Standard Operating Procedure for Campbell Visibility Sensor (CS 120A)

October 31, 2024

STI-7504

APPROVED:

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Sonoma Technology date

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Fenceline Monitoring Refinery Representative date

Contents

1. Scope and Applicability

This standard operating procedure (SOP) provides instructions for servicing the Campbell visibility sensors used in fenceline monitoring applications. The procedures here cover routine maintenance and calibration of the Campbell CS120A visibility sensor.

2. Routine Service and Maintenance

Routine service tasks are designed to maintain the visibility sensor in good working condition. This is intended to lower the frequency of non-routine maintenance. The routine service tasks are described below. The site should be serviced once every four weeks. If no problems are encountered, the site visit will take less than one hour.

When maintenance is complete, the maintenance forms in Section 6 should be saved in the maintenance folder for the project located on Sonoma Technology's shared drive. Data will be flagged in a manner consistent with the QAPP if there are issues that cannot be immediately corrected. In the case of extended down time, the sensor should be replaced with a working sensor.

2.1 Maintenance Checklist

Table 1 depicts the maintenance activities that must be performed during each site visit to ensure all instruments are performing correctly.

Table 1. Routine quarterly maintenance checklist.

Action
Visually inspect the system, including all cables. Ensure they are not fraying.
Inspect optics on detector and clean if necessary.
Check calibration. An acceptable % error is less than 25%

[a] Lowering the meteorological tower is not necessary for routine site maintenance visits. Do not attempt to lower the tower with fewer than two people.

After physically inspecting the meteorological sensors, the technician should take note of the current visibility reading from the instrument and confirm that it matches current atmospheric conditions. Visibility data from the National Weather Service can be used to aid in this task.

2.2 Securing the Shelter

Turn off the computer's display monitor, and record your completion time in the Site Log form. Turn off the shelter lights and lock the shelter.

3. Calibration and Standard Operating Procedures for Meteorological Sensors

Annual audits will be conducted on meteorological instrumentation. The meteorological instrumentation calibrations will be conducted with reference to the recommendations in the EPA's *Quality Assurance Handbook for Air Pollution Measurement Systems (QA Handbook), Volumes I, II, and IV* (U.S. Environmental Protection Agency, 2017, 1994, 2008) and in accordance with the *Technical Assistance Document for the National Air Toxics Trends Stations Program, Revision 3* (U.S. Environmental Protection Agency, 2016) and the *Technical Assistance Document for Sampling and Analysis of Ozone Precursors for the Photochemical Assessment Monitoring Stations Program*, Revision 2 (Battelle, 2018).

As part of the calibration process, each instrument will first be tested to determine whether it is operating within the prescribed operational limits and whether non-routine maintenance or adjustments are required. Based on an instrument's response to the initial performance test with respect to the minimum acceptable performance criteria (see data quality objectives in the QAPP), the instrument will then be repaired, calibrated, or in rare cases, replaced. A standard form will be used to document the performance of each sensor before and after any adjustments. A digital copy of this document is to be kept on the Sonoma Technology servers. Notes on what was performed are also to be recorded in the station logbook. The performance criteria for the visibility sensor is that the measured extinction coefficient must be within 25% of the reference value.

3.1 Visibility Sensor Testing and Calibration

3.1.1 Materials Needed

- Microfiber cloth
- Calibration bungs
- Calibration disk
- Micro-USB to USB-A cable

3.1.2 Startup Checklist

Verify that the following actions are completed when starting up the Campbell Visibility Sensor:

_____ Verify that serial connections (transmit [TX] and receive [RX]) to the datalogger are correct (sensor TX to logger RX, sensor RX to logger TX, and sensor ground to any ground terminal on the logger).

_____ Check datalogger to see if data are coming from the sensor.

_____ Check the data to make sure they make sense (visibility value is a reasonable number and the correct values are being recorded to the right parameters).

_____ Make sure the lenses are clean and clear of obstructions (spider webs, etc.).

_____ Use a microfiber cloth (you can use a blower first). Do not use abrasive cleaners; use isopropyl alcohol only if needed.

3.1.3 System Verification Procedure

The following tests will be performed as a verification of analyzer operation.

Testing and Calibration Prep

The sensor can be checked and adjusted using the optional sensor high-grade calibration kit Part Number 28678 from Campbell Scientific. The calibration must be performed using the onboard menu system. To access this menu via LoggerNet's terminal emulation program, see the procedure in Section 4.

The test should ideally be performed under the following conditions:

- Ambient temperature between 0ºC and 50ºC.
- The local visibility is approximately 10,000 meters or more.

To perform the verification test, follow these steps:

1. Select Menu Item 4 on the main terminal screen. Once you have selected Menu Item 4, the following is an example of what should appear on the screen.

```
CS120A INFORMATION - MENU 4
 ID 0
 S/N 1234
 OS version: 007646v12
                                  Alarm   Value
- Last visibility reading:         -       65m
- Overall system status:           0       No faults
- Emitter dirty window alarm:      0       0%
- Emitter internal temperature:    0       27.4
- Detector dirty window alarm:     0       -4%
- Detector internal temperature:   0       23.2
- Detector DC light saturation:    0       -
- Hood heater temperature:         0       16.9
- CS120A Calibrator Serial No:      -       1192
- CS120A Calibrator EXCO:           -       48.4
- Calibration value factory offset: -       0.025
- Calibration value factory scale:  -       0.02630
- Calibration value cal offset:     -       0.090
- Calibration value cal scale:      -       0.02814
- Signature fault:                  0       -
- Flash write errors:               0       0
- Flash read errors:                0       0
- Supply voltage:                   <7.0V  12.0V
- Aux supply voltages:              +5V=4.9 -5V=-5.1 +6V=6.0
(8) Get debug
(9) Refresh
(0) Return to main menu
```

2. Make note of the extinction coefficient on the sensor calibrator. Once suitable local visibility conditions have been verified, install the sensor calibrator by fastening it to the central mounting point.

3. Allow 5-10 minutes for the measurements to stabilize.

4. Record the As Found system parameters, which can be found in Menu 4.

5. Enter 9 as needed to continue to refresh the data to see the last visibility reading.

6. Once the last visibility reading is consistent, take note of the new reading.

7. The conversion of the visibility reading to the extinction coefficient for comparison is 3,000 divided by the last reading.

8. Calculate the percent error between this new value and the extinction coefficient. The percent error should be equal to or less than the %Error specified in the QAPP.

9. If the precent error is greater than specified in the QAPP, attempt cleaning the lenses. If the percent error is still greater than the value specified in the QAPP, proceed with calibration.

3.1.4 System Calibration Procedure

1. To perform the calibration, select Menu Item 3 on the main terminal screen. Once you have selected Menu Item 3, the following screen should appear.

```
CS125 CALIBRATION - MENU 3
ID 0
S/N 1006
(1) Perform calibration
(2) Restore the factory calibration
(3) Perform dirty windows zero offset calibration
(4) Restore dirty windows factory calibration

(9) Refresh
(0) Return to main menu
```

2. Select Option 1 to start the calibration.

3. Confirm that a calibration is to be performed. Please note that once "Yes" is entered, exiting the program is not possible until the test is complete. However, power cycling the unit at this point will have no adverse effect on the sensor.

4. Once the test has started, the program will ask for the sensor calibrator serial number and coefficient, with a confirmation at each step giving the opportunity to correct typing mistakes.

```
Starting calibration.
Input the sensor calibrator serial number ->E2002
Is E2002 correct? (Y/N)?
Input the sensor calibrator constant ->28.8
Is 28.8 correct? (Y/N)?
```

5. Start the dark level calibration by placing one calibration bung into each hood, and then pressing any key.

   Once calibrator information has been entered, the sensor will hold until the foam bungs are placed into the sensor hoods. The bungs are designed to block all light from the outside from reaching inside the head. Place one bung into each hood. If either of the bungs are damaged or appear to have any gaps around the edges, contact Campbell Scientific.

```
Starting dark level calibration.
This test will take approximately two minutes
```

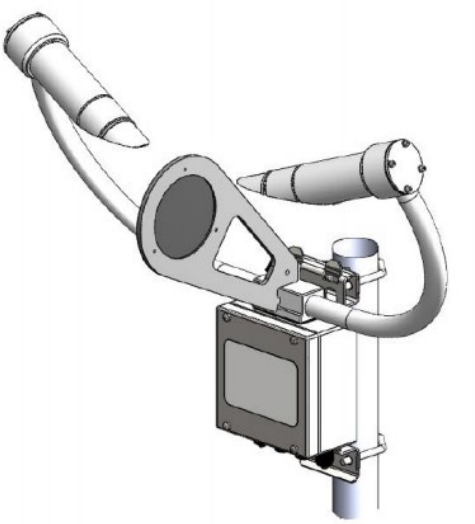
This part of the test will take approximately two minutes. Every ten seconds, a dot should appear indicating that the test is progressing as normal.

```
Dark level test complete. Please remove the bungs.
Now place the sensor calibrator into the sampling
volume.
Press any key once this is done.
```

6. Remove the bungs once the sensor instructs for this to be done.

Light Level Calibration

7. Place the sensor calibrator into the volume by fastening it to the central mounting point. Press any key.



```
Starting light level calibration.
This test will take approximately two minutes.
```

This part of the test will take approximately two minutes. Every ten seconds, a dot should appear indicating that the test is progressing as normal.

```
Calibration is now complete.
Saving user settings
Press any key to exit.
```

Once the second stage of the test has been completed, the new calibration constants will be saved automatically. Exit the menu by pressing any key. All calibration constants, including both the user and the factory settings, can be viewed from Menu Item 4 from the main menu once the test is completed.

8. Document the new user calibration constant and the factory setting each time a calibration is done.

9. REMEMBER to remove the calibration disk once finished.

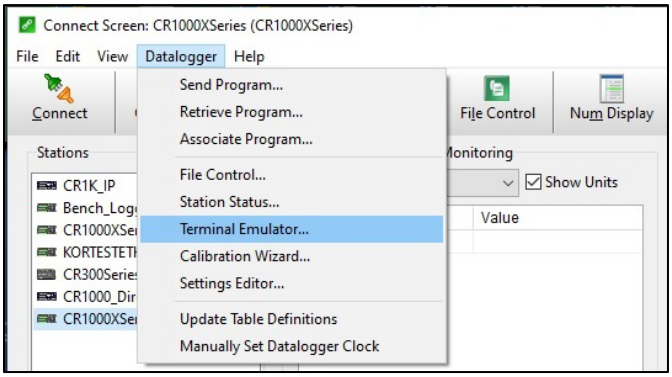
4. Campbell Terminal Emulator Connection Procedure

The following is a procedure to access the real-time visibility sensor data using a Campbell Scientific Data Logger through a LoggerNet Terminal Emulator.

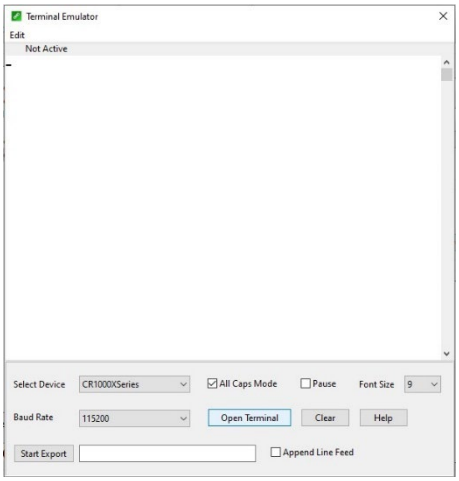
1. Connect a laptop to the Campbell Scientific Data Logger with a USB cable, RS232 cable, or via ethernet cable and IP address.

2. From the LoggerNet application, open the "Connect Screen" through "Main" and "Connect" options.

3. Select the "Datalogger" tab at the top right of the "Connect Screen." Then select "Terminal Emulator…" from the drop down menu.

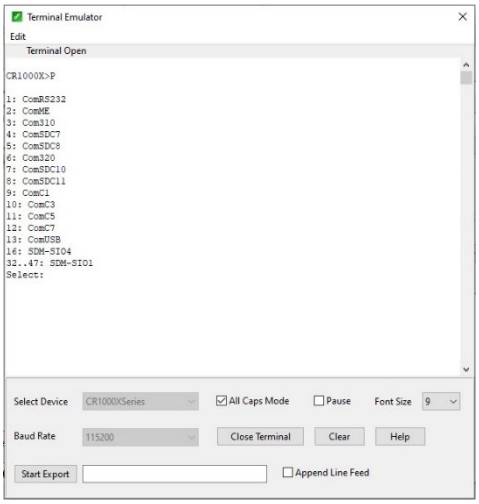


4. A blank window will display, but the terminal emulator is not open yet. To open the connection to the terminal emulator, select “Open Terminal” at the bottom of the Terminal Emulator window.



5. When the terminal is open, the button that previously said “Open Terminal” will change to “Close Terminal.” Press enter until “CR1000X>_” appears in the terminal.

6. Type the capital letter “P” to display the comport options.



7. Look at the lowest terminal bar on the data logger and identify which terminal port has a blue wire to the left of a white wire. The terminal port that the blue wire is connected to corresponds to the comport that needs to be selected. For example, the “C1” terminal port corresponds to the option “9: comC1.” Type the list number after “Select:_” that corresponds to the correct comport and press enter.

8. If the correct comport is selected, “opening [comport number]; press ESC ESC ESC ESC to close” will display and will sometimes be followed by an array of numbers. Now type “open

0" and press enter. Note that oftentimes the curser or the text will not be visible during this step. Also, frequently, the first attempt will not work. Allow time for the command to process. Typically, additional rows of array numbers will display after failed attempts are finished processing. Continue to enter "open 0" until the following setup menu displays.

```
WELCOME TO THE CAMPBELL SCIENTIFIC LTD CS120A SETUP MENU
 ID 0
 S/N 1234
 (1) Message output menu
 (2) User alarm menu
 (3) Calibrate CS120A
 (4) System information
 (5) Communications setup
 (6) System Configuration
 (9) Exit and save
 (0) Exit and don't save
  ->
```

9. Enter "4" for "System information" and the real-time data from the visibility sensor will display.
10. Enter "9" as needed to continue to display the most current data.
11. To exit the terminal emulator session, enter 0 to exit the information menu and return to the main menu.
12. Enter 0 again to exit and not save.
13. Press Esc four times to close.
14. Select "Close Terminal" to close the terminal
15. Close the terminal emulator window.
16. LoggerNet can be closed and the laptop can be disconnected from the logger.
17. Note: opening the terminal emulator will halt data transfer from the data logger. To re-establish data transfer, reset the data logger by disconnecting the power source, wait 10 seconds, and plug the power source back into the data logger.
18. Confirm data flow has been re-established.

5. References

Battelle (2018) Technical assistance document for sampling and analysis of ozone precursors for the Photochemical Assessment Monitoring Stations program, Revision 2. Revised draft prepared for the U.S. Environmental Protection Agency, Research Triangle Park, NC, by Battelle, Columbus, OH, March.

U.S. Environmental Protection Agency (1994) Quality assurance handbook for air pollution measurement systems, Volume I: a field guide to environmental quality assurance. Report prepared by the U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA/600/R-94/038a. Available at https://www3.epa.gov/ttn/amtic/qalist.html.

U.S. Environmental Protection Agency (2008) Quality assurance handbook for air pollution measurement systems, Volume IV: meteorological measurements version 2.0 (final). Prepared by the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC, EPA-454/B-08-002, March. Available at https://www3.epa.gov/ttn/amtic/qalist.html.

U.S. Environmental Protection Agency (2016) Technical assistance document for the National Air Toxics Trends Stations Program, Revision 3. Prepared for the Office of Air Quality Planning and Standards, Research Triangle Park, NC, by Battelle, Columbus, OH, October. Available at https://www3.epa.gov/ttnamti1/files/ambient/airtox/NATTS%20TAD%20Revision%203_FINAL%20October%202016.pdf.

U.S. Environmental Protection Agency (2017) Quality assurance handbook for air pollution measurement systems, Volume II: ambient air quality monitoring program. Prepared by the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Air Quality Assessment Division, Research Triangle Park, NC, EPA-454/B-17-001, January. Available at https://www3.epa.gov/ttnamti1/qalist.html.

6. Campbell Visibility Sensor Audit Record Example

Visibility
As Found

Site Name:	Field Site Name	**Date:**	January 1, 2024
Site Latitude:	12.345678 N	**Technician:**	Tech Name
Site Longitude:	-123.456789 W	**Reference Make:**	Campbell Scientific
Sensor Make:	Campbell Scientific	**Reference Model:**	CS125
Sensor Model:	CS120A	**Reference Serial No:**	E21192
Sensor Serial No:	E1234	**Reference Cal Date:**	N/A

	Reference	**Site Sensor**	**Error (%)**	**PASS/FAIL**
Extinction Coefficient (km^{-1})	48.4	50.0	3.3	PASS
Visibility (m)		60.0000		

Overall system status:	No faults	Calibration value factory offset:	-0.041
Emitter dirty window alarm:	-1%	Calibration value factory scale:	0.02619
Emitter internal temperature:	30.8	Calibration value cal offset:	0.064
Detector dirty window alarm:	0%	Calibration value cal scale:	0.029
Detector internal temperature:	25.7		
Hood heater temperature:	20.9		

Notes:

Sensor found to be within specification.
Will clean sensor lenses with alcohol wipes, lint-less lens tissue, and a blast of compressed air.

Visibility
As Left

	Reference	Site Sensor	Error (%)	PASS/FAIL
Extinction Coefficient (km^{-1})	48.4	52.6	8.7	PASS
Visibility (mi)		57.0000		

Overall system status:	No faults
Emitter dirty window alarm:	-1%
Emitter internal temperature:	31.2
Detector dirty window alarm:	-1%
Detector internal temperature:	26.1
Hood heater temperature:	21.2

Calibration value factory offset:	-0.041
Calibration value factory scale:	0.02619
Calibration value cal offset:	0.064
Calibration value cal scale:	0.029

Notes:

Sensor left within specification