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NORTH CAROLINA
Environmental Quality

DAQ-07-009.2 Standard Operating Procedure (SOP)
DAQ-07-009.3 SOP
Eppley CUV-5 Ultra-Violet (UV) Sensor Operator and Coordinator Responsibilities

Revision 0.0
Effective Date: May 24, 2021

1.0 Approval Sign Off-Sheet

I certify that I have read and approve of the contents of the Solar Radiation Standard Operating Procedure with an effective date of May 24th, 2021.

Director, Air Quality Division

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Disclaimer: This document, and any revision hereto, is intended solely as a reference guide to assist individuals in the operation of the instrument, related to the North Carolina Division of Air Quality's (DAQ) Ambient Monitoring Program.

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2.0 SCOPE AND PURPOSE

While outside entities such as the National Weather Service can provide atmospheric data across the state, there are many instances where knowing the exact conditions of the environment around a site is beneficial to interpreting pollutants. Meteorological data can influence the behavior of pollutants in the atmosphere. It can also be invaluable to determining the impact of commercial activity in the area that can help DAQ determine if regulatory action is required.

The SOP for the Eppley Model TUVR Radiometer Ultraviolet (UV) Sensor is for supporting the collection of meteorological data and is required by the United States Environmental Protection Agency's (EPA) Photochemical Assessment Monitoring Station (PAMS) monitoring program (updated in 40 Code of Federal Regulations, Part 58 Appendix D, Section 5.0). The purpose of this document is to provide guidance to the operators and coordinators responsible for the UV Radiation Sensor operation and Level-1/Level-2 data review.

Only UV Radiation is applicable to this SOP. Wind Speed, Wind Direction, Temperature, Relative Humidity, Barometric Pressure, Solar Radiation, and Mixing Height are dealt with in separate SOPs. Any records generated by the Operator will be reviewed and verified by the Regional Ambient Monitoring Coordinator (RAMC). The Raleigh Central Office (RCO) Chemist validates routine and associated Quality Control data monthly. The block of data generated by an individual monitor in one month is defined as the data set. Monthly review has proven to be the most efficient period for these verification and validation activities.

3.0 EQUIPMENT CHECKS AND MATERIALS

The Eppley Total Ultraviolet Radiometer uses a selenium barrier-layer photoelectric cell in a sealed-in quartz window to convert UV radiation into an electrical signal. The unit employs a bandpass filter to restrict the response of the photocell to the desired wavelength range of 295-385 nanometers (nm). A virgin Teflon™ diffusing disk is used to reduce the light intensity at the filtered photocell, allowing for increased stability with exposure time. The filter is shaped to allow the unit to also more closely adhere to the Lambert cosine law by uniformly diffusing light intensity evenly over the entire wavelength range and geometrically within the photoelectric cell. Incoming UV light, at the proper wavelengths, strikes the photoelectric cell and generates an electric current proportional to the relative intensity of the incoming light. The terminals of the photocell are connected through a potentiometer and the signal can be measured as a voltage drop across this resistance. The photoelectric cell is mounted in a painted brass tube with a desiccator installed in the base of the tube opposite the connector. The unit has a built in spirit level to aid in installation of the sensor.

3.1 Equipment and Material List

Eppley Model TUVR Radiometer Specifications

Application	Network Measurements
Traceability	National Institute of Standards and Technology
Spectral Range	295-385 nm
Output	0-10 millivolts (mV) analog
Sensitivity	approx. 150 microvolts per Watts per meter squared (µV / Wm-2)
Impedance	approx. 1,500 ohms (Ω)
95% Response Time	1 second
Non-Stability	5%
Non-Linearity	2%
Directional Response	5 watts per square meter (Wm-2)
Operating Temperature	-50 degrees Celsius (°C) to +80°C
Temperature Response	0.3% per/°C
Calibration Uncertainty	< 5%
Measurement Uncertainty	
Single Point	< 5 Wm-2
Hourly Average	approx. 5%
Daily Average	approx. 3%

4.0 SITE CHECKS

The site operator shall, when visiting the site for regular gaseous monitor operations, check that the Meteorological parameters, including UV Radiation, are communicating values to the Envidas site computer. On a daily basis, both the site operator and the RAMC shall check that the instrument has reported hourly values for UV Radiation.

4.1 Visual Inspection

While on site, the site operator or RAMC should visually inspect that the unit is undamaged and still securely fastened to the shelter's roof or railing. The Operator should also take note of any other environmental factors that could impact the quality of data at the site such as dust on the sensor and relative cloud cover impacting UV intensity. Should there be any obstruction on the lens, the operator should clean it (see section 5.1), otherwise any irregularities should be reported to the Electronics and Calibration Branch (ECB).

4.2 Operational Spot Checks

While not required, it is encouraged that the site operator or RAMC use weather events as opportunities when possible as an operational spot check. Should an event such as a clear, cloudless period of time or a full or partial solar eclipse occur, the site operator or RAMC reviewers should check the data collected by the instrument for corresponding readings the next day. If the instrument fails to show readings that logically match the weather event that occurred, the site operator reviewer should contact the ECB.

Note: While clouds generally decrease UV radiation, UV radiation can penetrate through thin clouds, and can still generate high levels of UV at ground level on overcast days. Patchy clouds can also intensify UV levels because radiation is reflected off the clouds' edge. Thick and dark clouds that produce heavy rain typically decrease UV radiation the most. Use caution when judging this sensor's functionality based on clouds and rain.

5.0 DETAILED PROCEDURES

Due to the nature of the Eppley Model TUVR, there is no regular maintenance for either the operator or RAMC to perform. The radiometer has no moving parts or pieces that can be manipulated or changed. Meteorological parameters are unique in their collection; unlike the criteria pollutants there are not daily precision zero span checks for site operators to use to check the validity of the data. The radiometer shall be covered and the output checked for "zeroing" but relative intensity cannot be tested by DAQ staff outside of the ECB.

The instrument will be formally audited every 6 months by ECB personnel. When precision and bias data are available, the precision and bias of the instrumentation shall be reviewed by the RAMC on a monthly basis. Should the site operator or RAMC believe that the Radiometer is not functioning properly, the ECB should be contacted to request an unscheduled audit.

5.1 Debris and Obstructions impacting the Eppley Model TUVR

Anything that blocks the signal path above the sensor will degrade the measurement. If the path is blocked sufficiently, measurements cannot be made. Dust, fallen vegetation, and animal waste from birds are common natural events that can diminish the path. Readings that are impacted by one of these events should be null coded back to the point that reasonable measurements were made.

If an operator observes that the sensor's Teflon lens has been covered by debris, the operator should lightly clean the lens with a clean, soft, and lint-free cloth or a cotton tipped swab. ***DO NOT apply pressure*** to the lens when cleaning. Should this fail to remove the debris from the lens, contact ECB.

If an operator observes anything above the sensor, the operator should attempt to remove whatever is blocking the area above the sensor if it can be done safely and without disrupting data collection. If it cannot, contact ECB to remove the obstruction.

6.0 DATA REVIEW

6.1 Logbook Submittal

The Elog, or Electronic Logbook, serves as the Transfer Record and Document for evaluating the Success/Failure of the operation of the Meteorological monitoring site and is the essential record for determining the quality of the meteorological data reported from each site.

1. The **Site Operator** must complete the Meteorological Elog to document the purpose of Every site visit, the observations and findings during the site visit, and the evaluation of the performance of the meteorological monitoring system for each site visit. This includes any and all startups and shutdowns (including severe weather events, temperature extremes, and etc.). The Site Operator must initial and date the last time the Elog was altered.
2. The Site Operator must submit the Elog to the RAMC or Designee for review and comment as soon as reasonably possible after the site visit and at a minimum by the end of each month. Additionally, a Site logbook page should be annotated with any site visit; i.e. shutting down for approaching weather, start-ups and shut downs, and etc. Each site visit should provide an Elog and an entry in the Site logbook stating, at a minimum, a purpose for the visit.
3. The **RAMC** or Designee must review site operator monthly submitted Elogs for each site in their region and evaluate each Elog for completeness and operator adherence to operating procedures. Following that review the RAMC must Initial and submit each logbook to the RCO Chemist for review.
4. The **RCO Chemist** must review the logbooks submitted for completeness and adherence to operating procedures. The RCO Chemist must also review the logbook submitted from each site and from all regions to determine if there is a systemic problem or pattern of operation that may be negatively impacting the overall operation of the metrological monitoring network and the quality of the metrological data reported.

6.2 Data Retrieval and End Processing

Every business day, the RCO statistician initiates a data review for the previous day by providing a raw data report (in a spreadsheet format) to each Regional Office (RO) (Reference DAQ-15-006.5 Data Validation SOP for Continuous Gaseous and Meteorological Monitors for details on data validation). The RCO may request the RO to send additional data that are needed beyond what the RCO requires for verifying any missing data supplied by the RO. These data can be retrieved from the site computer.

7.0 FILE MANAGEMENT

Site operators must have a personal computer (PC) (or laptop) to generate the e-log files from a Microsoft Excel template file. These Elogs are provided by the RCO and updated periodically. The file naming protocol is provided below. A formalized file naming convention has been established and should be used by all operators

7.1 File Naming Convention

The Elog template file used at the site should be stored on the PC used for field operations by the field technician. Elogs can also be found in DAQ's Internet Based Enterprise Application Management (IBEAM) system. To access this file, open the Elog template file using Excel. Every time a new Elog is filled out using the template, it must be renamed and saved as a separate and complete workbook (all sheets, i.e., tabs, saved) to preserve the record. Do NOT copy over a previously completed Elog.

NOTE: Refer to the Logbook file naming convention "Policy Memorandum" dated January 1, 2011 located in the DAQ IBEAM module (summarized below).

Renaming and Saving the Elog

1. Open the Elog workbook template file using Excel.
2. Left click the "file" toolbar icon. Scroll down to "save as" and left click.
3. Under file name change workbook file name using the following format: Site ID Met Date Activity. For example, MQ Met 20120730 SV.xlsx is a Site Visit at Millbrook on July 30, 2012
4. Change save location to operator's choice of folders (example: previously created folder named Met).
5. Left click "save".
6. Find the tab needed for the task involved. The first tab selected should be the Logbook. Fill in information as indicated.
7. Open other tabs as needed and fill in information as indicated.
8. Save the workbook when finished entering data.

8.0 Quality Assurance & Data Handling

All site files, Elogs or other supporting documents generated in the field will be stored on dedicated server space in the RO in a folder named for the official site operation files. These files should be transferred to the Official File on a frequent and regular schedule as established by the Region. This is necessary to prevent the potential loss of such files from the field computer and to maintain a "paper trail" for providing defensible data. This also makes the data easily and readily available for review by the RAMC and transfer to the P: drive for review by the RCO. The files on the site/operator PC can be copied and transferred to the common hard drive via email or flash drive for storage in the official file folder.

The site files should be transferred every three business days and backed up monthly. This serves as a backup system in the event the official PC fails or is removed, or the site files are damaged. These files will be retained for a minimum of five years. When the need arises to review a file for data validation or site operations, the official folder is used or a hardcopy is created from this file. For details on data validation procedures, please reference DAQ-15-006.5 Data Validation SOP for Continuous Gaseous and Meteorological Monitors. The following validation checks shall be completed every month:

1. Providing proper null codes indicating calibrations, audits etc.
2. Providing missing valid data.
3. Documenting any invalid data as to reason with proper null code.
4. Identifying any data that may be associated with exceptional events.

All data within the DAQ data set must meet the following conventions:

- All data must be reported in Eastern Standard Time year-around.
- Hourly data are reported at the start of the hour (1:00-1:59 is time stamped as 01:00)
- All missing or invalid data must be accounted for by the use of proper null codes. The null codes must be accompanied by the identifying reasons for the missing or invalid data on the monthly data verification and validation pages.
- All data, including any supporting documentation, must be kept for a minimum of three calendar years after the calendar year in which it was collected. Exceptions to this are discussed elsewhere in this SOP.
- Completeness - Data are considered complete if 75 percent or more of the total possible number of observations are present. Continuous measurement criteria for completeness are listed below:
    - 75 percent of the minutes in the hour must be valid; and
    - 75 percent of the hours in a quarter must be valid.

8.1 Monthly Verification and Validation

Preliminary verification is completed by the RO Operator. The operator must account for and identify the reasons for missing or invalid data within Envista using proper flags and null codes while performing maintenance or shortly thereafter. The operator must review the previous month of data and add any flags or void codes to the Status column as necessary. For each changed status, a comment must be entered with a description of why the status was changed.

The RAMC will perform the second level review of the month of data, adding any additional void codes and comments, and requesting additional information from the operator, as necessary. If required, the RO

Coordinator can send data back to the RO Operator for additional comments or to correct any codes. When possible the data will be verified within 15 workdays from the end of the collection month.

The RCO Chemist performs the final validation of the one-month period of data. Void codes and comments should all be added, and the RCO Chemist can send the data back to the previous reviewer. Final validation of the data should be completed within 30 days of the end of the collection month. Once the data has been approved and has had the "final validation" label applied by the RCO Chemist, it is automatically entered into a queue within Envista ARM. The Database Manager will send all approved data to AQS automatically on a regularly scheduled basis.

In some cases, "valid" data that are judged to be out of the ordinary are retained and an outlier or validated data flag is added in AQS by the RCO. An example would be high or low values resulting from an event that is not observed by another nearby site.

A list of Null Codes that are routinely used during data validation on the AQS monthly summary report are listed in the following table.

Table 1: Commonly Used EPA-AQS Null Value Codes (partial list)

AN	Machine or Equipment Malfunction
AS	Poor Quality Assurance Results
AV	Power Failure
BA	Maintenance and Routine Repairs
BJ	Operator Error
BK	Site Computer/Data Logger Down

8.2 Common Meteorological Trends

The Site Operator, RAMC, and RCO Chemist should use other metrological instrumentation at the site (such as the AIO2) and look for the following trends:

- **Solar Radiation vs. UV:** When Solar Radiation readings are high, UV radiation readings should also be high because UV radiation makes up approximately 8 percent of solar radiation. However, low solar radiation readings don't necessarily correlate to low UV radiation readings because UV radiation can penetrate through certain types of cloud cover that may block the other portions of solar radiation.

While cloud cover and rain can affect UV readings, they are not a predictable or accurate indicator on how UV readings will react or to the degree to which it will react (See the Note in section 4.2).

9.0 REVISION HISTORY

The following revisions were made:

1. This is a new SOP

10.0 REFERENCES

1. See “Eppley Model TUVR Sensor Instruction Manual Rev. 2008“