Continuous Emission Monitoring System (CEMS) Code

Replaces the original Continuous Emission Monitoring System (CEMS) Code published May 1998

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Continuous Emission Monitoring System (CEMS) Code
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Acknowledgements

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1.0 Introduction

This Continuous Emission Monitoring System Code (CEMS Code) establishes requirements for the installation, certification, operation and maintenance of continuous emission monitoring systems for the most commonly monitored emissions and parameters in Alberta. This CEMS Code (April 2021) replaces the previous Continuous Emission Monitoring System Code (Alberta Environmental Protection 1998).

1.1 Purpose and Intent

The purpose of this CEMS Code is to:

- establish requirements for the installation, certification, operation and maintenance of CEMS in Alberta;
- ensure consistent and effective measurement, recording, and standardized reporting of specified emissions and other parameters;
- establish requirements for the quality assurance and quality control of continuous emission monitoring systems and data;
- establish requirements for alternative and replacement monitoring systems; and
- provide guidance for meeting CEMS requirements.

The requirement to conduct continuous emission monitoring on a specific effluent source is established through an approval issued under the *Environmental Protection and Enhancement Act (*EPEA). The CEMS Code identifies methods and specifications acceptable to the Director for installation, certification, operation and maintenance of CEMS. The Alberta Stack Sampling Code provides reference methods and stack sampling procedures for manually measuring emissions from stationary sources. Chapter 4 of the Air Monitoring Directive (AMD) allows the use of EPA promulgated methodologies, as amended, for conducting CEMS performance tests.

The CEMS Code provides minimum requirements. It is not the intent of the CEMS Code to exclude any monitoring methodologies or systems which are able to achieve or surpass the minimum specifications. However, any proposed alternative methodologies require prior written authorization from the Director (see 1.2-B).

In all parts of the CEMS Code, the mandatory requirements, which are indexed and written in italicized text, are enforceable through the approval. Explanation, guidance and suggestions are provided in regular text to supplement the requirements.

1.1-A	*If there is any conflict between the guidance portion and a mandatory requirement of the CEMS Code, the mandatory requirement shall prevail.*

1.1-B	*If there is any conflict between the CEMS Code and EPEA or the Regulations, EPEA or the Regulations shall prevail over the CEMS Code.*
1.1-C	*Terms and conditions in the CEMS Code do not affect rights or obligations under any approval issued in accordance with EPEA.*

The CEMS Code includes Appendices A, B, C, D and E. Definitions are provided in Appendix A.

1.2 Application and Implementation

Application of the performance specifications and QA and QC requirements in the CEMS Code are intended to continuously maintain CEMS performance and data quality. Industrial operations are required to meet CEMS performance specifications from certification forward, including following any changes to the system, according to the timelines outlined in the CEMS Code. Figure 1 provides a summary of the requirements of the CEMS Code.

1.2-A	*The person responsible must comply with the requirements of the CEMS Code on or before January 1, 2022, unless otherwise specified in the CEMS Code.*
1.2-B	*The person responsible must receive written authorization from the Director prior to commencing any (a) CEMS monitoring or (b) CEMS reporting which deviates from the requirements specified in the CEMS Code.*
1.2-C	*The terms and conditions of the CEMS Code are severable. If any term or condition of the CEMS Code or the application of any term or condition is held invalid, the application of such term or condition to other circumstances and the remainder of the CEMS Code shall not be affected thereby.*
1.2-D	*If the approval requires CEMS monitoring for a parameter not included in the CEMS Code, the person responsible must get written authorization from the Director for:* *(a) design specifications;* *(b) performance specifications;* *(c) test procedures; and* *(d) QA and QC checks.*
1.2-E	*The person responsible must (a) deploy competent personnel and (b) where appropriate provide relevant training for personnel to perform tasks related to CEMS, including:* *(i) installation;* *(ii) operation;* *(iii) maintenance;* *(iv) performance assessment;* *(v) inspection;*

(vi) verification;
(vii) annual evaluation;
(viii) data collection;
(ix) reporting; and
(x) any other activities required by the CEMS Code.

Personnel competence refers to demonstrating that an activity can be adequately performed and should be based upon an appropriate combination of certification, education, training, and experience. Personnel competence can be demonstrated by an internal company process or through external qualification or training where applicable. AMD Chapter 9, Section 9.0, provides guidance on recommended training for source monitoring.

The person responsible is accountable for ensuring that the requirements in the CEMS Code are met, including any monitoring, reporting or maintenance activities conducted by a contractor on behalf of the person responsible. The person responsible is accountable to provide quality assured CEMS data by meeting the requirements of the CEMS Code.

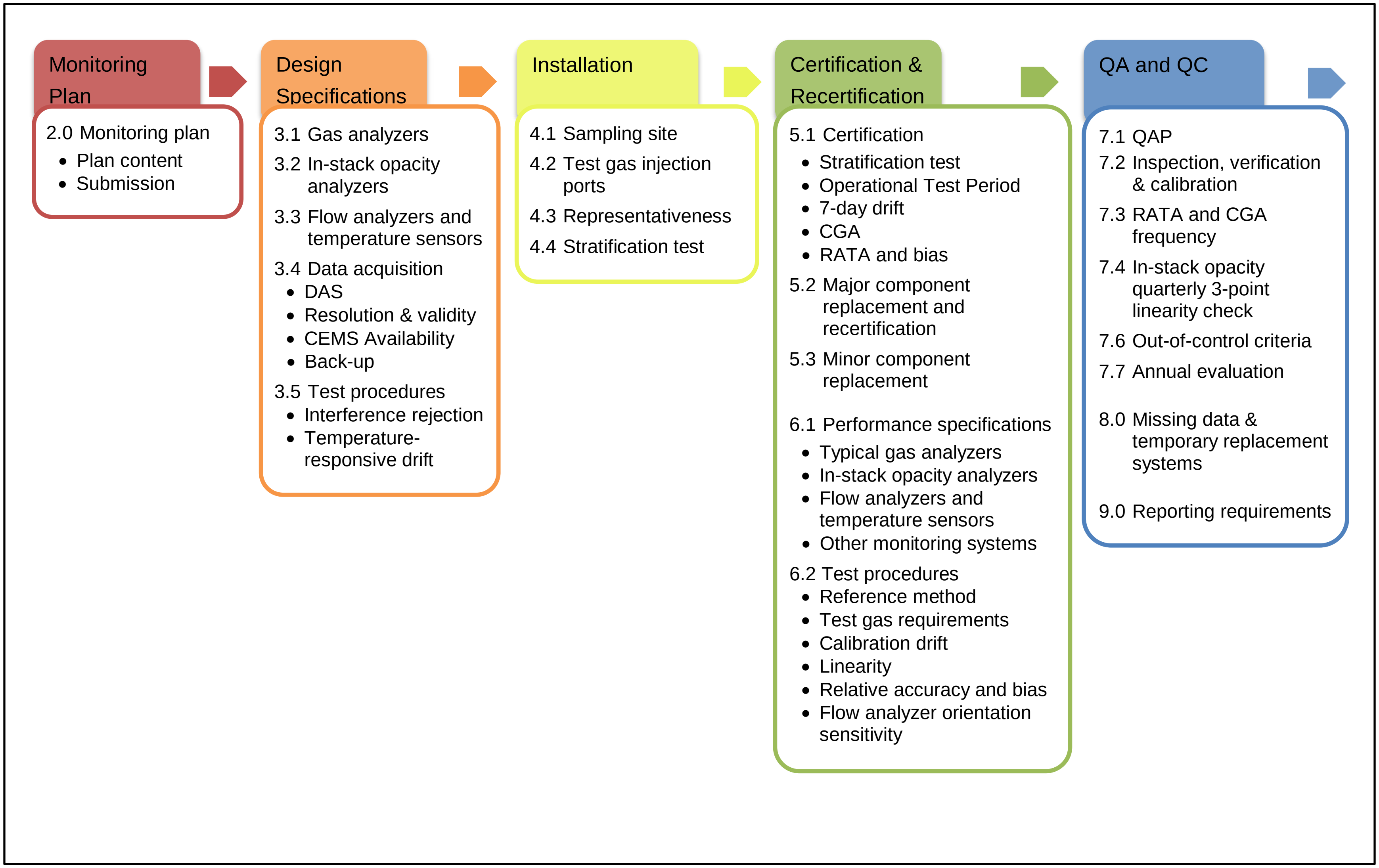

Figure 1 Summary of CEMS Code requirements

1.3 Amendments

Reserved for future use.

1.4 CEMS Data Use

Emissions data generated by a CEMS have multiple uses. The data are used to assess compliance with monitoring and reporting requirements in the industrial operation's approval and the CEMS Code. The data can also be used by the industrial operation for optimizing plant performance and determining the effectiveness of processes and air emission control equipment. CEMS data are used for reporting emissions to the Director and these data can be used for tracking and modelling emissions at the local, regional, provincial and national level as well as for environmental planning.

All data generated by a CEMS, where the use of that CEMS is required by an approval, may be used as a basis for enforcement against source emission limits.

1.5 CEMS Technology

CEMS monitoring techniques are based on the measurement of both physical and chemical properties of the parameter of interest. The method selected for analysis is normally based on the properties of the parameter being measured, but selection may be limited by the source or stack conditions or otherwise dictated by approval requirements. Commonly used analytical techniques for gases include those of spectroscopic absorption, luminescence, electroanalysis, electrochemical analysis and paramagnetism. Gas flow is normally measured using differential pressure, thermal, or ultrasonic techniques.

The Director does not directly or indirectly endorse any specific CEMS equipment, alternative methods, manufacturers or named technologies. No list of approved equipment or vendors will be maintained by the Director. The specifications and requirements in the CEMS Code are performance based, therefore the equipment selected must perform according to these specifications and requirements.

The specifications in the CEMS Code require the use of independent, certified test gases for assessing linearity across the operating range of an analyzer. An alternative to conducting CGAs will be accepted until such time that the industrial operation's CEMS analyzers are replaced (see 3.1-B and 6.2-O).

Development and use of Predictive Emission Monitoring Systems (PEMS) is covered in Section 10.0.

1.6 CEMS Data and Records Retention

1.6-A	*The person responsible must retain all raw CEMS data for a minimum of three years, including:* *(a) results of all performance tests;* *(b) maintenance logs;* *(c) corrective action logs; and* *(d) revisions made to the QAP.*

See 3.4-B for minimum raw data retention requirement and definition in Appendix A. Raw data should provide for demonstration of quality control activities as defined in the CEMS Code and the QAP.

1.6-B	*The person responsible must provide raw CEMS data to the Director upon request.*
1.6-C	*The person responsible must retain a copy of final reports and data summaries for a minimum of ten years.*

The format of records is not stipulated, however electronic format for documents, records and data is preferred.

2.0 Monitoring Plan

The purpose of the monitoring plan is to provide the Director with a plan of how CEMS equipment will be designed, installed, operated and maintained in order to meet approval and CEMS Code requirements. The monitoring plan outlines operational details that will be followed to monitor emissions continuously as well as how outages and out of range data will be handled.

The monitoring plan discloses to the Director how CEMS monitoring will be conducted, whereas the QAP is used for day-to-day CEMS operation (QA and QC activities) at the site (see QAP requirements in Section 7.1).

2.0-A	*The person responsible must submit a CEMS monitoring plan that meets the requirements of the CEMS Code to the Director a minimum of 90 days prior to planned commencement of a new CEMS installation.*

The 90-day monitoring plan submission timeline is a minimum. Monitoring plans may be submitted further in advance of CEMS commencement.

A new CEMS installation refers to no existing CEMS in place (and therefore no monitoring plan history). Upon the effective date of the CEMS Code, industrial operations with an existing CEMS presently in operation are not required to submit or resubmit a monitoring plan. For CEMS recertification, refer to notification requirements in Section 5.2.

2.0-B	*The person responsible must receive written authorization from the Director for any deviation from the CEMS Code or Alberta Stack Sampling Code prior to submitting a CEMS monitoring plan.*

The monitoring plan is not to be used to request authorization to deviate from requirements. Onus is on the person responsible to ensure CEMS Code and Alberta Stack Sampling Code requirements are met, or that any deviations are authorized (refer to 1.2-B).

The person responsible is able to proceed with CEMS commencement, according to the details and timeline set out in the submitted monitoring plan, unless otherwise directed by the Director.

2.0-C	*The person responsible must submit one monitoring plan for each individual CEMS, except in the case of multiple, simultaneous and equivalent CEMS with analyzers of identical make and model and measuring sources of equivalent size.*

For example, multiple steam generators of equivalent size equipped with analyzers of the same make and model, but different serial numbers, could be submitted in one monitoring plan. If two individual sources are coming online and the CEMS, sources, stacks or port locations are different, separate monitoring plans would be required for each CEMS unit.

2.0-D	*The person responsible must include a section in the monitoring plan in 2.0-A on industrial operation process information, including the following information at a minimum:* *(a) description of the industrial operation process(es) and source, including the unique source identifier as identified in the approval or approval application;* *(b) description of air emission control equipment that could influence the CEMS;* *(c) description of all factors that may affect the operation of the CEMS;* *(d) proposed timeline for initiation of industrial operation production and source emissions;* *(e) proposed date of CEMS installation; and* *(f) proposed timeline for initiation of CEMS operation and data submission.*
2.0-E	*The person responsible must include a section in the monitoring plan in 2.0-A on source and monitoring locations, including the following information at a minimum:* *(a) schematic diagram of source including above grade measurements for each of the following at a minimum:* *(i) source (1) location in latitude and longitude and (2) dimensions including internal stack, duct or flue diameter;*

(ii) sampling location access and egress points;
(iii) location of all CEMS components;
(iv) location of (1) CEMS sample acquisition points and paths in relation to flow disturbances (such as fans, elbows, inlets, outlets, emission control equipment), (2) flue walls, (3) emission point of the monitored effluent stream to the atmosphere, and (4) test gas injection location; and
(v) location of reference method measurement points in relation to CEMS sample ports and any flow disturbances;

(b) description of any known flow disturbances or stratification;
(c) confirmation that CEMS installation meets all location and separation requirements of the CEMS Code; and
(d) listing of any granted letters of authorization to deviate from the CEMS Code, including:

(i) the date each authorization was granted;
(ii) which sections and clauses of the CEMS Code are affected; and
(iii) a brief explanation of the deviation(s).

Measurements should be in metric and equivalent inside diameters.

For 2.0-E(a)(iii), an example is specifying whether temperature measurement will be conducted at the stack top or at the same location as the CEMS. The requirement in 2.0-E(c) may be satisfied by a table comparing sampling site and test gas injection port locations to the minimum requirements set out in Section 4.0. An example of 2.0-E(d) is deviation from the measurement location criteria for small diameter stacks, ducts or flues.

2.0-F The person responsible must include a section in the monitoring plan in 2.0-A on system information, including the following information at a minimum:

(a) CEMS principle of operation (e.g., extractive, in-situ) and any sample conditioning;
(b) parameters to be monitored;
(c) operating principle of each analyzer (e.g., chemiluminescence);
(d) number of (i) analyzers and (ii) acquisition points or paths for a dedicated source;
(e) equipment (i) manufacturer, (ii) model number and (iii) serial numbers (if known);
(f) expected normal and maximum (i) analyzer and (ii) flow rate readings;
(g) operating range of each analyzer, including description of how operating range was selected;
(h) response time for each analyzer from manufacturer's specifications;
(i) description of any dual-range analyzer operation and how use of upper range will be triggered; and
(j) description of data collection and storage, including:

(i) DAS configuration and software provider, if applicable;
(ii) description of the flow of data from capture to reporting;
(iii) description of how reporting intervals greater than 1-hour will be calculated, if applicable (e.g., 12-hour, 24-hour, 720-hour rolling average);

(iv) example calculations showing how units of the standard conversion will be calculated, if applicable; and
(v) any conversion factors that will be used for calculating CEMS output parameters including example calculations.

2.0-G The person responsible must include a section in the monitoring plan in 2.0-A on air emission information, including the following information, at a minimum:
(a) description of (i) the process operating parameters that affect air emission levels or parameters being monitored and (ii) the method to be used to record these parameters;
(b) description of (i) the air emission control equipment operating parameters that affect emission levels or parameters being monitored and (ii) the method to be used to record these parameters;
(c) description of how source operating times will be determined in accordance with the approval, including:
(i) how CEMS online and offline periods will be determined;
(ii) a description of how monitoring will be conducted during periods when processing is inactive but the source is emitting (e.g., start-up, cool down, purge modes, catalyst regeneration or catalyst burnout); and
(iii) batch or intermittent processing; and
(d) description of how production rate will be calculated.

2.0-H The person responsible must specify in the monitoring plan in 2.0-A the timeline for QAP development to include the requirements in Section 7.1.

2.0-I The person responsible must include a section in the monitoring plan in 2.0-A on proposed CEMS certification plan, including the following information at a minimum:
(a) proposed dates and methods for stratification testing; and
(b) proposed date for certification.

2.0-J The person responsible must include a section in the monitoring plan in 2.0-A on data submission, including the following information, at a minimum:
(a) parameters to be reported, including (i) intervals, (ii) duration and (iii) units;
(b) identification of the data qualifiers that will be used (e.g., data flags, sensor comment codes, operational mode codes); and
(c) procedures for validation of data reporting intervals.

2.0-K The person responsible must electronically submit the monitoring plan in 2.0-A to the Director in accordance with:
(a) the Acceptable Formats for EPEA Approval and Code of Practice Records and Submission Coordinates, as amended from time to time; and
(b) the EPEA Approval Industrial Monitoring Documentation Submission Naming Guideline, as amended from time to time.

The documents in 2.0-K(a) and (b) are available from the AMD website.

2.0-L	*The person responsible must include in the monitoring plan in 2.0-A any additional information requested by the Director.*

3.0 Design Specifications and Test Procedures

Minimum design specifications are prescribed for gas analyzers, in-stack opacity analyzers, flow analyzers and temperature sensors to ensure comparably accurate readings will be obtained for the parameter being measured, regardless of the analyzer manufacturer or operating principle.

3.1 Design Specifications for Gas Analyzers

3.1-A	*The person responsible must meet the minimum design specifications in Table 1 for any new gas analyzer installed after January 1, 2022.*
3.1-B	*If the person responsible installs a new gas analyzer for the parameters in Table 1 after January 1, 2022, the person responsible must (a) install a gas analyzer that is capable of conducting a CGA using flowing test gas and (b) operate the gas analyzer to use flowing test gas to conduct CGAs.*

Analyzers currently in place which are not capable of performing a CGA using flowing test gas may conduct alternate biannual audits as per Section 6.2.4 in place of CGAs until such time as the analyzer is replaced. As per 3.1-B, analyzers purchased after the effective date of this Code need to be equipped to conduct CGAs using flowing test gas.

Table 1 provides minimum design specifications for sulphur dioxide, nitrogen oxides, carbon monoxide, oxygen, carbon dioxide, total reduced sulphur and hydrogen sulphide analyzers incorporated in the CEMS. The lower detection limit, interference rejection and temperature-responsive drift may be determined either by the instrument manufacturer or the person responsible.

In Table 1, interference rejection refers to the sum of all interferences due to other gas species as measured by the procedures given in Section 3.5.1.

Section 3.5.2 provides the procedure for assessing temperature-responsive zero and span drift.

Methods for continuous monitoring of mercury emissions are provided in the CCME Monitoring Protocol in Support of the Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants.

Table 1 Minimum design specifications for gas analyzers

Analyzer	Lower detection limit	Interference rejection (sum total)	Operating range	Temperature-responsive zero drift[a]	Temperature-responsive span drift[a]	Conversion efficiency (if applicable)
Sulphur dioxide	≤ 2.0% of FS	≤ ±4.0% of FS	Set to encompass all anticipated concentrations	≤ ±2.0% of FS	≤ ±3.0% of FS	N/A
Nitrogen oxides	≤ 2.0% of FS	≤ ±4.0% of FS		≤ ±2.0% of FS	≤ ±4.0% of FS	≥ 90.0% (NO_2 to NO)
Carbon monoxide	≤ 2.0% of FS	≤ ±4.0% of FS		≤ ±2.0% of FS	≤ ±3.0% of FS	N/A
Oxygen	≤ 0.5% O_2 absolute	≤ ±1.0% O_2 absolute	0 – 21%	≤ ±0.5% O_2 absolute	≤ ±0.5% O_2 absolute	N/A
Carbon dioxide	≤ 0.5% CO_2 absolute	≤ ±1.0% CO_2 absolute	0 – 25 %	≤ ±0.5% CO_2 absolute	≤ ±0.5% CO_2 absolute	N/A
Total reduced sulphur	≤ 2.0% of FS	≤ ±4.0% of FS	1.5 times approval limit or 30 ppm[b]	N/A	N/A	N/A
Hydrogen sulphide	≤ 2.0% of FS	≤ ±4.0% of FS	1.5 times approval limit or 30 ppm[b]	N/A	N/A	N/A

[a] For every 10°C change in analyzer operating temperature over the temperature range 5°C - 35°C.
[b] Meeting either specification is adequate.
N/A = not applicable.

3.1.1 Operating Range

As per Table 1, the operating range for sulphur dioxide, nitrogen oxides and carbon monoxide analyzers is set to encompass all anticipated concentrations for the gas being monitored.

The analyzer operating range is set to be able to accurately quantify emissions on an ongoing basis. Choosing an appropriate operating range for each gas analyzer is important to ensure good measurement accuracy and maintain a high signal-to-noise ratio, while also allowing the CEMS to measure potential emission limit exceedances. When determining operating range, the majority of the readings obtained during typical unit operation ideally would fall between 20 to 80% of the analyzer full scale.

Since operating range (analyzer full scale) is tied to performance test and quality control calculations, it is critical that these are documented in the QAP and consistent from test to test.

If measured gas concentrations fall outside of the operating range of the analyzer, the data are not quality assured and cannot be used towards percent availability. However if out of range data is captured, the person responsible is still required to report it. See Section 9.0 for reporting requirements.

Data may be post-validated (quality assured) for emission concentrations outside the operating range of the analyzer as per procedures outlined in the QAP. For such situations, the QAP should outline how to challenge the analyzer to determine if it is still linear outside of the operating range.

A dual-range analyzer should be considered if normal emissions are well below the emission limit, but there is the possibility of emissions exceeding the range established for normal source operation (e.g., under pollution control equipment bypass conditions). A dual range analyzer should also be considered if during operations, emissions routinely undergo significant (i.e., order of magnitude) changes.

3.2 Design Specifications for In-Stack Opacity Analyzers

3.2-A For any new in-stack opacity analyzer installed after January 1, 2022, the person responsible must:

(a) only use an in-stack opacity analyzer that meets the design specifications of ASTM D6216, as amended from time to time;

(b) obtain a certificate of conformance from the manufacturer stating that the in-stack opacity analyzer meets the design specifications of ASTM D6216; and

(c) install the in-stack opacity analyzer in accordance with EPA Performance Specification 1 of 40 CFR 60 Appendix B, as amended from time to time.

3.3 Design Specifications for Flow Analyzers and Temperature Sensors

3.3-A The person responsible must meet the minimum design specifications outlined in Table 2 for all (a) flow analyzers and (b) temperature sensors installed after January 1, 2022.

Table 2 Minimum design specifications for flow analyzers and temperature sensors

Analyzer	Lower detection limit	Operating range	Physical Design
Flow	1.0 m/s	Set to encompass all anticipated values	a. Means of cleaning flow element b. No interference from moisture
Temperature	N/A		N/A

N/A = not applicable.

3.4 Specifications for Data Acquisition and Handling

Data acquisition and handling includes the full system to control the automatic functions of the CEMS, accept and handle output from analyzers, store data, display data, and all data manipulation, calculations and reporting out. The DAS may include several controllers, hardware and interfaces to carry out these functions.

The person responsible is required to report CEMS data for all times that the source is operating (9.0-A) and meet the CEMS availability requirements in Section 6.1.

3.4.1 DAS Requirements

3.4-A The person responsible must (a) install and (b) operate a DAS that meets the following requirements:

- *(i) accepts the signal output of all associated (1) gas analyzers, (2) flow analyzers, (3) temperature sensors and (4) any other measurement components for all times that the CEMS is in operation;*
- *(ii) converts the individual signal outputs to emission rates in the units of the standard, if applicable;*
- *(iii) captures the full range of emission concentrations from zero through to full scale; and*
- *(iv) records and computes automated zero and span drifts.*

Data collected by the DAS are used to generate hourly averages and are retained for validation and performance checks. The DAS captures data within the calibrated operating range (operating range set as per Sections 3.1 to 3.3), but may also record values outside of that range. Data within the calibrated range is quality assured, however all data captured is reportable (see Section 9.0).

3.4.2 Data Resolution and Validity

3.4-B The person responsible must retain 1-minute base averages from analyzer signal output, except in the case where the analyzer scan rate exceeds 1 minute.

3.4-C The person responsible must:

- *(a) calculate and retain 1-hour averages for all analyzers and sensors, except in-stack opacity; and*
- *(b) determine data validity for each 1-hour average calculated such that a valid hour contains at least 75% of the possible 1-minute base averages within the hour.*

Retention of 1-hour averages is required for gas concentrations as well as temperature and flow.

If the analyzer is not capable of producing 1-minute base averages due to a scan rate greater than 1 minute, the person responsible may use the base average frequency available, as defined in the QAP, to calculate a 1-hour average and determine a valid hour based on 75% of the possible base averages within the hour.

3.4-D	*When the source operates for less than a full hour, the person responsible must:* *(a) generate a partial hour based on all available data; and* *(b) determine data validity for each partial hour such that a valid partial hour contains at least 75% of the possible base averages in the portion of the hour that the source operates.*

CEMS data are reported for all periods that the source operates (as per 9.0-A), including any partial hours. See Section 9.0 for reporting requirements.

Both an hour and a partial hour require a minimum of 75% coverage within that averaging interval to be quality assured. If a valid hour or valid partial hour cannot be attained, the hour is considered missing.

For example, if a source operates for a full clock hour and the DAS captures 1-minute base averages, there is a possibility of 60 base averages within the hour. The valid hour requirement in 3.4-C(b) would be met as long as a minimum of 45 1-minute averages are available from the CEMS to calculate a 1-hour average. If the same source operates for just 12 minutes in the clock hour, there is a possibility of 12 1-minute averages and the valid partial hour requirement in 3.4-D(b) would be met as long as the CEMS records a minimum of 9 1-minute averages to calculate the partial hour. The partial hour is required to be calculated and reported.

When a scheduled daily zero and span drift test is performed, the activity should be planned so as to still obtain 75% of an hourly period, whenever possible, resulting in a valid hour. In the case of a daily zero and span test longer than 15 minutes in duration, the test can be scheduled to occur within the last 15 minutes of one hour and the first 15 minutes of the subsequent hour, to allow for 75% of each of the two consecutive hours to be collected.

3.4-E	*For in-stack opacity analyzers, the person responsible must use a 10-second scan rate, at a maximum.*
3.4-F	*For in-stack opacity, the person responsible must determine data validity for each average for reporting purposes such that a valid average contains at least 75% of the possible 1-minute base averages within the averaging period.*

The person responsible may use base averages of finer-resolution than 1-minute, while still following the 75% validity requirement in 3.4-F. In-stack opacity averaging intervals for reporting purposes are specified in the industrial operation's approval. If the averaging interval for reporting opacity is not specified in the approval, the default requirement is a 6-minute average (see 9.0-D).

3.4-G	*If (a) averages or (b) totals are generated at a time interval greater than one hour, the person responsible must operate the DAS to use every valid hour within the time interval to generate the average or total.*

Emission limits in the approval may be based on intervals other than one hour (e.g., 12-hour, 24-hour).

3.4-H	*For generating averages or totals at a time interval greater than one hour in 3.4-G, not including rolling averages, the person responsible must determine data validity for each time interval such that a valid interval contains at least 75% valid hours within the interval.*

A time interval is invalid if greater than 25% of the hourly averages within the interval are invalid or missing. This does not apply to rolling averages. Guidance on reporting rolling averages is provided in the CEMS User Manual.

For example, if an industrial operation has a 12-hour average approval limit, 12 valid hours would be averaged to give a 12-hour average. To meet the valid interval requirement in 3.4-H, 9 valid hours are required in order to report a valid 12-hour average. If an industrial operation has an approval containing a tonnes per day (daily) approval limit, 24 valid hours would be totaled to give a daily total. To meet the valid interval requirement in 3.4-H, 18 valid hours are required in order to report a valid 24-hour total. If a valid interval cannot be attained, the reporting interval is considered missing.

3.4-I	*When generating averages or totals other than one hour, if the source operates for less than the averaging interval for gases or in-stack opacity, the person responsible must:* *(a) generate a partial interval based on all available valid base averages; and* *(b) determine data validity for each partial interval such that a valid partial interval contains at least 75% of the possible base averages in the portion of the interval that the source operates.*

3.4.3 CEMS Availability

CEMS availability requirements in Section 6.1 ensure continuous emissions data is provided for the time the source is operating (as per 9.0-A). Percent availability specifications are mandated to avoid long periods of monitoring gaps when emissions data are unavailable or invalid.

For any CEMS, percent availability is represented by a ratio of analyzer operation to source operation over a calendar month, as represented in Equation 1. Source operation (or time the source operated) is the total time during which the source is emitting. This includes any time that effluent was discharged, which may include start-up, cool down, purge modes, catalyst regeneration or catalyst burnout, even if the unit(s) are not actively processing.

The monitoring plan is required to include a description of how source operating times will be determined (see 2.0-H) and the QAP should outline the procedures to track operational time (see Section 7.1).

3.4-J	*The person responsible must calculate percent availability for all times that the source is operating, using Equation 1, for each CEMS analyzer corresponding to the Codes for Electronic Reporting, as referenced in the CEMS User Manual.*

$$\textit{Percent availability} = \frac{t_a}{t} \times 100\% \qquad \textit{Equation 1}$$

where:

t_a = total hours during the month for which the analyzer was operationally available (in control and meeting performance specifications) while the source was operating; and

t = total time in hours that the source operated during the month.

Note: monthly percent availability may be determined using finer-resolution time periods (e.g., minutes) if the person responsible has the capability.

Percent availability requirements are provided in the performance specifications in Section 6.1. Percent availability is calculated for any time the source operated. If starting up a new CEMS, percent availability is not required to meet the percent availability performance specification until after certification of the CEMS. If a CEMS analyzer malfunctions and goes offline while the source is still operating, percent availability is still calculated. See Section 8.0 for options for continuing to report data during a CEMS outage.

In Equation 1, routine and pre-planned QA and QC activities (i.e., those described in the QAP) are included in the total analyzer operational hours (t_a). Examples of QA and QC activities for which the CEMS is still considered operational and in control include regular daily zero and span checks, performance checks (CGA and RATA), other pre-planned quality control checks, pre-planned calibrations, back purging, as well as scheduled preventative maintenance set out in the QAP.

Circumstances impacting analyzer operation which cannot be deemed as CEMS operational time include, but are not limited to: instrument malfunction, performance test failure, data impacted by zero or span failures, non-routine calibration to address failures, power outages, instrument repairs which are in response to malfunction (not pre-planned or preventative maintenance), or any period where the CEMS is out-of-control as per Section 7.6.

Note that percent availability is different from determination of valid hours. Percent availability measures the proportion of the month that an analyzer was operational. Valid hours represent quality assured, reportable data. During a calibration, linearity test or some preventative maintenance activities, the CEMS may be operational but it is not providing quality assured data. During such periods, the CEMS is operational but the data are not quality assured (representative of emissions), and therefore not reportable.

Example 1:
A CEMS analyzer had 31 daily zero and span test cycles in a 31-day month, averaging 20 minutes duration each, and had a CGA conducted, taking 3 hours to complete. There was no unplanned maintenance performed during the month or downtime from analyzer malfunction. In this case, t_a in Equation 1 would be reported as 744 hours. The regular daily zero and span tests and scheduled CGA are normal and pre-planned QA and QC activities, so they are deemed as analyzer operational time and there is no analyzer downtime.

In this example the source operated continuously throughout the 31-day month, therefore t in Equation 1 would be reported as 744 hours. In this case percent availability would be:

$$\text{Percent availability} = \frac{744\text{ hours}}{744\text{ hours}} \times 100\% = 100\%$$

Example 2:
A CEMS analyzer had 31 daily zero and span test cycles in a 31-day month, averaging 20 minutes duration each. No other planned QA and QC activities were conducted, but the analyzer failed a daily span test. If it takes 6 hours to troubleshoot, take corrective action and successfully pass a subsequent span test, the CEMS is out-of-control for 6 hours (could be a longer period if the root cause is determined to have occurred back at a specific point in time), and therefore the analyzer was not operational for that time. In this case, t_a in Equation 1 would be reported as:

$$t_a = 744\text{ hours} – 6\text{ hours} = 738\text{ hours}$$

In this example, the source operated continuously throughout the 31-day month, therefore t in Equation 1 would be reported as 744 hours and percent availability would be:

$$\text{Percent availability} = \frac{738\text{ hours}}{744\text{ hours}} \times 100\% = 99.2\%$$

3.4-K	*If the person responsible pre-plans replacement of a CEMS analyzer and cannot meet percent availability specifications in Section 6.1 during the analyzer replacement period, the person responsible is exempt from meeting percent availability requirements for that analyzer for a maximum of 2 consecutive months, as long as:* *(a) the analyzer replacement is complete in 30 days or less; and* *(b) percent availability is still reported, including a comment explaining the pre-planned analyzer replacement.*

If permanent replacement of an analyzer is planned (as part of preventative maintenance), the person responsible has time allotted to install and test the new analyzer. If percent availability requirements cannot be met during the transition, the person responsible still needs to report percent availability (on the AMD CEMS Summary Form; see AMD Chapter 9). However, the percent availability requirement in Section 6.1 does not need to be met for that month as per 3.4-K. The reason for not meeting percent availability requirements would be explained in the comments section of the reporting form. Planned replacement of an analyzer should be expedited to minimize data loss. See Section 5.2 for more on permanent analyzer replacement.

The exemption 3.4-K does not apply to replacement of an analyzer or installation of a temporary analyzer in response to analyzer malfunction or failure. Under these scenarios, if percent availability requirements cannot be met, the non-compliance would be reported as per AMD Chapter 9.

3.4.4 Use of Back-up Data Sources

3.4-L	*The person responsible must only use temporary back-up data sources during periods of primary DAS reporting loss if:* *(a) the back-up data source is known to yield identical CEMS data as the primary DAS data; and* *(b) the CEMS data submitted from the back-up data source adheres to the Codes for Electronic Reporting, as referenced in the CEMS User Manual.*

A back-up data source may be used as an alternative when the primary data source is unavailable, and data may be used towards meeting CEMS percent availability criteria. In 3.4-L(a), it may be demonstrated that data from a back-up data source is identical to the primary DAS reporting data by comparing primary DAS reporting data to the back-up data source before and after the primary DAS reporting data loss and documenting that the back-up data are not statistically different.

3.4-M	*The person responsible must outline the procedure for the use of back-up data in the QAP.*
3.4-N	*The person responsible must flag the use of a back-up data source according to the CEMS User Manual prior to submission if a back-up data source is used to fulfill CEMS data reporting requirements.*

3.5 Test Procedures for Verifying Design Specifications

3.5.1 Analyzer Interference Rejection Test

3.5-A	*For any new gas analyzer installed after January 1, 2022, the person responsible must meet the analyzer interference rejection specifications in Table 1 prior to certification by either:* *(a) obtaining a certificate of conformance from the manufacturer that certifies that:* *(i) an identical, randomly selected analyzer, manufactured in the same quarter as the analyzer purchased, was tested for interference rejection; and* *(ii) the randomly selected analyzer was found to meet or exceed the specifications in Table 1; or* *(b) conducting an interference rejection test on the gas analyzer according to the following procedure:* *(i) allow sufficient time for the analyzer to warm up;* *(ii) calibrate the analyzer by introducing (1) low and (2) high-range test gases, based on the analyzer operating range, directly to the analyzer sample inlet;* *(iii) introduce test gases, each containing a single interfering gas at a concentration representative of the species in the effluent stream to be monitored;* *(iv) determine the magnitude of the interference of each potential interfering species;* *(v) obtain a summed response of all interfering gases; and* *(vi) meet the interference rejection specification in Table 1 for the summed response.*

The test in 3.5-A(b) may be carried out after the analyzer has been installed in the CEMS or in a laboratory or other suitable location before the analyzer is installed.

3.5.2 Analyzer Temperature-Responsive Zero and Span Drift Test

3.5-B	*For any new gas analyzer installed after January 1, 2022, the person responsible must meet the temperature-responsive zero and span drift specifications in Table 1 prior to certification by either:* *(a) obtaining a certificate of conformance from the manufacturer that certifies that:* *(i) an identical, randomly selected analyzer, manufactured in the same quarter as the analyzer purchased, was tested for temperature-responsive zero and span drift; and* *(ii) the randomly selected analyzer was found to meet or exceed the specifications in Table 1; or* *(b) conducting a temperature-responsive zero and span drift test on the gas analyzer according to the following procedure:* *(i) place the analyzer in a climate chamber in which the temperature can be varied from 5°C to 35°C;* *(ii) allow sufficient time for the analyzer to warm up;*

> (iii) *calibrate the analyzer at 25°C using appropriate zero and span gases based on the analyzer operating range;*
> (iv) *wait for the analyzer temperature to stabilize;*
> (v) *introduce the test gases at constant flow and pressure conditions;*
> (vi) *note the response of the analyzer;*
> (vii) *repeat steps (iii) through (vi), adjusting the temperature of the chamber to 35°C, 15°C, and 5°C, respectively;*
> (viii) *calculate the temperature-responsive zero drift from the difference in the analyzer's zero response with the zero response at the next higher or lower temperature;*
> (ix) *calculate the temperature-responsive span drift from the difference in the analyzer's span response with the span response at the next higher or lower temperature; and*
> (x) *meet the temperature-responsive zero and span drift specifications in Table 1 for the difference between all zero and span responses.*

Analyzer power cannot be turned off during the temperature-responsive zero and span drift test procedure in 3.5-B(b).

4.0 Installation Specifications and Test Procedures

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

> *4.0-A The person responsible must meet the installation specifications in Section 4.0 (a) for any new CEMS installation from January 1, 2022 forward and (b) following any major structural modifications to the stack, duct or flue.*

A new CEMS installation refers to no existing CEMS in place, or anytime new sampling ports are established.

> *4.0-B The person responsible must install the CEMS according to the equipment manufacturer's documentation or manual.*

4.1 Location of the Sampling Site

Frequency and quality of maintenance on a CEMS is dependent on the accessibility of the stack-, duct- or flue-mounted portion of the CEMS.

4.1-A	*The person responsible must install stack-, duct- or flue-mounted CEMS analyzers in a location that is accessible at any time during normal weather conditions.*

Personnel safety is of the utmost concern. It is not expected that individuals place themselves at risk to service the CEMS equipment during thunderstorms, high winds, heavy snow or rain events or other hazards.

4.1-B	*The person responsible must install CEMS equipment that is capable of operating in the environmental conditions in which the equipment will be exposed.*

For example, at a thermal electric power generating plant, the stack-, duct- or flue-mounted equipment needs to operate and be maintained over the full range of temperatures experienced (i.e., approximately -40° to +40°C). This performance may be accomplished by enclosing the equipment in a heated and air conditioned shelter or enclosed annulus. Provisions for conducting adequate maintenance, as scheduled and identified in the QAP, would also need to be in place.

4.1-C *When installing each of (a) gas analyzers, (b) flow analyzers and (c) temperature sensors, the person responsible must locate these analyzers or sensors according to the following:*

- *(i) the requirements specified in:*
  - *(1) Method 1 of the Alberta Stack Sampling Code, as amended from time to time; or*
  - *(2) EPA promulgated methods;*
- *(ii) at least two equivalent stack, duct or flue diameters downstream from:*
  - *(1) the nearest control device;*
  - *(2) the point of emission generation; and*
  - *(3) any flow disturbance or other point at which a change in the gas concentration or emission rate may occur;*
- *(iii) at least a half equivalent stack, duct or flue diameter upstream from the effluent exhaust; and*
- *(iv) at least 0.3 metres downstream from reference method ports, except in the case of ultrasonic flow analyzers.*

4.1-D *When installing point or path-type CEMS, the person responsible must use a measurement point that is:*

- *(a) at least 1.0 m from the stack, duct or flue wall; or*
- *(b) within or centrally located over the centroid area of the stack, duct or flue cross-section.*

4.2 Location of Test Gas Injection Ports

The required location of test gas injection ports is dependent on the CEMS principle of operation according to Table 3.

4.2-A	*The person responsible must (a) locate test gas injection ports and (b) introduce test gas according to the specifications in Table 3.*

Table 3 Location of test gas injection ports

CEMS type	Subsystem	Specification for location of test gas injection port and introduction of test gas
In-situ	Point	Test gas must flood the measurement cavity of the analyzer.
	Path	Test gas must be introduced at a point to provide a check on the active optical and electronic components of the system.
Extractive	Direct measurement of gas concentration	Test gas must be introduced at the probe, or as close as possible to the stack flange at the probe exit.
	Dilution (in-stack and external)	Test gas must be introduced prior to dilution, at the probe, or as close as possible to the stack flange at the probe exit.

4.3 Representativeness

It is critical that CEMS sampling locations are chosen to obtain a representative sample of emissions (gas concentration and emission rate) in the stack, duct or flue. Flowing gases are generally well mixed, but stratification can occur when different gas streams intersect, gas temperatures differ, flow is reduced, or where the stack, duct or flue geometry changes. A helical flow pattern (cyclonic flow) may result from one or more ducts entering a stack, causing a swirling pattern of gas flow which can make it difficult to find a location to determine average representative emissions.

4.3-A	*The person responsible must install any (a) sampling probe or (b) in-situ analyzer in a location where effluent gases are well mixed.*
4.3-B	*The person responsible must select the location of sampling ports so as to avoid interference between the (a) flow analyzer, (b) concentration measurement point(s) or path and (c) reference method probes.*

4.4 Stratification Test

To help ensure the representative sampling of emissions, the degree of stratification is quantified to determine if gases are well mixed at a specific sampling location.

4.4-A	*For new CEMS installations from January 1, 2022 forward, the person responsible must test the degree of cyclonic flow in the stack, duct or flue prior to or at CEMS certification using:* *(a) Method 1 of the Alberta Stack Sampling Code, as amended from time to time;* *(b) EPA Method 1, as amended from time to time;* *(c) Method A of reference method EPS 1/RM/8, as amended from time to time; or* *(d) if the above methods are not possible, computational fluid dynamics modelling.*
4.4-B	*For new CEMS installations from January 1, 2022 forward, the person responsible must test the extent of stratification in the stack, duct or flue for each gas measured by the CEMS, including diluent gas(es), prior to or at CEMS certification, using the stratification test procedure in Appendix B.*

There may be circumstances where stratification or cyclonic flow would need to be retested or confirmed after CEMS certification (e.g., if there is a change to the flow profile, flow RATA failure or physical change at sampling locations).

4.4-C	*The person responsible must report the results of any stratification testing.*

See AMD Chapter 9 Reporting for reporting requirements.

4.4-D	*The person responsible must (a) retain on file at the industrial operation and (b) make available for inspection or audit the results of the stratification test.*

5.0 Certification, Recertification and Component Replacement

After installing a CEMS, certification is achieved when the person responsible demonstrates that the CEMS meets all performance specifications in the CEMS Code.

It is recommended that after the CEMS has been installed, that the entire CEMS be operated for a conditioning period of 168 hours, during which the source is operating and QA and QC procedures are carried out according to the QAP. This is optional, but can be used to ensure the system is operating properly prior to commencing the Operational Test Period.

5.1 Certification Requirements

Performance tests have been established to certify a CEMS and ensure that the system generates data that are representative of source emissions.

5.1-A	*The person responsible must certify any (a) new CEMS installation or (b) CEMS that is fully replaced.*

CEMS certification is only required initially when new systems are installed or when an existing CEMS is completely replaced; for example a change in monitoring principle such as from an extractive to an in-situ system. Replacement of one or more components of a CEMS may require recertification (see Section 5.2).

5.1-B	*For the certification in 5.1-A, the person responsible must meet all CEMS performance specifications in Section 6.1 within (a) 120 unit operating days or (b) 180 consecutive calendar days, whichever occurs first, from the date that emissions are first released to the atmosphere through the stack, duct or flue.*

In 5.1-B, the 120 unit operating days need not be consecutive, whereas the 180 calendar days is a consecutive lump sum upper limit, so that the CEMS must be certified within a maximum of 180 days.

5.1.1 Operational Test Period

5.1-C	*For certification, the person responsible must operate the entire CEMS for a minimum 168-hour Operational Test Period during which the source must be operating.*
5.1-D	*During the Operational Test Period in 5.1-C, the person responsible must operate the CEMS normally including:* *(a) measuring (i) gas concentrations and (ii) diluent gas concentrations, where applicable;* *(b) measuring (i) flow rate, (ii) temperature and (iii) in-stack opacity, where applicable;* *(c) full operation of the DAS;* *(d) calculating emission rates in units of the standard, where applicable;* *(e) following routine QA and QC procedures described in the QAP; and* *(f) no unscheduled maintenance, repairs, or adjustments.*

Sampling may be interrupted during the Operational Test Period only to carry out calibration drift tests and pre-planned QA and QC procedures as specified in the QAP.

5.1-E	*During the Operational Test Period in 5.1-C, the person responsible must:* *(a) conduct a 7-day calibration drift test using the procedure in 6.2.3 for each (i) gas analyzer, (ii) in-stack opacity analyzer and (iii) flow analyzer;* *(b) meet the (i) zero drift and (ii) span drift performance specifications in Tables 5 and 8 for gas analyzers each day of the 7-day calibration drift test;* *(c) meet the (i) zero drift and (ii) span drift performance specifications in Table 6 for in-stack opacity analyzers each day of the 7-day calibration drift test;* *(d) meet the (i) zero drift and (ii) span drift performance specifications in Table 7 for flow analyzers each day of the 7-day calibration drift test; and* *(e) compare against the (i) zero drift and (ii) span drift performance targets in Tables 9A and 9B each day of the 7-day calibration drift test.*

Calibration adjustments may be performed as described and scheduled in the QAP. Automatic zero and calibration adjustments made without operator intervention may be carried out at any time, but these adjustments need to be documented in the QAP and recorded by the DAS.

5.1-F	*During the Operational Test Period in 5.1-C, the person responsible must:* *(a) conduct a linearity test using the procedure in 6.2.4 for each gas analyzer;* *(b) meet the linearity performance specifications in Tables 5 and 8; and* *(c) compare against the linearity performance targets in Tables 9A and 9B.*
5.1-G	*For certification, the person responsible must:* *(a) conduct a RATA and bias test using the procedure in 6.2.5 for each (i) gas analyzer in Tables 6, 7, 8 and 9A, (ii) flow analyzer and (iii) temperature sensor;* *(b) meet the relative accuracy and bias performance specifications in Tables 5, 7 and 8; and* *(c) compare against the relative accuracy and bias performance targets in Table 9A.*
5.1-H	*The person responsible must conduct the RATA in 5.1-G:* *(a) during the Operational Test Period; or* *(b) within 168 hours after the completed Operational Test Period.*
5.1-I	*For certification, the person responsible must complete the flow analyzer orientation sensitivity test in 6.2.6 for flow analyzers that are applicable.*
5.1-J	*If the person responsible establishes a correction factor or correlation equation to correlate flow analyzer measurements with reference method measurements, the person responsible must:* *(a) establish the correction factor or correlation equation prior to or at certification; and* *(b) apply the correction factor or correlation equation to (i) CEMS flow output during the RATA and (ii) all CEMS flow output following certification, by means of the automated DAS.*

The correction factor or correlation equation in 5.1-J, often called a k-factor or pitot tube coefficient, is derived at certification to correlate flow measurement in-stack with reference method measurements. Significant changes to the k-factor should not be required over time and from RATA to RATA, unless hardware or flue gas conditions change (e.g., larger boiler installed or other process changes). The factor is not adjusted in response to a failed RATA or in order to meet a RATA (see 6.2-CC). Troubleshooting, testing and verification would be required to determine the cause of a failed RATA (see Section 7.6 for actions required following a failed RATA). A change to the correction factor is considered a major change to the CEMS (see Section 5.2 and Table 4).

5.1-K *If the Operational Test Period in 5.1-C is interrupted as a result of process shutdown, the person responsible must:*
(a) record the times and dates of the interruption; and
(b) continue the Operational Test Period when source operation continues.

5.1-L *If during the Operational Test Period in 5.1-C any of the performance specifications in 6.1 fail to be met, the person responsible must restart the entire Operational Test Period after completing the following:*
(a) investigating the cause of the failure; and
(b) taking corrective action.

5.1-M *If a certification RATA fails during or after the Operational Test Period, the person responsible must restart the Operational Test Period and conduct another RATA.*

The certification RATA needs to be successfully completed for certification. If the Operational Test Period needs to be restarted as per 5.1-L, a RATA performed during the unsuccessful Operational Test Period would need to be repeated. Conditions in Section 5.1.1 must be met in order to complete a successful Operational Test Period and to provide confidence (and a record) that the CEMS is functioning normally. See Section 7.6 for out-of-control procedures following a failed RATA.

A RATA performed for certification purposes can be used towards meeting the RATA frequency requirements in Section 7.3. Note that only one of the RATA or CGA can be used to meet frequency requirements in 7.3, as during certification these tests are not spaced apart according to the requirement in 7.3-D.

5.1-N *The CEMS is certified when the person responsible successfully meets the certification requirements in 5.1-B through 5.1-M.*

There is no Director sign-off required for certification. Once it is demonstrated that the CEMS meets all performance specifications in Section 6.1 and the Operational Test Period is successfully completed, the CEMS is certified.

See AMD Chapter 9 Reporting for CEMS reporting requirements. There is no specific report for certification. Rather, results of performance testing for certification are reported as per AMD Chapter 9 (i.e., RATA report, CGA report, AMD CEMS Summary Form) and the results of the certification would be summarized in monthly reporting.

5.2 Major Component Replacement and Recertification

This section covers actions required following permanent replacement of major CEMS components, including requirements for recertifying a CEMS. Temporary replacement of major CEMS components or swapping out (rotation) of analyzers is covered in Section 8.0.

5.2-A	*The person responsible must conduct performance testing to challenge the CEMS following (a) any permanent major component replacement, including but not limited to those listed in Table 4, and (b) any other change that has the potential to:* *(i) impair the performance of the system; or* *(ii) impact the accuracy of measured or recorded readings.*
5.2-B	*The performance testing in 5.2-A must include:* *(a) the minimum testing requirements in Table 4; or* *(b) for any CEMS changes not listed in Table 4, the (i) performance testing specified by the manufacturer and (ii) quality control procedures specified in the QAP.*

It is up to the person responsible to determine whether a change to the CEMS or source has the potential to impair system performance or impact data accuracy. Table 4 is not an exhaustive list of major changes that could impair CEMS performance or impact data accuracy. If after making a change to the system there is a failure in the subsequent CGA or RATA conducted, the onus is on the person responsible to demonstrate when the system went out-of-control (refer to Section 7.6 for actions required following a RATA or CGA failure).

The major component replacement or changes listed in Table 4 ties in to 5.2-A; changes that could impair the performance of the system or impact the accuracy of measured or recorded readings. The QAP should cover what actions the industrial operation will take when CEMS components are replaced.

Table 4 Performance testing for major component replacement and recertification

Major component replacement or change	Testing requirement
Permanently replace gas analyzer, flow analyzer or temperature sensor with like-kind	CGA (alternate biannual audit or RATA if CGA is not possible)
Permanently replace gas analyzer, flow analyzer or temperature sensor, not like-kind	Recertification: RATA, CGA, full OTP, 7-day calibration drift test
Change to critical orifice size, path length, probe or system optics	Recertification: RATA, CGA, full OTP, 7-day calibration drift test
Change in flow analyzer correction factor (coefficient) or correlation equation of > ± 5% annually (see 5.1-J)	Flow RATA for diagnostic purposes
Change in system design, locations, elevations (e.g., analyzer location or measurement path)	Recertification: RATA, CGA, full OTP, 7-day calibration drift test
Change in process or operations, change to source or equipment, that could change emission profile, effluent composition or gas/flow stratification	Recertification: RATA, CGA, full OTP, 7-day calibration drift test
Third party short-term continuous monitoring operated for > 720 hours (see Section 8.0)	Recertification: RATA, CGA, full OTP, 7-day calibration drift test
Following source offline or shut down of > 180 days	Recertification as soon as possible: RATA, CGA, full OTP, 7-day calibration drift test

Although recertification is not required for like-kind analyzer replacement, it is recommended that the person responsible conduct a regularly scheduled RATA shortly after a modification to the system.

A RATA performed for recertification purposes can be used towards meeting the RATA frequency requirements in Section 7.3. Note that only one of the RATA or CGA can be used to meet frequency requirements in 7.3, as during certification these tests are not spaced apart according to the requirement in 7.3-D.

Recertification should include testing for stratification if there is a change to the process or source that could affect gas flow.

5.2-C The person responsible must (a) complete the testing in 5.2-B and (b) meet any associated CEMS performance specifications from Section 6.1 within a maximum 90 calendar day period from the time the primary CEMS or analyzer ceases monitoring, unless otherwise specified in Table 4.

Recertification is complete when the person responsible successfully meets the requirements in 5.2-C. Recertification should be completed as soon as possible. The industrial operation is given 90 days for recertification or other performance testing after a major change to the CEMS. If the CEMS cannot be brought back online within this timeframe, the industrial operation may request Director authorization, providing justification for the additional time.

Data is not quality assured (is missing) until all testing in Table 4 is successfully completed following the major component replacement and percent availability still needs to be reported. See 3.4-K for allowances for pre-planned analyzer replacement for meeting percent availability requirements.

During periods of CEMS outage, CEMS data is still required to be reported for all periods that the source is operating (9.0-A). See Section 8.0 for requirements and options for maintaining continuous data reporting during periods when the primary CEMS is offline following analyzer failure or malfunction. Besides permanent analyzer replacement (as described in this section and Table 4), various short-term options can be put in place while CEMS components are being repaired or ordered. As per Section 8.0, missing data estimation is permissible for up to 168 hours. After that, back up or alternative monitoring is required to avoid further data loss.

5.2-D	*For any recertification that takes place, the person responsible must submit notification to the Director using the AMD Notification Template, including the following information, within 30 days following recertification:* *(a) a summary of what changes were made to the CEMS to require recertification; and* *(b) a listing of any changes made from the original CEMS monitoring plan.*

5.3 Minor Component Replacement

5.3-A	*For CEMS minor component replacement, repair or routine maintenance, the person responsible must (a) conduct the quality control checks specified by the manufacturer and (b) follow the quality control procedures specified in the QAP.*

Minor component replacement in 5.3-A refers to replacement of a CEMS component that does not have the potential to impair the performance of the system or impact the accuracy of measured or recorded readings.

Appendix C provides a table of recommended quality control checks for common system maintenance and minor component replacement or modification. This is not an exhaustive list of events requiring quality control checks or performance testing. It is up to the person responsible to determine what tests and diagnostics to perform and to document these in the QAP.

It is recommended that the person responsible closely monitor all system diagnostics following any component replacement, repair or routine maintenance. Although recertification is not required for minor component replacement, it is recommended that a regular RATA be scheduled shortly after a modification to the system.

6.0 Performance Specifications and Test Procedures

6.1 Performance Specifications

Performance specifications are used for determining the acceptability of the CEMS following installation and evaluating the effectiveness of ongoing QA and QC procedures and the quality of data produced by CEMS.

6.1.1 Performance Specifications for Typical Gas Analyzers

6.1-A	*The person responsible must (a) install, (b) operate and (c) maintain all of the following gas analyzers in accordance with the minimum performance specifications in Table 5:* *(i) sulphur dioxide;* *(ii) nitrogen oxides;* *(iii) carbon monoxide;* *(iv) oxygen;* *(v) carbon dioxide;* *(vi) total reduced sulphur; and* *(vii) hydrogen sulphide.*
6.1-B	*For nitrogen oxides, if the analyzer by design measures nitric oxide and nitrogen dioxide on separate channels, and nitrogen dioxide constitutes less than 5% of total nitrogen oxides, the person responsible is not required to include nitrogen dioxide in meeting the linearity specification in Table 5.*

The allowance in 6.1-B is for NOx analyzers that, by design, measure NO and NO_2 on two separate channels and cannot assess linearity of total NOx. In this case, the ratio of NO to NO_2 would be determined on a volume basis at the time of the linearity test to determine if criteria in 6.1-B are met. There are no specifications for nitrogen dioxide in the CEMS Code. Nitrogen dioxide would only be required to be monitored if the approval specifies it.

If the relative accuracy performance specification in Table 5 cannot be met for sulphur dioxide, nitrogen oxides or carbon monoxide, an alternative relative accuracy performance specification is available (6.1-D) if and only when the low emission criterion in 6.1-C is met.

Table 5 Minimum performance specifications for typical gas analyzers

Analyzer	Linearity	Relative accuracy[a]	Bias	Zero drift – 24 hr	Span drift – 24 hr	Availability per month
Sulphur dioxide	≤ ± 2.0% of FS	≤ ± 10.0%[b]	≤ ± 5.0% of FS	≤ ± 2.5% of FS	≤ ± 5.0% of FS	≥ 90.0%
Nitrogen oxides	≤ ± 2.0% of FS	≤ ± 10.0%[b]	≤ ± 5.0% of FS	≤ ± 2.5% of FS	≤ ± 5.0% of FS	≥ 90.0%
Carbon monoxide	≤ ± 2.0% of FS	≤ ± 10.0%[b]	≤ ± 5.0% of FS	≤ ± 2.5% of FS	≤ ± 5.0% of FS	≥ 90.0%
Oxygen	≤ ± 0.5% O_2 absolute	≤ ± 10.0% or ≤ 1% O_2[c]	≤ ± 5.0% of FS	≤ ± 0.5% O_2 absolute	≤ ± 0.5% O_2 absolute	≥ 90.0%
Carbon dioxide	≤ ± 0.5% CO_2 absolute	≤ ± 10.0% or ≤ 1% CO_2[c]	≤ ± 5.0% of FS	≤ ± 0.5% CO_2 absolute	≤ ± 0.5% CO_2 absolute	≥ 90.0%
Total reduced sulphur	≤ ± 5.0% of FS	≤ ± 20.0% or ≤ ± 2 ppm absolute average difference[c]	≤ ± 5.0% of FS	≤ ± 5.0% of FS	≤ ± 5.0% of FS	≥ 90.0%
Hydrogen sulphide	≤ ± 5.0% of FS	≤ ± 20.0% or ≤ ± 2 ppm absolute average difference[c]	≤ ± 5.0% of FS	≤ ± 5.0% of FS	≤ ± 5.0% of FS	≥ 90.0%

[a] Relative accuracy performance specifications apply to gas concentration only (i.e., units of the analyzer).
[b] Alternative relative accuracy performance specification is given in 6.1-D (only applicable when 6.1-C is met).
[c] Meeting either specification is adequate.

6.1-C *If the person responsible meets the low emission criterion of ≤ 50 ppm average measured gas concentration of reference method runs during a RATA for (a) sulphur dioxide, (b) nitrogen oxides or (c) carbon monoxide, the alternative relative accuracy performance specification in 6.1-D may be met in place of the relative accuracy performance specification in Table 5 for that same gas.*

6.1-D *When the low emission criterion in 6.1-C is met and the person responsible cannot meet the relative accuracy performance specification in Table 5 for (a) sulphur dioxide, (b) nitrogen oxides or (c) carbon monoxide, the person responsible must meet the alternative relative accuracy performance specification of ≤ ± 5.0 ppm absolute average difference.*

6.1-E *Prior to comparing against the alternative relative accuracy performance specification in 6.1-D, the person responsible must first:*
(a) calculate (i) relative accuracy and (ii) bias as per Section 6.2.5; and
(b) report the results against the performance specifications in Table 5.

6.1-F *If the person responsible meets the low emission criterion in 6.1-C for (a) sulphur dioxide, (b) nitrogen oxides or (c) carbon monoxide, the person responsible is not required to meet the bias performance specification in Table 5 for that same gas analyzer.*

If the alternative relative accuracy performance specification is used, the person responsible is still required to report relative accuracy and bias against the specifications in Table 5 first, before reporting relative accuracy as absolute average difference. See Appendix D for example calculation.

6.1.2 Performance Specifications for In-Stack Opacity Analyzers

6.1-G	*The person responsible must (a) operate and (b) maintain each in-stack opacity analyzer in accordance with:* *(i) ASTM D6216, as amended from time to time;* *(ii) EPA Performance Specification 1 of 40 CFR 60 Appendix B, as amended from time to time;* *(iii) the manufacturer's specifications; and* *(iv) the minimum performance specifications in Table 6.*

Table 6 Minimum performance specifications for in-stack opacity analyzers

Performance test	Performance specifications
Zero drift – 24-hr	≤ ± 2.0% in-stack opacity
Span drift – 24-hr	≤ ± 2.0% in-stack opacity
Availability per month	≥ 90.0%

6.1.3 Performance Specifications for Flow Analyzers and Temperature Sensors

6.1-H	*The person responsible must (a) install, (b) operate and (c) maintain all (i) flow analyzers and (ii) temperature sensors in accordance with the minimum performance specifications in Table 7.*

Table 7 Minimum performance specifications for flow analyzers and temperature sensors

Analyzer	Relative accuracy	Bias	Zero drift – 24 hr	Span drift – 24 hr	Orientation sensitivity	Availability per month
Flow	≤ ± 10.0% or 0.6 m/s absolute average difference[a]	≤ ± 5.0% of FS	≤ ± 3.0% of FS	≤ ± 3.0% of FS	≤ ± 4.0% of FS	≥ 90.0%
Temperature	≤ ± 10.0°C absolute average difference	N/A	N/A	N/A	N/A	≥ 90.0%

[a] Meeting either specification is adequate.
N/A = not applicable.

6.1.4 Performance Specifications and Targets for Other Monitoring Systems

6.1-I	*The person responsible must (a) install, (b) operate and (c) maintain all mercury analyzers in accordance with the minimum performance specifications in Table 8.*

Table 8 Minimum performance specifications for mercury analyzers

Analyzer	Linearity	Relative accuracy	Bias	Zero drift – 24 hr	Span drift – 24 hr	Availability annually
Mercury	≤ ± 10.0% of span	≤ ± 20.0%	≤ ± 5.0% of FS	≤ ± 5.0% of span	≤ ± 5.0% of span	≥ 80.0%

6.1-J	*The person responsible must report against the performance targets in (a) Table 9A for ammonia analyzers and (b) Table 9B for ethylene and ethylene oxide analyzers.*

Table 9A Performance targets for ammonia analyzers

Analyzer	Linearity	Relative accuracy	Bias	Zero drift – 24 hr	Span drift – 24 hr	Availability per month
Ammonia	≤ ± 5.0% of FS	≤ ± 35.0%	≤ ± 5.0% of FS	≤ ± 2.5% of FS	≤ ± 5.0% of FS	≥ 90.0%

Table 9B Performance targets for ethylene and ethylene oxide analyzers

Analyzer	Linearity	Bias	Zero drift – 24 hr	Span drift – 24 hr	Availability per month
Ethylene	≤ ± 5.0% of FS	≤ ± 5.0% of FS	≤ ± 2.5% of FS	≤ ± 5.0% of FS	≥ 90.0%
Ethylene oxide	≤ ± 5.0% of FS	≤ ± 5.0% of FS	≤ ± 2.5% of FS	≤ ± 5.0% of FS	≥ 90.0%

The performance targets in Tables 9A and 9B are for tracking analyzer performance only. Meeting the targets is not mandated. The person responsible is required to conduct the performance testing and compare and report against these targets.

6.2 Performance Specification Test Procedures

The following test procedures are used for confirming that the CEMS meets the performance specifications in Section 6.1.

6.2.1 Reference Method

Reference methods are used to certify that the installed CEMS yields results that are representative of emission concentrations and emission rates.

6.2-A	*The person responsible must conduct reference method tests in such a manner that they:* *(a) yield results representative of gas concentration, emission rate in units of the standard, diluent gas concentration, moisture content, temperature and effluent flow rate;* *(b) take into account stratification, if applicable; and* *(c) can be correlated with the CEMS measurements.*

The person responsible may use EPA promulgated methodologies in place of Alberta Stack Sampling Code methods. General source monitoring requirements for conducting RATAs and CGAs are given in Chapter 4 Monitoring of the AMD. The AMD requires disclosure of promulgated methods used when reporting on RATAs and CGAs.

6.2.2 Test Gas Requirements

6.2-B	*The person responsible must meet the following minimum requirements for the use of test gases:* *(a) EPA Protocol Gas, matching the gas being tested, must be used for conducting all:* *(i) CGAs;* *(ii) alternate biannual audits; and* *(iii) 7-day calibration drift tests for certification; and* *(b) for daily zero and span drift verification and routine calibration adjustments, use:* *(i) what is required by the analyzer manufacturer, as a minimum; or* *(ii) certified reference material; and* *(iii) zero air material.*

In rare circumstances, EPA Protocol gases may not be available. In such a case, the person responsible may use a gas manufacturer standard accurate to 2 percent in place of EPA Protocol Gas.

6.2.3 Calibration Drift Test

The following procedure is used for completing the 7-day calibration drift test for certification.

6.2-C	*The person responsible must conduct a calibration drift test each day, as close to 24-hour intervals as possible, for 7 consecutive days by measuring the (a) zero and (b) span drift of each:* *(i) gas analyzer;* *(ii) in-stack opacity analyzer; and* *(iii) flow analyzer.*
6.2-D	*For dual-range analyzers, the person responsible must conduct the calibration drift test in 6.2-C on both ranges.*

Calibration adjustments may be carried out, following scheduled QA and QC procedures in the QAP, but only after the calibration drift test is conducted so that the magnitude of drift can first be determined.

6.2-E	*During the calibration drift test in 6.2-C, the person responsible must record as found values for each verification point before any calibration adjustment.*
6.2-F	*During the calibration drift test in 6.2-C, the person responsible must record as left values for each verification point after any calibration adjustment.*

For 6.2-E and 6.2-F, if a system is capable of automated calibration drift tests, the DAS would record the as found values, as left values, and corresponding date and time.

6.2-G	*The person responsible must conduct the calibration drift test in 6.2-C for the gas analyzers in Table 5 according to the following procedure:* *(a) use test gases at two concentration ranges:* *(i) low-level range of 0-20% of full scale; and* *(ii) high-level range of 80-100% of full scale;* *(b) operate the analyzer in its normal sampling mode;* *(c) introduce each test gas at the gas injection port to challenge the CEMS;* *(d) for extractive and dilution type analyzers, pass the test gas through all (i) filters, (ii) scrubbers, (iii) conditioners, (iv) other analyzer components used during normal sampling and (v) through as much of the sampling probe as is practical;* *(e) for in-situ type analyzers, test gas must (i) flood the measurement cavity of the analyzer and (ii) be introduced at a point to provide a check on the active optical and electronic components of the system;* *(f) allow the system to stabilize; and* *(g) record the analyzer response from the DAS.*

For other gas analyzers (i.e., Tables 8, 9A and 9B), the person responsible may use methods recommended by the manufacturer and described in the QAP for conducting the calibration drift test.

See Table 3 for gas injection port location specifications and Section 6.2.2 for test gas requirements. The test gas cannot be injected at the back of the analyzer for a calibration drift test.

6.2-H	*As an alternative to the use of flowing test gas, if the analyzer manufacturer specifies use of one of the following for conducting calibration drift tests, the person responsible may use these for the procedure in 6.2-G:* *(a) a sealed cell containing a known concentration of gas;* *(b) reference spectra; or* *(c) calibrated filters.*

The use of flowing test gas for daily analyzer verification is an independent quality control check on the entire CEMS system. While alternatives to flowing test gas may provide important internal diagnostic information, they may not provide the same level of assessment of performance. As a result, it may be more challenging to determine when an analyzer entered an out-of-control condition. It is strongly recommended that flowing test gas be used for daily analyzer verification when possible.

6.2-I	*When the alternatives to the use of flowing test gas in 6.2-H are used, the person responsible must test for calibration drift at two concentration ranges:* *(a) low-level range of 0-20% of full scale; and* *(b) high-level range of 80-100% of full scale.*
6.2-J	*When the alternatives to the use of flowing test gas in 6.2-H are used, the person responsible must describe these in the QAP.*
6.2-K	*The person responsible must conduct the calibration drift test for in-stack opacity analyzers in 6.2-C according to the procedure specified in EPA Performance Specification 1 of 40 CFR 60 Appendix B, as amended from time to time, for measuring the (a) zero and (b) span drift.*
6.2-L	*The person responsible must conduct the calibration drift test for flow analyzers in 6.2-C according to the following procedure, for those analyzers capable:* *(a) introduce the flow analyzer’s reference signals to the sensor corresponding to flow rates of:* *(i) low-level range of 0-20% of full scale; and* *(ii) high-level range of 80-100% of full scale;* *(b) operate the analyzer in its normal sampling mode;* *(c) allow the system to stabilize; and* *(d) record the analyzer response from the DAS.*
6.2-M	*Following each calibration drift test in 6.2-C, the person responsible must calculate calibration drift:*

(a) according to Equation 2 at (i) each concentration for gas analyzers and (ii) each flow rate for flow analyzers; and
(b) according to EPA Performance Specification 1 of 40 CFR 60 Appendix B, as amended from time to time, for in-stack opacity analyzers.

$$\text{Calibration drift (\%)} = \frac{(R - A)}{FS} \times 100 \qquad \text{Equation 2}$$

where:

R = certified concentration of the low- or high-level test gas (ppm or %) or average gas flow rate as measured by the reference method (m^3/s, m^3/d, etc.);

A = the analyzer response value (in same units as R); and

FS = the full scale reading of the analyzer (in the same units as R).

6.2-N The person responsible must compare the calibration drift test results to the:
(a) zero drift and span drift performance specifications in:
(i) Tables 5 and 8 for each gas analyzer;
(ii) Table 6 for each in-stack opacity analyzer; and
(iii) Table 7 for each flow analyzer; and
(b) zero and span drift performance targets in Tables 9A and 9B.

Calibration drift test results are acceptable for CEMS certification if none of the daily calibration drift test results exceed the applicable CEMS performance specifications in Section 6.1. Required actions following a failed calibration drift test are provided in Section 7.6.

Ongoing required QA and QC checks are outlined in Section 7.2.

6.2.4 Linearity Test and Alternate Biannual Audit

The linearity test provides an important check on system response across the entire operating range of the analyzer. The use of EPA Protocol Gas provides traceability to NIST standards.

6.2-O The person responsible must test the linearity of all gas analyzers in Table 5, Table 9A and Table 9B by:
(a) conducting a CGA using flowing test gas; or
(b) until an analyzer that accepts flowing test gas is installed, conducting an alternate biannual audit using a portable analyzer.

Linearity test procedures for mercury analyzers are provided in the CCME Monitoring Protocol in Support of the Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants.

The required frequency of CGAs is provided in Section 7.3.

The alternate biannual audit in 6.2-O(b) provides an independent audit of the CEMS twice a year as an alternative to conducting a CGA. Note that 3.1-B requires that any new analyzer installed after the effective date of the CEMS Code must be able to accept flowing test gas and conduct CGAs. Therefore 6.2-O(b) would only apply in the interim, until analyzers incapable of accepting flowing test gas are replaced.

6.2-P *The person responsible must conduct the CGA in 6.2-O while:*

- *(a) the source is (i) combusting the primary fuel normal for that unit or (ii) producing the primary product normal for that unit, as applicable; and*
- *(b) the source is operating and producing effluent representative of normal facility operation.*

6.2-Q *At least 24 hours prior to and during a CGA, the person responsible must not conduct any of the following on any portion of the CEMS, or any other actions that could interfere with conducting the CGA under as found conditions, other than as required in the QAP for normal CEMS operation:*

- *(a) corrective maintenance;*
- *(b) repairs;*
- *(c) replacements; or*
- *(d) adjustments.*

A CGA is conducted under conditions that are representative of normal facility operation. The audit is an as found challenge, meant to be representative of the quarter it is conducted in. No adjustments or changes to operations can be made prior to the audit. However, daily checks and normal, routine preventative maintenance as prescribed in the QAP (e.g., zero and span drift tests and any calibration adjustment that may be required as a result, as per the QAP) may be completed prior to the CGA.

In 6.2-Q, any portion of the CEMS includes the DAS and parameters within the DAS.

6.2-R *The person responsible must conduct the linearity test in 6.2-O on both ranges for dual-range analyzers.*

6.2-S *The person responsible must conduct the CGA in 6.2-O according to the following procedure:*

- *(a) use test gases at three concentration ranges:*
  - *(i) low-level range of 1-20% of full scale;*

(ii) mid-level range of 40-60% of full scale; and
(iii) high-level range of 80-100% of full scale;

(b) maintain normal operation of the CEMS during the test as per the QAP, with all (i) pressures, (ii) temperatures and (iii) flows at representative values;

(c) challenge the system three times with each test gas by:
(i) introducing each test gas at the gas injection port;
(ii) alternating the gases presented to the system; and
(iii) not introducing the three test gas ranges (1) in succession or (2) in the same order for all three tests;

(d) for extractive and dilution type analyzers, pass the test gas through all (i) filters, (ii) scrubbers, (iii) conditioners, (iv) other analyzer components used during normal sampling and (v) through as much of the sampling probe as is practical;

(e) for in-situ type analyzers, test gas must (i) flood the measurement cavity of the analyzer and (ii) be introduced at a point to provide a check on the active optical and electronic components of the system;

(f) allow the system to stabilize; and

(g) record the concentration of the gas measured by the DAS.

The person responsible may use dynamic or static dilution of a test gas to generate lower concentration standards, provided that the corresponding QA and QC procedures are established, documented in the QAP and followed for the use of dynamic or static dilution systems. EPA Method 205 may be used for dilution of test gases.

6.2-T The person responsible must calculate the linearity response as measured in 6.2-S using Equation 3:

(a) for each gas analyzer; and

(b) at each of the (i) low-, (ii) mid- and (iii) high-level concentrations.

$$\text{Linearity (\%)} = \frac{(R - A)}{FS} \times 100 \qquad \text{Equation 3}$$

where:

R = the certified concentration of the test gas (% or ppm);

A = the average of the three system responses to either the low-, mid-, or high-level test gas (% or ppm); and

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

6.2-U	*Following the linearity calculation in 6.2-T, the person responsible must:* *(a) meet the linearity performance specifications in Table 5 and Table 8 for gas analyzers for each of the (i) low-, (ii) mid- and (iii) high-level concentration ranges; and* *(b) compare against the linearity performance targets in Tables 9A and 9B.*

As per 6.1-B, if a NOx analyzer by design measures NO and NO_2 on two separate channels and NO_2 constitutes less than 5% of total NOx by volume, the person responsible is not required to include nitrogen dioxide in meeting the linearity specification in Table 5.

6.2-V	*The person responsible must conduct the alternate biannual audit in 6.2-O(b) according to the following specifications, at a minimum:* *(a) the portable analyzer must have a lower detection limit of ≤ 2.0% of the portable analyzer full scale;* *(b) the portable analyzer must be (i) calibrated and (ii) operated according to the manufacturer's specifications;* *(c) the portable analyzer must be calibrated in the field with (i) low- and (ii) high-level test gases prior to the audit;* *(d) the calibration drift must be ≤ 2.0% of the expected value(s);* *(e) a minimum of 6 test runs must be conducted, providing sets of paired CEMS and portable analyzer data;* *(f) the portable analyzer must be fed a sample extracted from a point within 0.3 metres from the CEMS sensing point or path;* *(g) following the audit, the portable analyzer must be challenged with (i) low- and (ii) high-level test gases to assess drift; and* *(h) the difference between initial and final calibration drift results from each of the low- and high-level checks must be ≤ 3.0%.*

See 6.2-B for test gas requirements for the alternate biannual audit and Section 6.2.1 for ensuring results from the portable analyzer are correlated to CEMS measurements on the basis of moisture content and other factors. Paired CEMS and portable analyzer data should be correlated on the same basis, as per RATA requirements in 6.2-GG.

See Equation 2 in Section 6.2.3 for calculating calibration drift percentage.

6.2-W	*For the alternate biannual audit in 6.2-O(b), the person responsible must calculate the relative accuracy of the concurrent measurements taken in 6.2-V using Equations 4 through 7 in Section 6.2.5.*
6.2-X	*For the alternate biannual audit in 6.2-O(b), the person responsible must (a) meet and (b) report against the following specifications:* *(i) relative accuracy of oxygen and carbon dioxide analyzers must not exceed either*

	(1) ± 15.0% or (2) 0.5% absolute average difference; and *(ii) relative accuracy of other gas analyzers must not exceed either (1) ± 15.0% or (2) 12.0 ppm absolute average difference.*

In 6.2-X, meeting either specification is adequate. See 9.0-I for reporting requirements for the alternative biannual audit.

6.2-Y	*Prior to conducting the alternate biannual audit in 6.2-O(b), the person responsible must document the industrial operation's specific procedures for the alternate biannual audit in the QAP.*
6.2-Z	*If the linearity test or alternate biannual audit (a) fails to meet the performance specifications or (b) is aborted when test runs indicate that the linearity test or alternate biannual audit will fail to meet performance specifications, the person responsible must deem the CEMS out-of-control and follow the requirements for out-of-control periods in Section 7.6.*

Upon commencement of a CGA or alternate biannual audit, the CEMS must be able to demonstrate that the performance specifications are met in order for the CGA or alternate biannual audit to pass. If the CGA or alternate biannual audit fails, or the test is aborted because it is known that it will fail, the CEMS is out-of-control because it is not capable of demonstrating that the performance specifications are met. In this case the CGA or alternate biannual audit would be repeated and other actions would be taken to address the out-of-control condition as specified in Section 7.6.

6.2.5 Relative Accuracy and Bias Test

The RATA is an important test of CEMS performance specifications because it is an independent test of the entire system against the reference method, not just a test of an individual analyzer.

The data obtained during a RATA may be used toward fulfilling associated manual stack survey requirements in an approval. Refer to AMD Chapter 9 for how to report manual stack survey results with RATA results.

6.2-AA	*The person responsible must test the relative accuracy of each (a) gas analyzer, (b) flow analyzer and (c) temperature sensor by:* *(i) conducting a RATA;* *(ii) comparing the CEMS DAS output to the corresponding reference method values; and* *(iii) comparing relative accuracy to the performance specifications in Tables 5, 7 and 8 and the performance targets in Table 9A.*

The required frequency of RATAs is provided in Section 7.3.

6.2-BB	*The person responsible must conduct the RATA in 6.2-AA under representative conditions, that is while:* *(a) the source is (i) combusting the primary fuel normal for that unit or (ii) producing the primary product normal for that unit, as applicable; and* *(b) the source is operating at a rate of at least 90% of the average production rate from the previous 30 days.*
6.2-CC	*At least 24 hours prior to and during a RATA, the person responsible must not conduct any of the following on any portion of the CEMS, or any other actions that could interfere with conducting the RATA under as found conditions, other than as required in the QAP for normal CEMS operation:* *(a) corrective maintenance;* *(b) repairs;* *(c) replacements; or* *(d) adjustments.*

A RATA is conducted under conditions that are representative of normal facility operation. The audit is an as found challenge, meant to be representative of the quarter it is conducted in. No adjustments or changes to operations can be made prior to the audit based on third-party or reference method results. However, daily checks and normal, routine preventative maintenance as prescribed in the QAP (e.g., zero and span drift tests and any calibration adjustment that may be required as a result, as per the QAP) may be completed prior to the RATA.

In 6.2-CC, any portion of the CEMS includes the DAS and parameters within the DAS.

6.2-DD	*When conducting the RATA in 6.2-AA, if the gas flow has been found to be stratified or the absence of stratified flow has not been verified, the person responsible must collect the reference method sample at a number of points in the effluent stream according to the following procedure for gas analyzers:* *(a) establish a measurement line that (i) passes through the centroid area of the stack, duct or flue and (ii) is located within 30 cm of the CEMS sampling cross-section;* *(b) locate:* *(i) 3 sampling points at 16.7%, 50% and 83.3% along the length of the measurement line in (a); or* *(ii) 3 other sample points that can provide a representative sample of the gas flow over the period of the test;* *(c) locate the tip of the reference method probe within 3 cm of each traverse point; and* *(d) locate the tip of the reference method probe at least 7.5 cm away from the wall of the stack, duct or flue.*

6.2-EE	*When conducting the RATA in 6.2-AA, if it has been demonstrated that there is no stratification, the person responsible must meet the following requirements for reference method sampling for gas analyzers:* *(a) conduct reference method sampling at a single test point at a minimum;* *(b) the tip of the reference method probe must be located:* *(i) at least 7.5 cm from the wall of the stack, duct or flue;* *(ii) for in-situ point systems, at least 30 cm upstream from the CEMS probe; and* *(iii) for in-situ path systems, at least 30 cm upstream from the inner 50% of the measurement path; and* *(c) the reference method probe must be positioned so that it will not interfere with the operation of the CEMS being tested.*
6.2-FF	*When conducting a flow RATA, the person responsible must collect a minimum of 9 manual flow traverse measurements.*

EPA Methods 2F, 2G and 2H may be used for flow rate measurement.

It is recommended that the certification flow RATA be carried out at the following 3 loads (rates), with 9 manual traverse measurements at each load:

1. minimum safe and stable operating load (rate);
2. approximately mid-load (rate) (40 to 60%); and
3. full-load (rate) (90 to 100%).

6.2-GG	*For the RATA in 6.2-AA, the person responsible must confirm that the CEMS and reference method results are correlated on the same basis, including but not limited to:* *(a) moisture;* *(b) pressure;* *(c) temperature;* *(d) diluent concentration;* *(e) units of measurement; and* *(f) response times for comparing data.*
6.2-HH	*For every RATA conducted, the person responsible must:* *(a) conduct (i) a minimum of 9 test runs and (ii) a maximum of 12 test runs providing sets of paired CEMS and reference method test data;* *(b) sample to obtain a minimum of 30 minutes of valid CEMS and reference method data for each test run;* *(c) when stratification is present, divide each reference method 30-minute period equally over the 3 sampling points in 6.2-DD for gases; and* *(d) record the test data from the CEMS and reference methods.*

Every RATA in 6.2-HH applies to all parameters, including diluent gas, temperature and flow, and therefore 30-minute test runs are required for all parameters.

More than 9 sets of reference method tests may be conducted, up to a total of 12 tests. This can allow for addressing outliers. If this option is chosen, a maximum of three tests may be rejected from the test data if it can be shown using an appropriate statistical outlier test that the results are outliers or if the sampling error invalidates a specific test run. The total number of test results used to determine the relative accuracy and bias needs to be greater than or equal to 9 and all data points are reported (6.2-KK). The statistical outlier test should be outlined in the QAP.

In 6.2-HH, providing sets of paired CEMS and reference method test data means that the exact commencement time and end time of each reference method test run is marked, and the CEMS data are properly correlated with the corresponding reference method data for reporting purposes.

6.2-II	*For every RATA conducted, the person responsible must prepare a table comparing the measurement results obtained from the CEMS DAS against the corresponding reference method values.*

See example RATA calculations in Appendix D.

6.2-JJ	*For the RATA measurement results table in 6.2-II, the person responsible must indicate whether dry basis or wet basis is reported.*

6.2-KK	*The person responsible must report all RATA test results, including:* *(a) any outliers or rejected data;* *(b) all calculations;* *(c) results which fail to meet relative accuracy performance specifications; and* *(d) any incomplete or aborted tests.*

The results from all RATAs, including any that fail or are incomplete, are required to be reported as per AMD Chapter 9 Reporting.

A RATA may be aborted due to safety or operational issues (e.g., inclement weather, operational (plant) issues, and reference method equipment issues). In such circumstances, the RATA may be continued on the following day or rescheduled. The person responsible would submit the AMD Manual Stack Survey and RATA Notification Form to notify of a rescheduled test date along with rationale. The person responsible may then go ahead with the retest, unless otherwise directed by the Director. Aborting the RATA for these reasons would not result in an out-of-control period, nor affect any reduced RATA frequency.

6.2-LL The person responsible must calculate relative accuracy from the RATA measurement results in 6.2-II for each analyzer in units of the analyzer according to the following steps:

(a) calculate the mean of the analyzer values;

(b) calculate the mean of the reference method values;

(c) calculate the arithmetic differences between the reference method and CEMS analyzer data sets;

(d) calculate the absolute average difference using Equation 4;

(e) calculate the standard deviation using Equation 5;

(f) calculate the 2.5% error confidence coefficient using Equation 6; and

(g) calculate the relative accuracy using Equation 7.

6.2-MM For a flow RATA, the person responsible must:

(a) calculate the relative accuracy in terms of volumetric flow according to 6.2-LL for each load (rate) condition, if applicable; and

(b) if a correction factor or correlation equation has previously been established to correlate the reference method measurements with the flow analyzer measurements, report:

(i) the correction factor or factors for each load; or

(ii) the correlation equation developed for the flow analyzer.

Note that for flow, relative accuracy is based on volumetric flow, not velocity. To use the alternative relative accuracy specification in Table 7 for velocity, reference method results would also need to be compared to CEMS measurements in terms of velocity, however relative accuracy still needs be reported in terms of volumetric flow (6.2-OO). The RATA report would indicate use of the alternative specification.

Prior to or at certification, a correction factor or correlation equation may be established to correlate flow analyzer measurements with reference method measurements (see 5.1-J).

If the person responsible has an emission limit associated with a CEMS parameter, relative accuracy in units of the standard should also be calculated. This can provide helpful information to the industrial operation, should there be compound error, and a baseline can be developed to compare to in future audits.

The absolute average difference ($|\bar{d}|$) is calculated using:

$$|\bar{d}| = \left| \frac{1}{n} \sum_{i=1}^{n} (X_i - Y_i) \right| \qquad \textit{Equation 4}$$

where:

n = number of data points;

X_i = concentration from the reference method; and

Y_i = concentration from the CEMS.

Note: The numeric signs for each data pair in Equation 4 need to be retained. The absolute value of the sum of differences is used to calculate relative accuracy in Equation 7, not the sum of absolute values of the differences.

The standard deviation (S_d) is calculated using:

$$S_d = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} d_i\right)^2}{n-1}} \qquad \textit{Equation 5}$$

where:

d_i = the difference between individual pairs (Xi – Yi).

The 2.5% error confidence coefficient (cc) is calculated using:

$$cc = t_{0.025}\frac{S_d}{\sqrt{n}} \qquad \textit{Equation 6}$$

where:

$t_{0.025}$ = t-value at the 95% confidence level from Table 10.

Table 10 Values of t for 95% confidence level

t-values (adjusted for n-1 degrees of freedom)			
n	**$t_{0.025}$**	**n**	**$t_{0.025}$**
5	2.776	10	2.262
6	2.571	11	2.228
7	2.447	12	2.201
8	2.365	13	2.179
9	2.306	14	2.160

Relative accuracy (RA) is calculated using:

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} \times 100\% \qquad \text{Equation 7}$$

where:

$|\bar{d}|$ = absolute average difference;

$|cc|$ = absolute value of the confidence coefficient; and

$\overline{RM}$ = average reference method value.

Example relative accuracy calculations are provided in Appendix D.

6.2-NN	*Following the relative accuracy calculation in 6.2-LL and 6.2-MM, the person responsible must meet the relative accuracy performance specifications in Tables 5, 7 and 8 for (a) gas analyzers, (b) flow analyzers and (c) temperature sensors.*

In Table 5, this means that the person responsible is required to meet the relative accuracy specification for nitrogen oxides, not nitric oxide and nitrogen dioxide individually. Note that an alternative relative accuracy specification is provided in 6.1-D and is applicable only when the low emission criterion in 6.1-C is met.

6.2-OO	*When reporting relative accuracy results for (a) oxygen, (b) carbon dioxide, (c) total reduced sulphur, (d) hydrogen sulphide and (e) flow, the person responsible must show the comparison against both relative accuracy performance specification options in Table 5 and Table 7, as applicable.*

Table 5 provides two relative accuracy performance specification options for oxygen, carbon dioxide, total reduced sulphur and hydrogen sulphide, and Table 7 provides two relative accuracy performance specifications for flow. Meeting either specification is adequate for passing the RATA, although both results must be reported. Similarly, see 6.1-E for comparing and reporting against the alternative relative accuracy specification for sulphur dioxide, nitrogen oxides or carbon monoxide.

6.2-PP	*If a RATA (a) fails to meet the relative accuracy performance specifications or (b) is aborted when test runs indicate that the RATA will fail to meet the relative accuracy performance specifications, the person responsible must deem the CEMS out-of-control and follow the requirements for out-of-control periods in Section 7.6.*

Upon commencement of a RATA, the CEMS must be able to demonstrate that the performance specifications are met in order for the RATA to pass. If the RATA test fails, or the test is aborted because it is known that it will fail, the CEMS is out-of-control because it is not capable of demonstrating that the performance specifications are met. In this case the RATA would be repeated and other actions would be taken to address the out-of-control condition as specified in Section 7.6.

6.2-QQ	*For relative accuracy calculated in 6.2-LL and 6.2-MM, the person responsible must calculate bias according to Equation 8.*
6.2-RR	*The person responsible must meet the bias performance specifications for the matching parameter or gas species in Tables 5, 7 and 8, except when the condition in 6.1-F is met.*

Bias is calculated for nitrogen oxides, not nitric oxide and nitrogen dioxide individually.

Bias is determined on an analyzer basis, not on the system as a whole.

Bias (B), as percent of full scale, is calculated using:

$$B = \frac{|\bar{d}| - |cc|}{FS} \times 100\% \qquad \textit{Equation 8}$$

where:

FS = the full scale value of the analyzer.

6.2-SS	*If the result of the bias calculation in 6.2-QQ does not meet the bias performance specification in Tables 5, 7 and 8, then there is significant bias present, the RATA is failed, and the person responsible must deem the CEMS out-of-control and follow the requirements for out-of-control periods in Section 7.6.*

No data adjustments are applied to account for bias. Rather, the cause of the bias is identified and rectified. If the bias exceeds the performance specification, the CEMS is out-of-control until the source of the bias is rectified, as verified by a repeat of the RATA. See Section 7.6 for RATA out-of-control criteria.

As per 6.1-F, the bias performance specification is not required to be met when the low emission criterion from 6.1-C is met for sulphur dioxide, nitrogen oxides or carbon monoxide. However, the person responsible should still investigate and take action to address any systematic error found.

6.2.6 Flow Analyzer Orientation Sensitivity Test

Orientation sensitivity is the degree to which a flow monitoring system is affected by a change in its orientation to give an accurate flow measurement. The flow orientation performance specification is given in Table 7.

6.2-TT	*For CEMS certification, the person responsible must conduct the flow analyzer orientation sensitivity test in 6.2-UU for flow analyzers that are sensitive to the orientation of the sensor in the gas flow.*

This test is applicable to analyzers that are sensitive to the orientation of the sensor in the gas flow, for example differential pressure sensors. The test in 6.2-UU may be conducted prior to installation in a wind tunnel. If the technical design of the flow analyzer is not sensitive to flow orientation, the orientation sensitivity test would not apply and the analyzer would be installed and oriented as per the manufacturer's specifications.

6.2-UU *To conduct the flow analyzer orientation sensitivity test, the person responsible must use the following procedure:*

(a) conduct the test during a period of steady flow conditions;

(b) rotate the sensor in the gas flow:

(i) a total of 10 degrees on each side of the zero degree position;

(ii) directly into the gas flow with no cyclonic flow patterns; and

(iii) in increments of 5 degrees;

(c) note the response of the sensor at each angle; and

(d) generate a total of 5 flows for each load condition at (i) -10, (ii) -5, (iii) 0, (iv) +5 and (v) +10 degrees relative to the zero-degree position.

It is recommended, where possible, that the orientation sensitivity test in 6.2-UU be carried out at the following three loads (rates):

1. minimum safe and stable operating load (rate);
2. approximately mid-load (rate) (40 to 60%); and
3. full-load (rate) (90 to 100%).

6.2-VV	*Following the flow analyzer orientation sensitivity test in 6.2-UU, the person responsible must meet the orientation sensitivity performance specification in Table 7.*

7.0 Quality Assurance and Quality Control

CEMS QA and QC procedures are developed to:

- assess the quality of the CEMS data by estimating accuracy; and
- control and improve the quality of the CEMS data by implementing 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 is increased until the data quality meets the specification of the CEMS Code. A good QA program is necessary to provide high-quality data on a continual basis.

A QA program sets out high-level management policies to ensure that the necessary quality control activities are being adequately performed. QC activities include the day-to-day operation of the quality system (e.g., standard operating procedures).

7.1 Quality Assurance Plan

The QAP verifies and documents the environmental monitoring and reporting procedures so that uncertainties in the reported data can be controlled and quantified.

7.1-A	*The person responsible must (a) develop, (b) implement and (c) maintain a QAP for all installed CEMS to manage the quality of CEMS measurements.*
7.1-B	*For the QAP in 7.1-A, the person responsible must (a) include and (b) describe a complete program of QA and QC procedures specific to the CEMS it is developed for, including all of the sections in Table 11.*
7.1-C	*The person responsible must (a) develop the QAP in 7.1-A prior to CEMS certification for a new CEMS installed from January 1, 2022 forward or (b) update any existing QAP to meet CEMS Code requirements by September 1, 2022.*
7.1-D	*For the QA and QC procedures in 7.1-B, the person responsible must include all CEMS components, including but not limited to:* *(a) gas analyzers;* *(b) flow analyzers;* *(c) in-stack opacity analyzers;* *(d) temperature sensors;* *(e) pressure measurement devices;* *(f) moisture sensors; and* *(g) the DAS.*

Section 6.2.1 requires that reference method results are correlated to CEMS measurements. This may require correction for moisture. The person responsible should regularly assess moisture content and be aware of fluctuations in moisture. Moisture content of flue gas may be obtained by using a continuous moisture sensor, devising a correction factor from manual stack testing or the RATA, or by estimating moisture content using process parameters. Commonly, measurement of oxygen on both a wet and dry basis is used to compute moisture fraction in the flue gas. Manufacturer specifications and procedures should be followed for moisture sensor performance testing, operation and maintenance. The QAP would outline any moisture monitoring and data correction processes according to 7.1-D and Table 11.

7.1-E	*For the QAP in 7.1-A, the person responsible must, at a minimum, include the QA and QC procedures specified in the CEMS Code.*

Table 11 CEMS QAP Requirements

Section	Example Contents
Quality Assurance Policies and System Description	
1 Assurance Policy and Objectives	System goals relating to precision, accuracy, and completeness. Objectives as laid out in the approval and CEMS Code, including emission limits and emission reporting requirements.
2 CEMS Description and Design Considerations	System description, including principles of operation (e.g., extractive vs. in-situ), sample location layout, flow and temperature measurement, sample conditioning system, analyzer layout, CEMS shelter, and data handling system. Design considerations and engineering evaluation of CEMS options, including sample location, presence or lack of stratification, flow monitoring, and equipment supplier. List of CEMS component serial and model numbers.
3 Exceptions/Variances/Alternate Methods	Any authorized exceptions, variances or alternate methods from the CEMS Code or reference test methods.
4 Organization and Responsibilities	Description of the organization of who is involved with the CEMS and its quality system. The roles and responsibilities of the personnel involved as related to CEMS operation and maintenance, control of documents and records, and control of data.
5 Calibration and Quality Control Checks	Description of the calibrations and QC checks that are performed on a routine basis, generally daily, to determine whether the system is functioning properly. Including, but not limited to, daily zero and span drift checks and visual checks of system operating indicators, such as vacuum and pressure gauges, rotameters, analyzer displays, LEDs.
6 Data Acquisition and Analysis	Description of the DAS and data analysis program, including references to data completeness, validation, reporting, storage, revision management and back-up data sources. Roles and responsibilities of personnel involved in the data handling.
7 Preventative Maintenance Program	Description of the CEMS preventative maintenance program, including how preventative maintenance scheduling is determined and maintained along with roles and responsibilities of the personnel involved.
8 Performance Evaluations/Audits	Description of the policies and specifications for performance evaluations and audits (e.g., CGAs, RATAs, annual evaluation). Description of the actions to ensure that the appropriate evaluations are carried out on the appropriate schedule, including spare analyzers in rotation.
9 Corrective Action Program	Description of the policies for correcting any CEMS non-compliance, including roles and responsibilities of the personnel involved in the corrective action program.
10 Document Control System	Description of the policies and systems used to control all the documents that form part of the CEMS quality system. Including, where related documents are located, how they are reviewed and revised, and how they are approved for use and authorized prior to issue.
11 Reports and Records	Description of reports and records collected, including method of collection, responsible personnel, data storage location, data security, data distribution, and length of data storage.
12 Modifications and Upgrades	Description of policies regarding CEMS modifications, upgrades, outages and recertification. This section should include any applicable CEMS Code requirements pertaining to modification, upgrades or use of replacement systems.
13 Training and Qualification Policy	Training and qualification policy for CEMS maintainers, CEMS coordinators, computer and programming technicians, data validators, CGA and RATA testers. Including education and experience requirements, on-the-job training, job shadowing, and classroom training requirements.
14 References	References list for QAP.

Table 11 CEMS QAP Requirements (continued)

Section	Example Contents
Quality Control Procedures	
1 Start-up and Operation	Step-by-step procedures for the start-up and operation of the CEMS. Explanation of how periods of source operating will be determined, including start-up, cool down and purge modes.
2 Daily/Weekly CEMS Operation and Inspection	Description of periodic routine operation and inspection of the CEMS. Should include descriptions of equipment and data validation procedures. Examples of daily equipment checks and/or logbook entries should be included.
3 Calibration Procedures	Procedures for daily calibration verification, automatic or manual calibration, and calibration adjustment. Reference to specific original equipment manufacturer documentation or manuals may be made, however they should be relevant to the actual system installed. Should include schedule for manual calibration, if done.
4 Test Gas Check Procedures	Description of procedure to cross-reference test gases (e.g., cross-referencing to previous cylinders). Specifications for rejection of test gas cylinder.
5 Preventative Maintenance Procedures	Description of the CEMS preventative maintenance procedures and preventative maintenance schedule. This could include a description of such things as a preventative maintenance work order program for those facilities so equipped, along with reference to or examples of preventative maintenance work orders in use, as well as emergency work orders. A table of standing work orders listing specific preventative maintenance tasks and their frequency is recommended.
6 Equipment, Spare Parts List and Inventory Procedures	Descriptions of equipment and the spare parts inventory available for the CEMS, as well as procedures for obtaining spare parts from inventory and ensuring that the spare parts inventory is maintained.
7 Corrective Maintenance Procedures	Descriptions of the non-routine maintenance that is performed when the system or part of the system fails. May make reference to specific original equipment manufacturer documentation or manuals.
8 Evaluation Procedures – Cylinder Gas Audits	Procedures for conducting CGAs, including roles and responsibilities, test gas, scheduling, and test methods.
9 Evaluation Procedures – Relative Accuracy Tests	Pretest sampling plan for executing RATAs, including organization plan, sampling points, scheduling, test methods, calibration requirements, reporting schedule, reporting format, and site safety plan. Process for assessing bias. Description of how production rate is determined.
10 Missing Data Procedures	Procedures for missing data when a CEMS is not available or data is invalid. Data estimation algorithms, including those from the CEMS User Manual.
11 Data Back-up Procedures	Procedures for regular back-up of data and use of back-up data sources.
12 Data Reporting Procedures	Procedure for sign-off and reporting of CEMS data, including any systems for review, modifications, sign-off, summary, and release of data as well as use of electronic data reporting codes.
13 CEMS Security	Security actions for CEMS shelter or room, equipment, software and data.
14 Annual Evaluation Procedures	Procedure for annual evaluation, including selection of auditor, scheduling, audit plan, reporting and follow-up actions.
15 Contingency Procedures	Procedure for managing system change and CEMS outage when replacements are required due to failure of equipment, changes in regulation or changes in system management. Should include authorization process for accepting changes with roles and responsibilities. Addresses recertification or replacement of CEMS as well as any regular rotation or swapping out of analyzers.

Table 11 CEMS QAP Requirements (continued)

Section	Example Contents
Appendices	
1 CEMS Specifications 2 CEMS Operation and Maintenance Manuals 3 Approval Requirements 4 Reference Method Procedures 5 Blank Forms	These can be linked to in the QAP. Links should be current and accessible to anyone who uses the QAP.

7.2 Inspection, Verification and Calibration

CEMS inspection, verification and calibration adjustment (when required) are important aspects of the QA and QC program for ensuring high quality data.

Periodic inspection acts to verify that analyzers with internal diagnostic routines have not failed and are operating within prescribed guidelines (e.g., sample system flow rates are appropriate). The use of analyzers with internal diagnostic checks is recommended.

The method of verifying the accuracy of a CEMS component is to compare the value of the reference standard (e.g., reference gas) to the value displayed by the DAS. A calibration adjustment (output adjustment) is made, if necessary, following a verification to bring the CEMS back in line with the reference standard.

Table 12 summarizes the minimum frequency of ongoing QA and QC checks for individual CEMS components.

In addition to the QA and QC requirements summarized in Table 12, CEMS analyzer availability is required to be met on a monthly basis according to the specifications in Section 6.1.

Table 12 Minimum frequency for CEMS component QA and QC requirements

<table>
<tr><th colspan="2" rowspan="2">CEMS Component</th><th colspan="4">Frequency of Performance Verification Parameter</th></tr>
<tr><th>Zero and Span Drift</th><th>CGA or alternate biannual audit</th><th>RATA</th><th>Quarterly Check</th></tr>
<tr><td colspan="2">Gas analyzers in Tables 5 and 8</td><td>Daily</td><td>2/yr

(or 3 CGAs/yr under reduced RATA frequency)</td><td>2/yr*

(or 1/yr under reduced RATA frequency)</td><td>N/A</td></tr>
<tr><td colspan="2">Gas analyzers in Table 9A</td><td>Daily</td><td>2/yr</td><td>2/yr</td><td>N/A</td></tr>
<tr><td colspan="2">Gas analyzers in Table 9B</td><td>Weekly</td><td>2/yr</td><td>N/A</td><td>N/A</td></tr>
<tr><td colspan="2">In-stack opacity analyzers (Table 6)</td><td>Daily system checks</td><td>N/A</td><td>N/A</td><td>Quarterly 3-point linearity check</td></tr>
<tr><td rowspan="2">Temperature sensors (Table 7)</td><td>Multiple-analyzer system</td><td>2/yr</td><td rowspan="2">N/A</td><td>2/yr*</td><td rowspan="2">N/A</td></tr>
<tr><td>Temperature only</td><td>1/yr</td><td>1/yr</td></tr>
<tr><td colspan="2">Flow analyzers (Table 7)
(direct measurement, or differential pressure/ thermal systems)</td><td>2/yr
(Daily checks when capable)</td><td>N/A</td><td>2/yr*</td><td>Optional flow-to-load test</td></tr>
</table>

N/A = not applicable.
* = unless reduced RATA frequency criteria have been met (Section 7.3.1).

7.2.1 Inspection

7.2-A	*The person responsible must conduct regular inspections of all CEMS components according to the (a) frequency and (b) procedures specified in the QAP to verify that individual components have not failed and are operating within guidelines.*
7.2-B	*The person responsible must conduct visual inspections of flow analyzers annually at a minimum for signs of misalignment or plugging.*

A principle source of error in flow measurements made with a pitot tube is misalignment. Visual inspection can provide verification of the physical condition and alignment of the pitot tube and avoid data loss. Review of flow data (7.2-E) can also help identify drift and avoid analyzer failure and data loss.

It is recommended to remove the flow analyzer, when the opportunity presents itself, for visual inspection and cleaning of the transducer surface.

7.2-C	*For flow analyzers, the person responsible must follow any manufacturer recommendations for:* *(a) back purging or other methods to keep the sample port, probe and lines free of obstructions;* *(b) detecting leaks or plugging throughout the system; and* *(c) detecting probe fouling.*

Differential pressure sensors (e.g., pitot tubes) and thermal sensors have the tendency to get coated or plugged, which can lead to system failure. This can be avoided by using periodic high pressure blowback techniques, air purging or flash heating.

Back purging of flow measurement subsystem components is appropriate (as necessary) at a frequency to ensure accurate data and removal of any buildup of material, but should be timed so as to maximize sampling time of both flow and gas concentrations.

7.2-D	*The person responsible must test the optical alignment of in-stack opacity analyzers according to the manufacturer's recommendations and the frequency outlined in the QAP.*

If optical alignment varies with stack temperature, the optical alignment test should be performed when the unit is operating.

7.2-E	*The person responsible must (a) conduct regular reviews of CEMS data to check for potential analyzer malfunction and (b) include procedures in the QAP for these checks.*

It is recommended that CEMS data be reviewed daily to provide prompt identification of analyzer malfunction.

7.2.2 Verification

7.2-F	*The person responsible must verify individual CEMS component performance at the minimum frequency specified in Table 12, or as per the QAP for analyzers not listed in Table 12.*
7.2-G	*The person responsible must verify system performance in accordance with the procedures specified in:* *(a) the CEMS Code;* *(b) the QAP; and* *(c) the equipment manufacturer documentation.*

For analyzers not covered in the CEMS Code, the person responsible would follow the verification procedures specified by the equipment manufacturer, the QAP and any written authorization from the Director (see 1.2-D).

7.2-H	*For dual-range analyzers, the person responsible must verify both operating ranges when conducting drift tests.*

Verification of both ranges is also required when conducting linearity tests (6.2-R).

7.2-I	*For daily zero and span verification of gas analyzers as specified in Table 12, the person responsible must:* *(a) introduce test gas at the probe inlet or in the vicinity of the probe inlet; or* *(b) if specified by the analyzer manufacturer, use one of the following:* *(i) a sealed cell containing a known concentration of gas;* *(ii) reference spectra; or* *(iii) calibrated filters.*
7.2-J	*When alternatives to the use of flowing test gas are used for zero and span verification of gas analyzers in 7.2-I(b), the person responsible must describe these in the QAP.*

For the verification of gas analyzers using alternatives to flowing test gas, the person responsible should include in the QAP the criteria and procedure for determining when daily verification checks fail and the corresponding corrective actions. The use of flowing test gas for daily analyzer verification is an independent quality control check on the CEMS. While alternatives to flowing test gas may provide important internal diagnostic information, they may not provide the same level of assessment of performance. As a result, it may be more challenging to determine when an analyzer entered an out-of-control condition. It is strongly recommended that flowing test gas be used for daily analyzer verification when possible.

7.2-K	*For zero and span verification of gas analyzers, the person responsible must allow enough time to pass to attain a steady output by the DAS before recording the result.*
7.2-L	*For daily system checks of in-stack opacity analyzers as specified in Table 12, the person responsible must follow procedures for daily system checks specified in EPA 40 CFR 60, Appendix F, Procedure 3, as amended from time to time.*
7.2-M	*The person responsible must verify temperature sensors according to the methods specified in EPA 40 CFR 60, Appendix B, as amended from time to time.*
7.2-N	*For flow analyzers which are capable, the person responsible must perform daily diagnostic checks.*

These daily checks may include internal zero and upscale checks or electronic stability tests to ensure the analyzer is operating properly.

7.2.3 Calibration

Analyzer calibration may follow a routine frequency or be triggered by a verification threshold, as identified in the QAP. Analyzer calibration (output adjustment) may be needed when daily zero or span verification results fall outside of the performance specifications in Section 6.1. In this case, calibration would follow after investigation, corrective action, repairs or maintenance is complete.

An analyzer does not need to be calibrated after each verification, only when performance specifications or manufacturer specifications are not met.

7.2-O	*The person responsible must record (a) as found values for each zero and upscale test point before any adjustment occurs and (b) as-left values for each test point after an analyzer is adjusted.*
7.2-P	*For flow analyzers, the person responsible must have a wind tunnel calibration conducted* *(a) before initial installation; and* *(b) when visible damage has occurred, or if corrective action is unable to bring flow system inaccuracy back in line with performance specifications.*

Verification equipment should be calibrated or certified at least annually, as per the applicable verification methodology or equipment manufacturer's manual.

Verification equipment may include, but are not limited to, temperature sensors, pitot tubes and gas meters. For example, pitot tubes used for verification checks are calibrated as per the Alberta Stack Sampling Code. Portable analyzers should be verified and calibrated according to the equipment manufacturer's manual.

7.3 RATA and CGA Frequency

The minimum frequency of RATAs is specified at two per year, however the frequency may be reduced to once per year upon meeting the conditions for reduced RATA frequency in Section 7.3.1.

Frequency requirements below for RATAs and CGAs are on a calendar year basis.

7.3-A	*The person responsible must conduct RATAs on each gas analyzer according to the following requirements:* *(a) the RATA must be conducted according to the procedure in 6.2.5;*

(b) a minimum of two RATAs per year must meet performance specifications in Table 5, unless the criteria for reduced RATA frequency in 7.3-E are met;
(c) a minimum of two RATAs per year must meet performance specifications in Table 8; and
(d) a minimum of two RATAs per year must be compared to the performance targets in Table 9A.

7.3-B The person responsible must conduct RATAs on each (a) flow analyzer and (b) temperature sensor according to the following requirements:
(i) the RATA must be conducted according to the procedure in 6.2.5;
(ii) a minimum of two RATAs per year must meet the performance specifications in Table 7 for flow analyzers, unless the criteria for reduced RATA frequency in 7.3-E are met for gas analyzers;
(iii) a minimum of two RATAs per year must meet the performance specifications in Table 7 for temperature sensors that are part of a multiple-analyzer system, unless the criteria for reduced RATA frequency in 7.3-E are met for gas analyzers; and
(iv) beginning January 1, 2022 a minimum of one RATA per year must meet the performance specifications in Table 7 when temperature is the only CEMS measurement.

The frequency criteria for a temperature RATA in 7.3-B includes two possible scenarios: conducting a RATA on temperature along with conducting a RATA on gas analyzers (condition in 7.3-B(iii)) or conducting a temperature-only RATA (condition in 7.3-B(iv)) where temperature is the only parameter monitored by CEMS.

7.3-C The person responsible must conduct linearity tests on each gas analyzer according to the following requirements:
(a) the linearity test must be conducted according to the procedure in 6.2.4;
(b) a minimum of two CGAs per year must meet the performance specifications in Table 5, unless the criteria for reduced RATA frequency in 7.3-E are met and 7.3-G applies;
(c) a minimum of two CGAs per year must meet the performance specifications in Table 8; and
(d) a minimum of two CGAs per year must be compared to the performance targets in Tables 9A and 9B.

See Section 6.2.4 for the option to conduct an alternate biannual audit if a CGA cannot be conducted with flowing test gas.

7.3-D The person responsible must space successful RATA and CGA tests at least 30 days apart in order to meet the annual frequency requirements in 7.3-A, 7.3-B and 7.3-C.

The time required between RATA and CGA tests in 7.3-D applies to meeting annual frequency requirements, which may include the RATA or CGA conducted as part of certification or recertification testing. Following a failed test, the RATA or CGA retest should be conducted as soon as possible (see Section 7.6 for actions required following a failed RATA or CGA).

A RATA may be substituted in place of a CGA, however the person responsible may only substitute a CGA in place of a RATA under the criteria in 7.3.1 for reduced RATA frequency.

7.3.1 Reduced RATA Frequency

Reduced RATA frequency from twice per year to once per year is offered to reduce requirements for industrial operations who are able to go above the minimum performance specifications and maintain enhanced performance (meeting the criteria in 7.3-E). As part of the reduced RATA frequency, the minimum CGA frequency increases to three times per year.

Reduced RATA frequency is not an option if a CGA cannot be conducted using flowing test gas. New analyzers installed after the CEMS Code takes effect are required to be capable of using flowing test gas to conduct CGAs (see 3.1-B).

The person responsible is required to maintain the criteria in 7.3-E in order to keep the reduced RATA frequency. If any of the events outlined in 7.3-H occur, the reduced RATA frequency is automatically revoked. In order to return to reduced RATA frequency, the person responsible would need four consecutive RATAs passed with relative accuracy of ≤ ± 7.5% and all other criteria in 7.3-E met.

If an industrial operation was following a reduced RATA frequency prior to the CEMS Code taking effect, they may continue to do so, as long as none of the events in 7.3-H take place.

7.3-E In order to reduce RATA frequency to one RATA per year, the person responsible must meet the following criteria:

(a) all gas analyzers in Table 5, as applicable, must meet relative accuracy of ≤ ± 7.5% for four consecutive RATAs;
(b) flow analyzers must meet the relative accuracy performance specification in Table 7 for four consecutive RATAs;
(c) temperature sensors must meet the relative accuracy performance specification in Table 7 for four consecutive RATAs; and
(d) the gas analyzers in (a) must be capable of performing a CGA using flowing test gas.

If the CEMS has more than one of the gas analyzers listed in 7.3-E, all must meet the criteria in order to reduce RATA frequency. If the reduced RATA frequency criteria for gas analyzers is met, then the reduced RATA frequency applies to the temperature and flow RATA frequency as well.

7.3-F	*If the low emission criterion in 6.1-C is met for gas analyzers in Table 5 and the person responsible is not able to meet a relative accuracy of ≤ ± 7.5% to reduce RATA frequency, the person responsible must meet the alternative relative accuracy performance specification of ≤ ± 3.5 ppm absolute average difference in order to reduce RATA frequency to one RATA per year in place of 7.3-E(a).*
7.3-G	*If the conditions of 7.3-E are met and the person responsible converts to a reduced RATA frequency, the person responsible must:* *(a) indicate this in the AMD CEMS Summary Form; and* *(b) conduct a minimum of three CGAs per year using flowing test gas.*

RATA and CGA frequency are mandated on a calendar year basis. The reduced RATA frequency, and corresponding three CGAs per year, would commence the next calendar year following the successful four RATAs meeting the reduced RATA criteria in 7.3-E.

7.3-H	*If at any time one of the following events occur, the person responsible who has reduced the frequency of RATAs to once per year must revert back to conducting (a) a minimum of two RATAs per year and (b) a minimum of two CGAs per year in the next calendar year:* *(i) relative accuracy > ± 7.5% or failure to meet the alternative relative accuracy performance specification in 7.3-F when the low emission criterion is met, for any of the analyzers in Table 5;* *(ii) relative accuracy of the flow analyzer does not meet the specification in Table 7;* *(iii) relative accuracy of the temperature sensor does not meet the specification in Table 7;* *(iv) any RATA conducted (1) ends in an out-of-control event as per Section 7.6 or (2) is aborted when initial test runs indicate that the RATA will fail to meet any relative accuracy performance specifications;* *(v) CEMS is incapable of performing a CGA using flowing test gas;* *(vi) any CGA conducted (1) ends in an out-of-control event as per Section 7.6 or (2) is aborted when initial test runs indicate that the CGA will fail to meet linearity performance specifications; or* *(vii) the Director requires reverting back to two RATAs per year.*

If one of the events in 7.3-H occurs and the person responsible is required to revert back to two RATAs per year, they would do so the next calendar year. In that case, three CGAs would still be conducted that calendar year, and there would be two possible scenarios with the single RATA:

- the RATA passes the required minimum relative accuracy performance specification in Table 5 or 6.1-D and no additional RATA is required (the requirement of one RATA per calendar year was met for that year), however two RATAs would be required the following calendar year; or
- the RATA fails to pass the required minimum relative accuracy performance specification in Table 5 or 6.1-D, the CEMS is out-of-control until the RATA is repeated and passed (see required actions in Section 7.6), and two RATAs would be required the following calendar year.

As per 7.3-H(ii) and (iii), flow and temperature RATAs must pass in order to keep the reduced RATA frequency.

For clarity, 7.3-H(iv) applies to any relative accuracy performance specifications; those in Section 6.1 or the relative accuracy performance specifications for reduced RATA frequency in 7.3-E(a) and 7.3-F. If a RATA is aborted when it becomes known that a relative accuracy specification cannot be met, it is assumed that the RATA failed to meet the relative accuracy specification. See also 6.2-PP in the RATA procedure.

If recertification is necessary, the CEMS would need to continue to meet the reduced RATA frequency criteria in 7.3-E and 7.3-H after recertification in order to maintain the reduced RATA frequency.

The Director could require reverting back to two RATAs per year if any operational issues or poor performance indicate that more frequent performance testing is beneficial.

7.3-I	*If the person responsible no longer meets the conditions for reduced RATA frequency, as per 7.3-H, the person responsible must indicate this in the AMD CEMS Summary Form.*

Reducing RATA frequency is applied to CEMS as a package. If the criteria in 7.3-E are met for all of the analyzers specified, it applies to all subsystems (i.e., flow and temperature). As well, if the person responsible fails to maintain the criteria for reduced RATA frequency and reverts back to two RATAs per year, the revocation applies to all CEMS subsystems collectively. The flow and temperature subsystems must continue to meet regular performance specifications as per 7.3-H in order to maintain the reduced RATA frequency.

7.4 In-Stack Opacity Analyzer Quarterly 3-Point Linearity Check

7.4-A	*The person responsible must conduct a quarterly 3-point linearity check on any in-stack opacity analyzer using certified attenuation filters according to the manufacturer's manual and the QAP.*

For the quarterly 3-point linearity check for in-stack opacity analyzers, the following procedures may be used:

- EPA Performance Specification 1 of 40 CFR 60, Appendix B, as amended from time to time; or
- EPA Procedure 3 Quality Assurance Requirements for Continuous Opacity Monitoring Systems at Stationary Sources of 40 CFR 60, Appendix F, as amended from time to time.

7.4-B	*The person responsible must recalibrate in-stack opacity attenuation filters annually at a minimum.*
7.4-C	*Following the 3-point linearity check in 7.4-A, the person responsible must meet ≤ ± 3.0% of span for all in-stack opacity analyzers.*

The quarterly check of in-stack opacity analyzers is for analyzer performance management only and does not need to be reported.

7.4-D	*If the quarterly 3-point linearity check in 7.4-A does not meet ≤ ± 3.0% of span, the person responsible must take corrective action according to the manufacturer's manual and the QAP.*

7.5 Flow-to-Load Check

The flow-to-load check provides an optional check on flow analyzer performance. The flow-to-load check involves correlating flow analyzer data with plant load data. For most industrial operations, flow rate increases proportionally with load, therefore the flow rate at a given load should remain relatively constant over time. This check can act as a warning system for flow analyzers.

Appendix E provides the flow-to-load check procedure and example calculations.

The flow-to-load check is optional. If conducted, results do not need to be reported.

7.6 Out-of-Control Periods

The performance specifications in the CEMS Code are a critical operational requirement for CEMS. The CEMS is out-of-control if it is determined through performance testing (zero and span verification, CGA, RATA, bias test, alternate biannual audit) that the CEMS does not meet the applicable specifications.

When an analyzer 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 CEMS availability.

7.6-A	*For any out of-control period, as specified in clauses 7.6-B, 7.6-D and 7.6-E, the person responsible must:* *(a) report the out-of-control condition as part of AMD reporting;* *(b) investigate the root cause of the out-of-control condition;* *(c) take corrective action to address the root cause of the out-of-control condition;* *(d) repeat the test that failed, including: (i) zero and span verification, (ii) RATA, (iii) CGA, or (iv) alternate biannual audit;*

(e) if repeating a RATA at a future date, provide notification of the retest date; and

(f) flag CEMS data for the entire out-of-control period, including any previously submitted data, as per the CEMS User Manual, including:

(i) flagging any hour or other reported interval within the out-of-control period; and

(ii) providing a brief comment for each out-of-control period indicating (1) the cause of the out-of-control period, when known, and (2) what corrective action was taken.

In 7.6-A, out-of-control periods are reported according to requirements of the AMD Chapter 9. This would include monthly CEMS reporting as well as reporting of RATA and CGA results.

In the case of a RATA retest following a failure or aborting the test, the person responsible would retest as soon as possible after investigation and submit the AMD Manual Stack Survey and RATA Notification Form to notify of a rescheduled test date along with rationale. The person responsible may then go ahead with the retest, unless otherwise directed by the Director.

A failed CGA or RATA does not count towards the required frequency in 7.3.1.

Corrective action taken will depend on what the issue was deemed to be following investigation. However, actions will include trouble shooting, delineating and re-verifying. If the problem persists, trouble shooting, delineation and re-verification would be repeated. The situation would vary depending on the conditions. The QAP should describe system-specific trouble shooting and delineation processes.

Data is invalidated back to the time when the root cause is determined to have occurred and flagged as missing according to the CEMS User Manual. The investigation should include a thorough review of data trends, analyzer diagnostics and process parameters, as applicable. This is determined by the person responsible and should follow the QAP. For a failed RATA or CGA, if after investigation a root cause cannot be determined, data is invalidated back to the last previously passed performance audit (the most recent of any RATA, CGA or alternate biannual audit). See 7.6-F and 7.6-G for defining the out-of-control period start and end time.

See Section 8.0 for estimation of missing data that has been invalidated due to an out-of-control period.

When reporting the out-of-control period, the person responsible should include any information gathered through the investigation.

7.6-B Following daily analyzer verifications in 7.2.2, the CEMS is out-of-control when either the (a) zero drift or (b) span drift exceeds twice the performance specification in:

(i) Table 5 and Table 8 for gas analyzers;

(ii) Table 6 for in-stack-opacity analyzers; and

(iii) Table 7 for flow analyzers capable of assessing zero and span drift.

Table 13 provides a summary of acceptable drift and unacceptable drift that constitutes out-of-control conditions, as per 7.6-B.

The analyzer is not out-of-control until the zero or span drift exceeds twice the performance specification (i.e., reaches the 2X PS values in Table 13). Any drift that falls between the acceptable drift and out-of-control criteria in Table 13 should act as a trigger for action. In this case the performance specification is not being met, however data is still considered valid and reportable. In this zone, the person responsible should take preventative action, as determined by the QAP, to bring the analyzer back into the acceptable range and avoid going out-of-control. If twice the performance specification is reached, the analyzer is out-of-control. In this case data is invalid and corrective action must be taken, as per 7.6-A, to meet the performance specification (i.e., bring the analyzer back within the acceptable drift zone of Table 13).

7.6-C	*Following analyzer verifications in 7.2.2, if either the (a) zero drift or (b) span drift exceeds twice the performance targets in Tables 9A and 9B, the person responsible must:* *(i) follow corrective action procedures outlined in the QAP; and* *(ii) report these events as part of CEMS monthly reporting as per 7.6-A(a) and 7.6-A(f).*

Table 14 provides a summary of acceptable drift for ammonia, ethylene and ethylene oxide analyzers, as per 7.6-C. The zero drift and span drift values in Tables 9A and 9B are targets rather than performance specifications. If the zero or span drift of an ammonia, ethylene or ethylene oxide analyzer exceeds twice the performance targets in Tables 9A and 9B, the person responsible should investigate the root cause and take corrective action to bring the analyzer back within the acceptable drift criteria in Table 14. Although this is not considered “out-of-control”, these events need to be reported so that they can be tracked over time.

Reporting events of zero or span drift exceeding twice the performance specification or twice the performance target is completed within the submitted CEMS data (7.6-A(f)) and on the monthly AMD CEMS Summary Form (7.6-A(a)).

Table 13 Summary of out-of-control criteria based on analyzer drift

Analyzer	Acceptable Drift		Out-of-Control (2X PS)	
	Zero drift	Span drift	Zero drift	Span drift
Sulphur dioxide	±2.5%	±5.0%	±5.0%	±10.0%
Nitrogen oxides	±2.5%	±5.0%	±5.0%	±10.0%
Carbon monoxide	±2.5%	±5.0%	±5.0%	±10.0%
Oxygen	±0.5%.	±0.5%	±1.0%	±1.0%
Carbon dioxide	±0.5%.	±0.5%	±1.0%	±1.0%
Total reduced sulphur	±5.0%	±5.0%	±10.0%	±10.0%
Hydrogen sulphide	±5.0%	±5.0%	±10.0%	±10.0%
Mercury	±5.0%	±5.0%	±10.0%	±10.0%
In-stack opacity	±2.0%	±2.0%	±4.0%	±4.0%
Flow	± 3.0%	± 3.0%	± 6.0%	± 6.0%

2X PS = exceeds twice the performance specification in Section 6.1.

Table 14 Summary of acceptable drift for ammonia, ethylene and ethylene oxide analyzers

Analyzer	Acceptable Drift		2X PT	
	Zero drift	Span drift	Zero drift	Span drift
Ammonia	±2.5%	±5.0%	±5.0%	±10.0%
Ethylene	±2.5%	±5.0%	±5.0%	±10.0%
Ethylene oxide	±2.5%	±5.0%	±5.0%	±10.0%

2X PT = exceeds twice the performance target in Tables 9A and 9B.

7.6-D Following the (a) linearity test in 6.2-O or (b) RATA in 6.2-AA, the CEMS is out-of-control when the test result exceeds the performance specifications in:

(i) Table 5 and Table 8 for gas analyzers; and

(ii) Table 7 for flow analyzers and temperature sensors.

7.6-E If the alternate biannual audit in 6.2-O is conducted, the CEMS is out-of-control when the test result exceeds the specifications in 6.2-X.

7.6-F	*The out-of-control period in 7.6-B, 7.6-D and 7.6-E begins with:* *(a) the time when the root cause is determined to have occurred; or* *(b) if the root cause timing cannot be determined:* *(i) the start time of the failed zero and span verification, for failed daily zero and span verification; and* *(ii) the end time of the last successfully passed RATA, CGA or alternate biannual audit, for failed RATAs, CGAs or alternate biannual audits.*

If a RATA, CGA or alternate biannual audit fails and a specific point in time cannot be determined when the root cause occurred, data is invalidated back to the most recently passed performance audit (whether the last RATA, CGA or biannual audit). It need not be back to the last audit of the same type that failed. The use of flowing test gas for daily analyzer verification may establish helpful diagnostics for determining when an analyzer started to deviate.

7.6-G	*The out-of-control period in 7.6-B, 7.6-D and 7.6-E ends at the point after retest when it is demonstrated that the CEMS is operating within the performance specifications for (a) zero and span drift, (b) relative accuracy, (c) linearity or (d) the alternate biannual audit.*

The CEMS is out-of-control until the test (zero and span drift, RATA, CGA or alternate biannual audit) is repeated and is successfully passed.

7.6-H	*For the out-of-control period in 7.6-B, 7.6-D and 7.6-E, data generated by the out-of-control (a) gas analyzer, (b) in-stack opacity analyzer, (c) flow analyzer or (d) temperature sensor are missing and the person responsible must not use the data for meeting percent availability requirements.*

See requirements in Section 8.0 and the CEMS User Manual for estimation of missing data.

7.6-I	*If an analyzer is out-of-control and another CEMS analyzer is dependent on the data for correction purposes, then:* *(a) data from the dependent analyzer are also considered out-of-control until the independent analyzer is operating within the performance specifications; and* *(b) the data generated by the dependent analyzer are missing and the person responsible must not use the data for meeting percent availability requirements.*

For example, carbon dioxide, oxygen and flow analyzers can be used for correction purposes or to report an emission rate in units of the standard; they provide data that other reportable CEMS parameters are dependent on. When such an analyzer goes out-of-control, that analyzer brings any analyzer dependent on it into an out-of-control state.

7.7 Annual Evaluation

7.7-A	*The person responsible must have an annual evaluation conducted on the CEMS and QAP at least once every year.*

Annual evaluations should be scheduled as close as possible to 12 months apart.

7.7-B *The person responsible must use an auditor for the annual evaluation in 7.7-A that is:*

(a) knowledgeable in (i) auditing procedures, (ii) CEMS operations and (iii) the CEMS Code;

(b) independent of the daily CEMS operation; and

(c) independent of any CEMS testing, monitoring or reporting conducted for the industrial operation in the past audit year.

7.7-C *For the annual evaluation in 7.7-A, the person responsible must confirm that the auditor reviews the following, at a minimum, to determine if the procedures in the QAP and the CEMS Code are being followed:*

(a) quality control procedures;

(b) scheduled preventive maintenance procedures;

(c) system or analyzer changes;

(d) logbook recordkeeping adequacy;

(e) certifications, reports, and other associated records;

(f) response to previous annual evaluation findings and recommendations; and

(g) QAP updates and revisions.

7.7-D *The person responsible must confirm that the auditor findings and observations from the annual evaluation in 7-7-A are documented in a report for the person responsible's records.*

7.7-E *The annual evaluation report in 7.7-D must include:*

(a) any changes in the system or procedures since the last annual evaluation; and

(b) whether changes made have been reflected in the QAP.

The auditor's report may include recommendations for improvements to the CEMS or its operation.

7.7-F *In response to the annual evaluation report in 7.7-E, the person responsible must:*

(a) set out timelines to address findings and recommendations;

(b) take action on the findings and recommendations according to the timelines set out; and

(c) keep record of the (i) actions taken, (ii) date actions were taken and (iii) justification for any recommended actions not taken.

Examples of actions that could be taken to address annual evaluation findings include, but are not limited to: updates to the QAP, maintenance, repair, or replacement of CEMS components.

If the annual evaluation findings include any non-compliance, the non-compliance would be immediately reported to the Director as per the approval, and corrective action would be taken. If the annual evaluation findings include recommendations for improvement, the industrial operation would develop a plan and timeline to address the findings.

The annual evaluation report does not need to be submitted to the Director, however the Director may request the report. AMD Chapter 9 requires that a summary of audit findings be included in the monthly or annual report. This would include reporting on the result of the CEMS annual evaluation and the industrial operation's actions in response.

8.0 Missing Data Estimation and Temporary Replacement Systems

Occasionally, missing data may result when monitoring equipment malfunctions, equipment maintenance is required or routine performance tests fail. Data recorded during an out-of-control period are not quality assured and therefore count as missing data. Section 3.4.2 outlines valid data determination and situations where data is considered missing.

CEMS data is required to be reported whenever the source is operating (9.0-A) and CEMS availability requirements are outlined in Section 6.1. If the primary CEMS is not able to provide quality assured data, missing data can be estimated or data from a back-up analyzer or temporary monitoring system may be used for reporting purposes. Options for maintaining data reporting during times of CEMS outage are summarized in Figure 2.

8.0-A	*For analyzers in Tables 5 and 7 that are unable to provide quality assured data while the source is operating, the person responsible must use any combination of the following methods to report emissions data:* *(a) a redundant back-up analyzer which (i) is certified, (ii) is stack-, duct- or flue-mounted, (iii) continuously records data and (iv) is operated, maintained and quality assured in the same manner as the primary CEMS;* *(b) replacement with a like-kind spare analyzer, once a CGA is successfully passed;* *(c) permanent replacement with an analyzer that is not like-kind according to Section 5.2;* *(d) third party short-term continuous monitoring, once a CGA is successfully passed; and* *(e) estimating missing data, limited to a maximum of 168 hours per calendar month for each CEMS, using the methods described in the CEMS User Manual.*

If it is not possible to conduct a CGA (e.g., in case of temperature sensors or flow analyzers), the person responsible may conduct a RATA in place of a CGA.

If the person responsible is not able to use one of the methods in 8.0-A for temporary replacement monitoring, the person responsible may request authorization from the Director to provide non-continuous reference method testing (i.e., Manual Stack Survey). This would be considered on a case-by-case basis and the Director would prescribe how to report data and percent availability for the time period in question.

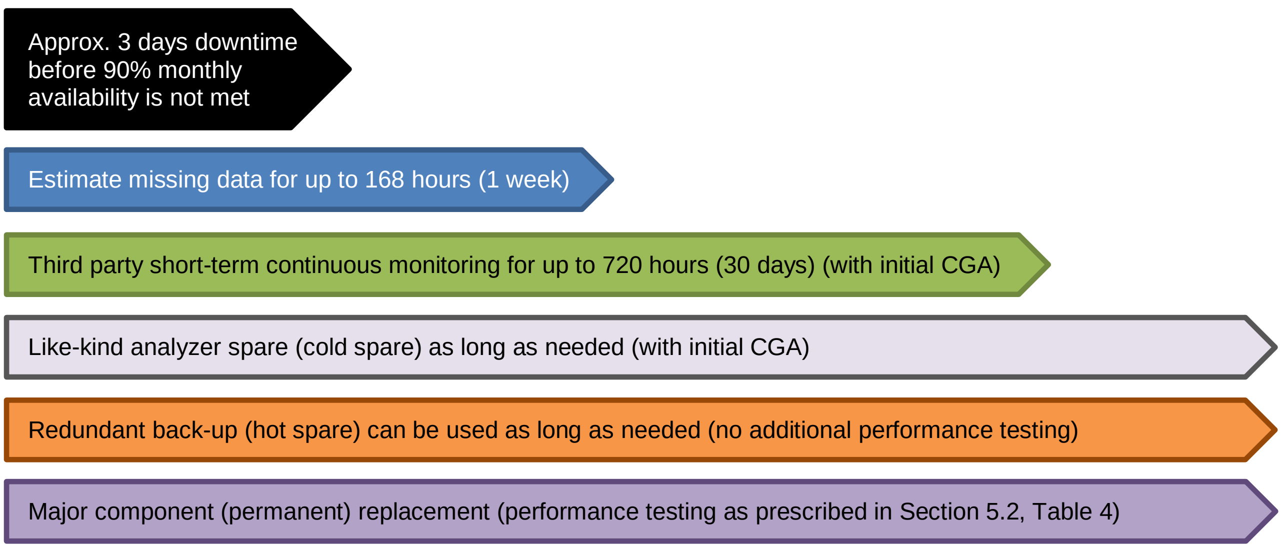

Figure 2 Summary of options with timescales for data reporting during primary CEMS outage
(Note: any combination of these options may be used in an additive manner)

8.0-B	*For 8.0-A, the person responsible must conduct a CGA each time a like-kind spare analyzer is brought into service or third party short-term continuous monitoring is used, within 168 hours of beginning operation.*

The QAP will outline a contingency plan describing which methods will be used to obtain emissions data when there is a CEMS outage (see Section 7.1).

For third party short-term continuous monitoring or replacement with a spare analyzer for temporary use, the person responsible should sample the effluent stream from ports that provide a sample representative of effluent conditions.

Additional quality control testing is not required when a redundant back-up monitoring system is used to replace the primary CEMS. A redundant back-up monitoring system (or hot spare) is kept in continual operation, is fully certified, and undergoes the same ongoing performance testing as the primary CEMS, including RATAs and CGAs, so the data from the redundant back-up monitoring system are quality assured.

In place of recertification, the person responsible is required to conduct a CGA when a like-kind spare analyzer is brought into service to ensure that the analyzer is working properly. There is no limit to the amount of time that the spare analyzer can be used, however any spare analyzers need to have an independent assessment by a RATA (see 8.0-C) at some point. If an analyzer is not capable of performing a CGA, a RATA may be conducted in place of the CGA.

Data from a like-kind spare analyzer (cold spare) or third party short-term continuous monitoring are quality assured once a CGA is successfully passed.

Data that have been estimated during out-of-control periods or CEMS outage, as described in 8.0-A(e) cannot be credited as quality assured or used towards meeting percent availability requirements. Refer to the CEMS User Manual for missing data estimation methods, including invalidating past data due to RATA, CGA or alternate biannual audit failure (Section 7.6).

8.0-C	*The person responsible must (a) describe in the QAP any schedule for planned rotation or replacement of analyzers and (b) follow a plan and schedule for challenging any spare analyzers or analyzers in rotation with a RATA.*

If analyzers are swapped in regularly as spares or on a rotating basis, besides conducting a CGA to bring a like-kind analyzer into service, each analyzer needs to be challenged by a RATA according to the schedule in the QAP.

8.0-D	*For 8.0-A(d), the person responsible is restricted to the use of third party short-term continuous monitoring for a maximum of 720 hours for each analyzer, unless certification is completed.*

Third party short-term continuous monitoring can be used for up to a total of 720 hours. Use beyond 720 hours is no longer regarded as short-term and requires certification (see Section 5.2 and Table 4).

8.0-E	*For 8.0-A, the person responsible must flag data obtained from (a) replacement with a like-kind spare analyzer, (b) third party short-term continuous monitoring or (c) estimated missing data according to the CEMS User Manual.*

8.0-F	*If the CGA in 8.0-B fails or is aborted, the person responsible must invalidate the data obtained from the spare analyzer or third party short-term continuous monitoring.*
8.0-G	*For the CGA in 8.0-B, all data beginning with the hour of a passed zero and span drift test and ending with the hour of the passed CGA is considered quality assured.*

Data from a like-kind spare analyzer or third party short-term continuous monitoring may be conditionally validated with a calibration drift test until the CGA is passed. Once a CGA has been successfully passed, the data back to the initial successful zero and span test can be considered quality assured for reporting purposes up to maximum of 168 hours (the timescale to perform the CGA in 8.0-B). Any subsequent checks (i.e., daily zero and span test) following the initial drift check would also need to be within specifications as per 8.0-H for quality assured data.

8.0-H	*The person responsible must meet all design, performance specifications and quality assurance requirements of the CEMS Code while using the temporary monitoring methods in 8.0-A.*

The same daily performance testing that was performed on the primary analyzer would also be completed for temporary replacement monitoring (redundant back-up spare analyzer, replacement with a like-kind spare analyzer, or use of third party short-term continuous monitoring).

9.0 Reporting Requirements

Chapter 9 of the AMD specifies CEMS reporting requirements, including submission of:

- CEMS data;
- monthly, quarterly and annual industrial air monitoring reports;
- summary data via electronic reporting forms; and
- RATA reports and CGA reports.

The results from all RATAs and CGAs, including any that fail or are incomplete, are required to be reported. Chapter 9 of the AMD also requires that written notification be provided to the Director prior to conducting any manual stack survey or RATA. The approval may also specify the timeline for advance notification. This notice provides the Director with the opportunity to observe testing.

9.0-A	*The person responsible must report CEMS data for all periods during which the source was operating, including:* *(a) all valid (i) hours and (ii) partial hours;* *(b) all valid (i) intervals and (ii) partial intervals;*

> *(c) any estimated missing data;*
> *(d) any out of range data; and*
> *(e) the pre-certification period.*

All continuous monitoring data captured is reported, including hours that are missing (estimated according to Section 8.0), out of range or representing a pre-certification period. There are never blanks in emissions data for periods during which the source is operating. The CEMS User Manual specifies flagging for periods when the source is not operating.

The pre-certification period includes all data captured after the source began emitting, before initial CEMS certification is complete.

> *9.0-B The person responsible must receive Codes for Electronic Reporting, according to the CEMS User Manual, before certification begins.*

The CEMS User Manual includes procedures for submission of continuous data, estimating missing data as well as the procedures for flagging out-of-control periods, data from temporary replacement monitoring, data from a back-up data source, data submitted prior to CEMS certification, and changes in correlation coefficients or correction factors.

> *9.0-C The person responsible must electronically report the (a) CEMS parameters and (b) intervals corresponding to the Codes for Electronic Reporting, as referenced in the CEMS User Manual.*
>
> *9.0-D If a reporting interval is not prescribed in the approval for in-stack opacity, the person responsible must electronically report 6-minute averages for all in-stack opacity analyzers.*

The reporting interval will be set up in the Codes for Electronic Reporting, as referenced in the CEMS User Manual.

> *9.0-E For all CEMS data reported, the person responsible must flag the following in accordance with the procedures in the CEMS User Manual:*
> *(a) partial hours;*
> *(b) partial intervals;*
> *(c) estimated missing data;*
> *(d) periods when the source is not operating;*
> *(e) out of range data;*
> *(f) changes to correlation coefficients or correction factors;*
> *(g) pre-certification periods; and*
> *(h) any other circumstances outlined in the CEMS User Manual.*

9.0-F	*For all CEMS data reported, the person responsible must:* *(a) consistently use either dry basis or wet basis for reporting gas concentrations and flow; and* *(b) indicate whether dry basis or wet basis is reported for gas concentrations and flow as per procedures in the CEMS User Manual.*

Refer to Section 6.2.1 for the requirement to conduct reference method tests to yield results that correlate to CEMS measurements on the basis of moisture, flow and other parameters. Volumetric flow should be reported using standard temperature and pressure, unless the approval states otherwise.

9.0-G	*Beginning January 1, 2022 the person responsible must electronically report 1-hour averages for all continuous temperature sensors in accordance with the procedures in the CEMS User Manual.*
9.0-H	*The person responsible must report percent availability for all CEMS parameters in 9.0-C according to the calculation in Section 3.4.3.*
9.0-I	*The person responsible must report the results of the alternate biannual audit in 6.2-O in the (a) AMD CEMS Summary Form and (b) the CGA report.*

AMD Chapter 9 Reporting provides requirements for the AMD CEMS Summary Form and CGA report. For reporting the alternate biannual audit, the CGA report will be submitted using the file naming conventions for CGA reports, but the filename comments and the report itself should indicate that it is an alternate biannual audit.

9.0-J	*For any previously submitted data that is invalidated, the person responsible must resubmit the data, as per the CEMS User Manual.*
9.0-K	*The person responsible must make the following available to the Director for inspection and audit upon request:* *(a) the QAP;* *(b) QC information generated as a result of the QAP; and* *(c) the annual evaluation report.*

10.0 Predictive Emission Monitoring Systems (PEMS)

PEMS are a form of indirect continuous monitoring, which uses a combination of appropriate process parameters (measured by sensors) and conversion equations, graphs, or algorithms to estimate emissions. The PEMS includes all equipment, software and data necessary for the determination of a gas concentration, or emission rate in units of the standard directly comparable to any applicable approval limits.

PEMS are an emerging technology in Alberta. Authorization for use of PEMS will be considered on a case-by-case basis and is provided in writing by the Director. Industrial operations are advised to contact the Director as early as possible in the planning process if they are considering the installation of a PEMS so that they can be given appropriate guidance for developing an acceptable PEMS.

A PEMS continuously collects data from various sensors (e.g., fuel gas, flow rate, combustion air inlet temperature, radiant chamber pressure) and inputs these measurements into a model designed to calculate emission levels indirectly. To develop and validate the model, actual sensor data and CEMS emission data under the full range of operating conditions are required. If the process operations change (e.g., fuel, product, source) or process parameters change, the algorithm or model may need to be updated or replaced.

A PEMS is not:

- a simple correlation based on a direct but short-term emission measurement (i.e., a manual stack survey) multiplied by operational hours;
- a simple correlation with load and manual stack survey data calculated on a much longer time interval; or
- an emissions calculation using emission factors and level of production.

The Director does not directly or indirectly endorse any specific PEMS model methodology or software.

10.0-A *The person responsible must provide the following to the Director to request authorization to use a PEMS to meet CEMS monitoring requirements in an approval:*

(a) a PEMS monitoring plan; and

(b) the complete raw data set of paired CEMS and sensor data used to develop the PEMS model, spanning both the training and validation periods and including any data that was removed.

10.0-B *The person responsible must not utilize a PEMS to meet CEMS monitoring requirements in an approval without the Director's prior written authorization.*

10.0-C For any PEMS developed to meet CEMS monitoring requirements in an approval, the person responsible must (a) develop, (b) operate and (c) maintain the PEMS in accordance with the CEMS Code and Director's written authorization.

The Predictive Emission Monitoring System (PEMS) Methodology Guide, as amended from time to time, provides recommended methodology for developing and testing a PEMS model. The person responsible should use this guide for PEMS model development and for preparation of the PEMS monitoring plan in 10.0-A.

10.0-D In the development of a PEMS to meet CEMS monitoring requirements in an approval, the person responsible must adhere to the following minimum requirements:

- *(a) the PEMS model must be based on at least three process parameters or variables to predict emission concentrations;*
- *(b) the final PEMS model must be based on at least 2880 measured CEMS quality assured hours of emission data paired with process parameter sensor data, covering seasonal variability;*
- *(c) the PEMS model must meet operating range design specifications in Table 1;*
- *(d) the PEMS model must be reproducible;*
- *(e) the software used to develop the PEMS model must be made available, upon request by the Director;*
- *(f) the PEMS must be validated so that:*
  - *(i) the validation data set is comprised of removing 30% of the total data set, at a minimum;*
  - *(ii) the validation and training data sets sample the same time period over all operational conditions; and*
  - *(iii) the validation and training data sets possess the same statistical properties;*
- *(g) the PEMS model validation residuals:*
  - *(i) must not deviate by more than 10% from the measured CEMS data for 95% of the validation data; and*
  - *(ii) must not show a temporal trend; and*
- *(h) the correlation between PEMS validation data and measured CEMS data, using the adjusted Pearson r-value to account for number of process parameters in the model, must be equal to or greater than 0.8.*

The final PEMS model is required to be based on 2880 hours of CEMS data, therefore additional hours should be used to account for any possible outliers that may need to be removed from the data set in model development. No hours may be removed from the 2880 quality assured CEMS base minimum hours.

The PEMS model should be developed for all possible operational conditions, including start-up, shut-down and operational upsets in order to provide equivalent monitoring and reporting to CEMS.

In 10.0-D(g), the PEMS model validation residuals should follow a normal distribution with zero mean, after correction for offset if a correction is required. If the residuals are not normally distributed, the deviation should be explained in the PEMS monitoring plan in 10.0-A.

The PEMS Methodology Guide provides procedures for model validation and correlation (adjusted Pearson r-value) determination.

10.0-E The person responsible must include any relevant information from the monitoring plan requirements in Section 2.0 as well as the following information, at a minimum, in the PEMS monitoring plan in 10.0-A:

(a) description of fuel gas for each piece of fired equipment being proposed for the PEMS, including (i) the composition and (ii) consistency of the fuel gas source, and (iii) any variability in hydrogen sulphide content (if present) to the piece(s) of equipment;

(b) description of (i) how process parameters or variables were chosen to develop the PEMS model and (ii) which process parameters or variables were used to develop the PEMS model;

(c) description of operating ranges for the sensors used for model development and how out of range results will be managed;

(d) description of the input data used for model development and validation of the model, including:

(i) the distribution of the data;

(ii) the mean, median, mode, skew and kurtosis of the data;

(iii) the degree of autocorrelation in the data and its impact on any required statistical tests; and

(iv) any other statistical description of the data that is relevant in describing the PEMS model;

(e) results of the PEMS correlation test (adjusted Pearson r-value) in 10.0-D(h);

(f) results of statistical tests for normality of the residuals for the validation data;

(g) results of statistical tests for autocorrelation of the residuals within the validation data;

(h) results of statistical tests for (i) distribution similarity and (ii) correlation between the residuals from the validation data set, after correction for autocorrelation has been applied, if applicable;

(i) description of (i) daily sensor validation procedures for QA and QC and (ii) what performance specifications or conditions will be used to quantify sensor validation;

(j) description of what methods will be used for (i) monthly, (ii) quarterly, (iii) semi-annual or (iv) annual performance testing to show that sensor readings are consistent with the PEMS model;

(k) description of how out-of-control conditions will be identified;

(l) description of how the PEMS will be brought back into control following an out-of-control event;

(m) description of (i) how sensors will be replaced and (ii) what statistical, mechanical or other tests will be conducted to verify replacement sensor operation is acceptable;

(n) description of how sensor readings will be used to predict emissions at the same frequency as those required for CEMS;

(o) description of how ongoing sensor information and performance test results will be used to fine-tune the PEMS and provide more accurate emission information;

(p) description of (i) how missing sensor data will be managed to meet the specifications in the CEMS Code and (ii) what circumstances will lead to PEMS downtime;

(q) description of how PEMS availability and reporting will be managed to meet the specifications in the CEMS Code;

(r) description of any proposed trial periods before beginning to report PEMS data, including timelines;

(s) all data, graphs, plots, or other information related to the statistical tests undertaken to construct the PEMS model; and

(t) any additional information requested by the Director.

10.0-F The person responsible must submit the PEMS monitoring plan and data in 10.0-A to the Director a minimum of 90 days prior to planned commencement of PEMS operation to meet CEMS monitoring requirements in an approval.

10.0-G For operation of a PEMS to meet CEMS monitoring requirements in an approval, the person responsible must adhere to the following minimum requirements:

(a) for PEMS certification, the person responsible must:

(i) meet the requirements in 10.0-D; and

(ii) complete a RATA as per Section 6.2.5 that meets (1) the relative accuracy performance specifications in Table 5 and (2) a bias test of $|d| \le |cc|$;

(b) retention of PEMS data as per Section 1.6;

(c) specifications for data acquisition and handling as per Section 3.4;

(d) the PEMS is considered not operational and emission data missing whenever a sensor for which the PEMS model was based on is not operational;

(e) conduct daily sensor validation as per manufacturer specifications and the QAP;

(f) for PEMS data that fall outside of the model operating envelope, the person responsible must detect and respond to these as per procedures in the QAP;

(g) meet performance specifications in Table 5 for percent availability;

(h) comply with reference method requirements in Section 6.2.1 with respect to RATAs;

(i) conduct two RATAs per year according to the procedure in Section 6.2.5 and meet (i) performance specifications in Table 5 for relative accuracy and (ii) $|d| \le |cc|$ for bias;

(j) for like-kind sensor replacement:

(i) the person responsible must (1) follow manufacturer specifications for sensor verification and (2) pass a RATA as soon as possible following installation; and

(ii) all data beginning with the hour of the completed sensor verification and ending with the hour of the passed RATA is considered quality assured;

(k) for replacement with a sensor that is not like-kind:

(i) the person responsible must (1) follow manufacturer specifications for sensor verification and (2) recertify the PEMS according to (a); and

> *(ii) all data beginning with the hour of the completed sensor verification and ending with the hour of the passed certification RATA is considered quality assured;*
>
> *(l) QAP requirements in Section 7.1;*
>
> *(m) out-of-control requirements in Section 7.6 with respect to RATAs;*
>
> *(n) annual evaluation requirements in Section 7.7; and*
>
> *(o) missing data and temporary replacement monitoring requirements as per Section 8.0.*

When a sensor is replaced, the person responsible should track data trending following replacement to look for any anomalies. The QAP should outline procedures for sensor replacement. As per 10.0-G(j) and (k), once a RATA has been successfully passed following replacement, the data back to the initial successful replacement sensor verification can be considered quality assured for reporting purposes.

Changes to fuel quality or excess air may require updates to the PEMS model. Performance testing should be conducted following any such process change.

> *10.0-H When reporting PEMS data, the person responsible must:*
>
> *(a) report 1-hour averages using all valid sub-hourly data available for that hour;*
>
> *(b) comply with the reporting requirements in Section 9.0; and*
>
> *(c) use the coding specified in the CEMS User Manual to identify PEMS methodology.*

PEMS data is reported for all times that the source is operating, just as with CEMS (see 9.0-A).

As per 10.0-G and 10.0-H, requirements in the CEMS Code also apply to PEMS operation (e.g., data acquisition, performance measures and assessment, reporting), unless otherwise authorized in writing by the Director.

Authorization for the use of PEMS will depend on the specific approval monitoring and reporting requirements, ability to adequately assess compliance, suitability of the application of PEMS for the industrial processes in use, and the person responsible’s ability to demonstrate that the PEMS meets equivalent CEMS requirements. In addition to the PEMS Methodology Guide, the person responsible may also refer to EPA Performance Specification 16 for Predictive Emissions Monitoring Systems.

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Appendix A Definitions and Acronyms

All definitions in EPEA and its regulations apply except where expressly defined in the CEMS Code.

The following definitions apply in the CEMS Code:

(1) “Alberta Stack Sampling Code” means the Alberta Stack Sampling Code (1995), as amended from time to time;

(2) “AMD” means Alberta’s Air Monitoring Directive (2016), as amended from time to time;

(3) “approval” means an approval issued under EPEA in respect of an activity, and includes the renewal of an approval;

(4) “as found” means the output value of the measurement device that corresponds to the reference value input before a calibration drift check or adjustment;

(5) “as left” means the output value of the measurement device corresponding to the reference value input after calibration adjustment;

(6) “ASTM” means American Society for Testing and Materials;

(7) “bias” means systematic error resulting in measurements that are either consistently low or high relative to the true value;

(8) “bypass” means any stack, duct or flue through which emissions from a unit may or do pass to the atmosphere, which either augments or substitutes for the principal ductwork and exhaust system during any portion of the unit's operation;

(9) “calibration” means the steps taken to establish a quantitative relationship between the actual value of a reference standard and an analyzer’s or device’s response;

(10) “calibration adjustment” means the procedure to adjust the output of an analyzer or 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);

(11) “CEMS” means Continuous Emission Monitoring System(s);

(12) “CEMS Code” means the Alberta Continuous Emission Monitoring System Code (2021), as amended from time to time;

(13) “CEMS User Manual” means the Electronic Reporting of Continuous Emission Monitoring (CEMS) Information User Manual (2021), as amended from time to time;

(14) “centroid area” means a concentric area that is geometrically similar to the stack, duct or flue cross-section and is not greater than 1% of the stack, duct or flue cross-sectional area;

(15) “certified reference material” means a cylinder gas that is characterized by a meteorologically valid procedure for one or more specified properties, accompanied by a certificate that provides the value of the specified property, its associated uncertainty, and a statement of metrological traceability;

(16) “CGA” means Cylinder Gas Audit;

(17) “CO_2” means carbon dioxide;

(18) “Continuous Emission Monitoring System” means the equipment required to analyze, measure, and provide, on a continuous basis, a permanent record of emissions and other parameters as established by the CEMS Code;

(19) “corrective action” means the steps taken to correct the root cause of a non-compliance with the CEMS Code in order to prevent re-occurrence;

(20) “cylinder gas audit” means a challenge of the monitoring system with a test gas of known concentration which is traceable to standard reference materials of NIST according to the EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards;

(21) “DAS” means data acquisition system;

(22) “data acquisition system” means one or more devices used to receive, compute, retain, and report CEMS measurement data from a single device or multiple measurement devices;

(23) “day” means a calendar day;

(24) “diluent gas” means a major gaseous constituent in an emission mixture or the gas used to dilute the emission mixture in dilution type systems (e.g., carbon dioxide, nitrogen and oxygen);

(25) “Director” means a person designated as a Director for the purposes of EPEA;

(26) “downstream” means in the direction of effluent stream flow;

(27) “drift” means a gradual increase or decrease in analyzer output over a period of time that is unrelated to input or adjustments;

(28) “dual-range analyzer” means an analyzer that has more than one operating range over which measurements are made;

(29) “effluent stream” means the gaseous medium released by or from an industrial operation;

(30) “emission” or “emitting” means the release of a substance or substances into the atmosphere;

(31) “EPA” means the United States Environmental Protection Agency;

(32) “EPA Protocol Gas” means a calibration gas mixture prepared and analyzed according to the EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards, May 2012, EPA-600/R-12/531, as amended from time to time;

(33) “EPEA“ means the *Environmental Protection and Enhancement Act*, RSA 2000, Chapter E-12, as amended from time to time;

(34) “equivalent diameter” means a calculated value used to determine the upstream and downstream distances for locating flow or gas analyzers in stacks, ducts or flues with rectangular cross-sections;

(35) “extractive” means a CEMS monitoring system that withdraws a gas sample from the stack, duct or flue and transports the sample to the analyzer;

(36) “flow analyzer” means any equipment that measures the volumetric flow of an effluent stream and includes both analyzers that measure flow directly (e.g., ultrasonic measurement) and those flow measurement subsystems that are used to indirectly calculate flow (e.g., differential pressure systems, thermal systems);

(37) “FS” means full scale;

(38) “full scale” means the upper value of the analyzer operating range;

(39) “gas analyzer” means any analyzer that measures the concentration of a gas, including both emission and diluent analyzers;

(40) “back-up data source” means a data system external to the primary DAS that communicates with the primary DAS and serves as the long term data storage mechanism for the DAS;

(41) “hour” means clock hour;

(42) “industrial operation” means any facility, plant, site, mine, structure or thing where an activity listed in the *Activities Designation Regulation*, AR 276/2003 as amended from time to time, occurs, including all the buildings, equipment, machinery and vehicles that are an integral part of the activity;

(43) “in-situ” means an analyzer that measures the gas concentration within the stack, duct or flue effluent stream and does not extract a sample for analysis;

(44) “inspection” means a check for conditions that are likely to affect the reliability of the system (e.g., damage to system components, leaks, alignment, a low flow condition in sample transport system, alarms, adequate supply of consumables such as test gases);

(45) “in-stack opacity” means the degree to which visible emissions obstruct the passage of light within a stack, duct or flue or stack breaching;

(46) “interference rejection” means the ability of a CEMS to measure a target gas without responding to other gases or substances, within specified limits;

(47) “invalid data” means data that are not quality assured or do not meet the CEMS Code requirements for valid hour, valid partial hour or valid interval;

(48) “like-kind” means the same type analyzer or device as the primary which monitors the same parameter by the same measurement principle, make and model;

(49) “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 operating range of the system;

(50) “load” means production rate or output rate of an industrial process unit;

(51) “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;

(52) “major component replacement” means replacement or change to a CEMS component that has the potential to impair the performance of the system or impact the accuracy of measured or recorded readings;

(53) “minor component replacement” means replacement or change to a CEMS component that does not have the potential to impair the performance of the system or impact the accuracy of measured or recorded readings;

(54) “missing data estimation” means the procedure to estimate data values during periods of time when data are not quality assured;

(55) “month” means a calendar month;

(56) “NIST” means United States National Institute of Standards and Technology;

(57) “nitrogen oxides” means the total of nitric oxide and nitrogen dioxide;

(58) “NO” means nitric oxide;

(59) “NO_2” means nitrogen dioxide;

(60) “non-compliance” means the failure to meet a requirement set out within the CEMS Code, the QAP or other requirement authorized in writing by the Director;

(61) “normal operation” means all processes and components of the CEMS are operating as intended and as described in the QAP;

(62) “NOx” means nitrogen oxides;

(63) “O_2” means oxygen;

(64) “orientation sensitivity” means the degree to which a flow monitoring system is affected by a change in its orientation to give an accurate flow measurement;

(65) “OTP” means Operational Test Period;

(66) “out-of-control” means a condition triggered when the CEMS does not meet performance specifications and therefore data can no longer be considered quality assured;

(67) “path system” or “path-type CEMS” means a CEMS that measures the gas concentration along a path greater than 10% of the equivalent diameter of the stack, duct or flue cross-section;

(68) “PEMS” means Predictive Emission Monitoring System(s);

(69) “person responsible” means (i) the owner of a facility that is the subject of an approval or other authorization under EPEA, or (ii) the holder of an approval or other authorization under EPEA;

(70) “point CEMS” or “point system” means a CEMS that measures the gas concentration either at a single point or along a path equal to or less than 10% of the equivalent diameter of the stack, duct or flue cross-section;

(71) “ppm” means parts per million;

(72) “Predictive Emission Monitoring System” means all of the equipment required to predict an emission concentration or emission rate (may consist of any of the following subsystems: sensors and sensor interfaces, emission model, algorithm, or equation) using process data to generate proportional output;

(73) “primary” (analyzer or CEMS) means the original, certified analyzer or CEMS for a particular source;

(74) “PS” means performance specification;

(75) “purge mode” means the period of time it takes to purge or remove emissions from the stack, duct or flue to achieve zero or near zero emissions;

(76) “QA” means quality assurance;

(77) “QAP” means quality assurance plan;

(78) “QC” means quality control;

(79) “quality assurance” means the administrative and procedural activities implemented in a quality system to prevent mistakes or defects and to avoid problems in the resulting product, service or activity;

(80) “quality assurance plan” means the documentation of a quality system;

(81) “quality assured” (data) means data that are representative of emissions, generated from a CEMS when the CEMS is in control and meets all the design and performance specifications of the CEMS Code;

(82) “quality control” means the technical activities implemented in a quality system to review and inspect the quality of a product, service or activity against defined standards or requirements;

(83) “quality system” means a structured system consisting of the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products, services and activities;

(84) “quarter” or “quarterly” means a time period of three consecutive months designated as January-February-March, April-May-June, July-August-September, and October-November-December;

(85) “range” (with respect to operating 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;

(86) “RATA” means Relative Accuracy Test Audit;

(87) “raw data” means the original, un-manipulated value obtained from an analyzer or device;

(88) “redundant back-up analyzer” means an installed, certified, stack-, duct- or flue-mounted analyzer that continuously records data and is kept on hot stand-by in case of a primary system outage and is continually operated, maintained and quality assured in the same manner as the primary system;

(89) “reference method” means any methods for sampling or analyzing for a substance or determining flow rate as (a) specified in the Alberta Stack Sampling Code (1995), as amended from time to time, or (b) promulgated by the EPA;

(90) “reference value” means the known concentration of a verification or test gas or the known value of a reference thermometer or output value of a temperature, pressure, current or voltage calibrator;

(91) “regulation” means any regulation that would be applicable to the CEMS Code;

(92) “RM” means reference method;

(93) “SO_2” means sulphur dioxide;

(94) “source operating”, “source operated” or “source is operating” means any time during which effluent was discharged (any time that the source is emitting), which could include start-up, cool down, purge modes, catalyst regeneration or catalyst burnout, even if the unit(s) are not actively processing;

(95) “span” means the algebraic difference between an analyzer’s upper and lower range values;

(96) “span drift” means the percent change in analyzer output in response to a consistent upscale reference value within a stated period of unadjusted continuous operation;

(97) “standard pressure” means 760 mm Hg (101.325 kpa) at 25°C;

(98) “standard temperature” means 25°C or 298°K;

(99) “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;

(100) “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;

(101) “third party short-term continuous monitoring” means a back-up monitoring system or analyzer operated by a third party to provide continuous measurements following acceptable methodology in the Alberta Stack Sampling Code or EPA promulgated, instrumental methods, that is used temporarily (not more than 720 hours per CEMS) when the primary analyzer malfunctions or needs maintenance;

(102) “test gas” means a reference cylinder gas used to challenge a CEMS (e.g., for conducting a calibration drift test or linearity test);

(103) “units of the analyzer” means units of concentration, flow or temperature, as measured by the CEMS analyzer;

(104) “units of the standard” means the emission limit units as stated in the approval;

(105) “upstream” means against or in opposition to the direction of effluent stream flow;

(106) “validation” means the confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use are fulfilled;

(107) “valid data” means data of known and documented quality that satisfy, at a minimum, the requirements set out in the CEMS Code;

(108) “valid hour” means a 1-hour average that is calculated based on at least 75% quality assured base averages within the hour;

(109) “valid interval” means an average or total greater than one hour which contains at least 75% valid hours within the interval;

(110) “valid partial hour” means an averaging period of less than one hour which is calculated from at least 75% of the possible base averages in the portion of the hour that the source operates;

(111) “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;

(112) “year” means calendar year;

(113) “zero” means an analyzer’s response as compared to a zero reference standard;

(114) “zero air material” means high purity air, or inert gas such as nitrogen, with less than 0.1 parts per million concentration of the gas being analyzed or less than 0.1 percent of the span value, whichever is greater, so as to not interfere with the CEMS reading and could include:

(a) a gas mixture certified by the supplier;
(b) ambient air conditioned by a certified zero air generator; or
(c) conditioned and purified ambient air provided by a conditioning system; and

(115) “zero drift” means the change in analyzer output in response to a consistent low scale reference value within a stated period of unadjusted continuous operation.

Appendix B Stratification Test Procedure

The following procedure is recommended for quantifying the degree of stratification in a duct or stack. It involves traversing the stack or duct, obtaining gas concentrations and comparing those to the gas concentration at a fixed location.

When performing a stratification test, it is good practice to sample at a single point over the entire sampling period, using the CEMS analyzer in place or another stationary analyzer. Stratification may not only be spatial, but could also change as a function of time as process load or other conditions change.

(1) A minimum of nine traverse sampling points are required for this test. Locate the points in a balanced matrix of equal area on the stack, duct or flue by using the procedures specified in:
   (a) Method 1 of the Alberta Stack Sampling Code, as amended from time to time;
   (b) EPA Method 1, as amended from time to time; or
   (c) Method A of reference method EPS 1/RM/8, as amended from time to time.

(2) Using two analyzers with similar response characteristics, measure the gas concentration at each of the sampling points in the matrix with one system, while simultaneously measuring the gas concentration with the other analyzer at a fixed location, usually near the center of the flue, duct or stack.

(3) Calculate the degree of stratification for each of the sampling points using Equation 9. If the concentration of the gas measured at the fixed location varies by more than ±10% of the average concentration for longer than one minute during this test, retest for stratification when more stable conditions prevail.

(4) At the conclusion of the traverse measurements, repeat the measurement of gas concentration at the initial measurement point with the traversing analyzer. 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 traversing measurements in (2) test for spatial variability, whereas the repeated measurement at the initial measurement point in (4) provides a post-test check of temporal variability over the course of the test with the traversing analyzer.

The fixed location in (2) is the stability reference measurement, which is used as an indicator of whether gas concentration or flow varies over time. The installed CEMS analyzer, which withdraws a sample from a fixed point, may be used as this stability reference for the stratification test.

The degree of stratification at each sampling point is calculated using:

$$\text{Stratification (\%) at point } i = \frac{(c_i - c_{ave})}{c_{ave}} \times 100 \qquad \text{Equation 9}$$

where:

c_i = concentration of the target gas or flow measurement at point i; and

c_{ave} = average of all measured concentrations or flow measurements.

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

If the presence of stratification is determined to be present at the proposed sampling location, serious consideration should be given to corrective measures that may include relocating the CEMS to a location determined to be non-stratified in order to meet 4.3-A.

Appendix C Recommended Quality Control Checks Following Minor Component Replacement

CEMS minor component replacement, repair or routine maintenance events may include but are not limited to those listed in Table C.1 and Table C.2. The quality control checks in Table C.2 are provided as suggested guidance. The person responsible is required to conduct the testing most appropriate for the circumstance and follow the QAP (see 5.3-A and 7.2-G).

Table C.1 Examples of CEMS minor components requiring replacement, repair or maintenance

Minor component/ Replacement, Repair or Maintenance Events		
Photomultiplier	Circuit Board	Power cord replacement
Lamp	Analyzer pumps	Replace/repair electronics
Filter replacement	Valves	CEMS shelter signal wiring replace/repair
Vacuum pump	PMT base	CEMS shelter sample tubing replace/repair
Capillary tube	O-rings	Moisture removal system replace/repair
Ozone generator	Optical windows	Flow analyzer sub-component replace/repair
Reaction chamber	Power supply	Moisture analyzer sub-component replace/repair
NO_2 converter	Zero air scrubber	Fuel flow meter: replace primary element
Ozonator dryer	Thermistor	Replace critical orifice with orifice of same size
Sample cell	Reaction chamber heater	Modification to dilution air supply
Optical filters, gratings	Cooler/fans	Disassemble/reassemble dilution probe for maintenance
Fibreoptic cables	Display	Replace probe heater or sample line heaters
Mirrors	Pressure pump	Routine probe filter maintenance

Table C.2 Suggested quality control checks for minor component replacement, repair or routine maintenance

Event	Quality Control Checks
Minor component replacement/repair, routine maintenance	zero/span, calibration drift test, system diagnostics
Permanently replace umbilical line	leak check, zero/span, calibration drift test, system diagnostics
Temporary replacement analyzer ≤ 720 hours (see Section 8.0)	CGA, zero/span, calibration drift test, system diagnostics
Replace entire DAS or changes to algorithms	formula verification, missing data verification, zero/span, calibration drift test, system diagnostics

Appendix D Relative Accuracy and Bias Example Calculations

Example RATA Calculation 1

Example data from a RATA conducted on a sulphur dioxide CEMS are shown in Table D.1.

Table D.1 Example RATA data for sulphur dioxide (SO_2) CEMS

Run number	SO_2 RM_w ppm	SO_2 $CEMS_w$ ppm	SO_2 Diff (d_i) ppm	$(d_i)^2$
1	500.1	475.2	24.9	620.0
2	505.7	480.4	25.3	640.1
3	510.3	480.0	30.3	918.1
4	510.5	480.5	30.0	900.0
5	500.2	480.2	20.0	400.0
6	500.8	500.3	0.5	0.3
7	510.0	510.0	0.0	0.0
8	505.1	505.4	-0.3	0.1
9	510.4	520.6	-10.2	104.0
Sum	4553.1	4432.6	120.5	3582.6
Average	505.9	492.5	13.4	398.1

RM_w = reference method data, wet basis
$CEMS_w$ = analyzer data, wet basis

The relative accuracy is calculated using the equations in Section 6.2.5, as shown here.

The absolute average difference $|\bar{d}|$ is calculated for the sulphur dioxide analyzer as:

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

$$= \frac{1}{9}(120.5) = 13.4 \text{ ppm}$$

where:

n = number of data points,

X_i = concentration from reference method (RM_w in Table D.1, in ppm_w), and

Y_i = concentration from the CEMS ($CEMS_w$ in Table D.1, in ppm_w).

The standard deviation S_d is calculated as:

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

$$= \sqrt{\frac{(3582.6) - \frac{1}{9}(120.5)^2}{8}}$$

$$= 15.7 \text{ ppm}$$

where:

d_i = the difference between individual pairs ($X_i – Y_i$).

The 2.5% error confidence coefficient (cc) is calculated as:

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

$$= 2.306 \frac{15.7}{\sqrt{9}} = 12.1 \text{ ppm}$$

where:

$t_{0.025}$ = t-value for 95% confidence level in Table D.2 for n = 9.

Table D.2 Values of t for 95% confidence level

t-values (adjusted for n-1 degrees of freedom)			
n	$t_{0.025}$	**n**	$t_{0.025}$
5	2.776	10	2.262
6	2.571	11	2.228
7	2.447	12	2.201
8	2.365	13	2.179
9	2.306	14	2.160

The relative accuracy (RA) is calculated as:

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} \times 100\%$$

$$= \frac{13.4 + 12.1}{505.9} \times 100\% = 5.0\%$$

where:

$|\bar{d}|$ = absolute average difference (ppm);

$|cc|$ = absolute value of the confidence coefficient (ppm); and

$\overline{RM}$ = average reference method value (ppm).

Relative accuracy specification (≤ 10.0%) is met.

<u>Bias Calculations</u>

The bias (B) is calculated as:

$$B = |\bar{d}| - |cc|$$

$$= 13.4 - 12.1$$

$$= 1.3$$

For an analyzer FS of 1000 ppm:

$$Percent\ bias = \frac{|\bar{d}| - |cc|}{FS} \times 100\%$$

$$= \frac{1.3}{1000} \times 100\%$$

$$= 0.1\%$$

Bias specification (≤ 5.0%) is met.

Example RATA Calculation 2

Example data from a RATA conducted on a nitrogen oxides CEMS, which meets the low emission criterion for use of the alternative relative accuracy performance specification are shown in Table D.3.

Table D.3 Example RATA data for nitrogen oxides (NOx) CEMS (alternative relative accuracy performance specification)

Run number	NOx RM_w ppm	NOx $CEMS_w$ ppm	NOx Diff (d_i) ppm	$(d_i)^2$
1	19.30	16.80	2.50	6.25
2	19.90	17.40	2.50	6.25
3	20.40	17.90	2.50	6.25
4	23.20	19.60	3.60	12.96
5	23.60	19.40	4.20	17.64
6	19.40	15.30	4.10	16.81
7	21.50	18.50	3.00	9.00
8	21.80	18.20	3.60	12.96
9	18.50	15.90	2.60	6.76
Sum	187.60	159.00	28.60	94.88
Average	20.84	17.67	3.18	10.54

RM_w = reference method data, wet basis
$CEMS_w$ = analyzer data, wet basis

The relative accuracy is calculated using the equations in Section 6.2.5, as shown here.

The absolute average difference $|\bar{d}|$ is calculated for the nitrogen oxides analyzer as:

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

$$= \frac{1}{9}(28.60) = 3.18 \text{ ppm}$$

where:

n = number of data points,

X_i = concentration from reference method (RM_w in Table D.3, in ppm_w), and

Y_i = concentration from the CEMS ($CEMS_w$ in Table D.3, in ppm_w)

The standard deviation S_d is calculated as:

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

$$= \sqrt{\frac{(94.88) - \frac{1}{9}(28.60)^2}{8}}$$

$$= 0.71 \text{ ppm}$$

The 2.5% error confidence coefficient (cc) is calculated as:

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

$$= 2.306 \frac{0.71}{\sqrt{9}} = 0.54 \text{ ppm}$$

where:

$t_{0.025}$ = t-value for 95% confidence level in Table D.2 for n = 9.

The relative accuracy (RA) is calculated as:

$$RA = \frac{|\bar{d}| + |cc|}{\overline{RM}} \times 100\%$$

$$= \frac{3.18 + 0.54}{20.84} \times 100\% = 17.85\%$$

where:

$|\bar{d}|$ = absolute average difference (ppm);

|cc| = absolute value of the confidence coefficient (ppm); and

$\overline{RM}$ = average reference method value (ppm).

Does not meet relative accuracy specification of ≤ 10.0%.

The absolute average difference = $|\bar{d}|$ = 3.18 ppm

The average reference method value is < 50 ppm, and therefore meets the low emission criterion in 6.1-C.

Alternative relative accuracy specification of ± 5 ppm absolute average difference is met.

<u>Bias Calculations</u>

The bias (B) is calculated as:

$$B = |\bar{d}| - |cc|$$

$$= 3.18 – 0.54$$

$$= 2.64$$

For an analyzer FS of 100 ppm:

$$\textit{Percent bias} = \frac{|\bar{d}| - |cc|}{FS} \times 100\%$$

$$= \frac{2.64}{100} \times 100\%$$

$$= 2.64\%$$

Bias specification (≤ 5.0%) is met.

Appendix E Flow-to-Load Check

For most industrial operations, flow rate increases proportionally with load, therefore the flow rate at a given load should remain relatively constant over time. The flow-to-load ratio can be established each time a RATA is conducted according to Equation 10 and compared to subsequent ratios thereafter using Equations 11 and 12.

The flow-to-load check is a statistical test of flow data that can be conducted on a quarterly or annual basis according to the following procedure:

1) Calculate the flow-to-load reference ratio using Equation 10 and flow data from the most recent RATA.
2) Calculate the average flow-to-load ratio using Equation 11.
    a. If conducting quarterly, the quarter should contain a minimum of 168 hours of valid flow monitoring data at unit output levels within ± 10% of the average unit output from which the flow-to-load reference ratio was calculated during the most recent RATA.
    b. If conducting annually, all hours of valid flow monitoring data at unit output levels within ± 10% of the average unit output from which the flow-to-load reference ratio was calculated during the most recent RATA should be used to calculate the annual average flow-to-load ratio.
3) Calculate the absolute percent difference between the average flow-to-load ratio and the flow-to-load reference ratio using Equation 12.

In general, an absolute percent difference of ≤ ± 10.0% indicates consistent flow measurement over a quarter. If emissions are low (e.g., low emission criterion for gas analyzers in 6.1-C is met for the most recent RATA), an absolute percent difference of ≤ ± 15.0% generally indicates consistent flow measurement over a quarter. An absolute percent difference of ≤ ± 10.0% indicates consistent flow measurement over a year.

The flow to load reference ratio, R_{ref}, is calculated with flow data from the most recent RATA using:

$$R_{ref} = \frac{1}{n}\sum_{r=1}^{n}\frac{Q_r}{L_r}$$ Equation 10

where:

R_{ref} = average flow-to-load reference ratio from the most recent normal-load flow RATA (units dependent on industrial operation specific load measure);

Q_r = flow rate measured by CEMS during each RATA test run (e.g., m^3/s);

L_r = unit load measured during each RATA test run (units dependent on industrial operation specific load measure); and

n = number of data pairs from the most recent RATA.

The quarterly or annual average flow-to-load ratio, R_h, is calculated using:

$$R_h = \frac{1}{n}\sum_{h=1}^{n}\frac{Q_h}{L_h} \qquad \text{Equation 11}$$

where:

R_h = quarterly or annual average flow-to-load ratio from the hours in which the unit load was within ± 10% of the average load during the most recent RATA (units dependent on industrial operation specific load measure);

Q_h = flow from the quarterly or annual hours in which the unit load was within ± 10% of the average load during the most recent RATA (e.g., m^3/s);

L_h = unit load from the quarterly or annual hours in which the unit load was within ± 10% of the average load during the most recent RATA (units dependent on industrial operation specific load measure); and

n = number of quarterly or annual hours in which the unit load was within ± 10% of the average load during the most recent RATA (n should be ≥ 168 hours for quarterly check).

The absolute percentage difference, E_Q, between R_{ref} and R_h is calculated using:

$$E_Q = \frac{|R_{ref} - R_h|}{R_{ref}} \times 100\% \qquad \text{Equation 12}$$

where:

E_Q = absolute percentage difference between the average flow-to-load ratio and the flow-to-load reference ratio at normal load (%);

R_h = average flow-to-load ratio (units specific to industrial operation load measure); and

R_{ref} = flow-to-load reference ratio from the most recent normal-load flow RATA (units specific to industrial operation load measure, same units as R_h).

An example quarterly flow-to-load check calculation is provided below.

Table E.1 Example RATA results for flow-to-load reference ratio

Variable	Q_r $Flow_{avg}$ (scmh x10^6)	L_r $Load_{avg}$ (MW)	$R_{ref} = \frac{Q_{ref}}{L_{ref}}$ (x 10^{-3})
Result	2.23	450	4.96

Table E.2 Flow-to-load quarterly data

Date	Time	Q_h Flow (scmh x10^6)	L_h Load (MW)	$R_h = \frac{Q_h}{L_h}$ (x 10^{-3})
10/9/18	8:00	1.87	447	4.18
10/9/18	9:00	1.93	466	4.14
10/9/18	10:00	1.94	466	4.16
10/9/18	11:00	1.94	464	4.18
10/9/18	12:00	1.95	464	4.20
10/9/18	13:00	1.58	465	3.40
10/9/18	14:00	1.79	464	3.86
10/9/18	15:00	1.68	449	3.74
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
10/10/18	14:00	1.50	447	3.36
10/10/18	15:00	2.20	464	4.74
10/10/18	16:00	2.21	461	4.79
10/10/18	17:00	2.21	463	4.77
10/10/18	18:00	2.21	463	4.77
10/10/18	19:00	2.21	463	4.77
10/10/18	22:00	2.20	462	4.76
10/10/18	23:00	2.12	451	4.70

•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
10/15/18	9:00	2.15	441	4.87
10/15/18	10:00	2.16	447	4.83
10/15/18	11:00	2.14	447	4.79
10/15/18	12:00	2.14	448	4.78
10/15/18	13:00	2.13	444	4.80
10/15/18	14:00	2.00	410	4.88
10/15/18	15:00	2.11	429	4.92
10/15/18	16:00	2.16	444	4.86
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
10/18/18	8:00	2.08	426	4.88
10/18/18	9:00	2.12	435	4.87
10/18/18	10:00	2.01	411	4.89
10/18/18	11:00	2.12	438	4.84
10/18/18	12:00	2.17	456	4.76
10/18/18	13:00	2.16	457	4.73
10/18/18	14:00	2.14	453	4.72
10/18/18	15:00	2.08	437	4.76
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
10/26/18	8:00	1.93	406	4.75
10/26/18	9:00	1.95	406	4.80
10/26/18	10:00	1.95	406	4.80

10/26/18	11:00	1.95	406	4.81
10/26/18	12:00	2.01	406	4.95
•	•	•	•	•
•	•	•	•	•
•	•	•	•	•
•	•	•	•	
11/06/18	9:00	2.36	424	5.56
11/06/18	10:00	2.60	440	5.91
11/06/18	13:00	2.66	417	6.38
11/06/18	18:00	2.31	417	5.54
11/06/18	19:00	2.37	459	5.16
11/06/18	20:00	2.37	462	5.13
11/06/18	21:00	2.47	465	5.31
11/06/18	22:00	2.47	464	5.32
11/06/18	23.00	2.38	456	5.22
			n	46*
			Sum	219.34
			Average	4.77

$$R_{h\ (avg)} = \frac{219.34}{46^{*}} = 4.77 \times 10^{-3} \text{ scmh/MW}$$

*A minimum of 168 hours of valid flow data are required where the unit load is within ±10% of the average load during the most recent RATA. This example data set is abbreviated to serve as an illustration of the calculation procedure.

$$E_Q = \frac{|R_{ref} - R_h|}{R_{ref}} \times 100\%$$

$$= \frac{|4.96 - 4.77|}{4.96} \times 100\%$$

$$= 3.83\%$$