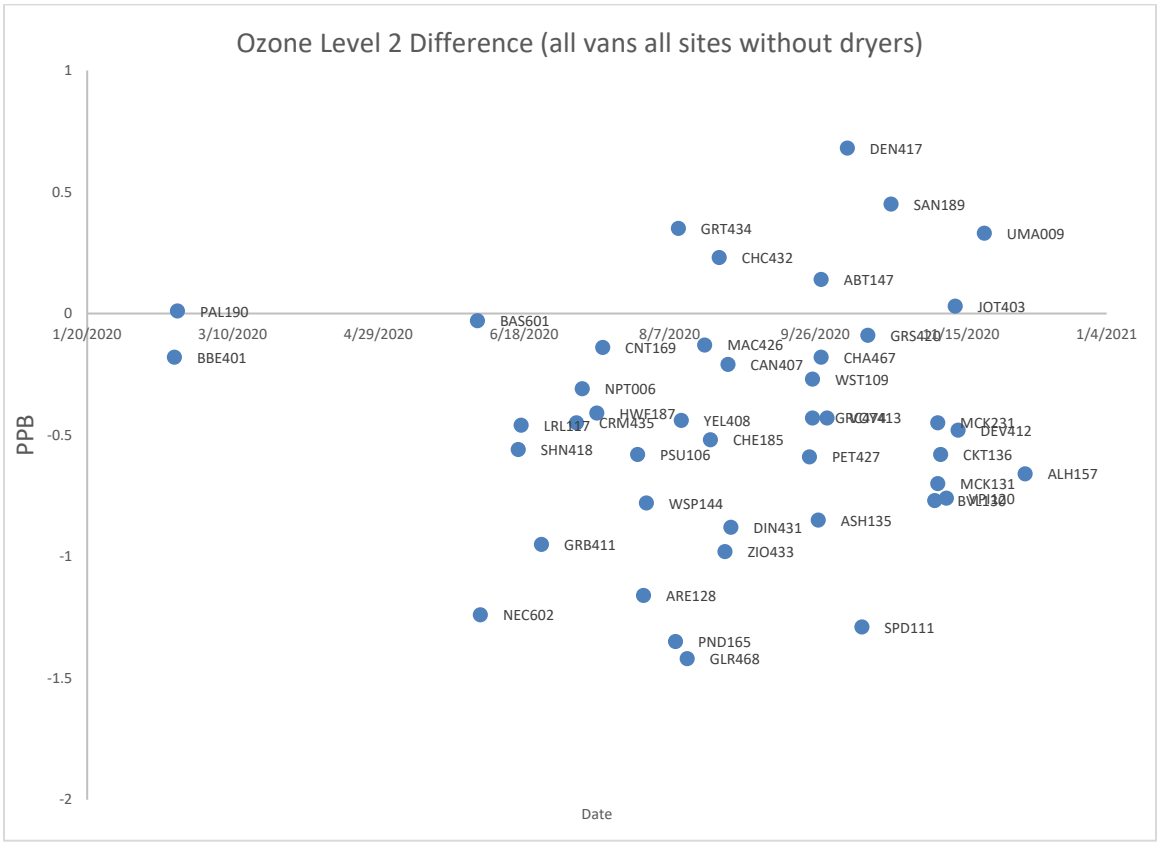


Two sites (PRK134 and UVL124) were outside the acceptance criteria for level 2 audit points. Since the analyses presented in this report are intended to focus on systematic differences and not monitor maintenance issues, those two points have been removed from the following charts.

Previous analyses have pointed to differences in the zero-air generation systems used in the EEMS (and NPAP) mobile labs and the systems at the CASTNET sites. It is theorized that the reference air used in the mobile labs is dryer than the reference air used in the stations, and much dryer than the ambient air being sampled continuously by the monitors. It is theorized that the change from ambient air, to audit gas causes loss in the site sample train as the sample train conditions to the very dry audit gas, and therefore results in a negative audit bias. The data presented in this report further investigates that theory.

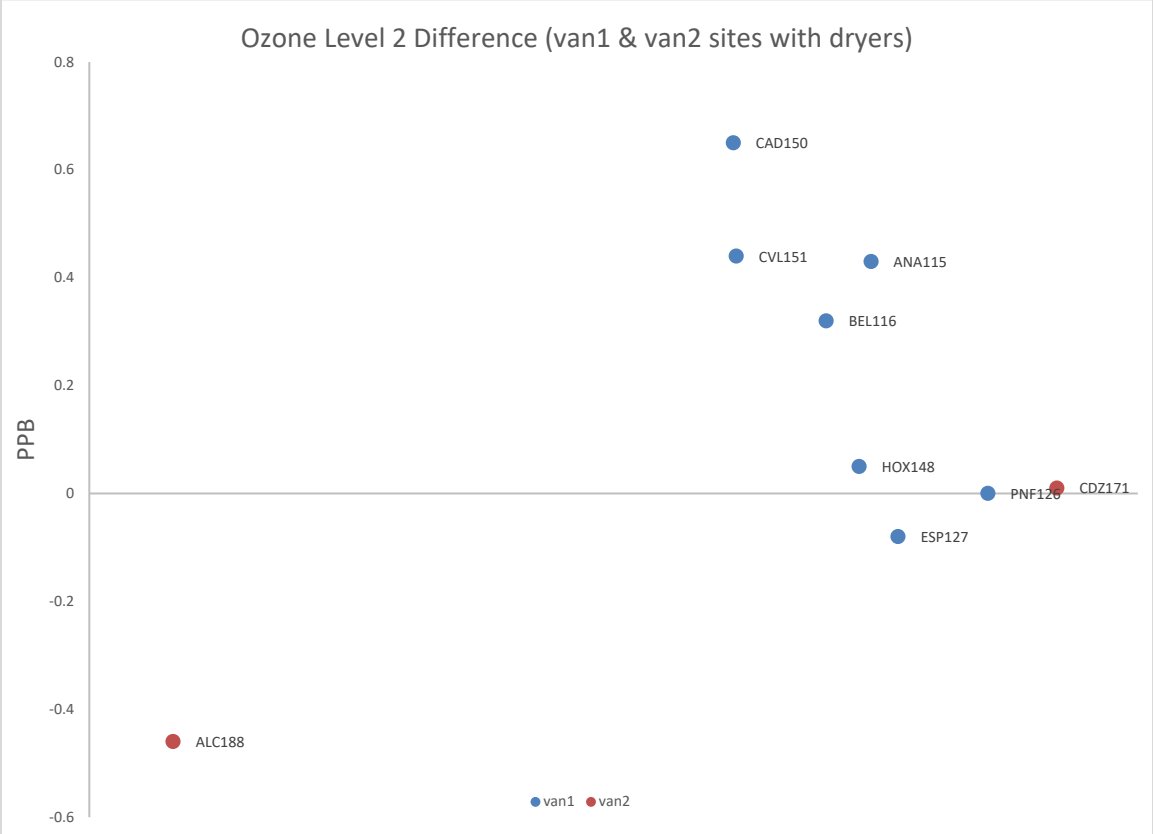
Since 2017 some CASTNET sites have been modified to include Nafion™ dryers in the ozone sample train in an effort to address the moisture content of the ambient air. In theory the dryers should help reduce the sample train conditioning time when audit gas is introduced. To the best of our knowledge, data presented below presents audit results of sites with dryers compared to those without dryers. There may be more sites with dryers that we are not aware of. Figure 4-2 presents the level 2 audit results of all sites that do not have dryers.

Figure 4-2. Ozone PE Actual Difference Level 2 Audits Sites Without Dryers



Results indicate that there is a negative bias at sites that do not have dryers installed in the ozone sample train. Therefore, it should follow those sites with dryers should have no bias. Figure 4-3 presents sites audited using EEMS Van1 and Van2 at sites that have Nafion™ dryers installed in the ozone sample train.

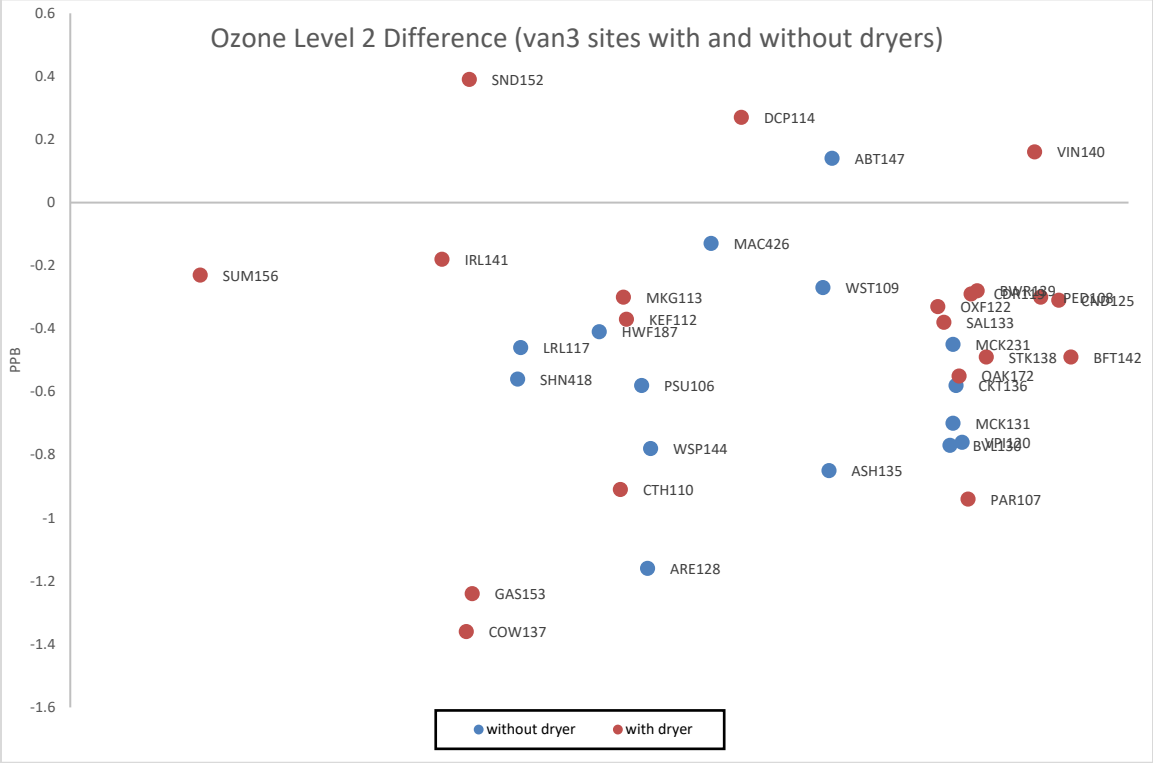
Figure 4-3. Ozone PE Actual Difference Level 2 Audits Vans1 & 2 Sites With Dryers



Although the dataset is small, there appears to be no bias, or possibly a slight positive bias. However, the EEMS Van3 audit data (presented in Figure 4-4) do not seem to indicate the same result. Figure 4-4 indicates there is a negative bias at sites with and without dryers. Since more audits are performed using Van3, those results are driving the negative bias for the network. It is important to note that most sites audited with Van2 do not have dryers (western and NPS sites) which may mean that analysis using Van2 data may not directly compare to Van3 data.

At this time there is still no clear cause for the negative bias observed. The Van3 data indicates that it may not be related to the moisture (or lack thereof) in the mobile lab zero air systems. This is reinforced by EEMS audit data from sites other than CASTNET (previously reported). EEMS will continue to investigate and report any findings.

Figure 4-4. Ozone PE Actual Difference Level 2 Audits Van3 Sites With & Without Dryers



4.2 Flow Rate

The controlled flow rate operated by the CASTNET filter pack system was audited at 35 sites in 2020. All flow rates are in standard temperature and pressure (at 25 ºC) (STP). A NIST-traceable dry-piston primary flow rate device was used for the tests. The readings obtained from this primary standard are the STP flow rate observed, while the DAS flow rate was read from the on-site data logger. All but one (PET427) of the flow rate data accuracy results were found to be within the acceptance limits.

4.3 Shelter Temperature

At each site reporting ozone concentrations to AQS, the hourly average shelter temperature must be maintained between 20.0 to 30.0 degrees C or per manufacturers specifications if designated to a wider temperature range. Shelter temperature was audited at 35 of the sites visited. All but one (PET427) of the shelter temperature data accuracy results were found to be within the acceptance criterion of ± 2 °C. The method consisted of placing the audit standard in close proximity (in situ) to the shelter temperature sensor and recording either instantaneous observations of both sensors, or averages from both sensors. A Resistance Temperature Detector (RTD) was used as the audit standard.

Nearly all of the site sensors were observed to lag behind the audit sensor during the rapid changes in temperature inside the shelter as the air conditioning or heating cycled on and off. In most instances the shelter temperature sensors never reached the minimum or maximum temperature measured with the audit standard. 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)[1] the actual hourly averages may be lower or higher than those measured by the site sensors.

The shelter temperature and flow rate audit 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

Site ID	Shelter Temp. Average Error (C)	Shelter Temp. Maximum Error (C)	STP Flow Rate Primary Standard (lpm)	STP Flow Rate Site DAS (lpm)	Flow Error (% diff)	Audit date
ABT147	0.19	0.5	1.49	1.50	0.89	9/28/2020
ANA115	0.71	0.89	1.50	1.50	0.00	10/7/2020
ARE128	0.45	0.7	1.55	1.50	-3.23	7/29/2020
ASH135	-0.13	-0.37	1.52	1.50	-1.32	9/27/2020
BEL116	1.18	1.72	1.53	1.50	-1.96	9/22/2020
CAN407	-0.03	0.79	3.03	3.00	-0.86	8/27/2020
CAVE	0.70	0.72	--	--	--	9/29/2020
CAT175	--	--	1.51	1.49	-1.04	10/20/2020
CHA467	0.86	1.49	2.99	3.01	0.74	9/28/2020
COW137	0.21	1.31	1.54	1.50	-2.60	5/30/2020
CTH110	0.03	0.1	1.53	1.50	-1.96	7/20/2020
DEN417	-0.28	-0.74	3.03	3.04	0.48	10/7/2020
DEV412	-0.02	-0.07	--	--	--	11/14/2020
DIN431	-0.48	-0.97	3.07	3.02	-1.57	8/28/2020
ESP127	0.59	0.82	1.51	1.50	-0.66	10/16/2020
FOR605	--	--	2.96	3.00	1.47	6/3/2020
GAS153	-0.10	0.85	1.51	1.50	-0.88	6/1/2020

[1] The revised acceptable operating temperature range for Thermo 49*i* monitor is 5 to 40 degrees C.

Site ID	Shelter Temp. Average Error (C)	Shelter Temp. Maximum Error (C)	STP Flow Rate Primary Standard (lpm)	STP Flow Rate Site DAS (lpm)	Flow Error (% diff)	Audit date
GRB411	0.57	0.87	3.00	3.02	0.59	6/24/2020
GRC474	0.59	1.68	3.06	3.00	-1.99	9/25/2020
GRT434	0.79	1.81	--	--	--	8/10/2020
HOX148	1.16	1.18	1.51	1.50	-0.88	10/3/2020
HWF187	-0.08	-0.39	1.50	1.51	0.89	7/13/2020
IRL141	0.16	0.3	1.53	1.50	-1.96	5/22/2020
JOT403	0.13	0.26	2.99	3.00	0.35	11/13/2020
KEF112	-0.39	-0.58	1.54	1.49	-3.03	7/22/2020
MKG113	-0.55	-0.71	1.54	1.49	-3.46	7/21/2020
NPT006	0.58	0.93	3.05	3.00	-1.46	7/8/2020
PET427	1.95	2.42	3.20	3.00	-6.19	9/24/2020
PNF126	0.61	1.1	1.57	1.50	-4.46	11/15/2020
PSU106	0.29	0.48	1.56	1.50	-3.85	7/27/2020
RED004	--	--	3.08	3.00	-2.81	9/29/2020
SAL133	0.31	0.6	1.50	1.50	0.00	11/4/2020
SND152	0.17	0.3	1.52	1.50	-1.32	5/31/2020
SPD111	1.43	1.67	1.57	1.50	-4.66	10/12/2020
SUM156	-0.01	-0.33	1.51	1.50	-0.88	3/3/2020
UMA009	-0.26	-0.34	3.02	3.00	-0.66	11/23/2020
UVL124	0.24	0.68	1.51	1.50	-0.66	10/6/2020
WST109	0.50	1.13	1.49	1.50	0.67	9/25/2020

4.4 Wind Speed

The wind speed sensors at one site equipped for meteorological measurements was audited. The wind speed data accuracy results at BEL116 were within the acceptance limits. The results of the wind speed performance audits are presented in Table 4-4.

4.4.1 Wind Speed Starting Threshold

The condition of the wind speed bearings was evaluated as part of the performance audits. The data acceptance criterion for wind speed bearing torque is not defined in the QAPP. However,

Appendix 1: CASTNET Field Standard Operating Procedures, states that the wind speed bearing torque should be ≤ 0.2 g-cm. To establish the wind speed bearing torque criterion for audit purposes the rational described in the QAPP measurement criteria was applied. The QAPP states that field criteria are more stringent than DQO and established to maintain the system within DQO. Typically, field measurement 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 manufacturers' specifications for a properly maintained system.

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.

The results of the wind direction performance audits are presented in Table 4-4. The average errors for the sensor at BEL116 were within the acceptance limits for the linearity test and the orientation test.

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 measurement criteria 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. The sensor at BEL116 tested within 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

Site ID	Wind Direction					Wind Speed				
	Orientation Error		Linearity Error		Starting Torque (g-cm)	Low Range Error		High Range Error		Starting Torque (g-cm)
	Ave (deg)	Max (deg)	Ave (deg)	Max (deg)		Ave (m/s)	Max (m/s)	Ave (% diff)	Max (% diff)	
BEL116	0.8	2	1	2	12	-0.04	-0.2	-0.001	-0.007	0.40

*** 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. (NP = not performed)**

4.6 Temperature and Two-Meter Temperature

The EPA sponsored site temperature measurement systems consist of a temperature sensor mounted on a tower approximately 9 meters above ground-level. Sites operated by the National Park Service have moved the temperature sensors to approximately two meters above the ground (2-meter temperature). The BLM-WSO has recently upgraded the temperature sensors at their sites to submersible RTD 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.

A total of 33 temperature sensors were tested, and all but two (DEV412 and PET427) were found to be within the acceptance criterion. The average errors for all sensors are presented in Table 4-5.

4.6.1 Temperature Shield Blower Motors

All none of the temperature systems with sensor shield blower motors (forced-air aspiration) encountered during the site audits conducted during 2020 were found to be functioning.

4.7 Relative Humidity

The relative humidity system audited at BEL116 was tested with a combination of primary standard salt solutions, and a NIST-traceable 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. The humidity sensor was within the acceptable limits.

As in previous years, operation of both temperature and humidity sensors with respect to natural or forced-air aspiration can vary between sites. At most EPA sponsored sites temperature and

humidity sensors are operating in naturally aspirated shields. At most NPS sponsored sites temperature and humidity sensors are operating in shields designed to be mechanically aspirated with forced-air blowers.

During humidity 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.

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

Audit Date	Site ID	9-meter Temperature Ave. Error (deg C)	2-Meter Temperature Ave. Error (deg C)	Relative Humidity	
				Range 0 – 100%	
				Ave. Error (%)	Max. Error (%)
9/28/2020	ABT147	0.02	--	--	--
10/7/2020	ANA115	0.07	--	--	--
7/29/2020	ARE128	-0.13	--	--	--
9/27/2020	ASH135	0.06	--	--	--
9/22/2020	BEL116	0.16	0.22	1.6	1.9
8/27/2020	CAN407	--	0.19	--	--
10/20/2020	CAT175	0.09	--	--	--
9/29/2020	CAVE	--	-0.16	--	--
9/28/2020	CHA467	--	0.42	--	--
5/30/2020	COW137	-0.07	--	--	--
7/20/2020	CTH110	-0.14	--	--	--
10/7/2020	DEN417	--	-0.07	--	--
11/14/2020	DEV412	1.17	--	--	--
8/28/2020	DIN431	--	-0.07	--	--
10/16/2020	ESP127	0.14	-	--	--
6/3/2020	FOR605	--	0.02	--	--
6/1/2020	GAS153	-0.01	--	--	--
6/24/2020	GRB411	--	0.05	--	--

Audit Date	Site ID	9-meter Temperature Ave. Error (deg C)	2-Meter Temperature Ave. Error (deg C)	Relative Humidity	
				Range 0 – 100%	
				Ave. Error (%)	Max. Error (%)
9/25/2020	GRC474	--	0.28	--	--
8/10/2020	GRT434	--	0.37	--	--
10/3/2020	HOX148	0.22	--	--	--
7/13/2020	HWF187	-0.09	--	--	--
5/22/2020	IRL141	-0.01	--	--	--
11/13/2020	JOT403	--	-0.20	--	--
7/22/2020	KEF112	-0.09	--	--	--
7/21/2020	MKG113	-0.04	--	--	--
7/8/2020	NPT006	-0.25	--	--	--
9/24/2020	PET427	--	0.98	--	--
11/15/2020	PNF126	0.19	--	--	--
7/27/2020	PSU106	0.07	--	--	--
9/29/2020	RED004	0.07	--	--	--
11/4/2020	SAL133	0.09	--	--	--
5/31/2020	SND152	-0.04	--	--	--
10/12/2020	SPD111	0.10	--	--	--
3/3/2020	SUM156	-0.05	--	--	--
11/23/2020	UMA009	0.01	--	--	--
10/6/2020	UVL124	0.14	--	--	--
9/25/2020	WST109	-0.03	--	--	--

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 or a model 8-48 were used as the audit standard system.

One site, BEL116, was tested. The site had daytime average results that were within the acceptance criterion. The results of the test are included in Table 4-6. The percent difference of the maximum single-hour average solar radiation value observed during the site audit is also reported in Table 4-6 although this criterion is not part of the CASTNET data quality indicators. The maximum value was also within ±10%.

4.9 Precipitation

Data were not recovered from the site DAS during the only precipitation audit performed in 2020 at BEL116, and therefore the results are not reported.

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

Site ID	Solar Radiation Error				Precipitation Ave. Error (% diff)
	Daytime Ave. (% diff)	Std. Max. Value (w/m2)	Site Max. Observed (w/m2)	Max. Value (% diff)	
BELL	2.5	809	815	1.11	--

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 Scientific loggers as their only DAS. The results presented in table 4-7 include the tests performed on the logger at each site. The BLM sites utilize a Campbell Scientific CR1000. The CR1000 and some of the other loggers encountered are not configured to allow analog tests.

4.10.1 Analog Test

The accuracy of each 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. All site data loggers were found to be set to the correct date and within ±5 minutes per the acceptance criterion for time. However, most of the NPS clocks were found to be 1 to 3 minutes

different than the standard, whereas the EPA sponsored site clocks were all within 2-3 seconds. The Campbell Scientific logger clocks at the EPA sites are synchronized with the internet, whereas the ESC loggers at the NPS sites are not. Only one site for BLM-WSO was visited for a systems audit and the logger time and date were not verified.

Table 4-7. Performance Audit Results for Data Acquisition Systems

Audit Date	Site ID	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
		Low Channel		High Channel			
		Average	Maximum	Average	Maximum		
9/28/2020	ABT147	-0.0001	-0.0001			Y	0.02
10/7/2020	ANA115	0.0000	0.0000			Y	0.03
7/29/2020	ARE128	-0.0001	-0.0001			Y	0.00
9/27/2020	ASH135	0.0000	0.0001			Y	0.00
9/22/2020	BEL116	0.0000	-0.0001			Y	0.02
8/27/2020	CAN407	-0.0002	-0.0003			Y	0.67
9/29/2020	CAV436	0.0002	0.0005			Y	0.13
9/28/2020	CHA467			0.0002	0.0005	Y	0.18
5/30/2020	COW137	0.0000	-0.0002			Y	0.00
7/20/2020	CTH110	-0.0001	-0.0002			Y	0.00
10/7/2020	DEN417	-0.0002	-0.0005			Y	0.05
11/14/2020	DEV412			0.0000	-0.0004	Y	0.35
8/28/2020	DIN431	-0.0003	-0.0006			Y	0.27
10/16/2020	ESP127	-0.0001	-0.0002			Y	0.00
6/1/2020	GAS153	0.0000	-0.0001			Y	0.00
6/24/2020	GRB411			-0.0002	-0.0005	Y	1.38
9/25/2020	GRC474			0.0002	0.0004	Y	1.17
8/10/2020	GRT434			0.0001	0.0003	Y	0.83
10/3/2020	HOX148	0.0000	0.0001			Y	0.03
7/13/2020	HWF187	0.0000	-0.0001			Y	3.45
11/13/2020	JOT403			0.0003	0.0005	Y	1.08
7/22/2020	KEF112	0.0000	0.0001			Y	0.02
7/21/2020	MKG113	-0.0001	-0.0002			Y	0.00

Audit Date	Site ID	Analog Test Error (volts)				Date Correct (Y/N)	Time Error (minutes)
		Low Channel		High Channel			
		Average	Maximum	Average	Maximum		
9/24/2020	PET427			0.0003	0.0006	Y	0.22
11/15/2020	PNF126	-0.0001	-0.0002			Y	0.50
7/27/2020	PSU106	-0.0001	-0.0002			Y	0.00
11/4/2020	SAL133	0.0000	0.0001			Y	0.00
5/31/2020	SND152	0.0000	0.0001			Y	0.02
10/12/2020	SPD111	-0.0002	-0.0004			Y	1.50
3/3/2020	SUM156	-0.0001	-0.0002			Y	0.03
10/6/2020	UVL124	0.0000	0.0001			Y	0.00
9/25/2020	WST109	0.0002	0.0003			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.

The CASTNET siting criteria (particularly for gaseous pollutant monitors) have been revised since the previous annual report. There are some discrepancies in the revised QAPP regarding siting criteria. For the audits performed in 2020, EEMS used 10 meters as the minimum distance to roads as provided in the image below from the CASTNET QAPP as Table 2-1

Table 2-1. CASTNET Siting Criteria (Page 1 of 2)

Onsite Criteria (Distance to Sensor or Inlet)		
Criterion	**Meteorology**	**Filter Pack and Gas Monitoring**
Distance from Tree Dripline	50 m	≥ 10 m from dripline
Obstacles to wind	10x obstacle height	2x obstacle height above inlet
Inlet Clearance		Unrestricted airflow arc of 270 degrees
Secondary road (> 100 ADT*)	500 m	500 m
Secondary road (≤ 100 ADT)	200 m	200 m
Feedlot operations	500 m	500 m
Intensive agricultural operations (including aerial spraying)	500 m	500 m
Limited agricultural operations	200 m	200 m
Large parking lot	200 m	200 m
Small parking lot	100 m	100 m
Gas Monitoring - Traffic Volume Criteria		
Roadway Average Daily Traffic* (vehicles/day)	**Minimum Distance O_3 and Oxides of Nitrogen (meters)**	**Minimum Distance CO (meters)**
≤ 1,000	10	
10,000	10	10
15,000	20	25
20,000	30	45
30,000		80
40,000	50	115
50,000		135
60,000		150 (maximum required)
70,000	100	
≥110,000	250	

*Measured or modeled traffic volumes and mixes or approximations based on nearby similar roads.

The CASTNET QAPP is currently being revised to more closely follow 40 CFR Part 58 Appendix E. The audit program will incorporate those changes when they are implemented beginning with audits in 2021.

5.2 Sample Inlets

Based on the siting criteria information provided in the CASTNET QAPP, with consideration given to the siting criteria compromises described in the previous section, all but four sites (LAV410, YEL408, VOY413, and SUM156) visited in 2020 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 26.6 degree angle (object distance must be at least two times the height) above the ozone inlet. There are trees that violate the 26.6 degree sample inlet requirement at the four sites listed above.

The dry deposition filter packs are designed to sample from a height of 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. A few sites were configured with the dry deposition filter face below the edge of the rain shield enclosure. This may impact the size of the particles collected on the filter. The standard CASTNET configuration is the filter face must not extend below the edge of the enclosure.

5.3 Infrastructure

Sites continue to be improved by repairing the site shelters which had deteriorated throughout the years of operation. 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. Wi-Fi routers with improved internet service have been installed at most sites.

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 Wood and ARS field operations centers. In most 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.

Many of the site operators have not been formally trained to perform the CASTNET duties by either Wood or ARS. They had been given instructions by the previous site operators and over the phone instructions from the field operation centers at Wood and ARS.

5.5 Documentation

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 always 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.

6.1 Analog to Digital Convertor Tests

EEMS continues to test at least one channel on any DAS where a channel is available to test. However, the value of this test has diminished over the years of the audit program and it may be time to reevaluate the necessity of testing the analog conversion function of the DAS due to the following:

1. Most modern sensors and monitors have moved away from using analog signals and are currently using digital signals for data reporting. There are very few analog inputs being used on the site data loggers.
2. When each parameter is challenged with an audit standard the response of the sensor is recorded from the DAS. This will inherently account for both the error of the sensor and the error of the DAS.
3. Since replacing the DAS at the majority (all EPA sponsored) of the sites approximately 10 years ago, there have been no analog tests that have exceeded the acceptance criteria. Data are presented below (Figures 6-1 and 6-2) that indicate there have been no failures (± 0.003v) and 99.7% of the test results were ±0.002 or less since 2010.

Given the evolution of data acquisition systems, and the move towards using digital signals from the monitors and sensors, the inherent ability to account for DAS error during challenges, and the excellent audit results over the past 10 years, it is suggested that consideration be given to eliminating the analog test from the audit procedures.

Figure 6-1. All Analog DAS Tests since 2005

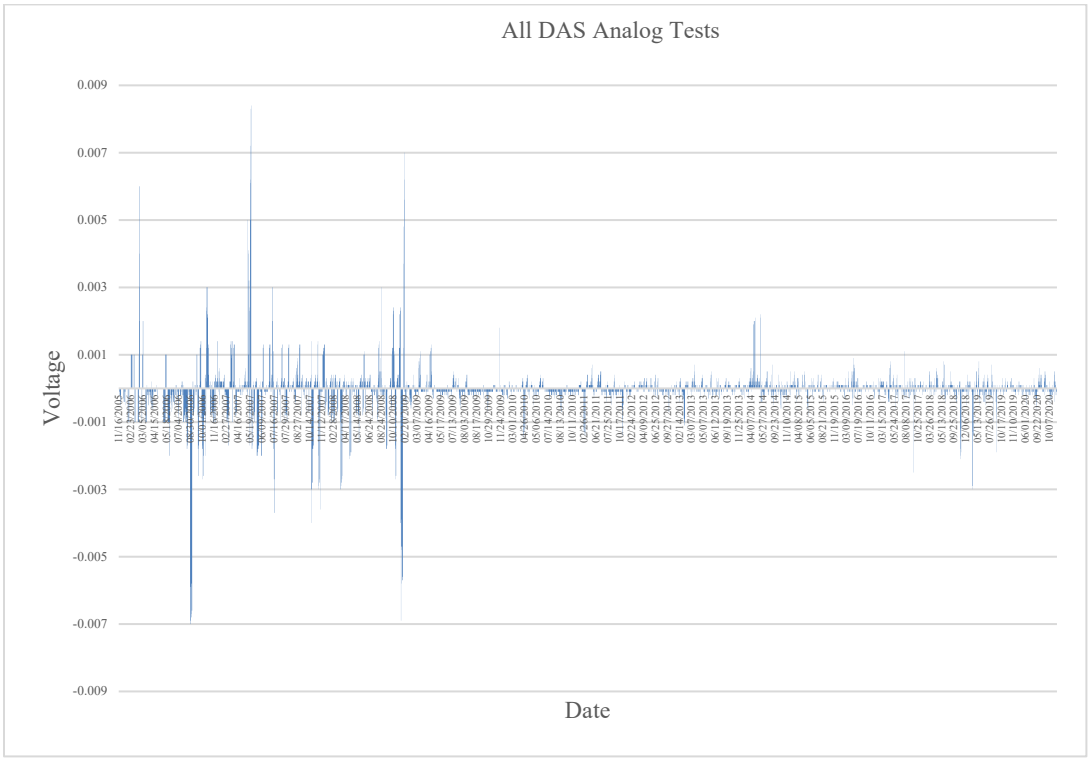
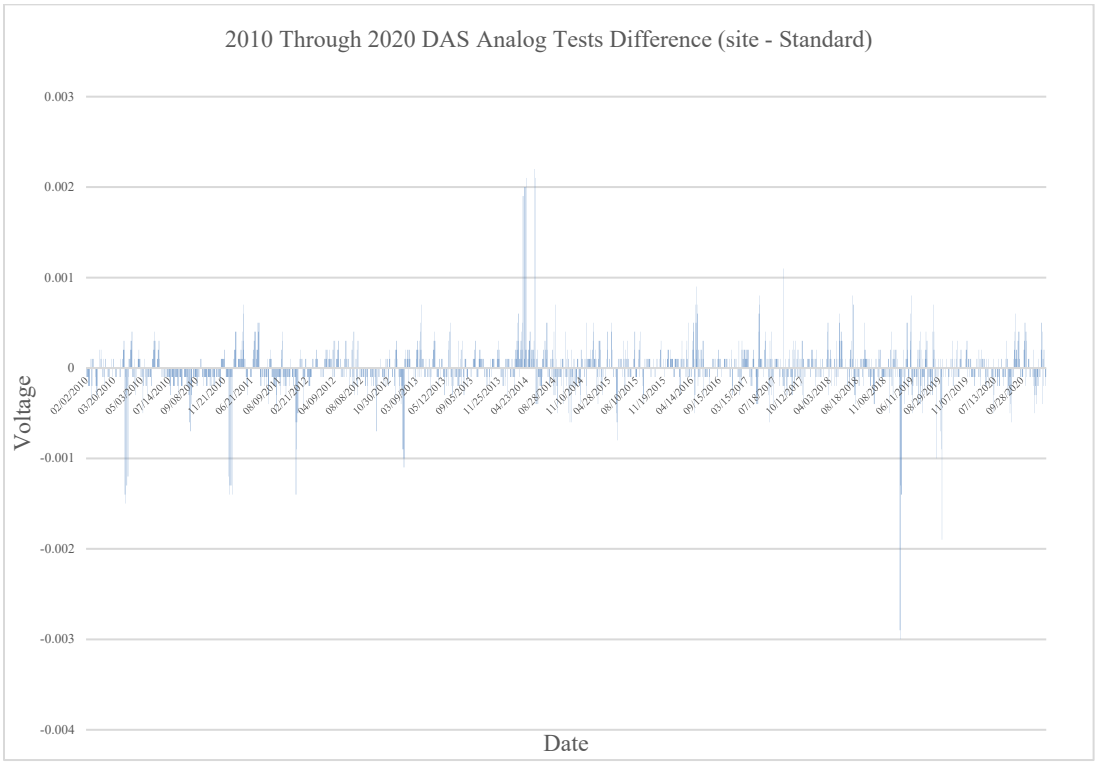


Figure 6-2. Analog DAS Tests 2010 Through 2020



7.0 References

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

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

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

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

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

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

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.

Schwede, D., & Lear, G.C. (2014). A novel hybrid approach for estimating total deposition in the United States. Atmospheric Environment, 92, 207-220.

APPENDIX 1

Audit Standards Certifications

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Laboratory Services & Applied Science Division
Quality Assurance and Program Services Branch
Quality Assurance Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA Region 4	NIST
Contact:	Keith Harris	EEMS
Make:	NIST	Thermo
Model:	SRP	49CPS
S/N:	10	70008-364

EEMS Van 2 01110

SESD Project #: 20-0157
Test #: # 1 "as found" and "as left"

Guest Test Status: PASS
Guest Known Offset: 0

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	1.0026	0.0359	0.9999989	422	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Cycle Start Date / Time	File Name	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
1/13/20 4:45 PM	Cal20011300.xls	1.0016	-0.0459	0.9999980	422	0.00
1/13/20 6:25 PM	Cal20011301.xls	1.0020	0.0251	0.9999997	423	-0.05
1/13/20 8:05 PM	Cal20011302.xls	1.0021	0.0460	0.9999985	423	-0.01
1/13/20 9:45 PM	Cal20011303.xls	1.0033	-0.0204	0.9999992	423	0.06
1/13/20 11:25 PM	Cal20011304.xls	1.0033	0.0943	0.9999991	423	0.06
1/14/20 1:05 AM	Cal20011400.xls	1.0026	0.1525	0.9999994	422	-0.06
1/14/20 2:45 AM	Cal20011401.xls	1.0034	0.0001	0.9999986	421	0.04

Comments: Instrument tested as found.

Ozone calibration factors at time of test: O3 BKG: 0.0 ppb O3 COEF: 1.018

Verification Expires on: January 14, 2021

Keith Harris Date 01/14/20

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Laboratory Services & Applied Science Division
Quality Assurance and Program Services Branch
Quality Assurance Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA Region 4	EEMS
Contact:	Keith Harris	Eric Hebert
Make:	NIST	Thermo
Model:	SRP	49i
S/N:	10	1180030022

EEMS Van 3

01114

SESD Project #: 20-0158
Test #: # 1 "as found" and "as left"

Guest Test Status: PASS
Guest Known Offset: 0

Level 2	Slope	Intercept	R^2	High O_3	Lower O_3
Averages:	0.9995	0.2901	0.999999	422	0.00
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Cycle Start Date / Time	File Name	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
1/13/20 4:45 PM	Cal20011300.xls	0.9992	0.1478	0.9999982	422	0.00
1/13/20 6:25 PM	Cal20011301.xls	0.9987	0.2732	0.9999992	423	-0.05
1/13/20 8:05 PM	Cal20011302.xls	0.9993	0.2565	0.9999984	423	-0.01
1/13/20 9:45 PM	Cal20011303.xls	0.9999	0.2851	0.9999989	423	0.02
1/13/20 11:25 PM	Cal20011304.xls	0.9995	0.4050	0.9999991	423	0.06
1/14/20 1:05 AM	Cal20011400.xls	0.9996	0.3926	0.9999998	422	-0.06
1/14/20 2:45 AM	Cal20011401.xls	1.0001	0.2708	0.9999984	421	0.04

Comments: Instrument tested as found.

Ozone calibration factors at time of test: O3 BKG: - 0.4 ppb O3 COEF: 0.990

Verification Expires on: January 14, 2021

Keith Harris Date 01/14/20

Ozone Transfer Standard Verification Summary Report

U. S. Environmental Protection Agency
Region 4 Laboratory Services & Applied Science Division
Quality Assurance and Program Services Branch
Quality Assurance Section
980 College Station Rd.
Athens, GA 30605

	EPA Standard	GUEST Instrument
Agency:	EPA Region 4	EEMS
Contact:	Keith Harris	Eric Hebert
Make:	NIST	Thermo
Model:	SRP	49 iQps
S/N:	10	1180930075
Guest Test Status:		PASS
Guest Known Offset:		0

FEMS 01115
Van 1

SESD Project #: 20-0156
Test #: # 1
"as left"

Level 2 Averages:	Slope	Intercept	R^2	High O_3	Lower O_3
	0.9949	0.3222	0.9999944	422	0
Upper Tolerance:	1.0300	3.0000			
LowerTolerance:	0.9700	-3.0000			

Cycle Start Date / Time	File Name	Slope	Intercept	R^2	Upper Range (ppb O_3)	Lower Range (ppb O_3)
1/13/20 4:45 PM	Cal20011300.xls	0.9988	0.0863	0.9999931	422	0.00
1/13/20 6:25 PM	Cal20011301.xls	0.9885	0.3766	0.9999991	423	-0.05
1/13/20 8:05 PM	Cal20011302.xls	0.9902	0.3919	0.9999979	423	-0.01
1/13/20 9:45 PM	Cal20011303.xls	0.9941	0.5503	0.9999843	423	0.02
1/13/20 11:25 PM	Cal20011304.xls	1.0007	0.0943	0.9999991	423	0.06
1/14/20 1:05 AM	Cal20011400.xls	1.0000	0.2294	0.9999891	422	-0.06
1/14/20 2:45 AM	Cal20011401.xls	0.9922	0.5266	0.9999982	421	0.04

Comments: Prior to test one instrument was adjusted to more closely match the SRP.

Ozone calibration factors at time of test: O3 BKG: 1.2 ppb O3 COEF: 0.998

Verification Expires on: January 14, 2021

Keith Harris Date 01/14/20

SESDFORM-046-R3

Date

2/14/2020 **- - Calibration and verification of three RTD meters with most recent certification of EEMS RTD**

TMI Cert data -- 1/29/2020

	TMI STD	EEMS RTD 01229	diff	corrected
Cert #	A3483085			
	-25.00	-25.05	0.050	-25.026
	0.00	0.01	-0.010	0.027
	100.00	100.02	-0.020	100.011
	150.00	150.01	-0.010	149.988

RTD 01229

2020 correction: slope= 1.00025954

intercept= -0.0170992

corr= 1.0000000

Eric Hebert 2/14/2020

At EEMS	Date 2/14/2020 RTD 01229 raw	corrected	RTD 01230 / 01231 EEMS AER raw	corrected	RTD 01227 / 1 EEMS van3 raw	corrected	RTD 01228 / 2 EEMS van1 raw	corrected
	0.08	0.10	0.11	0.09	0.21	0.08	-0.05	0.08
	11.06	11.07	11.09	11.08	11.29	10.82	11.04	11.32
	20.88	20.89	20.90	20.90	21.22	20.67	20.96	21.17
	30.65	30.66	30.65	30.66	31.01	30.64	30.78	30.65
	39.36	39.37	39.35	39.37	39.83	39.39	39.59	39.39
	50.87	50.87	50.83	50.86	51.39	50.86	51.15	50.85
	25.25	25.26	25.26	25.26	25.60	25.27	25.35	25.27
slope =			**0.998854**		**1.007968**		**1.008426**	
intercept =			**0.024392**		**0.129496**		**-0.12932**	
correlation =			**1.0000**		**1.0000**		**1.0000**	

Certificate Number
A3483224
Issue Date: 01/29/20

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

Van-1

ID Number: EEMS 01222

Description:	PSYCHROMETER W/ PROBE
Manufacturer:	AZ INSTRUMENTS
Model Number:	AZ 8723
Serial Number:	10325187
Technician:	STEVE TORRES
On-Site Calibration:	☐
Comments:	

Calibration Date:	01/29/2020
Calibration Due:	01/29/2021
Procedure:	TMI-M-HYGROTHERMOGRAPHS Rev: 2/22/2011
Temperature:	71 °F
Humidity:	36 % RH
As Found Condition:	**IN TOLERANCE**
Calibration Results:	**IN TOLERANCE**

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
0710649	THUNDER SCIENTIFIC	2500ST	6/21/2019	2/21/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483224
Issue Date: 01/29/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	50.0	49.0	51.0	49.3	49.3	°F	
Temperature Accuracy	70.0	69.0	71.0	69.3	69.3	°F	
Temperature Accuracy	90.0	89.0	91.0	89.2	89.2	°F	
Humidity Accuracy	33.0	30.0	36.0	31.1	31.1	%RH	
Humidity Accuracy	50.0	47.0	53.0	49.0	49.0	%RH	
Humidity Accuracy	75.0	72.0	78.0	73.9	73.9	%RH	

EEMS # 01222

Van - 1

$m =$ 1.0173

$b =$ -2.2459

$r^2 =$ 0.9999

EL 1/30/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483222
Issue Date: 01/29/20

Certificate of Calibration

Van-2

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01225 / 01220

Description:	THERMO HYGROMETER	Calibration Date:	01/29/2020
Manufacturer:	ROTRONIC	Calibration Due:	01/29/2021
Model Number:	HYGROPALM	Procedure:	TMI-M-HYGROTHERMOGRAPHS Rev: 2/22/2011
Serial Number:	40861 002/124431	Temperature:	71 °F
Technician:	STEVE TORRES	Humidity:	36 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments:

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
0710649	THUNDER SCIENTIFIC	2500ST	6/21/2019	2/21/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483222
Issue Date: 01/29/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	15.0	14.6	15.4	14.9	14.9	C	
Temperature Accuracy	25.0	24.6	25.4	24.7	24.7	C	
Temperature Accuracy	35.0	34.6	35.4	34.8	34.8	C	
Humidity Accuracy	33.0	31.4	34.6	32.8	32.8	%	
Humidity Accuracy	50.0	48.4	51.6	49.9	49.9	%	
Humidity Accuracy	75.0	73.4	76.6	73.6	73.6	%	

EEMS # 01220/01225

Van-2

m = 0.9697

b = 1.0302

r^2 = 0.9999

1/30/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483225
Issue Date: 01/29/20

Certificate of Calibration

Van -3

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01223

Description: PSYCHROMETER W/ PROBE
Manufacturer: AZ INSTRUMENTS
Model Number: AZ 8723
Serial Number: 10325189
Technician: STEVE TORRES
On-Site Calibration: ☐
Comments:

Calibration Date: 01/29/2020
Calibration Due: 01/29/2021
Procedure: TMI-M-HYGROTHERMOGRAPHS
Rev: 2/22/2011
Temperature: 71 °F
Humidity: 36 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
0710649	THUNDER SCIENTIFIC	2500ST	6/21/2019	2/21/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483225
Issue Date: 01/29/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	50.0	49.0	51.0	49.5	49.5	°F	
Temperature Accuracy	70.0	69.0	71.0	69.5	69.5	°F	
Temperature Accuracy	90.0	89.0	91.0	89.4	89.4	°F	
Humidity Accuracy	33.0	30.0	36.0	31.2	31.2	%RH	
Humidity Accuracy	50.0	47.0	53.0	49.0	49.0	%RH	
Humidity Accuracy	75.0	72.0	78.0	74.0	74.0	%RH	

EEMS # 01223

Van - 3

m = 1.0176

b = -2.1949

r^2 = 0.9999

ED 1/30/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483055
Issue Date: 01/29/20

Certificate of Calibration

Van - 2

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01226

Description:	DIGITAL STIK THERMOMETER	Calibration Date:	01/29/2020
Manufacturer:	FLUKE	Calibration Due:	01/29/2021
Model Number:	1551A EX	Procedure:	FLUKE 1551A EX,52A EX Rev: 11/1/2010
Serial Number:	2085085	Temperature:	71 °F
Technician:	STEVE TORRES	Humidity:	36 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments:

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
05535	FLUKE	5609-12-D	7/17/2019	7/17/2020
660TL18010015	ADDITEL CORPORATION	ADT875PC-155	6/4/2019	6/4/2020
A88072	FLUKE/HART	1502A	11/5/2019	2/28/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483055
Issue Date: 01/29/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	-25.00	-25.05	-24.95	-25.04	-25.04	°C	
Temperature Accuracy	0.00	-0.05	0.05	-0.01	-0.01	°C	
Temperature Accuracy	100.00	99.95	100.05	100.00	100.00	°C	
Temperature Accuracy	150.00	149.95	150.05	150.00	150.00	°C	

FEMS # 01226

Van-2

$m = 1.0001863$

$b = -0.022977$

$r^2 = 1.0000$

CD 1/30/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483085
Issue Date: 01/29/20

Certificate of Calibration

EEMS
Van-2

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01229

Description:	DIGITAL STIK THERMOMETER	Calibration Date:	01/29/2020
Manufacturer:	FLUKE	Calibration Due:	01/29/2021
Model Number:	1551A EX	Procedure:	FLUKE 1551A EX,52A EX Rev: 11/1/2010
Serial Number:	3275143	Temperature:	71 °F
Technician:	STEVE TORRES	Humidity:	36 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments:

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
05535	FLUKE	5609-12-D	7/17/2019	7/17/2020
660TL18010015	ADDITEL CORPORATION	ADT875PC-155	6/4/2019	6/4/2020
A88072	FLUKE/HART	1502A	11/5/2019	2/28/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3483085
Issue Date: 01/29/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Temperature Accuracy	-25.00	-25.05	-24.95	-25.05	-25.05	°C	
Temperature Accuracy	0.00	-0.05	0.05	0.01	0.01	°C	
Temperature Accuracy	100.00	99.95	100.05	100.02	100.02	°C	
Temperature Accuracy	150.00	149.95	150.05	150.01	150.01	°C	

EEMS # 01229

Van-2

m = 1.0002595

b = -0.017099

r^2 = 1.0000

1/30/2020

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

ANSI/NCSL Z540-1-1994

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

EEMS # -01245 and 01246

Calibration Certificate

Instrument: Precision Spectral Pyranometer, Model PSP, Serial Number 34341F3 Van 3

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: $S = 9.31\ \mu V / Wm^{-2}$**
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2)
Resistance: 699 Ω at 23°C

Date of Test: February 4, 2020

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 Twelfth International Pyrheliometric Comparisons (IPC XII) at Davos, Switzerland in September-October 2015. 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. Hunter In Charge of Test: Thomas D. Kirk Reviewed by:

Eppley SO: 65601

Date of Certificate February 5, 2020

Remarks: Amplifier #10765 set with gain = 76.72 so that 1 V = 1400 Wm^{-2}.

End of Report

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

EEMS # D1247

Calibration Certificate

Instrument: Black & White Pyranometer, Model 8-48, Serial Number 23824 Van 2

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 Black & White Pyranometer, Model 8-48, Serial Number 14061

Results: **Sensitivity: $S = 8.83\ \mu V / Wm^{-2}$**
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2)
Resistance: 346 Ω at 23°C

Date of Test: February 4, 2020

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 Twelfth International Pyrheliometric Comparisons (IPC XII) at Davos, Switzerland in September-October 2015. 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. Gentry In Charge of Test: Thomas J. Kirk Reviewed by:

Eppley SO: 65601

Date of Certificate February 5, 2020

Remarks:

End of Report

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

CERTIFICATE OF CALIBRATION AND TESTING

Model: 18802
Serial Number: CA04013

Description: Anemometer Drive - 200 to 15000 RPM
(Comprised of 18820A Control Unit and 18830A Motor Assembly)

R. M. Young Company certifies that the above equipment 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.

Nominal Motor RPM 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
10200	1700	10200	10200
12600	2100	12600	12600
15000	2500	15000	15000
☑ Clockwise and Counterclockwise rotation verified.			

(1) Measured output frequency of YOUNG model 27106D standard anemometer attached to motor shaft.
(2) YOUNG model 27106D produces 10 pulsed per revolution of the anemometer shaft.
(3) Indicated on the Control Unit LCD.

* Indicates out of tolerance.

☐ New Unit ☑ Service / Repair Unit ☐ As found
☑ No calibration adjustments required ☐ As left

EEMS # 01253 - Controller
01254 - motor - low
01255 - motor - high

m = 1 b = 0

EW
7/2/20

Traceable frequency meter used for calibration:
Model: 34405A Serial Number: TW46290020

Date: 18 June 2020
Calibration Interval: One year

Tested By : EC

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

Van 2
EEMS# 01261 & 01457

CERTIFICATE OF CALIBRATION AND TESTING

Model: 18802/18811
Serial Number: CA04353

Description: Anemometer Drive - 2 motors, 20 to 15,000 RPM
(18802 comprised of 18820A Control Unit and 18830A Motor Assembly)
(18811 comprised of 18820A Control Unit and 18831A Motor Assembly)

R. M. Young Company certifies that the above equipment 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.

Nominal Motor RPM RPM	27106D Output Frequency Hz (1)	Calculated RPM (2)	Indicated RPM (3)
18802	☑ Clockwise and Counterclockwise rotation verified.		
300	50	300	300
2700	450	2700	2700
5100	850	5100	5100
7500	1250	7500	7500
10200	1700	10200	10200
12600	2100	12600	12600
15000	2500	15000	15000
18811	☑ Clockwise and Counterclockwise 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 output frequency of YOUNG model 27106D standard anemometer attached to motor shaft.
(2) YOUNG model 27106D produces 10 pulsed per revolution of the anemometer shaft.
(3) Indicated on the Control Unit LCD.

* Indicates out of tolerance.

☐ New Unit ☑ Service / Repair Unit ☐ As found
☑ No calibration adjustments required ☐ As left

Traceable frequency meter used for calibration:
Model: 34405A Serial Number: TW46290020

Date: 14 May 2020
Calibration Interval: One year

Tested By : EC

Van 1

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: 70° Humidity: 34%
Customer Name	FEMS	Item Name	USHIKATA
Manufacturer		Model	S-25
Serial Number	191832	Calibration Date	3-2-20
Calibration Frequency		Job Card Number	S-26704
Customer Reference Number		Date of Certification	3-2-20

Measurement Standards

Theodolite Wild T-3 S/N 18801 Calibration 01/17/2020 Due 01/17/2021 NIST Number 738/229329-83 738/223398

Optical Wedge K&E 71-7020 S/N 5167 Calibration: 01/16/2019 Due 01/16/2024, 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

Repair Technician	John Noga, Quality Assurance

EEMS # 01265

Van 2

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: 70° Humidity: 39%
Customer Name	EE&MS	Item Name	USHIKATA
Manufacturer		Model	S-25
Serial Number	190037	Calibration Date	3-2-20
Calibration Frequency		Job Card Number	S-26703
Customer Reference Number		Date of Certification	3-2-20

Measurement Standards

Theodolite Wild T-3 S/N 18801 Calibration 01/17/2020 Due 01/17/2021 NIST Number ~~738/229328-83~~ 738/223398

Optical Wedge K&E 71-7020 S/N 5167 Calibration; 01/16/2019 Due 01/16/2024, 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 Paolozzi	John Noga, Quality Assurance
Repair Technician	John Noga

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

EEMS # 01272

Van 3

Calibration Data Record			Temperature: 70° Humidity: 39%
Customer Name	EE & 45	Item Name	OSHIKATA
Manufacturer		Model	S-25
Serial Number	199578	Calibration Date	3-2-20
Calibration Frequency		Job Card Number	S-26702
Customer Reference Number		Date of Certification	3-2-20

Measurement Standards

Theodolite Wild T-3 S/N 18801 Calibration 01/17/2020 Due 01/17/2021 NIST Number ~~738/229329-83 738/223398~~

Optical Wedge K&E 71-7020 S/N 5167 Calibration; 01/16/2019 Due 01/16/2024, 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 Paologgu	
Repair Technician	John Noga, Quality Assurance

Doc templates 2/wk-40-1360 survey compass calibration record

Certificate Number
A3488979
Issue Date: 02/04/20

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number: EEMS

ID Number: 01310

Van-1

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

Calibration Date: 02/04/2020
Calibration Due: 02/04/2021
Procedure: METCAL FLUKE 187
Rev: 6/15/2015
Temperature: 73 °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 SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
7040208	FLUKE	5520A	5/2/2019	5/2/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3479890
Issue Date: 01/28/20

Certificate of Calibration

Van - 2

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01312

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

Calibration Date: 01/28/2020
Calibration Due: 01/28/2021
Procedure: METCAL FLUKE 287
Rev: 6/15/2015
Temperature: 73 °F
Humidity: 39 % RH
As Found Condition: IN TOLERANCE
Calibration Results: IN TOLERANCE

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
7040208	FLUKE	5520A	5/2/2019	5/2/2020

TMI Technical Maintenance, Inc.
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Phone: 813-978-3054 Fax 813-978-3758
www.tmicalibration.com

ANSI/NCSL Z540-1-1994

Certificate Number
A3479886
Issue Date: 01/28/20

Certificate of Calibration

Van-3

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01311

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

Calibration Date:	01/28/2020
Calibration Due:	01/28/2021
Procedure:	METCAL FLUKE 287 Rev: 6/15/2015
Temperature:	73 °F
Humidity:	39 % RH
As Found Condition:	**IN TOLERANCE**
Calibration Results:	**IN TOLERANCE**

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

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Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
7040208	FLUKE	5520A	5/2/2019	5/2/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3506546
Issue Date: 02/16/20

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01414

Description:	PRIMARY FLOW CALIBRATOR	Calibration Date:	02/16/2020
Manufacturer:	MESA LABORATORIES INC	Calibration Due:	02/16/2021
Model Number:	DEFENDER 530+ H	Procedure:	TB 9-6680-293-40 Rev: 2/20/2013
Serial Number:	159956	Temperature:	70 °F
Technician:	KYLE HUITT	Humidity:	49 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments: Sensor Factor received at 1.000. Unit calibrated to a Standard Temperature of 25°C.

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

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Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
FL2146	FLUKE	MOLBOX1+A700-A	7/3/2018	7/3/2020
FL7536	FLUKE	3E4-VCR-V-Q	6/22/2018	6/22/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3506546
Issue Date: 02/16/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Flow Accuracy	5.0000	4.9500	5.0500	5.0123	5.0123	slm	
Flow Accuracy	10.000	9.900	10.100	10.038	10.038	slm	
Flow Accuracy	15.000	14.850	15.150	15.045	15.045	slm	
Flow Accuracy	20.000	19.800	20.200	20.064	20.064	slm	
Flow Accuracy	25.000	24.750	25.250	25.082	25.082	slm	
Flow Accuracy	30.000	29.700	30.300	30.109	30.109	slm	

EEMS # 01414

m = 1.0036257

b = -0.00507 (LPM)

r² = 0.99999

2/25/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3598861
Issue Date: 05/06/20

Certificate of Calibration

Van 2

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01416

Description:	PRIMARY FLOW CALIBRATOR	Calibration Date:	05/06/2020
Manufacturer:	BIOS INTERNATIONAL CORP.	Calibration Due:	05/06/2021
Model Number:	DEFINER 220-H	Procedure:	TB 9-6680-293-40 Rev: 2/20/2013
Serial Number:	122974	Temperature:	70 °F
Technician:	SEAN LEWIS	Humidity:	49 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments: Standard Conditions of 14.7 psia / 25 °C

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

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Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
FL2146	FLUKE	MOLBOX1+A700-A	7/3/2018	7/3/2020
FL7536	FLUKE	3E4-VCR-V-Q	6/22/2018	6/22/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3598861
Issue Date: 05/06/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Flow Measurement Accuracy	0.5005	0.4955	0.5055	0.4983	0.4983	slm	
Flow Measurement Accuracy	6.001	5.941	6.061	6.009	6.009	slm	
Flow Measurement Accuracy	11.999	11.879	12.119	12.030	12.030	slm	
Flow Measurement Accuracy	18.000	17.820	18.180	18.021	18.021	slm	
Flow Measurement Accuracy	24.007	23.767	24.247	24.031	24.031	slm	
Flow Measurement Accuracy	30.002	29.702	30.302	29.945	29.945	slm	

Van 2

EEMS # 01416

220-H

$m = 0.998843$

$b = 0.021567$ (slpm)

$r^2 = 0.99999$

Use Raw (uncorrected) Readings

5/15/20

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3508402
Issue Date: 02/17/20

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01417

Description:	PRIMARY FLOW CALIBRATOR	Calibration Date:	02/16/2020
Manufacturer:	BIOS INTERNATIONAL CORP.	Calibration Due:	02/16/2021
Model Number:	DEFINER 220-H	Procedure:	TB 9-6680-293-40 Rev: 2/20/2013
Serial Number:	131818	Temperature:	70 °F
Technician:	KYLE HUITT	Humidity:	49 % RH
		As Found Condition:	**OUT OF TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**LIMITED CALIBRATION**

Comments: Sensor Factor received at 1.000. Adjusted to 0.980. Unit calibrated to a Standard Temperature of 25°C.

Limiting Attribute: UNIT IS NOT CALIBRATED GREATER THAN 25 SLPM.

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
FL2146	FLUKE	MOLBOX1+A700-A	7/3/2018	7/3/2020
FL7536	FLUKE	3E4-VCR-V-Q	6/22/2018	6/22/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3508402
Issue Date: 02/17/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Flow Accuracy	5.0000	4.9500	5.0500	5.0790	4.9720	slm	A
Flow Accuracy	10.000	9.900	10.100	10.171	9.951	slm	A
Flow Accuracy	15.000	14.850	15.150	15.326	14.992	slm	A
Flow Accuracy	20.000	19.800	20.200	20.568	20.083	slm	A
Flow Accuracy	25.000	24.750	25.250	25.533	24.914	slm	A
Flow Accuracy	30.000	29.700	30.300	24.448	24.467	slm	L

EEMS # 01417

$m = 1.00032$

$b = -0.0224$ (Lpm)

$r^2 = 0.99997$

2/25/20

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3506549
Issue Date: 02/16/20

Certificate of Calibration

Customer: ENVIRONMENTAL ENGINEERING & MEASUREMENT SERVICES
4577 E NW 6TH STREET
GAINESVILLE, FL 36209
352-262-0802

P.O. Number:

ID Number: EEMS 01421

Description:	PRIMARY FLOW CALIBRATOR	Calibration Date:	02/16/2020
Manufacturer:	MESA LABORATORIES INC	Calibration Due:	02/16/2021
Model Number:	DEFINER 220-H	Procedure:	TB 9-6680-293-40 Rev: 2/20/2013
Serial Number:	148613	Temperature:	70 °F
Technician:	KYLE HUITT	Humidity:	49 % RH
		As Found Condition:	**IN TOLERANCE**
On-Site Calibration: ☐		**Calibration Results:**	**IN TOLERANCE**

Comments: Sensor Factor received at 1.000. Unit calibrated to a Standard Temperature of 25°C.

Limiting Attribute:

This instrument has been calibrated using standards traceable to the SI units through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI). The method of calibration is direct comparison to a known standard, derived from natural physical constants, ratio measurements or compared to consensus standards.

Reported uncertainties are expressed as expanded uncertainty values at an approximately 95% confidence level using a coverage factor of k=2. 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 17025:2017 and ANSI/NCSL Z540-1-1994. ISO/IEC 17025:2017 is written in a language relevant to laboratory operations, meeting the principles of ISO 9001 and aligned with its pertinent requirements. This calibration complies with all the requirements of ANSI/NCSL Z540-1-1994 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.

Measurements not currently on TMI's Scope of Accreditation are identified with an asterisk.

WALLY GYNN, BRANCH MANAGER

Scott Chamberlain, QUALITY MANAGER

Calibration Standards

Asset Number	Manufacturer	Model Number	Date Calibrated	Cal Due
FL2146	FLUKE	MOLBOX1+A700-A	7/3/2018	7/3/2020
FL7536	FLUKE	3E4-VCR-V-Q	6/22/2018	6/22/2020

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

ANSI/NCSL Z540-1-1994

Certificate Number
A3506549
Issue Date: 02/16/20

Certificate of Calibration

Data Sheet

Parameter	Nominal	Minimum	Maximum	As Found	As Left	Unit	ADJ/FAIL
Flow Accuracy	5.0000	4.9500	5.0500	5.0190	5.0190	slm	
Flow Accuracy	10.000	9.900	10.100	10.026	10.026	slm	
Flow Accuracy	15.000	14.850	15.150	15.040	15.040	slm	
Flow Accuracy	20.000	19.800	20.200	20.095	20.095	slm	
Flow Accuracy	25.000	24.750	25.250	25.106	25.106	slm	
Flow Accuracy	30.000	29.700	30.300	30.135	30.135	slm	

EEMS # 01421

$m = 1.0050$

$b = -0.01733$ (LPM)

$r^2 = 0.99999$

2/25/2020

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

ANSI/NCSL Z540-1-1994

Airgas
an Air Liquide company

Airgas Specialty Gases
Airgas USA, LLC
630 United Drive
Durham, NC 27713
Airgas.com

Van 2

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Part Number:	E02AI99E60A003C	Reference Number:	122-401714441-1
Cylinder Number:	JB03172	Cylinder Volume:	63.2 CF
Laboratory:	124 - Durham (SAP) - NC	Cylinder Pressure:	2436 PSIG
PGVP Number:	B22020	Valve Outlet:	590
Gas Code:	CO,BALA63	Certification Date:	Feb 06, 2020

Expiration Date: Feb 06, 2028

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a mole/mole basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON MONOXIDE	50.00 PPM	51.12 PPM	G1	+/- 0.6% NIST Traceable	02/06/2020
AIR	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	09010213	KAL004779	98.48 PPM CARBON MONOXIDE/NITROGEN	+/- 0.5%	Oct 16, 2024

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Horiba VIA510 CO 1G46EA07	Nondispersive Infrared (NDIR)	Jan 31, 2020

Triad Data Available Upon Request

PERMANENT NOTES:-NA-

NOTES:RAN TV01202020-B
S/N JB03172

Van 2 High CO

Approved for Release

Airgas
an Air Liquide company

Airgas USA, LLC
525 North Industrial Loop Road
Tooele, UT 84074
Airgas.com

Van 2

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Part Number:	E02AI99E60A001C	Reference Number:	153-401569729-1
Cylinder Number:	JB03465 COC	Cylinder Volume:	63.2 CF
Laboratory:	124 - Tooele (SAP) - UT	Cylinder Pressure:	2436 PSIG
PGVP Number:	B72019	Valve Outlet:	590
Gas Code:	CO,BALA	Certification Date:	Aug 23, 2019

Expiration Date: Aug 23, 2027

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON MONOXIDE	9.000 PPM	9.049 PPM	G1	+/- 0.7% NIST Traceable	08/23/2019
AIR	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	08011130	KAL004049	9.855 PPM CARBON MONOXIDE/NITROGEN	0.5%	Jun 05, 2024

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Thermo 48i-TLE 1163640031 CO	CO NDIR (Mason)	Aug 19, 2019

Triad Data Available Upon Request

PERMANENT NOTES:-NA-

Approved for Release

BLEND BOTTLE
VAN 2

Airgas
an Air Liquide company

Airgas Specialty Gases
Airgas USA, LLC
630 United Drive
Durham, NC 27713
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Part Number:	E04NI99E60A001C	Reference Number:	122-401714440-1A
Cylinder Number:	JB03448	Cylinder Volume:	62.2 CF
Laboratory:	124 - Durham (SAP) - NC	Cylinder Pressure:	2437 PSIG
PGVP Number:	B22020	Valve Outlet:	660
Gas Code:	CO,NO,NOX,SO2,BALN	Certification Date:	Feb 25, 2020

Expiration Date: Feb 25, 2023

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a mole/mole basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
NOX	15.00 PPM	14.95 PPM	G1	+/- 1.4% NIST Traceable	02/18/2020, 02/25/2020
NITRIC OXIDE	15.00 PPM	14.95 PPM	G1	+/- 1.4% NIST Traceable	02/18/2020, 02/25/2020
SULFUR DIOXIDE	15.00 PPM	14.88 PPM	G1	+/- 0.9% NIST Traceable	02/18/2020, 02/25/2020
CARBON MONOXIDE	3000 PPM	2996 PPM	G1	+/- 1.0% NIST Traceable	02/18/2020
NITROGEN	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	12010216	AAL073584	10.04 PPM NITRIC OXIDE/NITROGEN	+/- 1.0%	Oct 16, 2022
PRM	PRM	D562879	10.01 PPM NITROGEN DIOXIDE/AIR	+/- 1.9%	Aug 17, 2018
GMIS	124206889114	CC322698	4.432 PPM NITROGEN DIOXIDE/NITROGEN	+/- 2.0%	Aug 15, 2021
NTRM	14010338	ND48595	49.08 PPM SULFUR DIOXIDE/NITROGEN	+/- 0.9%	Apr 17, 2024
NTRM	08012224	KAL004602	2466 PPM CARBON MONOXIDE/NITROGEN	+/- 0.5%	May 09, 2024

The SRM, PRM or RGM noted above is only in reference to the GMIS used in the assay and not part of the analysis.

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Nicolet 6700 AHR0801549 CO	FTIR	Feb 05, 2020
Nicolet 6700 AHR0801549 NO	FTIR	Feb 05, 2020
Nicolet 6700 AHR0801549 NO	FTIR	Feb 05, 2020
Nicolet 6700 AHR0801549 SO2	FTIR	Feb 05, 2020

Triad Data Available Upon Request

PERMANENT NOTES:-NA-

Approved for Release

Airgas
an Air Liquide company

Airgas USA, LLC
525 North Industrial Loop Road
Tooele, UT 84074
Airgas.com

CERTIFICATE OF ANALYSIS

Grade of Product: EPA Protocol

Van 2

Part Number:	E02AI99E60A000C	Reference Number:	153-401569730-1
Cylinder Number:	JB03450 COC	Cylinder Volume:	63.2 CF
Laboratory:	124 - Tooele (SAP) - UT	Cylinder Pressure:	2436 PSIG
PGVP Number:	B72019	Valve Outlet:	590
Gas Code:	CO,BALA	Certification Date:	Aug 23, 2019

Expiration Date: Aug 23, 2027

Certification performed in accordance with "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (May 2012)" document EPA 600/R-12/531, using the assay procedures listed. Analytical Methodology does not require correction for analytical interference. This cylinder has a total analytical uncertainty as stated below with a confidence level of 95%. There are no significant impurities which affect the use of this calibration mixture. All concentrations are on a volume/volume basis unless otherwise noted.

Do Not Use This Cylinder below 100 psig, i.e. 0.7 megapascals.

ANALYTICAL RESULTS

Component	Requested Concentration	Actual Concentration	Protocol Method	Total Relative Uncertainty	Assay Dates
CARBON MONOXIDE	4.000 PPM	3.998 PPM	G1	+/- 1.1% NIST Traceable	08/23/2019
AIR	Balance				

CALIBRATION STANDARDS

Type	Lot ID	Cylinder No	Concentration	Uncertainty	Expiration Date
NTRM	08011130	KAL004049	9.855 PPM CARBON MONOXIDE/NITROGEN	0.5%	Jun 05, 2024

ANALYTICAL EQUIPMENT

Instrument/Make/Model	Analytical Principle	Last Multipoint Calibration
Thermo 48i-TLE 1163640031 CO	CO NDIR (Mason)	Aug 19, 2019

Triad Data Available Upon Request

PERMANENT NOTES:-NA-

Approved for Release

Challenge Cylinder #1 Certificate

EPA Protocol Gas Verification Program

Date of Assay: 26-Feb-19

Cylinder under Test:	**Scott Marrin** **JB03450**
Pollutant Gas:	**Carbon Monoxide**
Balance Gas:	**Air**
Cylinder Pressure After Assay:	**850 psig**

Assayed CO Concentration =	**9.384**
Vendor Certified CO Concentration =	**9.440**
% bias =	**-0.60%**
95% uncertainty of analysis =	**0.07%**

Reference Gas: SRM 1681b
FF20781

Expiration Date: 26-Sep-21

Analyst: T. Bui/ L. Sena

Analytical Facility: EPA Region 7 Ambient Air Standards Laboratory, Kansas City, KS

Challenge Cylinder #1 Certificate

EPA Protocol Gas Verification Program

Date of Assay: 26-Feb-19

Cylinder under Test:	**Scott Marrin** **JB03465**
Pollutant Gas:	**Carbon Monoxide**
Balance Gas:	**Air**
Cylinder Pressure After Assay:	**525 psig**

Assayed CO Concentration =	**4.509**
Vendor Certified CO Concentration =	**4.490**
% bias =	**0.42%**
95% uncertainty of analysis =	**0.27%**

Reference Gas:	**SRM 1680b** **CAL018075**
Expiration Date:	**20-Sep-21**
Analyst:	**T. Bui/ L. Sena**
Analytical Facility:	**EPA Region 7 Ambient Air Standards Laboratory, Kansas City, KS**

Challenge Cylinder #1 Certificate

EPA Protocol Gas Verification Program

Date of Assay: 5-Mar-19

Cylinder under Test:	**Scott Marrin** **JB03443**
Pollutant Gas:	**Carbon Monoxide**
Balance Gas:	**Air**
Cylinder Pressure After Assay:	**1450 psig**

Assayed CO Concentration =	**0.521**
Vendor Certified CO Concentration =	**0.502**
% bias =	**3.77%**
95% uncertainty of analysis =	**0.80%**

Reference Gas:	**SRM 1680b** **CAL018075**
Expiration Date:	**20-Sep-21**
Analyst:	**T. Bui/ L. Sena**
Analytical Facility:	**EPA Region 7 Ambient Air Standards Laboratory, Kansas City, KS**

Challenge Cylinder #1 Certificate

EPA Protocol Gas Verification Program

Date of Assay: 27-Feb-19

Cylinder under Test:	**Scott Marrin** **JB03389**
Pollutant Gas:	**Carbon Monoxide**
Balance Gas:	**Nitrogen**
Cylinder Pressure After Assay:	**1325 psig**

Assayed CO Concentration =	**504.8**
Vendor Certified CO Concentration =	**506.0**
% bias =	**-0.24%**
95% uncertainty of analysis =	**0.21%**

Reference Gas:	**SRM 1680b** **CAL018075**
Expiration Date:	**20-Sep-21**
Analyst:	**T. Bui/ L. Sena**
Analytical Facility:	**EPA Region 7 Ambient Air Standards Laboratory, Kansas City, KS**

Challenge Cylinder #1 Certificate

EPA Protocol Gas Verification Program

Date of Assay: 1-Mar-19

Cylinder under Test:	**Scott Marrin** **JB03389**
Pollutant Gas:	**Sulfur Dioxide**
Balance Gas:	**Nitrogen**
Cylinder Pressure After Assay:	**1350 psig**

Assayed SO2 Concentration =	**15.22**
Vendor Certified SO2 Concentration =	**15.26**
% bias =	**-0.27%**
95% uncertainty of analysis =	**0.23%**

Reference Gas:	**SRM 1693a** **CAL015195**
Expiration Date:	**22-Mar-19**
Analyst:	**T. Bui/L. Sena**
Analytical Facility:	**EPA Region 7 Ambient Air Standards Laboratory, Kansas City, KS**

Challenge Cylinder #1 Certificate

EPA Protocol Gas Verification Program

Date of Assay: 6-Mar-19

Cylinder under Test: Scott Marrin
JB03389

Pollutant Gas: Nitric Oxide
Balance Gas: Nitrogen
Cylinder Pressure After Assay: 1325 psig

Assayed NO Concentration =	**15.06**
Vendor Certified NO Concentration =	**14.91**
% bias =	**0.98%**
95% Uncertainty of Analysis =	**0.38%**
Assayed NOx Concentration =	**15.05**
Vendor Certified NOx Concentration =	**14.91**
% bias =	**0.91%**
95% Uncertainty of Analysis =	**0.41%**

Reference Gas: SRM 1683b
CAL018181
Expiration Date: 25-Mar-19

Analyst: T. Bui/L. Sena

Analytical Facility: EPA Region 7 Ambient Air Standards Laboratory, Kansas City, KS

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-3

Site Name: EPA R-7 Audit Date: 11/30/2020

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Actual Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Audit Level 6					N/A	
Audit Level 4					N/A	
Audit Level 3					N/A	
Audit Level 2					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	-0.0046	-0.012		-0.00769	Pass	
CO Audit level 4	2.5450	2.521	-1.0	-0.02453	Pass	
CO Audit level 4	1.5369	1.514	-1.5	-0.02343	Pass	
CO Audit level 3	0.5969	0.587	-1.7	-0.01037	Pass	
CO Audit level 2	0.1307	0.123	-6.2	-0.00816	Pass	
CO Audit level 1	0.0402	0.030	-25.4	-0.01021	Pass	
Post Zero	-0.0083	-0.009		-0.00077	Pass	
Oxides of Nitrogen						
Pre Zero	-0.00013	-0.00020		-0.00007	Pass	
NO Audit Point #1	0.07420	0.07440	0.3	0.00020	Pass	
NO Audit Point #2	0.04481	0.04490	0.2	0.00009	Pass	
NO Audit Point #3	0.01740	0.01750	0.6	0.00010	Pass	
NO Audit Point #4	0.00381	0.00390	2.4	0.00009	Pass	
NO Audit Point #5	0.00117	0.00120	2.6	0.00003	Pass	
Post Zero	-0.00024	-0.00020		0.00004	Pass	
Pre Zero	-0.00014	-0.00020		-0.00006	Pass	
NOx Audit Point #1	0.07549	0.07420	-1.7	-0.00129	Pass	
NOx Audit Point #2	0.04559	0.04470	-2.0	-0.00089	Pass	
NOx Audit Point #3	0.01770	0.01740	-1.7	-0.00030	Pass	
NOx Audit Point #4	0.00388	0.00380	-2.1	-0.00008	Pass	
NOx Audit Point #5	0.00119	0.00110	-7.6	-0.00009	Pass	
Post Zero	-0.00025	-0.00020		0.00005	Pass	
Pre Zero	0.00000	0.00010		0.00010	Pass	
NO2 Audit level 5	0.04659	0.04570	-1.9	-0.00089	Pass	
NO2 Audit level 4	0.01775	0.01710	-3.7	-0.00065	Pass	
NO2 Audit level 2	0.00409	0.00380	-7.1	-0.00029	Pass	
NO2 Audit level 1	0.00157	0.00130	-17.2	-0.00027	Pass	
Post Zero	0.00000	-0.00010		-0.00010	Pass	
Converter Efficiency NO2 level 5	100.9%				Pass	
Converter Efficiency NO2 level 4	101.8%				Pass	
Converter Efficiency NO2 level 2	102.7%				Pass	
Converter Efficiency NO2 level 1	93.2%				Fail	
Converter Efficiency calculated by OAQPS QA Guidance Doc 2.3 February 2002 =				**100.7%**	Pass	
Sulfur Dioxide						
Pre Zero	-0.00014	0.00008		0.00022	Pass	
SO2 Audit level 6	0.07688	0.07709	0.3	0.00021	Pass	
SO2 Audit level 5	0.04643	0.04694	1.1	0.00051	Pass	
SO2 Audit level 4	0.01803	0.01849	2.6	0.00046	Pass	
SO2 Audit level 2	0.00395	0.00372	-5.8	-0.00023	Pass	
SO2 Audit level 1	0.00121	0.00140	15.7	0.00019	Pass	
Post Zero	-0.00025	0.00012		0.00037	Pass	

FINAL SUMMARY AUDIT REPORT CO BASED
EEMS Van-2

Site Name: EPA Region 7 Audit Date: 11/30/2020

Parameter	NPAP Lab Response (ppm)	Station Response (ppm)	Percent Difference	Actual Difference (ppm)	Pass/Fail	Warning
Ozone						
Pre Zero						
Audit Level 6					N/A	
Audit Level 5					N/A	
Audit Level 4					N/A	
Audit Level 3					N/A	
Post Zero						
Carbon Monoxide						
Pre Zero	0.0017	-0.018		-0.0193	Pass	
CO Audit level 6	12.8589	12.954	0.7	0.0946	Pass	
CO Audit level 6	8.9173	8.994	0.9	0.0768	Pass	
CO Audit level 5	3.5806	3.616	1.0	0.0354	Pass	
CO Audit level 3	0.7868	0.793	0.8	0.0062	Pass	
CO Audit level 2					N/A	
Post Zero	-0.0017	-0.008		-0.0061	Pass	
Oxides of Nitrogen						
Pre Zero	0.0000	-0.0001		-0.0001	Pass	
NO Audit Point #1	0.0642	0.0639	-0.5	-0.0003	Pass	
NO Audit Point #2	0.0445	0.0444	-0.2	-0.0001	Pass	
NO Audit Point #3	0.0179	0.0175	-2.2	-0.0004	Pass	
NO Audit Point #4	0.0039	0.0037	-5.1	-0.0002	Pass	
NO Audit Point #5					N/A	
Post Zero	0	-0.0002		-0.0002	Pass	
Pre Zero	0.0000	-0.0001		-0.0001	Pass	
NOx Audit Point #1	0.0642	0.0637	-0.8	-0.0005	Pass	
NOx Audit Point #2	0.0445	0.0441	-0.9	-0.0004	Pass	
NOx Audit Point #3	0.0179	0.0174	-2.8	-0.0005	Pass	
NOx Audit Point #4	0.0039	0.0036	-7.7	-0.0003	Pass	
NOx Audit Point #5					N/A	
Post Zero	0.0000	-0.0002		-0.0002	Pass	
Pre Zero	0.0000	0.0000		0.0000	Pass	
NO2 Audit level 5	0.0441	0.0442	0.2	0.0001	Pass	
NO2 Audit level 4	0.0208	0.0207	-0.5	-0.0001	Pass	
NO2 Audit level 3	0.0057	0.0056	-1.8	-0.0001	Pass	
NO2 Audit level 1	0.0025	0.0024	-4.0	-0.0001	Pass	
Post Zero	0.0000	0.0000		0.0000	Pass	
Converter Efficiency NO2 level 7	100.9%				Pass	
Converter Efficiency NO2 level 6	101.0%				Pass	
Converter Efficiency NO2 level 5	100.0%				Pass	
Converter Efficiency NO2 level 4	100.0%				Pass	
Converter Efficiency calculated by OAQPS QA Guidance Doc 2.3 February 2002 =				**101.0%**	Pass	
Sulfur Dioxide						
Pre Zero	0.0000	0.0002		0.0002	Pass	
SO2 Audit level 6	0.0639	0.0644	0.7	0.0005	Pass	
SO2 Audit level 5	0.0443	0.0448	1.2	0.0005	Pass	
SO2 Audit level 4	0.0178	0.0180	1.1	0.0002	Pass	
SO2 Audit level 2	0.0039	0.0037	-5.4	-0.0002	Pass	
SO2 Audit level 1					N/A	
Post Zero	0.0000	0.0002		0.0002	Pass	

EPA United States Environmental Protection Agency

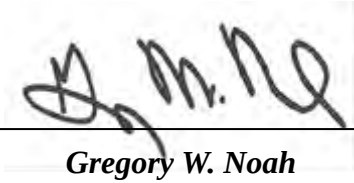
Field Scientist Certification

Eric Hebert

Has satisfactorily completed

The US Environmental Protection Agency's
"National Performance Audit Program (NPAP)
Field Scientist Re-certification Course"

Office of Air Quality Planning and Standards
Research Triangle Park, NC
Course Dates: October 2-4, 2019



Gregory W. Noah
NPAP National Coordinator
USEPA, OAQPS, AAMG

EPA United States Environmental Protection Agency

Field Scientist Certification

Korey Devins

Has satisfactorily completed

The US Environmental Protection Agency's
"National Performance Audit Program (NPAP)
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Office of Air Quality Planning and Standards
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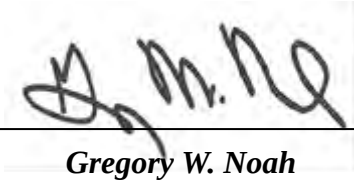
Course Dates: October 2-4, 2019



Gregory W. Noah
NPAP National Coordinator
USEPA, OAQPS, AAMG

EPA United States Environmental Protection Agency

Field Scientist Certification

Martin Valvur

Has satisfactorily completed

The US Environmental Protection Agency's
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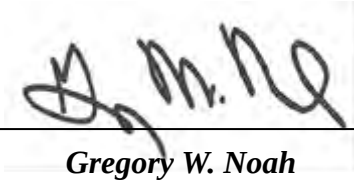

Gregory W. Noah
NPAP National Coordinator
USEPA, OAQPS, AAMG