Bureau of Land Management

National Petroleum Reserve – Alaska
Meteorological Monitoring Station
Quality Assurance Project Plan
Final
A Project Management Elements

A.1 Approvals

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Acknowledgements

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### A.3 Distribution List

The following individuals will be provided with a copy of this Quality Assurance Project Plan (QAPP).

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NPR-A QAPP

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A.4 Project/Task Organization

AECOM personnel will be responsible for overall project management, routine station operations and maintenance, calibrations, and data management. Duties and responsibilities of individuals associated with the project are presented in Table 1. Figure 1 presents a project organization chart depicting key personnel and responsibilities. The quality assurance (QA) auditor listed in Table 1 will be responsible for performing semi-annual independent quality assurance performance audits and annual quality assurance technical systems audits. A start-up audit and shut-down audit will also be performed by the auditor.

A.5 Problem Definition/Background and Project Objectives

The Bureau of Land Management (BLM) plans to establish a meteorological monitoring station in a remote location of the southeastern National Petroleum Reserve in Alaska (NPR-A) where it has an interest in identifying areas of maximum air quality impacts for existing and future oil and gas development. The meteorological data collected are intended to support BLM management decisions for the area through air modeling and to provide information for the BLM and other agencies with a study interest in the NPR-A.

The specific project objectives of this monitoring program are to:

- Establish a meteorological monitoring system to measure, with known accuracy and precision, the dispersion meteorology conditions at the project site for use in refined modeling; and
- Collect five years of Prevention of Significant Deterioration (PSD) quality data to characterize the climatic conditions at the site.

The monitoring station installation and operation will be the first step in a five year monitoring plan, in an effort to collect data suitable for a wide range of modeling applications. At present, there exists no PSD level station in the transition zone area between maritime and mountainous climate zones for comparison to modeled output. The station will also facilitate monitoring areas of maximum air quality impact and help establish locations and types of potential future meteorological monitoring and pollutant monitoring sites, if necessary. It is the goal of the project to achieve collection of high quality, high sensitivity data with a data completeness of at least 90% per quarter.

The five year time frame will provide a good representation of climatic conditions, as weather in this transition zone between maritime and continental air masses can vary widely. The monitoring equipment will comply with the recommendations put forth in two reference documents: The United States Environmental Protection Agency’s (USEPA) Quality Assurance Handbook for Air Pollution Measurement Systems (USEPA 2008) and the USEPA’s Meteorological Monitoring Guidance for Regulatory Modeling Applications (USEPA 2000).

Additionally, the meteorological monitoring station will allow the BLM and other Air Quality Memorandum of Understanding (MOU) (EPA, 2011) partner agencies to model various air quality impacts before development occurs. Model scenarios can be used to determine the maximum level of development allowable before reaching air quality thresholds set by the BLM or other agencies.

A.6 Project/Task Description

Monitoring is scheduled to commence March 1, 2014 and continue for five years. The project schedule is presented in Table 2. The schedule includes approximate dates for installation of the monitoring station, calibration checks, audits, and reports. Figure 2 shows the location of the proposed monitoring station relative to nearby existing oil and gas facilities – the Trans-Alaskan pipeline is denoted by the yellow line. Coordinates for the proposed monitoring station location are presented in Table 3. The monitoring station is located approximately 110-miles west-southwest of Deadhorse, Alaska; 52 miles west southwest of Nuiqsut, Alaska; and 50 miles northwest of Umiat.
Data reports and other project documentation are detailed in Table 4. Table 4 includes the type of documentation that needs to be generated, the frequency on which it is generated, who prepares the document, the archive location and how and if the document is provided to the reviewing agency(ies).

The meteorological parameters that will be measured as part of this monitoring program are listed in Table 5. Table 5 also provides detailed information about the equipment and measurement methods that will be used as well as sampling frequency, measurement ranges and detection limits.

A.7 Quality Objectives and Criteria for Measurement of Data

Measurement quality objectives (MQOs) are designed to evaluate and control various phases of the measurement process to ensure that total measurement uncertainty is within the range prescribed by the data quality objectives (DQOs). Project MQOs are defined in terms of the following data quality indicators (USEPA 2013):

**Precision**: A measure of the agreement among repeated measurements of the same property under identical, or substantially similar, conditions. This is the random component of error. Precision is estimated by various statistical techniques typically using some derivation of the standard deviation.

**Bias**: The systematic or persistent distortion of a measurement process which causes error in one direction. Bias will be determined by estimating the positive and negative deviation from the true value as a percentage of the true value.

**Detectability**: The determination of the low range critical value of a characteristic that a method specific procedure can reliably discern.

**Representativeness**: The degree in which data accurately and precisely represent a characteristic of a population, parameter variation at a sampling point, a process condition, or an environmental condition. Representativeness is determined qualitatively by siting and exposure conditions of the monitoring instruments, as discussed in Section B.1.2.

**Comparability**: A measure of confidence with which one data set can be compared to another. Comparability and detection limit objectives are met by using USEPA approved methods and reference or equivalent method instrumentation, as applicable for particular measurement parameters, and following USEPA monitoring guidance as described in this QAPP.

**Completeness**: A measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under correct, normal conditions.

Quantitative MQOs for detectability and completeness are provided in Table 7.

Representativeness is determined qualitatively by siting and exposure conditions of the meteorological sensors, as discussed in Section B.1.2.

Comparability and detection limit objectives are met by following USEPA monitoring guidance as described in this Quality Assurance Project Plan (QAPP).

A.8 Special Training Requirements/Certification

No special training or certifications are required for this monitoring project. However, all project data analysts, AECOM field technicians and the QA manager are either meteorologists or environmental scientists familiar with data management and data QA/quality control (QC) procedures as they apply to dispersion meteorological monitoring programs.
A.9 Documentation and Records

Table 4 provides a list of the documents and records that will be generated as part of the project and included in the applicable data reports. Future revisions to this QAPP will be provided in Appendix A. Copies of all field documentation will be maintained on site and at the AECOM office. All electronic data will be stored on AECOM’s server, and will be backed up periodically to alternate storage media to prevent data loss due to computer hardware failure.

Sample project forms are included in Appendix B. Data report submittal and content requirements are provided in Section C.2.
B Measurement and Data Acquisition

B.1 Sampling Process Design

The monitoring program will consist of an instrumented meteorological monitoring tower. The monitoring program, including the siting of the monitoring station and the selection of measurement parameters, is designed to meet the objectives outlined in Sections A.5 through A.7. All instrumentation is approved for use in PSD dispersion meteorological monitoring programs. The monitoring station will be sited in accordance with PSD guidance (USEPA 2000, 2008). The operation of the monitoring program, as outlined in the following sections and attached Standard Operating Procedures (SOPs), is designed in conformance with applicable guidance except as noted.

B.1.1 Parameter Configuration

Table 5 lists parameters that will be measured at the monitoring station and provides information about selected monitoring equipment and measurement methodologies. Equipment lists for data acquisition and support equipment are provided in Table 6. All monitoring equipment has been selected based on its ability to meet or exceed USEPA requirements for PSD monitoring.

A list of vendors and their addresses is provided in Table 17. Brochures and manufacturer specifications for all monitoring instrumentation are contained in Appendix D.

The monitoring tower will be equipped with a duplicate set of sensors in an effort to mitigate data loss. Data from the secondary sensors will be screened regularly, calibration checked, and audited to ensure operation. Because data collected from the secondary sensors is intended to be used as backup, data from these sensors will only be used if it meets the requirements listed in Section D, and if quarterly data recovery from the primary sensors has dropped below the completeness goal of 90% per quarter.

B.1.2 Monitoring Site Location

The proposed monitoring site is located along the arctic coastal plain approximately 110-miles southwest of Deadhorse, Alaska and 110-miles north of the Brooks Range. The arctic coastal plain is the dominant feature along the northern coast of Alaska. This low relief coastal plain is found along almost the entire length of Alaska’s northern coast and varies in width from 10 to 105-miles wide and extends from the foothills of the Brooks Range to the coast. The coastal plain is covered by tundra and underlain by permafrost; rivers generally flow to the north and build deltas along the coastline. Barrier bars, islands, and lagoons are common features associated with these deltas. The terrain is fairly flat and homogenous along the arctic coastal plain, pock-marked with many inland water bodies and rivers.

Figure 2 presents an area map showing the proposed monitoring site location. A more localized map is presented in Figure 3.

Climate

Climate at the proposed monitoring site is classified as arctic (Koppen), with long, bitterly cold winters, and short, cool summers. Winter lasts from late September/early October until late April/early May. October through January are typically the snowiest months with snow tapering off from February to May. Average winter low temperatures range from 11°F (−12°C) in October to −24°F (−31°C), but extremes can range from 49°F (9°C) to −58°F (−50°C). In summer, temperatures typically range between 47°F (9°C) and 56°F (13°C). The highest recorded temperature at the Kuparuk airport was 83°F (28°C), while the lowest was −58°F (−50°C). Summary climate data for the Kuparuk airport are shown in Table 8.
These widely varying temperature extremes are due to three main factors: temperature inversions, daylight, and wind direction. In winter, cold-dense air flows down from the Brooks Range to the south and accumulates in low-lying locations. Heating from available sunlight is limited because of the high latitude.

Land Use

Land use at the proposed monitoring station is primarily rural with some research activities occurring nearby. There is a remote airstrip located southeast of proposed monitoring site.

Land Cover

Land cover in the area is classified by the United States Geological Survey as grassland and shrub. The coastal Arctic plain is further described by Rieger et al. (1979) as including sedge tussocks, grasses, low shrubs, forbs, mosses, and lichens typically over a thick mat of partly decomposed organic matter and underlain by shallow permafrost. In addition, there are several small lakes that dot the area. None of the area in the vicinity of the project is classified as urban.

Meteorological Monitoring Tower Siting

The meteorological monitoring tower location was selected after consideration of project objectives, instrument exposure, general site logistics, and representativeness of future development locations. The practical issue associated with meeting the project monitoring objectives for the monitoring tower is selecting a site that will be well exposed to prevailing meteorological conditions while still satisfying siting logistics. Figure 2 shows the location of the proposed monitoring station. The site coordinates are listed in Table 3. The site will consist of a 10 m meteorological monitoring tower attached with bolts to the side of an unheated Conex container used to house moisture sensitive equipment. The orientation of the Conex and tower equipped with instrumentation will be carefully considered and positioned such that potential turbulence effects on the wind instruments will be minimized. Snow removal is not expected to be an issue since the Conex is seated on a 3 ft rack allowing air to circulate beneath it. The selected site meets requirements for instrument siting as outlined in applicable USEPA QA guidance documents (USEPA 2000, 2008).

The site will be representative of the area of interest, away from obstacles and obstructions, and capture dominant wind features. The dominant features for the area are dictated by the coastal/maritime zone to the north and the interior/continental zone to the south. The parameters most influenced by poor siting are wind speed and wind direction, but temperature and pressure can also be affected by surrounding environmental influences such as nearby trees and buildings.

Figure 4 through Figure 7 present photographs looking in each of the four cardinal directions of the proposed monitoring tower location.

Additional discussion regarding monitoring site selection can be found in the Station Siting Memo provided in Appendix F.

B.2 Sampling Methods

B.2.1 Standard Operating Procedures

Written SOPs are provided in Appendix C. These SOPs document site operation, maintenance, and calibration procedures in sufficient detail to minimize the possibility of producing inconsistent results through misinterpretation or a change of personnel. A list of all SOPs included in Appendix C is provided in Table 10. In the case of a conflict between what is stated in the body of the QAPP and in an SOP, the QAPP takes precedence. Systematic criteria for meteorology measurements are shown in Table 11. Performance requirements for all instrumentation are provided in Table 12.
B.2.2 Instrumentation and Support Equipment

This section summarizes the instrumentation proposed for the monitoring program. The selected equipment has been chosen based on USEPA guidance for PSD monitoring programs.

B.2.2.1 Station Support Equipment

Data Logger

The data acquisition system (DAS) for all meteorological sensors will be a Campbell Scientific, Inc. CR-3000 micro logger. This micro-processor based data logger provides a direct analog-to-digital interface, high speed sampling, calculation of computed variables and averages, and storage of data in random access memory. The data logger will be equipped with a modem and satellite interface to allow remote data acquisition and interrogation of the logger.

The data logger will sample individual sensor outputs once per second. These one-second samples will be used to compute 15-minute and hourly averages. For meteorological parameters excluding horizontal wind direction standard deviation, hourly averages will be computed by averaging over the entire hour (i.e., 3,600 data points). Hourly values for horizontal wind direction standard deviation will be calculated by first computing 15-minute values, then averaging the four 15-minute standard deviation values for each hour. The data logger can store up to several months of data in internal memory as back-up data storage, in the event the station telecommunications interface is inoperative for an extended period of time. The CR-3000 data logger will be mounted in the Conex container. Equipment specifications are provided in Appendix D.

Meteorological Tower

The meteorological monitoring tower will be anchored to the Conex container. The shelter will be placed on pipe racks to insulate the permafrost from the shelter in order to minimize shelter shifting due to freeze/thaw cycles. The tower will be equipped with lightning protection to minimize damage in the event of a lightning strike.

Power Supply

Because the site will not be connected to a power grid, proposed instrumentation and support systems have been selected to minimize power requirements. All systems will be powered from a series of low temperature rated batteries which will be charged using wind generated power. The system will be designed to rely primarily on wind generated power from multiple units (year-around). During times of little to no wind, the battery system is designed operate the instrumentation and data logger for several days without wind generated power.

B.2.3 Calibration and Maintenance Procedures

Calibration and maintenance procedures are discussed in Section B.7 and Section B.6, respectively.

B.3 Sample Handling and Custody Requirements

No measured parameters have any sample handling or custody requirements.

B.4 Analytical Method Requirements

No measured parameters have any analytical method requirements.

B.5 Quality Control

Quality Control (QC) is a system of technical activities designed to measure the attributes and performance of a system against defined standards and verify they meet the stated requirements, and also to fix any problems identified via the routine QC checks—it is both proactive and corrective. The goal of a QC system in this
context is to minimize loss of data through invalidation. The QC system is intertwined with the data management system and data validation. Topics that are discussed separately in Sections B.10 and D, but it is acknowledged here that the QC system cannot operate separately from these systems.

This section will focus on the analytical QC checks which are all utilized in some way in the data validation criteria which are documented in Table 12. When QC checks indicate that a particular attribute of the system has drifted significantly towards the validation limits listed in this table, the system will be reviewed to see if adjustment is warranted. The QC checks related to instrument calibration action limits are set at a value lower than the data validation limit to indicate when an instrument may require recalibration and/or some other form of maintenance. If an action limit is exceeded the instrument will be evaluated and the performance returned to more optimal standards as soon as logistically possible. QC checks are performed according to the instrument user's manual. The use of QC data in the data validation decision process is detailed in Section D.

B.5.1 Meteorological Measurements

Table 9 lists the project critical validation criteria from Table 7 that must be met to achieve the project data quality objectives listed in Section A.7. In the event that calibration or performance audit results are outside the acceptable ranges listed in this table, the results of the QC check will be examined and appropriate action will be taken. The evaluation process and conclusions regarding data validity will be documented in the each data report.

B.5.1.1 Calibration Checks

Instrument calibration checks will be performed using standards documented as traceable to NIST or other authoritative standards, and will be performed according to the schedule shown in Table 13. Calibration procedures and action limits for each parameter are provided in the applicable calibration SOPs (see Appendix C). In general, action limits are set to one-half the accuracy (bias) limits listed in Table 12.

B.5.1.2 Visual Inspection

The meteorological instruments will be visually inspected during each site visit as described in AECOM’s Operation and Maintenance SOPs to assess the physical condition of the instruments.

B.5.1.3 Performance Audits

Performance audits will be conducted by the qualified independent QA auditor listed in Table 1. Audit equipment and reference standards will be supplied by the auditor, will be different from that used for calibrations, and will be documented as traceable to NIST or other authoritative standards. The audit levels performed and the evaluation criteria are listed in Table 12. The audit schedule is shown in Table 14 and Table 15.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements

B.6.1 Acceptance and Operational Testing

Considerable testing of the monitoring equipment will be conducted during the pre-operation phases of the program. All project equipment tests are documented and, where appropriate, test equipment will be traceable to NIST or other authoritative standards.

Prior to systems integration and assembly, an operational check will be performed on each individual monitoring instrument. These operational checks will be conducted to determine instrument accuracy and stability. Should an instrument or system fail the operational check, appropriate repairs will be made, or the instrument will be replaced. The operational check for any repaired or replaced instrument will then be repeated.

After the equipment has been checked and accepted, the complete monitoring system will be assembled, integrated, and tested in the same configuration as anticipated in the field. The operational tests of the integrated monitoring systems consist of calibration checks on the sensors and confirmation that the data
The collection system is working as anticipated. The system will not ship until all components of the integrated system pass the operational tests.

### B.6.2 Routine Operations

A summary and schedule for the station field activities are provided Table 15. Between routine calibration check and performance audit site visits, telephone computer interrogation of the station data acquisition system each business day will be the primary means for confirming station systems are operational. This will allow for daily station performance evaluation by AECOM operations personnel responsible for the monitoring program, and will provide valuable information on a regular basis regarding condition of the monitoring systems. Daily data evaluation by AECOM air quality scientists will assist in detecting any instrument problems in a timely manner.

Documentation of site visits will be provided through several forms. Station logs and checklists, which detail inspection, calibration, and repair activities, will be maintained by AECOM field staff. Records and measurements taken during calibrations will be recorded on forms designed specifically for each respective instrument. Station logs, checklists, and calibration records will be printed on multi-copy forms for distribution, with one copy maintained on site.

Due to the remote location of the site, as well as logistical issues and concerns, there will be no regular field activities other than calibration checks and performance audits.

### B.6.3 Preventive Maintenance

The monitoring system has been designed to require minimal preventive maintenance. All system components have been selected based on dependability and stability through extensive field application, and will either be purchased new or will be completely refurbished used equipment. The preventive maintenance tasks and schedules recommended by each equipment manufacturer will be followed. Records will be maintained of all preventive maintenance activities. Specific preventive maintenance tasks for the various station systems are provided in each system-specific Operation and Maintenance (O&M) SOP.

Table 16 itemizes spare parts/expendable supply with the appropriate quantity in the inventory. A portion of these parts will be available at the project location for immediate installation; the remainder will be maintained at the AECOM Fort Collins Office for immediate shipment to the site if required. When any one of the spare parts is used, a replacement part will be ordered immediately or the failed component will be repaired to maintain the spare parts inventory. In addition, AECOM maintains a general inventory of most of the major equipment used at the monitoring station which can be deployed quickly in the event of a major instrument failure.

The following support documentation will be maintained at the monitoring location:

- Copies of manufacturer's operation and service manuals for each piece of monitoring, calibration, and test equipment.
- Copies of applicable SOPs covering tasks to be performed in the operation and servicing of the monitoring system.
- Station logs, and checklists for recording site visits and maintenance activities.
- A copy of the project QAPP.

### B.7 Instrument Calibration and Frequency

To facilitate collection of high quality data of known accuracy, routine calibration checks of the monitoring system will be performed to the schedule listed in Table 13. All calibration checks will be performed by AECOM field technicians. Calibration checks are required if any one of the following criteria is met for each instrument, as appropriate:
At project startup;
If an instrument is physically relocated;
If an instrument has been out of operation for more than three days; and
When any maintenance activity\(^1\) that may alter the response of the instrument is conducted.
If there is an indication of a potential malfunction in the data collection system.
As soon as possible following a performance audit that indicates that an instrument accuracy limit has
been exceeded.
Prior to the removal, repair or replacement of any instrument if it is still operational.
Immediately following the installation of a replacement instrument.
Immediately prior to project takedown.

The need for a calibration check will be evaluated if audit results show that the difference between the audit
standard and the instrument response exceeds designated action limits. If the instrument fails the calibration
check the instrument will be calibrated, repaired, and/or replaced as needed.

For the solar radiation sensor, failure to pass a calibration check performed when there is insufficient sunlight,
less than 200 W/m\(^2\), to accurately perform the calibration check will not result in data invalidation unless a
subsequent calibration check performed under more favorable conditions confirms the failure.

Calibration checks will be performed according to applicable AECOM SOPs provided in Appendix C, which
have been developed to meet the requirements of USEPA regulatory guidelines for traceability and
documentation. In addition, all calibration test equipment will be in current certification and traceable to
authoritative standards.

All test equipment used for calibration checks will be maintained and certified on a regular basis. Records that
provide traceability to the NIST or other authoritative standards of all equipment used for adjusting monitoring
systems will be maintained by AECOM. Table 18 provides a list of the calibration equipment that will be used.

Additionally, the data logger date and time will be checked to make sure that: 1) the date is correct, 2) the time
is correct to within ±5 minutes of Local Standard time. Results of the data collection system calibration check
will be recorded on the station log form.

Details of the calibration check of each monitoring system are provided in the AECOM SOPs provided in
Appendix C. Calibration criteria for each measured parameter are presented in Table 12. Calibration check
forms are provided in Appendix B.

### B.8 Inspection/ Acceptance of Supplies and Consumables

AECOM field technicians will inventory all spare parts and consumables during each site visit. During each site
visit the technician will enter the date and time of the site check, and will record the number of items on-site
and the number of items available at the AECOM shop for immediate shipment to the site if necessary.

Immediately upon returning from the field, the AECOM field technician will provide the original copy of the
checklist to the AECOM project manager for filing with other project documentation. At the same time, a copy
of the checklist will be provided to the Field Operations Manager, who is responsible for reviewing the checklist

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\(^1\) “Maintenance activity” means any change to any instrument or data logger including but not limited to parts replacement,
instrument adjustment, or data logger program change.
and making sure that an adequate spare parts inventory is maintained at all times according to project SOPs and the project QAPP.

**B.9 Data Acquisition Requirements for Non-Direct measurements**

The monitoring program does not include any non-direct measurements used in project implementation and/or project decision making.

**B.10 Data Management**

The primary data collection system will be the digital data logger installed at the monitoring station. This system averages, formats, and temporarily stores the data from which the primary data file is generated.

The following subsections provide an overview of how data collection, handling, reduction, correction, and checking are conducted as part of the data processing activities for the monitoring program.

Details of the data processing, validation, and editing process can be found in the applicable data validation SOP located in Appendix C and in Section D. The format for reports generated as part of the monitoring program is described in Section C.2.

**B.10.1 Data Collection**

Data will be retrieved from the monitoring station each business day via remote interrogation of the station data acquisition system. The data will be transferred into a data file on one of the file servers located at the AECOM, Fort Collins office. The primary source of monitoring data is the digital data retrieved during daily interrogation of the data acquisition systems, which is subsequently translated into the air quality data management system. The data management system is complete with error diagnostic systems, editing capability, and display systems which allow the user ready access and control of the data. The primary data set retrieved via remote interrogation will be hourly averages of each measured parameter.

**B.10.2 Data Handling**

Initial inspection of all data will be performed to verify completeness and continuity with respect to the previous shipment. After the inventory is verified, all data will be filed for future use in the project data validation process. Documentation of field operations will be reviewed for completeness, station performance, and compliance with station operating procedures.

**B.10.3 Data Storage, Edits and Backups**

After periods of invalid or missing digital data have been identified, any available backup data will be inserted into the data file. If backup data also are invalid or missing, an appropriate invalidation flag will be inserted in the data file.

All deletions or modifications to the original data will be thoroughly documented to ensure traceability of project data. All edits will be independently verified by a second data analyst. A backup copy of the original, unedited digital data will be maintained along with copies of all analog and analytical records.

Each monthly file of the validated data will be the source for subsequent interpretive analysis and report generation. Field operations documentation will be filed along with original data forms for future reference.

Data collected by the secondary sensors is intended to be used as backup to the data collected by the primary sensors. Experience has shown that mechanical wind sensors are subject to icing during the winter months, which may potentially result in valid wind data capture falling below the PSD data recovery requirement of 90 percent per quarter. In addition, the types of cold weather extremes anticipated at the site have been known to cause undue strain on electronic components such as thermocouples and wiring. In the event that the primary sensors do not meet the PSD-required data recovery goal of 90 percent per quarter, data from the secondary sensors will be used provided it meets the data validation criteria found in Section D.
C Assessments and Oversight

C.1 Assessments and Response Actions

C.1.1 Performance Audits

Performance audits will be conducted by the qualified independent QA auditor listed in Table 1. The audit schedule is shown in Table 14. Audit equipment and reference standards will be supplied by the auditor and will be different from that used for calibrations, and will be documented as traceable to authoritative standards. Instruments will be audited in situ where practical and if conditions permit. If any deficiencies are noted during the performance audits, corrective action will be initiated as described in Section C.2.4.

C.1.1.1 Meteorological Sensors

Meteorological data collection systems will be audited in conformance with the provisions of the USEPA document *Quality Assurance Handbook for Air Pollution Measurement Systems: Volume IV - Meteorological Measurements* and *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (USEPA 2000, 2008), which calls for physical challenging of each sensor with known inputs. Auditor forms and SOPs are provided in Appendix E.

Audit limits for each meteorological sensor are shown in Table 12. If the accuracy limit for any sensor is exceeded, a calibration check will be performed as soon as possible following the audit.

C.1.2 Technical Systems Audits

The purpose of the technical systems audit is to provide independent review of the design and operating practices of the monitoring program. The QA auditor listed in Table 1 will conduct independent technical systems audits according to the schedule shown in Table 14.

Prior to conducting the audit, the auditor will perform the following tasks:

- Review the project QAPP to become familiar with monitoring objectives, the monitoring system design, and applicable operating and quality assurance procedures.
- Ensure that all equipment used for the audit has been certified within required time limits and that all test equipment is in current calibration and traceable to authoritative standards.

C.1.2.1 Field Systems Audit

During the audit, the auditor will perform the following tasks:

Station Checks:

- Inspect the tower and surrounding area noting site accessibility, cleanliness, and orderliness.
- Inventory all monitoring and recording equipment by manufacturer, model number, serial number, age (if available), and date of last calibration, where appropriate.
- Verify all instruments are in current calibration. There should be documentary evidence showing that all calibrations are traceable to the NIST or other authoritative standards.
- Review the written procedures of the site. Written procedures should be available on site and should be adequate to ensure data validity.
- Review site documentation (i.e., logs, maintenance schedules, calibration documents, calibration stickers) to ensure that correct procedures are being followed.
Verify that the site location and configuration match those given in the project QAPP. Document any variances and note whether or not required approvals were granted.

Meteorological Tower Checks:

- Verify instrumentation is located at the proper heights and exposures, and they meet the probe siting criteria as contained in USEPA (2000). If any instrument is not properly sited, it should be determined whether there is documentation of an approved variance.
- Verify all meteorological systems meet minimum accuracy requirements as indicated by manufacturer and applicable USEPA or agency guideline specifications. Also, verify that each meteorological sensor meets the appropriate PSD specifications.

C.1.2.2 Data Quality Systems Audits

The data quality audit will consist of an evaluation of the project management organization, field operations, personnel qualifications and training, data management and processing procedures, QA program, and data reporting methods.

C.1.3 QAPP Revisions

Sections of this QAPP will be updated as necessary when additional information is received, to account for changes in any system or procedure, or when conditions at the site change. Any revisions to this QAPP will be made by a written and approved amendment, which will become a permanent part of this plan and placed in Appendix A.

C.2 Reports to Management

The frequency and responsibilities for reports to management are provided in Table 4. Reports will be distributed to the project personnel listed in Section A.3. Further details are provided below.

C.2.1 Performance and Technical Systems Audit Reports

The performance and technical systems audit reports will be prepared by the person/organization listed in Table 1 and submitted to the AECOM Project Manager and Quality Assurance Manager by the independent auditor within 45 days following the conclusion of each audit. There will be at most one technical systems audit report per year.

C.2.2 Quarterly Reports

Draft quarterly data reports will be prepared by AECOM and submitted to the BLM for review within 45 days following each monitoring quarter. These quarterly reports will include data summary tables and graphics in accordance with ADEC guidance in PSD Quality Ambient Air Quality & Meteorological Monitoring Quarterly Data Summary Format (ADEC 2011).

The quarterly report is intended to serve as an independent data reference guide. It will be a bound report and will include a brief introduction and an appendix section containing relevant formulae. The tabular listings will present hourly minimums, maximums, and averages for all monitored meteorological parameters.

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1 If monitoring commences between the first and fifteenth of the month, the beginning of that month will be defined as the beginning of the first monitoring quarter. If monitoring commences following the fifteenth day of the month, the beginning of the following month will be defined as the beginning of the first monitoring quarter.
C.2.3 Annual Reports

The draft annual data report will be prepared by the person(s) listed in Table 4 and submitted to BLM for review within 45 days of the end of the monitoring year. The final annual data report will be provided to BLM within 60 days of the end of the monitoring year.

Report contents and format will also follow guidelines in ADEC’s PSD Quality Ambient Air Quality & Meteorological Monitoring Annual Data Report Format document (ADEC 2011).

C.2.4 Corrective Action Reports

Any monitoring equipment problems or issues that are identified during calibration or audit visits, regular site visits, or during the data review process, or that may affect the quality of the data collected, will be documented and reported by the person(s) listed in Table 4 to the AECOM project manager within three business days of discovery. All monitoring equipment problems that may affect data quality, the person responsible for the corrective action, and the corrective actions taken to resolve them, will be documented using corrective action request forms and will be discussed in the appropriate data report.
D Data Validation and Usability

D.1 Data Review, Validation, and Verification Requirements

This section defines the criteria and processes for determining data validity. These criteria are applicable to all data collected and apply to all personnel performing these tasks. Table 12 details the criteria considered in validating, invalidating or qualifying data. Critical criteria, including the minimum standards listed in Section D.1.1, are those criteria which must be met for the data to be considered valid. Operational criteria are criteria which may indicate that the data deserves a more detailed review or potentially is invalid. Systematic criteria are those criteria which must be met for the dataset to be considered valid for the intended use but which do not pertain to the validity of any particular sample in an analytical sense. The data validation tables provide references, where applicable, for all criteria.

D.1.1 Minimum Standards for Data Acceptance

In order for data from the meteorological sensors and systems to be considered valid, the following conditions must be satisfied:

- The meteorological systems must be operated and calibrated according to applicable SOPs.
- The data must be bracketed by calibrations or tests which document that the systems are performing, at a minimum, within the project accuracy goals outlined in Section B.5.
- The data must be completely identified with respect to time, site, parameter, scale, and units.
- There must be sufficient documentary evidence in the form of calibration and audit data to support the validity of the data.

D.2 Validation and Verification Methods

This section defines the process for determining the validity of data collected as part of this monitoring program. Data validation procedures are described in further detail in AECOM QA SOPs (Appendix C). The overall process is diagramed in Figure 8.

For data to be considered valid, it should: 1) be accurate and precise within prescribed limits; 2) represent factual conditions; 3) be obtained from a calibrated, well-functioning instrument; 4) be from an environment sampled without interference or obstruction; and 5) be thoroughly documented as to traceability to recognized primary standards. The project MQOs, data validation criteria and minimum standards for acceptance are designed to ensure that all these factors are considered when determining data validity.

D.2.1 Roles and Responsibilities

The AECOM field technicians are responsible for the first phase of data validation, wherein first-hand knowledge of instrument performance to prescribed tolerances is required to determine data quality. Documentation of the AECOM field technician's data assessment is critical to validation. The AECOM field technicians use the criteria described in the AECOM QA SOPs to the extent that such information is available. Responsibility for instrument performance evaluation lies with the AECOM data analysts through interrogation and operational assessment of the data collectors via computer telecommunications link each business day. Documentation of the near real-time assessment will be part of the operation control information base and also will assist in the data validation task.

The data analyst, data manager, and QA manager are responsible for the second phase of data validation, wherein they selectively review the field data documentation, calibration data, and audits to ensure adherence to tolerances and procedures and to provide a review essential for QC. All such activities will be documented on standard forms and logs.
Final data validation activities are the responsibility of the AECOM project manager who has the ultimate responsibility for the project data quality and sign-off on finalized data reports.

Verification that the design and development of the monitoring program, as described in this QAPP, are in conformance with applicable monitoring guidelines is the responsibility of the QA manager and the approving regulatory agency.

D.2.2 Data Validation Methods

Data validation is the process of editing collected data with the end result being a dataset that contains only valid data that meet project data quality goals. Steps in the validation process may include deleting invalid data, or adjusting data values. Data values will be deleted only when there is documentation to support the judgment that the data are invalid. Sufficient documentation includes project forms that clearly indicate that calibration, audit, or maintenance activities were occurring during the time in question, or project forms that clearly indicate a problem with a sensor or data collection system. Such documentation should clearly indicate a beginning and ending time of the activity that affected data quality.

Data which satisfy the criteria in Section D.1.1 are considered to be valid. Those which do not satisfy these criteria are considered to be invalid. If any of the information necessary to make the above evaluations is not available, the data shall be considered suspect until further review, comparison, investigation, etc., shows it to be valid or invalid. If no conclusive evidence to the contrary can be found, the data are considered to be valid.

Steps in the daily data screening and validation process are as follows:

- The data analyst will review the printed data, following the data screening guidelines found in the Meteorological Data Screening Procedures SOP.
- The date, times, and affected parameter of all data that are ultimately determined to be either suspect or invalid, and the reason for considering the data suspect or invalid, will be recorded on the data printout and in the project Data Processing Notes and Comments form. If the data are determined to be invalid due to equipment problems, a Corrective Action Request (CAR) form will be initiated.
- The data analyst will forward all data printouts, and a copies of CARs (if applicable), to the project data manager. The project data manager will review the data printouts and the CAR (if applicable).
- The project data analyst and the project data manager are normally responsible for the determining validity of the data and providing backup documentation; however, final data validation is the responsibility of the AECOM project manager.
- Data that are accepted by the data review team will officially be deemed valid and the Data Processing Notes and Comments form will be updated and filed in the project file.

Steps in the monthly validation process are as follows:

- The data analyst will collect required documentation, including daily data printouts, CARs, calibration and/or audit reports for any calibrations/audits performed during the month, Data Processing Notes and Comments forms, project notes, and stations logs and checklists.
- All documentation of any problems or events that affected either data validity or data collection will be checked. These events will be noted on the Data Processing Notes and Comments form.
- Raw data values will be copied into a data validation workbook. The data validation workbook includes worksheets for raw and edited data. Initially, cells in the edited data worksheet are linked to the raw data worksheet. Note that the original copy of the raw data file will not be edited.
- Once the Data Processing Notes and Comments form is completed, missing data codes will be inserted in the edited data worksheet for all invalid data. Monthly data summary tables, which are linked to the edited data worksheet, will be produced and checked by the data analyst.
The data analyst will forward the *Data Processing Notes and Comments* form, data validation workbook, and monthly data summary tables to the data manager for review.

The data manager will review the monthly summaries, data validation workbook, and any pertinent documentation. The data manager will indicate either his/her agreement or disagreement with the data analyst’s assessment, or will indicate further action to be taken by the data analyst to determine the data validity. In this case, all documentation and the data validation workbook will be returned to the data analyst for further review.

The data validation process is dependent upon the documentation produced during the daily data screening process. The data screening methods are documented in AECOM QA SOPs. Calibrations methods are documented in the instrument specific AECOM Calibration SOPs. SOPs relevant to this monitoring program are listed in *Table 10* and are included in *Appendix C*. Data validation is performed on a monthly schedule with a second review of data validation occurring when the quarterly summary reports and are compiled.

### D.2.2.1 Data Calculations

The scalar averaging equations used by the data logger for all meteorological parameters are those specified in USEPA guidance (USEPA 2000). At least 45 minutes of valid meteorological data are required for calculating a valid hourly average (USEPA 2008).

Data recovery for meteorological data will be based on hourly average data collection. The data recovery percentage $P_t$ for each parameter is determined by:

$$ P_t = \left( \frac{hv}{ht} \right) \times 100 $$

where: $hv = $ the number of hours of valid data

$ht = $ total number of hours in the period

All other calculations used in evaluating the data validation criteria in *Table 9* are based upon those provided in USEPA guidance (USEPA 2008, 2000).

### D.3 Reconciliation with User Requirements

The objectives of this monitoring effort are described in Section A.5. This QAPP provides a description of the proposed monitoring program to meet the project objectives. AECOM will conduct monthly and quarterly review of the monitoring program following the end of each month and quarter and report the results obtained during the reporting period. These results will be compared against the established objectives to ensure that the monitoring objectives are being met.

If this data review shows that the objectives of the monitoring project are not being met or that the data are inconsistent or fail to meet the criteria or objectives of the monitoring project, then the AECOM project manager will make a reassessment of the QAPP, and propose any necessary changes to the BLM for agency approval.
E References


Code of Federal Regulations, Title 40, Chapter 1, Subchapter C, Appendix W to Part 51, Guideline on Air Quality Models.

Code of Federal Regulations, Title 40, Chapter 1, Subpart C, Part 50, National Primary and Secondary Ambient Air Quality Standards.


Tables
Table 1  Key Individuals and Responsibilities

<table>
<thead>
<tr>
<th>Key Role</th>
<th>Individual Fulfilling Role</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Manager (AECOM)</td>
<td>Ms. Linsey DeBell</td>
<td>Responsible for overseeing and coordinating all aspects of the project.</td>
</tr>
<tr>
<td>Data Manager (AECOM)</td>
<td>Mr. Kip Carrico</td>
<td>Responsible for overseeing all data collection, validation, management, and reporting tasks.</td>
</tr>
<tr>
<td>Data Analyst (AECOM)</td>
<td>Various</td>
<td>Responsible for routine data collection, validation, management, and reporting tasks.</td>
</tr>
<tr>
<td>Field Operations Manager (AECOM)</td>
<td>Mr. Chris Johnson</td>
<td>Responsible for coordinating all field activities including installation, calibrations, maintenance, and operation of the monitoring systems.</td>
</tr>
<tr>
<td>Field Technician (AECOM)</td>
<td>Various</td>
<td>Responsible for conducting field activities including installation, calibrations, maintenance, monitoring system operation, and site observer support.</td>
</tr>
<tr>
<td>Quality Assurance Manager (AECOM)</td>
<td>Mr. Peter Miller</td>
<td>Responsible for ensuring that established QA/QC procedures are followed, and reviewing the results of all QA/QC activities.</td>
</tr>
<tr>
<td>Technical Advisor (AECOM)</td>
<td>Mr. Tom Damiana</td>
<td>Provide technical assistance for all aspects of the monitoring program, including management, measurements, and reporting.</td>
</tr>
<tr>
<td>Independent Quality Assurance Auditor (ASRC Energy Services)</td>
<td>Mr. Ovi Popovici</td>
<td>Responsible for performing independent QA performance and technical systems audits.</td>
</tr>
<tr>
<td>Project Manager (BLM)</td>
<td>Alan Peck</td>
<td>Main point of contact for BLM project team.</td>
</tr>
<tr>
<td>Contracting Officer Representative/Technical Advisor (BLM)</td>
<td>Dave Maxwell</td>
<td>Contract management. Provide technical opinions for all aspects of the monitoring program, including management, measurements, and reporting.</td>
</tr>
</tbody>
</table>
Table 2  Project Schedule

<table>
<thead>
<tr>
<th>Activity</th>
<th>Frequency</th>
<th>Approximate Date/Due Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>Once</td>
<td>February 2014</td>
</tr>
<tr>
<td>Calibrations</td>
<td>At installation, approximately three months after installation, and</td>
<td>Installation, July 2014, January 2015, etc.</td>
</tr>
<tr>
<td></td>
<td>approximately semi-annually thereafter.</td>
<td></td>
</tr>
<tr>
<td>Site checks</td>
<td>Approximately quarterly</td>
<td>Site checks will occur during the semi-annual calibration checks and performance audits.</td>
</tr>
<tr>
<td>Audits¹</td>
<td>Immediately following installation and approximately semi-annually</td>
<td>Installation, October 2014, April 2015, October 2015, etc., shutdown</td>
</tr>
<tr>
<td></td>
<td>thereafter.</td>
<td></td>
</tr>
<tr>
<td>Reports</td>
<td>Quarterly</td>
<td>Final quarterly reports are due 60 days after the end of each monitoring quarter.</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>Final annual reports are due 60 days after the end of each monitoring year.</td>
</tr>
<tr>
<td>Final calibration,</td>
<td>Once, upon completion of the monitoring program</td>
<td>TBD², program is expected to run a minimum of one year.</td>
</tr>
<tr>
<td>project takedown</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ AECOM personnel will not always be on-site during audit visits. The auditor will not perform routine site maintenance.
² TBD = to be determined
³ Calibrations and audits will be performed at the frequency specified in this table if monitoring extends beyond one year.
### Table 3  Station Locations

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude</td>
<td>70° 0’ 14.22” N</td>
</tr>
<tr>
<td>Longitude</td>
<td>153° 5’ 6.05” W</td>
</tr>
<tr>
<td>UTM Zone</td>
<td>5</td>
</tr>
<tr>
<td>UTM Easting (m)</td>
<td>496755.5</td>
</tr>
<tr>
<td>UTM Northing (m)</td>
<td>7766315.9</td>
</tr>
<tr>
<td>Elevation (feet-mean sea level)</td>
<td>170</td>
</tr>
</tbody>
</table>

All coordinates are NAD83.
### Table 4  Summary of Project Documentation and Reports

<table>
<thead>
<tr>
<th>Type of Documentation Generated</th>
<th>Frequency Generated</th>
<th>Preparer</th>
<th>Archive Location</th>
<th>How Provided to BLM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw data (digital)</td>
<td>1-hour averages logged hourly and downloaded each business day</td>
<td>Data analyst</td>
<td>AECOM office server</td>
<td>Annual data report</td>
</tr>
<tr>
<td>Raw data (printed copy)</td>
<td>Each business day</td>
<td>Data analyst</td>
<td>AECOM office files</td>
<td>Annual data report</td>
</tr>
<tr>
<td>Validated data (digital)</td>
<td>Monthly</td>
<td>Data analyst</td>
<td>AECOM office server</td>
<td>Quarterly data report</td>
</tr>
<tr>
<td>Station logs</td>
<td>Each station visit</td>
<td>Anyone visiting the site</td>
<td>On-site</td>
<td>Annual data report</td>
</tr>
<tr>
<td>Corrective action requests</td>
<td>As needed</td>
<td>Data analyst</td>
<td>AECOM office</td>
<td>Annual data report</td>
</tr>
<tr>
<td>Calibration sheets</td>
<td>Semi-annually</td>
<td>AECOM field technician</td>
<td>AECOM office</td>
<td>Quarterly data report</td>
</tr>
<tr>
<td>Maintenance logs</td>
<td>As needed</td>
<td>AECOM field technician</td>
<td>On-site</td>
<td>Annual data report</td>
</tr>
<tr>
<td>Spare parts inventory</td>
<td>Quarterly</td>
<td>AECOM field technician</td>
<td>AECOM office files</td>
<td>Annual data report</td>
</tr>
<tr>
<td>Performance audit reports</td>
<td>Semi-annually</td>
<td>Independent QA auditor</td>
<td>AECOM office</td>
<td>Quarterly data report</td>
</tr>
<tr>
<td>Technical systems audit reports</td>
<td>Following initial audit</td>
<td>Independent QA auditor</td>
<td>AECOM office</td>
<td>Quarterly data report</td>
</tr>
<tr>
<td>Quarterly Data Report</td>
<td>Comprehensive quarterly data report, following each monitoring quarter. These reports will include all information necessary to approve the data collected for PSD purposes</td>
<td>Data analyst AECOM Project Manager</td>
<td>AECOM office BLM</td>
<td>Quarterly data report</td>
</tr>
<tr>
<td>Annual data report</td>
<td>Comprehensive annual data report, following one year of monitoring</td>
<td>Data analyst AECOM project manager</td>
<td>AECOM office BLM</td>
<td>Annual data report</td>
</tr>
<tr>
<td>QAPP revisions</td>
<td>As needed</td>
<td>AECOM project manager</td>
<td>AECOM office</td>
<td>Revised QAPP</td>
</tr>
</tbody>
</table>

Note: AECOM will retain all project documentation for a minimum of 5 years following the end of the monitoring year. After 5 years, project documentation will be archived per instructions from BLM.
### Table 5  Parameters, Equipment, and Measurement Methods

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measurement Level</th>
<th>Manufacturer/Model</th>
<th>Sample Frequency</th>
<th>Averaging Period</th>
<th>Measurement Range</th>
<th>Detection Limit</th>
<th>Measurement Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind speed (scalar)</td>
<td>10</td>
<td>RM Young 05305-AQ</td>
<td>Continuous</td>
<td>1-hour</td>
<td>0.4 to 50 m/s</td>
<td>0.4 m/s</td>
<td>Propeller anemometer/magnetically induced AC</td>
</tr>
<tr>
<td>Wind direction (scalar)</td>
<td>10</td>
<td>RM Young 05305-AQ</td>
<td>Continuous</td>
<td>1-hour</td>
<td>0 to 360º</td>
<td>0.5 m/s at 10º displacement</td>
<td>Lightweight vane and precision potentiometer</td>
</tr>
<tr>
<td>Wind speed standard deviation</td>
<td>10</td>
<td>Campbell Scientific CR-3000</td>
<td>Continuous</td>
<td>1-hour</td>
<td>n/a</td>
<td>n/a</td>
<td>Computed by data logger</td>
</tr>
<tr>
<td>Wind direction standard deviation</td>
<td>10</td>
<td>Campbell Scientific CR-3000</td>
<td>Continuous</td>
<td>1-hour</td>
<td>0 to 104º</td>
<td>n/a</td>
<td>Yamartino (1984), computed by data logger</td>
</tr>
<tr>
<td>Vertical wind speed</td>
<td>10</td>
<td>Climatronics 102236-G0</td>
<td>Continuous</td>
<td>1-hour</td>
<td>-25 to 25 m/s</td>
<td>0.22 m/s</td>
<td>Photochopper</td>
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<tr>
<td>Vertical wind speed standard deviation</td>
<td>10</td>
<td>Campbell Scientific CR-3000</td>
<td>Continuous</td>
<td>1-hour</td>
<td>n/a</td>
<td>n/a</td>
<td>Computed by data logger</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>2,10</td>
<td>YSI 44212</td>
<td>Continuous</td>
<td>1-hour</td>
<td>-50ºC to 50ºC</td>
<td>n/a</td>
<td>Motor aspirated dual-element thermistor</td>
</tr>
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<td>Vertical temperature difference</td>
<td>10-2</td>
<td>YSI 44212</td>
<td>Continuous</td>
<td>1-hour</td>
<td>-40ºC to 40ºC</td>
<td>n/a</td>
<td>Computed by data logger</td>
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<td>Total solar radiation</td>
<td>3</td>
<td>Eppley 8-48</td>
<td>Continuous</td>
<td>1-hour</td>
<td>0 to 1400 W/m²</td>
<td>n/a</td>
<td>Black and white pyranometer with a differential thermopile.</td>
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<tr>
<td>Relative Humidity</td>
<td>2</td>
<td>Vaisala HMP155</td>
<td>Continuous</td>
<td>1-hour</td>
<td>0 to 100%</td>
<td>n/a</td>
<td>Capacitance</td>
</tr>
<tr>
<td>Barometric Pressure</td>
<td>2</td>
<td>Vaisala PTB110</td>
<td>Continuous</td>
<td>1-hour</td>
<td>500 to 1100 mb</td>
<td>n/a</td>
<td>Silicon capacitive pressure sensor</td>
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1 Approximate measurement levels, installed heights will be provided in each quarterly and annual data report.
<table>
<thead>
<tr>
<th>System</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td><strong>Data Acquisition</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Data logger</td>
<td>Campbell Scientific</td>
<td>CR 3000</td>
<td>Digital data acquisition and averaging</td>
</tr>
<tr>
<td>Modem</td>
<td>Iridium</td>
<td>9255B</td>
<td>Remote communication and data logger interrogation interface</td>
</tr>
<tr>
<td><strong>Support</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-meter tower</td>
<td>Rohn and Tower Systems Inc.</td>
<td>Rohn 25G</td>
<td>Meteorological monitoring tower and instrument elevator</td>
</tr>
<tr>
<td>Equipment Shelter</td>
<td>n/a</td>
<td>n/a</td>
<td>Weatherproof shelter for data acquisition system</td>
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</table>
### Table 7  Quantitative Measurement Quality Objectives: Meteorological Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>Reporting Units</th>
<th>Operating Range</th>
<th>Resolution</th>
<th>Minimum Sample Frequency</th>
<th>Raw Data Collection Frequency</th>
<th>Accuracy</th>
<th>Completeness ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind direction</td>
<td>Vane</td>
<td>degrees</td>
<td>0 to 360</td>
<td>1.0</td>
<td>Hourly</td>
<td>1 second</td>
<td>Alignment within ±5 degrees</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Starting torque ≤0.5 m/s</td>
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<td></td>
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<td>Normalized linearity within</td>
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<td>±3 degrees</td>
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<td>75% valid data (within an hour)</td>
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<td>to calculate 1-hr average, and</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>consecutive quarters</td>
<td></td>
</tr>
<tr>
<td>Horizontal wind speed</td>
<td>Propeller anemometer</td>
<td>m/s</td>
<td>0.5 to 50</td>
<td>0.1</td>
<td>Hourly</td>
<td>1 second</td>
<td>0, 2 m/s and three upscale points</td>
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</tr>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>over sensor range; ±(0.2 m/s + 5% of actual)</td>
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<td>Starting torque ≤0.5 m/s</td>
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<td>consecutive quarters</td>
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</tr>
<tr>
<td>Vertical wind speed</td>
<td>Propeller anemometer</td>
<td>m/s</td>
<td>-25 to 25</td>
<td>0.1</td>
<td>Hourly</td>
<td>1 second</td>
<td>±(0.2 m/s + 5% of actual)</td>
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</tr>
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<td>Starting torque ≤0.25 m/s</td>
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<td>None ³</td>
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<tr>
<td>Temperature</td>
<td>Thermistor</td>
<td>°C</td>
<td>-50 to 50</td>
<td>0.1</td>
<td>Hourly</td>
<td>1 second</td>
<td>±0.5°C</td>
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<td>75% valid data (within an hour)</td>
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<td>consecutive quarters</td>
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<td>Vertical temperature difference</td>
<td>Thermistor</td>
<td>°C</td>
<td>-100 to 100</td>
<td>0.02</td>
<td>Hourly</td>
<td>1 second</td>
<td>±0.1°C</td>
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<td>75% valid data (within an hour)</td>
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<td>to calculate 1-hr average, and</td>
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<td>90% valid hourly data per quarter for 4</td>
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<td></td>
<td></td>
<td>consecutive quarters</td>
<td></td>
</tr>
<tr>
<td>Total solar radiation</td>
<td>Pyranometer</td>
<td>W/m²</td>
<td>0 to 1400</td>
<td>10</td>
<td>Hourly</td>
<td>1 second</td>
<td>±5%</td>
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<td>consecutive quarters</td>
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<td>Barometric pressure</td>
<td>Barometric pressure</td>
<td>mb</td>
<td>500 to 1100</td>
<td>0.1</td>
<td>Hourly</td>
<td>1 second</td>
<td>±3 mb</td>
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<tr>
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<td>sensor</td>
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<td>None ³</td>
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<td>Relative Humidity</td>
<td>Hygrometer</td>
<td>RH</td>
<td>0 to 100</td>
<td>1.0</td>
<td>Hourly</td>
<td>1 second</td>
<td>±7%</td>
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<td>None ³</td>
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</tbody>
</table>

¹ Calculated as the ratio of the number of valid hourly averages and the total number of possible hours over each monitoring quarter. A valid hourly average will consist of at least 45 minutes of valid data, with no more than 15 minutes of invalid data excluded from the average.

² Operating range for this parameter is selected to be representative of the ambient conditions anticipated. This range may be broader or narrower than the range recommended in EPA 454/B-08-002.

³ The current USEPA guideline dispersion model (AERMOD) does not require this parameter, and it is of limited utility for meeting other project objectives. Therefore, there is no completeness objective for this parameter. However, every effort will be made to achieve data completeness of 90 percent per monitoring quarter for this parameter.
Table 8  Climatological Values for Kuparuk Airport, Alaska (1983 – 2012)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Max. Temperature (F)</td>
<td>-11.3</td>
<td>-10.9</td>
<td>-8.4</td>
<td>8.7</td>
<td>28.1</td>
<td>47.4</td>
<td>56</td>
<td>50.8</td>
<td>39.2</td>
<td>21.5</td>
<td>4</td>
<td>-4.7</td>
<td>18.4</td>
</tr>
<tr>
<td>Average Min. Temperature (F)</td>
<td>-23.9</td>
<td>-24</td>
<td>-22.6</td>
<td>-6.3</td>
<td>17</td>
<td>33</td>
<td>39</td>
<td>36.9</td>
<td>28.9</td>
<td>10.9</td>
<td>-8.9</td>
<td>-17.8</td>
<td>5.2</td>
</tr>
<tr>
<td>Average Total Precipitation (in.)</td>
<td>0.13</td>
<td>0.17</td>
<td>0.08</td>
<td>0.14</td>
<td>0.07</td>
<td>0.32</td>
<td>0.87</td>
<td>1.06</td>
<td>0.48</td>
<td>0.35</td>
<td>0.16</td>
<td>0.13</td>
<td>3.96</td>
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<tr>
<td>Average Total Snow Fall (in.)</td>
<td>2.6</td>
<td>2.5</td>
<td>2.2</td>
<td>2.8</td>
<td>1.7</td>
<td>0.5</td>
<td>0</td>
<td>0.3</td>
<td>3</td>
<td>8.4</td>
<td>4.6</td>
<td>3.5</td>
<td>32</td>
</tr>
<tr>
<td>Average Snow Depth (in.)</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Data from the Western Regional Climate Center, www.wrcc@dri.edu
### Table 9  Critical Validation Criteria

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>Criteria</th>
<th>Frequency of Evaluation</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sensors</td>
<td>Acceptable Range (Table 7)</td>
<td>Continuous</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td>All sensors</td>
<td>Meet performance specifications in reference guidance</td>
<td>At purchase</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td>Calibration/audit equipment</td>
<td>Independent audit equipment</td>
<td>At purchase</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td></td>
<td>Traceable to NIST or equivalent</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Meet performance specifications</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DATA CAPTURE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hourly</td>
<td>≥ 75% of valid meteorological data</td>
<td>Hourly</td>
<td>EPA-454/B-08-002</td>
</tr>
<tr>
<td>Annual</td>
<td>≥ 90 percent valid data</td>
<td>Each monitoring quarter</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td><strong>CALIBRATION</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All sensors</td>
<td>See Table 12 and SOPs</td>
<td>Every 6 months</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td><strong>AUDIT and CALIBRATION STANDARDS</strong></td>
<td></td>
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</tr>
<tr>
<td>All standards</td>
<td>Within specified accuracy</td>
<td>Within specified certification frequency</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td><strong>QC ASSESSMENT</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calibration checks</td>
<td>See Table 12 and SOPs</td>
<td>Every 6 months</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td>Independent audit</td>
<td>See Table 12 and SOPs</td>
<td>Every 6 months</td>
<td>EPA-454/R-99-005</td>
</tr>
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</table>
### Table 10 List of Standard Operating Procedures

<table>
<thead>
<tr>
<th>Title</th>
<th>Revision Date</th>
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<tbody>
<tr>
<td><strong>Operations and Maintenance Procedures</strong></td>
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</tr>
<tr>
<td>O&amp;M 001 – Meteorological Monitoring Equipment Routine Operation and Maintenance</td>
<td>7/28/2008</td>
</tr>
<tr>
<td><strong>Calibration Procedures</strong></td>
<td></td>
</tr>
<tr>
<td>CAL 001 – Wind Direction Sensor Calibration</td>
<td>9/17/2008</td>
</tr>
<tr>
<td>CAL 003 – Wind Speed Sensor Calibration</td>
<td>9/17/2008</td>
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<tr>
<td>CAL 004 – Total Solar Radiation Sensor Calibration</td>
<td>11/21/2010</td>
</tr>
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<td>CAL 005 – Temperature Sensor Calibration</td>
<td>9/17/2008</td>
</tr>
<tr>
<td>CAL 008 – Vertical Wind Speed Sensor Calibration</td>
<td>9/17/2008</td>
</tr>
<tr>
<td>CAL 010 – Barometric Pressure Sensor Calibration</td>
<td>6/5/2008</td>
</tr>
<tr>
<td><strong>Quality Assurance Procedures</strong></td>
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</tr>
<tr>
<td>QA 001 – Ambient Monitoring Data Validation</td>
<td>Q2, 2011</td>
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<tr>
<td>QA 003 – Meteorological Data Screening Procedures</td>
<td>4/23/2003</td>
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<tr>
<td>QA 004 – Traceability of Standards for Ambient Monitoring</td>
<td>Q4, 2006</td>
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</table>
### Table 11 Data Validation Table: Meteorological Systematic Criteria Table

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Criteria</th>
<th>Samples Evaluated</th>
<th>Acceptable Range</th>
<th>Frequency of Evaluation</th>
<th>Evaluation Level</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station</td>
<td>Representativeness</td>
<td>Station Siting Parameters</td>
<td>See EPA-454/B-08-002, Table 1-2</td>
<td>At installation</td>
<td>Systematic</td>
<td>EPA-454/B-08-002</td>
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</table>
Table 12 Data Validation Table: Meteorological Calibration and Audit Criteria

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Criteria</th>
<th>Samples Evaluated</th>
<th>Acceptable Accuracy</th>
<th>Frequency of Evaluation</th>
<th>Evaluation Level</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>Wind direction</td>
<td>4 point alignment check</td>
<td>Audit or calibration</td>
<td>Alignment at each point within ±5 degrees</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td></td>
<td>Starting torque check</td>
<td>Audit or calibration</td>
<td>Starting torque ≤0.5 m/s</td>
<td></td>
<td></td>
<td>EPA-454/B-08-002</td>
</tr>
<tr>
<td></td>
<td>Linearity check</td>
<td></td>
<td>Normalized linearity within ±3 degrees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal wind speed</td>
<td>5 point accuracy check - 0, 2 m/s and three upscale points over sensor range</td>
<td>Audit or calibration</td>
<td>Accuracy: ±(0.2 m/s + 5% of actual)</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td></td>
<td>Starting torque check</td>
<td>Audit or calibration</td>
<td>Starting torque ≤0.5 m/s</td>
<td></td>
<td></td>
<td>EPA-454/B-08-002</td>
</tr>
<tr>
<td>Vertical wind speed</td>
<td>4-point accuracy check - 2 m/s and three upscale points over sensor range</td>
<td>Audit or calibration</td>
<td>Accuracy: ±(0.2 m/s + 5% of actual)</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td></td>
<td>Starting torque check</td>
<td>Audit or calibration</td>
<td>Starting torque ≤0.25 m/s</td>
<td></td>
<td></td>
<td>EPA-454/B-08-002</td>
</tr>
<tr>
<td>Temperature</td>
<td>Three-point accuracy check (near min expected at site, 0 °C, and near max expected site temperature)</td>
<td>Audit or calibration</td>
<td>Accuracy: ±0.5°C</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td>Vertical temperature difference</td>
<td>Three-point accuracy check (near min expected at site, 0 °C, and near max expected site temperature)</td>
<td>Audit or calibration</td>
<td>Accuracy: ±0.1°C</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td>Total solar radiation</td>
<td>Zero check Multi-point check over one full diurnal cycle, or within several hours of solar noon²</td>
<td>Audit or calibration</td>
<td>Accuracy: ±5% of observed ² when actual conditions are ≥200 W/m², ≤10 W/m² of observed otherwise</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
<tr>
<td>Barometric pressure</td>
<td>One-point accuracy check</td>
<td>Audit or calibration</td>
<td>Accuracy: ±3 mb</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/R-99-005</td>
</tr>
</tbody>
</table>

Continued on the next page…
Table 12 Data Validation Table: Meteorological Calibration and Audit Criteria (continued)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Criteria</th>
<th>Samples Evaluated</th>
<th>Acceptable Accuracy</th>
<th>Frequency of Evaluation¹</th>
<th>Evaluation Level</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Humidity</td>
<td>One-point accuracy check</td>
<td>Audit or calibration</td>
<td>Accuracy: ±7%</td>
<td>Every 6 months</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>EPA-454/B-08-002</td>
</tr>
<tr>
<td>Data Logger</td>
<td>Time and date accuracy</td>
<td>Audit or calibration</td>
<td>Date and time is correct to within ±5 minutes of standard time</td>
<td>Daily</td>
<td>Critical (calibrations) Operational (audits)</td>
<td>AECOM-proposed criteria</td>
</tr>
</tbody>
</table>

¹ Meteorological Monitoring Guidance for Regulatory Modeling Applications (MMGRMA, EPA-454/R-99-055) requires audits within 30 days of startup and every 6 months thereafter (Section 8.4.1). MMGRMA also requires calibration checks and if necessary calibrations at startup and at 6-month intervals (Section 8.3.5). Calibration checks and if necessary calibrations are performed immediately prior to takedown or removal of sensor.

² The AECOM SOP for the solar radiation calibration deviates from the procedure prescribed in EPA-454/B-08-002. For the solar radiation sensor, failure to pass a calibration check when there is insufficient sunlight, less than 200 W/m², to accurately perform the check will not result in data invalidation unless a subsequent calibration or audit check performed under more favorable conditions confirms the failure.

³ Evaluated as the average of all errors if the check is performed over a full diurnal cycle (sunrise through sunset). Evaluated at each test point if the check is performed over less than one full diurnal cycle.
Table 13 Calibration Check Schedule

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>At startup⁴</td>
<td>All meteorological parameters</td>
</tr>
<tr>
<td>Following ~4 months of startup and semi-annually thereafter</td>
<td>All meteorological parameters</td>
</tr>
<tr>
<td>Immediately prior to shutdown</td>
<td>All meteorological parameters</td>
</tr>
</tbody>
</table>

¹ If the station remains in operation for more than 12 months, the schedule will repeat with calibrations of the meteorological parameters occurring approximately every six months.
Table 14 Audit Schedule

<table>
<thead>
<tr>
<th>Schedule</th>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>At startup(^1,2)</td>
<td>All meteorological parameters</td>
</tr>
<tr>
<td>Following ~7 months of startup and semi-annually thereafter</td>
<td>All meteorological parameters</td>
</tr>
<tr>
<td>Prior to shutdown, within 45 days prior to the end of valid data collection</td>
<td>All meteorological parameters</td>
</tr>
</tbody>
</table>

\(^1\) The technical field systems audit and the data quality audit will be conducted in conjunction with the initial field performance audit and annually thereafter.

\(^2\) If the station remains in operation for more than 12 months, the schedule will repeat with audits of the meteorological parameters occurring approximately every six months.
Table 15  Scheduled Field Activities

<table>
<thead>
<tr>
<th>Field Operations Activities</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Each Visit</td>
</tr>
<tr>
<td>Perform calibration checks</td>
<td></td>
</tr>
<tr>
<td>Perform independent quality assurance audits</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** Due to the remote location of the site, as well as logistical issues and concerns, there will be no regular field activities other than calibration checks and performance audits.

Responsible Party:
- ✓ = AECOM field operations personnel
- O = Independent QA auditor
Table 16 Critical Spare Parts and Expendable Supplies Inventory

<table>
<thead>
<tr>
<th>Item</th>
<th>Number in Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind direction tail assembly</td>
<td>1</td>
</tr>
<tr>
<td>Wind speed propeller</td>
<td>1</td>
</tr>
<tr>
<td>Vertical wind speed propeller</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal wind speed sensor bearings</td>
<td>1</td>
</tr>
<tr>
<td>Horizontal wind direction sensor bearings</td>
<td>1</td>
</tr>
<tr>
<td>Vertical wind speed sensor bearings</td>
<td>1</td>
</tr>
</tbody>
</table>
### Table 17 Equipment Suppliers

<table>
<thead>
<tr>
<th>Equipment Suppliers</th>
<th>Contact Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Meteorological Monitoring Equipment</strong></td>
<td></td>
</tr>
<tr>
<td>Climatronics</td>
<td>The Eppley Laboratory, Inc.</td>
</tr>
<tr>
<td>140 Wilbur Place</td>
<td>12 Sheffield Avenue, PO Box 419</td>
</tr>
<tr>
<td>Bohemia, NY 11716</td>
<td>Newport, Rhode Island 02840 USA</td>
</tr>
<tr>
<td>(631) 567-7300</td>
<td>(401) 847-1020</td>
</tr>
<tr>
<td>Vaisala</td>
<td>Therm-X (distributor for YSI)</td>
</tr>
<tr>
<td>10-D Gill Street</td>
<td>1837 Whipple Rd.</td>
</tr>
<tr>
<td>Woburn, MA 01801</td>
<td>Hayward, CA 94544</td>
</tr>
<tr>
<td>(800) 408-9456</td>
<td>(510) 441-7566</td>
</tr>
<tr>
<td>R.M. Young Company</td>
<td></td>
</tr>
<tr>
<td>2801 Aero Park Drive</td>
<td></td>
</tr>
<tr>
<td>Traverse City, Michigan 49686</td>
<td></td>
</tr>
<tr>
<td>(231) 946-3980</td>
<td></td>
</tr>
<tr>
<td><strong>Data Acquisition System</strong></td>
<td></td>
</tr>
<tr>
<td>Campbell Scientific</td>
<td>Hughes</td>
</tr>
<tr>
<td>815 W 1800 N</td>
<td>11717 Exploration Lane</td>
</tr>
<tr>
<td>Logan, UT 84321-1784</td>
<td>Germantown, MD 20876</td>
</tr>
<tr>
<td>(435) 753-2342</td>
<td>(877) 337-3880</td>
</tr>
<tr>
<td><a href="http://www.campbellsci.com">www.campbellsci.com</a></td>
<td><a href="http://www.hughes.com">www.hughes.com</a></td>
</tr>
<tr>
<td><strong>Power Generation System</strong></td>
<td></td>
</tr>
<tr>
<td>ACV Enterprises</td>
<td></td>
</tr>
<tr>
<td>P.O. Box 670788</td>
<td></td>
</tr>
<tr>
<td>Chugiak, AK 99567</td>
<td></td>
</tr>
<tr>
<td>(907) 688-6321</td>
<td></td>
</tr>
</tbody>
</table>
## Table 18 Calibration and Audit Equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Certification Frequency</th>
<th>Minimum Certification Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified digital multi-meter</td>
<td>Annually</td>
<td>n/a</td>
</tr>
<tr>
<td>Wind direction linearity test fixture</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Compass</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Variable speed motor</td>
<td>Annually</td>
<td>0 to 50 m/s</td>
</tr>
<tr>
<td>Torque gauge</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>NIST-traceable temperature standard</td>
<td>Annually</td>
<td>-50°C to 50°C</td>
</tr>
<tr>
<td>Insulated temperature baths</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Computer program for solar siting data</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Reference barometer</td>
<td>Annually</td>
<td>500 to 1100 mb</td>
</tr>
<tr>
<td>Reference pyranometer</td>
<td>Annually</td>
<td>Single point at ~700 W/m²</td>
</tr>
<tr>
<td>Reference relative humidity standard</td>
<td>Annually</td>
<td>0 to 100%</td>
</tr>
</tbody>
</table>
Figures
Figure 1  Project Organization Chart

Legend

--- Lines of Communication
--- Direct Report
Figure 2  Area Map Showing Monitoring Location
Figure 3  Local Map Showing Monitoring Site Location
Figure 4  Monitoring Site Looking North

Figure 5  Monitoring Site Looking East
Figure 6  Monitoring Site Looking South

Figure 7  Monitoring Site Looking West
Figure 8  Data Processing Flow Chart

Remote Station

- Sensors
  - In-Station Data Logger
  - Satellite Modem
    - Station QC Documents and Forms
      - Shipping Service

AECOM Fort Collins Data Center

- AECOM Computer
  - Generate Daily Data Printouts Via Split and Excel
    - Review Daily Data Printouts
      - Update Data Processing Notes Specifying Invalid Data
        - Invalidate Data Identified - Generate Summary Data Tables
          - Corrections from data manager sent back to data analyst as necessary
            - Draft Report Written
              - Draft Report Reviewed by Data Manager and Project Manager
                - Final Report Produced
      - Review Station QC Documentation - Invalidate Data if Necessary
        - Summary Tables and Data Validation Reviewed by Data Manager
          - Corrections from data manager sent back to data analyst as necessary
            - Final Report Produced
Appendix A

QAPP Revisions
Appendix B

Standard AECOM Project Forms
AECOM HORIZONTAL WIND DIRECTION CALIBRATION/AUDIT FORM

GENERAL INFORMATION
CLIENT: DATE: TECHNICIAN:
LOCATION: START: OPERATOR:
SITE ID: END: INITIAL / FINAL:

SENSOR DESCRIPTION
MAKE: SERIAL #: HEIGHT:
MODEL: RANGE:

SENSOR PERFORMANCE (ALIGNMENT)

<table>
<thead>
<tr>
<th>LANDMARK 1</th>
<th>LANDMARK 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESCRIPTION:</td>
<td>DESCRIPTION:</td>
</tr>
<tr>
<td>DIRECTION (TRUE):</td>
<td>DIRECTION (TRUE):</td>
</tr>
<tr>
<td>VANE ORIENTATION</td>
<td>DIRECTION</td>
</tr>
<tr>
<td>(DEGREES)</td>
<td>(DEGREES)</td>
</tr>
<tr>
<td>TO LANDMARK 1</td>
<td>FROM LANDMARK 1</td>
</tr>
</tbody>
</table>

SENSOR PERFORMANCE (LINEARITY)

<table>
<thead>
<tr>
<th>CLOCKWISE</th>
<th>COUNTER-CLOCKWISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT VALUE</td>
<td>DAS ERROR</td>
</tr>
<tr>
<td>(DEGREES)</td>
<td>(DEGREES)</td>
</tr>
<tr>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>NOTE: Normalized error must be no more than +/- 3 degrees at each input value.</td>
<td></td>
</tr>
</tbody>
</table>

STARTING TORQUE/THRESHOLD

| DIRECTION OF ROTATION | STARTING TORQUE | K-FACTOR | STARTING THR | REQUIRED THR | PASS/FAIL |
| CW | (g-cm) | (m/s) | (m/s) | |
| CCW |

MISCELLANEOUS

CONDITION OF VANE: REPLACED? (YES/NO): 
CONDITION OF SENSOR CABLE/CONNECTIONS:
BEARINGS REPLACED? (YES/NO): 
Method used to determine sensor alignment (solar azimuth, magnetic compass, etc.): 
If solar azimuth method was used, enter site longitude and latitude: Longitude: Latitude:
If magnetic compass reading was used, enter site magnetic declination:

COMMENTS

Revision Date: 21-Feb-11
## AECOM HORIZONTAL WIND SPEED CALIBRATION/AUDIT FORM

### GENERAL INFORMATION

<table>
<thead>
<tr>
<th>CLIENT:</th>
<th>DATE:</th>
<th>TECHNICIAN:</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION:</td>
<td>START:</td>
<td>OPERATOR:</td>
</tr>
<tr>
<td>SITE ID:</td>
<td>END:</td>
<td>INITIAL / FINAL:</td>
</tr>
</tbody>
</table>

### SENSOR DESCRIPTION

<table>
<thead>
<tr>
<th>MAKE:</th>
<th>MODEL:</th>
<th>SERIAL #:</th>
<th>RANGE:</th>
<th>HEIGHT:</th>
<th>UNITS:</th>
</tr>
</thead>
</table>

### ANEMOMETER DRIVE MOTOR

<table>
<thead>
<tr>
<th>MAKE:</th>
<th>MODEL:</th>
<th>SERIAL #:</th>
<th>RANGE:</th>
<th>CAL. DATE:</th>
</tr>
</thead>
</table>

### SENSOR PERFORMANCE

#### DAS REQUIRED INPUT SPEED

<table>
<thead>
<tr>
<th>RPM</th>
<th>OUTPUT</th>
<th>ERROR</th>
<th>REQUIRED ACCURACY</th>
<th>PASS/FAIL</th>
</tr>
</thead>
</table>

RPM to Output Units Conversion Factors:

- Slope: 
- Intercept: 

### STARTING TORQUE/THRESHOLD

<table>
<thead>
<tr>
<th>DIRECTION OF ROTATION</th>
<th>STARTING TORQUE</th>
<th>K-FACTOR</th>
<th>STARTING THRESHOLD</th>
<th>REQUIRED THRESHOLD</th>
<th>PASS/FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW</td>
<td>(g-cm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### MISCELLANEOUS

- CONDITION OF PROPELLER/CUPS: REPLACED? (YES/NO): 
- CONDITION OF SENSOR CABLE/CONNECTIONS: 
- BEARINGS REPLACED? (YES/NO): 

### COMMENTS

Revision Date: 21-Feb-11
# AECOM Vertical Wind Speed Calibration/Audit Form

## General Information
- **Client:**
- **Date:**
- **Technician:**
- **Location:**
- **Start:**
- **Operator:**
- **Site ID:**
- **End:**
- **Initial / Final:**

## Sensor Description
- **Make:**
- **Model:**
- **Serial #:**
- **Range:**
- **Height:**
- **Units:**

## Anemometer Drive Motor
- **Make:**
- **Model:**
- **Serial #:**
- **Range:**
- **Cal. Date:**

## Sensor Performance

<table>
<thead>
<tr>
<th>Input Speed (Clockwise)</th>
<th>DAS Output Error</th>
<th>Required Accuracy</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RPM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Input Speed (Counter-Clockwise)</th>
<th>DAS Output Error</th>
<th>Required Accuracy</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RPM)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RPM to Output Units Conversion Factors:
- **Slope:** 0.00005
- **Intercept:** 0

## Starting Torque/Threshold

<table>
<thead>
<tr>
<th>Direction of Rotation</th>
<th>Starting Torque (g-cm)</th>
<th>K-Factor</th>
<th>Starting Threshold</th>
<th>Required Threshold</th>
<th>Pass/Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>CW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Miscellaneous
- **Condition of Propeller/Cups:**
  - **Replaced? (Yes/No):**
- **Condition of Sensor Cable/Connections:**
- **Bearings Replaced? (Yes/No):**

## Comments

---

**Revision Date:** 17-May-13
# AECOM Temperature Sensor Calibration Form

## General Information

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td></td>
</tr>
<tr>
<td>Technician</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td></td>
</tr>
<tr>
<td>Operator</td>
<td></td>
</tr>
<tr>
<td>Site ID</td>
<td></td>
</tr>
<tr>
<td>End</td>
<td></td>
</tr>
<tr>
<td>Initial/Final</td>
<td></td>
</tr>
</tbody>
</table>

## Reference Standard

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Multi-Meter</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Serial #</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>Cal Date</td>
<td></td>
</tr>
<tr>
<td>Temp. Reference</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Serial #</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>Cal Date</td>
<td></td>
</tr>
</tbody>
</table>

## Sensor Description

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor #1</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Serial #</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td></td>
</tr>
<tr>
<td>Sensor #2</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Serial #</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td></td>
</tr>
<tr>
<td>Sensor #3</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Serial #</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td></td>
</tr>
<tr>
<td>Height</td>
<td></td>
</tr>
<tr>
<td>Sensor #4</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Serial #</td>
<td></td>
</tr>
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**Temperature Output Units (C or F):**

## Sensor Calibration

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<td>Bath Temp</td>
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<tr>
<td>Sensor Output (mV)</td>
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<td>Sensor Output (mV)</td>
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**Multiplier:**

**Offset:**

**Correlation Coeff:**

## Comments

Revision Date: 21-Feb-11
# AECOM Temperature/Delta-Temperature Calibration/Audit Form

## General Information

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<tr>
<td>Operator</td>
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<td>Site ID</td>
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<td>End</td>
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## Sensor Description

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<tbody>
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## Reference Standard

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<td>Range</td>
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## Sensor Performance

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<td>Das Output Error</td>
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## Delta-Temperature

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<td>Required Accuracy</td>
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<td>Das Output Error</td>
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## Miscellaneous

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<tr>
<td>Condition of Aspirator/Radiation Shield:</td>
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## Comments

Revision Date: 21-Feb-11
<table>
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<th>RUN NUMBER</th>
<th>REFERENCE OUTPUT (millivolts)</th>
<th>SENSOR OUTPUT (millivolts)</th>
<th>ABSOLUTE ERROR</th>
<th>REQUIRED ACCURACY</th>
<th>PASS/FAIL</th>
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<td>AVERAGE</td>
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**MISCELLANEOUS**

CONDITION OF SENSOR: ____________

CONDITION OF SENSOR CABLE/CONNECTIONS: ____________

**COMMENTS**
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<th>DAS Indication RH</th>
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<th>Accuracy (%)</th>
<th>Pass/Fail</th>
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**MISCELLANEOUS**

Condition of Sensor Cable/Connections: 
Condition of Aspirator/Radiation Shield: 

**COMMENTS**
AECOM SOLAR RADIATION CALIBRATION/AUDIT FORM

GENERAL INFORMATION

CLIENT: ___________________________ DATE: _______________ TECHNICIAN: ___________________________
LOCATION: ___________________________ START: _______________ OPERATOR: ___________________________
SITE ID: ___________________________ END: _______________ INITIAL / FINAL: ___________________________

SENSOR DESCRIPTION

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<th>MODEL</th>
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<th>RANGE</th>
<th>DISPLAY UNITS</th>
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<td>W/m²</td>
<td>(millivolts per W/m²)</td>
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REFERENCE SENSOR

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<td></td>
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<td>W/m²</td>
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DVM

<table>
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</table>

SENSOR PERFORMANCE

Test commenced prior to sunrise and ended after sunset? [ ]

If No, then an explanation as to why the QC check did not include a full diurnal cycle must be provided in the Comments section below.

TEST REFERENCE SENSOR ABSOLUTE PERCENT POINT OUTPUT OUTPUT ERROR ERROR PASS/FAIL

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<thead>
<tr>
<th>(millivolts)</th>
<th>(W/m²)</th>
<th>(W/m²)</th>
<th>(%)</th>
<th>(W/m²)</th>
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<tbody>
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ENDING TIME OUTPUT ABSOLUTE PERCENT REQUIRED ACCURACY PASS/FAIL

<table>
<thead>
<tr>
<th>LST</th>
<th>REFERENCE OUTPUT</th>
<th>SENSOR OUTPUT</th>
<th>ERROR</th>
<th>ERROR</th>
<th>REQUIRED ACCURACY</th>
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<tbody>
<tr>
<td></td>
<td>(millivolts)</td>
<td>(W/m²)</td>
<td>(W/m²)</td>
<td>(%)</td>
<td>(W/m²) (%)</td>
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</table>

AVERAGE OVER DIURNAL CYCLE

Required accuracy is +/−10 W/m² if actual insolation is < 200 W/m², and +/−5% if greater than or equal to 200 W/m².

Accuracy is evaluated as the average of all errors if the check is performed over a full diurnal cycle (sunrise through sunset). Accuracy is evaluated at each test point if the check is performed over less than one full diurnal cycle.

MISCELLANEOUS

AT START OF TEST AT END OF TEST

PRECIPITATION: ___________________________ ___________________________
PERCENT SKY COVER: ________________ ________________

TIME OF SUNRISE (LST): ________________ TIME OF SUNSET (LST): ________________
CONDITION OF SENSOR: ___________________________ ___________________________
SENSOR LEVEL (YES/NO): ___________________________ ___________________________
CONDITION OF DESSICANT: ___________________________ DESSICANT REPLACED? (YES/NO) ___________________________

COMMENTS

Revision Date: 12-Apr-12
# METEOROLOGICAL SYSTEM SPARE PARTS INVENTORY

**Site Name:**

**Client Name:**

**Date:**

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<th>Number/Amount at AECOM Shop</th>
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<tr>
<td>Bearings</td>
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<tr>
<td>Propeller/cups</td>
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<tr>
<td><strong>Wind Direction</strong></td>
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<td><strong>Vertical Wind Speed</strong></td>
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DATA PROCESSING NOTES AND COMMENTS

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</tbody>
</table>
CORRECTIVE ACTION REQUEST FORM

Part A – To Be Completed By Requestor

General Information:
Date: 
Project Name: 
Project Number: 
To: 
From: 
Copies to: 

Urgency:
☐ Emergency (failure to take action immediately may result in personal injury or property damage)
☐ Immediate (4 hours) ☐ Urgent (24 hours) ☐ Routine (7 days)
☐ As resources allow ☐ Informational only; no corrective action required

Status of Project Data Collection:
☐ Affected instrument/system is not operating and is not collecting valid data. Requires Immediate or Urgent action.
☐ Affected instrument/system is operating, but is not collecting valid data. Requires Immediate or Urgent action.
☐ Status of instrument/system operation or data validity is unknown. Assumed to be inoperative and not collecting valid data. Requires Immediate or Urgent action.
☐ Affected instrument/system is operating and is collecting valid data. Urgency is at the discretion of the Originator.

Problem Identification:
Site ID: 
Affected instrument/system: 
Date problem identified: 

Describe problem in detail below. If possible, attach a copy of the data printout, strip chart, calibration report, etc. to this form.

Describe recommended corrective action (if any) below.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
CORRECTIVE ACTION REQUEST FORM

Part B: To Be Completed By Person Responsible for Corrective Action

Date corrective action taken: 
Person responsible for corrective action: 

Describe corrective action taken in detail below:

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
Appendix C

AECOM Standard Operating Procedures (SOPs)
1.0 Scope and Application
The purpose of this SOP is to provide instructions to on-site technicians and AECOM field technicians regarding routine operation and maintenance of meteorological monitoring equipment.

2.0 Cautions
On-site technicians should make only those checks listed in this SOP. In the event that these checks fall outside acceptable limits, the AECOM field operations manager or project manager should be contacted immediately. **On-site technicians should not make any adjustments to any equipment without specific instructions from AECOM project personnel.**

3.0 On-site technician- Checks to be Performed Each Site Visit
Upon arrival at the site, the on-site technician should do the following:

3.1 Note the date and time (data logger time) of the instrument check in the Station Log and the *Meteorological Station Checklist*.

3.2 Perform the following checks of the meteorological instruments using the *Meteorological Station Checklist*.

3.2.1. **Horizontal Wind Speed:** From the ground, visually check the propeller or cups to make sure that there are no broken blades or cups. Check to see if the sensor is loaded with ice or snow. Excessive vibration of the sensor or tower may indicate either broken blades/cups, or ice/snow loading. If the sensor is in good condition, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions. If so, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

3.2.2. **Wind Direction:** From the ground, visually check the wind vane to make sure that it is not broken and that it is turning freely in the wind. Check to see if the sensor is loaded with ice or snow. If the sensor is in good condition, check the
“Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions. If so, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

3.2.3. **Vertical Wind Speed:** From the ground, visually check the propeller to make sure that there are no broken vanes and that it is turning freely in the wind. Check to see if the sensor is loaded with ice or snow. If the sensor is in good condition, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions. If so, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

3.2.4. **Temperature Sensors:** From the ground, visually check the aspirators to make sure that they are running (mechanically aspirated sensors only), are free of dirt and debris, and that the aspirator opening is facing down toward the ground for vertically-oriented sensors, or facing north for horizontally-oriented sensors. For sensors higher than about 2-meters, you will usually be able to see the sensor well enough to see if it is dirty, and you will sometimes be able to hear the aspirator fan running (*do not climb the tower to perform this check*). Briefly place your palm over the 2-meter sensor aspirator opening and feel for a slight suction (mechanically aspirated sensors only). Visually check inside the aspirator opening for ice, snow, or dirt. Make sure that weeds, grass, or snow are less than about 1-foot high below the sensor. If necessary, carefully cut back weeds or grass, or shovel snow, within about a 5-foot radius from the sensor. Before cutting grass or weeds or shoveling snow, carefully check the ground in the area for any cables, wires, or obstructions. Take care not to damage the sensor or any wiring while cutting or shoveling. If the sensor is in good condition, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions. If so, check
3.2.5. **Relative Humidity:** Visually check the aspirator to make sure that it is running (mechanically aspirated sensors only), is free of dirt and debris, and that the aspirator opening is facing down toward the ground. Briefly place your palm over the aspirator opening and feel for a slight suction (mechanically aspirated sensors only). Visually check inside the aspirator opening for ice, snow, or dirt. If the sensor is in good condition, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions. If so, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

3.2.6. **Solar Radiation:** Visually check the sensor to make sure that it is level, and that the glass dome is free of dirt and scratches. Gently brush off any accumulated snow on top of the sensor. If the glass dome is dirty, clean it by gently wiping with a lens tissue. Check for condensation inside the sensor dome. Make sure the sensor is level by examining the bubble level on the sensor. If it is not level, use the thumbscrews to center the bubble in the level, and note on the *Station Log* that the sensor was re-leveled. If there are lots of scratches or pits on the glass dome, or if it is cracked or broken, make a note in the *Station Log*, and check the “No” box on the *Meteorological Station Checklist*. If the sensor is in good condition, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions. If so, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*.

3.2.7. **Barometric Pressure:** Visually check the sensor to make sure that it is free of dirt and debris. If the sensor is in good condition, check the “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*. 

The “Yes” box on the *Meteorological Station Checklist*, otherwise check the “No” box and make a note of the problem on the *Station Log*. 
Check the instantaneous sensor output from the data logger, and make sure that the data logger output seems reasonable based on current conditions (consult AECOM for a range of expected barometric pressure based on the station location and elevation). If so, check the “Yes” box on the Meteorological Station Checklist, otherwise check the “No” box and make a note of the problem on the Station Log.

3.2.8. Precipitation: Visually check the gauge to make sure that it is level, and that the collection funnel is free of dirt and debris. Clean out the collection funnel if necessary. Make sure the gauge is level by examining the bubble level on the gauge. If it is not level, make a note in the Station Log, and check the “No” box on the Meteorological Station Checklist. For weighing precipitation gauges, make sure that the liquid level inside the collection cylinder is between the high and low level marks, and make sure that the contents are not frozen. If necessary, drain the accumulated liquid according to instructions in Section 3.2.8.2. If a wind screen is present, check the windscreen to make sure that there are no missing or damaged panels. If the gauge is in good condition, check the “Yes” box on the Meteorological Station Checklist, otherwise check the “No” box and make a note of the problem on the Station Log.

3.2.8.1. If requested to perform an operational check of the precipitation gauge, use a graduated cylinder to add a known amount of water equivalent to between 0.05 inches and 0.20 inches of precipitation to the gauge. To avoid damage to the gauge, water should be poured slowly down the side of the collection cylinder, not directly onto the bottom of the collection cylinder. Record the time and the amount of water added to the gauge in the Station Log. At the conclusion of this operational check, call the AECOM field operations manager or project manager and tell them the time the check was performed and the amount of water (in cubic centimeters) added to the gauge. Do not perform this check if it has rained or snowed within the previous six hours, or there is a high chance of precipitation in the next six hours.

3.2.8.2. If it is necessary to drain and re-fill the precipitation gauge with oil/antifreeze, follow the instructions below:

- Collect the following equipment/supplies:

  ⇒ One to four gallons of new antifreeze and a small container of evaporation-suppressant oil. See the table below to estimate how
many gallons of antifreeze will be needed. Note: Only use antifreeze solution and oil designed for use in the precipitation gauge; these supplies will be provided by AECOM.

⇒ an empty container(s) sufficient to hold 4-5 gallons to catch the liquid that will be drained from the gauge
⇒ a funnel (a 1 liter plastic drink container with the end cut off can be used)
⇒ a plastic 12-inch ruler
⇒ The key to unlock the door to the precipitation gauge

- Unlock and open the door to the gauge. Inside is a black cylinder (the load cell). Disconnect the power to the cell by disconnecting the quick connect on the bottom of the load cell.

- Place the end of the drain tubing in the empty collection container and open the drain valve. Drain liquid from the gauge into the collection container, being careful to leave about one inch of liquid in the gauge. Note that the liquid in the gauge is mostly water and is non-toxic and biodegradable (provided that the proper antifreeze and evaporation-suppressant oil was used). If the rain gauge is full it will hold the equivalent of about 9 gallons of liquid, so it may be necessary to partially drain the gauge, dispose of the drained liquid in the collection container, then drain the remainder of the liquid. Dispose of the drained liquid by pouring it down a sink drain, then running clean water into the drain for at least 30 seconds.

- Close the drain valve when approximately 1 inch of liquid is remaining in the gauge.
• Gently pour new antifreeze into the gauge, with the amount to be added depending on the minimum temperature expected at the site (see the table below, and consult AECOM if you are not sure of the expected minimum temperature). Pour the antifreeze slowly down the side of the collection chamber; it may help to use a funnel. To avoid damage to the load cell, DO NOT pour antifreeze directly onto the load cell located at the bottom center of the collection chamber.

<table>
<thead>
<tr>
<th>Expected Minimum Temperature</th>
<th>Antifreeze Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>(C)</td>
<td>(F)</td>
</tr>
<tr>
<td>-45</td>
<td>-49</td>
</tr>
<tr>
<td>-35</td>
<td>-31</td>
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<tr>
<td>-25</td>
<td>-13</td>
</tr>
<tr>
<td>-15</td>
<td>5</td>
</tr>
<tr>
<td>-5</td>
<td>23</td>
</tr>
<tr>
<td>above 0</td>
<td>above 32</td>
</tr>
</tbody>
</table>

• Pour a thin film of oil on top of the antifreeze solution sufficient to cover the surface of the antifreeze solution.

• Wait about 5 minutes for the gauge to stabilize. Then re-connect the quick connect on the bottom of the load cell. You should hear a peep when it is connected.

• Dispose of the drained liquid by pouring it down a sink drain, then running clean water into the drain for at least 30 seconds.

• Record the starting and ending times of this procedure in the Station Log.

3.2.9. Current Weather: If any precipitation is occurring at the time of the site visit, enter the precipitation type on the Meteorological Station Checklist. Precipitation includes rain, snow, fog, freezing fog, hail, sleet, etc. If no precipitation is occurring, enter “None”.

3.2.10. Snow Conditions: Observe the area within about a 100 yard radius of the monitoring station. If more than 50 percent of the ground appears white due to snow cover, then check the “Yes” box on the Meteorological Station Checklist,
otherwise check the “No” box. If the “Yes” box is checked, make an estimate, to the nearest inch, of the average snow depth in the vicinity of the monitoring station, and record this estimate on the Meteorological Station Checklist. If the average snow depth is estimated to be less than 1 inch, enter “<1” for the estimated snow depth.

4.0 AECOM Field Technicians – Semi-Annual Preventive Maintenance

AECOM field technicians should perform the following preventive maintenance tasks annually. All annual preventive maintenance activities must be recorded in the Station Log.

4.1 Replace wind speed and wind direction sensor bearings. Be sure to do an as-found bearing torque test prior to changing the bearings, and an as-left torque test after changing them.

4.2 Inspect wind speed sensor cups/vane for cracks. Replace if necessary.

4.3 Inspect the wind vane to make sure it is not bent or damaged. Replace if necessary.

4.4 Inspect the temperature aspirators for proper operation, and replace if necessary.

4.5 Inspect drying agent in the solar radiation sensor, and replace as needed.

4.6 Check the level of the solar radiation sensor, and re-level if needed using the leveling screws on the sensor.

4.7 Inspect the barometric pressure sensor inlet for dirt or debris, and clean if needed.

4.8 Inspect all sensor connections, both mechanical and electrical. Tighten and/or replace as necessary.

4.9 Inspect all power and sensor cabling for wear or cracked/damaged insulation. Replace as necessary.

5.0 AECOM Field Technicians – Every Two Years Preventive Maintenance

AECOM field technicians should perform the following preventive maintenance tasks at least once every two years. All preventive maintenance activities must be recorded in the Station Log.

5.1 Replace the temperature sensor aspirator fans.
6.0 Spare Parts Inventory

The following minimum spare parts inventory must be maintained at all times either on-site or in AECOM’s in-house inventory.

- One set of wind speed sensor bearings per sensor
- One set of wind direction sensor bearings per sensor
- One set of vertical wind speed sensor bearings per sensor
- One wind speed sensor propeller or set of cups
- One wind direction sensor vane or tail assembly
- One wind direction sensor potentiometer
- One vertical wind speed sensor propeller
- One temperature sensor
- One temperature sensor aspirator fan
- A six-month supply of precipitation gauge antifreeze and oil
1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to calibrate wind direction sensors. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1 Field Technician

2.1.1 The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2 The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3 The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2 Field Operations Manager

2.2.1 The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2 The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3 The Field Operations Manager is responsible for the reviewing all documentation related to calibration activities for accuracy and completeness.

2.3 Project Manager

2.3.1 The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2 The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Required Materials

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Theodolite, transit, or compass
- Table of solar azimuth angles for calibration dates
- Digital voltmeter
- Torque watch or torque wheel
- Linearity test device
- Laptop computer
- Documentation for all calibration standards and equipment showing that they have been calibration-checked against a NIST-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:

- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.

5.0 Calibration Check Procedures

Before starting, set up all equipment and check the wind direction output for proper operation. Make all test measurements through the instrument cables.
5.1 Record the start time of the calibration (data logger time) in the Station Log and down the data channel. The procedure for "downing" a channel is located in the data logger Manufacturer's Manual.

5.2 Fill out all heading information on the calibration form.

5.3 Check the condition of the sensor. Look for cracked or broken wind vane, frayed sensor wiring, or loose sensor connections. Also check to make sure that the vane set screw is tight and that the vane is securely connected to the sensor shaft. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager or the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.

5.4 Identify appropriate landmarks and their associated angles from true North from the sensor. Two landmarks approximately 90 degrees apart should be used. Landmarks within about 10 degrees of true North should be avoided.

5.5 Point the vane directly toward the first landmark by sighting down the vane to the landmark. Record the data acquisition system output on the calibration form.

5.6 Rotate the vane 180 degrees so it is pointing directly away from the first landmark. Sight down the vane to the landmark. Record the data acquisition system output on the calibration form.

5.7 Repeat Steps 5.5 and 5.6 for the second landmark.

5.8 Check to make sure that the screw securing the alignment collar to the wind sensor is tight. Tighten if necessary, then remove the sensor from the crossarm and perform the bearing torque test.

5.8.1 Small air motions, such as a light breeze or drafts from fans or air conditioning equipment, can bias the torque test. Therefore, the test should be performed in an inside environment such as a monitoring station shelter. During the test make sure that any fans, heaters, or air conditioners are turned off.

5.8.2 Remove the vane from the sensor if necessary. Attach the torque watch or torque gauge to the sensor.
5.8.3 Determine the starting torque of the sensor in both the clockwise and counter-clockwise direction over the entire azimuth of the sensor. Record the maximum starting torque on the calibration form.

5.8.4 If any fans, heaters, or air conditioners were turned off for the torque test, turn them back on.

5.9 Perform the linearity check.

5.9.1 Attach the linearity test fixture to the sensor, and install the sensor in the test stand.

5.9.2 Rotate the vane each 30 degrees clockwise using the detents on the linearity disk. Record the data acquisition system output at each 30 degree interval on the calibration form. Stop when the vane has been rotated through a complete circle.

5.9.3 Rotate the vane each 30 degrees counter-clockwise using the detents on the linearity disk. Record the data acquisition system output at each 30 degree interval on the calibration form. Stop when the vane has been rotated through a complete circle.

5.10 If the wind vane is a 0-360 degree model, rotate the vane until the data logger output reads approximately 350 degrees. Rotate the vane slowly clockwise. The data logger output should switch cleanly from near 360 degrees (±5 degrees) to near 0 degrees (±5 degrees). Rotate the vane counter-clockwise to approximately 10 degrees, then slowly counter-clockwise to 355 degrees. The data logger output should switch cleanly from near 0 degrees (±5 degrees) to near 360 degrees (±5 degrees).

If the wind vane is a 0-540 degree model, rotate the vane until the data logger output reads approximately 510 degrees. Rotate the vane slowly clockwise through 540 degrees. The data logger output should switch cleanly from near 540 degrees (±5 degrees) to near 180 degrees (±5 degrees). Rotate the vane counter-clockwise to approximately 10 degrees, then slowly counter-clockwise to 355 degrees. The data logger output should switch cleanly from near 0 degrees (±5 degrees) to near 360 degrees (±5 degrees).

Record the results of the crossover check on the calibration form.

5.11 After verifying that all data were collected, check that the system performance is within the accuracy limits specified in the project QAPP.
5.12 If all measurements were within the specified accuracy limits, no further tests are required.

5.13 If the sensor failed the calibration check, immediately notify the Field Operations Manager or the Project Manager for further instructions. If it is necessary to calibrate the sensor to bring its response within acceptable limits, re-calibrate the sensor after notifying the Field Operations Manager or the Project Manager. If the sensor is re-calibrated, the calibration tests listed above must be repeated after the adjustment. Calibration procedures are found in Section 6.0.

5.14 If the maximum starting torque is greater than or equal to one-half of the maximum acceptable starting torque, replace the sensor bearings. Perform an as-left bearing torque test and record the results as an as-left calibration check on the calibration form.

5.15 Re-attach the sensor to the crossarm. Check all connections.

5.16 Fill out all heading information on a new calibration form. Make sure that this calibration form is marked “Final”.

5.17 Perform an as-left alignment check following the procedures in Steps 5.5 through 5.7. If necessary, adjust the sensor alignment so that the maximum alignment error is within accuracy limits specified in the project QAPP. Record the results on the “Final” calibration form.

5.18 Sign the calibration forms, enter the calibration check results and ending time (data logger time), plus any comments, on the Station Log form and calibration forms. Leave a copy of the calibration forms on-site.

6.0 Calibration Procedure

Calibration of the wind direction sensor involves making adjustments such that the sensor output is accurate to within specified limits. Normally the only adjustments that will be made include replacing the sensor bearings or re-aligning the sensor.

Do not make any of the adjustments described below until an as-found calibration check has been made.

6.1 Sensor bearings should be replaced following procedures specified in the manufacturer’s instruction or service manual.
6.2 To re-align the sensor, loosen the screw securing the alignment collar to the wind sensor.
Point the wind vane directly toward a landmark and rotate the sensor body until the wind
direction indicated by the data logger matches the true direction toward the landmark.
Tighten the set screw and perform the checks described in Steps 5.5 through 5.7. After
verifying that all data were collected, check that the system performance is within the
accuracy limits specified in the project QAPP.

7.0 Quality Control

7.1 The Field Operations Manager or his designee must review all calibration documentation
for accuracy and completeness. An initial review must be done before the field
technician leaves the site. Final review, including review by the Project Manager or his
designee, must be completed within 10 business days following the calibration.

7.2 Acceptance criteria are provided in the project QAPP.

8.0 Documentation

8.1 One copy of the completed calibration form must be retained at the site.

8.2 A record of the calibration, including the date, the time the sensor is taken off-line (local
standard time), the time the sensor is back on-line (local standard time), and the system
being calibrated must be entered in the Station Log.

9.0 References

Handbook for Air Pollution Measurement Systems Volume IV: Meteorological

United States Environmental Protection Agency (USEPA). 2000. Meteorological
February 2000.
1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to calibrate horizontal wind speed sensors. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1. Field Technician

2.1.1. The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2. The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3. The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2. Field Operations Manager

2.2.1. The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2. The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3. The Field Operations Manager is responsible for the reviewing all documentation related to calibration activities for accuracy and completeness.

2.3. Project Manager

2.3.1. The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2. The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Equipment Required:

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Synchronous motor or anemometer drive
- Digital voltmeter
- Torque watch or torque wheel
- Laptop computer
- Documentation for all calibration standards and equipment showing that they have been calibration-checked against a NIST-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:

- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.

5.0 Calibration Check Procedure

Before starting, set up all equipment and check the wind speed output for proper operation. Make all test measurements through the instrument cables.

5.1. Record the start time of the calibration check (data logger time) in the Station Log and down the data channel. The procedure for "downing" a channel is located in the data logger manufacturer's manual.
5.2. Fill out all heading information on the calibration form.

5.3. Remove the sensor from its mount, if this is necessary to perform the calibration check.

5.4. Check the condition of the sensor. Look for cracked or broken propeller or cups, frayed sensor wiring, or loose sensor connections. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager or the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.

5.5. After performing above initial checks the sensor output must be tested at the levels specified in the project QAPP.

5.6. For each test, rotate the sensor and record the motor output (RPM) and data acquisition system output on the calibration form. Convert the motor output in RPM to the appropriate engineering units using calibration curve information found in the manufacturer’s service manual.

5.7. Perform the bearing torque test.

5.7.1. Loosen the propeller/cup set screws and remove the propeller/cups. Attach the torque watch or torque wheel to the sensor shaft.

5.7.2. Determine the starting torque of the sensor over the entire azimuth of the sensor. Record the maximum starting torque on the calibration form.

5.8. After verifying that all data were collected, check that the system performance is within the accuracy limits specified in the project QAPP.

5.9. If all measurements were within the specified accuracy limits, no further tests are required.

5.10. If the sensor failed the calibration check, immediately notify the Field Operations Manager or the Project Manager for further instructions. If it is necessary to calibrate the sensor to bring its response within acceptable limits, re-calibrate the sensor after notifying the Field Operations Manager or the Project Manager. If the sensor is re-calibrated, the calibration tests listed above must be repeated after the adjustment. Calibration procedures are found in Section 6.0.
5.11. If the maximum starting torque is greater than or equal to 50 percent of the maximum acceptable starting torque, replace the sensor bearings. Perform an as-left bearing torque test and record the results as an as-left calibration check on the calibration form.

5.12. Replace the propeller/cups back on to the shaft. If the sensor uses a propeller, make sure to install the propeller such that the serial number faces away from the sensor.

5.13. Return the system back to sampling ambient conditions. Check all connections, and make sure that the instantaneous data reported by the data logger is reasonable for the current conditions.

5.14. Sign the calibration form, enter the calibration test results and ending time (data logger time), plus any comments, on the Station Log form and calibration form. Leave a copy of the calibration form on-site.

### 6.0 Calibration Procedure

Calibration of the wind speed sensor involves making adjustments such that the sensor output is accurate to within specified limits. Normally the only adjustments that will be made include replacing the sensor bearings or specifying the sensor slope and intercept in the data logger program.

Do not make any of the adjustments described below until an as-found calibration check has been made.

6.1. Sensor bearings should be replaced following procedures specified in the manufacturer’s instruction or service manual.

6.2. The correct sensor slope and intercept values can be found in the manufacturer’s instruction or service manual. These values must be provided to the data logger program by editing the proper program instruction. Normally they are programmed in at the initial installation and do not need to be re-entered unless one type of sensor is replaced with another. Note that changes to the data logger program will result in the loss of all data stored by the logger. Therefore, it is extremely important that all data be downloaded from the logger before making any program changes.

### 7.0 Quality Control

7.1. The Field Operations Manager or his designee must review all calibration documentation for accuracy and completeness. An initial review must be done before the field
7.2. Acceptance criteria are provided in the project QAPP.

8.0 Documentation
8.1. One copy of the completed calibration form must be retained at the site.

8.2. A record of the calibration, including the date, the time the sensor is taken off-line (local standard time), the time the sensor is back on-line (local standard time), and the system being calibrated must be entered in the Station Log.

9.0 References


1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to perform a total solar radiation sensor calibration. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1 Field Technician

2.1.1 The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2 The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3 The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2 Field Operations Manager

2.2.1 The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2 The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3 The Field Operations Manager is responsible for the reviewing all documentation related to calibration activities for accuracy and completeness.

2.3 Project Manager

2.3.1 The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2 The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Required Materials

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Reference digital multi meter or data logger capable of logging and averaging output from the reference pyranometer
- Opaque cover that completely blocks all light from sensor element
- Laptop computer
- Reference pyranometer
- Documentation for all calibration reference standards and reference equipment showing that they have been calibration-checked and certified against a NIST-or WMO-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:
- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.

5.0 Calibration Check Procedure

Before starting, set up all equipment and check the sensor output for proper operation. Make all test measurements through the instrument cables.
5.1 Record the start time of the calibration check (data logger time) in the Station Log and down the data channel. The procedure for "downing" a channel is located in the data logger Manufacturer's Manual.

5.2 Fill out all heading information on the calibration form.

5.3 Check and note the condition of the sensor. Look for scratches on the glass, the condition of the silica gel (for Epply black and white type pyranometers), the black and white surfaces (for Epply black and white type pyranometers), and the level of the instrument. Verify that the sensor is properly grounded. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager and the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.

5.4 After performing the above initial checks the sensor output must be tested. It is important that these tests be made when sky conditions are uniform and relatively cloud-free, and that the output from both the reference sensor and the sensor under test are steady. The tests must be conducted over a full diurnal cycle (from before sunrise to after sunset) if at all possible. If that is not possible, then the tests must be conducted over a period of several hours preceding or following solar noon such that the sensor performance can be evaluated over a range of ambient solar radiation intensities. If it is not possible to test the sensor over a full diurnal cycle the Field Operations Manager or the Project Manager must be immediately notified of, and must approve of, the deviation from the preferred method. The reason for the deviation must be noted on the calibration form.

5.4.1 Determine whether comparisons between the sensor and reference pyranometer will be made using short-term (e.g., 10 minute) or hourly average data. This may depend on how and whether the station data logger is set up to report sub-hourly averages. The preferred method is to perform comparisons between hourly average data.

5.4.2 Set up either the digital multi-meter or reference data logger to collect data from the reference pyranometer over the same averaging period as the station data logger, and synchronize times between the digital multi-meter/reference data logger and the station data logger such that these times match to within one minute or less.

5.4.3 Conduct a zero test using an opaque material to completely cover the sensor dome. This test may be performed as a “spot check” over a test period of at least five
minutes, during which time the data logger output should be stable and vary by no
more than 1 W/m². Notify the Field Operations Manager or the Project Manager
immediately if the output is not stable over the test period, or if the stable output
value is not between -1 W/m² and 1 W/m². Record the station data logger output on
the calibration form.

5.4.4 Collocate the reference pyranometer with the sensor and begin recording sub-hourly
or hourly average data from both the reference pyranometer and the sensor.

5.4.5 Record the sub-hourly or hourly average values from both the reference
pyranometer and sensor on the calibration form.

5.5 After verifying that all data were collected, check that the system is within the accuracy
limits specified in the project QAPP.

5.6 If all measurements were within the specified accuracy limits, no further tests are
required.

5.7 If the sensor failed the calibration check, immediately notify the Field Operations
Manager or the Project Manager for further instructions. If it is necessary to calibrate
the sensor to bring its response within acceptable limits, re-calibrate the sensor after
notifying the Field Operations Manager or the Project Manager. If the sensor is re-
calibrated, the calibration tests listed above must be repeated after the adjustment.
Calibration procedures are found in Section 6.0.

5.8 Return the system back to sampling ambient conditions. Check all connections, and
make sure that the instantaneous data reported by the data logger is reasonable for the
current conditions.

5.9 Sign the calibration form, enter the calibration check results and ending time (data logger
time), plus any comments, on the Station Log form. Leave a copy of the calibration
form on-site.

6.0 Calibration Procedure

Calibration of the solar radiation sensor involves making adjustments such that the sensor output
is accurate to within specified limits. Normally the only adjustment that will be made is
specifying a revised sensor slope and intercept in the data logger program.

Do not make any of the adjustments described below until an as-found calibration check has
been made.
6.1 The correct sensor slope and intercept values can be found in the manufacturer’s most recent calibration certification sheet. These values must be provided to the data logger program by editing the proper program instruction. Normally they are programmed in at the initial installation and do not need to be re-entered unless one type of sensor is replaced with another. Note that changes to the data logger program will result in the loss of all data stored by the logger. Therefore, it is extremely important that all data be downloaded from the logger before making any program changes.

6.2 Following any change to the sensor slope and intercept an as-left calibration check must be performed.

7.0 Quality Control

7.1 The Field Operations Manager or his designee must review all calibration documentation for accuracy and completeness. An initial review must be done before the field technician leaves the site. Final review, including review by the Project Manager or his designee, must be completed within 10 business days following the calibration.

7.2 Acceptance criteria are provided in the project QAPP.

8.0 Documentation

8.1 One copy of the completed calibration form must be retained at the site.

8.2 A record of the calibration, including the date, the time the sensor is taken off-line (local standard time), the time the sensor is back on-line (local standard time), and the system being calibrated must be entered in the Station Log.

9.0 References


1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to perform a temperature sensor calibration. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1 Field Technician

2.1.1 The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2 The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3 The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2 Field Operations Manager

2.2.1 The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2 The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3 The Field Operations Manager is responsible for the reviewing all documentation related to calibration activities for accuracy and completeness.

2.3 Project Manager

2.3.1 The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2 The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Required Materials

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Digital multi-meter
- Laptop computer
- Certified reference temperature device that can be read to an accuracy of 0.02°C or ±0.04°F
- Wide-mouth Thermos bottles (3)
- Source of hot water (~100°F or ~35°C) or an immersion heater
- Ice
- Dry ice or some other substance that can be used to obtain a test temperature below the freezing point
- Protective gloves
- Documentation for all calibration standards and equipment showing that they have been calibration-checked against a NIST-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:
- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.
5.0 Calibration Check Procedure

Before starting the initial calibration, set up all equipment and check the sensor output for proper operation. Make all test measurements through the instrument cables.

5.1 Record the start time of the calibration check (data logger time) in the Station Log and down the data channel. The procedure for "downing" a channel is located in the data logger manufacturer's manual.

5.2 Fill out all heading information on the calibration form.

5.3 Check the condition of the sensor. Check aspirator operation, make sure the aspirators are clear of dirt and debris, and that the aspirator fan is working. Make sure the aspirator is pointed down for vertically-oriented sensors, or pointed north for horizontally-oriented sensors. Check to make sure that the distance between the tip of the temperature probe and the probe shield opening is between about 1.5 inches to 2 inches. Verify that the sensor lead is properly grounded. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager or the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.

5.4 Remove the probes from the aspirator housing and set aside. Temperature probes can be damaged by rough handling (e.g., knocking against another object), so always handle them carefully.

5.5 After performing the above initial checks the temperature probes must be tested at the levels specified in the project QAPP.

5.6 Prepare a temperature bath by adding ice or warm water to the Thermos until the desired bath temperature is obtained. If the QAPP specifies that the one of the calibration points be a temperature below freezing (0 C), prepare the below zero temperature bath by adding dry ice to antifreeze in a Thermos. Be sure to use protective gloves when handling dry ice. If dry ice is not available, antifreeze left exposed to below-zero temperatures can be used.

5.7 Place the temperature probes with the reference temperature device into the temperature bath. It is important that the sensor and the reference device are very close to each other (it may be useful to use a rubber band or tape around the sensors and reference temperature device to keep them as close together as possible) and that they are constantly agitated in the temperature bath. To avoid damage to the sensors, do not
knock the probes into the sides of the Thermos. Avoid dipping the probes too far into the bath; any exposed circuitry, or circuitry enclosed in the plastic sensor housing, must not be allowed to get wet. After the temperature output has stabilized, record the temperature indicated by the temperature reference device and the data acquisition system on the calibration form. If the monitoring system includes vertical temperature difference, record the temperature difference as shown by the data acquisition system.

5.8 Using a clean cloth or paper towel, dry each probe immediately after removing it from the temperature bath; be sure to keep the probes vertical (probe tip downward) until they are thoroughly dry to avoid having water run down onto the probe circuitry. Set each probe aside in a safe place while preparing subsequent temperature baths.

5.9 Repeat Steps 5.6 through 5.8 until the probes have been checked at all required test points.

5.10 If the monitoring system includes vertical temperature difference, remove the lower-level sensor from the last temperature bath, and dry according to Section 5.8. Keep the upper-level sensors in the test bath. Check the sign of the delta-temperature output by the data acquisition system. The sign of the temperature difference should be positive (Note: this assumes that the temperature of the bath that the upper-level sensors are exposed to is warmer than ambient air. If not, the sign of the temperature difference should be negative). Note the results of the delta-temperature test in the Station Log and on the calibration form. If the sign of the temperature difference is negative (or positive if the upper-level sensor bath temperature is cooler than ambient), notify the Field Operations Manager or the Project Manager for further instructions.

5.11 After verifying that all data were collected, check that the system is within the accuracy limits specified in the project QAPP.

5.12 If all measurements were within specification then no further tests are required. If the calibration check shows that the instrument is out of tolerance at any data point, re-verify that the measurements were performed with a well-mixed temperature bath, and that all sensors and the reference temperature device were as close together as possible. When satisfied that the calibration has been performed correctly, record as initial response on the calibration form.

5.13 If one or more probes fails the calibration check, immediately notify the Field Operations Manager or the Project Manager for further instructions. If it is necessary to calibrate the probe(s) to bring its (their) response within acceptable limits, re-calibrate the probe(s) after notifying the Field Operations Manager or the Project Manager. If any
5.14 Return the system back to sampling ambient conditions. Check all connections, and make sure that the instantaneous data reported by the data logger is reasonable for the current conditions.

5.15 Sign the calibration form, enter the calibration check results and ending time (data logger time), plus any comments, on the Station Log form. Leave a copy of the calibration form on-site.

6.0 Calibration Procedure

Calibration of the temperature probes involves making adjustments such that the sensor output is accurate to within specified limits. Normally the only adjustment that will be made is specifying the sensor slope and intercept in the data logger program. In a multi-sensor system, if any single temperature sensor falls far outside a reasonable adjustment range then that sensor should probably be replaced. Temperature differential calculation is a function of how well the individual probes match each other at the specified temperature test ranges. An aberrant sensor can affect the quality of your delta-temperature. It is possible to recalibrate sensors following the procedure below but is not commonly done.

Do not make any of the adjustments described below until an as-found calibration check has been made.

6.1 The sensor slope and intercept is determined by finding the slope and intercept of the line created by plotting the actual temperature measured by the probe as a function of the millivolt output of the probe (this is done using spreadsheet SLOPE and INTERCEPT cell functions). Steps 5.6 through 5.8 should be repeated for a minimum of three temperature points spanning the temperature range of the probe should be used to create a best-fit line. Results of each check should be recorded on the temperature probe calibration form, which will automatically calculate the slope and intercept of each probe tested.

6.2 Once a new slope and intercept is determined, these values must be input to the data logger program by editing the proper program instruction. Note that changes to the data logger program will result in the loss of all data stored by the logger. Therefore, it is extremely important that all data be downloaded from the logger before making any program changes.
7.0 Quality Control

7.1 The Field Operations Manager or his designee must review all calibration documentation for accuracy and completeness. An initial review must be done before the field technician leaves the site. Final review, including review by the Project Manager or his designee, must be completed within 10 business days following the calibration.

7.2 Acceptance criteria are provided in the project QAPP.

8.0 Documentation

8.1 One copy of the completed calibration form must be retained at the site.

8.2 A record of the calibration, including the date, the time the sensor is taken off-line (local standard time), the time the sensor is back on-line (local standard time), and the system being calibrated must be entered in the Station Log.

9.0 References


1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to calibrate a vertical wind speed sensor. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1 Field Technician

2.1.1 The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2 The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3 The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2 Field Operations Manager

2.2.1 The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2 The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3 The Field Operations Manager is responsible for reviewing all documentation related to calibration activities for accuracy and completeness.

2.3 Project Manager

2.3.1 The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2 The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Required Materials

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Synchronous motor or anemometer drive
- Digital voltmeter
- Torque watch or torque wheel
- Laptop computer
- Documentation for all calibration standards and equipment showing that they have been calibration-checked against a NIST-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:

- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.

5.0 Calibration Check Procedure

Before starting, set up all equipment and check the vertical wind speed output for proper operation. If possible, make all test measurements through the instrument cables. If this is not possible, connect the sensor either at the base of the tower or in the shelter or system enclosure at the back of the rack or data logger panel. If the calibration is not done on the tower in situ, verify that the cable resistance is within tolerance.
5.1 Record the start time of the calibration (data logger time) in the Station Log and down the data channel. The procedure for "downing" a channel is located in the data logger Manufacturer's Manual.

5.2 Fill out all heading information on the calibration form.

5.3 Remove the sensor from its mount, if this is necessary to perform the calibration.

5.4 Check the condition of the sensor. Look for cracked or broken propeller, frayed sensor wiring, or loose sensor connections. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager and the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.

5.5 Loosen the propeller set screws and remove the propeller.

5.6 After performing above initial checks the sensor output must be tested at the levels specified in the project QAPP for both clockwise and counter-clockwise rotation.

5.7 For each test, rotate the sensor and record the motor output (RPM) and data acquisition system output on the calibration form. Convert the motor output in RPM to the appropriate engineering units using calibration curve information found in the manufacturer’s service manual.

5.8 Perform the bearing torque test.

5.8.1 Attach the torque watch or torque wheel to the sensor.

5.8.2 Verify the starting torque of the sensor in both the clockwise and counter-clockwise direction over the entire azimuth of the sensor. Record the maximum starting torque on the calibration form.

5.9 After verifying that all data were collected, check that the system is within the accuracy limits specified in the project QAPP.

5.10 If all measurements were within the specified accuracy limits, no further tests are required.

5.11 If the sensor failed the calibration check, immediately notify the Field Operations Manager or the Project Manager for further instructions. If it is necessary to calibrate
the sensor to bring its response within acceptable limits, re-calibrate the sensor after notifying the Field Operations Manager or the Project Manager. If the sensor is re-calibrated, the calibration tests listed above must be repeated after the adjustment. Calibration procedures are found in Section 6.0.

5.12 If the maximum starting torque is greater than or equal to 50 percent of the maximum acceptable starting torque, replace the sensor bearings. Perform an as-left bearing torque test and record the results as an as-left calibration check on the calibration form.

5.13 Replace the propeller back onto the propeller shaft, making sure to install the propeller such that the serial number faces away from the sensor. To test for correct propeller orientation, hold the sensor and blow gently on to the top of the propeller (top being defined as the end of the sensor that faces upward when the sensor is mounted on the tower), and note the sign of the wind speed output. Since this simulates wind flow down toward the ground, the wind speed output should be negative. If it is not, check the sensor wiring or circuit card operation and re-test.

5.14 Return the system back to sampling ambient conditions. Check all connections, and make sure that the instantaneous data reported by the data logger is reasonable for the current conditions.

5.15 Sign the calibration form, enter the calibration results and ending time (data logger time), plus any comments, on the Station Log form and calibration form. Leave a copy of the calibration form on-site.

6.0 Calibration Procedure

Calibration of the vertical wind speed sensor involves making adjustments such that the sensor output is accurate to within specified limits. Normally the only adjustments that will be made include replacing the sensor bearings or specifying the sensor slope and intercept in the data logger program.

Do not make any of the adjustments described below until an as-found calibration check has been made.

6.1 Sensor bearings should be replaced following procedures specified in the manufacturer’s instruction or service manual.

6.2 The correct sensor slope and intercept values can be found in the manufacturer’s instruction or service manual. These values must be provided to the data logger program.
by editing the proper program instruction. Normally they are programmed in at the initial installation and do not need to be re-entered unless one type of sensor is replaced with another. Note that changes to the data logger program will result in the loss of all data stored by the logger. Therefore, it is extremely important that all data be downloaded from the logger before making any program changes.

7.0 Quality Control

7.1 The Field Operations Manager or his designee must review all calibration documentation for accuracy and completeness. An initial review must be done before the field technician leaves the site. Final review, including review by the Project Manager or his designee, must be completed within 10 business days following the calibration.

7.2 Acceptance criteria are provided in the project QAPP.

8.0 Documentation

8.1 One copy of the completed calibration form must be retained at the site.

8.2 A record of the calibration, including the date, the time the sensor is taken off-line (local standard time), the time the sensor is back on-line (local standard time), and the system being calibrated must be entered in the Station Log.

9.0 References


1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to calibrate a digital barometric pressure sensor. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1 Field Technician

2.1.1 The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2 The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3 The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2 Field Operations Manager

2.2.1 The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2 The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3 The Field Operations Manager is responsible for reviewing all documentation related to calibration activities for accuracy and completeness.

2.3 Project Manager

2.3.1 The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2 The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Required Materials

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Laptop computer
- Certified barometric pressure reference
- Documentation for all calibration standards and equipment showing that they have been calibration-checked against a NIST-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:

- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.

5.0 Calibration Check Procedure

5.1 Record the start time of the calibration check (data logger time) in the Station Log and "down" the data channel. The procedure for "downing" a channel is located in the data logger Manufacturer's Manual.

5.2 Fill out all heading information on the calibration form.

5.3 Check the condition of the sensor. Make sure the sensor leads are properly connected, and that the sensor inlet is free of dirt and debris. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager or the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.
5.4 Connect the laptop computer, or other display device, to the data acquisition system so that real-time readings of the sensor output may be obtained.

5.5 Adjust the barometric pressure reference sensor to output pressure in the same units (millibars, inches of mercury, etc.) as the sensor to be calibrated.

5.6 Place the barometric pressure reference sensor near the sensor to be calibrated.

5.7 When the output from the pressure reference sensor and the station sensor are stable, record the pressure from both sensors on the calibration form.

5.8 After verifying that all data were collected, check that the system is within the accuracy limits specified in the project QAPP.

5.9 If the measurement was within the specified accuracy limits, no further tests are required.

5.10 If the sensor fails the calibration check, immediately notify the Field Operations Manager or the Project Manager for further instructions. If it is necessary to calibrate the sensor to bring its response within acceptable limits, re-calibrate the sensor after notifying the Field Operations Manager or the Project Manager. If the sensor is recalibrated, the calibration tests listed above must be repeated after the adjustment. Calibration procedures are found in Section 6.0.

5.11 Return the system back to sampling ambient conditions. Check all connections, and make sure that the instantaneous data reported by the data logger is reasonable for the current conditions.

5.12 Sign the calibration form, enter the calibration check results and ending time (data logger time), plus any comments, on the Station Log form and calibration form. Leave a copy of the calibration form on-site.

6.0 Calibration Procedure

Calibration of the barometric pressure sensor involves making adjustments such that the sensor output is accurate to within specified limits. Assuming the sensor is operating reasonably and near the value posed by the reference sensor, the only adjustments that will be made include a minor change to the multiplier in the data logger program. If the site sensor is badly out of tolerance then the reference sensor should first be checked for reasonableness. If the reference sensor is in certification and correct then the site sensor should be replaced.
7.0 Quality Control

7.1 The Field Operations Manager or his designee must review all calibration documentation for accuracy and completeness. An initial review must be done before the field technician leaves the site. Final review, including review by the Project Manager or his designee, must be completed within 10 business days following the calibration.

7.2 Acceptance criteria are provided in the project QAPP.

8.0 Documentation

8.1 One copy of the completed calibration form must be retained at the site.

8.2 A record of the calibration, including the date, the time the sensor is taken off-line (local standard time), the time the sensor is back on-line (local standard time), and the system being calibrated must be entered in the Station Log.

9.0 References


1.0 Purpose and Applicability

The purpose of this document is to outline the procedures used to calibrate a relative humidity sensor. The purpose of the calibration is to verify that the sensor meets or exceeds EPA ambient monitoring and quality assurance standards.

2.0 Responsibilities

2.1 Field Technician

2.1.1 The field technician is responsible for reading and understanding the appropriate calibration SOPs, calibration forms, and project Quality Assurance Project Plan (QAPP).

2.1.2 The field technician is responsible for performing the calibration according to procedures found in appropriate SOPs, the project QAPP, and applicable USEPA quality assurance guidance documents.

2.1.3 The field technician is responsible for properly documenting the calibration on all project forms, including the Station Log and the appropriate calibration form.

2.2 Field Operations Manager

2.2.1 The Field Operations Manager is responsible for supervising the activities of the Field Technician.

2.2.2 The Field Operations Manager is responsible for ensuring that all necessary calibration equipment is available and properly certified.

2.2.3 The Field Operations Manager is responsible for the reviewing all documentation related to calibration activities for accuracy and completeness.

2.3 Project Manager

2.3.1 The Project Manager is responsible for ensuring that calibrations are performed at the proper frequency.

2.3.2 The Project Manager is responsible for ensuring that all calibration documentation is reviewed in a timely manner, and is accurate and complete.
3.0 Required Materials

- Manufacturer's service manuals and/or operating manuals for the sensor and data logger
- Project QAPP
- Calibration form
- Laptop computer
- Certified relative humidity reference
- Documentation for all calibration standards and equipment showing that they have been calibration-checked against a NIST-traceable reference standard within the previous 12 months.

4.0 Required Calibration Frequency

The sensor must be calibrated in place (if possible) and under the following conditions:

- At installation.
- At least every 6 months after installation.
- Prior to takedown.
- Immediately prior to removal, repair, or replacement of the sensor or any of its components, provided that the sensor is operational.
- Immediately following installation, repair, or replacement of the sensor or any of its components.

5.0 Calibration Check Procedure

5.1 Record the start time of the calibration check (data logger time) in the Station Log and down the data channel. The procedure for "downing" a channel is located in the data logger Manufacturer's Manual.

5.2 Fill out all heading information on the calibration form.

5.3 Check the condition of the sensor. Make sure the sensor leads are properly connected, and that the sensor aspirator is free of dirt and debris. If any problems are found, note them in the Station Log, and then notify the Field Operations Manager or the Project Manager for further instructions. Do not proceed with any further steps until instructed to continue by either the Field Operations Manager or the Project Manager. If no problems are found, proceed with the calibration check.
5.4 Connect the laptop computer, or other display device, to the data acquisition system so that real-time readings of the sensor output may be obtained.

5.5 Place the relative humidity reference sensor near the sensor to be calibrated.

5.6 When the output from the relative humidity reference sensor and the station sensor are stable, record the relative humidity from both sensors on the calibration form.

5.7 After verifying that all data were collected, check that the system is within the accuracy limits specified in the project QAPP.

5.8 If the measurement was within the specified accuracy limits, no further tests are required.

5.9 If the sensor fails the calibration, perform Steps 5.5 through 5.7 again, taking particular care regarding the environmental exposure of both the reference sensor and sensor under test.

5.10 If the sensor again fails the calibration check, immediately notify the Field Operations Manager or the Project Manager for further instructions. If it is necessary to calibrate the sensor to bring its response within acceptable limits, re-calibrate the sensor after notifying the Field Operations Manager or the Project Manager. If the sensor is re-calibrated, the calibration tests listed above must be repeated after the adjustment. Calibration procedures are found in Section 6.0.

5.11 Return the system back to sampling ambient conditions. Check all connections, and make sure that the instantaneous data reported by the data logger is reasonable for the current conditions.

5.12 Sign the calibration form, enter the calibration check results and ending time (data logger time), plus any comments, on the Station Log form and calibration form. Leave a copy of the calibration form on-site.

6.0 Calibration Procedure

Calibration of the relative humidity sensor involves making adjustments such that the sensor output is accurate to within specified limits. Assuming the sensor is operating reasonably and near the value posed by the reference sensor, the only adjustments that will be made include a minor change to the multiplier in the data logger program. If the site sensor is badly out of tolerance then the reference sensor should first be checked for reasonableness. If the reference sensor is in certification and correct then the site sensor should be replaced.
7.0 Quality Control

7.1 The Field Operations Manager or his designee must review all calibration documentation for accuracy and completeness. An initial review must be done before the field technician leaves the site. Final review, including review by the Project Manager or his designee, must be completed within 10 business days following the calibration.

7.2 Acceptance criteria are provided in the project QAPP.

8.0 Documentation

8.1 One copy of the completed calibration form must be retained at the site.

8.2 A record of the calibration, including the date, the time the sensor is taken off-line (local standard time), the time the sensor is back on-line (local standard time), and the system being calibrated must be entered in the Station Log.

9.0 References


1.0 SCOPE AND APPLICABILITY

1.1 This standard operating procedure (SOP) defines the criteria and the process for determining the validity of continuous air measurements data. It is applicable to all validation, regardless of the person or group performing the function.

It is a quality assurance function which requires in its initial stage a person different from the field operator to review blocks of data and the documentation of data collection activities and to accept or reject data based on an established set of criteria. This procedure is based on the EPA Quality Assurance Handbook for Air Pollution Measurement Systems, Volumes I, II, and IV.

1.2 The criteria and methods described in this SOP are applicable in all programs where more stringent criteria or more elaborate methods of data validation are not imposed by a project-specific document such as a Quality Assurance Project Plan (QAPP) or Monitoring Plan. The QAPP/Monitoring Plan will clearly define the project and its measurement quality objectives. Project specific data validation criteria will be derived from the project specific measurement quality objectives and will be detailed in the QAPP/Monitoring Plan.

1.3 Validation of non-continuous particulate data and SODAR data is discussed in separate SOPs.

1.4 Valid Data are those data which are suitable for intended use with respect to the following measurement quality objectives: completeness (data capture or enough time to make a valid hour, month, etc.), representativeness (proper siting, appropriate measurement), accuracy and precision (calibration, instrument performance), comparability (use of standard methods, units, etc.), detection limit (associated with analysis method) and traceability (documented linkage to time and location of measurement, and to authoritative standards).

1.5 Validation is the process of confirming each of the above characteristics by measuring them against the requirements of the project specific measurement quality objectives as defined in the validation criteria detailed in the QAPP/Monitoring Plan. The process includes data reduction, handling, editing, checking, and review,
as well as the review of results from audits and inspections. Representativeness should be confirmed by reviewing the results of an audit of the siting with respect to the approved QAPP/Monitoring Plan.

1.6 Completeness - The absolute minimum portion of an hour that can represent a valid hourly average is 45 minutes for meteorological parameters and for continuous pollutant monitors. Minimum completeness criteria for other averaging periods are listed below:

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<td>6 valid hours</td>
</tr>
<tr>
<td>24-hour</td>
<td>18 valid hours</td>
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2.0 RESPONSIBILITIES

2.1 The on-site technician is responsible for the first phase of data validation, wherein first-hand knowledge of instrument performance to prescribed tolerances is required to determine data quality. Documentation of the operator's data assessment is critical to validation. The operator shall use the criteria presented in AECOM On-site Technician SOPs, the project-specific QAPP/Monitoring Plan, and the instrument manufacturer's documentation.

2.2 The immediate supervisor (supervisor, project manager, project engineer, etc.) is responsible for the second phase of data validation, in which the field documentation and operator data assessment are reviewed to ensure adherence to tolerances and procedures, and to provide the review essential to quality assurance. The extent of this review shall be determined by the contract, but shall assure that the minimum standards described in this procedure are accomplished.

2.3 The project manager is responsible for assigning a qualified individual to perform the validation activities in conformance with this procedure, to the extent defined in the contract and in the QAPP/Monitoring Plan.

3.0 REQUIRED MATERIALS

- AECOM SOP QA-004, Traceability of Standards
- Project-Specific Monitoring Plan or QAPP
- Data Processing Notes and Comments. These should have already been updated as part of daily data downloads and review.
- Corrective Action Request (CAR) forms
Calibration and/or audit reports for any calibrations/audits performed during the month. These reports must identify all test equipment and calibration standards used in the calibration and/or audit by make, model, and serial number, and must provide documentation that all test equipment and calibration standards are traceable to NIST or other authoritative standards.

- Project Notes
- Field documentation such as Station Logs and Station Checklists
- Chain of custody records

4.0 METHOD

4.1 Minimum Data Acceptance Criteria for Air Quality Analyzers

4.1.1 The entire sampling system must be demonstrated to be operating properly. Instruments shall be calibrated according to applicable requirements of AECOM SOPs, the project-specific QAPP/Monitoring Plan, and manufacturer's instruction manuals. Calibration will be verified by reviewing calibration forms.

4.1.2 The data must be bracketed by valid instrument calibration checks. The data shall be reviewed in blocks beginning and ending with a valid calibration check.

4.1.3 The calibrator used (i.e., transfer standard) shall have been calibrated in accordance with AECOM SOP (QA-004, Traceability of Standards) and manufacturer's instruction manuals.

4.1.4 The data must be completely identified with respect to time, site, parameter, scale and units.

4.1.5 The accuracy of the data, as indicated in the beginning and ending calibration check, must be within the accuracy goals stated in the QAPP/Monitoring Plan for the data to be considered valid.

4.1.6 Documentary evidence of the traceability of the data must exist in sufficient detail to substantiate the measurements. The minimum requirements are defined in the QAPP/Monitoring Plan for each project, but usually include the calibration data sheets, the field logs or status/data assessment sheets, and chain-of-custody records, if appropriate.
4.1.7 Data meeting all the criteria (4.1.1-4.1.7) are considered valid.

4.1.8 If any of the information necessary to make the above evaluations is not available, the data shall be considered suspect until further review, comparison or investigation demonstrates that the data are valid or invalid.

4.1.9 Data covered by 4.1.8 shall be considered valid if no conclusive evidence to the contrary can be found.

4.2 Minimum Data Acceptance Criteria for Meteorological Sensors

4.2.1 Meteorological sensors and systems must be demonstrated to be operating properly and be calibrated according to the applicable AECOM SOP and manufacturer's instruction manuals. Calibration will be verified by reviewing calibration forms.

4.2.2 The data must be bracketed by calibration checks or tests which document that the systems are performing within the accuracy tolerances specified in the project's QAPP/Monitoring Plan.

4.2.3 The data must be completely identified with respect to time, site, parameter, scale and units.

4.2.4 The accuracy of the data, as indicated in the beginning and ending calibration check, must be within the accuracy goals stated in the QAPP/Monitoring Plan for the data to be considered valid.

4.2.5 Documentary evidence of the traceability of the data must exist in sufficient detail to substantiate the measurements. The minimum requirements are defined in the QAPP/Monitoring Plan for each project, but usually include the calibration data sheets, the field logs or status/data assessment sheets.

4.2.6 Data which meet the criteria described in Sections 4.2.1 - 4.2.4 are considered valid.

4.2.7 Data for which any information required in 4.2.4 is missing will be considered suspect until further review, investigation or comparison demonstrates that the data are valid or invalid.
4.2.8 Data covered by 4.2.6 shall be considered valid if no conclusive evidence to the contrary can be found.

4.3 Data Correction

4.3.1 In rare circumstances, data may have a known quantifiable bias. They may be corrected only if all of the following conditions are met:

- The bias must have an identifiable cause.
- The bias must have a clearly defined beginning and ending time.
- The data in question must meet the criteria of 4.1.1 - 4.1.4 or 4.2.1-4.2.4.
- The data must be greater than the LDL of the instrument (air quality data only).

Some examples of a quantifiable bias are improper scale factor for data reduction, incorrect analysis of gas cylinder used for calibration, and clearly documented analyzer zero drift.

4.3.2 When any data corrections are made (baseline adjustments or any other justifiable adjustment), all audit, precision and calibration check results, obtained during the period of data adjustments, should also be adjusted by the same amount as the data. This procedure will adjust the audit, precision and calibration check data to accurately reflect the true accuracy of the monitored data residing in the valid data base.

5.0 QUALITY CONTROL

This procedure provides for the validation of air quality and meteorological monitoring data. As such, it is itself a quality control procedure.

6.0 DOCUMENTATION

6.1 The original, unedited data shall remain retrievable following validation, and the rationale and methodology associated with any differences between the original data and the final validated data shall be permanently documented.

6.2 All validated data and associated reports will remain in the project files for a period to be determined on a project-specific basis.

7.0 REFERENCES


1. **Scope and Application**

The following is a guide designed to assist data analysts in evaluating meteorological data collected as part of AECOM’s ambient monitoring programs.

2. **Frequency of Data Evaluation**

Data should be downloaded and evaluated every business day to maintain data integrity and to meet valid data collection requirements.

3. **Data Screening Procedure**

After printing data for the previous day(s), evaluate each parameter to determine whether data values exceed specified limits. If limits stated in the following data screening criteria are exceeded, refer to Section 4.

**Date, Time**

- There should be a data value for every parameter for every period since the last download.

- The data logger date and time should be checked at least once every four weeks, and should be correct to within ±3 minutes Local Standard time. Note that data loggers are **always** set to Local Standard time, **never** Daylight Savings time.

**Wind Speed**

- Wind speed should never be less than 0 m/s.
- Wind speed should never be greater than 20 m/s.
- Wind speed should vary by at least ±0.1 m/s over the course of three consecutive hours.
- Wind speed should vary by at least ±0.5 m/s over the course of 12 consecutive hours.
- The difference between two successive hourly averages should not be greater than ±10 m/s.
Wind Direction

- Wind direction should never be less than 0 degrees.
- Wind direction should never be greater than 360 degrees.
- Wind direction should vary by at least ±1 degree over the course of one hour.
- Wind direction should vary by at least ±10 degrees over the course of 12 consecutive hours.

Sigma-Theta

- Sigma values should never be less than 0 degrees.
- Sigma values should never be greater than 99 degrees.
- Sigma values should only rarely exceed 70 degrees. These extreme values should only occur under light and variable wind conditions.
- Low values of sigma-theta will usually occur with higher wind speeds. Conversely, higher sigma-theta values will usually occur at lower wind speeds.

Vertical Wind Speed

- Vertical wind speed should never be less than -10 m/s.
- Vertical wind speed should never be greater than 10 m/s.
- Vertical wind speed should vary by at least ±0.1 m/s over the course of 12 consecutive hours.
- By convention, vertical wind speed values are always positive for air moving up from the ground, and negative for air moving down toward the ground.

Temperature

- The minimum temperature should not be less than -30°C.
- The maximum temperature should not be greater than 40°C.
- Temperature should vary by at least ±0.1°C over the course of one hour.
• The difference between two successive hourly averages should not exceed ±5°C.

**Temperature Difference (10-2 meter)**

• Should never be greater than 0.1°C/meter during the daytime.
• Should never be less than –0.1°C/meter at night.
• Should never be greater than 5°C or less than –3°C.
• Is usually negative during the day (solar radiation heats the ground, resulting in higher temperatures near the surface) and positive at night.

**Solar Radiation**

• Solar radiation intensity should never be below 0 W/m².
• Solar radiation intensity should never be greater than 1,400 W/m².
• Solar radiation intensity should never be greater than 0 W/m² at night.

**Relative Humidity**

• Relative humidity should never be less than 0%.
• Relative humidity should never be greater than 100%.
• Relative humidity should rarely be less than about 20%.
• Relative humidity is usually higher at night and lower during the day.
• Relative humidity should increase during precipitation events.

**Barometric Pressure**

• Barometric pressure should not be less than 850 mb.
• Barometric pressure should not be greater than 1020 mb.
• Barometric pressure should not vary by more than 6 mb in three hours.
Rain

- Rainfall should never be less than 0 inch.
- Rainfall should not exceed 1 inch over the course of one hour.
- Periods of rainfall should generally coincide with a drop in temperature and high relative humidity.

Battery Voltage

- Battery voltage should vary between 11 V and 15 V.
- If the battery voltage declines steadily over time, there may be a problem with the power supply.
- For Campbell Scientific Data Loggers Only: at battery voltages below 9.6 V or above 18 V, the logger will not operate properly and at least some data channels will be corrupted. Battery voltages outside these limits should be reported to the Project Manager immediately.

4. Data Screening Guide

In the event that one or more of the data screening criteria are violated, the following steps should be followed to determine the validity of the data.

1. Determine whether the data make sense considering the current and past weather conditions. For example, if there are recorded temperatures that are lower than the screening value, but they occur in the middle of January during a record cold snap, then extremely cold temperatures would be expected.

2. Compare the data with an independent data set. For example, the National Weather Service (NWS) posts hourly temperature, pressure, wind speed, and wind direction data on a rolling 24-hour basis for many sites in the U.S. and around the world. These data can be found by going to http://weather.noaa.gov/index.html, and selecting either the State or country that you want data for. Once you do that you will be able to select a weather station. If the monitoring network consists of more than one station, compare data collected at each station to see whether one or more stations are reporting data that is inconsistent with the other stations.
3. Determine whether the questionable data are caused by damaged equipment, for example, a damaged anemometer or wind vane. If so, the Project Manager should be immediately contacted and informed of the problem. Damaged equipment should be noted in the project *Data Processing Notes and Comments* form.

4. Determine whether the questionable data occurred in conjunction with any maintenance, calibration, or audit activities. Data collected during these times should be considered invalid. Maintenance, calibration, or audit activities should be recorded in the project *Data Processing Notes and Comments* form.

5. Determine whether the questionable data occurred in conjunction with a site visit. If so, determine whether activities at the site may have caused erroneous data to be recorded.

6. If the data analyst determines that one or more data values are suspect or invalid, the project data manager or project manager must concur with this judgment before any edits can be made to the project database.

7. If the data analyst is unable to make a definitive determination as to the validity of the data, the Project Manager should be contacted for further instructions.

8. Always record the date, times, and affected parameter of all data that is ultimately determined to be either suspect or invalid, and the reason for considering the data suspect or invalid, on the data printout and in the project *Data Processing Notes and Comments* form. If the data are determined to be invalid due to equipment problems, fill out a *Corrective Action Request (CAR)* form in addition to completing the *Data Processing Notes and Comments* form. Follow the instructions on the *Corrective Action Request (CAR)* form.
Traceability of Standards for Ambient Monitoring

1.0 PURPOSE AND APPLICABILITY

1.1 This Standard Operating Procedure (SOP) presents the standard methods of establishing traceability for calibrations of field sampling, measurement and monitoring instrumentation to National Institute of Standards and Technology (NIST) or other recognized standards. It applies to calibrations throughout AECOM in all of its ambient air quality and air emissions measurements programs.

1.2 Traceability is defined as the documentation that provides a historical record of the relationship of a parameter such as gas concentrations, volume, or temperature to a recognized authoritative standard, as measured by an approved method.

2.0 RESPONSIBILITIES

2.1 It is the responsibility of the individual performing the calibration and/or making the field measurements to do so in accordance with the project-specific Quality Assurance Plan (QAPP), relevant AECOM Standard Operating Procedures, and instrument manufacturers' documentation.

2.2 It is also the responsibility of the practitioner to document the calibration.

2.3 It is the responsibility of the project manager or designee to ensure that all necessary equipment is available and properly certified.

2.4 It is the responsibility of the project manager or designee to ensure that all applicable documentation is reviewed for accuracy and completeness and is reviewed in a timely manner so as to avoid needless loss of data should an error be discovered.

3.0 REQUIRED MATERIALS

Materials specific to the standards at hand are defined in the relevant AECOM monitoring or QA plan, and/or in the manufacturer's documentation. Examples of fundamental calibration standards are listed below.

- Bubble Flow Meter (Hastings HBM-1 or equivalent) (gas volume, flow rate)
- Sealed Piston
• Spirometer (Collins or equivalent) (gas volume, flow rate)
• Wet Test Meter (gas volume, flow rate)
• Mass Flow Meter (flow rate)
• Ozone Primary Standard (V.V. Photometer) (ozone concentration)
• NIST-traceable Thermometer (in applicable ranges) (temperature)
• NIST-traceable variable voltage supply (voltage)

4.0  METHOD

4.1  Gas Cylinders

4.1.1 All gas cylinders used for calibrations or span checks of air monitors should be purchased traceable to NIST by an appropriate accepted procedure. For continuous ambient and emission monitoring programs, the certification should be in accordance with Protocol G1 or G2 as specified in "EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards", EPA-600/R93/224, September 1993.

4.1.2 If enough gas remains in the cylinder following the expiration of the certification, the cylinder should be shipped back to the manufacturer for recertification.

4.1.3 The manufacturer's tag shall remain attached to the cylinder. The information contained on the tag includes manufacturer, cylinder serial number, the protocol used for assay, identification of the Standard Reference Material (SRM) or NTIS Traceable Reference Material (NTRM) against which the concentration has been certified, tank pressure at certification, cylinder concentration, certification date and expiration date (see Table 1).

4.1.4 When the cylinder is received, the gas analysis report which accompanies the cylinder (or follows shortly thereafter by mail) should be retained in the project files. This report includes the same information as the cylinder tag, along with the actual data generated during the current analyses and any previous analyses.

4.1.5 Large gas cylinders (30 - 200 cubic feet) are to be used only when the tank pressure is >200 psi. Cylinders should be returned to the manufacturer for recertification if they contain greater than 750 psi. Similar considerations apply to smaller cylinders, and one detailed in the AECOM monitoring or QA plan and/or in the manufacturer's documentation.
4.2 Ozone Generators and Ozone Analyzer Calibration

4.2.1 Ozone concentrations are elevation-dependent and must be corrected for changes in elevation from the calibration location, if different from the monitoring site, by either 1) internal monitoring of bench temperature and pressure and corresponding adjustment of concentrations within the analyzer or, for analyzers without the ability to perform these internal adjustments, 2) manual temperature and pressure calculation and corresponding adjustments of ozone concentration as follows:

\[
\text{Corrected } O_3 \text{ conc} = (\text{uncorrected } O_3 \text{ conc }) \left( \frac{P_{\text{cal}}}{P_{\text{site}}} \right) \left( \frac{T_{\text{site}}}{T_{\text{cal}}} \right)
\]

4.2.2 Each AECOM laboratory performing ozone verification will maintain or have access to a reference ozone standard. The unit will be set up and maintained as a primary standard according to the method detailed in 40 CFR Part 50 Appendix D, and AECOM SOP 2405.

4.2.3 Ozone generators used as a transfer standard for calibration or audit will be qualified, certified and recertified by direct comparison of the primary and reference photometers two days each quarter following the procedures detailed in “Transfer Standards For The Calibration of Ambient Air Monitoring Analyzers for Ozone, Technical Assistance Document”, EPA-454/B-10-001, November 2010.

4.2.4 Ozone generators which are part of Gas Phase Titration Calibrators must be certified as above if they are to be used to calibrate ozone analyzers.

4.2.5 An instation O_3 calibrator such as an internal generator (TECO 49, Dasibi 1003) or the Monitor Labs 8500 may be used as a span tracking device only and not for calibration of analyzers.

4.3 Flow Standards

All flow meters, flow controllers, dry gas meters, orifices, and rotameters that are used for calibrations or calibration checks shall be calibrated on a quarterly basis, unless project requirements call for more frequent calibrations. Meter boxes such as those used in emissions testing should be calibrated according to the method indicated in paragraph 5.3.1 of 40 CFR 60 Appendix A Method 5. Type S pitot tubes used for determining stack velocity in source testing should be calibrated according to the procedure outlined in Section 4 of 40 CFR 60 Appendix A Method 4.

4.3.1 Flow measurement devices shall be calibrated using one or any combination of the following primary or transfer standards:
• Sealed piston flow meter (volume)
• Bubble meter (volume)
• Spirometer (volume)
• Wet test meter (volume)
• Mass flow meter calibrated to any of the above.

Single-point flow standards (e.g., critical orifice) require calibration at the specific flowrate for which they are to be used as a standard, and are not valid at any other flowrate. Standards that are to serve over a range of flowrates must undergo multipoint calibration.

Multi-point flow calibrations will be performed using at least 3 calibration points. If the calibration is a straight line, 3 points may be adequate. Non-linear calibrations must employ as many points as necessary to obtain a smooth curve. The calibration data should encompass the range over which the flow device will be used. AECOM SOP 2580-001 Flowmeter Calibration may be used as a guide.

4.3.2 Spirometers and wet test meters will be recertified at least annually.

4.3.3 Personal sampling pumps and other flow-regulated sampling devices should be calibrated using bubble meters, calibrated orifices (see Section 4.8.1), or other similar devices before and after each use.

4.4 Time

Stop watches used for calibration should be checked at least semi-annually against the time signals emitted by WWV (shortwave radio broadcasts of NIST time signals).

4.5 Temperature

4.5.1 Thermometers, thermocouples, and other temperature measuring devices will be calibrated traceable to NIST by direct comparison with either an NIST thermometer, or a transfer standard such as electronic transducer thermometer or mercury in glass thermometer.

4.5.2 The precision of the reference standard must be at least twice that of the unit under test (UUT).

4.5.3 Mercury thermometers retain their original calibration unless the mercury separates. This condition requires a new calibration.

4.6 Pressure
Anaeroid barometers, or equivalent, are calibrated annually by the manufacturer.

4.7 Electronic Test Equipment

4.7.1 Digital voltmeters and all other electronic test equipment should be calibrated annually by comparison to an NIST-traceable variable voltage supply.

4.7.2 The vendor should submit, with each calibration, full traceability documentation including standards and methods used, and "as found" and "as left" readings. Vendor documentation should be filed in the project file.

4.8 Hi-Volume Calibrators

4.8.1 Orifices will be calibrated against a positive displacement meter no less than annually, and whenever nicks or dents at the orifice are visible. Copies of orifice calibration documents will be kept with the orifice, and originals will be filed in the project file.

4.8.2 Magnehelic gauges are considered part of a HI-VOL sampling system and do not have a stand-alone calibration. They are, however, calibrated by the manufacturer and guaranteed to be accurate to \( \pm 2\% \) of full scale. They are not interchangeable.

4.9 Portable Gas Dilution Calibrators

4.9.1 Portable gas dilution calibrators shall be calibrated once each quarter in accordance with AECOM SOP 2580-001. In addition, the calibrator must have at least a one-point dynamic check performed for one pollutant test atmosphere prior to field use. The purpose of this check is to verify proper system operation.

4.9.2 Analyzer responses to inputs from the laboratory standard system and the test portable calibrator should agree within \( \pm 3\% \).

4.9.3 If the responses to not agree, the reason for the discrepancy must be identified and rectified before the calibrator may be released for field use.

5.0 PORTABLE DEVICES

5.1 Portable air measurement devices such as handheld Photoionization Detectors (PIDs) or Flame Ionization Detectors (FIDs) and field gas chromatographs should be calibrated in the field prior to use, and periodically during use, employing calibration standards appropriate for the gases or vapors to be detected.
5.2 Field Calibration may be accomplished using appropriate gaseous standards in compressed gas cylinders. Standards may also be prepared by injecting neat solutions into evacuated Tedlar bags and filling the bags with a known volume of analyte-free air.

5.3 Portable particulate monitors may by checked for baseline through the installation of a particulate filter on the sample inlet. Calibration may be checked against an internal optical or electronic span device. Dynamic calibration of these sensors must be accomplished by the vendor or in a controlled environment (wind tunnel).

6.0 QUALITY CONTROL

Completed calibration data sheets are subject to senior review in accordance with AECOM's senior review policy. Calculations, standard conditions, correction factors, project identification, and other data will be reviewed for accuracy, completeness and conformance to AECOM SOP and the project-specific QAPP.

7.0 DOCUMENTATION

Complete calibration traceability records shall be retained in the project file.

8.0 REFERENCES

- 40 CFR Part 50, Appendix D.
- Quality Assurance Handbook for Air Pollution Measurement Systems; (all volumes).
### TABLE 1
NBS STANDARD REFERENCE MATERIALS (SRM)

#### Permeation Tubes

<table>
<thead>
<tr>
<th>SRM</th>
<th>Type</th>
<th>Nominal Perm. Rate ( \mu g/m^3 ) at 25°F C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1625</td>
<td>Sulfur Dioxide</td>
<td>2.8</td>
</tr>
<tr>
<td>1626</td>
<td>Sulfur Dioxide</td>
<td>1.4</td>
</tr>
<tr>
<td>1627</td>
<td>Sulfur Dioxide</td>
<td>0.56</td>
</tr>
<tr>
<td>1629</td>
<td>Nitrogen Dioxide</td>
<td>(0.5 – 1.5)</td>
</tr>
</tbody>
</table>

#### Cylinder Gases

<table>
<thead>
<tr>
<th>SRM</th>
<th>Type</th>
<th>Volume</th>
<th>Nominal Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1683</td>
<td>Nitric Oxide in N(_2)</td>
<td>870 l.</td>
<td>50 ppm</td>
</tr>
<tr>
<td>1684</td>
<td>Nitric Oxide in N(_2)</td>
<td>870 l.</td>
<td>100 ppm</td>
</tr>
<tr>
<td>1685</td>
<td>Nitric Oxide in N(_2)</td>
<td>870 l.</td>
<td>250 ppm</td>
</tr>
<tr>
<td>2613</td>
<td>Carbon Monoxide in Air</td>
<td>870 l.</td>
<td>18 ppm</td>
</tr>
<tr>
<td>2614</td>
<td>Carbon Monoxide in Air</td>
<td>870 l.</td>
<td>42 ppm</td>
</tr>
<tr>
<td>1659</td>
<td>Methane in Air</td>
<td>870 l.</td>
<td>CH(_4), 9.5 ppm</td>
</tr>
<tr>
<td>1666</td>
<td>Propane in Air</td>
<td>870 l.</td>
<td>C(_3)H(_8), 9.5 ppm</td>
</tr>
</tbody>
</table>
Appendix D

Equipment Specifications
CR3000 Micrologger®
A Portable, Rugged, Powerful Data Acquisition System

CAMPBELL SCIENTIFIC, INC.®
WHEN MEASUREMENTS MATTER
CR3000 Micrologger®

The CR3000 Micrologger® is a compact, rugged, powerful datalogger. Housed in a portable, self-contained package, the Micrologger consists of measurement and control electronics, communication ports, keyboard, display, power supply, and carrying handle. The CR3000’s low power requirements allow extended field use from a dc voltage source.

**Features**

- Program execution rate of up to 100 Hz
- 16-bit analog to digital conversions
- 16-bit microcontroller with 32-bit internal CPU architecture
- Temperature compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Gas Discharge Tube (GDT) protected inputs
- Data values stored in tables with a time stamp and record number
- 4 Mbytes data storage memory
- Battery-backed SRAM and clock that ensure data, programs, and accurate time are maintained while the CR3000 is disconnected from its main power source
- Measures SDI-12 or serial sensors with four independent COM ports

**Sensor Connections**

**Analog Inputs:** Twenty-eight single-ended (14 differential) channels measure voltage levels with 16-bit resolution on five software selectable voltage ranges.

**Pulse Counting Channels:** Four 24-bit pulse channels measure switch closures, high frequency pulses, or low-level ac.

**Digital Control Ports:** Eight ports have multiple functions including digital control output, interrupt, pulse counting, switch closure, frequency/period measurements, edge timing, SDI-12 communication, or serial sensor communication at rates up to 115.2 kbps. Three additional ports are dedicated for measuring SDM devices.

**Switched Excitation Outputs:** Four switched voltage and three switched current outputs provide precision excitation for ratiometric sensor/bridge measurements.

**Power Connections:** The continuous 5 V and 12 V terminals are for connecting sensors and non-Campbell Scientific peripherals. Two switched 12 V terminals are program controlled.

**Operation in Harsh Environments**

The standard operating range is -25° to +50°C; an extended range of -40° to +85°C is available. A CR3000 housed in an environmental enclosure with desiccant is protected from humidity and most contaminants.

**Data Storage Capacity**

The CR3000 provides 2 Mbyte of FLASH memory for the Operating System and 4 Mbytes of battery-backed SRAM for CPU usage, program storage, and data storage. Data is stored in a table format. The storage capacity of the CR3000 can be increased by using a CompactFlash® card.

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**Removable Input/Output Connections**—Individually configured for ratiometric resistive bridge, thermocouple, switch closure, high frequency pulse, low-level ac, serial sensors, and more.

**Peripheral Port**—one 40-pin port interfaces with the CFM100 CompactFlash® module, which allows data to be stored on a CompactFlash card.

**Removable Power Terminal**—simplifies connection to external power supply.

**Computer RS-232**—provides a 9-pin electrically isolated DCE port.

**128 x 64 Backlit LCD**—provides a graphical or 8-line numeric display to view labeled real-time and historical data, program instructions, and help menus.

**CS I/O Port**—connects to data transfer and storage peripherals such as phone, RF, short-haul, and multidrop modems.

**Keyboard**—allows on-site program editing and command entries.

**Peripheral Port**—simplifies connection to external power supply.
**Datalogger Programming**

The CR3000 is programmed using the CRBasic language. CRBasic programs can be created using the Short Cut program generator or the CRBasic Editor. Short Cut generates CR3000 programs and wiring diagrams in four easy steps and supports almost all of Campbell Scientific sensors. The CRBasic Editor uses the flexible programming structure of Basic to create more complex CR3000 programs. Short Cut generated programs can be imported into the CRBasic Editor to add instructions, or for functionality not supported by Short Cut. Short Cut and the CRBasic Editor are available in both LoggerNet and PC400 Datalogger Support Software. LoggerNet includes the Transformer application that converts existing CR23X Edlog programs to CR3000 CRBasic programs.

**Communication Protocols**

The CR3000 supports the PakBus® communication protocol. PakBus networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in the case of delivery failure, allows automatic switch over to a configured backup route.

**Communications**

Compatible telecommunication options include Ethernet, phone modems (land-line and cellular), radios, short haul modems, GOES satellite transmitters, and multiplexers. Real-time and historical data can be displayed using the on-board graphical display or a PC. The PC connects to the CR3000 via an RS-232 cable or the CS I/O port and SC32B interface.

Customers can transport programs/data to a PC via CompactFlash® cards. The CFM100 module is used to store the programs/data on the card, and a SanDisk® ImageMate® card reader or CF1 module is used to download the programs/data to the PC.

**Channel Expansion**

**Synchronous Devices for Measurement (SDMs)**

SDMs are addressable peripherals that expand the CR3000’s measurement and control capabilities. For example, SDMs are available to add control ports, analog outputs, pulse count channels, interval timers, or even a CANbus interface to your system. Multiple SDMs can be connected to one CR3000 datalogger on its dedicated SDM ports.

**Multiplexers**

Multiplexers increase the number of analog sensors that can be measured by a CR3000 by sequentially connecting each sensor to the datalogger. Several multiplexers can be controlled by a single CR3000. The CR3000 is compatible with the AM16/32 and AM25T multiplexers.

**Battery Base Options**

The alkaline base option includes 10 D-cell batteries with a 10 Ahr rating at 20°C. The rechargeable base option provides an internal 7 Ahr sealed rechargeable battery that can be trickle-charged via vehicle power, solar panels, or ac power. For charging the battery via ac power, a 110 Vac wall charger is offered for US customers or other countries with 110 Vac outlets. A 100 to 240 Vac wall charger is also available. When using vehicle power, our DCDC18R Boost Regulator is used to increase the vehicle’s supply voltage to charging levels required by the CR3000.

The low-profile (no battery) option requires a user-supplied dc source. It is preferred when the system’s power consumption needs a larger capacity battery or when it’s advantageous to have a thinner, lighter datalogger.

**Applications**

- Eddy covariance systems
- Wireless sensor/datalogger networks
- Mesonet systems
- Wind profiling
- Water quality
- Avalanche forecasting, snow science, polar, high altitude
- Long-term climatological monitoring, meteorological research, routine weather measurement
- Air quality
- Agriculture, agriculture research
- Soil moisture, Time Domain Reflectometry
- Water level/stage
- Vehicle testing
- Aerospace/aviation
- Structural or fatigue analysis

The CR3000 can be used in networks of dataloggers that continuously monitor air quality.
ANALOG INPUTS (SE1-SE28 or DIF1-DIF14)
14 differential (DF) or 28 single-ended (SE) voltage measurements individually configured. Ratiometric resistive bridge, thermocouple, and period average (frequency) measurements also supported on all anal-
log input channels. Channel expansion provided by AM16/32 and AME1/32 multiplexers.

RANGES: RESOLUTION: Basic resolution (Basic Res). Resolution of DF measurements with input reversal is half the Basic Res (17-bits).

Input Range (mV) | DF Res (µV) | Basic Res (µV)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>±5000</td>
<td>83.33</td>
<td>167</td>
</tr>
<tr>
<td>±1000</td>
<td>33.33</td>
<td>66.7</td>
</tr>
<tr>
<td>±200</td>
<td>3.33</td>
<td>1.67</td>
</tr>
<tr>
<td>±50</td>
<td>0.83</td>
<td>0.67</td>
</tr>
<tr>
<td>±20</td>
<td>0.33</td>
<td>0.67</td>
</tr>
</tbody>
</table>

1 Range overhead of ±9% exists on all ranges to guarantee that the full-scale range values will not cause overrange.

2 Resolution of DF measurements with input reversal.

ACCURACY:
±0.04% of reading + offset, 0° to 40°C
±0.07% of reading + offset, -25° to 50°C
±0.09% of reading + offset, -40° to 85°C (-XT only)

3 Accuracy does not include sensor and measurement noise. Offsets are defined as:
Offset for DF w/o input reversal = 1.5 Basic Res + 1.0 µV
Offset for DF w/o input reversal = 3 Basic Res + 2.0 µV
Offset for SE = 3 Basic Res + 5.0 µV

MEASUREMENT SPEED: Time includes 250 µs for conversion to engineering units. For voltage mea-
surements, the CR3000 integrates the input signal.

Integration Settling Measurement Total Time
Type Time Time Standard Input Rev.
250 250 µs 200 µs ±0.7 ms ±1.4 ms
60 Hz filter 16.67 ms ±20 ms ±60 ms
50 Hz filter 20.00 ms 3 ms ±23 ms ±66 ms

INPUT NOISE VOLTAGE: For DF measurements with input reversal on ±20 mV input range; digital resolution dominates for higher ranges.

250 µs Integration: Non-CSI 0.4 µV RMS
50/50 Hz Integration: 0.19 µV RMS

COMMON MODE RANGE: ±5 V
DC COMMON MODE REJECTION: >100 dB
NORMAL MODE REJECTION: 70 dB @ 60 Hz when using 60 Hz rejection

SUSTAINED INPUT VOLTAGE W/O DAMAGE: ±16 VDC max.

INPUT CURRENT: ±1 nA typical, ±6 nA max.

50°C: ±2120 nA @ 85°C

INPUT RESISTANCE: 20 Gohms typical

ACCURACY OF BUILT-IN REFERENCE JUNCTION THERMISTOR (for thermocouple measurements):
±0.3°C, -25° to 50°C
±0.8°C, -40° to 85°C (-XT only)

PERIOD AVERAGE MEASUREMENTS: Any of the 28 SE analog inputs can be used for period aver-
aging. Accuracy is ±0.01% of reading + resolution where resolution is 96 ns divided by the specified number of samples to be measured.

Input Amplitude & Frequency:

Voltage: Gain Code Min (mV) Max (V) Min (µA) Max (μA) Hz
1 mV1000 200 10 2.5 200 100 5 500
5 mV500 20 20 2 50 500 20 2
20 mV50 5 5 10.0 50 5000 20 50 25.0 20

4 Maximum signal must be centered at datalogger ground.

Assuming 50% duty cycle.

ANALOG OUTPUTS (Vxt-Vx4, lx1-lx3, CAO1, CAO2)
4 switched voltage and 3 switched current outputs for ratiometric sensor bridge excitation and 2-switched current outputs. Switched outputs active only during measurement, one at a time.

INPUT STATE: high 3.8 to 5.3 V; low -0.3 to 1.2 V
INPUT HYSTERESIS: 1.4 V
INPUT RESISTANCE: 100 kohms
HIGH FREQUENCY MAX: 400 kHz
SWITCH CLOSURE FREQUENCY MAX: 150 Hz
OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1 V
OUTPUT RESISTANCE: 330 ohms

ADDITIONAL DIGITAL PORTS: SDM-C1, SDM-C2, SDM-C3 are dedicated for measuring SDM devices.

SWITCHED 12 V (SW12V)
Two independent 12 V unregulated sources switched on and off under program control. Thermal fuse hold current = 500 mA @ 20°C, 650 mA @ 50°C, 360 mA @ 85°C.

CE COMPLIANCE
STANDARD(S) TO WHICH CONFORMITY IS
DECLARED: IEC61326-2002

COMMUNICATION
RS-232 PORTS: 9-pin: DCE (electrically isolated) for computer or non-CSI mode connection
COM1 to COM4: Four independent Tx/Rx pairs on control ports (non-isolated)

Baud Rate: Selectable from 300 to 115.2 kbps
Format: 7, 8 data bits; 1, 2 stop bits; odd, even, or no parity

CS I/O PORT: Interface with CSI peripherals.

SDI-12: Digital Control ports 1, 3, 5, and 7 are individually configurable and meet Standard version 1.3 for datalogger mode. Up to ten SDI-12 sensors are supported per port.

SDM PORT: Interface with CSI Synchronous Devices for Measurement

PERIPHERAL PORT: Interface with CFM100 CompactFlash Module

SYSTEM
PROGRAM EXECUTION INTERVALS: 10 ms to 30 min. @ 10 ms increments

PROCESSOR: Renasas H8S 2674 (16-bit CPU with 32-bit internal core)

MEMORY: 2 Mbytes of Flash for operating system; 4 Mbytes of battery-backed SRAM for CPU usage, program storage and data storage

CLOCK ACCURACY: ±3 min. per year

SYSTEM POWER REQUIREMENTS
VOLTAGE: 10 to 16 VDC

TYPICAL CURRENT DRAIN: Sleep Mode: 2 mA
1 Hz Sample Rate (one fast SE meas.): 3 mA
100 Hz Sample Rate (one fast SE meas.): 10 mA
100 Hz Sample Rate (one fast SE meas. w/RS-232 communications): 38 mA

Display on: add 1 mA to current drain
Backlight on: add 42 mA to current drain

INTERNAL BATTERIES: 10 Ahr alkaline or 7 Ahr rechargeable base. 1200 mAhr lithium battery for clock and SRAM backup typically provides 3 years of back-up.

EXTERNAL BATTERIES: 12 VDC nominal; reverse polarity protected.

PHYSICAL SPECIFICATIONS
SIZE: 9.5" x 7.0" x 3.8" (241 x 17.8 x 9.6 cm)
Terminal strips extend 0.875" (2.2 cm) and terminal strip cover extends 1.575" (4.0 cm) above the panel.

WEIGHT: 3.6 lbs (1.6 kg) with low profile base; 8.3 lbs (3.8 kg) with alkaline base; 10.7 lbs (4.8 kg) with rechargeable base

WARRANTY
Three years against defects in materials and workmanship.
RM Young’s Wind Monitors are light-weight instruments that measure wind speed and direction. Their design emphasizes simplicity and lightweight construction. The Wind Monitors are made out of rigid UV-stabilized thermoplastic with stainless steel and anodized aluminum fittings. The thermoplastic material resists corrosion from sea air environments and atmospheric pollutants. The Wind Monitors use stainless steel precision-grade ball bearings for the propeller shaft and vertical shaft bearings. Cabled for use with our dataloggers, the Wind Monitors are compatible with all of our contemporary dataloggers and many of our retired dataloggers (e.g., CR10X, CR510, CR23X).

**Wind Speed**
The wind speed sensor for all the Wind Monitors is a helicoid-shaped, four-blade propeller. Rotation of the propeller produces an ac sine wave that has a frequency directly proportional to wind speed. The ac signal is induced in a transducer coil by a six-pole magnet mounted on the propeller shaft. The coil resides on the non-rotating central portion of the main mounting assembly, eliminating the need for slip rings and brushes.

**Wind Direction**
All of the Wind Monitors use a potentiometer to measure wind direction. The datalogger applies a known precision excitation voltage to the potentiometer element. The output is an analog voltage signal directly proportional to the azimuth angle.

**Model Descriptions**

_05103 Wind Monitor_
The 05103 Wind Monitor is a sturdy instrument for measuring wind speed and direction in harsh environments. Its simplicity and corrosion-resistant construction make it ideal for a wide range of wind measuring applications.

_05103-45 Alpine Wind Monitor_
The 05103-45 Wind Monitor is a rugged instrument designed for harsh alpine conditions. To discourage ice-buildup, the sensor’s housing is black and covered with an ice-resistant coating.
Model Descriptions (continued)

05106 Wind Monitor-MA
The 05106 Wind Monitor-MA is a robust instrument designed for offshore and marine applications. It features waterproof bearing lubricant and a sealed, heavy-duty cable pigtail instead of the standard junction box.

05305 Wind Monitor-AQ
The 05305 Wind Monitor-AQ is a high performance wind speed and direction sensor designed specifically for air quality measurements. It provides a lower starting threshold, faster response, and higher accuracy than the other wind monitors. However, to achieve the superior performance, the 05305 is less ruggedly constructed.

The Wind Monitor-AQ meets or exceeds the requirements published by the following regulatory agencies:

- **U.S. Environmental Protection Agency**—Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) and On-Site Meteorological Instrumentation Requirements to Characterize Diffusion from Point Sources
- **U.S. Nuclear Regulatory Agency**—NRC Regulatory Guide 1.23 Meteorological Programs in Support of Nuclear Power Plants
- **American Nuclear Society**—Standard for Determining Meteorological Information at Nuclear Power Plants

Mounting
The Wind Monitors can be attached to a CM202, CM204, or CM206 crossarm via a 17953 NU-RAIL fitting or CM220 Right Angle Mounting Bracket. Alternatively, the Wind Monitors can be attached to the top of our stainless-steel tripods via the CM216 Sensor Mounting Kit.

Wind Profile Studies
Wind profile studies measure many wind sensors. For these applications, the LLAC4 4-Channel Low Level AC Conversion Module can be used to increase the number of Wind Monitors measured by one datalogger. The LLAC4 allows datalogger control ports to read the wind speed sensor’s ac signals instead of using pulse channels. Dataloggers compatible with the LLAC4 are the CR200(X) series (ac signal ≤1 kHz only), CR800, CR850, CR1000, CR3000, and CR5000.
Ordering Information

<table>
<thead>
<tr>
<th>Wind Monitors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>05103-L</strong></td>
</tr>
<tr>
<td><strong>05103-45-L</strong></td>
</tr>
<tr>
<td><strong>05106-L</strong></td>
</tr>
<tr>
<td><strong>05305-L</strong></td>
</tr>
</tbody>
</table>

**Cable Termination Options (choose one)**

- **PT** Cable terminates in stripped and tinned leads for direct connection to a datalogger's terminals.
- **PW** Cable terminates in connector for attachment to a prewired enclosure.
- **CWS** Cable terminates in a connector for attachment to a CWS900-series interface. Connection to a CWS900-series interface allows this sensor to be used in a wireless sensor network.

<table>
<thead>
<tr>
<th>Mounts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>17953</strong></td>
</tr>
<tr>
<td><strong>CM220</strong></td>
</tr>
<tr>
<td><strong>CM216</strong></td>
</tr>
</tbody>
</table>

**Wind Profile Accessory**

- **LLAC4** 4-Channel Low-Level AC Conversion Module

**Recommended Cable Lengths**

<table>
<thead>
<tr>
<th></th>
<th>CM6</th>
<th>CM106</th>
<th>CM10</th>
<th>CM110</th>
<th>CM115</th>
<th>CM120</th>
<th>UT10</th>
<th>UT20</th>
<th>UT30</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ft</strong></td>
<td>10</td>
<td>13</td>
<td>13</td>
<td>13</td>
<td>19</td>
<td>24</td>
<td>13</td>
<td>24</td>
<td>34</td>
</tr>
</tbody>
</table>

*These cable lengths assume the sensor is mounted atop the tripod/tower via a CM202 crossarm.*
### Specifications

<table>
<thead>
<tr>
<th></th>
<th>05103 Wind Monitor¹</th>
<th>05103-45 Wind Monitor-Alpine¹</th>
<th>05106 Wind Monitor-MA¹</th>
<th>05305 Wind Monitor-AQ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wind Speed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0 to 224 mph (0 to 100 m s⁻¹)</td>
<td>0 to 224 mph (0 to 100 m s⁻¹)</td>
<td>0 to 224 mph (0 to 100 m s⁻¹)</td>
<td>0 to 112 mph (0 to 50 m s⁻¹)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±0.6 mph (±0.3 m s⁻¹) or 1% of reading</td>
<td>±0.6 mph (±0.3 m s⁻¹) or 1% of reading</td>
<td>±0.6 mph (±0.3 m s⁻¹) or 1% of reading</td>
<td>±0.4 mph (±0.2 m s⁻¹) or 1% of reading</td>
</tr>
<tr>
<td>Starting Threshold</td>
<td>2.2 mph (1.0 m s⁻¹)</td>
<td>2.2 mph (1.0 m s⁻¹)</td>
<td>2.4 mph (1.1 m s⁻¹)</td>
<td>0.9 mph (0.4 m s⁻¹)</td>
</tr>
<tr>
<td>Distance Constant (63% recovery)</td>
<td>8.9 ft (2.7 m)</td>
<td>8.9 ft (2.7 m)</td>
<td>8.9 ft (2.7 m)</td>
<td>6.9 ft (2.1 m)</td>
</tr>
<tr>
<td>Output</td>
<td>ac voltage (3 pulses per revolution); 1800 rpm (90 Hz) =19.7 mph (8.8 m s⁻¹)</td>
<td>ac voltage (3 pulses per revolution); 1800 rpm (90 Hz) =19.7 mph (8.8 m s⁻¹)</td>
<td>ac voltage (3 pulses per revolution); 1800 rpm (90 Hz) =19.7 mph (8.8 m s⁻¹)</td>
<td>ac voltage (3 pulses per revolution); 1800 rpm (90 Hz) =20.6 mph (9.2 m s⁻¹)</td>
</tr>
<tr>
<td>Resolution</td>
<td>(0.2192 mph)/(scan rate in seconds) or (0.0980 m s⁻¹)/(scan rate in seconds)</td>
<td>(0.2192 mph)/(scan rate in seconds) or (0.0980 m s⁻¹)/(scan rate in seconds)</td>
<td>(0.2192 mph)/(scan rate in seconds) or (0.0980 m s⁻¹)/(scan rate in seconds)</td>
<td>(0.2290 mph)/(scan rate in seconds) or (0.1024 m s⁻¹)/(scan rate in seconds)</td>
</tr>
<tr>
<td><strong>Wind Direction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>0° to 360° mechanical, 355° electrical (5° open)</td>
<td>0° to 360° mechanical, 355° electrical (5° open)</td>
<td>0° to 360° mechanical, 355° electrical (5° open)</td>
<td>0° to 360° mechanical, 355° electrical (5° open)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±3°</td>
<td>±5°</td>
<td>±3°</td>
<td>±3°</td>
</tr>
<tr>
<td>Starting Threshold @ 10° displacement</td>
<td>2.4 mph (1.1 m s⁻¹)</td>
<td>2.4 mph (1.1 m s⁻¹)</td>
<td>2.4 mph (1.1 m s⁻¹)</td>
<td>1.0 mph (0.5 m s⁻¹)</td>
</tr>
<tr>
<td>Delay Distance (50% recovery)</td>
<td>4.3 ft (1.3 m)</td>
<td>4.3 ft (1.3 m)</td>
<td>4.3 ft (1.3 m)</td>
<td>3.9 ft (1.2 m)</td>
</tr>
<tr>
<td>Damping Ratio</td>
<td>0.3</td>
<td>0.3</td>
<td>0.3</td>
<td>0.45</td>
</tr>
<tr>
<td>Damped Natural Wavelength</td>
<td>24.3 ft (7.4 m)</td>
<td>24.3 ft (7.4 m)</td>
<td>24.3 ft (7.4 m)</td>
<td>16.1 ft (4.9 m)</td>
</tr>
<tr>
<td>Undamped Natural Wavelength</td>
<td>23.6 ft (7.2 m)</td>
<td>23.6 ft (7.2 m)</td>
<td>23.6 ft (7.2 m)</td>
<td>14.4 ft (4.4 m)</td>
</tr>
<tr>
<td>Output</td>
<td>analog dc voltage from potentiometer—resistance 10 kohms; linearity 0.25%; life expectancy 50 million revolutions</td>
<td>analog dc voltage from potentiometer—resistance 10 kohms; linearity 0.25%; life expectancy 50 million revolutions</td>
<td>analog dc voltage from potentiometer—resistance 10 kohms; linearity 0.25%; life expectancy 50 million revolutions</td>
<td>analog dc voltage from potentiometer—resistance 10 kohms; linearity 0.25%; life expectancy 50 million revolutions</td>
</tr>
<tr>
<td>Power</td>
<td>switched excitation voltage supplied by datalogger</td>
<td>switched excitation voltage supplied by datalogger</td>
<td>switched excitation voltage supplied by datalogger</td>
<td>switched excitation voltage supplied by datalogger</td>
</tr>
</tbody>
</table>

¹Manufactured by RM Young (Traverse City, MI) and cabled by Campbell Scientific for use with our dataloggers.

### Physical

<table>
<thead>
<tr>
<th></th>
<th>-50° to +50°C, assuming non-riming conditions</th>
<th>-50° to +50°C, assuming non-riming conditions</th>
<th>-50° to +50°C, assuming non-riming conditions</th>
<th>-50° to +50°C, assuming non-riming conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>14.6 in. (37 cm)</td>
<td>14.6 in. (37 cm)</td>
<td>14.6 in. (37 cm)</td>
<td>15.0 in. (38 cm)</td>
</tr>
<tr>
<td>Overall Height</td>
<td>21.7 in. (55 cm)</td>
<td>21.7 in. (55 cm)</td>
<td>21.7 in. (55 cm)</td>
<td>25.6 in. (65 cm)</td>
</tr>
<tr>
<td>Overall Length</td>
<td>2.0 in. (5 cm)</td>
<td>2.0 in. (5 cm)</td>
<td>2.0 in. (5 cm)</td>
<td>2.0 in. (5 cm)</td>
</tr>
<tr>
<td>Main Housing Diameter</td>
<td>7.1 in. (18 cm)</td>
<td>5.5 in. (14 cm)</td>
<td>7.1 in. (18 cm)</td>
<td>7.9 in. (20 cm)</td>
</tr>
<tr>
<td>Mounting Pipe Diameter</td>
<td>1.34 in. (34 mm) OD; standard 1.0-in. IPS schedule 40</td>
<td>1.34 in. (34 mm) OD; standard 1.0-in. IPS schedule 40</td>
<td>1.34 in. (34 mm) OD; standard 1.0-in. IPS schedule 40</td>
<td>1.34 in. (34 mm) OD; standard 1.0-in. IPS schedule 40</td>
</tr>
<tr>
<td>Weight</td>
<td>3.2 lbs (1.5 kg)</td>
<td>2.2 lbs (1 kg)</td>
<td>3.2 lbs (1.5 kg)</td>
<td>2.5 lbs (1.1 kg)</td>
</tr>
</tbody>
</table>
VERITCAL COMPONENT ANEMOMETER

FEATURES:

- Very Low Threshold
- Fast Response
- Photochopper Detector
- Built-in Signal Conditioning
- Minimal Induced Turbulence
- Optional Heater

Climatronics' Vertical Component Anemometer (P/N 102236) is our latest generation of vertical wind speed sensors. It is an improved product superior in performance and directly interchangeable with our previous versions of component anemometers, P/N 101284 and P/N 101036, both which have been discontinued. Exceptionally low threshold and fast response are achieved through the use of mechanical features found in our proven F460 wind sensors. The anemometer body is slender and aerodynamic to ensure that minimal turbulence is introduced into the measured air stream.

The component anemometer may be supplied with either an expanded polystyrene (EPS) propeller featuring low threshold or a carbon fiber propeller for superior durability. Propeller rotation causes a 3-slot shutter to interrupt a solid-state light source. This pulse signal is processed by an internal signal conditioner which utilizes state-of-the-art surface mount technology.

The sensor produces a dual frequency and linear millivolt DC output. The DC output is identical to the DC generator output of our previous component anemometer (P/N 101284). Both signal outputs allow for full compatibility with Climatronics' and many other signal conditioning and data acquisition products. The component anemometer mates to its mount (P/N 102234) with a weatherproof connector identical to that of the previous component anemometer. The mount features a choice of three standard pipe adapters and includes a shielded signal cable prewired to the mating connector. The cable length may extend upwards of 1,000 ft. with no appreciable loss in signal strength or quality. The component anemometer and its propeller may be supplied with an optional NIST-traceable calibration (P/N 600025). An optional heater (P/N 101238) is available to prevent the build-up of snow and ice.
SPECIFICATIONS

PERFORMANCE
Accuracy ± 1.0% over range
Threshold G0: 0.5 mph (0.22 M/S) Carbon Fiber
G1: 0.3 mph (0.14 m/s) EPS
Distance Constant G0: 6.9 ft (2.1 m) Carbon Fiber
G1: 3.2 ft (1.0 m) EPS
Operating Range G0: ±80 mph (±35 m/s)
G1: ±55 mph (±25 m/s)

ELECTRICAL
Signal Output ±500 mV corresponding to 1800 rpm = 20.00 mph (8.94 m/s)
Analog Frequency 90 Hz corresponding to 1800 rpm = 20.00 mph (8.94 m/s)
Power Requirements 6.0 mA at +12 VDC (±3 Vdc)

PHYSICAL
Height: 30 inches (76.0 cm)
Body Diameter 1 inch (2.54 cm) tapering to 0.375 inch (0.95 cm)
Propeller Diameter: 8 inches (20.3 cm) (Nominal)
Weight: Sensor: <1 lb (0.45 kg)
Mount: 1 lb (0.45 kg)
Mounting: 102234-G0 for 1¼ inch IPS pipe
G1 for 1 inch IPS pipe
G2 for ¾ inch IPS pipe

Climatronics Corporation
140 Wilbur Place
Bohemia, NY 11716-2404
TEL: 631-567-7300
FAX: 631-567-7585
E-Mail: sales@climatronics.com
Rev. 10 Jan 2002
YSI THERMILINEAR® COMPONENT

YSI 44212
RANGE -50 to +50°C

This Thermilinear Thermistor Network is a composite device consisting of resistors and precise thermistors which produce an output voltage linear with temperature, see Fig. 1; or a linear resistance with temperature, see Fig. 2. The thermistor composite (included with the YSI 44212) is the YSI 4420.

Equations which describe the behavior of the device are:

Voltage Mode (Refer to Fig. 1)

For °C: \[ E_{out1} = (±0.00559149 \times E_{in}) \pm 0.004700 \times E_{in} \]

For °F: \[ E_{out1} = (±0.0031638 \times E_{in}) \pm 0.003766 \times E_{in} \]

Resistance Mode (Refer to Fig. 2)

For °C: \[ R_f = (129.1631 \times T) + 15.6959 \times T \]

For °F: \[ R_f = (1.1857 \times T) + 0.50494 \times T \]

Resistors are ±0.1% 25 ppm/°C metal film

(All dimensions are for reference only)

YSI THERMISTOR COMPOSITE 44020

SPECIFICATIONS

Voltage Mode

Thermistor Absolute Accuracy and Interchangeability: ±0.1°C

Linearity (deviation from best straight line): ±0.09°C

Maximum Uncertainty due to ±0.1% Fixed Resistors: ±0.05°C ±50°C

E_{in} Max: 3.5 Volts

R_{f} Max: 700 Ω

Sensitivity: 0.0031059 E_{in}/°C

Time Constant: The time required for the thermistor to indicate 63% of a newly impressed temperature, in well stirred oil, 1 sec; in free still air, 10 sec.

Storage Temperature: 80 to +110°C (-112 to +212°F)

Resistance Mode

Resistance Mode

Thermistor Absolute Accuracy and Interchangeability: ±0.1°C

Linearity (deviation from best straight line): ±0.09°C

Maximum Uncertainty due to ±0.1% Fixed Resistors: ±0.05°C ±50°C

E_{in} Max: 3.5 Volts

R_{f} Max: 700 Ω

Sensitivity: 0.0031059 E_{in}/°C

Time Constant: The time required for the thermistor to indicate 63% of a newly impressed temperature, in well stirred oil, 1 sec; in free still air, 10 sec.

Storage Temperature: 80 to +110°C (-112 to +212°F)

**E_{in} Max** and **R_{f} Max** Definitions:

E_{in} Max and R_{f} Max values have been assigned to control the thermistor self-heating error so they do not enlarge the component error band: i.e., the sum of the linearity deviation plus the thermistor tolerance.

E_{in} Max and R_{f} Max values are assigned using a thermistor dissipation constant of 8 MW/°Cin stirred oil. If better heat-sink methods are used or if an enlargement of the error band is acceptable, E_{in} Max and R_{f} Max values may be exceeded without damage to the thermistor.

U.S. Patent 3316765, Canadian Patent 782790

--------NORMAL LINEARITY DEVIATION

--------- THERMISTOR ACCURACY LIMITS

-------- MAXIMUM ERROR INCLUDING 10.1% RESISTORS

The maximum possible error at any temperature is the sum of the thermistor absolute accuracy, the linearity deviation and the uncertainty due to the ±0.1% fixed resistors. The linearity deviation may be corrected using the above curve. The thermistor uncertainty may be eliminated by using tighter tolerance resistors or by calibrating the readout while substituting precision decade resistors for the thermistor.

---WARNING---

Use heat sinks for small wires when soldering or welding to thermistor leads.

YSI Incorporated
Yellow Springs Instrument Co., Inc.
Yellow Springs, Ohio 45387, 513 767-7241

ITEM 003610 P/N 444532 E Printed in U.S.A.
The Vaisala HUMICAP® Humidity and Temperature Probe HMP155 provides reliable humidity and temperature measurement. It is designed especially for demanding outdoor applications.

Long-term Stability
The HMP155 has the proven Vaisala HUMICAP®180R sensor that has excellent stability and withstands well harsh environments. The probe structure is solid and the sensor is protected by default with a sintered teflon filter, which gives maximum protection against liquid water, dust, and dirt.

Warmed Probe and High Humidity Environment
Measuring humidity reliably is challenging in environments where humidity is near saturation. Measurements may be corrupted by fog, mist, rain, and heavy dew. A wet probe may not give an accurate measurement in the ambient air.

This is an environment to which Vaisala has designed a patented, warmed probe for reliable measuring. As the sensor head is warmed continuously, the humidity level inside it stays below the ambient level. Thus, it also reduces the risk of condensation forming on the probe.

Fast Measurements
With its fast response time, the additional temperature probe for the HMP155 is ideal for measurement in environments with changing temperatures. The new membrane filter speeds up the RH measurement.

Features/Benefits
- Vaisala HUMICAP®180R sensor - superior long-term stability
- Optional warmed humidity probe and chemical purge
- Plug-and-play
- USB connection for service use
- Fits with DTR13 and DTR503 radiation shields and also for a Stevenson screen
- Weather-proof housing IP66
- Optional, fast temperature probe
- Different output possibilities: voltage, RS-485, resistive Pt100
- Applications: meteorology, aviation and road weather, instrumentation

Long Lifetime
Protecting the sensor from scattered and direct solar radiation, and precipitation will increase its lifetime. Thus, Vaisala recommends installing the HMP155 in one of the following radiation shields: DTR503, DTR13, or a Stevenson screen. For the additional temperature probe, an installation kit is available to be used with DTR502 radiation shield.

Easy Maintenance
The probe can be calibrated using a pc with a USB cable, with the push buttons, or with the MI70 indicator.
Technical Data

Performance

**RELATIVE HUMIDITY**

Measurement range: 0 ... 100 %RH

Accuracy (incl. non-linearity, hysteresis and repeatability) at:
- +15 ... +25 °C (+59 ... +77 °F): ±1 %RH (0 ... 90 %RH) ±1.7 %RH (90 ... 100 %RH)
- -20 ... +40 °C (-4 ... 104 °F): ±(1.0 + 0.008 x reading) %RH
- -40 ... -20 °C (-40 ... -4 °F): ±(1.2 + 0.012 x reading) %RH
- +40 ... +60 °C (+104 ... +140 °F): ±(1.2 + 0.012 x reading) %RH
- -60 ... -40 °C (-76 ... -4 °F): ±(1.4 + 0.032 x reading) %RH

Factory calibration uncertainty (+20 °C/+68 °F):
- ±0.6 %RH (0 ... 40 %RH)*
- ±1.0 %RH (40 ... 97 %RH)*

* Defined as ±2 standard deviation limits. Small variations possible, see also calibration certificate.

**MEASUREMENT RANGE**

-80 ... +60 °C (-112 ... +140 °F)

Accuracy with voltage output at:
- -80 ... +20 °C: ±(0.226 - 0.0028 x temperature) °C
- +20 ... +60 °C: ±(0.055 + 0.0057 x temperature) °C

Accuracy over temperature range (opposite)

-80 ... +20 °C: ±(0.176 - 0.0028 x temperature) °C
- +20 ... +60 °C: ±(0.07 + 0.0025 x temperature) °C

**TEMPERATURE SENSOR**

Pt100 RTD Class F0.1 according to IEC 751

**RESISTIVE OUTPUT**

according to IEC 751 1/3 Class B

±(0.1 + 0.00167 x |temperature|)°C

**RS485 OUTPUT**

±(0.176 - 0.0028 x temperature) °C

RS485 output:
- -80 ... +20 °C: ±(0.176 - 0.0028 x temperature) °C
- +20 ... +60 °C: ±(0.07 + 0.0025 x temperature) °C

Accuracy over temperature range (opposite)

Temperature sensor: Pt100 RTD Class F0.1 IEC 60751

**RESPONSE TIME**

Response time with additional temperature probe in 3 m/s air flow:
- 63 %: <20 s
- 90 %: <35 s

**OTHER VARIABLES**

dew point/frost point temperature,
wet bulb temperature, mixing ratio

General

**OPERATING TEMPERATURE RANGE**

-80 ... +60 °C (-112 ... +140 °F)

**STORAGE TEMPERATURE RANGE**

-80 ... +60 °C (-112 ... +140 °F)

**CONNECTION**

8-pin male M12 connector

**CONNECTION CABLES**

3.5, 10, and 30 m

**CABLE MATERIAL**

PUR

**WIRE SIZE**

AWG26

**SERVICE CABLES**

USB connection cable

MI70 connection cable

**ADDITIONAL T PROBE CABLE LENGTH**

2 m

**HOUSING MATERIAL**

PC

**HOUSING CLASSIFICATION**

IP66

**SENSOR PROTECTION**

sintered PTFE

optional membrane filter

**WEIGHT**

86 g

Electromagnetic compatibility: Complies with the EMC standard EN61326-1, Electrical equipment for measurement control and laboratory use - EMC requirement for use in industrial locations

Inputs and Outputs

**OPERATING VOLTAGE**

7 ... 28 VDC*

* Note: minimum operating voltage 12 V with 0 ... 5 V output and 16 V with 0 ... 10 V output, probe heating, chemical purge or XHEAT.

**OUTPUTS**

- Voltage output: 0 ... 1 V, 0 ... 5 V, 0 ... 10 V
- Resitive Pt100 (4-wire connection) RS485

**AVERAGE CURRENT CONSUMPTION**

(+15 VDC, load 100 kOhm)

- 0 ... 1 V output: <3 mA
- 0 ... 10 V output: >0.5 mA
- RS485: <4 mA
- during chemical purge with warmed probe max. 110 mA
- max. 150 mA

**SETTLING TIME AT POWER-UP**

- Voltage output: 2 s
- RS485: 3 s

Dimensions

Dimensions in mm

- 40
- 86
- 267
- 12
- 19
- 24
- 5.5
- 40

Scan the code for more information

www.vaisala.com/requestinfo

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**PTB110 Barometer for Industrial Use**

The Vaisala BAROCAP® Sensor, a silicon capacitive absolute pressure sensor developed by Vaisala for barometric pressure measurement applications. The sensor combines the outstanding elasticity characteristics and mechanical stability of single-crystal silicon with the proven capacitive detection principle.

**Features/Benefits**
- Vaisala BAROCAP® sensor
- Several pressure ranges
- Accuracy ±0.3 hPa at +20 °C
- Long-term stability
- On/off control with external trigger
- Output voltage 0 ... 2.5 or 0 ... 5 VDC
- Current consumption less than 4 mA
- Mountable on a (35 mm wide) DIN rail
- NIST traceable (certificate included)

**PTB110**
The Vaisala BAROCAP® Barometer PTB110 is designed both for accurate barometric pressure measurements at a room temperature and for general environmental pressure monitoring over a wide temperature range.

**Accuracy and stability**
The excellent long-term stability of the barometer minimizes or even removes the need for field adjustment in many applications.

**Applications**
The PTB110 is suitable for a variety of applications, such as environmental pressure monitoring, data buoys, laser interferometers, and in agriculture and hydrology. The compact PTB110 is especially ideal for data logger applications as it has low power consumption. Also an external On/Off control is available. This is practical when the supply of electricity is limited.

**Vaisala BAROCAP® technology**
The PTB110 barometer uses the Vaisala BAROCAP® Sensor, a silicon capacitive absolute pressure sensor developed by Vaisala for barometric pressure measurement applications.
Technical data

### Operating range (1 hPa=1mbar)

<table>
<thead>
<tr>
<th>Pressure ranges</th>
<th>500 ... 1100 hPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>600 ... 1100 hPa</td>
</tr>
<tr>
<td></td>
<td>800 ... 1100 hPa</td>
</tr>
<tr>
<td></td>
<td>800 ... 1060 hPa</td>
</tr>
<tr>
<td></td>
<td>600 ... 1060 hPa</td>
</tr>
</tbody>
</table>

| Temperature range        | -40 ... +60 °C (-40 ... +140 °F) |
| Humidity range           | non-condensing |

### General

- **Supply voltage**: 10 ... 30 VDC
- **Supply voltage control**: with TTL level trigger
- **Supply voltage sensitivity**: negligible
- **Current consumption**: less than 4 mA, less than 1 µA
- **Output voltage**: 0 ... 2.5 VDC, 0 ... 5 VDC
- **Output frequency**: 500 ... 1100 Hz
- **Resolution**: 0.1 hPa
- **Load resistance**: minimum 10 kohm
- **Load capacitance**: maximum 47 nF
- **Settling time**: 1 s to reach full accuracy after power-up
- **Response time**: 500 ms to reach full accuracy after a pressure step
- **Acceleration sensitivity**: negligible
- **Pressure connector**: M5 (10-32) internal thread
- **Pressure fitting**: barbed fitting for 1/8"
- **Minimum pressure limit**: 0 hPa abs
- **Maximum pressure limit**: 2000 hPa abs
- **Electrical connector**: removable connector for 5 wires (AWG 28 ... 16)
- **Terminals**
  - Pin 1: external triggering
  - Pin 2: signal ground
  - Pin 3: supply ground
  - Pin 4: supply voltage
  - Pin 5: signal output
- **Housing material, plastic cover**: ABS/PC blend
- **Housing classification**: IP32
- **Metal mounting plate**: Al
- **Weight**: 90 g
- **Electromagnetic compatibility**: Complies with EMC standard EN 61326-1, Electrical equipment for measurement, control and laboratory use - EMC requirements - for use in industrial locations

### Accuracy

<table>
<thead>
<tr>
<th>Linearity*</th>
<th>±0.25 hPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hysteresis*</td>
<td>±0.03 hPa</td>
</tr>
<tr>
<td>Repeatability*</td>
<td>±0.03 hPa</td>
</tr>
<tr>
<td>Calibration uncertainty**</td>
<td>±0.15 hPa</td>
</tr>
<tr>
<td>Accuracy at +20 °C***</td>
<td>±0.3 hPa</td>
</tr>
</tbody>
</table>

* Defined as ±2 standard deviation limits of end-point non-linearity, hysteresis error or repeatability error.
** Defined as ±2 standard deviation limits of inaccuracy of the working standard including traceability to NIST.
*** Defined as the root sum of the squares (RSS) of end-point non-linearity, hysteresis error, repeatability error and calibration uncertainty at room temperature.

### Dimensions

Dimensions in mm (inches)

BAROCAP® is a registered trademark of Vaisala.
BLACK AND WHITE PYRANOMETER

Model 8-48

The Black & White Pyranometer has a detector consisting of a differential thermopile with the hot-junction receivers blackened and the cold-junction receivers whitened. The receiver is of radial wire-wound plated construction with the black segments coated with a flat black coating and the white with Barium Sulfate. Built-in temperature compensation with thermistor circuitry is incorporated to free the instrument from effects of ambient temperature. A precision ground optical glass hemisphere of Schott glass WG295 uniformly transmits energy from 0.285 to 2.8 µm.

The cast aluminum case carries a circular spirit level and adjustable leveling screws. Also supplied is a desiccator, which can be readily inspected.

A calibration certificate traceable to the World Radiation Reference is included.

SPECIFICATIONS

- Sensitivity: approx. 10 µV/Wm².
- Impedance: approx. 350 Ohms.
- Temperature Dependence: ±1.5% over ambient temperature range -20 to +40°C.
- Linearity: ±1% from 0 to 1400 Wm⁻².
- Response time: 5 seconds (1/e signal).
- Cosine:
  - ±2% from normalization 0-70° zenith angle;
  - ±5% 70-80° zenith angle.
- Mechanical Vibration: tested up to 20 g's without damage.
- Calibration: integrating hemisphere.
- Size: 5.75 inch diameter, 2.75 inches high.
- Weight: 2 pounds.
Appendix E

Independent Auditor Forms and SOPs
## TECHNICAL SYSTEM AUDIT

<table>
<thead>
<tr>
<th>Person(s) conducting Audit</th>
<th>Signature</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Audit Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Station</th>
<th>-client</th>
<th>Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Audit Executive Summary:

<table>
<thead>
<tr>
<th>Notes:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

### 1. Siting and Onsite Setup

#### Site Information
- Station name
- Site Location
- Site Coordinates
- Site Elevation
- Obstructions

#### Tower
- All Met references satisfied:
- 10H rule satisfied
- Tower secure against vibration
- True North Siting

#### Windset Integrity
- True North alignment
- Levelness of instruments
- Minimum wind speed response
- Wiring secure
- Clean and clear of debris
- 10m height confirmed
<table>
<thead>
<tr>
<th><strong>Temperature Sensors</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Clean and clear of debris</td>
<td></td>
</tr>
<tr>
<td>- 2m and 10m height confirmed</td>
<td></td>
</tr>
<tr>
<td>- Secure and wiring secure</td>
<td></td>
</tr>
<tr>
<td>- Fans operational</td>
<td></td>
</tr>
<tr>
<td>- Proper positioning on tower as indicated in siting report</td>
<td></td>
</tr>
<tr>
<td><strong>Solar Radiation Sensor</strong></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>- Clean and clear of debris</td>
<td></td>
</tr>
<tr>
<td>- 1.5m height confirmed</td>
<td></td>
</tr>
<tr>
<td>- wiring secure</td>
<td></td>
</tr>
<tr>
<td>- instrument level</td>
<td></td>
</tr>
<tr>
<td><strong>Datalogger</strong></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>- Review current program:</td>
<td></td>
</tr>
<tr>
<td>- Sampling rate satisfies Met. Guidance and QAPP</td>
<td></td>
</tr>
<tr>
<td>- Current calibration constants applied properly</td>
<td></td>
</tr>
<tr>
<td>- Grounded properly</td>
<td></td>
</tr>
<tr>
<td>- Battery hookup proper and secure</td>
<td></td>
</tr>
<tr>
<td>- Desiccant present and fresh</td>
<td></td>
</tr>
<tr>
<td>- Enclosure clean and free from debris</td>
<td></td>
</tr>
<tr>
<td>- All wiring correct</td>
<td></td>
</tr>
<tr>
<td><strong>Vertical Velocity Anemometer</strong></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>- Vertical alignment</td>
<td></td>
</tr>
<tr>
<td>- Levelness of instrument</td>
<td></td>
</tr>
<tr>
<td>- Wiring secure</td>
<td></td>
</tr>
<tr>
<td>- Clean and clear of debris</td>
<td></td>
</tr>
<tr>
<td>- Datalogger reading fine</td>
<td></td>
</tr>
<tr>
<td>- 10m height confirmed</td>
<td></td>
</tr>
<tr>
<td><strong>Spare Equipment, Project Literature/Reports, Forms storage</strong></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>- Spare equipment stored in proper location</td>
<td></td>
</tr>
<tr>
<td>- Event log in use</td>
<td></td>
</tr>
<tr>
<td>- QAPP and forms in proper folder</td>
<td></td>
</tr>
<tr>
<td>- All reports dated and stored properly</td>
<td></td>
</tr>
<tr>
<td><strong>Communication and Personnel</strong></td>
<td></td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>- Personnel and their tasks clearly defined</td>
<td></td>
</tr>
<tr>
<td>- Onsite Operations Manager</td>
<td></td>
</tr>
<tr>
<td>- Site Technician</td>
<td></td>
</tr>
</tbody>
</table>
## 2. Operational Activities

<table>
<thead>
<tr>
<th>Daily Download</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Conducted properly</td>
<td></td>
</tr>
<tr>
<td>• All days of data stored properly</td>
<td></td>
</tr>
<tr>
<td>• Stored properly and data present in backups</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Weekly Data QA/QC</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Review Weekly Data Analysis QA/QC data for consistency and Level1 checks</td>
<td></td>
</tr>
<tr>
<td>• Review Level 0, 1, and 2 results and methods</td>
<td></td>
</tr>
<tr>
<td>• Verification acceptable?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Onsite Operations Review</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Maintenance and calibrations being performed properly?</td>
<td></td>
</tr>
<tr>
<td>• Data integrity audits effective and performed timely and properly?</td>
<td></td>
</tr>
<tr>
<td>• Data transfer audits performed and acceptable</td>
<td></td>
</tr>
<tr>
<td>• Verification acceptable?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Event Logs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Being kept onsite?</td>
<td></td>
</tr>
<tr>
<td>• All events accounted for and reported in onsite operations reviews?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Corrective Actions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• If corrective actions have been done review the request and response reports and review process, communication, etc.</td>
<td></td>
</tr>
<tr>
<td>• All deficiencies reported have been addressed?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Backup</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Onsite and Offsite data storage proper.</td>
<td></td>
</tr>
<tr>
<td>• All data formats are backed up on the media as specified in the Data management SOP</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Communications</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Timely response to corrective action requests?</td>
<td></td>
</tr>
<tr>
<td>• Training conducted appropriately at project startup?</td>
<td></td>
</tr>
<tr>
<td>Are all parties specified in QAPP to receive reports receiving them timely?</td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Project Manager and Onsite Operator Availability</td>
<td></td>
</tr>
<tr>
<td><strong>Weekly Activities Performance</strong></td>
<td></td>
</tr>
<tr>
<td>- Onsite Operations Review Checklists filled out?</td>
<td></td>
</tr>
<tr>
<td>- Weekly communications between Project Manager and Onsite Coordinator happening?</td>
<td></td>
</tr>
<tr>
<td><strong>Quarterly Review (if available... i.e. not at startup)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Review Quarterly Review Process</strong></td>
<td></td>
</tr>
<tr>
<td>- Maintenance overhaul</td>
<td></td>
</tr>
<tr>
<td>- Calibration checks</td>
<td></td>
</tr>
<tr>
<td>- Quarterly Summary</td>
<td></td>
</tr>
<tr>
<td>- Quarterly Report</td>
<td></td>
</tr>
</tbody>
</table>
Performance System Audit

Person(s) conducting Audit ____________________________ Signature________________
Audit Date __________________________
Station __________________________
Client __________________________
Operator __________________________

Audit Executive Summary:

Notes:

1. Siting and Onsite Setup

<table>
<thead>
<tr>
<th>Site Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Station name</td>
</tr>
<tr>
<td>• Site Location</td>
</tr>
<tr>
<td>• Site Coordinates</td>
</tr>
<tr>
<td>• Site Elevation</td>
</tr>
<tr>
<td>• Obstructions</td>
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</tbody>
</table>

<table>
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<tr>
<th>Datalogger</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Review current program:</td>
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<tr>
<td>• Sampling rate satisfies Met. Guidance and QAPP</td>
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<td>• Current calibration constants applied properly</td>
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<tr>
<td>• Grounded properly</td>
</tr>
<tr>
<td>• Battery hookup proper and secure</td>
</tr>
<tr>
<td>• Enclosure clean and free from debris</td>
</tr>
<tr>
<td>• All wiring correct</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Tower</th>
</tr>
</thead>
<tbody>
<tr>
<td>• All Met references satisfied:</td>
</tr>
<tr>
<td>• 10H rule satisfied</td>
</tr>
<tr>
<td>• Tower secure against vibration</td>
</tr>
<tr>
<td>• True North Siting</td>
</tr>
<tr>
<td><strong>Windset Integrity</strong></td>
</tr>
<tr>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>• True North alignment</td>
</tr>
<tr>
<td>• Levelness of instruments</td>
</tr>
<tr>
<td>• Minimum wind speed response</td>
</tr>
<tr>
<td>• Wiring secure</td>
</tr>
<tr>
<td>• Clean and clear of debris</td>
</tr>
<tr>
<td>• Datalogger reading fine</td>
</tr>
<tr>
<td>• 10m height confirmed</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Temperature Sensors</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clean and clear of debris</td>
<td></td>
</tr>
<tr>
<td>• 2m and 10m height confirmed</td>
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<tr>
<td>• Secure and wiring secure</td>
<td></td>
</tr>
<tr>
<td>• Fans operational</td>
<td></td>
</tr>
<tr>
<td>• Proper positioning on tower as indicated in siting report</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Solar Radiation Sensor</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clean and clear of debris</td>
<td></td>
</tr>
<tr>
<td>• 1.5m height confirmed</td>
<td></td>
</tr>
<tr>
<td>• Wiring secure</td>
<td></td>
</tr>
<tr>
<td>• Instrument level</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Vertical Velocity Anemometer</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Vertical alignment</td>
<td></td>
</tr>
<tr>
<td>• Levelness of instrument</td>
<td></td>
</tr>
<tr>
<td>• Minimum wind speed response</td>
<td></td>
</tr>
<tr>
<td>• Wiring secure</td>
<td></td>
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<tr>
<td>• Clean and clear of debris</td>
<td></td>
</tr>
<tr>
<td>• Datalogger reading fine</td>
<td></td>
</tr>
<tr>
<td>• 10m height confirmed</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Relative Humidity</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Clean and clear of debris</td>
<td></td>
</tr>
</tbody>
</table>
- 2m height confirmed
- Secure and wiring secure
- Proper positioning on tower as indicated in siting report

**INSTRUMENT PERFORMANCE EXAMINATION** – see attached spreadsheet for details

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Instrument</th>
<th>Required System Accuracy</th>
<th>Required Measurement Resolution</th>
<th>Manufacturer Specified Accuracy</th>
<th>Manufacturer Specified Resolution</th>
<th>Audit Findings/Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed (m/s)</td>
<td></td>
<td>±0.2 m/s +5% of observed</td>
<td>0.25 m/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind Direction (° E of N)</td>
<td></td>
<td>±5° includes orientation error</td>
<td>1°</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vertical Wind Speed (m/s)</td>
<td></td>
<td>±0.2 m/s +5% of observed</td>
<td>0.1 m/s</td>
<td></td>
<td></td>
<td></td>
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**Comments**
S/N: S/N: S/N:

Comments

Date:

Start Time: End Time: Cal/Audit: Technician:

Sensors Information

Probe 1 Make: Model: S/N: Height:
Probe 2 Make: Model: S/N: Height:

Calibration equipment Information

Digital thermometre
Make: Model: S/N:
Range: Cal. Date:

Sensors performance

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Probe 1 Average Error
Probe 2 Average Error

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As Found
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Average Temp. Difference

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**Average Error**

**As Found**

**As Left**

**Calibration equipment Information**
- Solar Radiation Standard:
- Make: 
- Model: 
- S/N: 
- Cal. Date:
- Datalogger:
  - Make: 
  - Model: 
  - S/N:
  - Cal. Date:

**Sensor Information**
- Make: 
- Model: 
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- Height:
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| Sensor performance ||
|---------------------|
| Time | BP Standard Output | DAS Output | Error | Criteria | PASS/FAIL |
| Time | mb | mb | mb | mb |
| As Left | As Found |

Average Error: 3

Comments
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**Average Error**

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- Model: [Model]
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- Range: [Range]
- Cal. Date: [Cal. Date]

**Datalogger:**
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- S/N: [S/N]
- Cal. Date: [Cal. Date]

**Comments**
**Sensor Information**

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**Comments**

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Appendix F

Station Siting Memo
Introduction  
The following memo documents the siting plan for the meteorological monitoring station to be installed in the southeastern part of the National Petroleum Reserve, Alaska (NPR-A) near Inigok, Alaska. This area was selected because of the sparsity of data collected in the transition zone between the coastal areas and the Brooks range and the likelihood of oil and gas production in the vicinity of the station in the near future (discussed below).

The BLM's goal is to collect meteorological data with a high degree of versatility and application potential. The Bureau of Land Management (BLM) intends to share the data with other agencies or scientists conducting studies in Northern Alaska that could benefit from this dataset. To this end, it is intended that the dataset will be useful in the following capacities:

- photochemical modeling,
- far field air quality assessment,
- dispersion modeling of potential development in the region including near field impact analyses,
- comparison of real-time data with synthetic Weather Research and Forecasting (WRF) modeled meteorological data being developed for the Bureau of Ocean Energy Management (BOEM),
- biological and ecological studies, and
- climate change analyses.

For the dataset to be used to support modeling analyses the data collected must meet a high data quality standard. This is achieved most simply by requiring data quality adequate for Prevention of Significant Deterioration (PSD) permit applications. The PSD program outlines rigorous data quality standards, including quarterly data completeness of 90%, hourly minimum sampling frequency, and a specific operating range and resolution for each parameter, in addition to a strict QA/QC regime. Meeting these goals will create a complete, quality assured dataset that scientists and researchers may rely on for study basis and quantitative evidence of theories.

Monitoring Purpose  
The NPR-A spans almost 36,000 square miles and is comparable to the size of Indiana, with three very different ecosystems:

1. The coastal plain where ocean/sea ice influences to climate are significant.
2. The foothills of the Brooks Range, where topography dominates the microclimates.
3. The large transition zone between the coastal and continental climate regimes.

It was determined by BLM based on review of the 2013 lease map (Figure 1) that initial oil and gas development in the NPR-A was most likely in the transition zone (area between coastal plain and mountainous foothills) in the area NW of Umiat and SW of Nuiqsut. There are no PSD or similar quality meteorological datasets collected in this area (Figure 2). Reliable, year round data is only
available at three PSD level monitoring stations along the coast, under much different flow regimes. Figure 3 presents the locations of meteorological monitoring locations managed by various organizations (National Climate Data Center, Remote Automated Weather Stations run by the US Forest Service and BLM, etc.) as well as locations of current wellsites. While not of PSD quality, there is a National Weather Service (NWS) observation site with a long period of record in Umiat. The siting of the Umiat monitoring station is farther inland and into the mountainous flow regime of the Brooks Range foothills.

Given the existing monitoring locations it was decided that this study should focus on collecting data representative of the transition zone in the area NW of Umiat and SW of Nuiqsut. The meteorological data collected are intended to support BLM management decisions, and to provide information for the BLM and other agencies with study interest in the NPR-A.

In summary, the purpose of the project is to establish a meteorological monitoring site in a remote location of the southeastern NPR-A (NW of Umiat and SW of Nuiqsut), where future oil and gas development is likely within the near future. The dataset needs to be suitable for supporting air quality impact analyses of potential development activities, as the data quality required for this purpose is the highest of the applications considered. To support this purpose, the data need to be of high quality. PSD QA/QC standards were selected for establishing clear, rigorous quality guidelines.

Data Collection
The following sensors will be installed on the monitoring station:

- Horizontal wind speed and direction at 10m
- Vertical wind speed at 10 m
- Air temperature at 2m and at 10m
- Solar Radiation
- Relative Humidity at 2m
- Barometric Pressure at 2m
- Redundant sensors (to minimize the risk of data losses)

Station Siting
The siting of a meteorological monitoring station is of utmost importance for collecting meaningful data. The site must be representative of the area of interest, away from obstacles and obstructions, and capture dominant wind features. Locating the station so that it can be safely accessed in all seasons is also a critical program design consideration when PSD quality data is required. Given the remoteness of the region of interest, concern regarding site access was a dominant factor in deciding on the best location for the station within in the region of interest. The selected location (Table 1, Figures 4 and 5) has an airstrip and is actively utilized as a research site by BLM and other agencies.

The dominant features for the area are dictated by the coastal/maritime zone to the north and the interior/continental zone to the south. The elevation profile shown in Figure 6 indicates that the station is sited in the transition zone between the coastal plain and the foothills of the Brooks Range.

The parameters most influenced by poor siting are wind speed and wind direction, but temperature and pressure can also be affected by surrounding environmental influences such as nearby trees and buildings. The EPA guidelines on measurement systems for PSD studies direct users to locate monitoring stations at a distance of at least 10x the height of the nearest obstruction from that
obstruction. This wind fetch allows for low-level atmospheric turbulence caused by an obstruction to dissipate before the air mass encounters the station. The site selected meets all of these requirements, as detailed below.

The site maps in Figures 4 and 5 present the proximity of the future monitoring site to existing oil and gas facilities, as well as the landing strip at the Inigok airport. The yellow line on Figure 4 denotes the TransAlaskan Pipeline. The surrounding environment is relatively flat, with the majority of ground cover long grasses and low shrubs (please see Figures 7a through 7d). There is a slight elevation change to the south of the site, but other than three framed structures to the west, is completely unobstructed. The gravel pad was previously constructed on a firm section of the otherwise marshy surroundings, and there is no concern of station displacement due to a soft ground settling over the course time. This site will be representative of a large area 25 miles to the north, west, and east, and 10 miles to the south (due to elevation increase in the foothills of the Brooks Range).

The selected site is suitable for the intended monitoring purpose and given the options is expected to maximize the chances of collecting PSD quality meteorological data under challenging monitoring conditions.

**Table 1. Site Coordinates:**

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<th>Latitude</th>
<th>Longitude</th>
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<tr>
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<td>153.085014° W</td>
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Figure 1: Lease Map
Figure 2: Existing PSD Meteorological Monitoring Stations on the North Slope
Figure 3: Locations of Meteorological Data (part of the Beaufort/Chikchi Seas Mesoscale Meteorology Modeling Study Phase II)

http://mms-meso.gi.alaska.edu/
Figure 4: Site Map (yellow line denotes TransAlaskan Pipeline)
Figure 5: Near-Field Site Map
Figure 6: Elevation Profile
Site Photos

**Figure 7a:** Looking North:

**Figure 7b:** Looking East
Figure 7c: Looking South:

Figure 7d: Looking West:
Appendix G

QAPP Comments and Response to Comments

My cursory review does not imply approval of this Quality Assurance Project Plan (QAPP). The QAPP follows guidelines and meets most requirements for Meteorological Monitoring. However, I noted some discrepancies as outlined below. ADEC would value discussion with AECOM or EPA on any of the comments below.

Siting
Figure 7 Monitoring Site Looking West (page 50) shows some framed-in structures. No distances to the structures are provided. Will these structures be more complete during data collection that they are in photos? The distance between these structures and the meteorological instruments should be checked to ensure they meet the 10X distance as required by EPA-454/R-99-005, February 2000, Meteorological Monitoring Guidance for Regulatory Modeling Applications, Section 3.2.1.1 Wind Speed and Wind Direction, Probe Placement.

Solar Radiation
Recently, ADEC has experienced difficulties approving data collected at meteorological monitoring stations due to solar radiation calibration or audit discrepancies. There are discrepancies in this QAPP that should be addressed before data collection begins.

There are conflicts in the stated standard for solar radiation calibrations/audits. First it should be noted that calibrations for solar radiation instruments cannot be completed in the field – only field comparisons can be done in the field. For calibrations/audits the instruments should be returned to the manufacturer.

Second, the QAPP contains conflicting guidance. Section B.7 states:
For solar radiation sensor, failure to pass a calibration check performed when there is insufficient sunlight, less than 250 W/m², to accurately perform the calibration check will not result in data invalidation unless a subsequent calibration check performed under more favorable conditions confirms the failure.

Footnote 2 of Table 12, Data Validation Table: Meteorological calibration and Audit Criteria states:
“The AECOM SOP for the solar radiation calibration deviates from the procedure prescribed in EPA-454/B-08-002. For the solar radiation sensor, failure to pass a calibration check when there is insufficient sunlight, less than 250 W/m², to accurately perform the check will not result in data invalidation unless a subsequent calibration or audit check performed under more favorable conditions confirms the failure.”

Table 12, Data Validation Table: Meteorological calibration and Audit Criteria Acceptable Accuracy column, Total Solar line, states “Accuracy: ±5% of observed when actual conditions are ≥200W/m², ±10% of observed otherwise.”

There are 2 problems here: First, the difference of 200W/m² in some areas and 250W/m² in others. Second the statement in Table 12, Acceptable Accuracy column is not correct – it should be state: “Accuracy: ±5% of observed when actual conditions are ≥200W/m², ±10W/m² of observed otherwise.” Emphasis added.

On a previous occasion, EPA informed ADEC that solar radiation sensors must be within ±5% of the audited value when insolation is greater than or equal to 200 watts per square meter (W/m²). When insolation is less than 200W/m², the sensors must be within ±10 W/m². EPA intends to adopt this change in their guidance documents, as does the Department

Reports
Section D.3. states that if project objectives are not being met, the AECOM project manager will make a reassessment of the QAPP. There is no procedure to notify BLM. Should this be included?
From: **Wong, Herman** &lt;Wong.Herman@epa.gov&gt;  
Date: Mon, Nov 25, 2013 at 6:27 AM  
Subject:  
To: "Peck, Kenneth (Alan)" &lt;kpeck@blm.gov&gt;  
Cc: "michael.gravier@alaska.gov" &lt;michael.gravier@alaska.gov&gt;  

Alan:  

My comments.  

1. Section A.4: add Startup and Shutdown audit.  
2. Section A.5: third paragraph, the 90% should have a time scale (e.g., monthly, every 3 months...etc.)  
3. Table 2: Audit line, Approximate Date/Due Date column, add “shutdown.”  
4. Table 9: should include data screening consistent with Table 8.4 as well as historical minimum and maximum, and data invariability for all meteorological variables.  
5. Table 9: should include delta-T data screening.  
6. Unclear where spare parts, SOP document, log book and related document will be kept.  
7. Will 1-minute data be collected?  
8. Will there be a redundant set of all sensors? Didn’t see such wording in my scan.  
9. A web cam may be useful to identify problems at the monitoring station.  
10. Will there be a security fence surrounding the monitoring station?  

I would also suggest that you be at the monitoring site during installation and audit to observe, participate and take pictures.  

**Herman Wong**
Regional Atmospheric Scientist/Modeler

U.S. Environmental Protection Agency, Region 10

OEA-095

1200 Sixth Ave, Suite 900

Seattle, WA 98101

206.553.4878

wong.herman@epa.gov
The following are combined BLM comments on the Inigok QAPP:

Please add page numbers throughout the whole document.

Page 1: Add a signature line indicating EPA approval.

The final version of the Siting Memo and Project Plan should be relied on for revision of the QAPP section A. Based on QAPP existing text I would also suggest the following for section A, page 8:

Page 8, sec A.5, para. 3, sent. 2: replace “...there exists no station” with there exists no PSD level station

Page 8, sec A.5, para. 3, sent.3: replace “…of potential future pollutant monitoring sites” with “…of potential future meteorological monitoring and pollutant monitoring sites”

Page 8, sec A.5, para. 5, sent. 1: Cite the AQ MOU or use the complete title.

Page 8, sec A.6, para. 1, sent. 1: Should the date be February or changed to March 1?

Page 8, sec A.6, para. 1, sent. 6: Add location distance from Nuiqsut and Umiat

Page 12, sec. B.1.2, Land Cover, para. 1: Add additional land cover information from:


From page 103, Soil IQ6 description of principle components in the Arctic Coastal Plain. Vegetative cover includes sedge tussocks, grasses, low shrubs, forbs, mosses, and lichens typically over a thick mat of partially decomposed organic matter and underlain by shallow permafrost.

Page 12, sec. B.1.2, Meteorological Monitoring Tower Siting, para. 2, last sent: remove the words “nearby trees: since this is a tundra site.

Clarification needed: How will the Met Tower be attached to the container? Page 13 mentions the tower will be anchored to the conex container, and the container on pipe racks. With the installation being set for winter, will the entire area be shoveled free of snow prior to site installation? Will the Met Tower be on top or to the side of the conex container and could this become a hassle for access during wintertime snow drifts if the depth becomes high enough?

Clarification needed: Page 15 Sec B.7 has a mention of new calibration needed if a sensor fails for 3 days. Does this mean AECOM will fly to the site if a sensor fails or just switch over the the duplicate sensor? If both sensors fail will AECOM fly up to the site for an emergency visit?

Clarification needed: Will the duplicate sensors be located directly next to the priority sensors and if so, will the wind vanes interfere depending on wind direction? (Page 17)
Page 23, sec D.3, para. 2, sent. 1: add the following to the end of the sentence: “make a reassessment of the QAPP, and propose any necessary changes to the BLM for agency approval.”

Please make sure that BLM is kept abreast on all impacts to the project, including but not limited to impacts to data capture, data quality, changes to instruments or other changes to the QAPP.

Page 26, Table 1: please add Dave Maxwell and Alan Peck to the key individuals and responsibilities.

Page 27, Table 2: Clarify that the auditor will not perform site maintenance and that AECOM will be there each visit.

Page 27, Are site checks the same as site visits? Or will the inspections be data interrogation via computers and satellite?

Page 29, Table 4: in the cells under “How Provided to BLM” that contain the words “Upon Request” replace with “Provided on an annual basis”.

Page 29, Corrective Action Requests are provided to the BLM “upon request.” Would like to have these attached to a quarterly report for additional information on how AECOM solved flagged data.

Page 46, Figure 1: Replace the Project Org Chart on page 46 in the QAPP with the revised one (including legend) from the Final Project Plan document.

Unknown page number, Appendix C SOP, sec 3.2.8: Remove this section precipitation will not be collected.

Any precip mentioned should be taken out as this will not be recorded.

Unknown page numbers, Appendix C SOP: Remove ambient air quality sampling references.

Section 3 under Data Screening Procedure has triggers that are to be reviewed with things that will be very common in NPR (ie., min temperatures, high wind speeds, rapid change in barometric pressure, high precip levels) does AECOM want to adjust these, these could be a daily flag in data during winter months.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~

EPA (Herman Wong) comments.

1. Section A.4: add Startup and Shutdown audit.
2. Section A.5: third paragraph, the 90% should have a time scale (e.g., monthly, every 3 months...etc.)
3. Table 2: Audit line, Approximate Date/Due Date column, add “shutdown.”
4. Table 9: should include data screening consistent with Table 8.4 as well as historical minimum and maximum, and data invariability for all meteorological variables.
5. Table 9: should include delta-T data screening.
6. Unclear where spare parts, SOP document, log book and related document will be kept.
7. Will 1-minute data be collected?
8. Will there be a redundant set of all sensors? Didn’t see such wording in my scan.
9. A web cam may be useful to identify problems at the monitoring station.
10. Will there be a security fence surrounding the monitoring station?

I would also suggest that you be at the monitoring site during installation and audit to observe, participate and take pictures.

I read DEC’s comments and agreed with them.
<table>
<thead>
<tr>
<th>Comment Number</th>
<th>Agency</th>
<th>Reviewer</th>
<th>Comment</th>
<th>Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BLM</td>
<td></td>
<td>Please add page numbers throughout the whole document</td>
<td>Page numbers added to main document. No page numbers are used in appendices.</td>
</tr>
<tr>
<td>2</td>
<td>BLM</td>
<td></td>
<td>Page 1: Add a signature line indicating EPA approval</td>
<td>Signature line added.</td>
</tr>
<tr>
<td>3</td>
<td>BLM</td>
<td></td>
<td>Page 8, sec A.5, para. 3, sent: 2: replace &quot;...there exists no station&quot; with there exists no PSD level station&quot;</td>
<td>Phrasing revised.</td>
</tr>
<tr>
<td>4</td>
<td>BLM</td>
<td></td>
<td>Page 8, sec A.5, para. 3, sent:3: replace &quot;...of potential future pollutant monitoring sites&quot; with &quot;...of potential future meteorological monitoring and pollutant monitoring sites&quot;</td>
<td>Phrasing revised.</td>
</tr>
<tr>
<td>5</td>
<td>BLM</td>
<td></td>
<td>Page 8, sec A.5, para. 5, sent: 1: Cite the AQ MOU or use the complete title.</td>
<td>Citation added.</td>
</tr>
<tr>
<td>6</td>
<td>BLM</td>
<td></td>
<td>Page 8, sec A.6, para. 1, sent: 1: Should the date be February or changed to March 1?</td>
<td>Changed to March 1.</td>
</tr>
<tr>
<td>7</td>
<td>BLM</td>
<td></td>
<td>Page 8, sec A.6, para. 1, sent: 6: Add location distance from Nuiqsut and Umiat</td>
<td>Information added.</td>
</tr>
<tr>
<td>8</td>
<td>BLM</td>
<td></td>
<td>Page 12, sec. B.1.2, Land Cover, para. 1: add additional land cover information from: Rieger, Samuel; Schoepflin, Dale B.; Furbush, Clarence E. 1979. Exploratory soil survey of Alaska. USDA Soil Conservation Service. 213 pp. From page 103, Soil IQ6 description of principle components in the Arctic Coastal Plain. Vegetative cover includes sedges tussocks, grasses, low shrubs, forbs, mosses, and lichens typically over a thick mat of partially decomposed organic matter and underlain by shallow permafrost.</td>
<td>Text from pg 103 paragraph two has been added.</td>
</tr>
<tr>
<td>9</td>
<td>BLM</td>
<td></td>
<td>Page 12, sec. B.1.2. Meteorological Monitoring Tower Siting, para. 2, last sent: remove the words &quot;nearby trees: since this is a tundra site.&quot;</td>
<td>General phrase associated with QAPP template, leave as is.</td>
</tr>
<tr>
<td>10</td>
<td>BLM</td>
<td></td>
<td>Clarification needed: How will the Met Tower be attached to the container? Page 13 mentions the tower will be anchored to the conex container, and the container on pipe racks. With the installation being set for winter, will the entire area be shoveled free of snow prior to site installation? Will the Met Tower be on top of or to the side of the conex container and could this become a hassle for access during wintertime snow drifts if the depth becomes high enough?</td>
<td>Information added.</td>
</tr>
<tr>
<td>11</td>
<td>BLM</td>
<td></td>
<td>Clarification needed: Page 15 Sec B.7 has a mention of new calibration needed if a sensor fails for 3 days. Does this mean AECOM will fly to the site if a sensor fails or just switch over the the duplicate sensor? If both sensors fail will AECOM fly up to the site for an emergency visit?</td>
<td>If a primary sensor fails, data from the secondary sensor will be used until operations have resumed at the primary sensor. AECOM has taken one emergency trip to the station into account in the project budget. Additional trips will be discussed with the BLM as an out-of-scope action. This is viewed as a project management issue.</td>
</tr>
<tr>
<td>12</td>
<td>BLM</td>
<td></td>
<td>Clarification needed: Will the duplicate sensors be located directly next to the priority sensors and if so, will the wind vanes interfere depending on wind direction? (Page 17)</td>
<td>Horizontal redundant wind vane will be separated from the primary sensor by 6 ft on booms. Special consideration will be taken when positioning the conex, attached tower, and boom on site to avoid interference from dominant bi-modal wind directions.</td>
</tr>
<tr>
<td>13</td>
<td>BLM</td>
<td></td>
<td>Page 23, sec D.3, para. 2, sent: 1: add the following to the end of the sentence: &quot;make a reassessment of the QAPP, and propose any necessary changes to the BLM for agency approval.&quot;</td>
<td>Phrasing revised.</td>
</tr>
<tr>
<td>14</td>
<td>BLM</td>
<td></td>
<td>Please make sure that BLM is kept abreast on all impacts to the project, including but not limited to impacts to data capture, data quality, changes to instruments or other changes to the QAPP.</td>
<td>BLM will be kept abreast of all project related issues.</td>
</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Section A.4.4: add Startup and Shutdown audit</td>
<td>Text added to A.4.4.</td>
<td></td>
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</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Section A.5: third paragraph, the 90% should have a time scale (e.g., monthly, every 3 months,...etc.)</td>
<td>Quarterly - text added to section A.5 paragraph 3.</td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Table 2: Audit line, Approximate Date/Due Date column, add &quot;shutdown.&quot;</td>
<td>Text added to Table 2.</td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Table 9: should include data screening consistent with Table 8.4 as well as historical minimum and maximum, and data invariability for all meteorological variables.</td>
<td>Data screening is manual and site-specific. Data analysts use knowledge of site climatology and professional judgement. Violations of data screening criteria often do not indicate data validation issues; rather they are used to identify data points that potentially deserve additional scrutiny. Following standard QA/QC theory data is assumed valid if all QC checks indicate instruments are performing within tolerance unless a defensible reason for invalidating questionable values can be identified.</td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Table 9: should include delta-T data screening.</td>
<td>Data screening is manual and site-specific. Data analysts use knowledge of site climatology and professional judgement.</td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Unclear where spare parts, SOP document, log book and related document will be kept.</td>
<td>SOP documentation, log book, and related documentation will be kept on-site in the Conex shelter. Please see section B.6.3.</td>
<td></td>
</tr>
<tr>
<td>EPA</td>
<td>Herman Wong</td>
<td>Will 1-minute data be collected?</td>
<td>No. Hourly and 5-minute data are being collected. Hourly averages will be downloaded reviewed daily, 5 minute averages will be downloaded periodically and not reviewed unless further investigation is warranted.</td>
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</tr>
<tr>
<td>8</td>
<td>EPA</td>
<td>Herman Wong</td>
<td>Will there be a redundant set of all sensors? Didn’t see such wording in my scan.</td>
<td>Please see section B.1.1.</td>
</tr>
<tr>
<td>9</td>
<td>EPA</td>
<td>Herman Wong</td>
<td>A web cam may be useful to identify problems at the monitoring station</td>
<td>No plan for webcam at this site, data validation and review will be used to detect station issues.</td>
</tr>
<tr>
<td>10</td>
<td>EPA</td>
<td>Herman Wong</td>
<td>Will there be a security fence surrounding the monitoring station?</td>
<td>No fence is planned, general access is restricted by remote location of site. Shelter will be off the ground to protect permafrost as well as discourage animals from climbing</td>
</tr>
<tr>
<td>11</td>
<td>EPA</td>
<td>Herman Wong</td>
<td>I would also suggest that you be at the monitoring site during installation and audit to observe, participate and take pictures.</td>
<td>BLM field office staff will be included on audit trips as possible, based on seat availability on charter flights.</td>
</tr>
<tr>
<td>1</td>
<td>ADEC</td>
<td>Figure 7 Monitoring Site Looking West (page50) shows some framed-in structures. No distances to the structures are provided. Will these structures be more complete during data collection that they are in photos? The distance between these structures and the meteorological instruments should be checked to ensure they meet the 10X distance as required by EPA-454/R-99-005, February 2000, Meteorological Monitoring Guidance for Regulatory Modeling Applications, Section 3.2.1.1 Wind Speed and Wind Direction, Probe Placement.</td>
<td>These structures have been abandoned, there is no intended future use. The limited surface area of the framed structures is not expected to negatively impact the meteorological monitoring station.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>ADEC</td>
<td>There are conflicts in the stated standard for solar radiation calibrations/audits. First it should be noted that calibrations for solar radiation instruments cannot be completed in the field – only field comparisons can be done in the field. For calibrations/audits the instruments should be returned to the manufacturer.</td>
<td>Clarification added to Section B.7.</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>ADEC</td>
<td>Second, the QAPP contains conflicting guidance. Section B.7 states: For solar radiation sensor, failure to pass a calibration check performed when there is insufficient sunlight, less than 250 W/m², to accurately perform the calibration check will not result in data invalidation unless a subsequent calibration check performed under more favorable conditions confirms the failure.”</td>
<td>This has been changed to 200 W/m² in section B.7.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>ADEC</td>
<td>Foot note 2 of Table 12, Data Validation Table: Meteorological calibration and Audit Criteria states: “The AECOM SOP for the solar radiation calibration deviates from the procedure prescribed in EPA-454/B-08-002. For the solar radiation sensor, failure to pass a calibration check when there is insufficient sunlight, less than 250 W/m², to accurately perform the check will not result in data invalidation unless a subsequent calibration or audit check performed under more favorable conditions confirms the failure.”</td>
<td>250 W/m² has been changed to 200 W/m²</td>
<td></td>
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</tbody>
</table>
Table 12, Data Validation Table: Meteorological calibration and Audit Criteria

<table>
<thead>
<tr>
<th>ADEC</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADEC</td>
<td>Table 12, Data Validation Table: Meteorological calibration and Audit Criteria Acceptable Accuracy column, Total Solar line, states “Accuracy: ±5% of observed when actual conditions are ≥200W/m², ±10% of observed otherwise.” There are 2 problems here: First, the difference of 200W/m² in some areas and 250W/m² in others. Second the statement in Table 12, Acceptable Accuracy column is not correct – it should be state: “Accuracy: ±5% of observed when actual conditions are ≥200W/m², ±10W/m² of observed otherwise.” Emphasis added. On a previous occasion, EPA informed ADEC that solar radiation sensors must be within ±5% of the audited value when insolation is greater than or equal to 200 watts per square meter (W/m²). When insolation is less than 200W/m², the sensors must be within ±10 W/m². EPA intends to adopt this change in their guidance documents, as does the Department</td>
<td>changed to W/m²</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>ADEC</td>
<td>Section D.3. states that if project objectives are not being met, the AECOM project manager will make a reassessment of the QAPP. There is no procedure to notify BLM. Should this be included?</td>
<td>Section D.3 has been revised with a statement regarding BLM approval for any QAPP changes.</td>
</tr>
</tbody>
</table>
Alan,

All the changes I suggested have been incorporated. DEC does not need to be a signatory on this QAPP.

Thanks, and Happy New Year,

Mike

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Hi Mike,

Below is a follow up with the Inigok met station QAPP conference call. Please see the attachments and let me know if you feel the responses and changes are adequate or that additional revisions are needed. Also, you are currently not on the approval signatory page, but can be added if you think appropriate for DEC.

Thanks again for all time you have spent on this!

Alan
Alan and Dave,

Attached is the final draft QAPP for your approval. BLM’s approval of this deliverable can be indicated by signing the signature page and returning a digital copy of the signed pages to us. We have included additional signatories beyond yourselves on the QAPP to facilitate BLM’s internal processes including collaboration with the EPA. While we would prefer to have a completed signature page, the only signatures we are considering critical from a deliverable approval standpoint are yourselves as the PM and COR for the project.

To facilitate your review we have prepared a response to comments document to communicate how we addressed each concern raised during the comment period. While all of the comments and changes were fairly straightforward, if you find you wish to discuss further any of our responses or edits let me know and we can set up a conference call.

I also need to alert you to one unrequested change we have made to the QAPP and to the project team. We have adjusted the organization chart and related text to account for Vince Scheetz’s announcement this week that he is retiring at the end of this calendar year. We expected this transition to occur at some point in the anticipated lifespan of the project and that was one reason for Tom Damiana’s inclusion on the project team in the role of technical advisor. While we will certainly miss Vince, I expect the transition of the project director role to Tom Damiana to go very smoothly. Please let me know if you have any concerns with how we have elected to adjust the project team in response to this situation.

Happy Holidays!
R10 has received AECOM's responses to our comments on the QAPP for a proposed meteorological monitoring station in the Nuiqsut area. Should the collected hourly meteorological data be used in an ambient air quality impact analysis as part of a federal requirement that involves EPA, R10 will review the hourly measurements, independent audit reports, and monthly, quarterly and/or annual reports for consistency with federal regulations, guidance and standards.

Thanks,

Herman Wong
Regional Atmospheric Scientist/Modeler
U.S. Environmental Protection Agency, Region 10
OEA-095
1200 Sixth Ave, Suite 900
Seattle, WA 98101
206.553.4858
wong.herman@epa.gov