

CMS Definitions by Performance Specification (PS)

Note: For any definitions that are common to all Performance Specifications, please refer to the Master Glossary. Included in this handout are the definitions that are unique to a specific PS, where applicable.

Performance Specification 1

Data Recorder	The portion of the installed COMS that provides a permanent record of the opacity monitor output in terms of opacity. The data recorder may include automatic data reduction capabilities.
External Audit Device	The inherent design, equipment, or accommodation of the opacity monitor allowing the independent assessment of the COMS's calibration and operation.
Full Scale	The maximum data display output of the COMS. For purposes of recordkeeping and reporting, full scale will be greater than 80 percent opacity.
Operational Test Period	A period of time (168 hours) during which the COMS is expected to operate within the established performance specifications without any unscheduled maintenance, repair, or adjustment.
Primary Attenuators	Those devices (glass or grid filter that reduce the transmission of light) calibrated according to procedures in section 7.1.
Secondary Attenuators	Those devices (glass or grid filter that reduce the transmission of light) calibrated against primary attenuators according to procedures in section 7.2.
System Response Time	The amount of time the COMS takes to display 95 percent of a step change in opacity on the COMS data recorder.

Performance Specification 4B

Calibration Error (CE)	The difference between the concentration indicated by the CEMS and the known concentration generated by a calibration source when the entire CEMS, including the sampling interface is challenged. A CE test procedure is performed to document the accuracy and linearity of the CEMS over the entire measurement range.
Continuous Emission Monitoring System (CEMS)	This definition is the same as PS 2 section 2.1 with the following addition. A continuous monitor is one in which the sample to be analyzed passes the measurement section of the analyzer without interruption.

Performance Specification 6

Continuous Emission Rate Monitoring Systems (CERMS)	The total equipment required for the determining and recording the pollutant mass emission rate (in terms of mass per unit of time).
Flow Rate Sensor	That portion of the CERMS that senses the volumetric flow rate and generates an output proportional to that flow rate. The flow rate sensor shall have provisions to check the CD for each flow rate parameter that it measures individually (e.g., velocity, pressure).

Performance Specification 8A

Instrument Measurement Range	The difference between the minimum and maximum concentration that can be measured by a specific instrument. The minimum is often stated or assumed to be zero and the range expressed only as the maximum.
Organic Analyzer	That portion of the system that senses organic concentration and generates an output proportional to the gas concentration.
Span or Span Value	Full scale instrument measurement range. The span value must be documented by the CEMS manufacturer with laboratory data.

Performance Specification 9

Calibration Precision	The error between triplicate injections of each calibration standard.
Column	Analytical column capable of separating the analytes of interest.
Detector	A detection system capable of detecting and quantifying all analytes of interest.
Gas Chromatograph (GC)	That portion of the system that separates and detects organic analytes and generates an output proportional to the gas concentration. The GC must be temperature controlled.
Integrator	That portion of the system that quantifies the area under a particular sample peak generated by the GC.

Performance Specification 11

Appropriate Data Range for PM CEMS Correlation	The data range that reflects the full range of your source's PM emission concentrations recorded by your PM CEMS during the correlation test planning period or other normal operations as defined in the applicable regulations.
Appropriate Measurement Range of your PM CEMS	A measurement range that is capable of recording readings over the complete range of your source's PM emission concentrations during routine operations. The appropriate range is determined during the pretest preparations as specified in section 8.4 of PS 11.
Batch Sampling	A gas is sampled on an intermittent basis and concentrated on a collection medium before intermittent analysis and follow-up reporting. Beta gauge PM CEMS are an example of batch sampling devices.
Confidence Interval Half Range (CI)	A statistical term and means one-half of the width of the 95 percent confidence interval around the predicted mean PM concentration (y value) calculated at the PM CEMS response value (x value) where the confidence interval is narrowest. Procedures for calculating CI are

specified in section 12.3. The CI as a percent of the emission limit value (CI%) is calculated at the appropriate PM CEMS response value and must satisfy the criteria specified in section 13.2 (2).

Correlation

The primary mathematical relationship for correlating the output from your PM CEMS to a PM concentration, as determined by the PM reference method. The correlation is expressed in the measurement units that are consistent with the measurement conditions (e.g., mg/dscm, mg/acm) of your PM CEMS.

Correlation Coefficient (r)

A quantitative measure of the association between your PM CEMS outputs and the reference method measurements. Equations for calculating the r value are provided in section 12.3(1)(iv) for linear correlations and in section 12.3(2)(iv) for polynomial correlations.

Cycle Time

The time required to complete one sampling, measurement, and reporting cycle. For a batch sampling PM CEMS, the cycle time would start when sample gas is first extracted from the stack/duct and end when the measurement of that batch sample is complete and a new result for that batch sample is produced on the data recorder. “Data Recorder” means the portion of your CEMS that provides a permanent record of the monitor output in terms of response and status (flags). The data recorder may also provide automatic data reduction and CEMS control capabilities (see section 6.6 of PS 11).

Drift Check

A check of the difference between your PM CEMS output readings and the established reference value of a reference standard or procedure after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place. The procedures used to determine drift are specific to the operating principles of your specific PM CEMS. A drift check includes both a zero-drift check and an upscale drift check.

Exponential Correlation

An exponential equation used to define the relationship between your PM CEMS output and the reference method PM concentration, as indicated by Equation 11-37.

Flagged Data

Data marked by your CEMS indicating that the response value(s) from one or more CEMS subsystems is suspect or invalid or that your PM CEMS is not in source-measurement operating mode. “Linear

Correlation” means a first-order mathematical relationship between your PM CEMS output and the reference method PM concentration that is linear in form, as indicated by Equation 11-3.

Logarithmic Correlation

A first-order mathematical relationship between the natural logarithm of your PM CEMS output and the reference method PM concentration that is linear in form, as indicated by Equation 11-34.

Low-Emitting Source

A source that operated at no more than 50 percent of the emission limit during the most recent performance test, and, based on the PM CEMS correlation, the daily average emissions for the source, measured in the units of the applicable emission limit, have not exceeded 50 percent of the emission limit for any day since the most recent performance test.

Other Auxiliary Data Monitor(s) (if applicable)

The portion of your CEMS that provides the temperature, pressure, and/or moisture content, and generates an output proportional to the gas property.

Paired Trains

Two reference method trains that are used to conduct simultaneous measurements of PM concentrations. Guidance on the use of paired sampling trains can be found in the PM CEMS Knowledge Document (see section 16.5).

Polynomial Correlation

A second-order equation used to define the relationship between your PM CEMS output and reference method PM concentration, as indicated by Equation 11-16.

Power Correlation

An equation used to define a power function relationship between your PM CEMS output and the reference method concentration, as indicated by Equation 11-42. “Reference Method” means the method defined in the applicable regulations, but commonly refers to those methods collectively known as EPA Methods 5, 5I, and 17 (for particulate matter), found in Appendix A of 40 CFR 60. Only the front half and dry filter catch portions of the reference method can be correlated to your PM CEMS output.

Reference Standard

A reference material or procedure that produces a known and unchanging response when presented to the pollutant monitor portion of your CEMS. You must use these standards to evaluate the overall

operation of your PM CEMS, but not to develop a PM CEMS correlation.

Sample Volume Check

A check of the difference between your PM CEMS sample volume reading and the sample volume reference value. “Tolerance Interval half range (TI)” means one-half of the width of the tolerance interval with upper and lower limits, within which a specified percentage of the future data population is contained with a given level of confidence, as defined by the respective tolerance interval half range equations in section 12.3(1)(iii) for linear correlations and in section 12.3(2)(iii) for polynomial correlations. The TI as a percent of the emission limit value (TI%) is calculated at the appropriate PM CEMS response value specified in section 13.2(3).

Upscale Check Value

The expected response to a reference standard or procedure used to check the upscale response of your PM CEMS.

Upscale Drift (UD) Check

A check of the difference between your PM CEMS output reading and the upscale check value.

Zero Check Value

The expected response to a reference standard or procedure used to check the response of your PM CEMS to particulate-free or low-particulate concentration conditions.

Zero Drift (ZD) Check

A check of the difference between your PM CEMS output reading and the zero-check value.

Zero Point Correlation Value

A value added to PM CEMS correlation data to represent low or near zero PM concentration data (see section 8.6 for rationale and procedures).

Performance Specification 12A

Hg Analyzer

That portion of the Hg CEMS that measures the total vapor phase Hg mass concentration and generates a proportional output.

Measurement Error (ME)

The absolute value of the difference between the concentration indicated by the CEMS and the known concentration of a reference gas, expressed as a percentage of the span value, when the entire CEMS, including the sampling interface, is challenged.

Measurement Error Test

A test procedure in which the accuracy of the concentrations measured by a CEMS at three or more points over its measurement range is evaluated using reference gases. For Hg CEMS, elemental and oxidized Hg (Hg₀ and mercuric chloride, HgCl₂) gas standards of known concentration are used for this procedure.

Relative Accuracy (RA)

The absolute mean difference between the pollutant concentrations determined by the CEMS and the values determined by the RM plus the 2.5 percent error confidence coefficient of a series of tests divided by the mean of the RM tests. Alternatively, for sources with an average RM concentration less than 5.0 micrograms per standard cubic meter (µg/scm), the RA may be expressed as the absolute value of the difference between the mean CEMS and RM values.

Performance Specification 12B

Sorbent Trap Monitoring System

The total equipment required for the collection of gaseous Hg samples using paired three-partition sorbent traps.

Spike Recovery

The mass of Hg recovered from the spiked trap section, expressed as a percentage of the amount spiked. Spike recovery is used to assess sample matrix interference.

Relative Deviation (RD)

The absolute difference of the Hg concentration values obtained with a pair of sorbent traps divided by the sum of those concentrations, expressed as a percentage. RD is used to assess the precision of the sorbent trap monitoring system.

Performance Specification 15

Background Deviation

Any deviation (from 100 percent) in the one hundred percent line (or from zero absorbance). Deviations greater than ±5 percent in any analytical region are unacceptable. Such deviations indicate a change in the instrument throughput relative to the single-beam background.

Batch Sampling

A gas cell is alternately filled and evacuated. A Spectrum of each filled cell (one discreet sample) is collected and saved.

Calibration Spectrum

Infrared spectrum of a compound suitable for characterizing the FTIR instrument configuration (Section 4.5 in the FTIR Protocol).

CEM Measurement Time Constant

The Time Constant (TC, minutes for one cell volume to flow through the cell) determines the minimum interval for complete removal of an analyte from the FTIR cell. It depends on the sampling rate (Rs in Lpm), the FTIR cell volume (Vcell in L) and the chemical and physical properties of an analyte.

$$TC = V_{cell} R_s \text{ Eq. 1}$$

Continuous Operation

In continuous operation an FTIR CEM system, without user intervention, samples flue gas, records spectra of samples, saves the spectra to a disk, analyzes the spectra for the target analytes, and prints concentrations of target analytes to a computer file. User

intervention is permitted for initial set-up of sampling system, initial calibrations, and periodic maintenance.

Continuous Sampling

Sample is continuously flowing through a gas cell. Spectra of the flowing sample are collected at regular intervals.

FTIR System

Instrument to measure spectra in the mid-infrared spectral region (500 to 4000 cm^{-1}). It contains an infrared source, interferometer, sample gas containment cell, infrared detector, and computer. The interferometer consists of a beam splitter that divides the beam into two paths, one path a fixed distance and the other a variable distance. The computer is equipped with software to run the interferometer and store the raw digitized signal from the detector (interferogram). The software performs the mathematical conversion (the Fourier transform) of the interferogram into a spectrum showing the frequency dependent sample absorbance. All spectral data can be stored on computer media.

Gas Cell

A gas containment cell that can be evacuated. It contains the sample as the infrared beam passes from the interferometer, through the sample, and to the detector. The gas cell may have multi-pass mirrors depending on the required detection limit(s) for the application.

Independent Measurement

Two independent measurements are spectra of two independent samples. Two independent samples are separated by, at least 5 cell volumes. The interval between independent measurements depends on the cell volume and the sample flow rate (through the cell). There is no mixing of gas between two independent samples. Alternatively, estimate the analyte residence time empirically: (1) Fill cell to ambient pressure with a (known analyte concentration) gas standard, (2) measure the spectrum of the gas standard, (3) purge the cell with zero gas at the sampling rate and collect a spectrum every minute until the analyte standard is no longer detected spectroscopically. If the measured time corresponds to less than 5 * TC, use 5 * TC as the minimum interval between independent measurements. If the measured time is greater than 5 * TC, then use this time as the minimum interval between independent measurements.

Infrared Band (also Absorbance Band or Band)

Collection of lines arising from rotational transitions superimposed on a vibrational transition. An infrared absorbance band is analyzed to determine the analyte concentration.

Interferant

A compound in the sample matrix whose infrared spectrum overlaps at least part of an analyte spectrum complicating the analyte measurement. The interferant may not prevent the analyte measurement, but could increase the analytical uncertainty in the measured concentration. Reference spectra of interferants are used to distinguish the interferant bands from the analyte bands. An interferant for one analyte may not be an interferant for other analytes.

One Hundred Percent Line

A double beam transmittance spectrum obtained by combining two successive background single beam spectra. Ideally, this line is equal to 100 percent transmittance (or zero absorbance) at every point in the spectrum. The zero absorbance line is used to measure the RMS noise of the system.

PPM-Meters

Sample concentration expressed as the concentration-path length product, ppm (molar) concentration multiplied by the path length of the FTIR gas cell. Expressing concentration in these units provides a way to directly compare measurements made using systems with different optical configurations. Another useful expression is (ppm-meters)/K, where K is the absolute temperature of the sample in the gas cell.

Reference CEM

An FTIR CEM, with sampling system, that can be used for comparison measurements.

Reference Spectrum

Infrared spectra of an analyte, or interferant, prepared under controlled, documented, and reproducible laboratory conditions (see section 4.6 of the FTIR Protocol). A suitable library of reference spectra can be used to measure target analytes in gas samples.

Run

A single run consists of spectra (one spectrum each) of at least 10 independent samples over a minimum of one hour. The concentration results from the spectra can be averaged together to give a run average for each analyte measured in the test run.

Sample Analysis

Interpreting infrared band shapes, frequencies, and intensities to obtain sample component concentrations. This is usually performed by a software routine using a classical least squares (cls), partial least squares (pls), or K- or P- matrix method. (Target) Analyte. A compound whose measurement is required, usually to some established limit of detection and analytical uncertainty.

Sampling System

Equipment used to extract sample from the test location and transport the gas to the FTIR analyzer. Sampling system components include probe, heated line, heated non-reactive pump, gas distribution manifold and valves, flow measurement devices and any sample conditioning systems.

Sampling Time

In batch sampling—the time required to fill the cell with flue gas. In continuous sampling—the time required to collect the infrared spectrum of the sample gas.

Test Condition

A period of sampling where all process, and sampling conditions, and emissions remain constant and during which a single sampling technique and a single analytical program are used. One Run may include results for more than one test condition. Constant emissions means that the composition of the emissions remains approximately stable so that a single analytical program is suitable for analyzing all of the sample spectra. A greater than two-fold change in analyte or interferant concentrations or the appearance of additional compounds in the emissions, may constitute a new test condition and may require modification of the analytical program.

Performance Specification 16

Defective Sensor	A sensor that is responsible for PEMS malfunction or that operates outside the approved operating envelope. A defective sensor may be functioning properly, but because it is operating outside the approved operating envelope, the resulting predicted emission is not validated.
Diluent PEMS	The total equipment required to predict a diluent gas concentration or emission rate.
Operating Envelope	The defined range of a parameter input that is established during PEMS development. Emission data generated from parameter inputs that are beyond the operating envelope are not considered quality assured and are therefore unacceptable.
PEMS	All of the equipment required to predict an emission concentration or emission rate. The system may consist of any of the following major subsystems: sensors and sensor interfaces, emission model, algorithm, or equation that uses process data to generate an output that is proportional to the emission concentration or emission rate, diluent emission model, data recorder, and sensor evaluation system. Systems that use fewer than 3 variables do not qualify as PEMS unless the system has been specifically approved by the Administrator for use as a PEMS. A PEMS may predict emissions data that are corrected for diluent if the relative accuracy and relevant QA tests are passed in the emission units corrected for diluent. Parametric monitoring systems that serve as indicators of compliance and have parametric limits but do not predict emissions to comply with an emissions limit are not included in this definition.
PEMS Training	The process of developing or confirming the operation of the PEMS against a reference method under specified conditions.
Quarter	A quarter of a calendar year in which there are at least 168-unit operating hours.
Reconciled Process Data	Substitute data that are generated by a sensor evaluation system to replace that of a failed sensor. Reconciled process data may not be used without approval from the Administrator.

Reference Value	A PEMS baseline value that may be established by RM testing under conditions when all sensors are functioning properly. This reference value may then be used in the sensor evaluation system or in adjusting new sensors.
Relative Accuracy Audit	A quarterly audit of the PEMS against a portable analyzer meeting the requirements of ASTM D6522-00 or a RM for a specified number of runs. A RM may be used in place of the portable analyzer for the RAA.
Sensor Evaluation System	The equipment or procedure used to periodically assess the quality of sensor input data. This system may be a sub-model that periodically cross-checks sensor inputs among themselves or any other procedure that checks sensor integrity at least daily (when operated for more than one hour in any calendar day).
Sensors and Sensor Interface	The equipment that measures the process input signals and transports them to the emission prediction system.

Performance Specification 18

Beam Attenuation	Is the reduction in electromagnetic radiation (light) throughput from the maximum beam intensity experienced during site specific CEMS operation.
Beam Intensity	The electromagnetic radiation (light) throughput for an IP-CEMS instrument measured following manufacturers specifications.
Calibration Cell	A gas containment cell used with cross stack or integrated path (IP) CEMS for calibration and to perform many of the test procedures required by this performance specification. The cell may be a removable sealed cell or an evacuated and/or purged cell capable of exchanging reference and other calibration gases as well as zero gas standards. When charged, it contains a known concentration of HCl and/or interference gases. The calibration cell is filled with zero gas or removed from the optical path during stack gas measurement.
Centroidal Area	A central area that is geometrically similar to the stack or duct cross section and is no greater than 10 percent of the stack or duct cross-sectional area.

Dynamic Spiking (DS)	The procedure where a known concentration of HCl gas is injected into the probe sample gas stream for extractive CEMS at a known flow rate to assess the performance of the measurement system in the presence of potential interference from the flue gas sample matrix.
HCl Analyzer	That portion of the HCl CEMS that measures the total vapor phase HCl concentration and generates a proportional output.
Independent Measurement(s)	The series of CEMS data values taken during sample gas analysis separated by two times the procedure specific response time (RT) of the CEMS.
Integrated path CEMS (IP-CEMS)	An in-situ CEMS that measures the gas concentration along an optical path in the stack or duct cross section.
Interference	A compound or material in the sample matrix other than HCl whose characteristics may bias the CEMS measurement (positively or negatively). The interference may not prevent the sample measurement, but it could increase the analytical uncertainty in the measured HCl concentration through reaction with HCl or by changing the electronic signal generated during HCl measurement.
Interference Test	The test to detect CEMS responses to interferences that are not adequately accounted for in the calibration procedure and may cause measurement bias. Level of detection (LOD) means the lowest level of pollutant that the CEMS can detect in the presence of the source gas matrix interferences with 99 percent confidence.
Liquid Evaporative Standard	A reference gas produced by vaporizing National Institute of Standards and Technology (NIST) traceable liquid standards of known HCl concentration and quantitatively diluting the resultant vapor with a carrier gas.
Measurement Error (ME)	Is the mean difference between the concentration measured by the CEMS and the known concentration of a reference gas standard, divided by the span, when the entire CEMS, including the sampling interface, is challenged.

Optical Path	The route light travels from the light source to the receiver used to make sample measurements.
Path Length	For an extractive optical CEMS, the distance in meters of the optical path within a gas measurement cell. For an IP-CEMS, path length means the distance in meters of the optical path that passes through the source gas in the stack or duct.
Response Time (RT)	The time it takes for the measurement system, while operating normally at its target sample flow rate, dilution ratio, or data collection rate to respond to a known step change in gas concentration, either from a low- or zero-level to a high-level gas concentration or from a high-level to a low or zero-level gas concentration, and to read 95 percent of the change to the stable instrument response. There may be several RTs for an instrument related to different functions or procedures (e.g., DS, LOD, and ME).
Span Value	An HCl concentration approximately equal to two times the concentration equivalent to the emission standard unless otherwise specified in the applicable regulation, permit or other requirement. Unless otherwise specified, the span may be rounded up to the nearest multiple of 5.
Stack Pressure Measurement Device	A NIST-traceable gauge or monitor that measures absolute pressure and conforms to the design requirements of ASME B40.100-2010, "Pressure Gauges and Gauge Attachments" (incorporated by reference—see §60.17).
Standard Addition	The addition of known amounts of HCl gas (either statically or dynamically) to the actual measurement path or measured sample gas stream.
Zero Gas	A gas or liquid with an HCl concentration that is below the LOD of the measurement system.