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WBEA – Standard Operating Procedure			
SOP Title		Procedures for operating continuous Carbon Monoxide (CO) analyzers	
SOP Number		WBEA SOP-ANA-007 CO	
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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 Carbon Monoxide (CO) 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

Principle of the Method

The continuous Carbon Monoxide (CO) Analyzer measures the amount of infrared light absorbed by CO in a sample of ambient air. The quantity of light absorbed is proportional to the concentration of CO in the air sample. A detailed discussion of the analyzer's measurement principle is contained in the Manufacturer's Instruction Manual. This procedure supplements the Manufacturer's Manual with instructions specific to the local requirements for operating the analyzer.


The analyzer determines the concentrations of CO in ambient air by passing non-dispersive single beam infrared (IR) radiation through a rotating gas filter wheel to the sample cell and then the detector. The wheel contains two different entrapped gases: CO and nitrogen. The CO side of the wheel acts to produce a reference beam which cannot be further affected by CO in the sample cell. The nitrogen side of the filter wheel is transparent to the IR radiation and therefore produces a measure beam which can be absorbed by CO linear to the CO concentration. The detector converts the light to electrical energy, and the signal processing electronic system manipulates the electrical information and displays the CO concentration.

Measurement Range and Sensitivity

The CO analyzers used in this method are commercially available models. The measurement range is user selectable at ranges between 0 to 1000 parts per million by volume (ppm). The typical range selection used within the WBEA network is 0 to 50 ppm.

The detection limit of the analyzer is specified by the manufacturer and specific settings applied to the analyzer when placed in the field. This is also governed by the noise level of the output signal, whether analog or digital. Two times the noise level is generally accepted as the lower detectable limit (LDL); generally it is at the 0.05 ppm level. The health of the analyzer is important as poor health = higher noise = higher LDL.

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Equipment and Apparatus

CO analyzers used in the WBEA network include:

- Thermo Environmental Instruments – model 48C analyzer

Carbon Monoxide analyzers in use are all EPA approved and AMD compliant monitors. This does not exclude the use of other equipment that has received the USEPA Reference and Equivalent Method designation.

Interferences

Other gases do not cause modulation of the detector signal since they absorb the reference and measure beams equally. Thus the Gas Filter Correlation (GFC) system responds specifically to CO.

Particulate matter present in the measurement cell or sample lines may interfere with analyzer response. This problem is normally eliminated by using a particle filter of 5.0µm pore size made of inert material, such as Teflon, at the sample inlet of the instrument.

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 span checks and monthly calibrations.

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). As with precision, accuracy is confirmed by the daily span and monthly calibration checks. Refer to the sections identified above for further information on accuracy relating to calibration and audit procedures.

Site Requirements

All CO analyzers are housed in a temperature controlled ambient air monitoring shelter in a standard instrument rack. Sample air is brought into the shelter using a glass sample inlet system and made available to the CO analyzer. The station is sited according to appendix A-2, Station Site Criteria section of the AMD.

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Site location for CO monitoring should be determined according to the intended application of the monitoring data. Detailed requirements for selection of sites for monitoring ambient CO can be found in “Selecting Sites for Carbon Monoxide Monitoring” EPA-450/3-75-07.

Installation Requirements


All the installation requirements are specified by the manufacturer in the installation procedures of the manual. General requirements listed below must also be followed:

- The ¼ inch outside diameter connection tubing from the manifold to the analyzer inlet must be made of Teflon or equivalent material for chemical inertness.
- A Teflon particulate filter with a pore size of no larger than 5.0µm must be placed in the sampling line before the air sample enters the detection cells and is recommended to be located as close as possible to the inlet manifold. The holder for such filter must also be made of Teflon, Stainless Steel or Delrin.
- 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. In the WBEA network the standard is 5V full scale and is scaled to convert the output signal to the concentration range outlined in section 3. For serial or LAN connection there must be a station router in place and configurations made to the analyzer settings, the router, and the data logger. 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.
- The analyzer has the capability to output specific alarms or a general alarm via a contact closure. These outputs are connected to the digital input section of the DAS. See the DAS operations manual for instructions on configuring these channels.
- Range Set – the typical range used for monitoring CO is 0 to 50.0 ppm. This is done as soon as the analyzer is powered up after installation. Refer to the operations manual for instructions on this procedure.

Operational and Maintenance Requirements

The following activities must be performed when operating a continuous automated Gas Filter Correlation CO analyzer in the WBEA network. All operational activities conducted at any ambient monitoring station must be documented in the Doc-It system. This allows other operators to access a history of the station if the regular technician is not available. The following documentation must be

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available to the operators on site: operational and maintenance manual(s), quality system manual and station site documentation.

Daily Requirements

Zero/Span Check – a zero/span cycle is required every day to verify the analyzer’s performance. This involves diverting the sample flow of the analyzer so that the analyzer subsequently samples zero air for the zero cycle and air with a known amount of CO for the span cycle. . These two sources are provided by the in-situ calibration system. A zero air point of dilution air only is generated through a saved sequence in the calibrator, and span is generated by a saved calibration point in the calibrator, typically the high point of the routine multipoint calibration sequence. This cycle is controlled by the data system in the station, as it also flags the collected data as calibration and not sample data. During the daily zero/span cycle WBEA runs zero for twenty minutes to ensure stability, followed by a twenty minute span. The remaining twenty minutes of the hour is flagged down to allow the analyzer to return to ambient air prior to collecting valid data again. Refer to the analyzer manual for more information.

Analyzer Test Parameters

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 recorded digitally via DAS collection or documented on calibration reports.

Inlet Filter Change

The sample inlet filter is typically replaced when the monthly multipoint calibration is being done. The filter change is completed after the as found points have been completed and before the multipoint calibration is carried out. This is done to establish a reference prior to the removal of the filter.


Analyzer Maintenance

Preventative maintenance tasks should be completed on the analyzer on a periodic basis. These tasks are outlined in the operations manual. A strict regiment of these tasks should be adhered to as they are intended to fix a problem before it happens. Any maintenance must be recorded in the Doc-It system. This is also recorded in the instrument log that accompanies each instrument.

Multipoint Calibration

Multipoint calibrations are conducted on the CO analyzer to verify precision, accuracy and linearity of the instrument. This procedure must be completed after the analyzer has been installed following at least a 24 hour warm up period, prior to removal, and monthly to comply with Alberta Environment regulations. This procedure is also completed after any major maintenance to confirm the precision and accuracy after repairs.

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Analyzer Audit

CO analyzers operating in Alberta are required to undergo an on-site audit once per year. This audit involves the Alberta Environment Audit Program staff visiting the site with the NIST traceable standards to verify the accuracy and linearity of the instrument.

Calibration Requirement

The calibration procedure for CO analyzers is similar to calibration of other continuous ambient air analyzers. This procedure involves generating a known amount of CO, which is introduced to the analyzer to verify its performance. There are certain specifics to the CO calibration that are identified in this section. The main calibration procedure can be referenced in WBEA SOP-OPS-002 Dilution Calibration Procedure.


- Three upscale points must be used, spaced approximately 15%, 30% and 60% of full scale as well as minimum of a single zero point from a separate zero air source.
- Calibration results must be graphed as indicated concentrations (C_i) versus calculated concentrations (C_c) from which the slope of the graph, the intercept and final correction coefficient are calculated.
- The acceptance criteria are slope of 1.0, ± 0.05 , and intercept of $\pm 3\%$ full scale and a coefficient of correlation (CC) > 0.995 .
- A zero/span check cycle is run through the DAS following the calibration to verify the span values and to pick up and zero offset.
- A recorded trace of the instrument, response over time is required to demonstrate stability and accuracy.

Data Collection and Management

The analog output of the ozone analyzer is typically wired to the analog input channels of the station Campbell's Scientific CR3000 data logger. This data recorded at 5 minute intervals and is then polled remotely via cellular modem. Alternatively the data can be polled digitally via the serial or Ethernet port, and can be accompanied by the diagnostic or meta-data information.

Reference Documents

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- Thermo Environmental Instruments (TEI) Models 48, 48C, 48CLT CO Analyzer Operating Manual
- State of California Air Resources Board (CARB) Method Volume II Standard Operating Procedures for Air Quality Monitoring Appendix Y dated April 1996
- Selecting Sites for Carbon Monoxide Monitoring EPA-450/3-75-07