CONTINUOUS MONITORING MANUAL

DEPARTMENT OF ENVIRONMENTAL QUALITY
AIR QUALITY DIVISION
811 SW SIXTH AVENUE
Portland, Oregon 97204

January 23, 1992

Continuous Monitoring Manual
Table of Contents

APPENDICES:

1.0 INTRODUCTION

Continuous Monitoring Systems (CMS) are required to be installed in facilities specified by Oregon Department of Environmental Quality (DEQ) Air Contaminant Discharge Permits (ACDP), Oregon Administrative rules (OAR), and Federal Environmental Protection Agency (EPA) New Source Performance Standards (NSPS-40 CFR Part 60). The CMS are used to continuously monitor the effectiveness of air pollution control techniques and to determine if source control requirements are being met.

This manual has been prepared to specify the requirements for CMS operation, reporting, and quality assurance/quality control (QA/QC). For the purposes of this manual, continuous monitoring system is defined as the total equipment (sample interface, analyzer, and data recording) required for determining emissions and/or operating parameters. There are three basic categories of CMS. These are continuous opacity monitoring systems (COMS), continuous emission monitoring systems (CEMS), and continuous parameter monitoring systems (CPMS). The CMS may be required for continuously monitoring compliance with a specific pollutant emission limit or may be required to monitor compliance with source and pollution control device operating limits.

Effective January 23, 1992, this manual supercedes any previously existing continuous monitoring manual, draft or otherwise, provided by the DEQ.

2.0 DEFINITIONS

A. "Calibration gas" means any gas containing a known concentration of pollutant and traceable to the National Institute of Standards and Technology (NIST) - standard reference materials (SRM), Environmental Protection Agency (EPA) - certified reference material (CRM), or certified according to EPA Protocol - 1.

B. "Continuous Emissions Monitoring System (CEMS)" means a CMS used for measuring and recording gaseous pollutant emissions (i.e. SO_2, NO_x, CO, etc.).

C. "Continuous Monitoring System (CMS)" means the total equipment required for measuring and recording an emission and/or operating parameter at a source.

D. "Continuous Opacity Monitoring System (COMS)" means a CMS used for measuring and recording visible emissions.

E. "Continuous Parameter Monitoring System (CPMS)" means a CMS

used for measuring and recording the operating conditions of a source or pollution control device (i.e. steam pressure, scrubber pressure drop, temperatures, etc.).

F. "Monitor" means the analyzer component of the CMS (i.e. CO analyzer, transducer, etc.)

G. "Out-of-control" means the CMS is not operating within performance specifications and the data is invalid.

H. "Site" means the entire plant regulated by an Air Contaminate Discharge Permit.

I. "Source" means the regulated process at a site (i.e. hogged fuel boiler #1).

J. "Span gas" means any gas containing a known concentration of pollutant as certified by the manufacturer of the gas.

K. "Zero Gas" means any calibration gas containing less than 0.25% of the span of the monitor for the pollutant being measured.

3.0 CONTINUOUS MONITORING SYSTEMS REQUIREMENTS

The source operator shall prepare and maintain written standard operating procedures (SOP) and a quality assurance plan (QAP) for each CMS used at a source. The SOP and QAP shall be written by the permittee, and approved by the DEQ, prior to operation of a CMS and revised as necessary based on operator experience with the CMS. The SOP and QAP shall contain detailed, complete, step-by-step written procedures. Appendix B contains further explanations and requirements for the SOP and QAP. Both documents shall be made available to DEQ personnel for inspection upon request.

3.1 Standard operating procedures

Standard operating procedures shall be written for each CMS. The contents of the SOP shall include, as a minimum, the following information:

A. Source owner or operator name and address.

B. Identification, description, and location of monitors in the CMS.

C. Description and location of the sample interface (i.e. sample probe).

D. Manufacturer and model number of each monitor in the CMS.

E. Equipment involved in sample transport, sample conditioning, analysis, and recording.

F. Procedures for routine operation checks, including daily zero and span calibration drift (CD) check.

G. Procedures for routine preventive maintenance. Initially, these procedures can be taken from the manufacturer's installation and operation manuals. However, as the CMS operators gain more experience with the CMS, it may be necessary or desirable to modify these procedures to increase or decrease frequency of maintenance and add or delete some procedures.

H. Routine maintenance spare parts inventory.

I. Procedures for calculating and converting CMS data into units of the standard.

J. Documentation of the activities described in 3.1 A - I.

3.2 Quality Assurance Plan

A quality assurance plan (QAP) shall be written for each CMS or for the entire site when more than one CMS exists. The contents of the QAP shall include as a minimum the following information:

A. Data quality objectives.

B. Chain of responsibility for CMS operation, corrective action, and training program.

C. Procedure for measuring the CMS accuracy and precision including the following:

1. CMS calibrations

2. Zero and span drift checks

3. Performance audits

4. System audits

D. Procedures for quality control activities

E. Procedures for quality control documentation

F. Procedures for data recording, calculations, and reporting

G. Criteria for corrective action

H. Procedures for corrective action

4.0 SPECIFIC CMS OPERATING REQUIREMENTS

This section addresses specific requirements for the operation of CMS, including performance criteria, location, installation, calibrations, routine maintenance, and data recording. These are minimum requirements. The source operator is encouraged to add additional requirements for their specific CMS that will improve data quality and completeness.

4.1 Continuous Opacity Monitoring Systems (COMS)

A. Existing COMS installed prior to 6/1/91 shall be maintained and operated in accordance with ACDP requirements; and, unless otherwise specified, are not subject to the requirements of this manual.

B. COMS installed after 6/1/91 and/or installed on NSPS sources shall continuously monitor and record the opacity of emissions discharged into the atmosphere from the regulated emission point. Single pass or double pass transmissometers may be used in the COMS as long as the calibration drift can be measured and recorded daily. The Span of COMS for non-NSPS sources shall be set at 100% Opacity, or a span agreed upon by the source and DEQ. Sources which must follow NSPS requirements must set COMS span at the value specified in the applicable subpart of 40 CFR Part 60.

C. COMS put into service after 6/1/91 on non-NSPS sources shall be installed at a location in the stack or duct work where opacity measurements are representative of emissions, as far as practicable from bends and obstructions; in an area of the stack or duct work where condensed water vapor is absent; shielded from interference by ambient light (if the transmissometer is responsive to ambient light); and be accessible for routine maintenance including lens cleaning, alignment checks, calibration checks, blower maintenance, and audits.

COMS put into service to replace existing COMS may be installed at the same location as the previous COMS with the

approval of the DEQ.

COMS for all NSPS sources and COMS installed after 6/1/91 must comply with the provisions of Performance Specification 1 (PS-1), 40 CFR 60 Appendix B (Appendix D).

D. COMS installed after 6/1/91 shall be calibrated prior to installation to cover the appropriate opacity range using a minimum of three (3) optical filters with neutral spectral characteristics (calibrated according to procedures in 40 CFR 60, Appendix B, Performance Specification 1, section 7.1.2 - 7.1.3); and of sufficient size to attenuate the entire light beam received by the transmissometer detector.

1. Transmissometers shall be calibrated to measure percent opacity at the stack exit (i.e. the point where emissions are released into the environment). Although this correction is frequently made electronically, when the instrument is installed it must be documented and verifiable. Measurements shall be corrected for Stack Taper Ratio (STR) - the ratio of the optical pathlength at the stack exit (L_2) to the optical pathlength at the transmissometer (L_1) - using Eq-A1:

$$\text{Opacity} = 1 - 10^{-(STR)(D)} \qquad \text{Eq-A1}$$

where: $STR = L_2/L_1$ = "Stack Taper Ratio"
D = optical density of attenuator @ L_1
L_1= transmissometer pathlength (feet)

L_2= stack exit pathlength (feet)

Note: For circular stacks, the stack exit pathlength is the diameter at the outlet. For noncircular stacks, the stack exit pathlength equals (2LW)/(L+W), where L is the length of the outlet and W is the width of the outlet.

2. Correction of calibration filters is necessary to compensate for the Stack Taper Ratio (STR). Since the measurements are being made upstream of the emission point, the measured opacity must be adjusted to reflect the opacity at the emission point by calibrating the COMS with optical density filters corrected for the stack taper ratio. Correction is accomplished using Eq-A2, knowing the Certified Optical Density of the calibration filters (O.D.), the stack exit pathlength at the emission point (L_2), and the transmissometer

pathlength at the measurement point (L_1). Each calibration filter must be corrected. Appendix A contains a table (A-1) listing correction values.

$$\text{Corrected \%Op} = \{1-[1-(Op_c/100)]^{(STR)}\}x100 \qquad \text{Eq-A2}$$

where:

Corrected %Op = corrected calibration filter opacity
Op_c = certified %Op value of calibration filter
STR = L_2/L_1
L_1 = transmissometer pathlength (feet)
L_2 = stack exit pathlength (feet)

3. Calibration attenuators (filters) shall be selected based on the appropriate span value using Table 1-2, 40 CFR 60 Appendix B, PS-1. Calculate the specific filter attenuator optical density needed, using Eq-A3, and purchase certified neutral density filters closest to the calculated values.

$$D_1 = D_2\ (L_1/L_2) \qquad \text{Eq-A3}$$

where:

D_1 = Optical density of required calibration filter.
D_2 = Nominal attenuator optical density from Table (Table 1-2, 40 CFR 60 Appendix B, PS-1).
L_1 = Transmissometer pathlength (feet).
L_2 = Stack exit pathlength (feet).

D. The zero and span calibration drift shall be measured and recorded daily when the COMS is in operation. (See appendix B for details of this procedure.)

4.1.1 Correlating opacity with mass emission rates

It may be possible to correlate opacity measurements with mass emission rates by assuming that the density, particle size distribution, and optical properties of the particulate material remain reasonably constant. In order to determine the relationship between opacity and mass emission rates for non-NSPS sources, these guidelines must be followed:

A. The relationship between opacity and mass emission rate must

be documented.

1. Each data pair must consist of a one-hour particulate sample collected using pre-approved EPA or DEQ Methods and a one-hour average %Opacity monitored during that same time period. Each one-hour average %Opacity must have at least 90% data recovery.

2. Sufficient data pairs must be collected to show a reasonable correlation between particulate emissions and opacity. This may vary from source to source and may require tests at several different operating rates. A plan for determining the relationship shall be prepared and approved by the DEQ prior to testing. The final correlation constants must be approved by the DEQ.

3. For this relationship to be acceptable to the Department the source must demonstrate the COMS to be operating within EPA's Performance Specification 1 (40 CFR 60, Appendix B).

4.2 Sodium ion electrode continuous emission monitoring system

When sodium is a major constituent of the particulate effluent, present at a known and nearly constant percentage, the sodium concentration in a measured volume of stack gas may be relatable to effluent particulate concentration. Such is the case for some Kraft Process recovery furnaces.

A. The sampling probe must be installed in the stack to obtain a sample which is representative of the average particulate concentration (normally the point of average velocity).

B. A material balance shall be performed and documented monthly, according to a written operating procedure.

C. The CEMS shall be inspected for fouling of electrode(s) and cleaned weekly.

D. Accuracy must be demonstrated monthly by documentation of instrument response to challenges from two solutions of known sodium concentration; at between 10 - 20% and 90% of full-scale range.

E. Due to the effect of pH on sodium ion electrode measurements it is necessary to buffer the scrubbing solution at pH 10. The pH of the scrubbing solution shall be checked daily with a calibrated pH meter.

1. The temperature of the pH electrode must be known and constant because pH varies with electrode temperature.

2. The pH electrode shall be calibrated before each use, using pH 7 and pH 10 buffers, according to a written procedure.

F. Gas flow rates, in and out of the system, must be checked and documented three times each week. Liquid flow rates must be checked once per month. There must be a written procedure for checking flows, and a procedure for correcting those flows found to be out of limits.

G. Flow measurement devices for liquids and gases must be calibrated at least annually, and the calibration documented. Flow measurement accuracy must be within ± 3%.

H. Water vapor content (i.e. absolute humidity) of the gas exiting the CEMS and the particulate scrubbing efficiency of the CEMS shall be verified and documented annually. The particulate scrubbing efficiency shall be determined by measuring the amount of particulate matter collected on a one-hour glass-fiber filter sample of the CEMS exiting gas stream.

I. The percent sodium in the stack particulate shall be measured annually using an isokinetic impinger sample train and flame atomic absorption analysis. The sampling and analytical method shall be described in a written procedure and results documented.

4.3 Continuous Emissions Monitoring Systems (CEMS)

4.3.1 NSPS sources and CEMS installed after 6/1/91

A. The CEMS shall continuously monitor and record the concentration of gaseous pollutant emissions on a wet or dry basis discharged into the atmosphere consisting of subsystems for sample extraction, conditioning, detection, analysis, and data recording/processing.

B. All CEMS must meet the performance specifications of 40 CFR 60, Appendix B. (Included for reference in Appendix D of this manual). The specific performance specifications are listed below:

1. SO_2 and NO_x CEMS - Performance Specification 2

2. CO_2 and O_2 CEMS - Performance Specification 3

3. CO CEMS - Performance Specification 4 and 4a

4. TRS CEMS - Performance Specification 5

C. The span of the CEMS shall be set at 200% of the emission standard or a level specified by a specific subpart of 40 CFR Part 60 and approved by the DEQ.

1. The CEMS must be capable of recording down-scale drift below zero (see Appendix B).

D. Sample probes for all CEMS shall be installed downstream of the control device(s); in a location representative of emissions from the source; accessible for routine maintenance, cleaning, calibration, and audits.

E. Extractive CEMS operating procedures shall include automatic back-flushing of the sample line and probe to purge condensed moisture and particulate material.

F. The CEMS analyzer must be installed and maintained in an environment conducive to analyzer stability.

G. The calibration drift must be measured and recorded daily when the CEMS is in operation. Span gases used for this procedure need not be NIST traceable. However, the concentration of the gases should be verified by an analyzer calibrated with SRM or CRM calibration gases. It may be necessary to periodically respecify the concentration of the zero and span drift check gases.

H. The CEMS must be audited at least once each quarter. Successive audits shall occur no closer than 2 months apart. (See Appendix B for auditing procedures.)

I. Data shall be recorded in units of the ACDP limits.

1. CEMS installed for demonstrating compliance with concentration standards shall report concentrations on a dry basis.

2. Equations for correcting emissions measured on a wet basis to a dry basis are found in Appendix A.

4.3.2 CEMS installed prior to 6/1/91

A. The CEMS shall continuously monitor and record the

concentration of gaseous pollutant emissions discharged to the atmosphere from any stationary source using CEMS approved by the Department of Environmental Quality.

B. The span of the CEMS shall be set:

1. At 200% of the permit requirement concentration or the emission standard, whichever is lower. The span may be set at alternative values with DEQ approval.

2. The CEMS must be capable of recording down-scale drift below zero (See Appendix B).

C. The CEMS shall be pollutant specific and free from interferences. (e.g.: For TRS CEMS, a method must be used to monitor TRS which excludes SO_2)

D. The CEMS analyzer must be maintained in an environment conducive to analyzer stability.

E. Extractive CEMS operating procedures shall include automatic back-flushing of sample line and probe to purge condensed moisture and particulate material.

F. If the emissions must be corrected for diluent oxygen, periodically test and record the concentration of oxygen in the exhaust gases using an oxygen CEMS, Orsat Analyzer, or equivalent.

1. An Oxygen CEMS, if used, must be calibrated according to written procedures, approved by the Department, at least twice each year using two calibration gases having oxygen concentrations of approximately 5 and 15 volume percent, and accurate to within 0.5% oxygen.

2. Oxygen must be measured at least semi-annually, after any major maintenance/repair on duct work, and frequently enough to be representative of average oxygen concentration.

G. The zero and span drift of CEMS must be measured and recorded daily when the CEMS is in operation. Span gases used for this procedure need not be NIST traceable. However, the concentration of the gases should be verified by an analyzer calibrated with SRM or CRM calibration gases. It may be necessary to periodically respecify the concentration of the zero and span drift check gases.

H. A cylinder gas audit (CGA) of the CEMS shall be performed

weekly with successive CGAs performed no closer than six days apart. The CGA shall include a "zero" gas and a minimum of one upscale gas concentration at approximately 60 percent of analyzer full-scale.

1. If 4 consecutive CGAs result in the CEMS being within specifications (see appendix B), the frequency of the CGAs may be reduced to once each month with successive CGAs performed no closer than 21 days apart.

2. If three consecutive monthly CGAs result in the CEMS being within specifications, the frequency of the CGAs may be reduced to once each quarter with successive CGAs performed no closer than two months apart.

3. If two consecutive quarterly CGAs result in the CEMS being within specifications, the CGA frequency may be reduced to once every six months with successive CGAs no closer than five months apart.

4. The minimum CGA frequency shall be once every six months with successive CGAs no closer than five months apart.

5. The CGA frequency shall revert back to a weekly frequency if a CGA results in the CEMS failing to meet the performance specifications (Appendix B).

    a. The concentration of the cylinder audit gases must be traceable to National Institute of Standards and Technology (NIST) standard reference materials (SRM) or EPA certified reference materials (CRM) and reanalyzed every 6-months using EPA Reference Methods (40 CFR 60, Appendix A). Gases may be analyzed at less frequent intervals if the manufacturer guarantees their certified concentration for longer time periods.

    b. Cylinder gases must be introduced to include as much of the monitoring system as feasible, in no case shall gas conditioning subsystems (i.e. SO_2 scrubbers for TRS CEMS) be excluded or by-passed.

I. A Relative Accuracy Audit (RAA) shall be performed at least once each year. The RAA may satisfy one of the CGA requirements. (See Appendix B for auditing procedures)

J. Data shall be recorded in units of the standard.

4.4 Continuous Parameter Monitoring Systems (CPMS)

A CPMS shall continuously monitor source or pollution control device operating parameters. These may include, but are not limited to: fuel consumption rates; production rates; exhaust gas flow rates; process temperatures; pollution control device pressure drop, voltages, water flow and pressure, etc. There are three basic types of CPMS: 1) CPMS used for the purpose of determining pollutant emissions rates (i.e. stack gas flow monitoring devices); 2) CPMS used for the purpose of monitoring pollution control device operations; and, 3) CPMS used for the purpose of monitoring source operations. It is not the intention of this manual to cover each and every possible CPMS. General requirements for CPMS are provided below.

4.4.1 CPMS general requirements:

A. CPMS shall be installed in a location that is representative of the monitored process and free from interferences.

B. CPMS shall be installed and maintained in an environment conducive to CPMS stability and data reliability.

C. CPMS shall be calibrated and certified by the manufacturer prior to installation. (Applies to CPMS installed after 6/1/91)

4.4.2 Pollutant emissions related CPMS

A. CPMS for the purpose of determining emission rates (i.e. stack gas flow monitoring devices) require the highest level of QA/QC.

   1. CPMS installed after 6/1/91 must meet 40 CFR Part 60 Appendix B performance specification 6. The reference methods for determining relative accuracy (RA) shall be EPA or DEQ methods 1 through 4.

   2. Performance audits shall be conducted quarterly in conjunction with the CEMS audits (see Appendix B). It may not be possible to conduct audits on some CPMS. Exemption from this requirement must be approved by the DEQ.

B. Stack Gas Flow Monitoring

   CPMS data are necessary for converting emission concentrations to units of the standard. This is

accomplished by continuously monitoring stack gas flow rates to calculate the emissions as a rate (pounds per hour) in addition to the CEMS output (percent or parts per million).

There are several acceptable procedures and equipment for measuring flow rates (pitot tubes, hot wire anemometers, process rates - steam, air flows, etc.). The CPMS shall include the capability to measure and/or assume the six variables for determining the stack gas flow rate. These variables are: 1) stack gas temperature, 2) stack absolute pressure, 3) stack gas moisture content, 4) stack gas molecular weight, 5) stack gas velocity, and 6) the cross-sectional area of the stack at the point of velocity measurements.

Provided below is a discussion of each of these variables and one or more methods for measuring their values. As mentioned before, there are other acceptable methods for determining stack gas flow rates. Each method must be approved by the DEQ.

1. The stack gas temperature should be continuously monitored with a temperature monitoring device.

2. The absolute stack pressure is the static pressure, usually measured in inches of water converted to inches of mercury, added to the barometric pressure, measured in inches of mercury.

3. The stack gas moisture content can be determined by one of three alternative methods:

    a. EPA method 4: A sample of the stack gas is extracted from the stack and passed through a condensing chamber to collect the moisture in the stack gas. The moisture collected is measured in milliliters or grams and converted to cubic feet. The moisture content is determined by dividing the moisture collected (cubic feet) by the quantity: dry gas sampled (cubic feet) plus the volume of moisture collected (cubic feet). (40 CFR Part 60 Appendix A Method 4).

        It is recommended that this test be performed in triplicate at least once per week at normal operating rates.

    b. Wet bulb/dry bulb alternative method: The temperature of the stack gas is measured with a

standard temperature measuring device (dry bulb) and with a temperature measuring device altered to include a wetted sock over the tip (wet bulb). The relationship of the wet bulb, dry bulb, and stack absolute pressure will determine the moisture content of the stack gas using vapor pressure tables. (Oregon Source Sampling Manual Method 4).

It is recommended that this procedure be performed in triplicate at least once per week at normal operating rates.

c. The third alternative is to use an assumed value for stack gas moisture content based on operating parameters. This method must be demonstrated to be accurate within ±2 percent moisture by conducting a series of tests as described in either option 1 or 2 above. A plan for determining the assumed moisture shall be submitted to the DEQ for approval prior to collecting data.

4. Stack gas dry molecular weight can be determined or assumed by two methods.

a. Extract a dry gas sample from the stack and measure the oxygen and carbon dioxide content of the gas with an Orsat analyzer. The balance of the gas is considered to be nitrogen. (EPA method 3).

This procedure should be performed in triplicate at least once per week.

b. If the source has an oxygen and/or carbon dioxide CEMS, the percent composition of gases can be determined from this system. It is important, however, that the gases are measured in the stack and not in the combustion zone. All gas concentrations must be measured as dry volume percents, or converted to dry volume percents. If only one analyzer is available, the percent oxygen or carbon dioxide can be determined by subtracting the known gas concentration from 20 to obtain the unknown gas concentration. This will be an approximation of the stack gas composition. Calculate the molecular weight in accordance with Method 3.

Since the gas analyzers are CEMS it would be possible to determine the dry gas molecular weight on a continuous basis.

c. A constant molecular weight may be assumed for some sources. Contact the DEQ for approval.

5. Stack gas velocity may be measured with a pitot tube and pressure gauge. Other types of instruments and technologies are available.

The pitot tube method involves inserting a pitot tube (type S) into the stack at some predetermined point of average velocity and measuring continuously the velocity pressure. The pitot tube is connected to a pressure gauge (transducer) with tubing. Initially, the stack shall be traversed to determine the point of average velocity. In addition, due to the harsh environment, the pitot tube shall be back purged at least daily and the tubing shall be inspected for plugging by particulate matter and/or moisture. In erratic velocity stacks, it may be necessary to include a pressure damping device in the connecting tubing. This consists simply of an air- tight plastic or glass jar in line with the tubing. Prior to installation of the pitot tube, it must be calibrated against a standard pitot tube or, if constructed properly, assigned a pitot tube coefficient. The manufacturer can assist or provide documentation of this coefficient. (Refer to EPA Method 2 for more detailed explanation.)

Since the transducer can continuously measure the velocity pressure, the stack gas velocity can be recorded continuously.

6. Cross-sectional area of the stack:

Measure the diameter (circular stacks) or dimensions (rectangular stacks) of the stack at the point where the stack gas temperature, moisture content, dry molecular weight, and velocity pressure are measured. Calculate the area of the stack from the measurements.

Note: All flow rate variables shall be measured at approximately the same location in the stack.

4.4.3 Pollution control device related CPMS.

A. Pollution control device related CPMS include but are not limited to scrubber pressure drop, water flow, temperature, and pressure, gas temperature, electrostatic precipitator current and voltage, etc.

B. Calibration checks shall be performed in accordance with the manufacturer's procedures at least once per month. Depending on the CPMS, an exemption from this requirement may be obtained from the DEQ upon written request. For example, water flow devices are typically calibrated prior to installation and not calibrated again.

4.4.4 Source related CPMS.

A. Source related CPMS include but are not limited to steam flow meters, fuel meters, temperatures, etc. As a minimum, source related CPMS shall meet the general CPMS requirements listed above. Depending on the CPMS, an exemption from this requirement may be obtained from the DEQ upon written request. Temperature CPMS shall be calibrated during each planned maintenance outage or annually, whichever is more frequent.

5.0 RECORD KEEPING AND REPORTING

5.1 Record keeping

The source owner or operator shall maintain records of all CMS activities in a file and/or log book. This record shall be used by the CMS operator to ensure that the CMS is operating correctly. The record must also be made available to DEQ personnel upon request. The record shall include as a minimum the following information:

A. Records of routine observation checks.

B. Records of routine maintenance and adjustments.

C. Records of parts that are replaced.

D. Spare parts inventory for the CMS.

E. Records of CMS calibrations.

F. Records of CMS daily calibration drift.

G. Records of CMS audits.

H. Records of corrective action taken to bring an out-of-control CMS into control.

I. Records of date and time when CMS is inoperative or out-of-control.

5.2 Reporting Requirements

As a condition of installing a CEMS, the source owner or operator will be required to submit reports to the DEQ. These reports shall include as a minimum the following information:

A. Reporting period (determined by permit condition or 40 CFR Part 60).

B. CMS type, manufacturer, serial number, and location.

C. Specific CMS reporting requirements:

1. All continuous opacity monitoring systems (COMS) shall complete a minimum of one cycle of sampling and analyzing for each successive 10-second period (15 seconds for non-NSPS sources if approved by the DEQ). Unless otherwise specified by an ACDP, the data shall be reduced and reported as follows:

   a. 6-minute (clock) averages (NSPS sources only)

   b. Hourly (clock) averages

   c. averages of 10 or 15-second data that exceed the emission limit when the aggregate period is greater than 3-minutes in a 1-hour (clock) period, and the aggregate period (OAR 340-21-015).

   d. Monthly average of the hourly averages.

2. All continuous emissions monitoring systems (CEMS) and continuous parameter monitoring systems (CPMS) shall complete a minimum of one cycle of sampling and analyzing for each successive 15-minute period unless the DEQ has specified a different frequency (i.e. Medford AQMA requires one minute cycle). The data shall be reduced and reported as:

   1. Hourly (clock) averages.

   2. Monthly average of the hourly averages.

D. For a CMS data average to be accepted, a minimum of 75% of the data for a 6-minute or 1-hour period and 90% of a 24-hour or monthly period must be included in the average. Insufficient data completeness, excluding CMS downtime due to daily zero and span checks and performance audits, will void that data period. All data collected shall be reported. Non-valid data shall be highlighted.

E. Data recorded during periods of CMS breakdowns, repairs, audits, calibration checks, and zero and span adjustments shall not be included in the data averages.

F. The magnitude of excess emissions computed in accordance with any conversion factor(s), and the date and time of commencement and completion of each period of excess emissions.

G. Specific identification of each period of excess emissions that occurs during startups, shutdowns, and malfunctions of the affected source. The nature and cause of any malfunction (if known), the corrective action taken or preventative measures adopted.

H. The date and time identifying each period during which the CMS was inoperative (out-of-control) except for zero and span checks and the nature of the CMS repairs or adjustments.

I. Results of all CMS audits conducted during the reporting period.

J. DEQ approved reporting forms are provided in Appendix C. Additional reporting requirements may be stipulated in an Air Contaminate Discharge Permit or DEQ communication.

6.0 REFERENCES

A. Useful Quality Control/Quality Assurance information and criteria to maintain CMS data quality at an acceptable level can be found in EPA's Quality Assurance Handbook for Air Pollution Measurement Systems: Volume 3. Stationary Sources Specific Methods, sections 3.0.4, 3.0.7, 3.0.9, and 3.0.10 (Nov. 26, 1987), EPA/600/4-77/027b.

B. Other references:

1. Code of Federal Regulations: 40 CFR Part 60 Appendices A, B, and F.

2. Continuous Emission Monitoring: Present and Future, Air and Waste Management Association International Specialty Conference SP-71, Nov. 1989.

3. Field Inspectors Audit Techniques: Gas CEMS's Which Accept Calibration Gases; EPA/340/1-89-003, June 1989.

7.0 GLOSSARY OF ACRONYMS

ACDP = Air Contaminate Discharge Permit
CD= Calibration Drift
CEMS = Continuous Emissions Monitoring System
CGA = Cylinder Gas Audit
CMS = Continuous Monitoring System
CO= Carbon Monoxide
CO_2 = Carbon Dioxide
COMS = Continuous Opacity Monitoring System
CPMS = Continuous Parameter Monitoring System
CRM = Certified Reference Material
DEQ = Department of Environmental Quality (Oregon)
EPA = Environmental Protection Agency (U.S.)
NIST = National Institute of Standards and Technology
NO_x = Oxides of Nitrogen
NSPS = New Source Performance Standard
OAR = Oregon Administrative Rules
O_2 = Oxygen
QA/QC = Quality Assurance and Quality Control
QAP = Quality Assurance Plan
SOP = Standard Operating Procedures
SO_2 = Sulfur Dioxide
SRM = Standard Reference Material
STR = Stack Taper Ratio
TRS = Total Reduced Sulfur

APPENDIX A
CMS Data Corrections

Continuous Monitoring Manual
Appendix A
Table of Contents

CMS Data Corrections

A.1.0 MOISTURE CORRECTION

A. Stack gas concentrations measured by CEMS are to be reported on a dry basis (dry gas concentration by volume). The CEMS may be designed to measure concentrations on either a wet basis or dry basis. If concentrations are measured on a dry basis, no correction is necessary. However, if the stack gas sample is measured wet, the CMS response must be corrected for the moisture content of the gases.

Correcting CEMS response from wet basis to dry basis:

$$C_{dry} = \frac{C_{wet}}{(1-B_{ws})}$$

where:

C_{dry} = concentration in stack gas corrected to dry conditions

C_{wet} = concentration in stack gas as measured on wet basis

B_{ws} = stack gas moisture content as a volume fraction (% volume moisture/100)

B. All concentrations (pollutants and/or diluent gases) shall be corrected for moisture before any other corrections are performed (i.e. diluent gas corrections).

A.2.0 DILUENT GAS CORRECTIONS

A regulation may require that an emission concentration be corrected to a standard diluent gas (oxygen or carbon dioxide) concentration. The formulas for these corrections are presented below.

A.2.1 Correction of measurements for percent oxygen

$$C_{corr} = C_{meas}\ (20.9 - X)/(20.9 - Y)$$

where: C_{corr} = concentration corrected for oxygen.

C_{meas} = concentration measured by CMS.

X = Percent volumetric oxygen concentration to be corrected to.

Y = Measured average percent volumetric oxygen concentration.

A.2.1 Correction of measurements for percent carbon dioxide

$$C_{corr} = C_{meas} (12/Y)$$

where: C_{corr} = concentration corrected for CO_2.

C_{meas} = concentration measured by CEMS.

Y = Measured average percent volumetric CO_2 concentration.

A.3.0 MEASUREMENT CORRECTION EXAMPLE

Situation: A CEMS measures 200 ppm carbon monoxide (CO), 5% oxygen, and 12% carbon dioxide. The CEMS measures concentrations on a wet basis. The stack gas moisture is 20%. Correct the CO concentration to a dry concentration, 3% oxygen, and 12% carbon dioxide.

Solution: $C_{co,dry} = C_{co,wet}/(1-B_{ws})$
$= 200/(1 - 20/100)$
$= 200/(1-.2)$
$= 200/.8$
$= 250$ ppm, dry

$C_{oxygen, dry} = C_{oxygen, wet}/(1-B_{ws})$
$= 5/.8$
$= 6.25\%$, dry

$C_{carbon\ dioxide, dry} = C_{carbon\ dioxide, wet}/(1-B_{ws})$
$= 12/.8$
$= 15\%$, dry

$C_{co,3\%O2} = C_{co,dry}[(20.9-3)/(20.9-6.25)]$
$= 250(17.9/14.65)$
$= 250 * 1.2222$
$= 305.5$ ppm, dry at 3% oxygen

$C_{co,12\%CO2} = C_{co,dry}(12/15)$
$= 250 * 0.80$
$= 200$ ppm, dry at 12% carbon dioxide

A.4.0 TRANSMISSOMETER CALIBRATION WITH ADJUSTMENT FOR STACK EXIT

Table A-1, page A-3, shows corrected % Opacity for calibration filters from 10 - 80%, for different stack exit diameters and transmissometer pathlengths, which are corrected for the actual Stack Taper Ratio.

TABLE A-1. Calibration filters corrected to "L_2" STACK DIAMETER

			%OP OF CALIBRATION FILTERS CORRECTED TO "L_2" STACK EXIT DIAMETER							
L_2 FT	L_1 FT	STR= L_2/L_1	NOM.%OP: O.D.=	10 0.0458	20 0.0969	30 0.1549	40 0.2218	50 0.3010	60 0.3979	70 0.5229	80 0.6990
10	10	1.000		10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%
10	12	0.833		8.4%	17.0%	25.7%	34.7%	43.9%	53.4%	63.3%	73.8%
10	14	0.714		7.2%	14.7%	22.5%	30.6%	39.0%	48.0%	57.7%	68.3%
10	16	0.625		6.4%	13.0%	20.0%	27.3%	35.2%	43.6%	52.9%	63.4%
10	18	0.556		5.7%	11.7%	18.0%	24.7%	32.0%	39.9%	48.8%	59.1%
10	20	0.500		5.1%	10.6%	16.3%	22.5%	29.3%	36.8%	45.2%	55.3%
10	22	0.455		4.7%	9.6%	15.0%	20.7%	27.0%	34.1%	42.1%	51.9%
10	24	0.417		4.3%	8.9%	13.8%	19.2%	25.1%	31.7%	39.4%	48.9%
12	12	1.000		10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%
12	14	0.857		8.6%	17.4%	26.3%	35.5%	44.8%	54.4%	64.4%	74.8%
12	16	0.750		7.6%	15.4%	23.5%	31.8%	40.5%	49.7%	59.5%	70.1%
12	18	0.667		6.8%	13.8%	21.2%	28.9%	37.0%	45.7%	55.2%	65.8%
12	20	0.600		6.1%	12.5%	19.3%	26.4%	34.0%	42.3%	51.4%	61.9%
12	22	0.545		5.6%	11.5%	17.7%	24.3%	31.5%	39.3%	48.1%	58.4%
12	24	0.500		5.1%	10.6%	16.3%	22.5%	29.3%	36.8%	45.2%	55.3%
14	14	1.000		10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%
14	16	0.875		8.8%	17.7%	26.8%	36.0%	45.5%	55.1%	65.1%	75.5%
14	18	0.778		7.9%	15.9%	24.2%	32.8%	41.7%	51.0%	60.8%	71.4%
14	20	0.700		7.1%	14.5%	22.1%	30.1%	38.4%	47.3%	56.9%	67.6%
14	22	0.636		6.5%	13.2%	20.3%	27.8%	35.7%	44.2%	53.5%	64.1%
14	24	0.583		6.0%	12.2%	18.8%	25.8%	33.3%	41.4%	50.5%	60.9%
16	16	1.000		10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%
16	18	0.889		8.9%	18.0%	27.2%	36.5%	46.0%	55.7%	65.7%	76.1%
16	20	0.800		8.1%	16.3%	24.8%	33.5%	42.6%	52.0%	61.8%	72.4%
16	22	0.727		7.4%	15.0%	22.8%	31.0%	39.6%	48.6%	58.3%	69.0%
16	24	0.667		6.8%	13.8%	21.2%	28.9%	37.0%	45.7%	55.2%	65.8%
18	18	1.000		10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%
18	20	0.900		9.0%	18.2%	27.5%	36.9%	46.4%	56.2%	66.2%	76.5%
18	22	0.818		8.3%	16.7%	25.3%	34.2%	43.3%	52.7%	62.7%	73.2%
18	24	0.750		7.6%	15.4%	23.5%	31.8%	40.5%	49.7%	59.5%	70.1%
20	20	1.000		10.0%	20.0%	30.0%	40.0%	50.0%	60.0%	70.0%	80.0%
20	22	0.909		9.1%	18.4%	27.7%	37.1%	46.7%	56.5%	66.5%	76.8%
20	24	0.833		8.4%	17.0%	25.7%	34.7%	43.9%	53.4%	63.3%	73.8%

L_2=STACK EXIT DIAMETER L_1=STACK DIAMETER AT TRANSMISSOMETER

STR=STACK TAPER RATIO FOR CORRECTING ACTUAL STACK DIAMETER = L_2/L_1

CORRECTED % OPACITY = $[1-(1-OP)^{STR}]*100$

APPENDIX B
Quality Assurance

Continuous Monitoring Manual
Appendix B
Table of Contents

GENERAL
CMS Quality Assurance Plan

B.1.0 QUALITY ASSURANCE AND QUALITY CONTROL

The terms "Quality Assurance" (QA) and "Quality Control" (QC) are frequently applied very loosely (sometimes interchangeably) without clear understanding of the differences between them. In these guidelines, the terms are defined as follows:

A. "Quality Control" refers to an activity carried out during routine internal operations to ensure that the data produced are within known limits of accuracy and precision. Examples of QC activities include periodic calibrations, routine zero and span checks, routine leak checks, routine check of optical alignment, etc. QC represents the core activity in a Quality Assurance program.

B. "Quality Assurance" refers to all of the planned and systematic activities carried out externally and independent of routine operation to document data quality. QA activities include written documentation of operation, calibration, and QC procedures; independent system and performance audits; data validation; evaluation of QC data; etc. QA requires documentation of every aspect of the CMS effort, from responsibilities of each person involved to how the data is reported.

B.2.0 QUALITY ASSURANCE PROJECT PLANNING

Implementation of a Quality Assurance program calls for detailed planning to identify and control critical characteristics of the total measurement system.

A. The planning process may include any or all of the following activities:

1. Sampler location and environment
2. Sample handling, pretreatment, conditioning
3. Sample analysis method & equipment
4. Method parameters, criteria for performance, limits
5. Data retrieval, data validation, etc
6. Equipment specifications and acquisition
7. Reference standards for calibration, span check, zero check, etc.

B. Questions typically asked during the planning process may

include the following:

1. Which activities are most critical to data quality?
2. What acceptance limits are necessary to ensure
3. How frequently should the activity be checked?
4. What methods should be used to check?
5. What should be done if the acceptance limits are not met?

C. Once the plan is developed it must be communicated to those whose job it is to implement and follow it. This takes the form of a written Quality Assurance Plan (QAP) which, for CMS, shall address the following elements:

1. Data Quality Objectives; completeness, precision, accuracy,etc.

2. Chain of responsibility for CEMS operation, maintenance, data reduction and reporting.

3. Procedures for assessing precision and accuracy: control charts, calibration checks, secondary standards, audits, CRM or SRM calibration gas traceability documentation, etc.

4. Routine Quality control checks, and frequency, to assess zero or span drift, flow rates, calibration, data retrieval, etc.

5. Criteria for corrective actions.

6. Procedures for corrective action if criteria exceeded.

7. Procedures for documenting activities in 1 - 6.

After the QAP is written it shall not be considered a static document but rather a dynamic one which can be changed to reflect what is learned as it is used. If the CEMS system is modified, operating procedures changed, or the organization of the group responsible for the system changed the QAP shall be revised to reflect these changes; as a minimum, the entire CEMS system and QAP shall be reviewed in detail on an annual basis (see System audit).

B.3.0 QUALITY ASSURANCE PLAN

B.3.1 Data Quality Objectives

Each quality assurance plan (QAP) shall include specific data quality objectives. These are data completeness, representativeness, accuracy, and precision. A brief description and general requirements are provided below.

A. Completeness is the measure of the number of valid data points collected over the possible number of data points in a period of time. For continuous measurements, the data is considered complete when at least 75% of the possible observations in an hour and 90 percent of the daily or monthly hourly averages are present and valid. This means that at least 45 minutes of continuously monitoring data must be present and valid to report an hourly average; likewise, at least 22 hourly averages must be valid to report a daily average, and 648 hourly averages for a 30 day month.

B. Representativeness refers to measurements which accurately depict the condition of interest. One aspect of representativeness involves the method chosen to perform the monitoring; it must be accurate in a qualitative, as well as quantitative, sense. If the permit calls for monitoring SO_2 the CMS must be specific for SO_2...a CMS that measures "total sulfur" would not be adequate. CEMS for "Total Reduced Sulfur (TRS) shall report data which represents TRS only, not TRS and sulfur dioxide.

   Representativeness can be expressed by describing the CMS components by type, manufacturer, identification number, and location.

C. Accuracy describes how close the measurement is to the "true concentration" of the quantity being measured. The difference between the CEMS response to the standard (Y) and the true value of the certified standard (X) is expressed as a percentage of the certified standard value and describes the CEMS "bias."

$$\text{Accuracy} = \% \text{ Bias} = (Y - X)/X \times 100$$

   1. Bias may arise from changes in procedure, instrument malfunction, leak in the sample line, dirty optics, contaminated reference standard, etc..

   2. Minimum accuracy limits are listed in the "criteria for corrective action" section of this document.

   3. Accuracy is measured by conducting routine performance

audits.

D. Precision is a measure of variability, or scatter, of the CEMS response to repeated challenges by the same standard. It is not necessary for the concentration of a precision test sample to be known, as long as it remains stable. However, the concentration of the precision test sample should periodically be verified by an analyzer calibrated with either CRM or SRM calibration gases. Normal variability may be attributable to small random changes in flow rate, temperature, pressure, intermittent electrical loading, etc.. Precision is commonly measured as standard deviation (s), variance (s^2), or relative standard deviation (RSD) [sometimes called the coefficient of variation].

Precision measures:

$$\text{standard deviation} = s = [\Sigma(x_i - x_{avg})^2/(n-1)]^{1/2}$$

$$\text{variance} = s^2$$

$$\text{relative standard deviation (RSD)} = (s/x_{avg})100$$

where: $x_{avg.}$ = mean of measurements
n = number of measurements
x_i = individual measurement

1. The goal for any monitoring activity is to obtain data with minimum bias and scatter. Regardless of what is being monitored it is important to document the quality of data being produced to ensure that it is adequate for the intended purpose: in this instance, compliance with the conditions of the ACDP.

2. Minimum precision limits are listed in the "criteria for corrective action" section of this document.

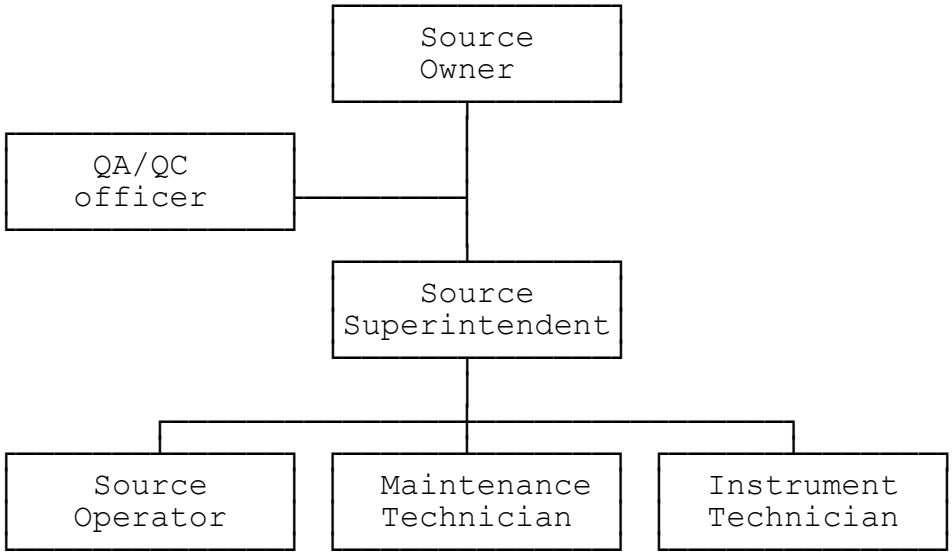
3. Precision is measured by conducting routine zero and span drift checks.

B.3.2 Chain of Responsibility and Training

The individuals and their responsibilities involved with the CMS shall be clearly defined in the QAP. This can be accomplished by means of flow charts and position descriptions. An example of a typical flow chart is provided below with descriptions of the personnel involved in the operation, maintenance, and reporting

of CMS. The number of people involved and titles will depend on the complexity and number of CMS and the existing plant organization.

A. Flow Chart



B. Responsibilities

1. The source operator uses the CMS data for correct operation of the process being controlled, including the pollution control device. This person is the first one to detect problems with the CMS. Should problems develop, and the CMS data be considered invalid, the source superintendent would be notified so that a maintenance or instrument technician would be sent to correct the problem. In some cases, it may be advantageous to have the source operator communicate directly with the technicians.

2. The maintenance technician is responsible for conducting routine maintenance on the CMS. This would require daily inspections of the CMS. Any problems not corrected immediately would be communicated to the source superintendent. Generally, the maintenance technician is concerned with the mechanics of the system, such as pumps, sample lines, filters, etc. The maintenance technician would be responsible for maintaining records of all quality control and maintenance activities that he or she performs, including maintaining an inventory of spare parts

necessary for the CMS.

3. The instrument technician would be responsible for conducting the daily zero and span checks, cylinder gas audits, electronic tests, etc. Should a problem be detected that cannot be immediately corrected, the source superintendent would be notified. Like the maintenance technician, the instrument technician is also responsible for maintaining a record of all quality control activities such as the results of zero and span checks, performance audits, and corrective action that he or she performs.

4. The source superintendent is responsible for the correct operation of the CMS and coordinates all activities associated with maintenance, quality control, and data recording. This person shall be familiar enough with the CMS to correct just about any problem that occurs and develop procedures for ensuring that problems do not occur. The source superintendent would most likely also be responsible for preparing reports to source management and DEQ. The source superintendent must have the authority to authorize appropriate corrective action if necessary.

5. The QA/QC officer is responsible for reviewing the data and reports prepared by the source superintendent; assessing the data completeness, precision, and accuracy; and performing annual system audits. The QA/QC officer would develop the quality assurance plan and ensure that the quality control activities are being performed and documented. The QA/QC officer shall not be directly involved in the day-to-day operation of the CMS.

6. The source owner is ultimately responsible for the source operation and validity of CMS data. The source owner shall be periodically apprised of the CMS working condition and quality of data through summary reports prepared by the source superintendent and reviewed by the QA/QC officer.

C. Each individual involved with the CMS shall be made aware of the CMS goals and criteria for corrective action (see section B.3.6) so that they can effectively make decisions about corrective action. The QAP shall include a training program consisting of the type (e.g. in-house, certificate, etc.) and frequency of the training. Records of training

shall be maintained at the site and made available to DEQ personnel upon request.

B.3.3 Measures of Accuracy and Precision

There are four distinct activities for measuring and ensuring the accuracy and precision of the CMS. Provided below is a description of each of these activities and the frequency at which they shall occur.

A. CMS Calibration

1. Calibration procedures shall be in written form in the SOP. These procedures must be available to both source personnel, who operate the system, and Agency personnel for review. Simple reference to the instrument manual is inadequate unless procedures are identical to those of the manufacturer.

2. Calibration of a CEMS shall include running "zero" and two upscale points using reference standards. The upscale standards shall be between 10 - 20 and 80 - 90 percent of the full-scale response. Single upscale point calibrations are not acceptable: they assume a linear response, which must be demonstrated.

3. Calibrations shall be fully documented and take place on a schedule. At a minimum, the CMS must be calibrated prior to installation or just after installation, whichever is most appropriate for the CMS. Whenever the CMS requires major maintenance or repair a full calibration shall be performed before data is declared valid. The actual schedule for calibrations will be determined by the source operator. The frequency will depend upon CMS performance and audit results.

4. Calibration standards

   a. For COMS, the reference standards are neutral density optical filters which have optical densities certified to be traceable to National Institute of Standards and Technology (NIST) reference material (40 CFR Part 60, Appendix B, sec 3.4 & 7.1.3).

   b. For CEMS (SO_2, NO_2, CO_2 and O_2, TRS, CO), the reference standards can be either Certified

compressed gases; a permeation device (for SO_2, NO_x, TRS) whose permeation rate is Certified at some fixed temperature; or a sealed gas cell containing a gas whose concentration is Certified. Certified standards must be traceable to NIST standards.

i. Calibration accuracy is dependent on the quality of the reference standard used. Ideally, compressed gas standards shall be either NIST-Standard Reference Materials (SRMs), EPA- Certified Reference Material (CRMs), or Primary Standard quality. Calibration gases analyzed by the user employing the appropriate EPA Reference Method and at least one NIST traceable standard would be acceptable providing the necessary documentation is available. Permeation device permeation rates must be certified by the manufacturer or the user, either gravimetrically or by Reference Method analysis. Permeation devices must be used in an oven capable of maintaining the set temperature within $\pm$ 0.1°C.

c. For CPMS, typical reference standards would be liquid (water or mercury) manometers, NIST traceable thermometers, NIST traceable pitot tubes, etc.

B. Zero (low level) & span checks (Calibration Drift)

1. Zero (low level) and span checks, sometimes referred to as Calibration Drift (CD) checks, must be performed daily. The CMS response to zero or low level and span (high level) standards must be recorded to evaluate the performance of the CMS over a period of time. The CD checks are the first criteria for determining the degree of control of the CMS.

The drift must be checked at two levels: zero and high. If the instrument technology is such that it is not possible to check the zero level, a low level point shall be checked instead. The calibration drift levels are defined as follows:

a. Zero = <0.25% of instrument span
b. Low level = 0 to 20% of instrument span

c. High level = 50 to 100% of instrument span

2. Daily span standards need not be certified reference materials, but they should be reanalyzed immediately after each full-scale calibration or audit and their nominal concentration "renamed" to match the instrument response.

3. On some CMS the CD can be performed automatically at preset times. The zero and span trace on the strip chart shall be verified for timing as well as magnitude of response; the observed/reference values shall be written directly on the strip chart as documentation.

4. For CMS that automatically correct for drift, the CMS must be designed to record the observed zero and span values prior to any adjustments.

C. Performance audits for data accuracy

1. The performance audit shall be conducted independently of normal calibrations and calibration drift checks using specially assigned reference standards.

2. For CMS installed on NSPS sources and all CMS installed after 6/1/91, the performance audit shall be conducted at least quarterly. Successive audits shall be conducted no closer than 2 months apart. There are three types of audits: Relative Accuracy Test Audit (RATA), Relative Accuracy Audit (RAA), and the Cylinder Gas Audit (CGA). At least one of the four required audits in one year shall be a RATA. The other three audits may be RAAs or CGAs. If the RATA is performed once per year, the RATA shall not be conducted in successive quarters.

3. For CMS installed on non-NSPS sources and prior to 6/1/91, the performance audit shall be conducted at least two times per year. The source operator may want to conduct audits more frequently to ensure that a minimum amount of data is not put in jeopardy.

4. If it is demonstrated by a compliance source test that the emissions monitored by a CMS are less than 50% of the ACDP limit, the permittee may petition the DEQ to change the annual RATA requirements to once every 3 years. This option does not apply to CMS installed specifically for demonstrating compliance with an ACDP

limit.

5. A description of each type of audit is provided below. These are explained in detail in 40 CFR Part 60 Appendix F.

   a. Relative Accuracy Test Audit (RATA)

      i. The RATA is conducted upon initial startup of the CMS and at least annually thereafter.

      ii. The RATA consists of conducting a minimum of nine reference method test runs and comparing the results to the CMS output using a 95% confidence coefficient. The reference methods are from 40 CFR Part 60 Appendix A. The CMS specific reference methods are listed below:

         (1) SO_2 CEMS - Reference Method 6 or 6c
         (2) NO_x CEMS - Reference Method 7 or 7e
         (3) CO CEMS - Reference Method 10
         (4) TRS CEMS - Reference Method 16 or 16a
         (5) O_2 CEMS - Reference Method 3 or 3a
         (6) CO_2 CEMS - Reference Method 3 or 3a

      iii. For SO_2, TRS, and NO_x testing, EPA audit samples shall be analyzed by the same individual that performs the reference method sample analysis. The audit samples may be obtained from the DEQ. Contact the Source Testing Coordinator (503) 229-5069.

      iv. When the emissions are reported as emission rates (lb/hr), the RATA shall include methods 1 through 4 for determining stack gas flow rates.

   b. Relative Accuracy Audit (RAA)

      i. Three of the required 4 audits performed each year may be the RAA.

      ii. The RAA procedure is identical to the RATA procedure except that a minimum of three reference method test runs instead of nine are required. The reference methods are the same as for the RATA.

iii. The sample analysis shall include analysis of audit samples as described for the RATA.

c. Cylinder Gas Audit (CGA)

i. Three of the required 4 audits performed each year may be a CGA.

ii. A CGA consists of challenging the CMS three times with each audit standard: an independent "zero" and two independent upscale Certified Standards (at approximately 1 and 0.5 times the permitted emission standard). **Audit standards used must not be the same ones used for daily checks or calibration.** Standards which are acceptable include those from the National Institute of Standards and Technology-Standard Reference Materials (NIST-SRMs), gas vendor Certified Reference Materials (CRM), or a Primary Standard gas which is traceable to NIST-SRMs or CRMs using EPA's Revised Traceability Protocol No.1 (DEQ Lab can provide copy).

iii. CGA audit samples shall be introduced into the CEMS operating in the normal sampling mode to include as much of the system as possible (e.g. at or as close as possible to the sampling probe for extractive systems). Most in-situ CEMS incorporate a gas fitting at the point the sampling probe penetrates the stack wall for introduction of audit gases.

iv. Results of each audit shall be available to DEQ for review.

4. NSPS sources with SO_2, NO_x, or TRS CEMS must audit the pollutant channel and the diluent (O_2 or CO_2) CEMS because the emission standard is based on both the pollutant and diluent CEMS.

D. System Audits

1. System audits shall be done at least annually.

2. A System audit is performed by a person other than the person who does routine daily checks, repair and maintenance, or data reporting; preferably a supervisor who is familiar with the CEMS but does not have daily contact with it. Generally, system audits are "paper audits," concerned with verifying the existence of documentation, adherence to procedures as written, verifying complete documentation and the physical condition of the CEMS operation. All documentation and procedures called for in the QAP shall be examined for completeness and timeliness. Data resulting from routine daily checks shall be reviewed for completeness.

3. The system audit shall result in a written report to management indicating whether the QAP is being followed, the quality of CEMS data, and recommending changes.

B.3.4 Quality Control

A. Internal Quality Control Checks

Internal quality control check procedures and the frequency with which they are conducted will vary depending on the type of CMS, its history, and its operating environment. The following checks shall be made at the indicated frequency on all CMS:

1. Daily

   Daily checks shall be limited to relatively simple aspects of the CMS and may vary depending on the parameter being monitored and the type of monitor being used. Manuals provided by the manufacturer will normally indicate what needs to be inspected and how to test it.

   a. Zero & span checks. Sometimes referred to as Zero or Calibration Drift (CD) checks. The monitor response to zero and span standards shall be recorded. Daily span standards need not be certified reference materials but they should be reanalyzed immediately after each full-scale calibration or performance audit and their nominal concentration "renamed" to match the instrument response.

      On some CMS the zero and span can be performed

automatically at preset times. The zero and span trace on the strip chart shall be verified for timing as well as magnitude of response; the observed/reference values shall be written directly on the strip chart as documentation.

b. Flow rate shall be checked in the probe, for extractive monitors, and at the analyzer sampling point to ensure that the sample is getting to the monitor. In-line filter plugging or a leak could cause reduced flow. Condensed water traps shall be emptied or checked for proper drainage.

c. Sample conditioning equipment shall be checked for effectiveness, leaks or condensation; particulate filters shall be checked for integrity and plugging; thermal converter temperatures shall be verified; etc.

d. Fault indicators shall be checked to make certain that they are functioning properly; if any are activated, the cause shall be determined and corrected immediately. In computerized CMS, "error messages" on the printout shall be followed up.

e. Auxiliary monitor performance parameters shall be checked and values noted. Many CMS have electronic reference or zero compensation values which can be monitored. They can be used to evaluate stability of the electronics and reliability of the fault indicators. After some history is obtained, frequency of checking may be reduced.

2. Weekly

QC checks that are performed on a weekly, monthly, or quarterly frequency shall be designed to identify developing or existing problems which cannot be detected in the daily checks and will usually incorporate some preventative maintenance activities. The integrity of sampling lines are verified; in-line filters are checked or changed; pump and motor bearings are lubricated; optical path alignment is verified; optical surfaces are cleaned; purge system checked; replacement of expendable supplies (chart paper, recorder ink, printer ribbon,etc); etc. Preventative

maintenance activities on the schedule recommended by the CMS component manufacturer shall be performed and the date of completion documented.

a. Data recording/display devices shall be checked for accuracy and stability. Most CMS have a panel meter (digital or analog) and a strip chart recorder; some use a computer to log data and perform calculations. The recording/display device used to obtain the data which is reported to DEQ shall be of primary concern. A check shall be done to verify that the panel meter and the strip chart are displaying the same value; the "zero" of the display device has not drifted appreciably; the proper strip chart paper is being used; the recorder is responsive to changes in CMS output; and the recorder is set for the proper full-scale range.

   The recorder "zero" may be offset upscale by 5% of full-scale to permit observation of down-scale drift in CMS response (e.g. for a COMS monitoring 0 - 100% Opacity on a strip chart having 100 scale divisions, set the recorder zero at 5 scale divisions). Although the upper 5% of the monitoring range is lost, it is an acceptable trade-off for the ability to observe negative zero drift on the low end. Values are not routinely expected in the upper 5% of the range anyway.

3. Monthly

a. Plumbing associated with sample handling and conditioning shall be inspected for leaks, corrosion, etc. Fittings, valves, and gas regulators also need to be checked. Solenoid valves, commonly used to automate flow systems, shall be tested to ensure they function properly.

b. Electrical cables and heat traced lines shall be inspected regularly. In an industrial environment physical damage can occur easily, and exposure to chemicals or weather can cause insulation to deteriorate rapidly.

B.3.5 Quality Control Documentation

A. Calibrations, QA and QC activities, routine maintenance, or repair activities shall be documented in a bound laboratory notebook with pre-numbered pages dedicated to each CMS monitor. A brief description of the activity and data is written any time anything is done to the CMS; each entry is initialed and dated by the person performing the activity. The complete chronological history of the CMS is then available in one document for review. The notebook is kept with the CMS at all times.

B. All data resulting from daily QC checks (e.g. zero, span, flow rates, fault lamp condition, probe vacuum, etc.) must be recorded because they document the operating condition of the CMS. If several persons are involved in performing the daily checks, a change in these parameters is easier to monitor if the data is plotted on a control chart.

B.3.6 Data Recording, Calculations, and Reporting

The QAP must include detailed procedures for recording and reporting CMS data, including all calculations used to obtain emissions in units of the standard.

A. Recording

There are several techniques for recording CMS data ranging from manually recorded data to computer recorded data. Many CMS will utilize more than one technique to ensure that data is not lost. This might include a strip chart recorder combined with an electronic data logger. The QAP will include the following information:

1. Type, manufacturer, identification number, and location of all equipment used for recording the CMS data.

2. Equipment maintenance procedures such as changing chart paper and pens, computer printer paper, cleaning, etc.

3. Electronic check procedures

4. Calibration procedures if necessary.

B. Calculations

All calculations used to convert CMS data to reporting values shall be clearly defined in the QAP. Each formula shall be written out with explanations of the variables and constants. Constants that have been estimated or assumed shall be

highlighted and the rational or justification for using the value provided. Example calculations shall be provided. The accuracy of the calculations shall be periodically reviewed.

C. Reporting

The QAP shall include examples of the specific reporting formats for all CMS data, performance audits, CMS out-of-control periods, and excess emissions. Reporting summaries are provided in Appendix C.

B.3.7 Criteria for Corrective Action

For QC/QA activities to serve the purpose of maintaining and documenting data quality it is necessary to set up performance criteria which trigger or initiate some corrective action when the limits are exceeded. In the case of daily drift checks it is necessary to set an "allowable" standard; as long as the CMS drift is within the limits nothing is done; as soon as the limit is exceeded some action must be taken to get the system back into control, and a decision must be made regarding the quality of the data that has been produced since the last acceptable check.

A. Performance Specifications

1. The Environmental Protection Agency (EPA) has established Performance Specifications (PS) for CMS installed after March 30, 1983 as a requirement of a subpart in 40 CFR Part 60, to generate data of acceptable quality: PS-1,-2,-3,-4, and -5 deal with Opacity, SO_2 & NO_x, diluent gases (O_2 & CO_2), CO, and Total Reduced Sulfur (TRS) CMS, respectively. A summary of these PS's (from 40 CFR Part 60, Appendix B) are shown in Table B-1 on page B-17. The State of Oregon DEQ has adopted these performance specifications for CMS installed for the purpose of demonstrating continuous compliance with emission limits.

2. CPMS performance specifications (40 CFR Part 60 Appendix B specification 6) are as follows:

   a. Flow rate and pressure analyzers shall not drift or deviate from either of their reference values by more than 3% of 1.25 times the average potential absolute value for that measurement.

   b. A temperature analyzer shall not drift or deviate from its reference value by more than 1.5% of 1.25 times the average potential absolute value for that measurement.

c. The relative accuracy (RA) for CPMS shall be not greater than 20% of the mean value of the reference method's test data in terms of the units of the emission standard, or 10% of the applicable standard, whichever is greater.

d. For existing CPMS, the DEQ may approve less stringent performance specifications on a case by case basis.

3. These Performance Specifications are goals for operation of the CMS; whenever they are exceeded, data quality deteriorates and something must be done to restore the system to control. When the CMS is "out-of-control" the data shall be invalidated until "control" can be restored.

B.3.8 Corrective Action

A. There are three degrees of "control" for setting action and data quality criteria: "acceptable," "marginal," and "out-of-control." "Acceptable" data is self-explanatory; the data is valid and the CMS is operating within specifications. "Marginal" data is still valid but some action needs to take place to prevent further deterioration to the point where the data is invalid and the CMS is out of specification. When the third level of control is reached a serious problem exists in the system and data shall be invalidated until the problem can be identified and fixed.

Criteria	Degree of Control	Action
CD≤(2xspec) or Accuracy audit OK	"acceptable"	valid data, proceed as normal until next CD
CD≤(4xspec) but CD≥(2xspec) for four consec.days	"marginal"	valid data, identify problem, correct, may adj. zero & span with due care, repeat CD check
CD≥(4xspec) or CD≥(2xspec) for five consec. days	"out-of-control"	invalid data, identify problem, correct, recalibrate, repeat CD check
RA specification exceeded	"out-of-control" invalidate data, repair, repeat accuracy audit	

B. When CD≥(2xspec), adjustment of both the zero and span of the CMS are permitted to regain control. This must be done carefully as it is possible to make the situation worse without realizing it by "chasing" an instrument response to an erroneous standard. Recheck the zero and/or span gas supply system for leaks, excess/reduced flow, permeation tube temperature, etc. before making any adjustments.

C. If, for whatever reason, a CMS is declared out-of-control, data shall be invalidated back to the last check which was not out-of-control and shall remain invalid until a check is performed which is within criteria.

D. The QAP shall include contingency procedures for anticipated problems with the CMS. Initially, this may be very brief until source personnel become more familiar with CMS and problems that could be encountered.

Table B-1. Summary of 40 CFR 60, Appendix B, Performance Specifications

Parameter	PS-1	PS-2	PS-3	PS-4	PS-5
Calibration error	≤3%OP[a]	≤5%Span	≤5%Span	≤5%Span	≤5%Span
Calibration drift(CD)	≤2%OP[a]	≤2.5% Span	≤0.5%O_2 or CO_2	≤5%Span	≤5%Span (1.5ppm/ 30ppmFS)
Relative Accuracy(RA)	-------	≤20%RM[b] ≤10%Std	≤20%RM[b] or ≤1%$O_2$$CO_2$	≤10%RMb or 5% Std	≤20%RMb or 10% Std

Where: %OP = % opacity
Std = emission standard
Span = FS = full scale range of CMS
RM = concentration of pollutant by reference method.

and

a = sum of absolute value of mean and absolute value of confidence coefficient(95%)

$= |x_{avg}| + |t_{.975} * s/\sqrt{n}|$

b = % mean difference between RM concentration and CMS response plus 2.5% confidence coefficient divided by the RM concentration.

$= [|d_{avg}| + |t_{.975}s/\sqrt{n}|] * 100/RM$

$|d| = |CEMS\ resp - RM|$

APPENDIX C
Reporting Forms

Continuous Monitoring Manual
Appendix C
Table of Contents

C.1.0 CONTINUOUS MONITORING REPORT

I. Source Information

Reporting Period: From_____ To_____
Company name: _____
Plant name: _____
Source: _____
ACDP#: _____
Operation time (hrs) _____

II. Continuous Monitor Information

Continuous Monitor	Manufacturer	ID#	Type	Span	Location

III. Continuous Monitor Operation Summary+

Continuous Monitor	Downtime* From	To	Reason	Corrective Action

* Excluding zero and span checks (calibration drifts)
Total monitor downtime as a percent of source operating time ____

IV. Excess Emissions Summary+

Pollutant/ Parameter	Excess Period From	To	Average Excesses	Reason

Total excess emissions as a percent of source operating time ___

+ Attach extra sheets if necessary

V. Data Averages

Attach summaries of 1-hour data averages of pollutant emissions for the reporting period. Note the overall emissions average for the reporting period below.

Pollutant	Average Emissions	Units

VI. Accuracy Assessment Results

Complete forms A, B, or C for each CMS or for each pollutant and diluent analyzer, as applicable. If the quarterly audit results show the CMS to be out-of-control, report the results of both the quarterly audit and the audit following corrective action showing the CMS to be operating properly. Attach the forms to this report.

VII. Calibration Drift Assessment

Continuous Monitor	Out-of-Control Periods From	To	Corrective Action Taken

Report Prepared by _____ Date_____

C.1.1 Continuous Monitoring Report Instructions

I. Source Information

Enter the reporting period (i.e. 1/1/91 to 1/21/91), the company name, the plant name or location, the facility (i.e. hogged fuel boiler #1), and the Oregon Air Contaminate Discharge Permit (ACDP) number.

II. Continuous Monitor Information

Enter the manufacturer of the major component(s) of the CMS (i.e. Horiba for a CO analyzer), the serial number and model number, the type (i.e. in-situ or extractive non-dispersive infrared), the span (i.e 1000 ppm), and the location (i.e. downstream of the wet scrubber in the stack). This information will remain the same for each report unless a component is changed.

III. Continuous Monitor Operation Summary

If the monitor was inoperative for any reason other than routine calibration drift checks and maintenance, note the time period the CMS was down, the reason, and the corrective action taken to get the CMS back on line. The reason and corrective action explanations shall be provided in detail.

IV. Excess Emissions Summary

List the duration and magnitude of all excess emissions for regulated pollutants (i.e. CO) and operating parameters (i.e. scrubber pressure differential). Provide a detailed explanation for the excess emissions if there is a discernible reason (i.e. feed water pump failure, grate cleaning, etc.).

V. Data Averages

Attach a summary of the data collected during the reporting period. The format for the data summary shall be developed by the source operator and approved by the DEQ. It shall include some means of "high-lighting" excess emission periods. List the reporting period average emissions for all regulated pollutants (i.e. opacity, carbon monoxide, etc.) and the units of the emissions (i.e. lbs/hr).

VI. Accuracy Assessment Results

If performance audits were required during the reporting period, complete and attach the appropriate section (A, B, or C and D if

applicable) of the accuracy assessment form showing the results of the audit and the accuracy of the CMS.

VII. Calibration drift assessment

List any periods of CMS out-of-control during the reporting period due to excessive calibration drift and a detailed explanation of the corrective action taken to bring the CMS into control.

C.2.0 ACCURACY ASSESSMENT RESULTS REPORT

A. Relative Accuracy Test Audit (RATA) for _____

1. Date of audit _____

2. Reference methods (RM's) used _____

3. Average RM value _____

4. Average CMS value _____

5. Absolute value of mean difference (d) _____

6. Confidence coefficient (CC) _____

7. Percent relative accuracy (RA) _____

8. EPA performance audit results:

   a. Audit lot number (1)_____, (2)_____

   b. Audit sample number (1)_____, (2)_____

   c. Results (mg/dscm) (1)_____, (2)_____

   d. Actual value (mg/dscm) (1)_____, (2)_____

   e. Relative error (1)_____, (2)_____

B. Relative accuracy audit (RAA) for _____

1. Date of audit _____

2. Reference methods (RM's) used _____

3. Average RM value _____

4. Average CMS value _____

5. Percent accuracy _____

6. EPA performance audit results:

   a. Audit lot number (1)_____, (2)_____

   b. Audit sample number (1)_____, (2)_____

c. Results (mg/dscm) (1)_____, (2)_____

d. Actual value (mg/dscm) (1)_____, (2)_____

e. Relative error (1)_____, (2)_____

C. Cylinder gas audit (CGA) for _____

	Audit Point 1	Audit Point 2
1. Date of audit		
2. Cylinder ID number		
3. Date of certification		
4. Type of certification		
5. Certified audit value		
6. CMS response value		
7. Accuracy (percent)		

D. Corrective Action for excessive inaccuracy:

1. Out of control periods: Dates

2. Number of days

3. Corrective action taken _____

_____

_____

4. Results of audit following corrective action. (Use A, B, or C above, as applicable, to report results.)

C.2.1 Accuracy Assessment Report Instructions

Complete section A, B, or C, and D if applicable, each time a performance audit is conducted. Attach the report to the monthly continuous monitoring report.

Line-by-line instructions:

A. Enter the continuous monitoring system (i.e. carbon monoxide) that is being checked by a RATA

1. Enter the date of the audit (i.e. 1/1/91)

2. Enter the reference methods used (i.e. EPA methods 1 through 4 for stack gas volumetric flow and method 10 for carbon monoxide, write them as follows: EPA M 1-4, 10).

3. Average the reference method values (at least 9 results and reported in units of the permit limit: i.e. lbs/hr).

4. Average the CMS values (in units of the permit limit) during the testing.

5. Calculate the arithmetic mean of the difference (d) between the RM and CMS.

6. Enter the confidence coefficient (CC) as calculated from the following formula and the t-value table.

$$CC = t_{0.975} * S_d/\sqrt{n}$$

where;

$t_{0.975}$ = t-value from table

n = number of test RM results

S_d = standard deviation

$$= \{[\Sigma\ d_i^2 - (\Sigma\ di)^2/n]/(n-1)\}^{1/2}$$

where;

n = number of RM test results

d = difference between individual RM and CMS results

7. Calculate the relative accuracy (RA) by the following formula:

$$RA = 100 * (|\bar{d}| + |CC| / \overline{RM})$$

where;

$|\bar{d}|$ = absolute value of the arithmetic mean of the RM and CMS difference.

$|CC|$ = absolute value of the confidence coefficient calculate above.

$\overline{RM}$ = Average reference method value or applicable standard.

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.

8. If it is required that EPA audit samples be analyzed during the reference method testing (i.e. Method 6 and 7, SO_2 and NO_x), enter the results in the space provided. The actual value will be entered by the DEQ and the relative error will be calculated by the DEQ. The DEQ will notify the source operator and testing company if the percent error is greater than 5%. Results of the audit analysis are available upon request.

B. Relative accuracy audit (RAA)

The instruction for lines 1 through 4 and 6 are the same as for lines 1 through 4, and 8 above.

5. Calculate the percent accuracy (A) using the following formula:

$$A = (C_m - C_a)/C_a * 100$$

where;

C_m = Average of CMS response during the audit in units of the standard.

C_a = Average audit value (reference method results) in units of the standard.

C. Cylinder gas audit (CGA)

Complete the table as follows:

1. Enter the date of the audit.

2. Enter the calibration gas identification number.

3. Enter the date that the cylinder gas was certified.

4. Enter the type of certification (i.e. NIST-SRM, EPA-CRM, Protocol-1, reference method).

5. Enter the certified audit value (concentration: percent or parts per million).

6. Enter the CMS response value.

7. Calculate the accuracy (A) using the following formula:

$$A = (C_m - C_a)/C_a * 100$$

where;

C_m = Average of CMS response during the audit in units of the appropriate concentration.

C_a = Average audit value (CGA certified value) in units of the appropriate concentration.

Note: audit point 1 shall be 20-30% of the span value, audit point 2 shall be 50-60% of the span value.

D. Corrective action for excessive inaccuracy

1. Enter the dates that the CMS is out-of-control due to excessive inaccuracy.

2. Enter the number of days that the CMS is out-of-control due to excessive inaccuracy.

3. Describe in detail the corrective action taken to bring the CMS back into control (i.e. replaced leaking sample line, replaced detector, etc.)

4. Complete the appropriate form (A, B, or C) to show that the CMS successively completed an audit and is back in control.

Appendix D
Code of Federal Regulations
Appendices B and F

Appendices B and F of 40 CFR Part 60 will be included in the final version of the Continuous Monitoring Systems Manual. This material is directly from 40 CFR Part 60.