SOP #5

Nephelometer Data Acquisition and Processing

1.1 Purpose and Applicability

This quality assurance/control procedure describes the practices for conducting nephelometer performance checks and calibrations. A set of performance checks are performed to check the state of the nephelometer under normal operating conditions, without special preparation or adjustment. These permit the Site Manger to determine if maintenance and/or repairs are necessary, if recalibration is warranted, or if adjustment to operation should be made. On-site calibrations are performed when nephelometers are operating as expected, but to correct excess baseline drift in scattering measurements and to prolong the normal, on-site operation of the nephelometer. As material is accumulated on the walls of the nephelometer tube, cleaning of the nephelometer tube becomes necessary. When this point is reached, the nephelometer is sent to the SPARTAN Central Lab at Dalhousie University for maintenance, cleaning, and recalibration before being returned to the site. The ultimate aim of this protocol is to ensure the integrity of the SPARTAN scattering data and assess the data for accuracy.

REVISION HISTORY			
Revision No.	Change Description	Date	Authorization
2.0	Addition of Clean-Air Reference system procedures	June, 2016	Graydon Snider

1.2 Responsibilities

Frequency: Every 2 months coinciding with on-site cartridge change and/or reported issue or event by Site Operator

Responsibility of: SPARTAN Site Manager

Responsibilities include:

• Coordinate with site operator to receive nephelometer data on a regular basis (at least monthly).

• Process raw nephelometer data to look at markers for performance checks (see Section 6.2.2 Parameters for Performance Checks)

• Direct appropriate corrective action if indicated by performance checks.

• Review and identify flagging of data due to failed performance check.

• Document performance check result in the site-specific log

• Assess timeline for on-site calibration and central lab calibration/cleaning

1.3 Parameters for Performance Check

There are a number of variables that are recorded by the nephelometer that are used in calculating scatter. Therefore, it is necessary to assess the stability of the sensors used to measure 28 these variables. This is done by creating times series plots of all relevant variables and checking data as outlined below.

• The variance in reference sensor signals should not be more than 10%.

• Dark PMT values should be significantly lower than PMT measurements at all three wavelengths for both forward and backward. The value and magnitude of the PMT signal is specific for each nephelometer, however and example is shown below in Figure 1.

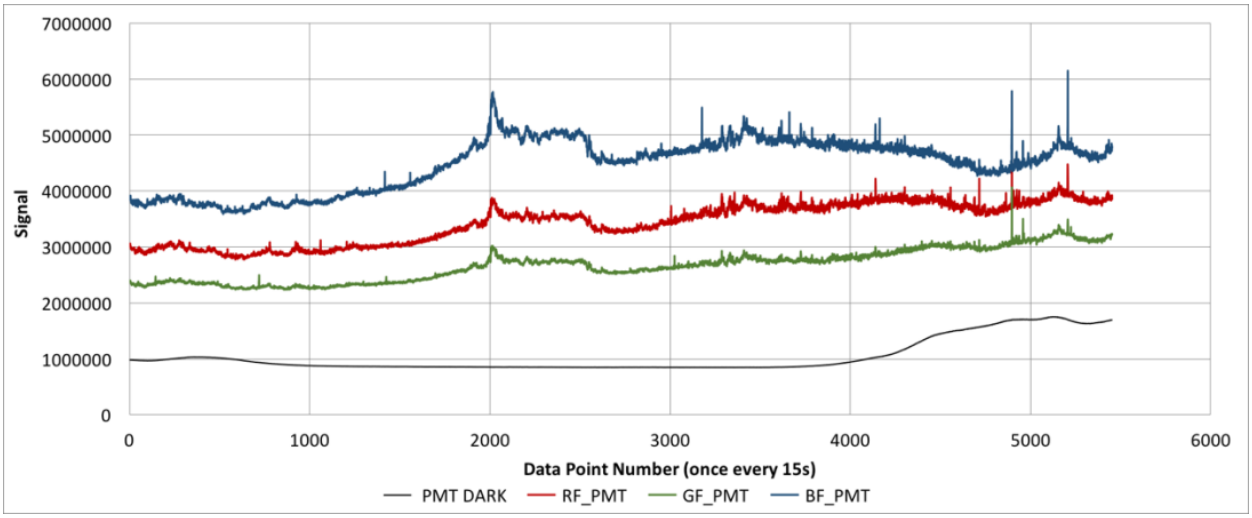

Figure 1: Dark PMT signal (PMT DARK) compared to the forward PMT signal at each wavelength

• Check that the following is true in scatter measurements: red > green > blue

• Dark reference sensor values are significantly lower than reference measurements at all wavelengths. Similar to PMT signals, reference sensor signals vary between nephelometers. An example is shown below in Figure 2.

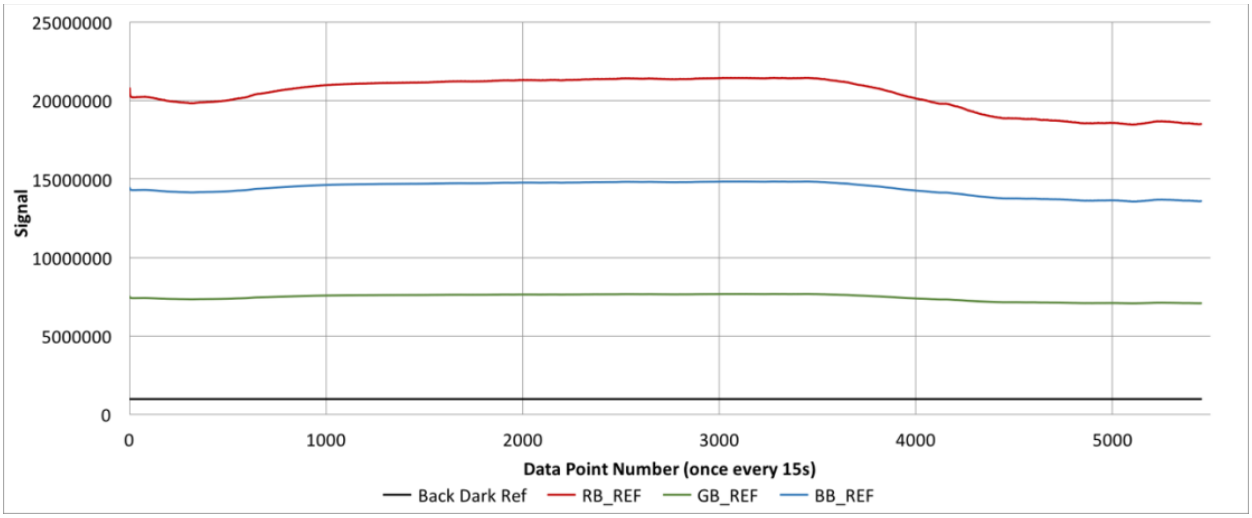

Figure 2: Back scatter dark reference signal compared to back scatter reference signal at each wavelength

• Time series plots of temperature, RH, and pressure should be compared to that of the dark reference sensor measurements. Ambient conditions should not show a similar signal/pattern to the dark reference measurement.

1.4 Nephelometer Calibration

Nephelometer calibration is fundamental to obtaining accurate scatter data. Whenever a calibration is performed, it is compared to the previous calibration conducted at Dalhousie University to evaluate the validity of the performed calibration. The step-by-step instructions for calibrating the nephelometer are found below

1.5 Determine Calibration Frequency

Nephelometers sample continuously at a flow rate of approximately 3.4 lpm and as a result are prone to accumulation of dirt inside the nephelometer tube where scatter measurements are made. When possible, on-site calibrations are performed to maintain and assess the condition of the nephelometer and correct for accumulation of dirt inside the nephelometer, even when a clean air reference system (CR) is installed at the site. However, over time the amassing of dirt inside the nephelometer will be too much for on-site calibrations and the nephelometer will require detailed maintenance, cleaning, and calibration at the SPARTAN Central Lab at Dalhousie University.

Determining the frequency of on-site and central lab calibrations is an ongoing process. It is the responsibility of the Site Manager to continually assess the need for calibration during performance checks. There are various metrics that are used to determine the frequency of nephelometer recalibration but generally,

• **On-site calibrations** are recommeded when the baseline drift reaches 15 % of the average total green scatter $B_{sp,532at}$ the site.

• **When on-site calibrations are not possible, detailed cleaning and calibration** are required when the baseline drift reaches 30 % of $B_{sp,532}$ at the site.

-If on-site calibrations are possible, detailed cleaning and recalibration will be conducted after 2 on-site calibrations have been performed. Therefore, three consecutive on-site recalibrations should not be performed, rather when the third is due the nephelometer will be returned to the SPARTAN Central Lab.

Every SPARTAN site operates with a clean air reference system that is programmed to perform a clean air reference (for baseline drift correction) once every 24 hours. Therefore, the correction values calculated from clean air reference periods are used to determine the magnitude of baseline drift. For sites where the clean air reference is not automatically applied to the scatter measurements the baseline drift can also be determined by inspection of the baseline in the Bsp,532 time series.

1.6 Required Equipment

There is a minimal amount of equipment required for the calibration of a nephelometer, whether on-site or at the central SPARTAN Lab at Dalhousie University. The following two gases (> 99% purity) are required for every nephelometer calibration:

- N2 or clean air (Clean Air Reference system can be used as clean air source) cylinder.
- CO2 cylinder

Additional equipment required:

- Regulator for gas cylinders
- Clean plastic tubing
- Inlet for gases to run into nephelometer
- AirPhoton program for determining calibration configuration variables (NephCal1.1.htm)

1.7 Calibration Procedure

Whether a calibration is conducted on-site or at the central SPARTAN lab at Dalhousie University, the procedure is the same with the exception of sections *in bold italic font* as a few extra steps are required for on-site calibrations. The steps to be taken are as follows:

1. Transfer any data on the nephelometer memory card to a computer *for transfer to the Site Manager*.
2. Disconnect fan from Clean Air Reference (CR) system
3. Turn CR system ON in MANUAL mode and let run for 10 minutes
4. 4. Turn off CR system, but leave the nephelometer ON • The scatter from the clean air and CO2 need to be in the same file for processing.
5. 5. Connect CO2 to nephelometer and let run for 10 minutes
6. Turn OFF nephelometer
7. Remove nephelometer memory card and transfer file with CR and CO2 to computer. • Scatter from N2, or clean air, and CO2 are compared to the scatter values from the previous calibration to guarantee consistency. *On-site exception: the site operator will send the data file to the site manager to assessment.*
8. Open NephCal1.1.htm and load in data file
9. Get configuration numbers from NephCal program and transfer to config.txt file. *On-site exception: site manager will send the new config.txt file to the site operator via email.* • Set CR values to zero in the config.txt file.
10. Insert the memory card back into the nephelometer.
11. Turn the nephelometer ON and wait 10 seconds for the nephelometer to set the new calibration values
12. Turn the nephelometer OFF and remove the memory card to confirm that the config.txt file is no longer on the card.
13. Create a new config.txt file to dump the configuration information on the nephelometer • In a blank config.txt file use the following command: DUMP=1. *On-site exception: site manager will send this config.txt file to the site operator.*
    • Save the new config.txt file to the memory card and reinsert in the nephelometer.
    • Turn the nephelometer ON and wait 10 seconds for the nephelometer to take the new config.txt file
    • Turn the nephelometer OFF and remove the memory card

    •Copy the resulting DUMP.txt file on the memory card to your local device for saving in the SPARTAN nephelometer database
14. Return the nephelometer to normal operation

1.8 On-Site Calibration

The ability to conduct on-site calibrations are an ideality, many SPARTAN sites do not have easy access to the gases required for calibration of the nephelometer. In the case that a site does have a clean air reference system and easy access to CO2

(and N2 if no clean air reference system), then on-site calibrations will be conducted. The frequency of on-site calibrations are site-specific and are scheduled as determined by the protocol described in section 6.3.1 Determining Calibration Frequency.

1.9 Cleaning and Calibration at SPARTAN Central Lab at Dalhousie University

Upon receiving the nephelometer from the site, a physical condition check of the outer nephelometer body needs to be conducted and all information recorded in a SPARTAN Service Report (see SPARTAN Service Report). After external physical check is complete the cleaning of the nephelometer tube is to be completed. This requires removing the nephelometer tube from the body. Supplies required for removing the tube from the body and cleaning the nephelometer tube are:

1. Clean cloth
2. Lint-free tissues (e.g. Kim-wipes)
3. Methanol
4. Water
5. Hex-keys
6. Screwdriver
7. Wrench

After cleaning of the nephelometer tube is complete, any remaining dust or lint needs to be blown away using compressed air. Once this is completed the nephelometer is reassembled and the calibration is completed following the steps outlined in section **1.7.**