CONTINUOUS EMISSION MONITORING SYSTEM (CEMS) CODE

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CONTINUOUS EMISSION MONITORING SYSTEM

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1.0 INTRODUCTION

1.1 General

This code establishes requirements for the installation, operation, maintenance, and certification of continuous emission monitoring systems. These requirements will ensure effective measurement, recording, and standardized reporting of specified emissions and other parameters. In addition, the code establishes requirements for alternative monitoring systems and for the quality assurance and quality control of continuous emission monitoring data.

1.2 Purpose and Intent

Approvals issued under the Environmental Protection and Enhancement Act (EPEA) may require continuous emissions monitoring on an effluent source. The Alberta Continuous Emission Monitoring System (CEMS) Code, hereafter referred to as the "CEMS Code," identifies acceptable methods and specifications for the installation and operation of such monitoring systems.

The Alberta CEMS Code is largely based on methodology developed and used by both the U.S. Environmental Protection Agency and Environment Canada.

The CEMS Code contains performance specifications for the majority of CEM system requirements that are referenced in facility approvals. For those CEM systems for which specifications are not included in this code, new methods will be incorporated into the CEMS Code as they are developed.

The final decision on any matter dealing with the CEMS Code rests with the Director of Air and Water Approvals, hereafter referred to as the "Director," in Alberta Environmental Protection.

1.3 CEMS Data Use

All data generated by a CEMS (where the use of that CEMS is linked to the EPEA approval for its associated facility) can be used as a basis for enforcement. Exceptions include in-stack opacity data except as noted otherwise or data specified in the approval as not useable for compliance. These other CEMS data would be used only to fulfil performance assessment requirements. For the purposes of this Code, opacity and in-stack opacity are defined differently and are not equivalent.

Within the thermal electric power generating industry, in-stack opacity limits for start-up and shutdown have been established and CEMS generated data for this industry can be used as a basis for compliance.

For opacity, the "visible emissions reader" will continue to be the only official compliance method for determining opacity levels as currently referenced in the Substance Release Regulation. In the event that this compliance requirement changes, the "Director," will provide a minimum advance notice of at least two years of the intent to implement in-stack opacity CEMS as compliance monitors (except as already noted above). This transition period would allow sufficient lead time for implementation of any required equipment changes to in-stack opacity monitors.

1.4 Implementation

The CEMS Code applies to all facilities where continuous emission monitoring is a condition of an EPEA approval.

The requirements in the CEMS Code come into effect on January 1, 1999.

1.5 Application of CEMS Code to Existing and New CEMS Installations

1.5.1 Code Requirements for Existing Installations

A number of facilities, approved prior to the issuance of this CEMS Code, may have CEMS that do not fully comply with the CEMS Code with respect to either of the following, namely: (a) installation requirements; or (b) equipment required to conduct various quality control procedures (for example, calibration gas may not be introducible at the proper location in some of the older designs, etc.).

Each facility shall assess (within 6 months of this code coming into effect or alternatively according to a schedule agreed to by the Director), on the basis of technical merit, whether CEMS operational and performance specification requirements (as specified in Section 4) can be achieved with the existing configuration. This assessment is to ensure that the facility's CEMS can meet CEMS Code performance specification requirements. If the CEMS can meet these requirements, then no further action would be required; if not, then the facility shall establish a program, acceptable to Alberta Environmental Protection, to upgrade the CEMS installation so it meets performance specification requirements.

Replacement of the existing data handling system associated with a CEMS will not require that initial performance specification testing requirements be conducted; however, the Quality Assurance Plan (QAP) for the facility should detail the appropriate quality control procedures to ensure data quality of the new data acquisition system.

Facilities for which installation received approval prior to the effective date of the CEMS Code are still required to meet ongoing Quality Assurance/Quality Control (QA/QC) requirements as specified in the code.

1.5.2 Code Requirements for New Installations

All new CEMS required after the issuance of this Code must comply with all design, installation, performance, and quality control requirements of this Code. All new CEMS will be required to conduct the initial performance specification testing as contained in this CEMS Code and be certified in accordance with Section 4.0 of this code.

1.6 CEMS Technology

In general, monitoring techniques are based on the direct measurement of both physical and chemical properties of the component of interest. The method selected for the gas analysis depends primarily upon the characteristics of the subject gas, but it can also be affected by other parameters such as regulatory requirements and stack conditions. Commonly used analytical techniques include those of spectroscopic absorption, luminescence, electroanalysis, electro-chemical analysis and paramagnetism.

The specifications of this Code address the use of independent, certified gases for calibration and audit for CEMS that accept calibration gases. The Director reserves the right to review

CEMS that do not accept independent, certified gases for calibration or audit. Alternative methods of calibration will be authorized if equivalent performance to gas calibrated systems can be demonstrated.

The Director also reserves the right to review proposed indirect monitoring systems that use operating parameters correlated to emissions. Such "parameter" or "predictive" emission monitoring systems must be validated initially for the range of operating and control conditions likely to occur at the facility. Parameter and predictive emission monitoring systems must also provide for a method of daily validation that results in continuous performance equivalent to that of gas calibrated CEMS.

1.7 Endorsement

Alberta Environmental Protection does not endorse specific CEMS equipment, alternative methods, or equipment suppliers. No list of approved equipment will be maintained by Alberta Environmental Protection.

1.8 CEMS Data Retention Requirements

Each facility shall maintain "raw" data for a period of at least 3 years and "summary" data for a period of at least 10 years. "Raw" data must be consistent with the definition of continuous as defined in Appendix A and should provide for "satisfactory demonstration" of quality control activities as defined in the CEMS Code and the facility Quality Assurance Plan (QAP). The media for storage of "raw" data shall be designated by the facility and documented in the facility QAP. Raw data shall be made available for inspection if requested by Alberta Environmental Protection.

1.9 Monitoring Plan

For new installations, the following information regarding the CEM system must be submitted to the Director at least sixty (60) days prior to system installation : [1]

A. Describe in general terms the process(es) and pollution control equipment, along with all factors that may affect the operation of the monitoring system.

B. Describe the location of the monitoring system/sample acquisition point(s) or path(s) in relation to flow disturbances (fans, elbows, inlets, outlets), pollution control equipment, flue walls, and emission point of the monitored effluent streams to the atmosphere. Explain any deviations from the location criteria that are specified in Section 3.0.

C. List the following system information:

- pollutant(s) or parameters to be monitored,
- the operating principles of the analyzer(s),
- the number of analyzers, and the number of acquisition point(s) or path(s) for a analyzer, or bank of analysers sharing multiple ducts (time sharing systems),
- the equipment manufacturer and model number(s),
- a copy of the checklist to be used by the instrument technician for periodic checking of the analyzer(s), and
- the expected normal and maximum analyzer or flow rate readings.

D. Describe the process and pollution control equipment operating parameters that affect the emission levels of the pollutants being monitored or the parameters being monitored, and also explain the method to be used to record these parameters.

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[1] The listed information requirements may be included as part of the QAP. It is not necessary to duplicate this information elsewhere.

E. Describe calibration, operational and maintenance procedures, along with recommended schedules.

F. Explain procedures to be used to satisfy the requirements for record keeping as defined by the Director.

2.0 DESIGN SPECIFICATIONS

Continuous Emission Monitoring Systems for monitoring gases consists of the following four subsystems:

- Sample Interface/Conditioning;
- Gas Analyzers;
- Data Acquisition;
- Flow monitor (where applicable).

The acceptability of emission monitoring systems is in general, performance based; however minimal design specifications are specified for gas analyzers, in-stack opacity monitors, and flow monitoring systems. These specifications have been established either to ensure the overall stability of the CEMS once the analyzers are incorporated into the system, or to ensure that accurate readings will be obtained for the parameter being measured. Procedures for the verification of design specifications are given in Section 4.0.

Unless otherwise authorized by the Director, the chosen range of each monitor is specified in Tables 1 to 4. If the average monthly parameter of any analyzer should fall outside these limits, the analyzer span should be adjusted so that the average is brought back within these limits. If emission values vary widely, the use of multi-range analyzers is encouraged. Data that fall outside the range of an analyzer are considered to be missing.

2.1 Design Specifications for Gas Analyzers

Design specifications for gas analyzers for monitoring sulphur dioxide, oxides of nitrogen, and carbon monoxide are given in Table 1.

Table 1 Design Specifications for CEM system gas analyzers

Design Specifications	Sulphur Dioxide Analyzers	Oxides of Nitrogen Analyzers	Carbon Monoxide Analyzers
Lower detection limit	$\leq$ 2% of span	$\leq$ 2% of span	$\leq$ 2% of span
Interference rejection (sum total)	$\leq \pm$ 4% of span	$\leq \pm$ 4% of span	$\leq \pm$ 4% of span
Response time (95%)	200 s (Max.)	200 s (Max.)	200 s (Max.)
Analyzer range	1.5 times approval limit		
Temperature-responsive zero drift[a]	$\leq \pm$ 2% of span	$\leq \pm$ 2% of span	$\leq \pm$ 2% of span
Temperature-responsive span drift[a]	$\leq \pm$ 3% of span	$\leq \pm$ 4% of span	$\leq \pm$ 3% of span

[a] for every 10°C change in analyzer operating temperature.

Table 2 Design Specifications for Total Reduced Sulfur analyzers

Design Specification	TRS Analyzer
Lower detection limit	$\leq$ 2% of span
Interference rejection (sum total)	$\leq \pm$ 4% of span
Response time (95%) and cycle time	15 minutes (Max.)
Analyzer range	1.5 times approval limit or 30 ppm whichever is the greater

Design specifications for oxygen and carbon dioxide (diluent) monitors are given in Table 3.

Table 3 Design Specifications for diluent monitors

Design Specification	0_2 Analyzers	CO_2 Analyzers
Lower detection limit	$\leq$ 0.5% 0_2	$\leq$ 0.5% $C0_2$
Interference rejection	$\leq \pm$ 1.0% 0_2	$\leq \pm$ 1.0% $C0_2$
Response time (95%)	200s (Max.)	200s (Max.)
Analyzer range	0 - 21%	0 - 25%
Temperature-responsive zero drift[a]	$\leq \pm$ 0.5% 0_2	$\leq \pm$ 0.5% 0_2
Temperature-responsive span drift[a]	$\leq \pm$ 0.5% 0_2	$\leq \pm$ 0.5% 0_2

[a] for every 10°C change in analyzer operating temperature.

2.1.1 Interference Rejection
Each analyzer shall exhibit a response of less than that specified in Tables 1 to 3 for the sum of all interferences due to other gas constituents as measured by the procedures given in Section 4.0.

2.1.2 Temperature-Responsive Drifts
Each pollutant or diluent gas analyzer used in the system must exhibit a zero drift less than 2% of the full-scale setting for any 10°C change over the temperature range of 5° to 35°C. Additionally, each analyzer must exhibit a span drift of less than 3 or 4% of the full-scale setting for any 10°C change in temperature from 5° to 35°C. Both the zero and span drift tests are to be carried out within the acceptable temperature operating range of the analyzer, as specified by the manufacturer. Follow the procedures outlined in Section 4.4.2 or alternatively confirm that Section 4.4.3 has been complied with to determine the temperature-responsive drift.

2.1.3 Cycle-time/Response Time
The cycle-time/response-time specification applies to systems, as opposed to analyzers. One complete measurement or cycle of measurements of all effluent streams must be completed in 15 minutes or less.

2.2 Design Specifications for In-Stack Opacity Monitors

Design Specifications for in-stack opacity monitors are given in Table 4.
These specifications establish specific design criteria for the in-stack opacity monitoring system.

Table 4 In-Stack Opacity Monitor Design specifications

Design Specification	In-Stack Opacity Monitors
Spectral response	Photopic
Angle to view	$\leq 5°$
Angle of projection	$\leq 5°$
Response time	10 sec (Max.)
Range	0 - 100%
Temperature-Responsive zero drift[a]	2% opacity
Temperature-Responsive span drift[a]	2% opacity
Physical design	a. Simulated zero and upscale calibration system b. Access to external optics c. Automatic zero compensation d. External calibration filter access e. Optical alignment sight

[a] for every 10°C change in analyzer operating temperature

Alternatively, a certificate of conformance stating that the in-stack opacity monitor meets the design specifications of the U.S. EPA given in 40 CFR 60 Appendix B - Performance Specification 1, obtained from the manufacturer would be acceptable to the Director.

Then, the in-stack opacity monitor is calibrated, installed, and operated for a specified length of time. During this specified time period, the system is evaluated to determine conformance with the established performance specifications given in Section 4.0 of this Code.

2.2.1 Peak and Mean Spectral Responses

The peak and mean spectral responses must occur between 500 nm and 600 nm. The response at any wavelength below 400 nm or above 700 nm shall be less than 10% of the peak spectral response.

2.2.2 Angle of View

The total angle of view shall be no greater than 5 degrees.

2.2.3 Angle of Projection

The total angle of projection shall be no greater than 5 degrees.

2.2.4 Simulated zero and upscale calibration system
Each analyzer must include a calibration system for simulating a zero in-stack opacity and an upscale in-stack opacity value for the purpose of performing periodic checks of the monitor calibration while on an operating stack or duct. This calibration system will provide, as a minimum, a system check of the analyzer internal optics and all electronic circuitry including the lamp and photodetector assembly.

2.2.5 Access to external optics
Each analyzer must provide a means of access to the optical surfaces exposed to the effluent stream in order to permit the surfaces to be cleaned without requiring removal of the unit from the source mounting or without requiring optical realignment of the unit.

2.2.6 Automatic zero compensation
If the system has a feature that provides automatic zero compensation for dust accumulation on exposed optical surfaces, the system must also provide some means of indicating when a compensation of 4% in-stack opacity has been exceeded.

2.2.7 External calibration filter access
The monitor must provide a design that accommodates the use of an external calibration filter to assess monitor operation.

2.2.8 Optical Alignment sight
Each analyzer must provide some method for visually determining that the instrument is optically aligned. The method provided must be capable of indicating that the unit is misaligned when an error of ± 2 percent in-stack opacity occurs due to misalignment at a monitor pathlength of 8 metres.

2.3 Design Specifications for Flow Monitors

Design specifications for flow monitors are given in Table 5.

Table 5 Flow Monitor Design specifications

Design Specification	Flow Monitors
Lower detection limit	1.0 m/sec
Range	1.5 times expected max. value
Response time (95%)	10 sec (Max.)
Physical design	a. Means of cleaning flow element b. No interference from moisture

2.3.1 Cleaning

If necessary, differential pressure flow monitors shall provide an automatic, timed period of backpurging or equivalent method of sufficient force and frequency to keep the sample port and probe and lines free of obstructions. Differential pressure flow monitors shall provide a method (either manual or automated) for detecting leaks or plugging throughout the system. Thermal flow monitors and ultrasonic monitors shall provide a method for detecting probe fouling and a means of cleaning the transducer surface in situ or by removal and cleaning.

2.3.2 Calibration
The entire flow monitoring system including the flow probe or equivalent and including the data acquisition and handling system shall be calibrated as per the requirements contained in Table 16.

2.4 Design Specifications for Temperature Sensors

Table 6. Temperature sensor design specifications.

Design Specification	Temperature Sensors
Response time (95%)	60 sec (Max.)
Range	1.5 times approval limit

2.5 Specifications for the Data Acquisition System

2.5.1 General
The CEMS shall include a data acquisition system that accepts the output of the analyzers and flow monitors (where applicable) and converts these to emission rates of the gaseous pollutants in appropriate units as specified in the facility approval. These systems shall be capable of interpreting and converting the individual output signals from each monitor to produce a continuous readout in appropriate units as specified in the facility approval. Where diluent emissions are measured with a CEMS, the data acquisition system shall also be capable of producing a readout in appropriate units as specified in the facility approval.

The system shall maintain a permanent record of all parameters in a format acceptable to the Director.

The system must also record and compute daily zero and span drifts (as specified in Table 16), and provide for backfilling and substitution for missing data, if required by an approval.

Automated data acquisition and handling systems shall:

1. read and record the full range of pollutant concentrations from zero through to span, and
2. provide a continuous, permanent record.

Data shall be reduced to valid one-hour averages and shall be computed from four (4) or more values equally spaced or averaged over each one-hour period and in accordance with the definition of a “valid hour” as defined in Appendix A.

During each 24 hour period, one, one-hour average may consist of a minimum of two (2) data points (representing 30 minutes of data) to allow for calibration, quality assurance activities, maintenance, or repairs. If this minimum data accumulation is not achieved, the hour will be counted as missing data for the purposes of calculating availability.

2.5.2 Data Recorder Resolution
Data recorder hard copy resolution for system response shall be ±0.5% of full scale or better. Data recorder hard copy time resolution shall be 1 minute or less.

2.5.3 Availability

The percentage availability for the system and each analyzer shall be calculated monthly either by the data acquisition system or manually, using the following equation:

$$\% \text{ Availability (System or Analyzer)} = \frac{T_a}{T} \times 100$$

where:

T_a = the time in hours during which the system or analyzer was generating quality assured data (as defined in Appendix A) during the time the source operated during the month.

T = the total time in hours the source operated during the month and is defined as those hours during which the fuel is burned* (for combustion-related processes) or those hours during which effluent is being discharged from an effluent source as described in an approval (for noncombustion-related sources).

* for combustion sources, the operational time also includes any time period(s) attributable to "cool down" or "purge" modes.

Time periods necessary for CEMS calibration, quality control checks or backpurging, shall not be considered as downtime when calculating T_a.

2.5.4 Backfilling and Substitution for Missing Data

Upon the authorization of the Director, emissions data that are missing due to a malfunction of the CEMS may be substituted for a period of up to 120 hours for any single episode using data derived from operational parameter correlation or predictive modelling techniques. Reference Method test data or data obtained from a monitor previously certified for the application may also be used for substituting data. The technique used to obtain substitute data must be fully described in the QAP developed for each CEMS, and must be authorized in writing by the Director prior to implementation.

For sources authorized to backfill or substitute data, when a CEMS malfunction extends beyond 120 hours for any single episode, data must be generated by another authorized CEMS or valid Reference Method.

Other CEMS used for this purpose must meet all design and performance specifications given in this Code. When using another system, the effluent stream sample shall be extracted from the sample port used for the Reference method during certification of the installed CEMS.

Data that are substituted using the correlation technique cannot be credited towards meeting the CEMS availability criteria. Data generated by an acceptable alternate CEMS may be credited to the availability requirement.

Data substitution shall be limited to a maximum of 120 hours per calendar month for each CEMS, unless specified otherwise by the Director.

3.0 INSTALLATION SPECIFICATIONS

This Section contains guidelines for selecting a suitable sampling site on the flue, duct, or stack and determining the representativeness of the desired location with respect to the homogeneity of the effluent stream.

3.1 Location of the Sampling Site

The frequency and quality of maintenance on the CEMS have been shown to be directly related to the accessibility of the stack-mounted portion of the CEMS.

The stack-mounted analyzing equipment generally must be installed in a location that is accessible at all times and during any normal weather conditions. Overshadowing this criterion is the over-riding concern for personal safety; it is not expected that individuals place themselves at risk to service the CEMS equipment under conditions of severe thunderstorms, or during high wind or heavy icing/snow/rain events.

To achieve the required up-time, the CEMS equipment must be able to operate in any environmental condition under which the plant will be operating. For example: a thermal power plant will require stack-mounted equipment to operate and be maintainable over the full range of ambient temperatures experienced (at least -40^o to +40^{o}C). Such performance may be accomplished by enclosing the instruments in heated/air conditioned shelters, enclosed stack annulus, etc., and ensuring that provisions are in place for conducting adequate maintenance procedures on schedule as per the QAP.

Gaseous pollutant monitors, in-stack opacity monitors, volumetric flow monitors and temperature sensors shall be sited in accordance with the requirements specified in Method 1 of the Alberta Stack Sampling Code as amended from time to time.

3.1.1 Measurement Locations

The measurement location shall be (1) at least two equivalent diameters downstream from the nearest control device, the point of pollutant generation, or other point at which a change in the pollutant concentration or emission rate may occur, and (2) at least a half equivalent diameter upstream from the effluent exhaust or control device.

3.1.2 Point CEM Systems

The measurement point shall be (1) no less than 1.0 m from the stack or duct wall, or (2) within or centrally located over the centroidal area of the stack or duct cross section.

3.1.3 Flow Monitors

The installation of a flow monitor is acceptable if the location satisfies the siting criteria of Method 1 of the Alberta Stack Sampling Code. Check for non-cyclonic or non-swirling flow conditions shall be made to ensure the suitability of the sampling site.

3.2 Representativeness

The sampling probe or in-situ analyzer must be installed in a location where effluent gases are completely mixed or at a location authorized by the Director. Flowing gases are generally well mixed, but stratification can occur when there are differing temperatures or when dissimilar gas streams intersect or where the duct/flue geometry changes. The degree of stratification in a duct or stack can be quantified. One method of quantification has been proposed (U.S. EPA 1979) that involves traversing the stack or duct and obtaining gas concentrations and comparing those concentrations to the target gas at a fixed concentration. To verify that the effluent stream is not stratified, the procedure outlined in Section 3.2.1 of this code is recommended or an alternative method as authorized by the Director, may be used.

3.2.1 Stratification Test Procedure

A minimum of nine (9) traverse points are required for this test. Locate the points in a balanced matrix of equal area on the stack or duct, using the procedures of Method 1 of the Alberta Stack Sampling Code. Using two automated systems with similar response characteristics, the concentration of a target gas is measured at each of the sampling points in the matrix with one system (traversing system), while simultaneously measuring the target gas concentration at a fixed location, usually at the centre of the flue, duct or stack.

For determining flow stratification, a pitot tube may be used (instead of automated gas monitoring systems) following the procedures of Method 2 of the Alberta Stack Sampling Code.

If the concentration of the gas measured or the velocity of the effluent stream at the fixed location varies by more than $\pm$10% of the average concentration for longer than one minute during this test, retest for stratification when more stable conditions prevail.

Alternately, if the stability of the emission source has been demonstrated at a chosen load, using the output of a chosen automated analyzer withdrawing a sample from a fixed point, the single automated analyzer may be used to measure the degree of stratification.

The concentration of a target gas or the velocity of the effluent stream shall be measured at each of the sampling points in the matrix. At the conclusion of the traverses, repeat the measurement of the concentration at the initial measurement point. If the concentrations differ by more than 10% for the pre- and post-test values at this point, retest for stratification when more stable conditions prevail.

The degree of stratification at each sampling point can be calculated as:

$$\%\text{ of stratification at point } i = \frac{(c_i - c_{ave})}{c_{ave}} \times 100$$

where:

c_i = concentration of target gas at point i
c_{ave} = average of target gas concentration

The sampling plane across the stack or duct is considered stratified if any of the calculated values are greater than $\pm$10%.

4.0 PERFORMANCE SPECIFICATIONS and TEST PROCEDURES

4.1 General

This section addresses how to evaluate the acceptability of a CEMS at the time of installation and whenever specified in the CEMS Code. The specifications are not designed to evaluate CEMS performance over an extended period of time, nor do they identify detailed calibration procedures to assess CEMS performance. It is the responsibility of the source owner or operator to properly calibrate, maintain, and operate the CEMS.

Performance specifications and test procedure requirements for each specific CEMS are detailed in this section.

4.1.1 Initial Certification Requirements and Test Procedures
Subject to Section 1.5.1, the owner or operator of the facility shall demonstrate that the CEMS meets all the applicable system performance specifications within six (6) months of the installation of a new CEMS, upon recertification, or as specified otherwise by the Director. The satisfactory demonstration by the approval holder of meeting all of these performance specifications, along with notice of such to the Director, shall constitute certification of the CEMS.

4.2 Performance Specifications

Performance specifications for continuous emission monitoring systems are given in Tables 7 to 12.

4.2.1 Performance Specifications for Sulphur Dioxide, Oxides of Nitrogen, and Carbon Monoxide Emission Monitoring Systems.
Any owner or operator, subject to the provisions of an applicable approval, shall install, calibrate, maintain, and operate sulphur dioxide, oxides of nitrogen, and/or carbon monoxide monitoring systems and record the output of the systems.

Table 7 provides a summary of the general performance specifications of sulphur dioxide, oxides of nitrogen, and carbon monoxide emission monitoring systems. These specifications are not meant to limit the types of technologies that can be used or prevent the use of equivalent methods. Both technologies and methods can be varied upon authorization of the Director.

Table 7. Performance specifications for sulphur dioxide, oxides of nitrogen, and carbon monoxide emission monitoring systems.

Performance Specifications	Sulphur Dioxide Systems	Oxides of Nitrogen Systems	Carbon Monoxide Systems
Analyzer linearity	$\leq \pm$ 2% of span from cal. curve	$\leq \pm$ 2% of span from cal. curve	$\leq \pm$ 2% of span from cal. curve
Relative accuracy[a]	$\leq \pm$ 10% of RM	$\leq \pm$ 10% of RM	$\leq \pm$ 10% of RM
Zero drift - 24 hr	$\leq \pm$ 2% of span	$\leq \pm$ 2% of span	$\leq \pm$ 2% of span
Span drift - 24 hr	$\leq \pm$ 4% of span	$\leq \pm$ 4% of span	$\leq \pm$ 4% of span

a If the reference method value is less than 50% of the analyzer full scale, then use 10% of full scale for relative accuracy for SO_2, NO_x, and CO.

4.2.2 Performance Specifications for Oxygen and Carbon Dioxide Monitors

Any owner or operator, subject to the provisions of an applicable approval, shall install, calibrate, maintain, and operate oxygen and/or carbon dioxide monitoring systems and record the output of the systems.

Table 8 provides a summary of the general performance specifications for oxygen and carbon dioxide monitors. These specifications are not meant to limit the types of technologies that can be used or prevent the use of equivalent methods. Both technologies and methods can be varied upon the written authorization of the Director.

Table 8. Performance Specifications for oxygen and carbon dioxide monitors.

Performance Specifications	Oxygen Monitors	Carbon Dioxide Monitors
Relative accuracy	$\leq \pm$ 10% of RM or within 1% of O_2 (whichever is greater)	$\leq \pm$ 10% of RM or within 1% CO_2 (whichever is greater)
Analyzer linearity	$\leq \pm$ 0.5% O_2	$\leq \pm$ 0.5% CO_2
Zero drift - 24 hr	$\leq \pm$ 0.5% O_2	$\leq \pm$ 0.5% CO_2
Span drift - 24 hr	$\leq \pm$ 0.5% O_2	$\leq \pm$ 0.5% CO_2

4.2.3 Performance Specifications for Total Reduced Sulphur Monitoring Systems

Any owner or operator, subject to the provisions of an applicable approval, shall install, calibrate, maintain, and operate a Total Reduced Sulphur (TRS) monitoring system and a data acquisition system for the continuous measurement and recording of the TRS emissions from the affected facility.

A summary of the performance specifications for operation of TRS Monitors are provided in Table 9. These specifications are not meant to limit the use of alternative technology and may be varied upon the written authorization of the Director to accommodate the use of alternative technology.

Table 9. Performance specifications for Total Reduced Sulphur monitoring systems.

Performance Specifications	Total Reduced Sulphur Systems
Analyzer linearity	$\leq$ 5% of span
Relative accuracy	$\leq \pm$ 20% of RM or within $\pm$ 2 ppm (whichever is greater)
Zero drift - 24 hr	$\leq \pm$ 5.0% of span
Span drift - 24 hr	$\leq \pm$ 5.0% of span

4.2.4 Performance Specifications for In-Stack Opacity Monitoring Systems.

The specifications given in Table 10 shall be adhered to until final requirements for in-stack opacity monitors are specified at a later date. As required in the approval, the approval holder shall install, operate, and maintain each continuous in-stack opacity monitoring system in accordance with the specifications and procedures as contained in Table 10.

Certain design requirements and test procedures established in this specification may not apply to all instrument designs. In such instances, equivalent design requirements and test procedures may be used with prior written authorization of the Director.

Laboratory and field verification procedures have been established for in-stack opacity monitors by the U.S. Environmental Protection Agency and are found in the reference USEPA 1996c. These specifications are to be used to evaluate the acceptability of continuous in-stack opacity monitoring systems.

Table 10. Performance Specifications for In-Stack Opacity Monitors

Performance Specifications	In-Stack Opacity Monitors
Zero drift - 24 hr	≤ ± 2% In-Stack Opacity
Span drift - 24 hr	≤ ± 2% In-Stack Opacity

4.2.5 Performance Specifications for Volumetric Flow/Velocity Monitoring Systems.
Table 11 provides a summary of the general performance specifications of flow monitors. These specifications are not meant to limit the types of technologies to be used or prevent the use of equivalent methods (such as the use of F-factors). Both technologies and methods can be varied upon written authorization of the Director.

Table 11. Performance specifications for volumetric flow/velocity monitors.

Performance Specifications	Volumetric Flow/Velocity Monitors
System Relative Accuracy for velocity ≥ 3 m/sec	≤ ± 15% of Reference Method
System Relative Accuracy for velocity < 3 m/sec	within 0.5 m/sec of Reference Method
Orientation Sensitivity	≤ ± 4% of span
Zero drift - 24 hr	≤ ± 3% of span
Span drift - 24 hr	≤ ± 3% of span

4.2.6 Performance Specifications for Temperature Sensors
The approval holder shall install, operate, and maintain a continuous temperature sensing system on each stack or source, and record the output of the system, for effluent streams released to the atmosphere, as specified in an EPEA approval.

Table 12 provides a summary of the general performance specifications of temperature sensors. These specifications are not meant to limit the types of technologies to be used or prevent the use of equivalent methods. Both technologies and methods can be varied upon the written authorization of the Director.

Table 12. Performance specifications for temperature sensors.

Performance Specification	Temperature Sensors
System Accuracy	± 10°C of the reference method

The response time should also be verified in "small" step changes in the process, as the opportunity presents itself (i.e., internal audits).

4.2.7 Performance Specifications for other Pollutant Monitoring Systems

The following requirements shall be adhered to until final requirements for other categories of pollutant monitors are specified.

Design requirements and test procedures established in these specifications may not apply to all emission monitoring system designs. Approval holders, who are required to continuously monitor other pollutant parameters that are not specified in the CEMS Code, shall install, operate, and maintain those CEMS in a manner satisfactory to the Director.

Each owner or operator shall develop and implement a Quality Assurance Plan (QAP) for the overall CEMS (See Section 5.0). As a minimum, each QAP must include a written plan that describes in detail complete, step-by-step procedures and operations for each of the activities. Quality control procedures for the calibration of the CEMS may require some variance from the procedures in Section 4.5.3 (e.g., how gases are injected, adjustments of flow rates and pressure). These variances must be documented in the QAP.

The details of what is required for the QAP are outlined in Section 5.0 as quality assurance and quality control. This section provides a description of the procedures required for a QAP.

Sixty (60) days before the CEMS is installed and begins operation, the approval holder must submit a Monitoring Plan that provides the information specified in Section 1.9.

4.3 Test Procedures - Administrative

The test procedures needed to demonstrate compliance with the relevant performance specifications are given here for each CEMS. Test procedures for determining compliance with the applicable performance specifications include the following:

- Conditioning and Performance Evaluation Periods
- Relative Accuracy Test Audit and Bias Calculation
- Zero Drift (24 hour)
- Span Drift (24 hour)
- Linearity
- Response Time
- Interference Rejection

The Director must be advised in writing (or facsimile) of the intent to test (complete with tentative test schedule[s]) at least two weeks before the performance testing is to occur. This notice enables the Director or his/her designate to have the opportunity to observe any or all testing.

The owner or operator of the facility shall retain on file at the facility, and make available for inspection or audit, the performance test results on which the certification was based.

Recertification is required following any major change in the CEMS (e.g., addition of components or replacement of components with different makes/models, change in gas cells, path length, probe or system optics, relocation) that could impair the system from meeting the applicable performance specifications for that system. Recertification should be conducted at the earliest possible opportunity or as agreed to in writing by the Director.

The comparison of CEMS measurements to the reference method values during certification or recertification shall be based only on the output as recorded by the data acquisition system.

4.4 Test Procedures for Verifying Design Specifications

4.4.1 Analyzer Interference Rejection

This test may be carried out after the analyzers have been installed in the CEMS or in a laboratory or other suitable location before the analyzers are installed. Sufficient time must be allowed for the analyzer under test to warm up, then the analyzer must be calibrated by introducing appropriate low- and high-range gases directly to the analyzer sample inlet. After the initial calibration, test gases shall be introduced, each containing a single interfering gas at a concentration representative of that species in the gas flow to be monitored. The magnitude of the interference of each potential interfering species on the target gas shall then be determined.

The analyzer is acceptable if the summed response of all interfering gases is less than 4% of the full-scale value.

4.4.2 Analyzer Temperature-Responsive Zero and Calibration Drifts

Place the analyzer in a climate chamber in which the temperature can be varied from 5 to 35°C. Allow sufficient time to warm up, then calibrate the analyzer at 25°C using appropriate zero and span gases. Adjust the temperature of the chamber to 35, 15, and 5°C, respectively. Ensure that the analyzer temperature has stabilized. Do not turn off the power to the analyzer over the duration of this test.

When the analyzer has stabilized at each climate chamber temperature, introduce the calibration gases at the same flow or pressure conditions, and note the response of the analyzer. Calculate the temperature-responsive zero drift from the difference in the indicated zero reading and the next higher or lower temperature. The analyzer is acceptable if the difference between all adjacent (i.e. 5/15, 15/25, and 25/35°C) zero responses is less than 2% of the full-scale setting.

Calculate the temperature-responsive span drift from the differences between adjacent span responses. An analyzer is acceptable if the difference between all adjacent span responses is less than 4% of the full-scale setting.

4.4.3 Manufacturer's Certificate of Conformance

It may be considered that specifications for both interference rejection and temperature-responsive drift have been met if the analyzer manufacturer certifies that an identical, randomly selected analyzer, manufactured in the same quarter as the delivered unit, was tested according to the procedures given above in Subsections 4.4.1 and 4.4.2, and the parameters were found to meet or exceed the specifications.

4.5 Performance Specification Test Procedures

4.5.1 Conditioning Test Period

After the CEMS has been installed according to the manufacturer's written instructions, the entire CEMS shall be operated for a period of not less than 168 hours, during which the emission source must be operating. During this period, the entire CEMS must operate normally, which means all processes of the entire system must work, including the analyzing of both the concentrations of the pollutant and diluent gases, and the effluent stream flow rate (where applicable). The only exceptions are for periods during which calibration procedures are being carried out, or other procedures as indicated in the QAP. Note that the data acquisition system forms an integral part of the overall system and must be fully operational during this period.

The system must output emission rates of the pollutants in units as specified in the facility approval.

System modifications may be carried out, along with fine-tuning of the overall system, in preparation for the Operational Test Period.

Daily calibration checks shall be conducted, and when the accumulated drift exceeds the daily control limits, the analyzers shall be adjusted using the procedures defined in the CEMS QAP. The data acquisition system must reflect any calibration adjustments. Any automatic adjustments made in response to the daily zero and span checks must also be indicated in the data acquisition system. If the Conditioning Test Period is interrupted as a result of a process shutdown, the times and dates of the shutdown period shall be recorded and the 168-hour test period shall be continued, after the emission source has resumed operation.

4.5.2 Operational Test Period

When the Conditioning Test Period has been successfully completed, the CEMS must be operated for an additional 168-hour period during which the emission source is operating under typical conditions. The Operational Test Period need not immediately follow the Conditioning Test Period.

During the Operational Test Period, the CEMS must continue to analyze the gases without interruption and produce a permanent record, using the data acquisition system, of the emission data. Sampling may be interrupted during this test period only to carry out system calibration checks and specified procedures as contained in the QAP.

During this period, no unscheduled maintenance, repairs, or adjustments should be carried out. Calibration adjustments may be performed at 24-hour intervals or more frequently, if specified by the manufacturer and stated in the QAP. Automatic zero and calibration adjustments made without operator intervention may be carried out at any time, but these adjustments must be documented by the data acquisition system.

If the test period is interrupted because of process shutdown, the times and dates of this period should be recorded, and the test period continued when the process continues operation. If the test period is interrupted as a result of CEMS failure, the entire test period must be restarted after the problem has been rectified.

The Performance Specifications tests outlined in Section 4.5 are carried out during the Operational Test Period, with the exception of the relative accuracy tests, which may be conducted during the Operational Test Period or during the 168-hour period immediately following the Operational Test Period. These tests are to be carried under conditions that typify the day-to-day operation of the CEMS and should be described in the QAP.

4.5.3 Calibration Drift Test Protocol for Gas and Flow Monitoring Systems

(a) General - For those systems that are not designed (and authorized as such by the Director) for the dynamic use of calibration gases, alternative protocols (as authorized by the Director) may be used in place of the following. These alternative procedures shall be included and detailed in the facility QAP.

Measure the zero and span drift of the CEMS once each day at 24-hour intervals (to the extent possible) for 7 consecutive operating days according to the following procedures. Units using dual span monitors must perform the calibration drift test on both high- and low-end scales of the pollutant concentration monitor.

(b) Calibration Adjustments - Automatic or manual calibration adjustments may be carried out each day. The Calibration Drift Test must be conducted immediately before these adjustments, or in such a manner that the magnitude of the drifts can be determined. A zero drift adjustment may be made prior to the span drift determinations.

(c) Test Procedures - At approximately 24-hour intervals for seven (7) consecutive days, perform the calibration drift tests at two concentration ranges:

low-level range (0-20% of full scale)
high-level range (80-100% of full scale)

Operate each monitor in its normal sampling mode. For extractive and dilution type monitors, pass the audit gas through all filters, scrubbers, conditioners and other monitor components used during normal sampling and through as much of the sampling probe as is practical. For in situ-type monitors, perform calibration by checking all active electronic and optical components, including the transmitter, receiver, and analyzer. Challenge the CEMS once with each gas. Record the monitor response from the data acquisition system.

(d) Calculations - Determine the calibration drift, at each concentration, once each day (at 24-hour intervals) for 7 consecutive days according to the following calculation:

$$\text{Calibration Drift (\%)} = \frac{(R - A)}{FS} \times 100$$

where:

R = the true value of the reference standard (ppm or % for gas analyzers, kPa for pressure transducers, ^{o}C for temperature transducers, m^3/d or tonnes/d for flow elements).

A = the CEM component value (in same units as R).

FS = the full scale reading of the CEM system component (in the same units as R).

With dual span CEMS, the above procedure must be conducted on both concentration ranges. Use only NIST (National Institute of Standards and Technology) -traceable reference material, standard reference material, Protocol 1 calibration gases (certified by the vendor to be within 2% of the label value, or where applicable, zero air material).

Calibration drift test results are acceptable for CEMS certification, if none of these daily calibration system test results exceed the applicable CEMS specifications in Section 4.2.

4.5.4 Linearity

Perform a linearity test using the following test gases and procedures:

(a) General - For those systems that are not designed (and authorized as such by the Director) for the dynamic use of calibration gases, alternative protocols (as authorized by the Director) may be used in place of the following. These alternative procedures shall be included and detailed in the facility QAP.

(b) Test Gases - Use Protocol 1 gases at low (0 to 20% FS (full scale)), mid-(40 to 60% FS), and high-level (80 to 100% FS) for each pollutant and diluent gas analyzer. Dynamic or static dilution of a test gas to generate lower concentration standards is acceptable provided that the corresponding QA/QC plan/procedures are established and followed for the use of dynamic or static dilution systems.

(c) Calibration Gas Injection Port -Test gases may be injected immediately before each analyzer.

(d) Procedures - The system must operate normally during the test, with all pressures, temperatures, and flows at nominal values. Introduce each test gas and allow the system response to stabilize, then record the concentration of the pollutant or diluent gas indicated by the data acquisition system output. Challenge the system three (3) times with each gas, but not in succession. To do this, alternate the gases presented to the system.

Calculate the average response of the system as indicated by the data acquisition system to the three (3) challenges of each gas for each pollutant or diluent gas analyzer at low-, mid-, and high-level.

(e) Calculations and Acceptable Results - Determine the linearity, at each concentration, according to the following calculation:

$$\text{Linearity (\%)} = \frac{(R - A)}{FS} \times 100$$

R = the true value of the test gas (% or ppm).

A = the average of the three system response to the low-, mid-, or high-range calibration gas, (% or ppm).

FS = the full scale value of the monitoring system (% or ppm).

With dual span CEMS, the above procedure must be conducted on both concentration ranges. Use only NIST-traceable reference material, standard reference material, Protocol 1 calibration gases (certified by the vendor to be within $\pm$2 % of the label value, or where applicable, zero ambient air material).

The system is acceptable if each of the three values of the linearity do not exceed the value for linearity, specified in Table 7, 8, or 9, as applicable.

4.5.5 Flow Monitor Calibration Drift

Use the zero and span reference signals generated by the system for this test, following the procedures given in 4.5.3 above (where, instead of calibration gas, read reference signal).

Once a day over the 168-hour Operational Test Period, introduce the flow monitors reference signals to the sensor, corresponding to low (0 to 20% FS) and high (80 - 100%) flow rates, and record the response of the monitor to each signal, as reported by the data acquisition system.

The unit is acceptable if the drift does not exceed 3% of the corresponding input signal for any day during the 168-hour test period.

4.5.6 Flow Monitor Orientation Sensitivity

This test is intended as a test for flow rate monitors that are sensitive to the orientation of the sensor in the gas flow, such as differential pressure flow sensors. Where possible, it is recommended that this test is carried out at three loads (rates):

a) minimum safe and stable operating load (rate);
b) approximately mid-load (rate) (40 to 60%); and
c) full load (rate) (90 -100%).

During a period of steady flow conditions at each load (rate), rotate the sensor in the gas flow a total of 10 degrees on each side of the zero degree position (directly into the gas flow, with no cyclonic flow patterns) in increments of 5 degrees, noting the response of the sensor at each angle. A total of five (5) flows will be generated for each load (rate) condition, at -10, -5, 0, +5, +10 degrees relative to the zero-degree position.

The sensor is acceptable if the flow measurements do not exceed a difference of 4% from the zero-degree orientation.

4.5.7 System Cycle Time/Response Time Test

Perform a response time test for each CEMS according to the following procedures.

Use a low-level and a high-level calibration gas as used in the calibration drift assessment alternately. While the CEMS is measuring and recording the concentration, inject either a low-level or a high-level concentration calibration gas into the injection port. Continue injecting the gas until a stable response is reached. Record the amount of time required for the monitor or monitoring system to complete 95.0% of the concentration step change using the data acquisition system output. Then repeat the procedure with the other gas. For CEMS that perform a series of operations (such as purge, sample, and analyze), time the injections of the calibration gases so they will produce the longest possible response time. (Note: for some CEMS, such as TRS/H_2S and CO_2/O_2 CEMS, it will be necessary to simultaneously inject calibration gases into the pollutant and diluent monitors, in order to measure the step change in the emission rate.)

Cycle time/response time test results are acceptable for monitoring or monitoring system certification, if none of the response times exceeds the applicable specifications in Section 4.2.

4.5.8 Relative Accuracy and Bias Tests for Gas Monitoring Systems

Perform a Relative Accuracy Test audit (RATA) for each CEMS. Record the CEMS output from the data acquisition system. For each CEMS, calculate bias as well as relative accuracy for each test.

(a) Plant Operating Conditions - For new CEMS installations, complete the RATA test during the operational test period or within 168 hours after the completed operational test period has been completed or when the unit is combusting its primary fuel or producing its primary product (as applicable). Perform the test for each CEMS at a normal rate for the unit.

For existing CEMS installations, RATA tests shall be conducted at a frequency as specified in Table 16.

When the test is performed on a CEMS or component(s) installed on bypass stacks/ducts or combined units exhausting into a common stack, perform the test for each CEMS installed to monitor the individual units when the units are operating. Use the fuels normally combusted by the units or operate the unit in a normal manner (as the case may be for combustion related or non combustion sources).

(b) CEMS Operating Conditions - Do not perform corrective maintenance, repairs, replacements or adjustments on the CEMS during the RATA other than as required in the operation and maintenance portion of the QAP.

(c) Reference Method Sampling Points - When the absence of stratified flow has not been verified, or if the gas flow has been found to be stratified, the Reference Method samples must be collected at a number of points in the effluent stream. Establish a "measurement line" that passes through the centroidal area of the flue or duct. This line should be located within 30 cm of the CEM sampling system cross section. Locate three (3) sampling points at 16.7, 50, and 83.3% along the length of the measurement line. Other sample points may be selected if it can be demonstrated that they will provide a representative sample of the effluent flow over the period of the test. A tip of the Reference Method probe must be within 3 cm of each indicated traverse point, but no closer than 7.5 cm to the wall of the stack or duct.

Where two or more probes are in the same proximity, care should be taken to prevent probes from interfering with each other's sampling.

(d) Reference Method Sampling Conditions - Conduct the Reference Method tests in accordance with the Alberta Stack Sampling Code, and in such a manner that they will yield results representative of the pollutant concentration, emission rate, moisture content, temperature, and effluent flow rate from the unit and can be correlated with the CEMS measurements. Conduct the diluent (O_2 or CO_2) measurements and any moisture measurements that may be needed simultaneously with the pollutant concentration measurements. To properly correlate individual CEMS data, with the Reference Method data, mark the beginning and end of each Reference Method test run (including the exact time of day) on the data acquisition system, individual chart recorder(s) or other permanent recording device(s).

(e) Consistency - Confirm that the CEMS and Reference Method test results are based on consistent moisture, pressure, temperature, and diluent concentration and in the same units. In addition, consider the response times of the CEMS to ensure comparison of simultaneous measurements.

For each RATA conducted, compare the measurements obtained from the monitor via the data acquisition system (in ppm, % CO_2, lb./M Btu, or other units as appropriate) against the corresponding Reference Method values. Display the paired data in a table.

(f) Sampling Strategy - Perform a minimum of nine sets of paired monitor (or monitoring system) and Reference Method test data for every required (i.e., certification, semiannual, or annual) relative accuracy or Bias Test audit. Each test shall take a minimum duration of thirty (30) minutes, sampling for equal periods at the three (3) sampling points for stratified flow testing, or at the single point for nonstratified flow.

NOTE: the tester may choose to perform more than nine sets of Reference Method tests up to a total of 12 tests. If this option is chosen, the tester may reject a maximum of three sets of the test results, if an appropriate statistical test applied to the data demonstrates that these results are outliers, and as long as the total number of test results used to determine the relative accuracy or bias is greater than or equal to nine. All data must be reported, including the outliers, along with all calculations.

(g) Calculations - Analyze the test data from the Reference Method and CEMS tests for the applicable CEMS.

Summarize the results on a data sheet. Calculate the mean of the monitor or monitoring system measurement values. Calculate the mean of the Reference Method values. Using data from the automated data acquisition system, calculate the arithmetic differences between the Reference Method and monitor measurement data sets. Then calculate the arithmetic mean of the difference, the standard deviation, the % confidence coefficient, and the monitor or monitoring system relative accuracy using the following procedures and equations.

The absolute value of the average difference, $|\;\;|$, is calculated using the equation:

$$|\bar{d}| = \frac{1}{n} \sum_{i=1}^{n} (X_i - Y_i)$$

Where: n = number of data points

X_i = concentration from the Reference Method

Y_i = concentration from the CEMS

The standard deviation, S_d, is calculated using the equation:

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} d_i\right)^2}{n - 1}}$$

Where: d_i = difference between individual pairs

The 2.5% error confidence coefficient, $|cc|$, is calculated using the equation:

$$|cc| = t_{0.025} \frac{S_d}{\sqrt{n}}$$

Where: $t_{0.025}$ = t - table value from Table 13.

Table 13. Range of t-values applicable for calculating confidence coefficients in Relative Accuracy Tests of CEMS.

t-VALUES

n	$t_{0.025}$	n	$t_{0.025}$
2	12.706	10	2.262
3	4.303	11	2.228
4	3.182	12	2.201
5	2.776	13	2.179
6	2.571	14	2.160
7	2.447	15	2.145
8	2.365	16	2.131
9	2.306		

The Relative Accuracy (RA) is calculated using the equation:

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} \; X \; 100$$

Where:

$|\bar{d}|$ = Absolute value of the mean difference

$|cc|$ = Absolute value of the confidence coefficient

RM = Average Reference Method value

(h) The Bias Test

A bias, or systematic error is considered to be present if:

$|d| \geq |cc|$

(i) Acceptance Criteria for Analyzer Bias-

For each pollutant and diluent gas analyzer in the CEMS, calculate $|d|$ and $|cc|$, in the units of the analyzer. If

$|d| - |cc| \geq 4\%$ of FS

the analyzer has significant bias. The cause of the bias must be determined and rectified. After corrections have been made, the Relative Accuracy Tests must be repeated to determine if the systematic error has been eliminated or reduced to an acceptable level.

4.5.9 Relative Accuracy Test for Flow Monitors

For new systems, carry out this test during the Operational Test Period, or during the week immediately following. It is recommended, if possible, that the testing be carried out at the three (3) loads (rates) as per section 4.5.6. For existing systems, conduct this test in accordance with the frequency specified in Table 16.

Carry out a minimum of nine (9) manual velocity traverse measurements at each load condition. Calculate the Relative Accuracy for each load (rate) condition as shown in 4.5.8.

The flow monitor is satisfactory if it meets the performance specifications given in Table 11.

4.5.10 Relative Accuracy Test for Temperature Sensors

Temperature sensors shall be verified using a certified reference thermometer or certified resistance temperature device (RTD)/readout or thermocouple/readout combination when conducting the RATA test.

5.0 QUALITY ASSURANCE AND QUALITY CONTROL

The Quality Assurance (QA) procedures consist of two distinct and equally important functions. One function is the assessment of the quality of the CEMS data by estimating accuracy. The other function is the control and improvement of the quality of the CEMS data by implementing Quality Control (QC) policies and corrective actions. These two functions form a control loop. When the assessment function indicates that the data quality is inadequate, the control effort must be increased until the data quality is acceptable.

To provide high-quality data on a continuing basis a good QA program is necessary. The approval holder shall develop a QAP for each installed CEMS to ensure the quality of the CEMS measurements.

A "Quality Assurance" program is defined as a management program to ensure that the necessary quality control activities are being adequately performed, whereas "Quality Control" activities are those that detail the day-to-day operation of the system. The program shall be fully described in a Quality Assurance Plan (QAP) that is specific to the CEMS.

5.1 Quality Assurance Plan (QAP) for CEMS

The QAP must include and describe a complete program of activities to be implemented to ensure that the data generated by the CEMS will be complete, accurate, and precise. As a minimum, the manual must include QA/QC procedures specified in this code. The recommended Table of Contents for a QAP is shown in Table 14.

5.1.1 Section 1 - Quality Assurance Activities

This section of the manual describes the CEM system QAP, and describes how the QA program is managed, provide personnel qualifications, and describe the QA reporting system. It must describe the CEMS, how it operates, and the procedures for calibration and inspection. It must also include preventative maintenance and performance evaluation procedures.

5.1.2 Section 2 - Quality Control Activities

This section of the manual provides the detailed descriptions of the step-by-step procedures, the standard operating procedures required to operate and evaluate the system, including details about daily calibration procedures, CGAs, Relative Accuracy Tests, and tests for system bias. Minimum criteria and procedures for these activities are provided in Section 4.2, Section 4.4, and Section 4.5.

Table 14. Example Table of Contents for facility CEMS QAP.

SECTION	SUBSECTION	CONTENTS
		The Quality Assurance Plan
I	1	Assurance Policy and Objectives
	2	Document Control System
	3	CEMS Description
	4	Organization and Responsibilities
	5	Facilities, Equipment and Spare Parts Inventory
	6	Methods and Procedures
	7	Calibration and Quality Control Checks
	8	Preventative Maintenance Schedule
	9	Systems Evaluations
	10	Performance Evaluations
	11	Corrective Action Program
	12	Reports
	13	Data Backfilling Procedures (where authorized)
	14	References
		Quality Control Procedures
II	1	Start-up and Operation
	2	Daily CEMS Operation
	3	Calibration Procedures
	4	Preventative Maintenance Procedures
	5	Corrective Maintenance Procedures
	6	Evaluation Procedures - Cylinder Gas Audits
	7	Evaluation Procedures - Relative Accuracy Tests
	8	System and Subsystem Evaluation Procedures
	9	Data Backup Procedures
	10	Training
	11	CEMS Security
	12	Data Reporting Procedures
		Appendices
III	1	Facility Approval
	2	CEMS Specifications
	3	Reference Method Procedures
	4	Blank Forms

5.1.3 Inspection, Verification, and Calibration

Inspection, verification and calibration (when required) of the CEMS performance are among the most important aspects of the QA/QC program. The following summarizes the requirements for inspection, verification and calibration, all of which must appear in the QAP.

The method of verifying the accuracy of a CEMS component is to compare the value of the reference standard (e.g., reference gas or dead weight tester output) to the value displayed by the data acquisition system.

(a) Frequency - All CEMS components shall be inspected periodically (approval holder shall identify frequency in the QAP) to verify that individual components have not failed and are operating within prescribed guidelines (e.g., sample system flow rates are appropriate). The use of system components with integral fault detection diagnostics is highly desirable.

The minimum verification frequency for individual CEMS components (e.g., analyzers and temperature transmitters) performance shall be as specified in Table 16. The minimum frequency may be reduced (upon the written authorization of the Director) provided the operator can demonstrate (using historical data) that a lower verification frequency will not affect system performance at the 95% confidence level.

(b) Accuracy of Verification/Calibration Equipment and Materials - The minimum accuracy requirement for verification/calibration equipment and materials shall be a factor of two or better than the performance requirement specified for that system component in Section 4.2. (For example, if a performance specification requires an accuracy of ± 2% then the verification/calibration equipment shall be accurate to within ± 1%.)

For analyzers, the use of certified reference gases is acceptable for routine analyzer system performance verifications. Protocol 1 gases are required for a CGA. All other calibration equipment such as test pressure gauges, dead weight testers and multi-meters must be calibrated at least every 2 years in a manner that is traceable either through the Canadian Standards Association (CSA) or the U.S. National Institute of Standards and Technology (NIST).

For parameters for which cylinder gases are not available at reasonable cost, are unstable, or are unavailable, alternative calibration techniques are acceptable, if the Director has given prior written authorization.

(c) Calibration Adjustment - A CEMS component must be calibrated (i.e., output adjusted) whenever the observed inaccuracy exceeds the limits for that system component accuracy as specified in the Performance Specifications. A CEMS component need not be calibrated after each verification, only when it exceeds the specified tolerance.

(d) Out-of-Control Conditions - Only quality assured data may be used to determine CEMS availability. When an analyzer or system is out-of-control, the data generated by the specific analyzer or system are considered missing and does not qualify for meeting the requirement for system availability.

An out-of-control period occurs if either the low level (zero) or high level calibration results exceed twice the applicable Performance Specification. The criteria that pertain to out-of-control periods for specific CEMS are illustrated in Table 15.

Table 15. Criteria for out-of-control periods[e].

Instrument	Acceptable		2X[(a,b)]		4X[(c)]	
	Zero drift	Span drift	Zero drift	Span drift	Zero drift	Span drift
SO_2 [g]	±2%	±4%	±4%	±8%	±8%	±16%
NO_x [g]	±2%	±4%	±4%	±8%	±8%	±16%
TRS[g]	±5%	±5%	±10%	±10%	±20%	±20%
O_2 [d,f]	±0.5%	±0.5%	±1%	±1%	±2%	±2%
CO_2 [d,f]	±0.5%	±0.5%	±1%	±1%	±2%	±2%
In-Stack Opacity[g]	±2%	±2%	±4%	±4%	±8%	±8%
CO[g]	±3%	±4%	±6%	±8%	±12%	±16%

[a] Corrective action must be taken, at a minimum, whenever the daily zero calibration drift or daily span calibration drift exceeds two times the limits stated above.

[b] If either the zero or span calibration drift results exceeds twice the above stated calibration drift for five consecutive daily periods, the CEMS is out-of-control beginning on the fifth day of error.

[c] If either the zero or span calibration drift results exceeds four times the applicable calibration drift, the CEMS is out-of-control back to the previous calibration drift found to be within tolerance unless a decisive point error occurrence can be defined.

[d] If the CO_2/O_2 CEMS is defined as being out-of -control, the TRS/SO_2/NO_x will also be out-of-control, until the CO_2/O_2 CEMS is defined as being within acceptable limits.

[e] If the CEMS is out-of-control, assess and identify the cause of the excessive drift and correct accordingly. Once the appropriate corrective action has been implemented, repeat the calibration drift test in order to demonstrate the CEMS is back within acceptable limits.

[f] Values are given as a % of gas concentration.

[g] Values are given as a % of full scale reading.

In addition, an out-of-control period also occurs if any of the quarterly, semiannual, or annual performance evaluations exceed the applicable performance specification criteria (i.e., Relative Accuracy, Bias, etc.). In this case, the out-of-control period begins with the hour when this condition occurred and ends with the hour after this condition ends.

(e) Verification/Calibration—Data Logging, and Tabulation - The "as found" values for each verification point shall be recorded before any calibration occurs. The "as left" values for each verification point shall also be recorded after any component is calibrated (i.e., adjustment). For systems capable of automated calibrations, the data system shall record the "as found" and "as left" values including a time stamp (date and time). If strip chart recorder data are reported, any automatic calibration adjustments must be noted on the strip chart recorder.

All verification data must be time-stamped and tabulated on a daily (where applicable) and monthly basis. The use of quality control charts is recommended.

The approval holder must retain the results of all performance evaluations including raw test data as well as all maintenance logs, corrective action logs and the QAP (including sample calculations) for a period of at least 3 years for inspection by Alberta Environmental Protection.

(f) Gas Analyzer/ System Verification - For all CEMS, the system is calibrated rather than the analyzer.

System performance shall be verified in accordance with the procedures specified in the facility QAP. For multi-range analyzers, all applicable operating ranges must be verified.

For systems amenable to verification through the use of standard reference gases, the standard reference gas must be introduced at the probe inlet or in the vicinity of the probe inlet. A calibration filter may be used for daily system zero and span verification for path in-situ CEMS only.

Ensure enough time passes to allow the system to attain a steady output, as shown by the data acquisition system, before recording.

For CGAs, the process and analyzer system must be operating at normal conditions (e.g., pressure, temperature, flow rate, pollutant concentration). The analyzer system must be challenged three times with each gas, but not in succession. To do this, alternate the gases presented to the system. Calculate the average response of the system as indicated by the data acquisition system or chart recorder to the three challenges of each concentration of reference gas.

For analyzers not amenable to verification/calibration through the use of reference gases, the operator shall detail verification/calibration procedures in the facility's QAP.

(g) In-Stack Opacity Analyzer Verification - Procedures for verification of in-stack opacity monitors are shown in US EPA 40 CFR 60, Appendix B.

(h) Temperature Measurement Subsystem Verification - The temperature measurement shall be verified using a certified reference thermometer or certified resistance temperature device (RTD)/readout or thermocouple/ readout combination when conducting the RATA test.

(i) Pressure Measurement Subsystem Verification - The static pressure and differential measurement devices shall be verified using a certified manometer, dead weight tester or test gauge when conducting the RATA test.

(j) Flow Element Subsystem Verification - For pitot tube or similar systems visual inspection at turnaround (or at least once per year) and as opportunities present themselves for visible signs of plugging or damage. Wind tunnel calibration of flow-measuring devices should be carried out before initial installation, when visible damage has occurred, or when flow system inaccuracy exceeds acceptable tolerances and inaccuracy cannot be attributed to any component other than the flow element. For pitot tube systems, if, when compared to the stack survey data, $|d| > \pm 15\%$, then pitot tubes must be pulled and recalibrated unless the source of the error is found to be in the transmitter. ($|d|$ refers to absolute difference.)

Backpurging (as necessary) of the primary flow measuring elements at an appropriate frequency is acceptable to ensure accurate data (and remove any build up of materials) but should be done when analyzer is being calibrated (or zeroed) so that actual complete sampling time of both flow and pollutant concentration is maximized.

For other flow methods such as ultrasonic meters, anemometers, etc., the QA/QC procedures and frequency shall be specified in the facility QAP and be followed accordingly.

Table 16. Minimum frequency for CEM system component Quality Assurance/Quality Control (QA/QC) requirements.

CEMS COMPONENT	Frequency of Performance Verification Parameter				
	Inspection	Zero Drift	Span Drift	Cylinder Gas Audit[a]	Relative Accuracy Test Audit[a]
Analyzers					
Sulphur Dioxide	Daily	Daily	Daily	2/yr.	2/yr.
Oxides of Nitrogen	Daily	Daily	Daily	2/yr.	2/yr.
Carbon Monoxide	Daily	Daily	Daily	2/yr.	2/yr.
Total Reduced Sulphur	Daily	Daily	Daily	2/yr.	2/yr.
In-Stack Opacity	Daily	Daily	Daily	na	na
Oxygen	Daily	Daily	Daily	2/yr.	2/yr.
Carbon Dioxide	Daily	Daily	Daily	2/yr.	2/yr.
Other Monitors	as specified in QAP	as specified in QAP	as specified in QAP	as specified in QAP	as specified in QAP
Rate Measurement Components					
Temperature	Daily	NA	semi-annual	NA	
Diff. Pressure	Daily	semi-annual	semi-annual	NA	
Static Pressure	Daily	semi-annual	semi-annual	NA	
Flow Element	1/yr.	NA	at RATA	NA	
Data Acquisition Components					
Recorder	Daily	See Note b	See Note b		
PLC/DCS	Daily	See Note b	See Note b		

[a] Frequency is subject to requirements in Section 5.2.
[b] The inputs to a PLC/SCADA or DCS must be checked as part of the trouble shooting procedures, only if the analyzer or flow system is found to be out-of-control.

(k) Data Receiver Subsystem Verification
The inputs to the digital data acquisition system (e.g., PLC, DCS, Scada) or chart recorder must be verified at the frequency specified in Table 16 using an appropriate calibrator as identified in the QAP.

5.2 Relative Accuracy Test Audits and Cylinder Gas Audits

5.2.1 General Requirements (applicability)
The approval holder shall conduct Relative Accuracy Tests and Cylinder Gas Audits on each CEMS. For the 1st year of CEMS operation a minimum of two Relative Accuracy Tests and a minimum of two CGAs must be conducted on each CEMS. A RATA may be substituted in place of a CGA; however, a CGA cannot be substituted in place of a Relative Accuracy Test. For the second and succeeding years, the minimum frequency of Relative Accuracy Tests may be decreased to once per year upon the Director being satisfied that the QAP demonstrates compliance with ongoing CEMS performance requirements (as detailed in Section 4.2). In lieu of the decreased RATA frequency, the minimum CGA frequency would be increased to three times per year.

The data obtained during a Relative Accuracy Test may also be used toward fulfilling associated stack survey requirements as provided for in an approval issued under EPEA.

5.2.2 Relative Accuracy Test Procedures
The procedure for carrying out the relative accuracy and bias tests is given in Subsections 4.5.9 of this Code.

5.2.3 Cylinder Gas Audits
The Cylinder Gas Audit procedure and acceptance criteria are the same as the Linearity Procedure of 4.5.4.

For those systems that are not designed for the dynamic use of calibration gases, alternative protocols (as authorized by the Director) may be used in place of the cylinder gas audit. These alternative procedures shall be included and detailed in the facility QAP.

5.2.4 Test Procedure Requirements
The associated QA/QC test procedures applicable to each CEMS and a description of the actual test procedures shall be contained in the facility QAP and adhered to by the facility operator.

During periods of scheduled CEMS quality control procedures, such as Relative Accuracy Test, the facility should be operated at a rate of at least 90 % of "normal" production. Normal production is defined as the average production or throughput for the facility over the previous month. Any exceptions to this would need to be authorized in writing by the Director.

At least one month must elapse between conducting either a CGA or a RATA, unless otherwise authorized by the Director.

5.3 Annual Evaluation

The CEMS and QAP must be evaluated every twelve (12) months.

An auditor, knowledgable in auditing procedures and in CEMS operations, and independent of the CEMS operation, must review the QAP, the CEMS operation, reports, and other associated records to determine if the procedures in the QAP are being followed. The auditor shall also note any changes in the system or the procedures since the last yearly evaluation and ensure that these have been included in the QAP.

The auditor shall report the findings and observations to the facility management. This report may include recommendations for improvements in the CEMS or its operation.

5.4 Minimum System Availability Requirements

The operational time or "availability" for both the CEMS and each individual monitor shall be greater than or equal to 90% based on the calendar month.

For CEMS applications requiring CO_2, O_2, mass or volumetric measurements, whenever these CEM subsystems are out-of-control, the data generated by the entire CEMS are considered missing and do not qualify for meeting the requirement for system availability. For other applications (e.g., in-stack opacity, concentration limit on a specific pollutant), only when that monitoring system is found to be out-of-control (See Table 15) are the data generated by that system considered missing and not qualified for meeting the requirement for system availability.

6.0 REPORTING REQUIREMENTS

6.1 General

All reporting requirements regarding continuous source emission data generated by the CEMS will be specified in the Air Monitoring Directive issued by Alberta Environmental Protection and as amended from time to time.

The approval holder shall make the QAP (and related QC information generated as a result of the QAP) available for inspection and audit to Alberta Environmental Protection upon request.

Detailed reporting requirements for the CEMS will be incorporated through the Air Monitoring Directive. In the interim, Section 6.2 shall apply until such time it can be formally incorporated into the Air Monitoring Directive, at which time Section 6.2 will cease to apply.

6.2 Quality Assurance Reporting Requirements

Within 1 month following the end of each quarter, the CEMS operator must report a summary of the following performance evaluations carried out within the quarter; these include: a) initial certification performance tests, b) Relative Accuracy Test Audits, and c) Cylinder Gas Audits. All other data records for the facility's QAP shall be retained at the facility site and be made available for inspection and audit by Alberta Environmental Protection upon request.

In addition, the CEMS availability for each month must be calculated in a manner as specified in Section 2.5.3 of the CEMS Code and reported in accordance with the reporting frequency as specified in the facility's approval. Section 6.2 ceases to apply upon the amendment of the Air Monitoring Directive to incorporate applicable CEMS reporting requirements.

The annual report shall contain confirmation of whether the annual evaluation (as required in Section 5.3) has been conducted and the date of completion of the evaluation.

APPENDIX A - DEFINITIONS

APPENDIX A - DEFINITIONS

Accuracy means the closeness of the measurement made by a CEMS, a pollutant concentration monitor or a flow monitor, to the true value of the emissions or volumetric flow. It is expressed as the difference between the measurement and a Reference Method value, which is assumed to be equivalent to the true value. Variation among these differences represents the variation in accuracy that could be caused by random or systematic error.

Alberta Stack Sampling Code means Publication No. REF. 89, published by Alberta Environmental Protection and as amended from time to time.

Alternative monitoring system means a system designed to provide direct or indirect determinations of mass per unit time emissions, pollutant concentrations, and/or volumetric flow data that does not use analyzers that accept independent, certified calibration gases. For the purposes of this Code, acceptable alternative monitoring systems are those that meet the same criteria of performance with respect to accuracy, precision, and availability, as CEMS that accept calibration gases.

As found or unadjusted value means the output value of the measurement device that corresponds to the reference value input before a calibration check or adjustment.

As left or adjusted value means the output value of the measurement device corresponding to the reference value input after calibration adjustment.

Available means that the CEMS or continuous in-stack opacity monitoring system is functional and operating within the calibration drift limits and other applicable performance specifications.

Bias means systematic error. The result of bias is that measurements will be either consistently low or high, relative to the true value.

Bypass means any flue, duct, stack, or conduit through which emissions from an unit may or do pass to the atmosphere, which either augments or substitutes for the principal ductwork and stack exhaust system during any portion of the unit's operation.

Calibration adjustment means the procedure to adjust the output of a device to bring it to a desired value (within a specified tolerance) for a particular value of input (typically the value of the reference standard).

Calibration check means the procedure of testing a device against a known reference standard without adjusting its output.

Calibration drift means the difference between (1) the response of a gas monitor to a reference calibration gas and the known concentration of the gas, 2) the response of a flow monitor to a reference signal and the known value of the reference signal, or (3) the response of a continuous in-stack opacity monitoring system to an attenuation filter and the known value of the filter after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

Calibration gas means for the purposes of this Code, a known concentration of a gas (1) that is traceable to either a standard reference material (SRM) or a U.S. National Institute of Standards and Technology (NIST), 2) an authorized certified reference gas, or (3) a Protocol 1 gas.

Calibration gas cell or a filter means a device that, when inserted between the transmitter and detector of the analyzer, produces a desired output level on the data recorder.

Centroidal area means a concentric area that is geometrically similar to the flue, duct or stack cross section and is not greater than 1% of the stack or duct cross-sectional area.

Continuous means that a device is capable of making a measurement at least once every 15 minutes and operates with an availability greater than 90% on a monthly basis.

Continuous emission monitoring system (CEMS) means the equipment required to analyze, measure, and provide, on a continuous basis, a permanent record of emission and other parameters as established by this code.

Cylinder gas audit (CGA) means a challenge of the monitoring system with a cylinder gas of a known concentration which is traceable to standard reference materials (SRMs) of the U.S. National Institute of Standards and Technology (NIST) according to Protocol 1 of the US EPA.

Data acquisition system (DAS) means one or more devices used to receive, compute, store, and report CEMS measurement data from single or multiple measurement devices.

Data backfilling means the act of transferring data from one portion of the data acquisition system to another after electronic communications have been restored. For example, delayed transfer of data from a datalogger to the main or central computer normally used for data processing and storage.

Data recorder means a device capable of providing a permanent record of both "raw" and "summary" data.

Data substitution means the procedure using data from a calculation or alternate device as a source of replacement data for periods of time during which a continuous emission monitoring system was "out-of-control," as defined in Table 15. For example, data generated by other means such as a "predictive emissions" program or an alternative monitoring system (or some combination) would be designated as substituted data.

Diluent gas means a major gaseous constituent in a gaseous pollutant mixture or the gas used to dilute the pollutant mixture in dilution type analyzer systems. For combustion sources, carbon dioxide, nitrogen and oxygen are the major diluent gases.

Director means a person designated as a Director for the purposes of the Environmental Protection and Enhancement Act by the Minister of Alberta Environmental Protection.

Drift means an undesired change in output, over a period of time, that is unrelated to input or equipment adjustments.

Dual span system means a pollutant concentration monitor, flow monitor, or in-stack opacity monitor that has two ranges of values over which measurements are made.

Emission standard level means the maximum emission level (either as a concentration or mass) as stated in an approval issued under the Environmental Protection and Enhancement Act.

Equivalent diameter means a calculated value used to determine the upstream and downstream distances for locating flow or pollutant concentration monitors in flues, ducts or stacks with rectangular cross sections.

Extractive monitoring system means one that withdraws a gas sample from the stack and transports the sample to the analyzer.

Flow monitor means an analyzer that measures the velocity and volumetric flow of an effluent stream.

Full scale reading means the upper value of the monitor or analyzer range (as contained in Section 2.0).

In-situ monitor means a monitor that senses the gas concentration in the flue, duct or stack effluent stream and does not extract a sample for analysis.

Inspection means a check for conditions that are likely to affect the reliability of the system. Examples of these conditions could include the following: damage to system components, leaks, a low flow condition in sample transport system, alarms, adequate supply of consumables such as chart paper and calibration gases, etc.

Interference rejection means the ability of a CEMS to measure a gaseous species without responding to other gases or substances, within specified limits.

Invalid data means data that were generated while the measurement device(s) was out-of-control.

Linearity means the degree to which a CEMS exhibits a straight line (first order) response to changes in concentration (or other monitored value), over the range of the system. Nonlinearity is expressed as the percentage difference of the response from a straight line response.

Lower detection limit means the minimum value that a device can measure, which may be a function of the design and materials of construction of the device rather than of its configuration.

Month means a calendar month.

NIST/EPA-approved certified reference material means, a reference material for which one or more of its values are certified by a technically valid procedure, such as Traceability Protocol 1 (U.S. Code of Federal Regulations (40 CFR 75 Appendix H), accompanied by or traceable to a certificate or other documentation that is issued by a certifying body and approved by U.S.-EPA. A current list of certified reference material cylinder gases and certified reference material vendors is available from the Quality Assurance Division (MD-77), Environmental Monitoring Systems Laboratory, U.S.-EPA, Research Triangle Park, NC 27711.

Operational period means a minimum period of time over which a measurement system is expected to operate within certain performance specifications, as set forth in this code, without unscheduled maintenance, repair, or adjustment.

Orientation sensitivity means the degree to which a flow monitoring system is affected by its change in orientation to give an accurate flow measurement.

Path continuous emission monitoring system means a CEMS that measures the pollutant concentration along a path greater than 10% of the equivalent diameter of the flue, duct or stack cross section.

Point continuous emission monitoring system means a CEMS that measures the pollutant concentration either at a single point or along a path equal to or less than 10% of the equivalent diameter of the flue, duct or stack cross section.

Precision means the closeness of a measurement to the actual measured value expressed as the uncertainty associated with repeated measurements of the same sample or of different samples from the same process (e.g., the random error associated with simultaneous measurements of a process made by more than one instrument). A measurement technique is determined to have increasing precision as the variation among the repeated measurements decreases.

Protocol 1 gas means a calibration gas mixture prepared and analyzed according to "Revised Traceability Protocol No. 1," U.S Code of Federal Regulations, 40 CFR 75 Appendix H to Part 75. The certified concentrations for calibration gas mixtures developed using "Revised Traceability Protocol No. 1" are traceable to a standard reference material or an NIST/EPA-approved certified reference material.

Quality assured data means data generated from a CEMS when the CEMS is in control, and meets both the design and performance specifications of this Code.

Range means the algebraic difference between the upper and lower limits of the group of values within which a quantity is measured, received or transmitted.

Raw data means the generation and recording of data at the minimum specified frequency where required in this code and the generation and recording of data associated with quality control activities where required by this code or as a result of a facility's quality assurance plan.

Reference Method means any method of sampling and analyzing for a substance or determining the flow rate as specified in the Alberta Stack Sampling Code (as amended from time to time), or any other such method as authorized by the Director.

Reference value means the known concentration of a verification or calibration gas or the known value of a reference thermometer or output value of a temperature, pressure, current or voltage calibrator.

Relative accuracy is the absolute mean difference between the gas concentration or emission rate determined by a CEMS and the value determined by an appropriate Reference Method plus the 2.5 percent error confidence coefficient of a series of tests, divided by the mean of the Reference Method tests. The relative accuracy provides a measure of the systematic and random errors associated with data from a CEMS.

Response time means the amount of time required for the CEMS to display on the data recorder 95% of a step change in pollutant concentration. This period includes the time from when the sample is first extracted from the flue, duct or stack (if extractive system) to when the concentration is recorded.

Sample interface means that portion of a system used for one or more of the following: sample acquisition, sample transportation, sample conditioning, or protection of the monitor from the effects of the flue, duct or stack effluent stream.

Sensitivity means the minimum change of input to which a device is capable responding and is defined as two times the noise level.

Span means the algebraic difference between the upper and lower range values.

Standard absolute pressure means 760 mm Hg (101.325 kpa) at 25°C.

Standard absolute temperature means 25°C, 298°K, 77°F, or 537°R.

Standard reference material means a reference material distributed and certified by the National Institute of Standards and Technology (NIST) or the Canadian Standards Association (CSA).

Temperature-responsive zero drift means the zero drift of an analyzer for any 10° C change in temperature over the temperature range of 5 to 35°C.

Temperature-responsive span drift means the span drift of an analyzer for any 10° C change in temperature over the temperature range of 5 to 35°C.

Valid hour means data for a given hour consisting of at least four equally spaced data points. For example, if scans occur once every 15 minutes, then four 15-minute scans must be collected for the hour to be valid.

Valid in-stack opacity period means data for a given time period consisting of at least 36 equally spaced data points. For example, for a 6-minute time period, a minimum of 36 samples (cycles) must be obtained, based on a standard rate of sampling at no less than 6 samples (cycles) per minute.

Verification means to ascertain the extent of error in a device or system by comparing the output of that device or system to the reference value.

Zero drift means the difference between the CEMS's response to a lower range calibration value and the reference value after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

APPENDIX B - RELATIVE ACCURACY SAMPLE CALCULATIONS

APPENDIX B - RELATIVE ACCURACY SAMPLE CALCULATIONS

Relative Accuracy Test Audit Calculations

Example data from RATA on a $SO_2/0_2$ CEMS are shown in Table B.1.

$$CEMS_{ppm,\ dry} = \frac{CEMS_{ppm,\ wet}}{1 - B_{ws}}$$ **Equation B-1**

where: B_{ws} = moisture fraction of the CEMS gas sampled.

Table B.1 Relative Accuracy Test Audit Data for SO_2 and O_2 CEMS

Run Number	SO_2 Rm$_{d'}$ ppm	SO_2 CEMS$_{d'}$ ppm	O_2 Rm$_{d'}$ %	O_2 CEMS$_{d'}$ %	SO_2 Rm$_{d'}$ ng/J	SO_2 CEMS$_{d'}$ ng/J	SO_2 Diff ng/J
1	500	475	3.0	3.1	422.4	403.5	18.9
2	505	480	3.0	3.1	426.6	407.7	18.9
3	510	480	3.0	3.0	430.8	405.4	25.4
4	510	480	2.9	2.9	428.4	403.2	25.2
5	500	480	2.9	3.0	420.0	405.4	14.6
6	500	500	3.0	3.1	422.4	424.7	-2.3
7	510	510	3.0	3.1	430.8	433.3	-2.5
8	505	505	2.9	3.0	424.2	426.6	-2.4
9	510	520	2.9	3.0	428.4	439.3	-10.9
Avg	---	---	---	---	426.0	413.1	9.43

Rm$_{d'}$ = reference method data, dry basis
CEMS$_{d'}$ = monitor data, dry basis

The SO_2 and O_2 CEMS and RATA data in Table B.1 were converted to the units of the applicable standard using Equation B-2:

$$E = CF \frac{20.9}{20.9 - \text{percent } 0_2}$$ **Equation B-2**

where

E = pollutant emission, ng/J (lb/million Btu),

C = pollutant concentration, ng/dsm^3 (lb/dscf),

F = factor representing a ratio of the volume of dry flue gas generated to the caloric value of the fuel, dsm^3/J (dscf/million Btu), and

Percent 0_2 = oxygen content by volume (expressed as percent), dry basis.

Note: For the calculations shown in Table B.1, ppm of SO_2 was converted to ng/J using a conversion factor of 2.66×10^6 ng/scm/ppm and an F factor of 2.72×10^{-7} dsm^3/J.

For complete explanation of the equations and calculations, see 40 CFR; Part 60; Appendix A; Method 19; 5. Calculation of Particulate, Sulfur Dioxide, and Nitrogen Oxides Emission Rates.

After the data are converted to the units of the standard, the Relative Accuracy (RA) is calculated by using the equations in Section 4.5.8. For convenience in illustrating the calculation, these equations (B-3 through B-8) are also shown here.

The average difference d, is calculated for the SO_2 monitor using Equation B-3.

Equation B-3

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n}(X_i - Y_i) = \frac{1}{n}\sum_{i=1}^{n} d_i$$

$$= \frac{1}{9}(84.9) = 9.43 \; ng/J$$

where

n = number of data points,
X_i = concentration from reference method (Rm_d in Table B.1), ng/J,
Y_i = concentration from the CEMS ($CEMS_d$ in Table B.1),
d_i = signed difference between individual pairs, X_i and Y_i, ng/J, and
$\sum d_i$ = algebraic sum of the individual differences, d_i, ng/J.

The standards deviation S_d is calculated using Equation B-4:

Equation B-4

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \frac{1}{n}(\sum_{i=1}^{n} d_i)2}{n-1}}$$

$$= \sqrt{\frac{(2344) - \frac{1}{9}(84.9)^2}{8}} = 13.9\ ng/J$$

The 2.5 percent error confidence coefficient, CC, is calculated using Equation B-5.

$$CC = t_{0.975} \frac{s_d}{\sqrt{n}}$$

Equation B-5

$$= 2.306\ \frac{13.9}{\sqrt{9}} = 10.68\ ng/J$$

where

$t_{0.975}$ = t-values in Table B.2 for n = 9

Table B.2 Values of t for 95 Percent Probability[a]

n[a]	$t_{0.975}$	n[a]	$t_{0.975}$	n[a]	$t_{0.975}$
2	12.706	7	2.447	12	2.201
3	4.303	8	2.365	13	2.179
4	3.182	9	2.306	14	2.160
5	2.776	10	2.262	15	2.145
6	2.571	11	2.228	16	2.131

[a] The values in this table are already corrected for n^{-1} degrees of freedom. Use n equal to the number of individual values.

The RA for the RATA is calculated using Equation B-6

$$RA = \frac{|\bar{d}| + |CC|}{\overline{RM}} X\ 100 \qquad \textbf{Equation B-6}$$

$$= \frac{|9.43| + |10.68|}{426} x\ 100 = 4.72\%$$

Where

RA	=	relative accuracy, %,
$\lvert\bar{d}\rvert$	=	absolute value of the mean differences from Equation B-3, ng/J.
$\lvert CC\rvert$	=	absolute value of the confidence coefficient from Equation B-5, ng/J, and
$\overline{RM}$	=	average reference method value or applicable standard, ng/J.

APPENDIX C - BIBLIOGRAPHY

APPENDIX C - BIBLIOGRAPHY

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