APPENDIX D

PERFORMANCE SPECIFICATION FOR Cl_2 CEMS

PERFORMANCE SPECIFICATION 14 -- Specifications and test procedures for chlorine continuous monitoring systems in stationary sources

1. *Applicability and Principle*

1.1 Applicability. This specification is to be used for evaluating the acceptability of chlorine (Cl_2) continuous emission monitoring systems (CEMS) at the time of or soon after installation and whenever specified in the regulations. This performance specification applies only to those CEMS capable of directly measuring the gas phase concentration of the chlorine (Cl_2) molecule. The CEMS may include, for certain stationary sources, a) a diluent (O_2) monitor (which must meet its own performance specifications: 40 CFR part 60, Appendix B, Performance Specification 3), b) flow monitoring equipment to allow measurement of the dry volume of stack effluent sampled, and c) an automatic sampling system.

This specification is not designed to evaluate the installed CEMS' performance over an extended period of time nor does it identify specific calibration techniques and auxiliary procedures to assess the CEMS' performance. The source owner or operator, however, is responsible to properly calibrate, maintain, and operate the CEMS. To evaluate the CEMS' performance, the Administrator may require, under Section 114 of the Act, the operator to conduct CEMS performance evaluations at other times besides the initial test.

1.2 Principle. Installation and measurement location specifications, performance specifications, test procedures, and data reduction procedures are included in this specification. Calibration error tests, and calibration drift tests, and interferant tests are conducted to determine conformance of the CEMS with the specification. Calibration error is assessed with cylinder gas standards for chlorine. The ability of the CEMS to provide an accurate measure of chlorine concentration in the flue gas of the facility at which it is installed is demonstrated by comparison to manual reference method measurements.

2. *Definitions*

2.1 Continuous Emission Monitoring System (CEMS). The total equipment required for the determination of a pollutant concentration. The system consists of the following major subsystems:

2.1.1 Sample Interface. That portion of the CEMS used for one or more of the following: sample acquisition, sample transport, and sample conditioning, or protection of the monitor from the effects of the stack effluent.

2.1.2 Pollutant Analyzer. That portion of the CEMS that senses the pollutant concentration(s) and generates a proportional output.

2.1.3 Diluent Analyzer (if applicable). That portion of the CEMS that senses the diluent gas (O_2) and generates an output proportional to the gas concentration.

2.1.4 Data Recorder. That portion of the CEMS that provides a permanent record of the analyzer output. The data recorder may provide automatic data reduction and CEMS control capabilities.

2.2 Point CEMS. A CEMS that measures the pollutant concentrations either at a single point or along a path equal to or less than 10 percent of the equivalent diameter of the stack or duct cross section.

2.3 Path CEMS. A CEMS that measures the pollutant concentrations along a path greater than 10 percent of the equivalent diameter of the stack or duct cross section.

2.4 Span Value. The upper limit of a pollutant concentration measurement range defined as twenty times the applicable emission limit. The span value shall be documented by the CEMS manufacturer with laboratory data.

2.5 Accuracy. A measurement of agreement between a measured value and an accepted or true value, expressed as the percentage difference between the true and measured values relative to the true value. For these performance specifications, accuracy is checked by conducting a calibration error (CE) test.

2.6 Calibration Drift (CD). The difference in the CEMS output readings from the established reference value after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.7 Zero Drift (ZD). The difference in the CEMS output readings for zero input after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.8 Representative Results. Defined by the RA test procedure defined in this specification.

2.9 Response Time. The time interval between the start of a step change in the system input and the time when the pollutant analyzer output reaches 95 percent of the final value.

2.10 Centroidal Area. A concentric area that is geometrically similar to the stack or duct cross section and is no greater than 1 percent of the stack or duct cross sectional area.

2.11 Calibration Standard. Calibration standards consist of a known amount of pollutant that is presented to the pollutant analyzer portion of the CEMS in order to calibrate the drift or response of the analyzer. The calibration standard may be, for example, a gas sample containing known concentration.

2.12 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.

3. *Installation and Measurement Location Specifications*

3.1 CEMS Installation and Measurement Locations. The CEMS shall be installed in a location in which measurements representative of the source's emissions can be obtained. The optimum location of the sample interface for the CEMS is determined by a number of factors, including ease of access for calibration and maintenance, the degree to which sample conditioning will be required, the degree to which it represents total emissions, and the degree to which it represents the combustion situation in the firebox. The location should be as free from in-leakage influences as possible and reasonably free from severe flow disturbances. The sample location should be at least two equivalent duct diameters downstream from the nearest control device, point of pollutant generation, or other point at which a change in the pollutant concentration or emission rate occurs and at least 0.5 diameter upstream from the exhaust or control device. The equivalent duct diameter is calculated as per 40 CFR part 60, appendix A, method 1, section 2.1. If these criteria are not achievable or if the location is otherwise less than optimum, the possibility of stratification should be investigated as described in section 3.2. The measurement point shall be within the centroidal area of the stack or duct cross section.

3.1.1 Point CEMS It is suggested that the measurement point be (1) no less than 1.0 meter from the stack or duct wall or (2) within or centrally located over the centroidal area of the stack or duct cross section.

3.1.2 Path CEMS. It is suggested that the effective measurement path (1) be totally within the inner area bounded by a line 1.0 meter from the stack or duct wall, or (2) have at least 70 percent of the path within the inner 50 percent of the stack or duct cross-sectional area.

3.2 Stratification Test Procedure. Stratification is defined as a difference in excess of 10 percent between the average concentration in the duct or stack and the concentration at any point more than 1.0 meter from the duct or stack wall. To determine whether effluent stratification exists, a dual probe system should be used to determine the average effluent concentration while measurements at each traverse point are being made. One probe, located at the stack or duct centroid, is used as a stationary reference point to indicate the change in effluent concentration over time. The second probe is used for sampling at the traverse points specified in 40 CFR part 60 appendix A, method 1. The monitoring system samples sequentially at the reference and traverse points throughout the testing period for five minutes at each point.

4. *Performance and Equipment Specifications*

4.1 Data Recorder Scale. The CEMS data recorder response range must include zero and a high level value. The high level value must be equal to the span value. If a lower high level value is used, the CEMS must have the capability of providing multiple outputs with different high level values (one of which is equal to the span value) or be capable of automatically changing the high level value as required (up to the span value) such that the measured value does not exceed 95 percent of the high level value.

4.2 Relative Accuracy (RA). The RA of the CEMS must be no greater than 20 percent of the mean value of the RM test data in terms of units of the emission standard, or 10 percent of the applicable standard, whichever is greater.

4.3 Calibration Error. Calibration error is assessed using certified NIST traceable cylinder gas standards for chlorine. The mean difference between the indicated CEMS concentration and the reference concentration shall be no greater than ±15 percent of the reference concentration. The reference concentration shall be the greater of 80 to 120 % of the applicable emission standard or 50 ppm Cl_2, in nitrogen.

4.4 Calibration Drift. The CEMS design must allow the determination of calibration drift at concentration levels commensurate with the applicable emission standard. The CEMS calibration may not drift or deviate from the reference value (RV) of the calibration standard by more than 2 percent of the reference value. The calibration shall be performed at a level equal to 80 to 120 percent of the applicable emission standard.

4.5 Zero Drift. The CEMS design must allow the determination of calibration drift at the zero level (zero drift). The CEMS zero point shall not drift by more than 2 percent of the emission standard.

4.6 Sampling and Response Time. The CEMS shall sample the stack effluent continuously. Averaging time, the number of measurements in an average, and the averaging procedure for reporting and determining compliance shall conform with that specified in the applicable emission regulation.

4.6.1 Response Time. The response time of the CEMS should not exceed 2 minutes to achieve 95 percent of the final stable value. The response time shall be documented by the CEMS manufacturer.

4.7 CEMS Interference Response. While the CEMS is measuring the concentration of chlorine in the high-level calibration source used to conduct the CE test, the gaseous components (in nitrogen) listed in Table I shall be introduced into the measurement system either separately or in combination. The interference test gases must be introduced in such a way as to cause no change in the calibration concentration of chlorine being delivered to the CEMS. The concentrations listed in the table are the target levels at the sampling interface of the CEMS based on the known cylinder gas concentrations and the extent of dilution (see Section 9). Interference is defined as the difference between the CEMS response with these components present and absent. The sum of the interferences must be less than 2 percent of the emission limit value. If this level of interference is exceeded, then corrective action to eliminate the interference(s) must be taken.

Table I

Interference Test Gas Concentrations in Nitrogen

Gas	**Concentration**
Carbon Monoxide	500 ± 50 ppm
Carbon Dioxide	10 ± 1 percent
Oxygen	20.9 ± 1 percent
Sulfur Dioxide	500 ± 50 ppm
Nitrogen Dioxide	250 ± 25 ppm
Water Vapor	25 ± 5 percent
Hydrogen Chloride (HCl)	50 ± 5 ppm

5. *Performance Specification Test Procedure*

5.1 Pretest Preparation. Install the CEMS and prepare the RM test site according to the specifications in Section 3, and prepare the CEMS for operation according to the manufacturer's written instructions.

5.2 Calibration and Zero Drift Test Period. While the affected facility is operating at more than 50 percent of normal load, or as specified in an applicable subpart, determine the magnitude of the calibration drift (CD) and zero drift (ZD) once each day (at 24-hour intervals) for 7 consecutive days according to the procedure given in Section 6. To meet the requirements of Sections 4.4 and 4.5 none of the CD's or ZD's may exceed the specification. All CD determinations must be made following a 24-hour period during which no unscheduled maintenance, repair, or manual adjustment of the CEMS took place.

5.3 CE Test Period. Conduct a CE test prior to the CD test period. Conduct the CE test according to the procedure given in Section 8.

5.4 CEMS Interference Response Test Period. Conduct an interference response test in conjunction with the CE test according to the procedure given in Section 9.

6.0 *The CEMS Calibration and Zero Drift Test Procedure*

This performance specification is designed to allow calibration of the CEMS by use of gas samples, filters, etc that challenge the pollutant analyzer part of the CEMS (and as much of the whole system as possible), but which do not challenge the entire CEMS, including the sampling interface. Satisfactory response of the entire system is covered by the RA and CE requirements.

The CD measurement is to verify the ability of the CEMS to conform to the established CEMS calibration used for determining the emission concentration. Therefore, if periodic automatic or manual adjustments are made to the CEMS zero and calibration settings, conduct the CD test immediately before the adjustments, or conduct it in such a way that the CD and ZD can be determined.

Conduct the CD and ZD tests at the points specified in Sections 4.4 and 4.5. Record the CEMS response and calculate the CD according to:

$$CD = \frac{\left(R_{CEM} - R_V \right)}{R_V} X\ 100\ , \tag{1}$$

where CD denotes the calibration drift of the CEMS in percent, R_{CEM} is the CEMS response, and R_V is the reference value of the high level calibration standard. Calculate the ZD according to:

$$ZD = \frac{\left(R_{CEM} - R_V \right)}{R_{EM}} X\ 100\ , \tag{2}$$

where ZD denotes the zero drift of the CEMS in percent, R_{CEM} is the CEMS response, R_V is the reference value of the low level calibration standard, and R_{EM} is the emission limit value.

7. *Calibration Error Test Procedure*

7.1 Sampling Strategy. The CEMS calibration error shall be assessed using the calibration source specified in Section 4.3. Challenge the CEMS at the measurement levels specified in Section 4.3. During the test, operate the CEMS as nearly as possible in its normal operating mode. The calibration gases should be injected into the sampling system as close to the sampling probe outlet as practical and shall pass through all filters, scrubbers, conditioners, and other monitor components used during normal sampling.

7.2 Number of tests. Challenge the CEMS three non-consecutive times at each measurement point and record the responses. The duration of each challenge should be for a sufficient period of time to ensure that the CEMS surfaces are conditioned and a stable output obtained.

7.3 Calculations. Summarize the results on a data sheet. Calculate the mean difference between the CEMS response and the known reference concentration at each measurement point according to equations 5 and 6 of Section 10. The calibration error (CE) at each measurement point is then given by:

$$CE = \left| d / R_V \right| X100\ , \tag{3}$$

where R_V is the reference concentration value.

8. *Interference Response Test Procedure*

8.1 Test Strategy. Perform the interference response test while the CEMS is being challenged by the high level calibration source (after the CE determination has been made). The interference test gases should be injected into the sampling system as close to the sampling probe outlet as practical and shall pass through all filters, scrubbers, conditioners, and other monitor components used during normal sampling.

8.2 Number of tests. Introduce the interference test gas three times alternately with the high-level calibration gas and record the responses both with and without the interference test gas. The duration of each test should be for a sufficient period of time to ensure that the CEMS surfaces are conditioned and a stable output obtained.

8.3 Calculations. Summarize the results on a data sheet. Calculate the mean difference between the CEMS response with and without the interference test gas by taking the average of the CEMS responses with and without the interference test gas (see equation 5) and then taking the difference (d). The percent interference (I) is then given by:

$$I = |d/R_{HL}| X100, \qquad \textbf{(4)}$$

where R_{HL} is the value of the high-level calibration standard. If the gaseous components of the interference test gas are introduced separately, then the total interference is the sum of the individual interferences.

9. *Equations*

9.1 Arithmetic Mean. Calculate the arithmetic mean of a data set as follows:

$$\overline{x} = \frac{1}{n} \sum_{i=1}^{n} x_i , \qquad \textbf{(5)}$$

where n is equal to the number of data points.

9.1.1 Calculate the arithmetic mean of the difference, d, of a data set, using Equation 5 and substituting d for x. Then

$$d_i = x_i - y_i , \qquad \textbf{(6)}$$

where x and y are paired data points from the CEMS and RM, respectively.

10. *Reporting*

At a minimum (check with the appropriate regional office, or State, or local agency for additional requirements, if any) summarize in tabular form the results of the CE, interference response, CD and RA tests. Include all data sheets, calculations, and records of CEMS response necessary to substantiate that the performance of the CEMS met the performance specifications.

The CEMS measurements shall be reported to the agency in units of $\mu g/m^3$ on a dry basis, corrected to 20°C and 7 percent O_2.

11. *Bibliography*

1. 40 CFR Part 60, Appendix B, "Performance Specification 2 - Specifications and Test Procedures for SO_2 and NO_x Continuous Emission Monitoring Systems in Stationary Sources."

2. 40 CFR Part 60, Appendix B, "Performance Specification 1 - Specification and Test Procedures for Opacity Continuous Emission Monitoring Systems in Stationary Sources."

3. 40 CFR Part 60, Appendix A, "Method 1 - Sample and Velocity Traverses for Stationary Sources."

4. 40 CFR Part 266, Appendix IX, Section 2, "Performance Specifications for Continuous Emission Monitoring Systems."

5. "Continuous Emission Monitoring Technology Survey for Incinerators, Boilers, and Industrial Furnaces: Final Report for Metals CEM's," prepared for the Office of Solid Waste, U.S. EPA, Contract No. 68-D2-0164 (4/25/94).

APPENDIX E

PERFORMANCE SPECIFICATIONS FOR MULTI-METALS CEMS

PERFORMANCE SPECIFICATION 10 -- Specifications and test procedures for multi-metals continuous monitoring systems in stationary sources

1. *Applicability and Principle*

1.1 Applicability. This specification is to be used for evaluating the acceptability of multi-metals continuous emission monitoring systems (CEMS) at the time of or soon after installation and whenever specified in the regulations. The CEMS may include, for certain stationary sources, a) a diluent (O_2) monitor (which must meet its own performance specifications: 40 CFR part 60, Appendix B, Performance Specification 3), b) flow monitoring equipment to allow measurement of the dry volume of stack effluent sampled, and c) an automatic sampling system.

A multi-metals CEMS must be capable of measuring the total concentrations (regardless of speciation) of two or more of the following metals in both their vapor and solid forms: Antimony (Sb), Arsenic (As), Barium (Ba), Beryllium (Be), Cadmium (Cd), Chromium (Cr), Lead (Pb), Mercury (Hg), Silver (Ag), Thallium (Tl), Manganese (Mn), Cobalt (Co), Nickel (Ni), and Selenium (Se). Additional metals may be added to this list at a later date by addition of appendices to this performance specification. If a CEMS does not measure a particular metal or fails to meet the performance specifications for a particular metal, then the CEMS may not be used to determine emission compliance with the applicable regulation for that metal.

This specification is not designed to evaluate the installed CEMS' performance over an extended period of time nor does it identify specific calibration techniques and auxiliary procedures to assess the CEMS' performance. The source owner or operator, however, is responsible to properly calibrate, maintain, and operate the CEMS. To evaluate the CEMS' performance, the Administrator may require, under Section 114 of the Act, the operator to conduct CEMS performance evaluations at other times besides the initial test. See Sec. 60.13 (c) and "Quality Assurance Requirements For Multi-Metals Continuous Emission Monitoring Systems Used For Compliance Determination."

1.2 Principle. Installation and measurement location specifications, performance specifications, test procedures, and data reduction procedures are included in this specification. Reference method tests and calibration drift tests are conducted to determine conformance of the CEMS with the specification.

2. *Definitions*

2.1 Continuous Emission Monitoring System (CEMS). The total equipment required for the determination of a metal concentration. The system consists of the following major subsystems:

2.1.1 Sample Interface. That portion of the CEMS used for one or more of the following: sample acquisition, sample transport, and sample conditioning, or protection of the monitor from the effects of the stack effluent.

2.1.2 Pollutant Analyzer. That portion of the CEMS that senses the metals concentrations and generates a proportional output.

2.1.3 Diluent Analyzer (if applicable). That portion of the CEMS that senses the diluent gas (O_2) and generates an output proportional to the gas concentration.

2.1.4 Data Recorder. That portion of the CEMS that provides a permanent record of the analyzer output. The data recorder may provide automatic data reduction and CEMS control capabilities.

2.2 Point CEMS. A CEMS that measures the metals concentrations either at a single point or along a path equal to or less than 10 percent of the equivalent diameter of the stack or duct cross section.

2.3 Path CEMS. A CEMS that measures the metals concentrations along a path greater than 10 percent of the equivalent diameter of the stack or duct cross section.

2.4 Span Value. The upper limit of a metals concentration measurement range defined as twenty times the applicable emission limit for each metal. The span value shall be documented by the CEMS manufacturer with laboratory data.

2.5 Relative Accuracy (RA). The absolute mean difference between the metals concentrations determined by the CEMS and the value determined by the reference method (RM) plus the 2.5 percent error confidence coefficient of a series of tests divided by the mean of the RM tests or the applicable emission limit.

2.6 Calibration Drift (CD). The difference in the CEMS output readings from the established reference value after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.7 Zero Drift (ZD). The difference in the CEMS output readings for zero input after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.8 Representative Results. Defined by the RA test procedure defined in this specification.

2.9 Response Time. The time interval between the start of a step change in the system input and the time when the pollutant analyzer output reaches 95 percent of the final value.

2.10 Centroidal Area. A concentric area that is geometrically similar to the stack or duct cross section and is no greater than 1 percent of the stack or duct cross sectional area.

2.11 Batch Sampling. Batch sampling refers to the technique of sampling the stack effluent continuously and concentrating the pollutant in some capture medium. Analysis is performed periodically after sufficient time has elapsed to concentrate the pollutant to levels detectable by the analyzer.

2.12 Calibration Standard. Calibration standards consist of a known amount of metal(s) that are presented to the pollutant analyzer portion of the CEMS in order to calibrate the drift or response of the analyzer. The calibration standard may be, for example, a solution containing a known metal concentration, or a filter with a known mass loading or composition.

3. *Installation and Measurement Location Specifications*

3.1 The CEMS Installation and measurement location. Install the CEMS at an accessible location downstream of all pollution control equipment where the metals concentrations measurements are directly representative or can be corrected so as to be representative of the total emissions from the affected facility. Then select representative measurement points or paths for monitoring in locations that the CEMS will pass the RA test (see Section 7). If the cause of failure to meet the RA test is determined to be the measurement location and a satisfactory correction technique cannot be established, the Administrator may require the CEMS to be relocated.

Measurement locations and points or paths that are most likely to provide data that will meet the RA requirements are listed below.

3.1.1 Measurement Location. The measurement location should be (1) at least eight equivalent diameters downstream of the nearest control device, point of pollutant generation, bend, or other point at which a change of pollutant concentration or flow disturbance may occur and (2) at least two equivalent diameters upstream from the effluent exhaust. The equivalent duct diameter is calculated as per 40 CFR part 60, Appendix A, Method 1, Section 2.1.

3.1.2 Point CEMS. The measurement point should be (1) no less than 1.0 meter from the stack or duct wall or (2) within or centrally located over the centroidal area of the stack or duct cross section. Selection of traverse points to determine the representativeness of the measurement location should be made according to 40 CFR part 60, Appendix A, Method 1, Section 2.2 and 2.3.

3.1.3 Path CEMS. The effective measurement path should be (1) totally within the inner area bounded by a line 1.0 meter from the stack or duct wall, or (2) have at least 70 percent of the path within the inner 50 percent of the stack or duct cross sectional area, or (3) be centrally located over any part of the centroidal area.

3.2 Reference Method (RM) Measurement Location and Traverse Points. The RM measurement location should be (1) at least eight equivalent diameters downstream of the nearest control device, point of pollutant generation, bend, or other point at which a change of pollutant concentration or flow disturbance may occur and (2) at least two equivalent diameters upstream from the effluent exhaust. The RM and CEMS locations need not be the same, however the difference may contribute to failure of the CEMS to pass the RA test, thus they should be as close as possible without causing interference with one another. The equivalent duct diameter is calculated as per 40 CFR part 60, Appendix A, Method 1, Section 2.1. Selection of traverse measurement point locations should be made according to 40 CFR part 60, Appendix A, Method 1, Sections 2.2 and 2.3. If the RM traverse line interferes with or is interfered by the CEMS measurements, the line may be displaced up to 30 cm (or 5 percent of the equivalent diameter of the cross section, whichever is less) from the centroidal area.

4. *Performance and Equipment Specifications*

4.1 Data Recorder Scale. The CEMS data recorder response range must include zero and a high level value. The high level value must be equal to the span value. If a lower high level value is used, the CEMS must have the capability of providing multiple outputs with different high level values (one of which is equal to the span value) or be capable of automatically changing the high level value as required (up to the span value) such that the measured value does not exceed 95 percent of the high level value.

4.2 Relative Accuracy (RA). The RA of the CEMS must be no greater than 20 percent of the mean value of the RM test data in terms of units of the emission standard for each metal, or 10 percent of the applicable standard, whichever is greater.

4.3 Calibration Drift. The CEMS design must allow the determination of calibration drift at concentration levels commensurate with the applicable emission standard for each metal monitored. The CEMS calibration may not drift or deviate from the reference value (RV) of the calibration standard used for each metal by more than 5 percent of the emission standard for each metal. The calibration shall be performed at a point equal to 80 to 120 percent of the applicable emission standard for each metal.

4.4 Zero Drift. The CEMS design must allow the determination of calibration drift at the zero level (zero drift) for each metal. If this is not possible or practicable, the design must allow the zero drift determination to be made at a low level value (zero to 20 percent of the emission limit value). The CEMS zero point for each metal shall not drift by more than 5 percent of the emission standard for that metal.

4.5 Sampling and Response Time. The CEMS shall sample the stack effluent continuously. Averaging time, the number of measurements in an average, and the averaging procedure for reporting and determining compliance shall conform with that specified in the applicable emission regulation.

4.5.1 Response Time for Instantaneous, Continuous CEMS. The response time for the CEMS must not exceed 2 minutes to achieve 95 percent of the final stable value.

4.5.2 Waiver from Response Time Requirement. A source owner or operator may receive a waiver from the response time requirement for instantaneous, continuous CEMS in section 4.5.1 from the Agency if no CEM is available which can meet this specification at the time of purchase of the CEMS.

4.5.3 Response Time for Batch CEMS. The response time requirement of Sections 4.5.1 and 4.5.2 do not apply to batch CEMS. Instead it is required that the sampling time be no longer than one third of the averaging period for the applicable standard. In addition, the delay between the end of the sampling period and reporting of the sample analysis shall be no greater than one hour. Sampling is also required to be continuous except in that the pause in sampling when the sample collection media are changed should be no greater than five percent of the averaging period or five minutes, whichever is less.

5. *Performance Specification Test Procedure*

5.1 Pretest Preparation. Install the CEMS and prepare the RM test site according to the specifications in Section 3, and prepare the CEMS for operation according to the manufacturer's written instructions.

5.2 Calibration and Zero Drift Test Period. While the affected facility is operating at more than 50 percent of normal load, or as specified in an applicable subpart, determine the magnitude of the calibration drift (CD) and zero drift (ZD) once each day (at 24-hour intervals) for 7 consecutive days according to the procedure given in Section 6. To meet the requirements of Sections 4.3 and 4.4 none of the CD's or ZD's may exceed the specification. All CD determinations must be made following a 24-hour period during which no unscheduled maintenance, repair, or manual adjustment of the CEMS took place.

5.3 RA Test Period. Conduct a RA test following the CD test period. Conduct the RA test according to the procedure given in Section 7 while the affected facility is operating at more than 50 percent of normal load, or as specified in the applicable subpart.

6.0 *The CEMS Calibration and Zero Drift Test Procedure*

This performance specification is designed to allow calibration of the CEMS by use of standard solutions, filters, etc that challenge the pollutant analyzer part of the CEMS (and as much of the whole system as possible), but which do not challenge the entire CEMS, including the sampling interface. Satisfactory response of the entire system is covered by the RA requirements.

The CD measurement is to verify the ability of the CEMS to conform to the established CEMS calibration used for determining the emission concentration. Therefore, if periodic automatic or manual adjustments are made to the CEMS zero and calibration settings, conduct the CD test immediately before the adjustments, or conduct it in such a way that the CD and ZD can be determined.

Conduct the CD and ZD tests at the points specified in Sections 4.3 and 4.4. Record the CEMS response and calculate the CD according to:

$$CD = \frac{\left(R_{CEM} - R_V \right)}{R_V} X\ 100\ , \tag{1}$$

where CD denotes the calibration drift of the CEMS in percent, R_{CEM} is the CEMS response, and R_V is the reference value of the high level calibration standard. Calculate the ZD according to:

$$ZD = \frac{\left(R_{CEM} - R_V \right)}{R_{EM}} X\ 100\ , \tag{2}$$

where ZD denotes the zero drift of the CEMS in percent, R_{CEM} is the CEMS response, R_V is the reference value of the low level calibration standard, and R_{EM} is the emission limit value.

7. *Relative Accuracy Test Procedure*

7.1 Sampling Strategy for RA Tests. The RA tests are to verify the initial performance of the entire CEMS system, including the sampling interface, by comparison to RM measurements. Conduct the RM measurements in such a way that they will yield results representative of the emissions from the source and can be correlated to the CEMS data. Although it is preferable to conduct the diluent (if applicable), moisture (if needed), and pollutant measurements simultaneously, the diluent and moisture measurements that are taken within a 30- to 60-minute period, which includes the pollutant measurements, may be used to calculate dry pollutant concentration.

A measure of relative accuracy at a single level is required for each metal measured for compliance purposes by the CEMS. Thus the concentration of each metal must be detectable by both the CEMS and the RM. In addition, the RA must be determined at three levels (0 to 20, 40 to 60, and 80 to 120 percent of the emission limit) for one of the metals which will be monitored, or for iron. If iron is chosen, the three levels should be chosen to correspond to those for one of the metals that will be monitored using known sensitivities (documented by the manufacturer) of the CEMS to both metals.

In order to correlate the CEMS and RM data properly, note the beginning and end of each RM test period of each run (including the exact time of day) in the CEMS data log. Use the following strategy for the RM measurements:

7.2 Correlation of RM and CEMS Data. Correlate the CEMS and RM test data as to the time and duration by first determining from the CEMS final output (the one used for reporting) the integrated average pollutant concentration for each RM test period. Consider system response time, if important, and confirm that the pair of results are on a consistent moisture, temperature, and diluent concentration basis. Then compare each integrated CEMS value against the corresponding average RM value.

7.3 Number of tests. Obtain a minimum of three pairs of CEMS and RM measurements for each metal required and at each level required (see Section 7.1). If more than nine pairs of measurements are obtained, then up to three pairs of measurements may be rejected so long as the total number of measurement pairs used to determine the RA is greater than or equal to nine. However, all data, including the rejected data, must be reported.

7.4 Reference Methods. Unless otherwise specified in an applicable subpart of the regulations, Method 3B, or its approved alternative, is the reference method for diluent (O_2) concentration. Unless otherwise specified in an applicable subpart of the regulations, the manual method for multi-metals in 40 CFR part 266, Appendix IX, Section 3.1 (until superseded by SW-846), or its approved alternative, is the reference method for multi-metals.

As of 3/22/95 there is no approved alternative RM (for example, a second metals CEMS, calibrated absolutely according to the alternate procedure to be specified in an appendix to this performance specification to be added when an absolute system calibration procedure becomes available and is approved) to Method 29.

7.5 Calculations. Summarize the results on a data sheet. An example is shown is shown in Figure 2-2 of 40 CFR part 60, Appendix B, Performance Specification 2. Calculate the mean of the RM values. Calculate the arithmetic differences between the RM and CEMS output sets, and then calculate the mean of the differences. Calculate the standard deviation of each data set and CEMS RA using the equations in Section 8.

7.6 Undetectable Emission Levels. In the event of metals emissions concentrations from the source being so low as to be undetectable by the CEMS operating in its normal mode (i.e., measurement times and frequencies within the bounds of the performance specifications), then spiking of the appropriate metals in the feed or other operation of the facility in such a way as to raise the metal concentration to a level detectable by both the CEMS and the RM is required in order to perform the RA test.

8. *Equations*

8.1 Arithmetic Mean. Calculate the arithmetic mean of a data set as follows:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \, , \tag{3}$$

where n is equal to the number of data points.

8.1.1 Calculate the arithmetic mean of the difference, d, of a data set, using Equation 3 and substituting d for x. Then

$$d_i = x_i - y_i \, , \tag{4}$$

where x and y are paired data points from the CEMS and RM, respectively.

8.2 Standard Deviation. Calculate the standard deviation (SD) of a data set as follows:

$$SD = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2}{n - 1}} \, , \tag{5}$$

8.3 Relative Accuracy (RA). Calculate the RA as follows:

$$RA = \frac{\bar{d} + \frac{t_{0.975}}{\sqrt{n}}(SD)}{\bar{R}_{RM}} \, , \tag{6}$$

where $\bar{d}$ is equal to the arithmetic mean of the difference, d, of the paired CEMS and RM data set, calculated according to Equations 3 and 4, SD is the standard deviation calculated according to Equation 5, $\overline{R}_{RM}$ is equal to either the average of the RM data set, calculated according to Equation 3, or the value of the emission standard, as applicable (see Section 4.2), and $t_{0.975}$ is the t-value at 2.5 percent error confidence, see Table 1.

TABLE 1

t-Values

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

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

9. *Reporting*

At a minimum (check with the appropriate regional office, or State, or local agency for additional requirements, if any) summarize in tabular form the results of the CD tests and the RA tests or alternate RA procedure as appropriate. Include all data sheets, calculations, and records of CEMS response necessary to substantiate that the performance of the CEMS met the performance specifications.

The CEMS measurements shall be reported to the agency in units of $\mu g/m^3$ on a dry basis, corrected to 20°C and 7 percent O_2.

10. *Alternative Procedures*

A procedure for a total system calibration, when developed, will be acceptable as a procedure for determining RA. Such a procedure will involve challenging the entire CEMS, including the sampling interface, with a known metals concentration. This procedure will be added as an appendix to this performance specification when it has been developed and approved. The RA requirement of Section 4.2 will remain unchanged.

11. *Bibliography*

1. 40 CFR part 60, Appendix B, "Performance Specification 2 - Specifications and Test Procedures for SO_2 and NO_x Continuous Emission Monitoring Systems in Stationary Sources."

2. 40 CFR part 60, Appendix B, "Performance Specification 1 - Specification and Test Procedures for Opacity Continuous Emission Monitoring Systems in Stationary Sources."

3. 40 CFR part 60, Appendix A, "Method 1 - Sample and Velocity Traverses for

Stationary Sources."

4. 40 CFR part 266, Appendix IX, Section 2, "Performance Specifications for Continuous Emission Monitoring Systems."

5. Draft Method 29, "Determination of Metals Emissions from Stationary Sources," Docket A-90-45, Item II-B-12, and EMTIC CTM-012.WPF.

6. "Continuous Emission Monitoring Technology Survey for Incinerators, Boilers, and Industrial Furnaces: Final Report for Metals CEM's," prepared for the Office of Solid Waste, U.S. EPA, Contract No. 68-D2-0164 (4/25/94).

APPENDIX F

PERFORMANCE SPECIFICATION FOR O_2 AND CO CEMS

PERFORMANCE SPECIFICATION 4B - - Specifications and test procedures for carbon monoxide and oxygen continuous monitoring systems in stationary sources

1. *Applicability and Principle*

1.1 Applicability. This specification is to be used for evaluating the acceptability of carbon monoxide (CO) and oxygen (O_2) continuous emission monitoring systems (CEMS) at the time of or soon after installation and whenever specified in the regulations. The CEMS may include, for certain stationary sources, a) flow monitoring equipment to allow measurement of the dry volume of stack effluent sampled, and b) an automatic sampling system.

This specification is not designed to evaluate the installed CEMS' performance over an extended period of time nor does it identify specific calibration techniques and auxiliary procedures to assess the CEMS' performance. The source owner or operator, however, is responsible to properly calibrate, maintain, and operate the CEMS. To evaluate the CEMS' performance, the Administrator may require, under Section 114 of the Act, the operator to conduct CEMS performance evaluations at other times besides the initial test.

The definitions, installation and measurement location specifications, test procedures, data reduction procedures, reporting requirements, and bibliography are the same as in PS 3 (for O_2) and PS 4A (for CO) except as otherwise noted below.

1.2 Principle. Installation and measurement location specifications, performance specifications, test procedures, and data reduction procedures are included in this specification. Reference method tests, calibration error tests, and calibration drift tests, and interferant tests are conducted to determine conformance of the CEMS with the specification.

2. *Definitions*

2.1 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.

2.2 Response Time. The time interval between the start of a step change in the system input and the time when the pollutant analyzer output reaches 95 percent of the final value.

2.3 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.

3. *Installation and Measurement Location Specifications*

3.1 The CEMS Installation and Measurement Location. This specification is the same as PS 2 Section 3.1 with the following additions. Both the CO and O_2 monitors should be installed at the same general location. If this is not possible, they may be installed at different locations if the effluent gases at both sample locations are not stratified and there is no in-leakage of air between sampling locations.

3.1.1 Measurement Location. Same as PS 2 Section 3.1.1.

3.1.2 Point CEMS. The measurement point should be within or centrally located over the centroidal area of the stack or duct cross section.

3.1.3 Path CEMS. The effective measurement path should be (1) have at least 70 percent of the path within the inner 50 percent of the stack or duct cross sectional area, or (2) be centrally located over any part of the centroidal area.

3.2 Reference Method (RM) Measurement Location and Traverse Points. This specification is the same as PS 2 Section 3.2 with the following additions. When pollutant concentrations changes are due solely to diluent leakage and CO and O_2 are simultaneously measured at the same location, one half diameter may be used in place of two equivalent diameters.

3.3 Stratification Test Procedure. Stratification is defined as the difference in excess of 10 percent between the average concentration in the duct or stack and the concentration at any point more than 1.0 meter from the duct or stack wall. To determine whether effluent stratification exists, a dual probe system should be used to determine the average effluent concentration while measurements at each traverse point are being made. One probe, located at the stack or duct centroid, is used as a stationary reference point to indicate change in the effluent concentration over time. The second probe is used for sampling at the traverse points specified in method 1, appendix A, 40 CFR part 60. The monitoring system samples sequentially at the reference and traverse points throughout the testing period for five minutes at each point.

4. *Performance and Equipment Specifications*

4.1 Data Recorder Scale. For O_2, same as specified in PS 3, except that the span shall be 25%. The span of the O_2 may be higher if the O_2 concentration at the sampling point can be greater than 25%. For CO, same as specified in PS 4A, except that the low-range span shall be 200 ppm and the high range span shall be 3000 ppm. In addition, the scale for both CEMS must record all readings within a measurement range with a resolution of 0.5 percent.

4.2 Calibration Drift. For O_2, same as specified in PS 3. For CO, the same as specified in PS 4A except that the CEMS calibration must not drift from the reference value of the calibration standard by more than 3 percent of the span value on either the high or low range.

4.3 Relative Accuracy (RA). For O_2, same as specified in PS 3. For CO, the same as specified in PS 4A.

4.4 Calibration Error (CE). The mean difference between the CEMS and reference values at all three test points (see Table I) must be no greater than 5 percent of span value for CO monitors and 0.5 percent for O_2 monitors.

4.5 Response Time. The response time for the CO or O_2 monitor shall not exceed 2 minutes.

5. *Performance Specification Test Procedure*

5.1 Calibration Error Test and Response Time Test Periods. Conduct the CE and response time tests during the CD test period.

6.0 *The CEMS Calibration Drift and Response Time Test Procedures*

The response time test procedure is given in PS 4A, and must be carried out for both the CO and O_2 monitors.

7. *Relative Accuracy and Calibration Error Test Procedures*

7.1 Calibration Error Test Procedure. Challenge each monitor (both low and high range CO and O_2) with zero gas and EPA Protocol 1 cylinder gases at three measurement points within the ranges specified in Table I.

TABLE I: Calibration Error Concentration Ranges

Measurement Point	CO Low Range (ppm)	CO High Range (ppm)	O_2 (%)
1	0-40	0-600	0-2
2	60-80	900-1200	8-10
3	140-160	2100-2400	14-16

Operate each monitor in its normal sampling mode as nearly as possible. The calibration gas shall be injected into the sample system as close to the sampling probe outlet as practical and should pass through all CEMS components used during normal sampling. Challenge the CEMS three non-consecutive times at each measurement point and record the responses. The duration of each gas injection should be sufficient to ensure that the CEMS surfaces are conditioned.

7.1.1 Calculations. Summarize the results on a data sheet. Average the differences between the instrument response and the certified cylinder gas value for each gas. Calculate the CE results according to:

$$CE = |d/FS| \ X \ 100 \tag{1}$$

where *d* is the mean difference between the CEMS response and the known reference concentration and *FS* is the span value.

7.2 Relative Accuracy Test Procedure. Follow the RA test procedures in PS 3 (for O2) section 3 and PS 4A (for CO) section 4.

7.3 Alternative RA Procedure. Under some operating conditions, it may not be possible to obtain meaningful results using the RA test procedure. This includes conditions where consistent, very low CO emission or low CO emissions interrupted periodically by short duration, high level spikes are observed. It may be appropriate in these circumstances to waive the RA test and substitute the following procedure.

Conduct a complete CEMS status check following the manufacturer's written instructions. The check should include operation of the light source, signal receiver, timing mechanism functions, data acquisition and data reduction functions, data recorders, mechanically operated functions, sample filters, sample line heaters, moisture traps, and other related functions of the CEMS, as applicable. All parts of the CEMS must be functioning properly before the RA requirement can be waived. The instrument must also successfully passed the CE and CD specifications. Substitution of the alternate procedure requires approval of the Regional Administrator.

8. *Bibliography*

1. 40 CFR Part 266, Appendix IX, Section 2, "Performance Specifications for Continuous Emission Monitoring Systems."

APPENDIX G

PERFORMANCE SPECIFICATION FOR TOTAL HYDROCARBON CEMS

PERFORMANCE SPECIFICATION 8A - - Specifications and test procedures for total hydrocarbon continuous monitoring systems in hazardous waste burning stationary sources

1. Applicability and Principle

1.1 Applicability. These performance specifications apply to hydrocarbon (HC) continuous emission monitoring systems (CEMSs) installed on hazardous waste burning stationary sources. The specifications include procedures which are intended to be used to evaluate the acceptability of the CEMS at the time of its installation or whenever specified in regulations or permits. The procedures are not designed to evaluate CEMS performance over an extended period of time. The source owner or operator is responsible for the proper calibration, maintenance, and operation of the CEMS at all times.

1.2 Principle. A gas sample is extracted from the source through a heated sample line and heated filter to a flame ionization detector (FID). Results are reported as volume concentration equivalents of propane. Installation and measurement location specifications, performance and equipment specifications, test and data reduction procedures, and brief quality assurance guidelines are included in the specifications. Calibration drift, calibration error, and response time tests are conducted to determine conformance of the CEMS with the specifications.

2. Definitions

2.1 Continuous Emission Monitoring System (CEMS). The total equipment used to acquire data, which includes sample extraction and transport hardware, analyzer, data recording and processing hardware, and software. The system consists of the following major subsystems:

2.1.1 Sample Interface. That portion of the system that is used for one or more of the following: Sample acquisition, sample transportation, sample conditioning, or protection of the analyzer from the effects of the stack effluent.

2.1.2 Organic Analyzer. That portion of the system that senses organic concentration and generates an output proportional to the gas concentration.

2.1.3 Data Recorder. That portion of the system that records a permanent record of the measurement values. The data recorder may include automatic data reduction capabilities.

2.2 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.

2.3 Span or Span Value. Full scale instrument measurement range. The span value shall be documented by the CEMS manufacturer with laboratory data.

2.4 Calibration Gas. A known concentration of a gas in an appropriate diluent gas.

2.5 Calibration Drift (CD). The difference in the CEMS output readings from the established reference value after a stated period of operation during which no unscheduled maintenance, repair, or adjustment takes place. A CD test is performed to demonstrate the stability of the CEMS calibration over time.

2.6 Response Time. The time interval between the start of a step change in the system input (e.g., change of calibration gas) and the time when the data recorder displays 95 percent of the final value.

2.7 Accuracy. A measurement of agreement between a measured value and an accepted or true value, expressed as the percentage difference between the true and measured values relative to the true value. For these performance specifications, accuracy is checked by conducting a calibration error (CE) test.

2.8 Calibration Error (CE). The difference between the concentration indicated by the CEMS and the known concentration of the cylinder gas. A CE test procedure is performed to document the accuracy and linearity of the monitoring equipment over the entire measurement range.

2.9 Performance Specification Test (PST) Period. The period during which CD, CE, and response time tests are conducted.

2.10 Centroidal Area. A concentric area that is geometrically similar to the stack or duct cross section and is no greater than 1 percent of the stack or duct cross-sectional area.

3. Installation and Measurement Location Specifications

3.1 CEMS Installation and Measurement Locations. The CEMS shall be installed in a location in which measurements representative of the source's emissions can be obtained. The optimum location of the sample interface for the CEMS is determined by a number of factors, including ease of access for calibration and maintenance, the degree to which sample conditioning will be required, the degree to which it represents total emissions, and the degree to which it represents the combustion situation in the firebox. The location should be as free from in-leakage influences as possible and reasonably free from severe flow disturbances. The sample location should be at least two equivalent duct diameters downstream from the nearest control device, point of pollutant generation, or other point at which a change in the pollutant concentration or emission rate occurs and at least 0.5 diameter upstream from the exhaust or control device. The equivalent duct diameter is calculated as per 40 CFR part 60, appendix A, method 1, section 2.1. If these criteria are not achievable or if the location is otherwise less than optimum, the possibility of stratification should be investigated as described in section 3.2. The measurement point shall be within the centroidal area of the stack or duct cross section.

3.2 Stratification Test Procedure. Stratification is defined as a difference in excess of 10 percent between the average concentration in the duct or stack and the concentration at any point more than 1.0 meter from the duct or stack wall. To determine whether effluent stratification exists, a dual probe system should be used to determine the average effluent concentration while measurements at each traverse point are being made. One probe, located at the stack or duct centroid, is used as a stationary reference point to indicate the change in effluent concentration over time. The second probe is used for sampling at the traverse points specified in 40 CFR part 60 appendix A, method 1. The monitoring system samples sequentially at the reference and traverse points throughout the testing period for five minutes at each point.

4. CEMS Performance and Equipment Specifications

If this method is applied in highly explosive areas, caution and care shall be exercised in choice of equipment and installation.

4.1 Flame Ionization Detector (FID) Analyzer. A heated FID analyzer capable of meeting or exceeding the requirements of these specifications. Heated systems shall maintain the temperature of the sample gas between 150 °C (300 °F) and 175 °C (350 °F) throughout the system. This requires all system components such as the probe, calibration valve, filter, sample lines, pump, and the FID to be kept heated at all times such that no moisture is condensed out of the system. The essential components of the measurement system are described below:

4.1.1 Sample Probe. Stainless steel, or equivalent, to collect a gas sample from the centroidal area of the stack cross-section.

4.1.2 Sample Line. Stainless steel or Teflon tubing to transport the sample to the analyzer.

Note: Mention of trade names or specific products does not constitute endorsement by the Environmental Protection Agency.

4.1.3 Calibration Valve Assembly. A heated three-way valve assembly to direct the zero and calibration gases to the analyzer is recommended. Other methods, such as quick-connect lines, to route calibration gas to the analyzers are applicable.

4.1.4 Particulate Filter. An in-stack or out-of-stack sintered stainless steel filter is recommended if exhaust gas particulate loading is significant. An out-of-stack filter must be heated.

4.1.5 Fuel. The fuel specified by the manufacturer (e.g., 40 percent hydrogen/60 percent helium, 40 percent hydrogen/60 percent nitrogen gas mixtures, or pure hydrogen) should be used.

4.1.6 Zero Gas. High purity air with less than 0.1 parts per million by volume (ppm) HC as methane or carbon equivalent or less than 0.1 percent of the span value, whichever is greater.

4.1.7 Calibration Gases. Appropriate concentrations of propane gas (in air or nitrogen). Preparation of the calibration gases should be done according to the procedures in EPA Protocol 1. In addition, the manufacturer of the cylinder gas should provide a recommended shelf life for each calibration gas cylinder over which the concentration does not change by more than ±2 percent from the certified value.

4.2 CEMS Span Value. 100 ppm propane.

4.3 Daily Calibration Gas Values. The owner or operator must choose calibration gas concentrations that include zero and high-level calibration values.

4.3.1 The zero level may be between zero and 0.1 ppm (zero and 0.1 percent of the span value).

4.3.2 The high-level concentration shall be between 50 and 90 ppm (50 and 90 percent of the span value).

4.4 Data Recorder Scale. The strip chart recorder, computer, or digital recorder must be capable of recording all readings within the CEMS's measurement range and shall have a resolution of 0.5 ppm (0.5 percent of span value).

4.5 Response Time. The response time for the CEMS must not exceed 2 minutes to achieve 95 percent of the final stable value.

4.6 Calibration Drift. The CEMS must allow the determination of CD at the zero and high-level values. The CEMS calibration response must not differ by more than ±3 ppm (±3 percent of the span value) after each 24-hour period of the 7-day test at both zero and high levels. 4.7 Calibration Error. The mean difference between the CEMS and reference values at all three test points listed below shall be no greater than 5 ppm (±5 percent of the span value).

4.7.1 Zero Level. Zero to 0.1 ppm (0 to 0.1 percent of span value).

4.7.2 Mid-Level. 30 to 40 ppm (30 to 40 percent of span value).

4.7.3 High-Level. 70 to 80 ppm (70 to 80 percent of span value).

4.8 Measurement and Recording Frequency. The sample to be analyzed shall pass through the measurement section of the analyzer without interruption. The detector shall measure the sample concentration at least once every 15 seconds. An average emission rate shall be computed and recorded at least once every 60 seconds.

4.9 Hourly Rolling Average Calculation. The CEMS shall calculate every minute an hourly rolling average, which is the arithmetic mean of the 60 most recent 1-minute average values.

4.10 Retest. If the CEMS produces results within the specified criteria, the test is successful. If the CEMS does not meet one or more of the criteria, necessary corrections must be made and the performance tests repeated.

5. Performance Specification Test (PST) Periods

5.1 Pretest Preparation Period. Install the CEMS, prepare the PTM test site according to the specifications in section 3, and prepare the CEMS for operation and calibration according to the manufacturer's written instructions. A pretest conditioning period similar to that of the 7-day CD test is recommended to verify the operational status of the CEMS.

5.2 Calibration Drift Test Period. While the facility is operating under normal conditions, determine the magnitude of the CD at 24-hour intervals for seven consecutive days according to the procedure given in section 6.1. All CD determinations must be made following a 24-hour period during which no unscheduled maintenance, repair, or adjustment takes place. If the combustion unit is taken out of service during the test period, record the onset and duration of the downtime and continue the CD test when the unit resumes operation.

5.3 Calibration Error Test and Response Time Test Periods. Conduct the CE and response time tests during the CD test period.

6. Performance Specification Test Procedures

6.1 Relative Accuracy Test Audit (RATA) and Absolute Calibration Audits (ACA). The test procedures described in this section are in lieu of a RATA and ACA.

6.2 Calibration Drift Test.

6.2.1 Sampling Strategy. Conduct the CD test at 24-hour intervals for seven consecutive days using calibration gases at the two daily concentration levels specified in section 4.3. Introduce the two calibration gases into the sampling system as close to the sampling probe outlet as practical. The gas shall pass through all CEM components used during normal sampling. If periodic automatic or manual adjustments are made to the CEMS zero and calibration settings, conduct the CD test immediately before these adjustments, or conduct it in such a way that the CD can be determined. Record the CEMS response and subtract this value from the reference (calibration gas) value. To meet the specification, none of the differences shall exceed 3 percent of the span of the CEM.

6.2.2 Calculations. Summarize the results on a data sheet. An example is shown in Figure 1. Calculate the differences between the CEMS responses and the reference values.

6.3 Response Time. The entire system including sample extraction and transport, sample conditioning, gas analyses, and the data recording is checked with this procedure.

6.3.1 Introduce the calibration gases at the probe as near to the sample location as possible. Introduce the zero gas into the system. When the system output has stabilized (no change greater than 1 percent of full scale for 30 sec), switch to monitor stack effluent and wait for a stable value. Record the time (upscale response time) required to reach 95 percent of the final stable value.

6.3.2 Next, introduce a high-level calibration gas and repeat the above procedure. Repeat the entire procedure three times and determine the mean upscale and downscale response times. The longer of the two means is the system response time.

6.4 Calibration Error Test Procedure.

6.4.1 Sampling Strategy. Challenge the CEMS with zero gas and EPA Protocol 1 cylinder gases at measurement points within the ranges specified in section 4.7.

6.4.1.1 The daily calibration gases, if Protocol 1, may be used for this test.

SOURCE:	DATE:
MONITOR:	LOCATION:
SERIAL NUMBER:	SPAN:

	DAY	DATE	TIME	CALIBRATION VALUE	MONITOR RESPONSE	DIFFERENCE	PERCENT OF SPAN (1/)
ZERO / LOW LEVEL	1						
	2						
	3						
	4						
	5						
	6						
	7						
HIGH LEVEL	1						
	2						
	3						
	4						
	5						
	6						
	7						

1/ = Acceptance Criteria: ≤ 3% of span each day for seven days.

FIGURE 1: Calibration Drift Determination

6.4.1.2 Operate the CEMS as nearly as possible in its normal sampling mode. The calibration gas should be injected into the sampling system as close to the sampling probe outlet as practical and shall pass through all filters, scrubbers, conditioners, and other monitor components used during normal sampling. Challenge the CEMS three non-consecutive times at each measurement point and record the responses. The duration of each gas injection should be for a sufficient period of time to ensure that the CEMS surfaces are conditioned.

6.4.2 Calculations. Summarize the results on a data sheet. An example data sheet is shown in Figure 2. Average the differences between the instrument response and the certified cylinder gas value for each gas. Calculate three CE results according to Equation 1. No confidence coefficient is used in CE calculations.

7. Equations

7.1 Calibration Error. Calculate CE using Equation 1.

$$CE = |d/FS| \times 100 \qquad \textbf{(Eq. 1)}$$

where:

d = Mean difference between CEMS response and the known reference concentration, determined using Equation 2.

$$d = \frac{1}{n}\sum_{i=1}^{n} d_i \qquad \textbf{(Eq. 2)}$$

d_i = Individual difference between CEMS response and the known reference concentration.

8. Reporting

At a minimum, summarize in tabular form the results of the CD, response time, and CE test, as appropriate. Include all data sheets, calculations, CEMS data records, and cylinder gas or reference material certifications.

SOURCE:	DATE:
MONITOR:	LOCATION:
SERIAL NUMBER:	SPAN:

RUN NUMBER	CALIBRATION VALUE	MONITOR RESPONSE	DIFFERENCE		
			Zero/Low	Mid	High
1 - Zero				▨	▨
2 - Mid			▨		▨
3 - High			▨	▨	
4 - Mid			▨		▨
5 - Zero				▨	▨
6 - High			▨	▨	
7 - Zero				▨	▨
8 - Mid			▨		▨
9 - High			▨	▨	
		Mean Difference =			
		Calibration Error =	%	%	%

FIGURE 2: Calibration Error Determination

9. References

1. Measurement of Volatile Organic Compounds-Guideline Series. U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 27711, EPA-450/2-78-041, June 1978.

2. Traceability Protocol for Establishing True Concentrations of Gases Used for Calibration and Audits of Continuous Source Emission Monitors (Protocol No. 1). U.S. Environmental Protection Agency ORD/EMSL, Research Triangle Park, North Carolina, 27711, June 1978.

3. Gasoline Vapor Emission Laboratory Evaluation-Part 2. U.S. Environmental Protection Agency, OAQPS, Research Triangle Park, North Carolina, 27711, EMB Report No. 76-GAS-6, August 1975.

APPENDIX H

DATA QUALITY ASSURANCE REQUIREMENTS

APPENDIX J--Quality Assurance Procedures for Continuous Emissions Monitors Used for Hazardous Waste Combustors

1. *Applicability and Principle*

1.1 Applicability. These quality assurance requirements are used to evaluate the effectiveness of quality control (QC) and quality assurance (QA) procedures and the quality of data produced by continuous emission monitoring systems (CEMS) that are used for determining compliance with the emission standards on a continuous basis as specified in the applicable regulation. The QA procedures specified by these requirements represent the minimum requirements necessary for the control and assessment of the quality of CEMS data used to demonstrate compliance with the emission standards provided under subpart X, part 63, of this chapter. Owners and operators must meet these minimum requirements and are encouraged to develop and implement a more extensive QA program. These requirements supersede those found in Appendix F of this Part. Appendix F does not apply to hazardous waste burning devices.

Data collected as a result of the required QA and QC measures are to be recorded in the operating record. In addition, data collected as a result of CEM performance evaluations required by Section 5 in conjunction with an emissions performance test are to be submitted to the Director as provided by §63.8(e)(5) of this chapter. These data are to be used by both the Agency and the CEMS operator in assessing the effectiveness of the CEMS QA and QC procedures in the maintenance of acceptable CEMS operation and valid emission data.

1.2 Principle. The QA procedures consist of two distinct and equally important functions. One function is the assessment of the quality of the CEMS data by estimating accuracy. The other function is the control and improvement of the quality of the CEMS data by implementing QC policies and corrective actions. These two functions form a control loop. When the assessment function indicates that the data quality is inadequate, the source must immediately stop burning hazardous waste. The CEM data control effort must be increased until the data quality is acceptable before hazardous waste burning can resume.

In order to provide uniformity in the assessment and reporting of data quality, this procedure explicitly specifies the assessment methods for response drift and accuracy. The methods are based on procedures included in the applicable performance specifications provided in Appendix B. These procedures also require the analysis of the EPA audit samples concurrent with certain reference method (RM) analyses as specified in the applicable RM's.

Because the control and corrective action function encompasses a variety of policies, specifications, standards, and corrective measures, this procedure treats QC requirements in general terms to allow each source owner or operator to develop a QC system that is most effective and efficient for the circumstances.

2. *Definitions*

2.1 Continuous Emission Monitoring System (CEMS). The total equipment required for the determination of a pollutant concentration. The system consists of the following major subsystems:

2.1.1 Sample Interface. That portion of the CEMS used for one or more of the following: sample acquisition, sample transport, and sample conditioning, or protection of the monitor from the effects of the stack effluent.

2.1.2 Pollutant Analyzer. That portion of the CEMS that senses the pollutant concentration and generates a proportional output.

2.1.3 Diluent Analyzer. That portion of the CEMS that senses the diluent gas (O_2) and generates an output proportional to the gas concentration.

2.1.4 Data Recorder. That portion of the CEMS that provides a permanent record of the analyzer output. The data recorder may provide automatic data reduction and CEMS control capabilities.

2.2 Relative Accuracy (RA). The absolute mean difference between the pollutant concentration determined by the CEMS and the value determined by the reference method (RM) plus the 2.5 percent error confidence coefficient of a series of test divided by the mean of the RM tests or the applicable emission limit.

2.3 Calibration Drift (CD). The difference in the CEMS output readings from the established reference value after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.4 Zero Drift (ZD). The difference in CEMS output readings at the zero pollutant level after a stated period of operation during which no unscheduled maintenance, repair, or adjustment took place.

2.5 Tolerance Interval. The interval with upper and lower limits within which are contained a specified percentage of the population with a given level of confidence.

2.6 Calibration Standard. Calibration standards produce a known and unchanging response when presented to the pollutant analyzer portion of the CEMS, and are used to calibrate the drift or response of the analyzer.

2.7 Relative Accuracy Test Audit (RATA). Comparison of CEMS measurements to reference method measurements in order to evaluate relative accuracy following procedures and specification given in the appropriate performance specification.

2.8 Absolute Calibration Audit (ACA). Equivalent to calibration error (CE) test defined in the appropriate performance specification using NIST traceable calibration standards to challenge the CEMS and assess accuracy.

2.9 Response Calibration Audit (RCA). For PM CEMS only, a check of stability of the calibration relationship determined by comparison of CEMS response to manual gravimetric measurements.

2.10 Fuel Type. For the purposes of PM CEMs, fuel type is defined as the physical state of the fuel: gas, liquid, or solid.

2.11 Rolling Average. The average emissions, based on some (specified) time period, calculated every minute from a one-minute average of four measurements taken at 15-second intervals.

3. *QA/QC Requirements*

3.1 QC Requirements. Each owner or operator must develop and implement a QC program. At a minimum, each QC program must include written procedures describing in detail complete, step-by-step procedures and operations for the following activities.

1. Checks for component failures, leaks, and other abnormal conditions.
2. Calibration of CEMS.
3. CD determination and adjustment of CEMS.
4. Integration of CEMs with the automatic waste feed cutoff (AWFCO) system
5. Preventive Maintenance of CEMS (including spare parts inventory).
6. Data recording, calculations, and reporting.
7. Checks of record keeping.
8. Accuracy audit procedures, including sampling and analysis methods.
9. Program of corrective action for malfunctioning CEMS.
10. Operator training and certification.
11. Maintaining and ensuring current certification or naming of cylinder gasses, metal solutions, and particulate samples used for audit and accuracy tests, daily checks, and calibrations.

Whenever excessive inaccuracies occur for two consecutive quarters, the current written procedures must be revised or the CEMS modified or replaced to correct the deficiency causing the excessive inaccuracies. These written procedures must be kept on record and available for inspection by the enforcement agency.

3.2 QA Requirements. Each source owner or operator must develop and implement a QA plan that includes, at a minimum, the following.

1. QA responsibilities (including maintaining records, preparing reports, reviewing reports).
2. Schedules for the daily checks, periodic audits, and preventive maintenance.
3. Check lists and data sheets.
4. Preventive maintenance procedures.
5. Description of the media, format, and location of all records and reports.
6. Provisions for a review of the CEMS data at least once a year. Based on the results of the review, the owner or operator shall revise or update the QA plan, if necessary.

4. *CD and ZD Assessment and Daily System Audit*

4.1 CD and ZD Requirement. Owners and operators must check, record, and quantify the ZD and the CD at least once daily (approximately 24 hours) in accordance with the method prescribed by the manufacturer. The CEMS calibration must, at a minimum, be adjusted whenever the daily ZD or CD exceeds the limits in the Performance Specifications. If, on any given ZD and/pr CD check the ZD and/or CD exceeds two times the limits in the Performance Specifications, or if the cummulative adjustment to the ZD and/or CD (see Section 4.2) exceed(s) three times the limits in the Performance Specifications, hazardous waste burning must immediately cease and the CEM must be serviced and recalibrated. Hazardous waste burning cannot resume until the owner or operator documents that the CEM is in compliance with the Performance Specifications.

4.2 Recording Requirements for Automatic ZD and CD Adjusting Monitors. Monitors that automatically adjust the data to the corrected calibration values must record the unadjusted concentration measurement prior to resetting the calibration, if performed, or record the amount of the adjustment.

4.3 Daily System Audit. The audit must include a review of the calibration check data, an inspection of the recording system, an inspection of the control panel warning lights, and an inspection of the sample transport and interface system (e.g., flowmeters, filters, etc.) as appropriate.

4.4 Data Recording and Reporting. All measurements from the CEMS must be retained in the operating record for at least 5 years.

5. Performance Evaluation

5.1 Multi-Metals CEMS. The CEMS must be audited at least once each calendar year. In years when a performance test is also required under §63.568 of this chapter to document compliance with emission standards, the performance evaluation (i.e., audit) shall coincide with the performance test. Successive yearly audits shall be at least 9 months apart. The audits shall be conducted as follows.

5.1.1 Relative Accuracy Test Audit (RATA). The RATA must be conducted at least once every three years (five years for small on-site facilities defined in §63.568(b)(1)(ii)). Conduct the RATA as described in the RA test procedure (or alternate procedures section) described in the applicable Performance Specifications. In addition, analyze the appropriate performance audit samples received from the EPA as described in the applicable sampling methods (i.e., SW-846 method 0060).

5.1.2 Absolute Calibration Audit (ACA). The ACA must be conducted at least once each year except when a RATA is conducted instead. Conduct an ACA using NIST traceable calibration standards at three levels for each metal that is being monitored for compliance purposes. The levels must correspond to 0 to 20, 40 to 60, and 80 to 120 percent of the applicable emission limit for each metal. (For the SVM and LVM standards where the standard applies to combined emissions of several metals, the average annual emission concentration for each individual metal in a group for which a standard applies should be assumed by projecting emissions based on feedrate estimates determined from the waste management plan required under §63.___ of this chapter. The estimated average annual emission concentration should be used as a surrogate metal emission limit for purposes of the ACA.) At each level and for each metal, make nine determinations of the RA as defined in Section 8 of the applicable Performance Specifications using the value of the calibration standard in the denominator of Equation (6).

5.1.3 Reference method. The reference method is SW-846 method 0060.

5.1.4 Excessive Audit Inaccuracy. If the RA using the RATA or ACA exceeds the criteria in Section 4.2 of the Performance Specifications, hazardous waste burning must immediately cease. Before hazardous waste burning can resume, the owner or operator must take necessary corrective action to eliminate the problem, and must audit the CEMS with a RATA to document that the CEMS is operating within the specifications.

5.2 Particulate Matter CEMS. The CEMS must be audited at least once each quarter (three calendar months.) A response calibration audit (RCA) shall be conducted every 18 months. An absolute calibration audit (ACA) shall be conducted quarterly, except when an RCA is conducted instead. The audits shall be conducted as follows.

5.2.1 Response Calibration Audit (RCA). The RCA must be conducted at least every 18 months (30 months for small on-site facilities defined in §63.568(b)(1)(ii)). Conduct the RCA as described in the CEMS Response Calibration Procedure described in the applicable Performance Specifications (Sections 5 and 7). A minimum of nine tests are required at three particulate levels. The three particulate levels should be at the high-end, low-end, and midpoint of the particulate range spanned by the current calibration of the CEMS.

5.2.2 Absolute Calibration Audit (ACA). The ACA must be conducted at least quarterly, except when an RCA is conducted instead. Conduct an ACA using NIST traceable calibration standards, making three measurements at three levels (nine measurements total). The levels must correspond to 10 to 50 percent, 80 to 120 percent, and 200 to 300 percent of the emission limit. At each level make a determination of the instrument response and compare it to the nominal response by calculating the calibration error CE:

$$CE = \frac{\left(R_{CEM} - R_N\right)}{R_{EM}} \; X \; 100$$

where R_{CEM} is the CEMS response, R_N is the nominal response generated by the calibration standard, and R_{EM} is the emission limit value.

5.2.3 Excessive Audit Inaccuracy.

5.2.3.1 RCA. If less than 75% percent of the test results from the RCA fall within the tolerance interval established for the current calibration (see Sections 7 and 8 of the Performance Specifications), then a new calibration relation is required. Hazardous waste burning must cease immediately, and may not be resumed until a new calibration relation is calculated from the RCA data according to the procedures specified in Section 8 of the Performance Specifications.

5.2.3.2 ACA. If the calibration error is greater than 2% of the emission limit for any of the calibration levels, hazardous waste burning must cease immediately. If adjustments to the instrument reduce the calibration error to less than 2% of the emission limit at all three levels, then hazardous waste burning can resume. If not, the instrument must be repaired and must pass a complete ACA before hazardous waste burning can resume.

5.2.4 Calibrating for Fuel Type. The owner or operator shall derive a sufficient number of calibration curves to use for all fuel type and mixtures of fuel type.

5.2.5 Reference Method. The reference method is Method 5 found in 40 CFR, Appendix A.

5.3 Total Mercury CEMS. An Absolute Calibration Audit (ACA) must be conducted quarterly, and a Relative Accuracy Test Audit (RATA) must be conducted every three years (five years for small on-site facilities defined in §63.568(b)(1)(ii)). An Interference Response Tests shall be performed whenever an ACA or a RATA is conducted. In years when a performance test is also required under §63.568 of this chapter to document compliance with emission standards, the RATA shall coincide with the performance test. The audits shall be conducted as follows.

5.3.1 Relative Accuracy Test Audit (RATA). The RATA must be conducted at least every three years (five years for small on-site facilities defined in §63.568(b)(1)(ii)). Conduct the RATA as described in the RA test procedure (or alternate procedures section) described in the applicable Performance Specifications. In addition, analyze the appropriate performance audit samples received from the EPA as described in the applicable sampling methods.

5.3.2 Absolute Calibration Audit (ACA). The ACA must be conducted at least quarterly except in a quarter when a RATA is conducted instead. Conduct an ACA as described in the calibration error (CE) test procedure described in the applicable Performance Specifications.

5.3.3 Interference Response Test. The interference response test shall be conducted whenever an ACA or RATA is conducted. Conduct an interference response test as described in the applicable Performance Specifications.

5.3.4 Excessive Audit Inaccuracy. If the RA from the RATA or the CE from the ACA exceeds the criteria in the applicable Performance Specifications, hazardous waste burning must cease immediately. Hazardous waste burning cannot resume until the owner or operator take corrective measures and audit the CEMS with a RATA to document that the CEMS is operating within the specifications.

5.3.4 Reference Methods. The reference method for mercury is SW-846 method 0060.

5.4 Hydrogen Chloride (HCl), Chlorine (Cl_2), Carbon Monoxide (CO), Oxygen (O_2), and Total Hydrocarbon (THC) CEMS. An Absolute Calibration Audit (ACA) must be conducted quarterly, and a Relative Accuracy Test Audit (RATA) (if applicable, see sections 5.4.1 and 5.4.2) must be conducted yearly. An Interference Response Tests shall be performed whenever an ACA or a RATA is conducted. In years when a performance test is also required under

§63.568 of this chapter to document compliance with emission standards, the RATA shall coincide with the performance test. The audits shall be conducted as follows.

5.4.1 Relative Accuracy Test Audit (RATA). This requirement applies to O_2 and CO CEMS. The RATA must be conducted at least yearly. Conduct the RATA as described in the RA test procedure (or alternate procedures section) described in the applicable Performance Specifications. In addition, analyze the appropriate performance audit samples received from the EPA as described in the applicable sampling methods.

5.4.2 Absolute Calibration Audit (ACA). This requirements applies to all CEMS listed in 5.4. The ACA must be conducted at least quarterly except in a quarter when a RATA (if applicable, see section 5.4.1) is conducted instead. Conduct an ACA as described in the calibration error (CE) test procedure described in the applicable Performance Specifications.

5.4.3 Interference Response Test. The interference response test shall be conducted whenever an ACA or RATA is conducted. Conduct an interference response test as described in the applicable Performance Specifications.

5.4.4 Excessive Audit Inaccuracy. If the RA from the RATA or the CE from the ACA exceeds the criteria in the applicable Performance Specifications, hazardous waste burning must cease immediately. Hazardous waste burning cannot resume until the owner or operator take corrective measures and audit the CEMS with a RATA to document that the CEMS is operating within the specifications.

6. Other Requirements

6.1 Performance Specifications. CEMS used by owners and operators of HWCs must comply with the following performance specifications in Appendix B:

Table I: Performance Specifications for CEMS

CEMS	Performance Specification
Carbon monoxide	4B
Oxygen	4B
Total hydrocarbons	8A
Mercury, semivolatile metals, and low volatile metals	10
Particulate matter	11
Mercury	12
Hydrochloric acid (hydrogen chloride)	13
Chlorine gas (diatomic chlorine)	14

6.2 Downtime due to Calibration. Facilities may continue to burn hazardous waste for a maximum of 20 minutes while calibrating the CEMS. If all CEMSs are calibrated at once, the facility shall have twenty minutes to calibrate all the CEMSs. If CEMSs are calibrated individually, the facility shall have twenty minutes to calibrate each CEMS. If the CEMSs are calibrated individually, other CEMSs shall be operational while the individual CEMS is being calibrated.

6.3 Span of the CEMS.

6.3.1 Multi-metals, Particulate Matter, Mercury, Hydrochloric Acid, and Chlorine Gas CEMSs. The span shall be at least 20 times the emission limit at an oxygen correction factor of 1.

6.3.2 CO CEMS. The CO CEM shall have two ranges, a low range with a span of 200 ppmv and a high range with a span of 3000 ppmv at an oxygen correction factor of 1. A one-range CEM may be used, but it must meet the performance specifications for the low range in the specified span of the low range.

6.3.3 O_2 CEMS. The O_2 CEM shall have a span of 25%. The span may be higher than 25% if the O_2 concentration at the sampling point is greater than 25%.

6.3.4 THC CEMS. The THC CEM shall have a span of 100 ppmv, expressed as propane, at an oxygen correction factor of 1.

6.3.5 CEMS Span Values When the Oxygen Correction Factor is Greater than 2. When a owner or operator installs a CEMS at a location of high ambient air dilution, i.e., where the maximum oxygen correction factor as determined by the permitting agency is greater than 2, the owner or operator shall install a CEM with a lower span(s), proportionate to the larger oxygen correction factor, than those specified above.

6.3.6 Use of Alternative Spans. Owner or operators may request approval to use alternative spans and ranges to those specified. Alternate spans must be approved in writing in advance by the Director. In considering approval of alternative spans and ranges, the Director will consider that measurements beyond the span will be recorded as values at the maximum span for purposes of calculating rolling averages.

6.4.1 Oxygen Correction Factor. Measured pollutant levels shall be corrected for the amount of oxygen in the stack according to the following formula:

$P_c = P_m \times 14/(E - Y)$

where:

P_c = concentration of the pollutant or standard corrected to 7% oxygen;

P_m = measured concentration of the pollutant;

E = volume fraction of oxygen in the combustion air fed into the device, on a dry basis (normally 21% or 0.21 if only air is fed);

Y = measured fraction of oxygen on a dry basis at the sampling point.

The oxygen correction factor is:

$OCF = 14/(E - Y)$

6.4.2 Moisture Correction. Method 4 of appendix A of this Part shall be used to determine moisture content of the stack gasses.

6.4.3 Temperature Correction. Correction values for temperature are obtainable from standard reference materials.

6.5 Rolling Average. A rolling average is the arithmetic average of all one-minute averages over the averaging period.

6.5.1 One-Minute Average. One-minute averages are the arithmetic average of the four most recent 15-second observations and shall be calculated using the following equation:

Where:

$\bar{c}$ = the one minute average

c_i = a fifteen-second observation from the CEM

Fifteen second observations shall not be rounded or smoothed. Fifteen-second observations may be disregarded only as a result of a failure in the CEMS and allowed in the source's quality assurance plan at the time of the CMS failure. One-minute averages shall not be rounded, smoothed, or disregarded.

6.5.2 Ten Minute Rolling Average Equation. The ten minute rolling average shall be calculated using the following equation:

$$C_{RA} = \sum_{i=1}^{10} \frac{\overline{c}_i}{10}$$

Where:

C_{RA} = The concentration of the standard, expressed as a rolling average

$\overline{c}_i$ = a one minute average

6.5.3 *n*-Hourly Rolling Average Equation. The rolling average, based on a specific number integer of hours, shall be calculated using the following equation:

$$C_{RA} = \sum_{i=1}^{60*N} \frac{\overline{c}_i}{60*N}$$

Where:

C_{RA} = The concentration of the standard, expressed as a rolling average

N = The number of hours of the rolling average

$\overline{c}_i$ = a one minute average

6.5.4 New rolling averages. When a rolling average begins due to the provisions of §6.5.4.2 of this appendix or when no previous one-minute average have been recorded, the rolling average shall be the average all one-minute averages since the rolling average commenced. Then when sufficient time has passed such that there are enough one-minute averages to calculate a rolling average specified in §6.5.2 or 6.5.3 of this appendix, i.e., when the period of time since the rolling average was started is equal to or greater than the averaging period, the average shall be calculated using the equation specified there.

6.5.4.1 Short term interruption of a rolling average. When rolling averages which are interrupted (such as for a calibration or failure of the CEMS), the rolling average shall be restarted with the one-minute averages prior to the interruption being the i = 1 to (60*N-1) values and the i = 60*N value being the one minute average immediately after the interruption. A short term interruption is one with a duration of less than the averaging period for the given standard or parameter.

6.5.4.2 Long term interruptions of the rolling average. When ten minute rolling averages are interrupted for periods greater than ten minutes, the rolling average shall be restarted as provided in §6.5.4 of this appendix. When rolling averages with averaging periods in excess of the averaging period for the given standard or parameter, the rolling average shall be restarted as provided in §6.5.4 of this appendix.

6.6 Units of the Standards for the Purposes of Recording and Reporting Emissions. Emissions shall be recorded and reported expressed after correcting for oxygen, temperature, and (where appropriate) moisture. Emissions shall be reported in metric, but may also be reported in the English system of units, at 7% oxygen, 20°C, and on a dry basis, except that THC emissions shall be reported on a wet basis.

6.7 Rounding and Significant Figures. Emissions shall be rounded to two significant figures using ASTM procedure E-29-90 or its successor. Rounding shall be avoided prior to rounding for the reported value.

7. *Bibliography*

1. 40 CFR Part 60, Appendix F, "Quality Assurance Procedures: Procedure 1. Quality Assurance Requirements for Gas Continuous Emission Monitoring Systems Used For Compliance Determination".