WBEA – Standard Operating Procedure

SOP Title	**Procedures for operating continuous Thermo Scientific SHARP 5030 PM_{10} and $PM_{2.5}$ Analyzers**
SOP Number	**WBEA SOP-PAR-010**
Author	
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Revision History

Revision #	Date	Description	Author

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Introduction and Background

This document is intended to be used as a reference for use in the calibration, maintenance and operation of continuous analysis of particulate matter in ambient air. The proper utilization of this procedure in conjunction with the operators manual will conform to the current Alberta Air Monitoring Directive (AMD) and enable the data to be included in provincial and national air quality data bases

The SHARP 5030 provides real time nephelometry and mass measurement of selected size particles in ambient air samples. This instrument is used to measure mass concentrations of particulate matter (PM) of 10µm aerodynamic diameter and less (PM10) or 2.5µm aerodynamic diameter and less (PM2.5) in ground level ambient air.

Principle of the Method

This method is a continuous mass measurement of PM present in ambient air. Air is drawn through a size selective cyclone impactor inlet at the rate of 16.7 lpm. The SHARP 5030 incorporates two different measuring techniques, of both nephelometry and beta attenuation, to obtain highly accurate particulate monitoring. A humidity measuring and sample heating system is used to monitor and reduce the effects of moisture on the measurement and mitigate volatile compounds and interferences.

The conditioned sample first drawn through an optical assembly which uses an 880 nm light beam source and a detector measure the light scattering of the sample. This is the principle of nephelomtety and the response of the detector is linear to aerosol concentration.

After the optical assembly the sample stream passes through glass fiber filter tape. Particulate matter builds up and will advance prior to the saturation point of the tape. As the sampling is taking place beta attenuation is used to measure the mass of the deposited particulate. Radiographic sensor also detect alpha emissions enabling the monitoring of negative mass artifacts and giving a more accurate measurement.

The analyzer output is based on one minute averages of the nephelometer, multiplied by a correction factor. The correction factor is the ratio of the dynamic beta concentration to the dynamic nephelometer concentration.

$$Output = N_{ave} \times \left(\frac{B}{N}\right)$$

Where

Nave is the one minute Nephelometry average (µg/m^3)

B is the dynamically filtered Beta Attenuated Concentration (µg/m^3)

N is the dynamically filtered Nephelometery Concentration (µg/m^3)

(Thermo Scientific, Model 5030 Instruction Manual,2007 , section 1-3,)

Measurement Range and Sensitivity

The manufacturer states that the minimum detectable limit for the mass transducer is <0.5 µg. Thermo Scientific states the SHARP 5030 has an operational range of up to 10 000 µg/m^3.

Equipment and Apparatus

The following models are used in this method.

- Thermo Sceintific Model 5030 Synchronized Hybrid Ambien Real Time Particulate Monitor

Interferences

The SHARP 5030 is susceptible to several types of interference. It's overall design has two mechanical potential sources of error. The cyclone impactor head and sample tube may become encrusted with dust and particulate which may later become free and cause erroneous instantaneous readings. The tubing may also become susceptible to leaks which can affect the overall performance and invalidate the calculations.

Precision and Accuracy

The measurement precision is generally considered to be the "repeatability of the measurement". Precision of the data output by the analyzer is established by the manufacturer, but confirmed during daily and monthly maintenance, HEPA filtered zero verification and flow audits.

The accuracy of the sensor is generally considered the "deviation from true". This means how close it is to what it should be. The benchmark of "what it should be" is provided by the Alberta Environment Audit Program staff and the use of high quality transfer standards such as available from the National Institute of Standards and Technology (NIST). The manufacturer states the instrument has an hourly precision of ±2.0 µg/m^3 (>80 µg/m^3) and ±5.0 µg/m^3 (<80 µg/m^3) and an accuracy of ±5.0 compared to 24 hour FRM.

Site Requirements

Site location of the particulate monitoring station in urban, industrial and rural areas should be determined according to the intended application of the monitoring data. Detailed requirements for selection of sites for monitoring PM_{10} and $PM_{2.5}$ for the Canada Wide Standard (CWS) determination can be found in "Guidance Document on Achievement Determination-Canada Wide Standards for

Particulate Matter and Ozone section 3.0. Requirements for the immediate surroundings of the site can be found in the Station Site Criteria section of the AMD.

Installation Requirements

The installation procedures of the SHARP 5030 are detailed in the operating manual. All the steps outlined therein must be followed closely. In particular, attention should be given to locating the system so as to minimize potential rapid fluctuations in room temperature.

Probe Location Criteria

The location of the SHARP 5030 inlet must conform to the probe location criteria below:

- Height above ground — 2 to 15 meters.
- Distance from support structure — > 1 meter.
- Distance from trees — > 20 meters or twice the height of tree above the inlet whichever is greater.
- Distance from obstacle — 2×height of obstacle above the inlet.
- Airflow Restrictions — unrestricted in at least 3 of the 4 wind quadrants.
- Local Source Influences — Local source influences must be considered in locating the site for ambient PM10 or PM2.5 monitoring.

Temperature Stability

Temperature fluctuations in the air sample should not influence the performance of the instrument. However if the sensor and control units are placed in close proximity to air conditioning units and/or heating sources, the temperature control of the instrument may not be able to compensate rapidly enough to maintain the temperature stability of the sensor unit. The flow sensor in the control unit may also be affected by rapid fluctuations in temperature. These problems may be manifested as noise or baseline drifts in the data output.

Electric Power Supply

The electrical line voltage to the instrument can influence its performance. Variations in the vacuum pump speed can create feedback problems with the flow controller and hence the stability in the output of the instrument. This problem is often encountered in remote sites where power supply frequency, voltage and spikes may fluctuate significantly.

Exterior Enclosures

Where the site does not allow a straight intake from the sampling inlet to the sensor unit, an exterior installation must be considered. This would involve the installation of a temperature-controlled enclosure with heating and cooling capabilities to house the control and sensor modules and the pump. The outdoor enclosure must maintain the instrument temperature within the range of 2 to 25°C and it

should be insulated to reduce the effect of rapid ambient temperature changes. A flat roof or surface would be required to mount such an enclosure.

Operating Parameters and Instrument ConfigurationThe SHARP 5030 are installed within stations inclusive of RH control via temperature driven sample stack using the 3 meter stack as the standard configuration for ambient monitoring. Typical installation will control RH to maximum levels of 40% prior to control via temperature manipulation of the sample stack. Data capture can be configured at 0-5 VDC with a range of 0-1000 ug/m3, the preferred method of data capture will be digital via serial communication link.

Operational and Maintenance Requirements

The following activities must be performed when operating a continuous SHARP 5030 monitor in Alberta. Maintenance schedules such as filter tape change and cyclone inlet cleaning need to be developed for each individual site. There are sites with heavy PM concentrations that require more frequent service. All operational activities conducted at any ambient monitoring station, must be documented in the station logbook, and/or station checklists. This allows other operators to access a history of the station if the regular technician is not available. The following documentation must be available to the operators on site: operational and maintenance manual(s), quality system manual and station site documentation. Cyclone at minimum is cleaned monthly or during audit cycles.

Operational Checks

The analyzer monitors and displays test functions in order for the operator to monitor the performance of specific systems within the analyzer. These test parameters should be monitored during scheduled station calibrations and recorded.

System Leak Check

The system leak check should be completed every month following the manufacturers instructions laid out in the operations manual.

Sample Filter Tape Change

Filter tape should be monitored to ensure there is adequate tape on the feed reel to last until the next visit. Change immediately if the feed reel is empty. The tape should be replaced approximately every 6 – 9 months however, if heavy loading is occurring this frequency may need to be increased.

Inlet Head Cleaning

The sample fractioning head must be kept clean on a regular basis to avoid poor cut points as described in interferences. If the system is set up to monitor $PM_{2.5}$, both heads must be cleaned. Clean the heads as per the instructions found in the operations manual. They must be dismantled and cleaned with water only. To dry, blow clean dry compressed air on the wetted surfaces to avoid any contamination.

The frequency of inlet head cleaning must be at least monthly or every filter change, whichever is the shorter period of time.

Sample Tube Cleaning

Other components of the inlet system, mainly the main sample tubes, need to be cleaned on a periodic basis as well. Fine particulates will build up on the walls of these tubes and potentially cause erroneous readings. This procedure should be completed once per year or as per manufacturer if recommended frequency is less than one year. Follow the instructions in the manufacturer's operations manual.

Temperature and Humidity Verification

As the SHARP 5030 is reliant on the temperature and humidy sensors to accurately monitor and measure particulate matter it is part of a continuous maintenance schedule to verify and even calibrate the temperature and humidity sensors. Refer to the instructions in the manufacturer's operations manual.

Pump Overhaul

The vacuum pump needs to be rebuilt on a periodic basis in order to maintain the required vacuum for proper operation of the monitor. This procedure should be completed at least once per year, or more frequently as required.

Calibration Requirement

Full calibrations should be conducted as per manual guidance, and include the following:

1. Full flow calibration
2. Leak check verification
3. Temperature and relative humidity calibration
4. Foil calibration of the beta attenuation monitor
5. Zero reference of the nephelometer

Upon completion of the calibration all analyzer settings should be digitally collected and stored at the site for reference.

Data Collection and Management

Where possible the PM should be configured to interrogate and gather the signal via serial communications. This will ensure data capture continues in the event of high readings outside of the set range. If using the analog output of the SHARP 5030 PM_{10} and $PM_{2.5}$ monitor wire the analog input channels of the station Campbell's Scientific CR3000 Micro Logger. This data will be averaged over 5 minute intervals and is then polled remotely via cellular modem. It is a best practice to down load all the data filed into a separate storage device monthly to ensure data is backed up.

Reference Documents

- MODEL 5030 INSTRUCTION MANUAL, SYNCHRONIZED HYBRID AMBIENT REAL-TIME PARTICULATE MONITOR, Thermo Fisher Scientific Inc, 27 Forge Parkway, Franklin, Ma 2007
- Canada Wide Standard (CWS) “Guidance Document on Achievement Determination-Canada Wide Standards for Particulate Matter and Ozone” 2000 and 2007 Amendments