# Guidance on the 2021 Continuous Emission Monitoring System (CEMS) Code

Last updated: October 12, 2023 (updated sections are highlighted)

Alberta Environment and Protected Areas provides this document as additional guidance on the 2021 CEMS Code to assist with interpretation and clarification of requirements. For mandatory requirements, refer to the CEMS Code. Please note that this document is subject to frequent updates. Users should use the online version of this document instead of referring to a downloaded copy.

## General and Administrative

### Application of Updated Requirements

Requirements in the revised CEMS Code apply to all CEMS – there is no grandfathering for CEMS in place prior to the January 1, 2022 effective date.

There are only three sections that apply specifically to new CEMS installations going forward: monitoring plan, installation requirements, and analyzer design specifications. These are specified in the clauses. All other requirements apply to both existing and new CEMS.

### Authorizations to Deviate

Authorization to deviate granted under the 1998 CEMS code does not apply under the 2021 Code. Licensees seeking authorization to deviate from requirements in the 2021 CEMS Code should contact their *Environmental Protection and Enhancement Act* (EPEA) approval coordinator to request an authorization to deviate. The only exceptions are existing authorizations to deviate under Section 4 of the code, Installation Specifications and Test Procedures. These may remain in force until major structural modifications are made to the stack, duct, or flue, at which time the source should be brought into compliance with the 2021 CEMS Code.

### Contacts for Questions on the CEMS Code

For general questions regarding the CEMS Code, please contact AEP.CEMSCode@gov.ab.ca.

For questions related to the reporting of CEMS data, please contact CEM UserCoord at CEM.UserCoord@gov.ab.ca.

Questions specific to EPEA approvals or meeting approval CEMS requirements should be directed to the facility's approval coordinator.

## Data Validation

### Post-validation of Out of Range Data (Section 3.1.1)

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.

This should be a rare occurrence. If a measurement is above the analyzer operating range it can be assumed that the approval limit has been exceeded. The revised CEMS Code requires that over range values are reported. Post-validation confirms the validity of the measurement, and thereby whether a limit has been exceeded. The operating range is set to capture emissions that will be measured, including exceedances of emission limits. The procedure for post-validation is up to

the facility and would be set out in their QAP. An example procedure could be a one-point span check, like a daily span check, to post-validate an over-range value. A full CGA is also possible. Note that the post-validation is meant to back validate for that specific instance, not to increase the operating range going forward.

If the facility was frequently seeing values outside their operating range they should consider changing their operating range.

## Design Specifications

### Test Procedures for Verifying Design Specifications (Section 3.5)

Sections 3.5-A(a) and 3.5-B(a) require certificates of conformance from the manufacturer that certify quarterly batch testing of analyzers manufactured within that batch meet or exceed the design specifications in Table 1. In cases where the manufacturer may not conduct quarterly testing, it is acceptable for manufacturer to conduct periodic testing and confirm Table 1 specifications are met through their certificate of conformance (subject to the passing of installation performance testing).

Both 3.5-A and 3.5-B require that either (a) a certificate of conformance from the manufacturer or (b) that you conduct testing according to the code, to confirm design specification requirements. If one is unable to meet the requirement in 3.5-A(a) or 3.5-B(a), for a certificate of conformance, then the testing in 3.5-A(b) or 3.5-B(b) would be the alternative option respectively.

## Certification and Recertification

### Timing of RATA and CGA for Certification (Section 5.1)

For CEMS certification, you must successfully complete both a RATA and a CGA for CEMS (as per 5.1-F and 5.1-G). The CGA and RATA are conducted in close temporal range to ensure all performance specifications are met before data is considered quality assured.

The spacing requirement for CGAs and RATAs in Section 7.3-D is set to ensure performance testing of the CEMS throughout the year (ideally quarterly) and does not apply to the certification period. Clause 7.3-D requires spacing RATAs and CGAs apart by a minimum of 30 days in order for them to count towards the annual frequency requirement in section 7.3 (reiterated in Table 12).

For certification, only one of the RATA or the CGA can count towards the annual requirement for CGAs and RATAs, not both, because they are not spaced apart by a minimum of 30 days. See also the guidance below 5.1-M.

### Reporting for Certification (Section 5.1)

There is no specific certification report. The Air Monitoring Directive (AMD), Chapter 9 Reporting includes requirements for reporting CEMS data and performance test results. Therefore performance testing results from certification are reported as per the AMD (i.e., RATA report, CGA report, AMD CEMS Summary Form) and the results of the certification would be summarized in monthly reporting.

### Typographical Error (Section 5.1)

On October 3, 2023; the CEMS Code was updated to correct a typographical error in 5.1-G(a) by adding a reference to Table 5 and removing references to Tables 6 and 7.

### Notification and Reporting for Recertification (Section 5.2)

Recertification is required when you replace an analyzer with a different make or model. Reporting and notification follow the Air Monitoring Directive (AMD) and would include:

- Submission of the AMD11 Notification Form to give advance notice of the recertification Relative Accuracy Test Audit (RATA);
- Noting on the AMD2 CEMS Summary Form that recertification took place for an analyzer for the month it was recertified; and
- Recertification notification is submitted in place of submitting an updated monitoring plan to briefly describe the reason for recertification and list any changes from the monitoring plan (see 5.2-D in the 2021 CEMS Code).

- Required within 30 days following recertification (so not advanced notice).
- Content and submission requirements are specified in the AMD Notification Template (submission is currently via ETS as per the AMD and Acceptable Formats for EPEA Approval and Code of Practice Records and Submission Coordinates guide).

## Performance Specifications

### CEMS Failure to Meet Performance Specifications

When the CEMS is unable to meet performance specifications, the CEMS is out of control. The facility needs to investigate the root cause, take corrective action, and repeat the performance test according to Section 7.6 of the CEMS Code. For a failed RATA or Cylinder Gas Audit (CGA), if a point in time for the root cause of the failure cannot be determined, the data would be invalidated back to the last successful test (most recent RATA or CGA). This data would be resubmitted according to the CEMS User Manual.

## Linearity / Cylinder Gas Audit (CGA)

### Linearity for Nitrogen Oxides (6.1-B)

An allowance for nitrogen dioxide ($NO_2$) linearity is given in 6.1-B for analyzers that by design measure nitric oxide (NO) and $NO_2$ on separate channels. When $NO_2$ constitutes less than 5% of total nitrogen oxides (NOx), linearity does not need to be met for $NO_2$.

When $NO_2$ and NO are measured on individual channels, you would assess the relative proportion of each by volume in the effluent stream (emissions) prior to the CGA. The allowance in 6.1-B is with respect to the $NO_2$ emission concentration, not the CGA result or cylinder gas concentration.

The allowance provided in 6.1-B is that linearity of 2.0% does not need to be met for $NO_2$ if and when $NO_2$ accounts for < 5% of total NOx in emissions. The facility determines how to assess the NO/$NO_2$ ratio, as applicable, and this should be documented in the Quality Assurance Plan (QAP). For example, you could take an average of each component of emissions to determine the ratio (e.g., over the 30-day period prior to CGA, or some other timescale that makes sense for the facility context). If $NO_2$ accounts for < 5% of total NOx, linearity would only be required to be met for NO.

### Facility Operating Rate during a CGA

In the 2021 CEMS Code, there is no requirement for a particular production rate while conducting a CGA. However, the source must be combusting and producing effluent that is representative of the normal facility operation (see 6.2-P). A CGA cannot be conducted when the source is not operating (i.e., during facility shutdown).

### Stable Response for Linearity Testing

The CEMS Code is not specific about what constitutes a stable response. This is difficult to define without getting really prescriptive, as each system is unique and there are a variety of methods for determining the stable response. This should be captured in the CEMS QAP (or third-party QAP) so the facility or stack tester is consistent from test to test.

For example, once the operator is satisfied that readings have leveled off, they could use five 1-minute readings to make an average for that point. This would work to give an average response. The raw data is then provided in the CGA report appendix.

### Low Point Test Gases

In the 2021 CEMS Code, the low-point test gas requirement for CGAs was changed to a range of 1-20% of analyzer full scale. This means that zero gas cannot be used to challenge an analyzer during a linearity test and reiterates the long-standing requirement that EPA Protocol gas is required for conducting CGAs.

### Test Gas Requirements for Nitrogen Oxides (6.2-B)

There have been recent issues around the stability and definition of NOx EPA Protocol Gas. It is the responsibility of the approval holder to ensure that a representative test gas is being used as per the 2021 CEMS Code. Please review the current list of EPA Protocol Gases (as updated) and check with your gas suppliers to ensure continued compliance.

Clause 6.2-B(a) requires that the EPA Protocol Gas used matches the gas being tested. For Nitrogen Oxides, depending on the analyzer being challenged (if the reference analyzer measures both NO and $NO_2$ on a single channel, with a converter), then NO EPA Protocol Gas may be used according to the guidance referenced in the link below. Note that the gas must be EPA Protocol Gas and match the gas being tested as per the guidance link below.

**USEPA Q&A Question 9.34** on pages 5 of 28 and 6 of 28: https://www.epa.gov/sites/default/files/2018-01/documents/questions_answers_protocol_508_final.pdf

### Order of Introducing Test Gases (6.2-S)

Clause 6.2-S(c) requires that the CEMS be challenged with test gases by alternating the gases presented to the system and not introducing three gases in succession or in the same order for all three tests.

It is best practice to challenge the analyzer response between differing concentrations. You want to challenge the CEMS like a source would – randomly, with the gas and system response varying from one run to the next. This clause requires that:

- within one test, the gases not be repeated (e.g., not high-high-high or high-high-mid) but are alternating,
- from one test to the next (succession), that gases not be repeated (e.g., not low-mid-**high** followed by **high**-mid-low),
- the order be different (not the same order) for the three tests (e.g., not low-mid-high, low-mid-high, low-mid-high).

So an example that would meet the requirements in 6.2-S could be: high-mid-low, mid-low-high, low-high-mid. Other combinations are possible, as long as the system is challenged three times with each test gas as per 6.2-S, comprising of 3 sets of 3 runs.

### Alternative Biannual Audit (Section 6.2.4)

An alternative biannual audit may be conducted in place of a CGA for testing linearity when an analyzer is not capable of accepting flowing test gas. This is an interim alternative until an analyzer that accepts flowing test gas is installed and CGAs can be conducted. The alternate biannual audit is conducted at the same frequency as a CGA (twice per year). It is conducted with a portable analyzer.

### Reporting Results of an Alternative Biannual Audit (9.0-I)

Section 9 of the 2021 CEMS Code (9.0-I) requires that results of an alternative biannual audit be reported using the AMD2 CEMS Summary Form and CGA Report. The Air Monitoring Directive Chapter 9 Reporting provides requirements for the AMD2 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.

E.g., CGA-<8 Digit Approval Number>-<Monitoring Year>-<Date>-<Unique Stack Identifier>-Alternate Biannual Audit <comments>

On the AMD2 CEMS Summary Form, it would be indicated that an alternate audit was performed (in column AH - Performance Test Conducted this Month). The alternate biannual audit would also be noted in the monthly Industry Air Monitoring report.

## Relative Accuracy Test Audit (RATA)

### Reduced RATA Frequency (Section 7.3.1)

One of the requirements that must be met in order to qualify to reduce to one RATA per year is that CGAs must be conducted. An analyzer that is not capable of conducting a CGA would not be eligible for reduced RATA frequency. Therefore, when reducing to one RATA per year, and conducting three CGAs per year, you are not able to conduct the alternate biannual audit for the three CGAs.

### Timing of RATA Runs (6.2-HH)

The former (1998) CEMS Code required 30-minute RATA runs for gas analyzers but was vague on flow or temperature runs. The 2021 CEMS Code states (6.2-HH) that a minimum of 30 minutes of valid CEMS data must be obtained for each test run, for all RATAs (and guidance makes it clear that temperature and flow RATAs require 30-min test runs). This is to eliminate inconsistency from run to run, test to test, and contractor to contractor.

For flow and temperature RATAs, this means capturing 30 minutes of CEMS data and ensuring the reference method testing is performed in such a way that is representative of that window. This likely means slowing down and spacing traverse points out. If flow fluctuates, then this becomes very important.

Section 6.2 requires that reference method testing be conducted in such a manner that will yield representative results, including "gas concentration, emission rate in units of the standard, diluent gas concentration, moisture content, temperature and effluent flow rate". This principle (a representative average) drives the requirement of 30 minutes of CEMS data for gas analyzer RATA runs and holds true for other parameters as well.

The recommendation is to stick with 30-minute flow/temperature RATA runs and ensure the reference method tests are representative over that period. In some specific instances (i.e., very small diameter stack), the facility or stack testers could make a case for a different time base for averaging runs, but this would have to documented in the QAP and consistent from test to test for that particular source.

## Temperature

### CEMS versus Stack-top Measurement

Temperature measurement at the stack-top (exit level) is required by the approval and is used in air dispersion modelling assessments. The purpose of the stack-top measurement is to ensure adequate combustion (i.e., oxidation of total reduced sulphur compounds). CEMS, or mid-level temperature measurement, corresponds to the continuous measurement required in the monitoring/reporting tables in an approval, and adherence to the CEMS Code is specified. The CEMS Code then sets out the performance specifications and testing required to quality-assure CEMS data. The CEMS/mid-level temperature measurement does not negate the need to measure temperature at stack-top as required by approval conditions. The stack-top measurement acts as a performance indicator (similar to in-stack opacity). If the approval limit for stack-top temperature were not met, the facility would need to report the contravention, give an explanation, and take corrective action.

The CEMS temperature measurement is reported as quality assured temperature data. It has been assumed that the temperature measured at stack-top does not markedly differ from that measured at the CEMS/mid-level (and the facility should be tracking whether they are in fact close in magnitude or not). If they do not agree (if temperature values are markedly different in magnitude; > 10°C difference), the facility should report both stack-top and CEMS/mid-level temperatures in their monthly submission (using a separate reporting code for stack-top).

The CEMS Code does not include performance testing and specifications for measurement of temperature at the stack-top. However, the stack-top sensor should, and is expected to, have the same performance/technical specifications (accuracy, etc.) as a temperature sensor used for CEMS. The QAP is where a company would document how they intend to ensure stack top temperature measurement requirements are met.

Performance at the stack-top is inferred by performance specifications being met at the CEMS/mid-level (and the two measurements being close in magnitude). Since maintenance or a RATA on a stack-top thermocouple is not possible during operation, there should be ongoing diagnostics on the thermocouple at stack-top to gauge performance/operation, following the QAP and the manufacturer's recommended procedures. Facilities should be checking/monitoring stack-top temperature readings on an ongoing basis, and this should be outlined in the QAP. If there were an issue with stack-top temperature measurement or performance, the facility would need to follow their QAP and take corrective action.

### Temperature Verification (7.2.2)

Clauses 7.2-F and 7.2-G, when applied to temperature analyzers, require analyzers to be verified at the frequency specified according to Table 12, other requirements in the CEMS Code, the QAP, and equipment manufacturer documentation. If there are no applicable Performance Specifications in Section 6.1.3, ensure that you follow verification steps and QA/QC in the QAP, and that verification according to manufacturer documentation/specifications is followed and met.

## Calibration

### Flow Analyzer Calibration (7.2-P) and Orientation Sensitivity (6.2.6)

Clause 7.2-P requires flow analyzers to have wind tunnel calibration before initial installation and when visible damage has occurred or corrective action cannot bring the analyzer back in line with performance specifications.

Not all flow sensors will be calibrated/verified using a wind tunnel. It is meant for pitot tube type systems, which are sensitive to the orientation of the sensor in the gas flow. For other flow methods such as ultrasonic meters, anemometers, etc., the person responsible should follow manufacturer and QAP procedures for calibration.

Conducting wind tunnel calibration of flow analyzers prior to installation was guidance in the 1998 CEMS Code but is now required in the 2021 CEMS Code. Calibration required in 7.2-P is completed prior to certification (initially, it is assumed this is completed by the manufacturer). Equivalency will be accepted for wind tunnel calibration by way of the pitot tube manufacturer providing a Certificate of Calibration showing equivalency to EPA promulgated methods (e.g., geometric calibration using EPA promulgated methods will be accepted as equivalent). The AMD Chapter 4 Monitoring, Section 7.1 allows the use of EPA promulgated methods.

The calibration referred to in 7.2-P is not for Pitot tube orientation sensitivity. Section 6.2.6 sets out the requirements and procedure for testing flow analyzer orientation sensitivity, and the guidance says the test may be conducted prior to installation in a wind tunnel. The requirement in 6.2.6 has the caveat that it is only applicable to analyzers that are sensitive to the orientation of the sensor in the gas flow, differential pressure sensors for example.

The pitot tube orientation sensitivity test in the CEMS Code is only specified for yaw angles. However, the Alberta Stack Sampling Code does provide direction that both pitch and yaw angles should be checked. While it isn't mandated in the CEMS Code to check the pitch angle, if it is suspected that the flow regime is complex, this could be a reasonable action to ensure the representativeness of the site.

## CEMS Data Reporting and Submission

### Timeline for Missing Data Estimation during CEMS Outage

In the 2021 CEMS Code, the missing data estimation timeline was extended to 168 hours (was 120 hours previously). The 168-hour maximum in clause 8.0-A is for a discrete, single episode of CEMS outage. You cannot estimate 168 hours of missing data in one month and then 168 hours consecutively into the following month (for a total of 336 hours). That is, it doesn't reset the next month with a consecutive episode.

Director authorization is required to approve the method for estimating missing data beyond 168 hours in the case of invalidation of past data (Method 4 in the CEMS User Manual).

### Missing Data Estimation in Section 8.0-A and Method 4 in the CEMS User Manual

Method 4 for missing data estimation is provided as an option in the CEMS User Manual for periods greater than 168 hours of missing data. The Director reviews and must authorize the data estimation method proposed in order to use Method 4. Method 4 was retained in the CEMS User Manual because it allows emissions data to be filled in for periods where past (previously submitted) data is invalidated, thereby allowing estimated emissions data to still be provided to the regulator as required by the CEMS code. Clause 9.0-A requires data to be reported whenever the source is operating, therefore if no quality assured data is available then estimated data is reported. Estimated data does not count towards percent availability requirements, but it avoids large gaps in the emissions data set.

The 2021 Code added replacement monitoring requirements in clause 8.0-A (a) through (d). This is meant for periods of analyzer outage. Requirements were put in place to ensure facilities have a contingency plan in place for times when an analyzer goes out of service or needs to be sent away for repairs. This avoids the loss of quality assured data moving forward and allows for meeting percent availability requirements. Clause 8.0-A (e) allows a short time period for estimating missing data during periods of analyzer outage, to provide some breathing room before putting contingency plans into place.

If past CEMS data is invalidated during data review and QA/QC procedures, it is not possible to fill that data in with replacement monitoring; therefore 8.0-A (a) through (d) are not applicable as the data gap is in the past. In this case the

analyzer appeared to be functioning and it was not known that there were data quality issues until after the fact. The use and stipulations around data submission/resubmission and use of missing data estimation are provided in the CEMS User Manual, they were not part of the previous Code nor are they provided in the current Code.

In clause 8.0-A(e), the cap is 168 hours for use of missing data estimation, after which Director authorization would be required (i.e., to use Method 4 in the CEMS User Manual, or via clause 1.2-B in the CEMS Code). However, estimating missing data for past data correction and estimating missing data going forward into the future due to analyzer outage are two different scenarios. Facilities cannot use missing data estimation for long periods going forward when an analyzer needs replacement or service (see 3.4-K). The revised Code requires contingency monitoring be put into place to avoid CEMS data loss (8.0-A). Method 4 has been used in the past and will continue to be used as a way to fill in past CEMS data following data invalidation to avoid large emission data gaps.

Note that estimated data does not count towards percent availability requirements. If 90% percent availability is not met, the industrial operation is in contravention of the CEMS Code and approval for not continuously monitoring emissions. As part of an authorization to use Method 4 in the CEMS User Manual for estimating missing data beyond 168 hours, the Director may also initiate an investigation into, or order corrective action, to address analyzer malfunction and recurring incidences of Method 4 use. Method 4 cannot be used as the fix for analyzer issues; i.e., if an analyzer is continually having issues and has not been repaired (leading to ongoing data issues). Data and analyzer problems need to be investigated and resolved and this is clear in the revised CEMS Code.

### Use of Method 5 for Flagging Missing Data (in the CEMS User Manual)

Method 5 has been added to the CEMS User Manual for flagging data in the situation where data has been invalidated back to the last previously passed performance specification. If a RATA or CGA fails and the root cause is not known, it is not known when the data became invalid so all data in the period back to the last passed RATA or CGA is flagged as questionable.

As per clause 7.6-A, data during an out-of-control period can be retained if flagged as not quality assured and it does not require Director authorization. This allows the facility to flag a large period of data back to the last successful performance test as opposed to providing an estimation. The facility does have the option of estimating the data instead if it is deemed the data will be more representative. For both options, data does not counts towards percent availability requirements as the CEMS is deemed out-of-control. If 90% percent availability is not met, the industrial operation is in contravention of the CEMS Code and approval for not continuously monitoring emissions.

Use of Method 5 is only for invalidation of past data as per the CEMS User Manual.

The requirement to back-invalidate data following a failed RATA or CGA took effect starting January 1, 2022 when the 2021 CEMS Code took effect (see section 7.6 of the CEMS Code and #44 in the Summary of Changes document on the CEMS webpage). This applies to flagging of 2021 data back to the last successful performance test. The data needs to be backed out and resubmitted with the correct qualifiers and percent availability. Refer to the CEMS User Manual for use of Method 5.