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DAQ-07-009.1 Standard Operating Procedure (SOP) Ultraviolet Radiation Sensor ECB RESPONSIBILITIES

Revision 0



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1.0 Approval Sign Off-Sheet

I certify that I have read and approve of the contents of the DAQ-07-009.1 Standard Operating Procedures for Ultraviolet Radiation Sensor ECB Responsibilities with an effective date of March 2, 2022.

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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 Ambient Monitoring Program.

SOP Acronym Glossary

| | |
|---|---|
| ADQ - Audit of data quality | PM – Particulate matter |
| AQS - Air Quality System (EPA's Air database) | PPB – Projects and Procedures Branch |
| °C – Degrees Celsius | QA – Quality assurance |
| CFR – Code of Federal Regulations | QA/QC - Quality assurance/quality control |
| Chief – Ambient Monitoring Section chief | QAPP - Quality assurance project plan |
| DAQ - North Carolina Division of Air Quality | QC – Quality control |
| DAS – Data acquisition system | RCO – Raleigh central office |
| DEQ – North Carolina Department of Environmental Quality | RS-232 – Recommended Standard 232 |
| Director – Division of Air Quality Director | SOP - Standard operating procedure |
| ECB – Electronics and Calibration Branch | TSA - Technical systems audit |
| e-log – electronic logbook | TUVR – Total ultraviolet radiation |
| EPA – United States Environmental Protection Agency | USB – Universal Serial Bus |
| FEM – Federal equivalent method | μV – microvolts |
| FRM – Federal reference method | μV / Wm ⁻² – microvolts per watts per meter squared |
| MDL – Method detection limit | UV – Ultraviolet |
| mV - millivolts | V - Volt |
| nm – nanometer | Wm ⁻² – watts per meter squared |
| Ω – ohms | % - percent |

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2.0 SCOPE AND PURPOSE

The purpose of this document is to describe the procedures that should be employed, at a minimum, by Electronic and Calibration Branch (ECB) staff and site operators for the acceptance testing, deployment in the field, regular maintenance, and performance auditing of the Eppley Model TUVR Radiometer ultraviolet (UV) Sensor.

3.0 EQUIPMENT SELECTION

The Eppley Total Ultraviolet Radiometer utilizes a selenium barrier-layer photoelectric cell in a sealed-in quartz window to convert UV radiation into 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 adhere to the Lambert cosine law more closely 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.

4.0 EQUIPMENT DESCRIPTION

Eppley TUVR Sensor

| | |
|------------------------------|--|
| Application | Network Measurements |
| Traceability | National Institute of Standards and Technology (NIST) |
| Spectral Range | 295-385 nm |
| Output | 0-10 millivolts (mV) analog |
| Sensitivity | approx. 150 microvolts per watts per meter squared ($\mu\text{V} / \text{Wm}^{-2}$) |
| Impedance | approx. 1,500 ohms (Ω) |
| 95 percent (%) Response Time | 1 second |
| Non-Stability | 5% |
| Non-Linearity | 2% |
| Directional Response | 5 watts per meter squared (Wm^{-2}) |
| Operating Temperature | -50 degrees Celsius ($^{\circ}\text{C}$) to +80 $^{\circ}\text{C}$ |
| Temperature Response | 0. 3% per degree C |
| Calibration Uncertainty | < 5 % |
| Measurement Uncertainty | |
| Single Point | < 5 Wm^{-2} |
| Hourly Average | approx. 5 % |
| Daily Average | approx. 3 % |

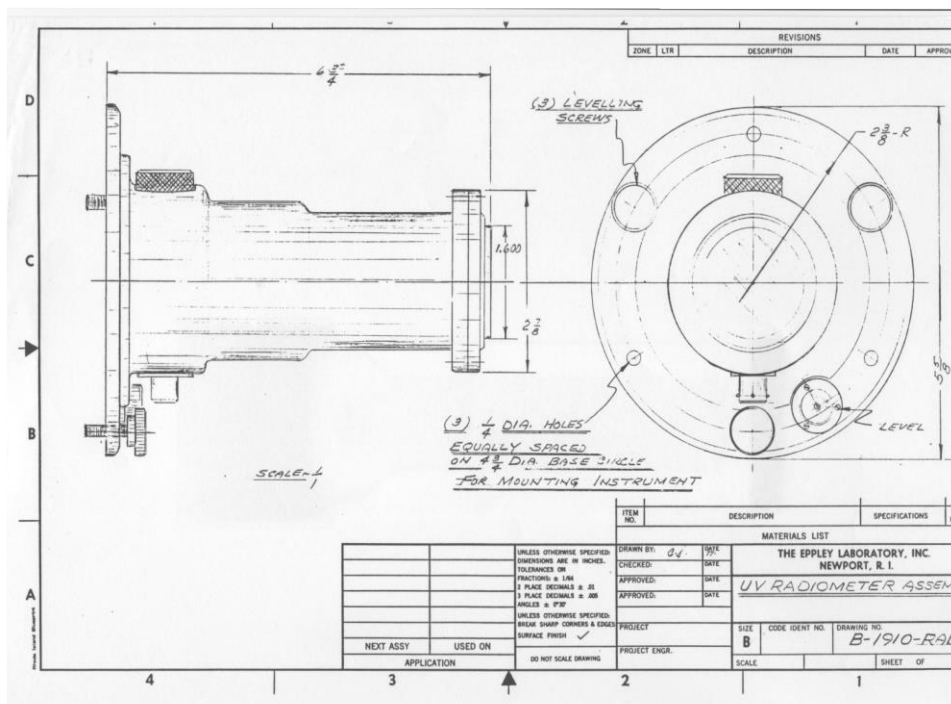


Figure 1 - Scale Drawing of the Eppley Model TUVR Radiometer



Figure 2 - Photograph of the Eppley TUVR Radiometer

5.0 DESCRIPTION OF EQUIPMENT CHECKS

This section provides a description of checks to be performed on the sensor upon receipt from the manufacturer and the checks performed on the instrument prior to deployment in the field.

5.1 Shipment Inspection

The UV radiation sensor shipping container must be inspected for damage and all documents should be filed away properly. **Section 6.1** provides exact procedures for shipment inspection.

5.2 Instrument Inspection

The UV radiation sensor must be checked for functionality prior to field deployment. Typically, functionality tests include connecting the instrument to a datalogger and computer and verifying instrument response. **Section 6.2** provides detailed procedures for instrument acceptance inspection.

6.0 INITIAL STARTUP PROCEDURES

6.1 Shipment Inspection

1. Immediately upon receipt and before opening the shipping container, inspect the shipping container for any signs of damage. In the event of damage, photographs should be taken to document the state of the packaging as received. These photographs will be shared with the equipment manufacturer if the instrument is found to be damaged.
2. Upon unpacking the instrument, locate the calibration test certificate and packing slip and match the model number and serial numbers printed on the test certificate and verify all items shipped match the packing slip.
3. Initial and date the test certificate, scan it and save a scanned copy on the p-drive located here:
P:\Ambient\SThomas\MET Equipment\Instruments Calibration Certificates\Ultra Violet Radiation Sensor Test Certificates
4. Send the packing slip to the administrative assistant.

6.2 Instrument Acceptance Inspection

1. Remove the TUVR radiometer from the package.
2. Place the instrument on a level work bench. Visually inspect the sensor for any dents, scratches, or missing parts. Compare the unit to the photograph in **Figure 2**.
3. If so equipped, carefully remove any cap covering the sensor's lens. Using a soft lint-free cloth carefully inspect and clean the lens.
4. Document any scratches or damage to the sensor. Note all findings in the acceptance sheet for the instrument. Avoid scratching or marring the lens on top of the instrument.
5. Mount the sensor to a solid surface. Use the three adjusting screws to center the bubble in the middle of the built-in level. The gauge must be level to function correctly.
6. Through the view port on the side of the instrument visually check the condition of the desiccant. The Eppley TUVR uses a silica gel drying agent, or desiccant, to maintain moisture levels inside the sensor. The desiccant should be dark blue in color. If the desiccant is pink or white, replace with fresh material before proceeding.

7. To replace desiccant, use a wrench or pliers to unscrew the view port. Remove the desiccant holder. Remove the used desiccant from the holder and replace with new desiccant. Replace the desiccant holder and carefully thread and tighten the view port. Do not over tighten. Used desiccant may be reclaimed by heating at 135 °C for a minimum of 4 hours, or until the color changes to dark blue.
8. Test sensor functionality using the supplied weatherproof cabling or a shielded, twisted pair cable. Connect the cable to the sensor and to a datalogger (**as described in Section 6.3**) or a voltmeter capable of measuring and displaying or recording signal in the range of 0- 10 mV. This input measurement range is required to cover the UV radiation spectrum from the sun. For maximum measurement resolution, the input range of the measurement device should closely match the output range of the sensor.
9. Connect the MetOne AutoMet 580 Datalogger as described in **Section 6.3** below.
10. Program the data logger to convert mVs to Wm^{-2} . (Raw signal x calibration factor = Wm^{-2})
11. Setup an UV radiation channel in the **Envidas SETUP** program to capture intensities transmitted by the data logger. Save your settings and restart the **Envidas SETUP** program.
12. Open **Envidas VIEWER** to see instant readings from the UV radiation sensor.
13. Expose the sensor to a light source emitting in the visible spectrum. Ideally functionality should be tested in direct sunlight. If operating properly, the 10600 data module should yield a value proportional to the intensity of the light source. Remove the light source and cover the sensor lens with some opaque material. The datalogger display should read near zero. (If using a voltmeter, current from the sensor should drop to zero.)
14. Record results of all tests on acceptance sheet. Include data module or voltmeter readings. If sensor passes acceptance tests it is ready for deployment in the field. If sensor fails tests, the manufacturer should be contacted to facilitate repairs or return of the sensor.

6.3 MetOne AutoMet 580 Datalogger Installation and Setup

6.3.1 MET Module

1. Open the MetOne AutoMet 580 Datalogger cover.
2. Connect a Recommended Standard-232 (RS-232)/Universal Serial Bus (USB) data cable from the Computer to the MetOne AutoMet 580 Datalogger.

6.3.2 Ultraviolet (UV) Sensor

1. Connect UV radiation sensor wires onto 580 datalogger terminal TB3 **SIG 8 (+ve), GND (-ve) & Shield (white/brown)** terminals (refer to manufacturers manual, if needed).
2. Strap all wires/cable to be as secure as possible, and then close the 580 Datalogger box cover.
3. Set Dip **switch #4 to ON**.
4. Connect 12 volt (V) power supply that came with the AutoMet 580 Datalogger and power on.

6.3.3 Comet 2 Setup to read MET data via Model 10600 Module

1. Connect RS-232/USB data cable from MetOne AutoMet 580 Data Logger to the desired **COM PORT** on the computer for communication with the Comet 2 App.
2. Check continuity via Device Manager to confirm chosen **COM PORT** number.
3. On site computer, open Comet 2 software.
4. Add Datalogger to Comet 2 (If not yet added):
 - **Select** the ☰ icon on top left of screen
 - **Click on add new station**
 - **Click MET and click <next>**

- Click **digital sensor (AUTOMET 500 SERIES)** and click **<next>**
- **Select serial port** and click **<next>**
- From Drop Down Menu select **COM PORT #** and click **<next>**
- **Enter** station name and click **finish**
- **Click the Terminal Icon**

Note: Envidas COMM PORT must be disabled before programming model 10600 module and then must be enabled before proceeding

- **Press enter at least three times** until asterisk symbol appears (*)
- Enter **Oi1** and press **enter**

7.0 SITE INSTALLATION

1. The chosen site for installation must adhere to siting criteria listed in the EPA Volume IV Meteorology handbook.
2. The sensor should be located such that (a) no shadows will be cast on it at any time; (b) it is not too close to light-colored walls or other objects likely to reflect sunlight onto it; and (c) it is not exposed to artificial radiation sources.
3. Mount the instrument on a solid, sturdy, and level surface, paying special attention that nothing obstructs sunlight to the sensor. Securely attach the radiometer to a mounting stand using the holes provided in the instrument's baseplate (4, ¼ inch diameter circle bolts). The mounting stand selected should be sufficiently rigid to prevent the horizontal position of the instrument from moving, especially in high winds.
4. Carefully level the sensor using the instrument's internal bubble level. Adjust the leveling screws provided until the bubble level is centered. Precautions should be taken to avoid subjecting the instrument to shocks or vibration during installation.
5. Follow steps 8-14 in **Section 6.2, and Section 6.3** to connect the instrument to the datalogger, site computer, and **Envidas SETUP**.
6. Record the site installation details in the site logbook. Fill out and sign an **AQ109 form**, give a copy of the signed form to the ECB supervisor for signature and retention.

8.0 ROUTINE MAINTENANCE

Additional routine maintenance items may include, grass cutting, pest control, cleaning the mesh screens, cleaning gauge surfaces with water, visually checking wire condition and connections outside of gauge, but at a minimum a technician should conduct the following:

8.1 Regular Maintenance

On a monthly basis, or more often, if necessary, a technician should:

1. Inspect the sensor for any damage.
2. Carefully clean the lens by wiping gently with a soft, lint free cloth.
3. Check the instrument's level to ensure the sensor has not moved. If the sensor requires fine adjustment to regain level, the technician may adjust the 3 leveling screws until the internal bubble is centered in the level. If it is not possible to center the level, the instrument, or the structure upon

which it is mounted has shifted. In this case a note should be made in the site logbook and the ECB supervisor contacted immediately.

4. Carefully inspect the state of the desiccant by checking the color through the view port. A blue or dark color indicates that the desiccant is in good condition. A pinkish white or very light color indicates that the desiccant requires replacement. Desiccant replacement is outlined in **Acceptance Testing Section 6.2 #7**.

8.2 Performance Checks

At least twice per year, or more often, if necessary, an ECB technician must:

1. Verify that conditions for Onsite Installation **Section 7 #1 and #2** outlined above are still applicable to the sensor. Document the results of the check and place in the site logbook and e-log. Immediately contact the ECB supervisor if conditions for the checks have changed.
2. Perform a field functionality test to determine if the sensor is operating correctly. Field functionality tests should follow the directions listed in **Section 6.2 #13**, as discussed above. The results of all functionality tests should be documented in the appropriate maintenance logbook, the site logbook and the e-log for one of the instruments at the site.
3. Sensors that fail field functionality tests must be immediately removed from the field and returned to the manufacturer for repair, recalibration, or recertification as necessary.

9.0 ACCURACY AUDITS

As of this SOP revision, the North Carolina Division of Air Quality (DAQ) is in the process of developing the Accuracy Audit procedures. Since the DAQ procured and started using the Eppley Model TUVR Radiometer UV sensor, the manufacturer has stopped supporting it. The DAQ is currently looking for alternative UV models to use.

When a sufficient model is procured, it ideally should come calibrated from the factory. No field calibration or adjustment would be attempted. A calibration should last at least once every 3 calendar years and the sensor would be returned to the manufacturer for calibration and recertification at the end of that period. Alternatively, the sensor would be returned to the manufacturer for calibration and recertification immediately upon a failed field functionality test attributable to the sensor. When either of these events occur, copies of all recertification records would be retained, and copies would be placed in the sensor specific maintenance logbook.

10.0 REVISION HISTORY

1. 02/07/2022 **ML & JP** – Initial Publication

11.0 REFERENCES

1. United States Environmental Protection Agency: Office of Air Quality Planning and Standards (2008). Quality Assurance Handbook for Air Pollution Measurement Systems Volume IV: Meteorological

Measurements. Version 2.0. Research Triangle Park, NC. Mikel, Dennis; Landreneua, Joey; Fields, Daniel; Bush, David; Fransiola, Paul; Eagan, Tammy; Field, Kent; Baxter, Bob; Dye, Tim; Acemount, Gary and Heffern, Richard.

12.0 APPENDICES

1. Appendix A – UV Radiation Audit Form
2. Appendix B – AQ-109 Form

Appendix A – Ultraviolet Radiation Audit Form

| Ultraviolet Radiation Audit | | | | | |
|--|---|--|-----------------|--------------|------------|
| Data Logger SN | | | | | |
| Site | | | Date | | |
| Start Time | | | Stop Time | | |
| Audit Sensor Model | | | Audit Sensor SN | Exp. Date | |
| Site Sensor Model | | | Site Sensor SN | | |
| Test | Audit Sensor Ultraviolet Radiation Reading (W/m2) | Site Sensor and Data logger Ultraviolet radiation reading (W/m2) | Difference | % Diff ± 5 % | |
| Test 1 | | | #DIV/0! | #DIV/0! | |
| Test 2 | | | #DIV/0! | #DIV/0! | |
| Test 3 | | | #DIV/0! | #DIV/0! | |
| Acceptable: | Yes | No | | | Auditor |
| | | | | | Calibrator |
| If any point above fails. Clean site sensor surface and perform test again using space below. | | | | | |
| Site Sensor Model | | | Site Sensor SN | | |
| Test | Audit Sensor Ultraviolet Radiation Reading (W/m2) | Site Sensor and Data logger Ultraviolet radiation reading (W/m2) | Difference | % Diff ± 5 % | |
| Test 1 | | | #DIV/0! | #DIV/0! | |
| Test 2 | | | #DIV/0! | #DIV/0! | |
| Test 3 | | | #DIV/0! | #DIV/0! | |
| Acceptable: | Yes | No | | | Auditor |
| | | | | | Calibrator |

If any point fails again, replace site sensor with freshly calibrated sensor and perform test again using space below

| Site Sensor Model | | | | Site Sensor SN | | |
|-------------------|---|--|--|----------------|------------|--------------|
| Test | Audit Sensor Ultraviolet Radiation Reading (W/m2) | | Site Sensor and Data logger Ultraviolet radiation reading (W/m2) | | Difference | % Diff ± 5 % |
| Test 1 | | | | | #DIV/0! | #DIV/0! |
| Test 2 | | | | | #DIV/0! | #DIV/0! |
| Test 3 | | | | | #DIV/0! | #DIV/0! |
| Acceptable: | Yes | | No | | Auditor | |
| | | | | | Calibrator | |
| Comments: | | | | | | |
| | | | | | | |

Appendix B – AQ-109 Form

**AIR QUALITY SECTION
MAINTENANCE ORDER**

Region: _____ Site: _____ Date of Service: _____

Requested By: _____

Action Requested: Repair _____ Supply _____ Maintain _____ Audit _____ Installation _____ Removal _____

Requested Action: _____

Action Taken (Shop Use Only): _____

Parts Used: _____

Cylinders (Installed):

Cylinder: Type _____ PPM _____ SN _____ PSI _____ Expires _____

Cylinder: Type _____ PPM _____ SN _____ PSI _____ Expires _____

Cylinders (Removed):

Cylinder: Type _____ PPM _____ SN _____ PSI _____ Expires _____

Cylinder: Type _____ PPM _____ SN _____ PSI _____ Expires _____

Travel Time: Departed: _____ AM PM Returned: _____ AM PM

Vehicle (1): _____ Vehicle (2): _____

Vehicle Number: _____ Vehicle Number: _____

Logbook(s) Updated: YES NO N/A Comment(s): _____

Comment(s): _____

Date Signed: _____ Technician(s): _____ Supervisor's Initials _____