| Title: Standard Operating Procedure for Elemental and Organic Carbon (EC and OC) using Non-Dispersive Infrared Detection (NDIR) | | |
|---|---|---|
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## 1. INTRODUCTION AND SCOPE

To obtain timely data for the purpose of air quality assessment, air quality trend reporting and to meet the requirements for inclusion of the data in provincial and national air quality databases, a continuous method of analyzing Elemental and Organic Carbon concentration in ambient air samples is used. This method is capable of measurement updates at a rate of once every three hours or faster. A collection period from 1 to 12 hours can be specified by the operator. Readings from instruments of this method enables the calculation of hourly/multi-hourly averaged concentrations of Elemental and Organic Carbon. Commercially available Elemental and Organic Carbon analyzers are used in the method.

This method is applicable to the measurement of Elemental and Organic Carbon concentration in ambient air in the range of 0 - 50 micrograms per cubic meter (µg/$m^3$) to 0 - 500 µg/$m^3$.

This method adheres to the requirements of the current Air Monitoring Directive (AMD) drafted by Alberta Environment in 1989 where applicable since this technology is not included in the AMD. In some cases the limits and specifications exceed the requirements of the current AMD and subsequent amendments. It should be considered that the current and any future amendments or drafts of the AMD will be used as the benchmark for requirements and criteria for ambient air monitoring practices conducted in the Province of Alberta. Information used to write this procedure was also taken from sources identified in the reference section.

## 2. PRINCIPLE OF THE METHOD

The method employs direct measurement to determine the concentration of elemental and organic carbon in particulate matter, in the PM 2.5 fraction, suspended in ambient air. The instrument cycle is made up of two phases: (i) a collection phase during which sample is gathered in a collector, and (ii) an analysis phase during which the collected matter is oxidized and the carbon content is quantified. Using a non-dispersive infrared (NDIR) $CO_2$ detector, the instrument measures the amount of $CO_2$ released when the sample is oxidized at elevated temperatures. The value obtained bears a direct relationship to the amount of carbon oxidized in the collector, and is used together with the volume sampled to determine the concentration of carbon in ambient air (ug/$m^3$) during the sampling period. To provide continuous sampling the instrument contains two collectors where simultaneously one is in the collection phase while the other is in the

analysis phase. The sampling flow rate is 16.7 L/min. which allows the use of a range of size selective inlets.

As part of the analysis phase of the instrument cycle, a closed loop is formed which includes the collector containing the particulate sample, afterburner, circulating pump and NDIR $CO_2$ detector. Initially the instrument measures the $CO_2$ concentration in the closed loop as a reference for later measurements. The organic carbon component of the sample is measured by raising the temperature of the collector to 340°C during which the instrument measures the $CO_2$ concentration in the analysis loop. The elemental carbon component of the sample is then quantified by raising the temperature of the collector to 750°C while the instrument measures the $CO_2$ concentration in the analysis loop. The instrument may also be used to provide a snapshot of the $CO_2$ ambient concentration if outdoor ambient air is used in the purge cycle.

## 3. MEASUREMENT RANGE AND SENSITIVITY

The Elemental and Organic Carbon analyzers used in this method are commercially available models. The measurement range is selectable at 0 - 50 micrograms per cubic meter (µg/m$^{3)}$ to 0 - 500 µg/m$^3$.

The detection limit of the analyzer is specified by the manufacturer. Generally it is at the 2.0 µg/m$^3$ level.

## 4. EQUIPMENT AND APPARATUS

The following commercial analyzer is suitable for use in this method R&P Series 5400 Ambient Carbon Particulate Monitor

## 5. INTERFERENCES

The Elemental and Organic Carbon analyzer used by AENV requires 240 VAC power to operate properly. If this power requirement is not met, the afterburner temperature will not attain its set point. Units operating from a 120 VAC are now also available.

## 6. PRECISION AND ACCURACY

The measurement precision of the particular model of the analyzer is established by the manufacturer. 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 standards such as available from the National Institute of Standards and Technology (NIST).

## 7. SITE REQUIREMENTS

Site location of the Elemental and Organic Carbon monitoring station in an urban area should be determined according to the intended application of the monitoring data. Detailed requirements for selection of sites for monitoring ambient Elemental and Organic Carbon are similar to those for the Canada Wide Standard (CWS) determination which can be found in, "Guidance Document on Achievement Determination-Canada Wide Standards for Particulate Matter and Ozone". Requirements for the immediate surroundings of the site can be found in the AMD.

## 8. INSTALLATION REQUIREMENTS

All the installation requirements as specified by the manufacturer in the installation procedures as well as the general requirements below must be followed.

Trees and vegetation can affect the collection of ambient Elemental and Organic Carbon. To minimize this effect, the distance between the sample inlet probe of the Elemental and Organic Carbon analyzer and the drip line of the tree must be at least twice the height of the tree above the inlet probe or at least 10 metres away whichever is greater.

Other spacing requirements for the inlet probe such as: distance from roads; height above ground; distance from obstructions and distance from horizontal or vertical support are as followed.

| | |
|---|---|
| Height above ground | 2 to 15 metres |
| Distance from support structure | > 1 metre |
| Distance from any air flow obstacle, i.e. buildings | > 2×height of obstacle above the inlet |
| Airflow obstructions | Unobstructed airflow in all directions for more than 2 metres |

All connectors and fittings used in the sampling system are made of stainless steel or Teflon.

A data acquisition system (DAS) should be connected to the analyzer to record or download the signal output from the analyzer. For connection to record analog voltage signals, the system should be set to match the voltage range of the analyzer output. Generally this is 1V or 10V full scale and is scaled to convert the output signal to the concentration range outlined in section 3. See the DAS operations manual for instructions on configuring these channels.

The monitoring station temperature should be controlled within the range of 15 to 30°C. It is important to note that the analyzer will operate properly at any temperature within this range; however, the stability of the station temperature is most important.

## 9. OPERATIONAL REQUIREMENTS

The following activities must be performed when operating a continuous automated Elemental and Organic Carbon analyzer in Alberta. 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.

## Analyzer Operational Requirements

| Action | Time and Frequency | Procedure | Documentation | Action by |
|---|---|---|---|---|
| Set analyzer and data system range (500 µg/m$^3$) | After installation | As per manufacturer's manual | Entry to log book | Station operator |
| Zero and span verification | Minimum weekly | As per manufacturer's manual | Entry to log book | Station operator |
| Verification of operational parameters | Weekly | As per manufacturer's manual | Entry to log book | Station operator |
| Analyzer maintenance | As recommended by manufacturer | As per manufacturer's manual | Entry to log book and Work Orders | Station operator or Instrument Technicians |
| Clean inlet lines | As required | Replacement with new lines | Entry to log book | Station operator |
| Calibration | After installation or repair and as required thereafter | See section 10.0 | Entry to log book; report to network manager | Instrument Technicians |

Four types of calibration/verification procedures can be conducted on the Elemental and Organic Carbon analyzer, these are:

- Complete calibration of the analyzer (9 step procedure).
- Audit or verification procedure (5 step procedure).
- Calibration procedure (5 step procedure).
- Weekly verification (3 step procedure).

All procedures are documented in the R&P SERIES 5400 Manual in Section 10 and must be followed step by step in order to accomplish them properly. The calibration

procedures listed below identify the individual procedures recommended for each type of calibration.

COMPLETE ANALYZER CALIBRATION - ANNUALLY

| Task | Audit/Calibration Procedure | Service Manual Section |
|---|---|---|
| 1 | Analog I/O Calibration - Software | 3.1 |
| 2 | Analog I/O Calibration - Hardware | 3.2 |
| 3 | Collection Path Leak Test | 3.3 |
| 4 | Flow Audit | 3.4 |
| 5 | Flow Meter Calibration | 3.5 |
| 6 | Analysis Loop Leak Test | 3.6 |
| 7 | Temperature Circuit Calibration | 3.7 |
| 8 | CO2 Calibration - Automatic | 3.8 – F2 |
| 9 | Storage of Calibration Data | 3.12 |

AUDIT or CALIBRATION VERIFICATION - WEEKLY

| Task | Audit/Calibration Procedure | Service Manual Section |
|---|---|---|
| 1 | Collection Path Leak Check | 3.3 |
| 2 | Flow Audit | 3.4 |
| 3 | Analysis Loop Leak Check | 3.6 |
| 4 | 1st CO2 Calibration – Audit | 3.8 – F3 |
| 5 | 2nd CO2 Calibration - Audit | 3.8 –F3 |

CALIBRATION PROCEDURE - QUARTERLY

| Task | Audit/Calibration Procedure | Service Manual Section |
|---|---|---|
| 1 | Analog I/O Calibration – Software | 3.1 |
| 2 | Analog I/O Calibration - Hardware | 3.2 |

| | | |
|---|---|---|
| 3 | Flow Meter Calibration | 3.5 |
| 4 | Temperature Calibration | 3.7 |
| 5 | Storage of Data Calibration | 3.12 |

VERIFICATION PROCEDURE - WEEKLY

| Task | Audit/Calibration Procedure | Service Manual Section |
|---|---|---|
| 1 | Maximum Flow Test | 3.24 |
| 2 | Analysis Loop Leak Test | 3.6 |
| 3 | $CO_2$ Audit | 3.8 – F3 |

## 10. CALIBRATION

Before calibration work is done, verify that the flow system from the intake manifold to the analyzer inlet is intact by visually checking the integrity of the tubing for cracks or holes. Check the connections visually and by hand for tightness.

Calibration Equipment:

- Calibration gas cylinders: $CO_2$ free air, low concentration $CO_2$ (e.g., 400 ppm ± 1%), high concentration $CO_2$ (e.g., 2500 ppm ± 1%).
- Low pressure regulators for each of the three gas cylinders
- Primary flow measurement standard.
- Voltmeter

Before a calibration takes place ensure that the data acquisition system is off line so that the output will not be included in the hourly or daily averages. Conduct the appropriate calibration and document responses. Attach a label at a visible location on the instrument indicating the date of most recent calibration.

## 11. APPLICABLE DOCUMENTS

- **EM-025a** Rupprecht & Patashnick Series 5400 Ambient Carbon Particulate Monitor Operating Manual

## 12. LITERATURE REFERENCES


- Standard Operating Procedure for Routine Operation of the R&P Series 5400 Ambient Carbon Particulate Monitor in CRPAQS STI-999214 Sonoma Technology, Inc. April 2001 http://www.arb.ca.gov/airways/crpaqs/STI/AppA4.pdf
- "Guidance Document on Achievement Determination-Canada Wide Standards for Particulate Matter and Ozone". ISBN: 1-896997-41-4 PN 1330, October 2002, Canadian Council of Ministers of the Environment.
- Quality Assurance and Quality Control Guidelines - National Air Pollution Surveillance Network Report Series No. AAQD 2004-1


## 13. REVISION HISTORY

Revision 1.0 Section 1, reference to AMD where applicable

## 14. APPROVAL

**Approved by:** **Harry Benders** **Date: January 21, 2011**

**Title:** **Air Monitoring Manager**