Guidelines for CEMS Performance Specifications and Quality Assurance Requirements for Municipal Waste Combustion Facilities

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This guideline document is based on discussions of a workgroup organized by the Northeast States for Coordinated Air Use Management (NESCAUM). The workgroup was created to provide guidance to state and local agencies which use or plan to use continuous emission monitoring systems (CEMS) to determine compliance at municipal waste combustion (MWC) facilities. The guidelines are intended to promote consistency in designing and operating CEMS and reporting monitoring data. The document reflects the recommendations of state and federal agency staff. In addition, a draft of these guidelines was distributed to other agencies, CEM equipment vendors, and MWC owners and operators. Their comments and suggestions were reviewed and discussed by the workgroup and appropriate changes were made to the guidelines.

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SECTION 1 -- SUMMARY

This guideline document is based on discussions of a workgroup organized by the Northeast States for Coordinated Air Use Management (NESCAUM). The workgroup was created to provide guidance to state and local agencies which use or plan to use continuous emission monitoring systems (CEMS) to determine compliance at municipal waste combustion (MWC) facilities. The guidelines are intended to promote consistency in designing and operating CEMS and reporting monitoring data. The document reflects the recommendations of state and federal agency staff. In addition, a draft of these guidelines was distributed to other agencies, CEM equipment vendors, and MWC owners and operators. Their comments and suggestions were reviewed and discussed by the workgroup and appropriate changes were made to the guidelines.

The NESCAUM recommendations reflect a consensus of the workgroup participants arrived at through discussions during several meetings. The resulting recommendations reflect the collective experience, opinions, and judgement of the workgroup participants from the regulatory agency perspective. The scope of this project did not include the acquisition or analysis of data or other information to serve as the basis for specific requirements or recommendations.

The NESCAUM workgroup recommends that states adopt regulations which require the use of CEMS to determine compliance with emission standards on a continuous basis at MWC facilities. The regulations should:

· Establish initial certification procedures and requirements for CEMS

· Define quality assurance (QA) procedures and criteria for the ongoing determination of the acceptability of the CEMS and the monitoring data

· Specify minimum data capture requirements

The CEMS requirements in 40 CFR 60, including 60.13 "Monitoring requirements", Appendix B - Performance Specifications, and Appendix F - Quality Assurance Procedures are recommended as a working base for state regulations. The federal requirements, however, are recognized as the minimum needed to ensure reliable CEMS performance and acceptable emissions data. The federal regulations have not been recently revised to keep up with the evolution of CEM technology. Recommendations are included here to address problems encountered in actual practice which are not adequately resolved by the existing federal regulations. The recommendations are specifically designed for CEMS programs at MWC facilities and they attempt to address technical issues that may be encountered in the implementation of monitoring programs subject to a wide variety of state regulations. It is hoped that these recommendations will facilitate a more consistent approach in state

CEMS programs and requirements.

State requirements for emission standards, percent removal requirements, averaging times, and reporting may differ substantially from the EPA New Source Performance Standards currently being developed. Significant differences among the various state regulations are also likely. Therefore, the NESCAUM workgroup recommendations for performance specifications and quality assurance procedures are presented in general terms rather than in specific regulatory language. States desiring to adopt these recommendations will need to make appropriate modifications to them so that they are compatible with the applicable emission standards and other existing regulations. Specific language for requirements based on the modified recommendations and the referenced federal regulations will also need to be developed by each state agency.

The following sections of this document present detailed recommendations for performance specifications and quality assurance requirements for gas and opacity CEMS. Many of the specifications are expressed in terms of "percent of span" since the actual measurement range of the instrumentation should be specified by the state agency to be compatible with the applicable regulations and enforcement policies. In specifying the span value, the agency should consider trade-offs between an expanded measurement range and more accurate data at typical emission levels or at the level of the emission standard. Some factors to consider in specifying the span value include: the applicable emission standard or percent removal requirement, the averaging time for the standard, the inherent variability of uncontrolled and controlled emissions during normal operation and during malfunctions of the facility, and the actions to be taken by the agency and the source owner or operator if emissions exceed the measurement range of the CEMS.

The recommendations presented in this document were developed for MWC facilities. Many of these recommendations could also be applied to other sources; however, no attempt was made in this project to identify or address the specific technical and regulatory issues associated with CEMS programs at other source categories. These issues include:

· procedures used to convert gas concentration measurements to units of the standard,

· emissions variability associated with the process and control equipment and the corresponding averaging time for CEMS data recording and reporting and determining compliance with applicable standards,

· likelihood of substances within the effluent stream causing analytical interferences with either CEMS measurements or reference measurements used for relative accuracy determinations

· effluent conditions such as temperature, pressure, moisture content, and the presence of other materials within the effluent stream that may affect the operation and reliability of

instrumentation.
Careful consideration of these and other issues is warranted in applying the recommendations presented here to other source categories.

The recommended performance specifications provide the basis for determining the initial acceptability of the CEMS and the quality assurance requirements provide a basis for determining the ongoing acceptability of data and monitoring equipment. The quality assurance recommendations include criteria for deciding that a monitoring system is "out-of-control" and state that data collected during such periods cannot be used to satisfy minimum data capture (i.e., data availability) requirements. A minimum data availability requirement has been included in the quality assurance recommendations. It is recognized that some states may require higher levels of CEMS availability, or define CEMS availability in other terms.

The additional requirements associated with the workgroup recommendations will increase the costs of CEMS performance tests and quality assurance activities. However, for many sources the additional cost will be relatively small since effective CEM programs which can meet the recommended requirements have already been developed and implemented. It is hoped that the guidelines will help avoid costly misunderstandings between the source and the agency which can result in the purchase or installation of unacceptable equipment. The incremental costs attributable to the NESCAUM workgroup recommendations are believed to be a relatively small fraction of the total costs for MWC facilities.

1. Summary of Performance Specification Recommendations for Gas CEMS

NESCAUM workgroup recommendations for performance specifications for SO2 and NOx CEMS, CO CEMS, and HCl CEMS are presented in Section 2 through 4 of this document, respectively. The recommendations reference the federal regulations. Major differences include:

a. Calibration gases are required to be used for daily calibration checks, performance tests and periodic audits of all CEMS. Calibration of the entire measurement system is required. Procedures are included to allow source owners or operators to demonstrate alternate procedures and alternate methods for calibration checks and audits. These requirements are designed to eliminate use of calibration procedures that check only a portion of the measurement system and procedures that have not been evaluated and documented by the user.

b. The values of calibration gases used for drift tests and daily calibration checks must be determined quantitatively. Several procedures are provided to establish the values of the gases. These requirements are necessary to assess the accuracy of the monitoring data on a daily basis.

c. A four-point linearity test must be performed for gas monitors.

This can be done with the two gases used for the daily checks and two Protocol 1 gases used for quarterly audits. (A three-point check is required for HCl monitors.) This requirement is necessary to eliminate the use of non-linear monitoring systems which may be adjusted to provide the correct response at zero and upscale calibration check points but do not necessarily provide accurate data at other concentrations.

d. An additional minimum accuracy specification e.g., mean difference not to exceed 5 ppm, or equivalent (10 ppm for CO monitors) is added to prevent the accuracy specifications from being overly restrictive for those applications where emission levels are very low. The relative accuracy test procedures are also clarified to eliminate some of problems that are encountered in conducting these tests at MWC facilities.

e. A cycle time/response time specification and test procedure is added for all monitors. The specification for SO2 , NOx, diluent, and HCl monitors is 15 minutes which is consistent with the EPA requirements in 40 CFR 60.13. A one-minute cycle time/response time specification is included for CO monitors since some states will require reporting of one-minute values for this pollutant.

2. Summary of Quality Assurance Recommendations for Gas CEMS

NESCAUM workgroup recommendations for quality assurance requirements for all gas CEMS are presented in Section 5 of this document. The recommendations reference the federal regulations. Major differences include:

a. Submission of a preliminary monitoring plan to the agency is required in most cases. The plan should set forth the basic approach that will be used to comply with the monitoring requirements. It is hoped that agency review of the plan will help resolve misunderstandings, unacceptable approaches, and confusion about the monitoring requirements before costly mistakes occur.

b. A CEMS quality assurance plan should be developed for each facility. Detailed guidance is provided with respect to the QA plan content.

c. An annual review of the QA plan and results of its implementation is required to be performed by the source owner or operator. The results of this review and changes to the QA plan are reported to the agency.

d. Routine zero and upscale calibration checks of the monitoring system must be performed on a daily basis. This requirement is equivalent to the daily calibration check in 40 CFR 60.13 except that the procedures recommended here are similar to those described for the performance specification test.

e. A cylinder gas audit consisting of the four-point linearity test described in the performance specification recommendations should be performed each calendar quarter. Only routine calibration adjustments according to the written procedures in the QA plan are permitted before the audit.

f. A relative accuracy test should be performed in one calendar quarter immediately before or after the cylinder gas audit. The

CEMS must pass both tests for performance to be considered acceptable.

g. A minimum data availability specification of 90 percent of source operating hours is included. The time required for zero and upscale calibration checks, cylinder gas audits, and certain QA activities included in approved plans is not subtracted from CEMS availability.

3. Summary of Performance Specification Recommendations for Opacity CEMS

NESCAUM workgroup recommendations for performance specifications for opacity CEMS are presented in Section 6 of this document. The recommendations reference the federal regulations. Major differences include:

a. All opacity monitors must provide external calibration filter access to facilitate performance audits.

b. All opacity monitors must provide access to instantaneous or one-minute opacity measurements in addition to six-minute averages.

c. Calibration error tests must be performed in the field or a performance audit must be conducted to demonstrate that test results from the manufacturer are representative of performance of the installed monitor.

4. Summary of Quality Assurance Recommendations for Opacity CEMS

NESCAUM workgroup recommendations for quality assurance requirements for opacity CEMS are presented in Section 7 of this document. The recommendations are similar to the requirements for gas CEMS except:

a. A opacity monitor performance audit is conducted instead of the cylinder gas audit that is required for gas monitors.

b. A zero alignment procedure is performed for opacity monitors instead of the relative accuracy test that is required for gas CEMS.

SECTION 2
PERFORMANCE SPECIFICATIONS FOR SO2 AND NOx CEMS AT MUNICIPAL WASTE COMBUSTION FACILITIES

This section describes the NESCAUM workgroup recommendations for monitor location requirements, equipment and performance specifications, and corresponding test procedures for SO2 and NOx CEMS installed at MWC facilities. Specifically, the NESCAUM workgroup recommends that states consider adopting the EPA requirements contained in "PERFORMANCE SPECIFICATION 2 - SPECIFICATION AND TEST PROCEDURES FOR SO2 AND NOx CONTINUOUS EMISSION MONITORING SYSTEMS IN STATIONARY SOURCES" of 40 CFR 60, Appendix B revised as of July 1, 1988, with the changes detailed in Items 1 through 8 below. When emission standards necessitate use of a diluent monitor (O2 or CO2) to determine emissions in units of the standard, NESCAUM recommends that states consider adopting the EPA requirements contained in "PERFORMANCE SPECIFICATION 3 - SPECIFICATIONS AND TEST PROCEDURES FOR O2 AND CO2 CONTINUOUS EMISSION MONITORING SYSTEMS IN STATIONARY SOURCES" of 40 CFR 60, Appendix B revised as of July 1, 1988, with the changes detailed below.

1. Use of Calibration Gases

A design specification should be added to require that SO2, NOx and diluent monitors be able to accept calibration gases for daily calibration checks, performance specification tests, and periodic quality assurance audits. Furthermore, the design specification should require that the calibration gas injection point be in the sample probe or at the probe outlet so that the entire measurement system is checked when calibration gases are introduced to the monitoring system. For measurement systems employing dilution probes or similar devices, the calibration gases must be introduced prior to the dilution point and in such a manner that they are diluted to the same extent as the sample gases from the effluent stream. Similarly, for sample acquisition systems using aspirators or eductors, the calibration gases must be introduced prior to these devices even if these components are part of the sample probe assembly.

Source owners or operators (or instrument vendors) may demonstrate that alternate daily calibration check procedures or devices provide results comparable to those obtained by using calibration gases to check the entire measurement system. For example, a source owner or operator may elect to demonstrate the validity of an alternate calibration check procedure for (1) in-situ monitors that accept calibration gases and which also use calibration gas cells, or (2) for extractive monitors where daily calibration checks of the entire system are unnecessarily burdensome. In such cases, a demonstration can be accomplished by conducting concurrent calibration drift tests using both the

specified method and the alternate method during the performance specification test. If the results indicate acceptable monitor performance with respect to the applicable drift specifications, the alternate procedure may be used for the daily zero and upscale checks of the monitor. However, the quality assurance plan must include (1) a detailed discussion of all assumptions associated with the alternate procedure, and (2) mandatory procedures for conducting periodic comparisons of the specified and alternate calibration methods. Such comparisons should be performed on a monthly or more frequent basis until the alternate procedure has been evaluated and documented to the satisfaction of the agency.

Source owners or operators may request approval of alternate routine calibration check procedures for monitors that cannot accept calibration gases and alternate procedures for conducting the linearity and response time tests for these monitors. Source owners or operators are cautioned that alternate calibration procedures need to be evaluated carefully and thoroughly and that a single relative accuracy test at one operating condition does not provide a sufficient evaluation of the validity of a particular calibration procedure. The source owner or operator should submit a written plan to the agency for conducting such a demonstration. If the plan is approved, the source owner or operator may carry out the demonstration program and submit a detailed report describing the alternate procedure, all assumptions associated with the alternate procedure, the procedures and conditions of the demonstration, the results of the tests conducted, and appropriate revisions to the CEMS quality assurance plan, as applicable. The validity of any alternate procedure would be re-examined during quarterly accuracy audits.

2. Data Availability and Back-Up Data Recording Devices

All CEMS must operate continuously without repairs, unscheduled maintenance, or non-routine adjustments during the performance specification tests to determine calibration drift, linearity, and relative accuracy. In addition, minimum data availability specifications are included as QA requirements and are applicable to the operation of the CEMS after completion of the performance specification tests. (See Section 5, Quality Assurance Requirements for SO2, NOx, CO, and HCL CEMS, 8. Minimum Data Availability Requirements of this document.)

Most CEMS at MWC facilities will include a computer data acquisition system that performs various operations including (1) recording effluent concentration measurements, (2) recording daily calibration check results, (3) compensation of effluent measurements for drift, (4) calculation of emissions in units of the standard, (5) averaging of measurement data, (6) generating excess emission reports, and (7) interfacing with telecommunication systems where required by the agency. Data acquisition systems are inherently monitor- and source-specific and may need to accommodate diverse reporting requirements of various states, therefore much

flexibility in the design of these systems is needed. When the data acquisition system is inoperative, many vital CEMS functions are suspended and data availability is immediately affected. Source owners and operators are encouraged, but not required, to include a back-up recording device or other appropriate redundancy within the data acquisition system to maximize data availability. Where such devices are used, conformance with the calibration drift and linearity specifications should be determined based on results obtained from both the primary data acquisition system and the back-up recording devices in order to avoid additional testing when the back-up recording device is placed in service. However, failure of a performance specification based on data from a back-up recording device should not necessitate retesting.

3. Calibration Drift Test and Reference Values

The calibration drift specifications for SO2 and NOx monitors (2.5 percent of span) and O2 and CO2 monitors (0.5 percent O2 or CO2) as well as the calibration drift test procedures in Performance Specifications 2 and 3 should be maintained except that (1) the calibration drift tests must be performed using calibration gases or other prior approved alternate calibration procedure, and (2) the concentration value of the calibration gases must be known. The values of the calibration gases may be established through the use of certified reference materials (CRMS), standard reference materials (SRMS), or EPA Protocol 1 gases. Alternatively, calibration gas values determined by the gas manufacturer's certified analysis (i.e., + 2 % of tag value) may be used if the concentration is checked by direct comparison with Protocol 1 gases, or by triplicate analysis using an appropriate EPA test method or an equivalent procedure. The direct comparison of tag values and Protocol 1 gases can be accomplished using the installed CEMS in most cases.

Comparison with Protocol 1 gases may be accomplished by introducing both the subject gas, a zero concentration gas and at least two Protocol 1 gases into an analyzer demonstrated previously to meet the linearity test specification in Item 4, below. (Ambient air and two Protocol 1 gases may be used for O2 monitors which cannot analyze zero gas.) The Protocol 1 gases should satisfy the audit range specifications of Appendix F, Procedure 1; however, alternate ranges including at least two Protocol 1 gases which bracket the concentration value of the subject gas may also be used, subject to the approval of the agency. The analyzer responses to all of the Protocol 1 calibration gases shall be used to construct a calibration curve for the analyzer. The analyzer response to the subject gas and the calibration curve shall be used to determine the concentration of the subject gas. If the difference between the measured concentration and the tag value of the subject gas is less than 3 percent of the tag value, use the tag value as the actual concentration. If the difference between the measured concentration and the tag value is greater than 3

percent of the tag value, repeat all gas injections and check all calculations. If the difference still exceeds 3=percent of the tag value, use the measured concentration as the actual concentration. (See 40 CFR 60, Appendix A, Method 6C, "6.1.2 Alternative Number 2" for specific requirements for the analysis of SO2 calibration gases by EPA test methods. Similar procedures may be used for the analysis of NO and diluent calibration gases. See Method 7E , Section 6.1 for analysis criteria for NO calibration gases.)

Calibration drift tests are intended to identify problems that affect the stability of the monitor calibration; however, such tests are conducted over a short period and therefore cannot represent the full range of operating conditions for the CEMS. Experience has shown that many of the problems resulting in excessive calibration drift and loss of monitoring data are related to poorly conditioned electrical power, inadequate or unsuitable compressed air supply, excessive vibration, ambient temperature changes, ambient dust loading, and other site-specific application problems. Source owners and operators are strongly encouraged to identify these and other problems that may affect CEMS performance and take appropriate actions to minimize the loss of CEMS data due to these problems.

4. Linearity Test

A new performance specification and test procedure should be added to require a four-point cylinder gas audit to demonstrate the linearity of each pollutant and diluent monitoring channel. The linearity specification and test procedure applies to the entire monitoring channel, including the data acquisition system, as installed and operated at the MWC facility. (A non-linear analyzer used in conjunction with appropriate adjustments by the data acquisition system is acceptable.) Source owners and operators are encouraged, but not required, to have equipment vendors demonstrate conformance with the linearity specification prior to shipment of the CEMS to the subject facility. However, the linearity test is required to be conducted for each CEMS after installation.

The linearity test should use the zero and upscale calibration values used for the daily calibration checks and the two audit points specified for cylinder gas audits by Appendix F, Procedure 1. If the high range audit point (i.e., 50 to 60 percent of the pollutant monitor span) of Procedure 1 is used for the daily upscale checks, an audit gas of 80 to 90 percent of span should be substituted for the high range audit point. Protocol 1 gases, CRMS or SRMS should be used for the two audit points that supplement the daily calibration checks. Three non-consecutive measurements should be made for each of the calibration gases (e.g., zero, low, mid, high, zero, low, mid, high, etc.)

The linearity specification should require that the mean difference between the calibration gas value and the monitor responses at each of the four points be calculated from the three measurements. The mean difference at all four test points must be

less than 5 percent of span for SO2 and NOx monitors and 0.5 percent O2 or CO2 for diluent monitors.

The linearity test should be performed as soon as practical before or after the relative accuracy test. Only the routine calibration drift adjustments are allowed between the two tests. Other adjustments or repairs to the monitoring system would necessitate repeating the linearity and the accuracy test. (During subsequent quarterly audits, only calibration drift adjustments according to the written procedure contained in an approved QA plan are allowed prior to the linearity test or the relative accuracy test.)

5. Relative Accuracy Test

The workgroup recommends that states maintain the performance specification test procedures for the relative accuracy test in Performance Specification 2 with the clarifications described below. The daily calibration checks should be performed on each day that the relative accuracy testing is performed and that no adjustments or repairs to the monitoring system other than the routine calibration drift adjustments may be conducted. The distinction between routine adjustments and corrective action for a malfunctioning CEMS is particularly difficult for the initial relative accuracy test since there is little or no track record on which to base decisions and since the QA plan is usually incomplete. The following approach is recommended to resolve this issue. Prior to conducting the test, the source operator must establish (1) the criteria for adjustment of the monitor calibration, (2) the criteria or schedule for the performance of routine maintenance activities, and (3) the frequency or criteria for conducting additional calibration checks. This information should be made available to the agency observer. The daily calibration checks should be performed following the normal procedure before initiating the test and adjustments should only be made as indicated by the applicable criteria. During the test, the source may check the calibration at reasonable intervals and abort the test if unscheduled maintenance or adjustment are necessary. If corrective action other than routine adjustments are required, a 24-hour period should elapse to verify that the CEMS drift is within acceptable limits before a new test is begun. The new test may begin immediately, subject to the approval of the agency, if it can be shown that the corrective action or adjustment does not affect the calibration drift of the CEMS.

Performance Specifications 2 and 3 require only that the relative accuracy test be performed for the entire measurement system (i.e., pollutant and diluent monitor) in units of the applicable standard. However, the source owner or operator is strongly encouraged, but not required, to determine also the relative accuracy for each monitoring channel in units of concentration in order to obtain a more complete evaluation of monitor performance.

Problems in conducting the relative accuracy tests may be encountered where significant fluctuations in the emission levels or very low emission levels are encountered. Therefore, both relative accuracy specifications in Performance Specification 2 (i.e., relative accuracy less than 20 percent of the mean reference value or less than 10 percent of the standard) should be retained. Also, an additional specification should be added to provide an absolute minimum accuracy specification of 5 ppm mean difference for SO2 or NOx CEMS relative to the test method. (See Appendix A for a technical discussion of the various accuracy specifications.) Thus, for a concentration standard corrected to 7 percent O2 the following accuracy specifications should apply; relative accuracy less than 20 percent of the mean reference value, relative accuracy less than 10 percent of the standard, or mean difference less than 5 ppm corrected to 7 percent O2, whichever is least restrictive. For cases where the emission standard is expressed in units of lb/MM=Btu, an equivalent absolute accuracy specification may be calculated using an average or typical diluent concentration. For example, it can be shown that 5 ppm SO2 at 7 percent O2 is approximately equivalent to 0.01 lb/MM=Btu using the F-Factors and conversion values in EPA Method 19.

For sources subject to an SO2 or NOx percent removal standard that is more restrictive than the emission standard (or where there is no absolute emission standard) an implicit emission standard should be determined as:

Implicit Standard = [1-Percent Removal/100] x Avg. Uncontrolled Emissions

The implicit emission standard should be used to calculate the relative accuracy result as "10 percent of the standard." For this determination, the uncontrolled emissions may be obtained by averaging all of the reference test data from the relative accuracy test of the CEMS at the inlet to the control device.

The relative accuracy test procedures should be clarified to explicitly prohibit modification of the operation of time-shared CEMS during the test to increase the sampling frequency, to minimize the frequency of sample system cleaning (blow-back) operations or, to reduce the number of locations from which CEMS samples are obtained. In order to minimize the effects of fluctuating emission levels, the source owner or operator may choose (1) to extend the sampling time to at least 1 hour for integrated sampling methods, or (2) to increase the number of samples that are obtained during a run for grab sampling methods. Alternate relative accuracy test procedures for time-shared CEMS that reduce the number of locations for which reference samples are obtained may be approved by the agency on a case-by-case basis.

The source owner or operator may use EPA Method 6 or instrumental Method 6C for SO2 concentration measurements for relative accuracy tests. Methods 7, 7A, 7C, or 7D or instrumental Method 7E may be used for NOx concentration measurements, and Method 3 or=instrumental Method 3A may be used for O2 or CO2

concentration concentration measurements for relative accuracy tests. NOTE: Methods 7C and 7D may be subject to analytical interferences when used at MWC sources; the applicability of these methods has not been established by field testing at this time.

6. Alternate Accuracy Test Procedure

Section 10. Alternative Procedures of Performance Specification 2 contains procedures for conducting a cylinder gas audit in place of a relative accuracy test when a waiver of the relative accuracy test requirement is granted under the conditions specified in 60.13 (j). According to these regulations, a source owner or operator may petition the Administrator for a waiver of the relative accuracy test requirement when the CEMS is not the compliance method and when the emissions are less than 50=percent of the standard as determined by a source performance test. The regulations specify the content of the petition, the conditions when it may be applied for, and the conditions under which the waiver may be rescinded.

The Performance Specification 2 cylinder gas audit procedures are not needed because the same audit test points are already included as part of the more elaborate linearity test that is recommended for all CEMS installed at MWC facilities. (See Item 4 above.) As with any requirement, the agency may waive the relative accuracy test requirement in cases where the emission levels are very low as indicated by the results of source performance tests or other independent effluent measurements regardless of whether the CEMS are used as the compliance method. However, no general guidance or criteria is provided here for waiving the relative accuracy test requirement.

7. Cycle Time and Response Time Test

A specification should be added that requires all SO2, NOx, and diluent CEMS to complete at least one cycle of operation (sampling, analyzing, and data recording) for each successive 15-minute period, (i.e., a minimum of four samples per hour). Extractive monitoring systems may be time-shared between two measurement locations; however, the cycle time requirement must be met for both measurement locations. (Some states have adopted regulations or policies prohibiting any time-sharing of monitors at MWC facilities, and some states will allow time-sharing only as an emergency backup provision.)

Source owners and operators are encouraged to install monitoring systems fully capable of representing emissions from the facility. The agency should not excuse apparent excess emissions that may be due to nonrepresentative sampling because of long CEMS cycle times or minimum CEMS sampling frequencies. In addition, sources required to install and operate NOx control equipment may be subject to shorter measurement cycle time specifications in the future.

A response time test should be added to determine if each monitoring channel of the CEMS complies with the cycle time/sampling frequency specification. The average upscale and downscale response times should be determined from three repetitions of each test. The greater of the average upscale or average downscale response times should be reported as the response time for the system.

The upscale response time should be determined by injecting zero gas into the measurement system and then recording the amount of time required for the system to return to the effluent concentration after the zero gas injection has been stopped. Similarly, the downscale response time should be determined by injecting a high range calibration gas and then recording the amount of time required for the monitoring system to return to the effluent concentration after the gas injection is stopped. Specifically, the response time may be measured as the time required for the monitor to complete 95 percent of the concentration step-change occurring after the gas injection is stopped during each test. For monitoring systems that perform a series of operations, (purge-blow back, sample, analyze, etc.) the injection of calibration gases should be timed to produce the longest response time.

In many cases, the actual response time of the measurement system is only a few seconds as compared to several minutes to perform the necessary cycle of operations. In these cases, it is often possible to establish conformance with the cycle time requirement by inspection of the system rather than by injection of calibration gases. Such determinations are subject to the approval of the agency.

8. Data Reporting Equipment Specifications

Additional equipment or design specifications may be added by states to facilitate the specific record keeping and reporting requirements that may apply. Various state agencies are currently considering a wide range of alternatives including: automated data reporting using magnetic media, telecommunication systems that allow agency representatives to obtain or review data on-demand from remote locations, and real-time or intermittent telemetry systems for CEM data and information. No additional guidance is included because of the diversity of state requirements and approaches.

SECTION 3
PERFORMANCE SPECIFICATIONS FOR CARBON MONOXIDE CEMS AT MUNICIPAL WASTE COMBUSTION FACILITIES

This section describes the NESCAUM workgroup recommendations for monitor location requirements, equipment and performance specifications, and corresponding test procedures for CO CEMS installed at MWC facilities. Specifically, the NESCAUM workgroup recommends that states consider adopting the EPA requirements contained in "PERFORMANCE SPECIFICATION 4 - SPECIFICATION AND TEST PROCEDURES FOR CARBON MONOXIDE CONTINUOUS EMISSION MONITORING SYSTEMS IN STATIONARY SOURCES" of 40 CFR 60, Appendix B revised as of July 1, 1988, the Federal Register Vol. 53, No. 204, October 21,1988, and the changes detailed in Items 1 through 8 below.

Many of the changes that are recommended for CO monitors are the same as those recommended for SO2 and NOx CEMS. For the purposes of these discussions it is assumed that the CO monitor is used to measure emission levels in units of concentration (ppm). Where a diluent monitor is used to adjust the data to a consistent basis (e.g., 7 percent O2 or 12 percent CO2) or where data is to be reported in terms of combustion efficiency, appropriate adjustments to the recommended requirements should be made. It is assumed that the upper limit of the CO measurement range (span value) would be approximately 300 to 500 ppm. Greater measurement ranges may be needed for facilities using refuse-derived-fuels particularly during start-up. Alternate measurement ranges may be used subject to the approval of the agency when emission levels are consistently much lower than the standard.

1. Use of Calibration Gases

A design specification should be added to require that CO monitors be able to accept calibration gases for daily calibration checks, performance specification tests, and periodic quality assurance audits. In addition, the recommendations regarding where the gases are introduced to the measurement system, the application to dilution sampling systems, and the requirements for demonstrating the adequacy of alternate calibration techniques are the same as described in Section 2 for SO2 CEMS.

Special considerations may apply to CO monitors which utilize a correction procedure to eliminate the influence of CO2. It may be necessary to use CO calibration gases with a specific concentration of CO2 to assess monitor performance. Additional monitor-specific procedures would be needed to verify the accuracy of the correction procedure. These procedures should be evaluated and approved by the agency on a case-by-case basis.

2. Data Availability and Back-Up Data Recording Devices

All CEMS must operate continuously without repairs, unscheduled maintenance, or non-routine adjustments during the

performance specification tests to determine calibration drift, linearity, and relative accuracy. In addition, minimum data availability specifications are included as QA requirements and are applicable to the operation of the CEMS after completion of the performance specification tests. (See Section 5, Quality Assurance Requirements for SO2, NOx, CO, and HCL CEMS, 8. Minimum Data Availability Requirements.)

Recommendations and suggestions regarding the use and performance testing of back-up recording devices for CO CEMS are the same as described in Section 2 for SO2 CEMS.

3. Calibration Drift Test and Reference Values

In many cases, the daily upscale calibration check value required by Performance Specification 4 (i.e., 50 to 90 percent of span) is very much greater than both the normal CO operating level and the level of the emission standard. Calibration checks at these levels may not represent actual performance of the monitor. The requirement should be revised to allow the use of an upscale calibration check value that either (a) approximates the CO concentration equivalent to the applicable emission limit, or (b) is within 50 to 90 percent of the span value. Other upscale calibration check values may be used subject to the approval of the agency. Source operators may elect to conduct additional checks of the CO monitor calibration to evaluate the monitoring data for their own uses.

The calibration drift specification for CO monitors in Performance Specification 4 (drift not to exceed 5 percent of span for 6 out of 7 test days) should be changed to restrict drift to 3 percent of span for 7 consecutive days. The more restrictive limit is consistent with the capabilities of contemporary instrumentation. Also, the expression of the limit not to be exceeded for 7 consecutive days is necessary for the implementation of Appendix F, Procedure 1 control limits.

The drift test procedures in Performance Specification 4 should be maintained except that (1) the calibration drift tests must be performed using calibration gases or other prior approved alternate calibration procedure, and (2) the concentration value of the calibration gases must be known. The specifications and procedures that may be used for establishing the values of the calibration gases are the same as described in Section 2 for SO2 CEMS. The suggestion that the source owner or operator identify application problems that may affect the stability of the CO CEMS is also the same as for SO2 CEMS.

4. Linearity Test

A new performance specification and test procedure should be added to require a four-point cylinder gas audit to demonstrate the linearity of CO monitors. The linearity specification and test procedures apply to the entire monitoring channel, including the data acquisition system, as installed and operated at the MWC

facility. (A non-linear analyzer used in conjunction with appropriate adjustments by the data acquisition system is acceptable.) Source owners and operators are encouraged, but not required, to have equipment vendors demonstrate conformance with the linearity specification prior to shipment of the CEMS to the facility. However, the linearity test is required to be conducted for each CEMS after installation.

The requirements for the selection of the audit points for the linearity test and the test procedures for CO monitors are the same as described in Section 2 for SO2 CEMS. The linearity specification should require that the mean difference between the calibration gas value and the monitor responses at each of the four points be calculated from the three measurements. The mean difference at all four test points must be less than 5 percent of span for CO monitors.

The linearity test should be performed as soon as practical before or after the relative accuracy test. Only the routine calibration drift adjustments are allowed between the two tests. Other adjustments or repairs to the monitoring system would necessitate repeating the linearity and the accuracy test. (During subsequent quarterly audits, only calibration drift adjustments according to the written procedure contained in an approved QA plan are allowed prior to the linearity test or the relative accuracy test.)

5. Relative Accuracy Test

The recommended procedures and conditions for the relative accuracy test are the same as those described above for SO2 CEMS. In addition, the workgroup recommends that both of the relative accuracy specifications in Performance Specification 4 (i.e., relative accuracy less than 10 percent of the mean reference value or less than 5 percent of the standard) be retained. Also, an additional specification should be added to provide an absolute minimum accuracy specification of 10 ppm mean difference for CO CEMS relative to the reference test method. Thus, for a concentration standard the following accuracy specifications should apply: relative accuracy less than 10=percent of the mean reference value, relative accuracy less than 5 percent of the standard, or mean difference less than 10 ppm, whichever is least restrictive. Where necessary, the 10 ppm mean difference limit may be converted to an equivalent limit expressed in units of the applicable standard using the average diluent concentration measured during the relative accuracy test and applicable conversion factors.

The relative accuracy test should be performed using Method 10. When the installed CEMS uses a nondispersive infrared (NDIR) analyzer, Method 10 shall use the alternative interference trap specified in section 10.1 of the method. Method 10B is an acceptable alternative to Method 10. The following alternatives

may be approved by the agency in specific cases.

Alternative 1 - The test may be conducted using Method 10 without the interference trap if a laboratory interference test is performed for the analyzer prior to the field test. The laboratory interference test should include the analysis of SO2, NO, and CO2 calibration gases representing the range of expected effluent concentrations. Acceptable performance is indicated if the CO analyzer response to each of the gases is less than 1 percent of the applicable measurement range of the analyzer.

Alternative 2 - The test may be conducted using Method 10 without an interference trap, and without a CO2 trap, subject to the approval of the agency, based on the submission of information demonstrating the absence of CO2 interference for the test analyzer. (If this option is chosen, any interferences that are present will cause the test analyzer to be biased high. There is also a possibility that the installed monitor would be subject to the same interference which would not be detected during the relative accuracy test. The potential for the high bias may be acceptable to the agency provided that the source owner or operator accepts the potential bias and cannot later challenge the accuracy of the data.)

6. Alternate Accuracy Test Procedure

As described in Section 2 for SO2 CEMS, the alternate accuracy test procedure for CO monitor are not needed since the more elaborate linearity test is required for all CO monitors installed at MWC facilities. The agency may waive the relative accuracy test requirement if the emissions are consistently very low (e.g., less than 20 ppm) based on source performance test results (i.e., "compliance tests") or other independent effluent measurements. The agency should be cautious in waiving the relative accuracy test requirement based solely on CEMS data since some analyzers have been found to respond poorly to low concentrations of CO.

7. Cycle Time and Response Time Test

For sources subject to an emission limit with a one-hour or shorter averaging period, an additional specification should be included that requires the CO CEMS to complete at least one cycle of operation (sampling, analyzing,
and data recording) for each successive one-minute period, (i.e., 60 samples per hour) with an allowance of 10=minutes per hour for cleaning and calibration operations. For sources subject to limits with longer averaging periods, alternate cycle time specifications may be established by the agency. A response time test should be added to determine if the CO monitor meets the cycle time/sampling frequency specification. The response time test should be conducted according to the procedures described above for

SO2 CEMS.

CO monitors with response times exceeding the applicable cycle time specification are acceptable if the longer response time is due to delay or "lag" time attributable to the sample acquisition equipment. For these monitors, performance is acceptable if the time between the analyzer's initial response and the response equivalent to 95 percent of the actual concentration change is less than the cycle time specification (regardless of the delay between the analyzer's initial response and the time that the gas injection is stopped during the response time test) provided that the total response time does not exceed 15 minutes.

8. Data Reporting Equipment Specifications

Additional equipment or design specifications may be added by states to facilitate the specific record keeping and reporting requirements that may apply. Various state agencies are currently considering a wide range of alternatives including: automated data reporting using magnetic media, telecommunication systems that allow agency representatives to obtain or review data on-demand from remote locations, and real-time or intermittent telemetry systems for CEM data and information. No additional guidance is included because of the diversity of state requirements and approaches.

SECTION 4
PERFORMANCE SPECIFICATIONS FOR HCl CEMS AT MUNICIPAL WASTE COMBUSTION FACILITIES

Some states may require that HCl CEMS be used to monitor emissions and/or determine HCl control efficiency at MWC facilities. The NESCAUM workgroup did not address nor attempt to determine whether HCl CEMS should be installed at MWC facilities. It is noted that the EPA has not adopted performance specifications for HCl monitors in Part 60 and has not announced plans to require HCl monitors at MWC facilities or any other sources regulated under the New Source Performance Standards. Nevertheless, the NESCAUM workgroup recommends appropriate monitor location requirements, equipment and performance specifications, and corresponding test procedures for HCl CEMS installed at MWC facilities. This section describes the NESCAUM workgroup recommendations for HCl CEMS performance specifications based on currently available information. Changes to these specifications may be appropriate as additional information and operational experience with HCl CEMS is obtained.

For the purposes of these discussions it is assumed that Performance Specification 2 would serve as a basic model for HCl requirements. Also, many of the changes that are recommended above for SO2 and NOx CEMS are also appropriate for HCl CEMS. It is assumed that HCl monitors would be used to measure emission levels in units of concentration (ppm). Where a diluent monitor is used to adjust the data to a consistent basis (e.g., lb/MM=Btu, 7 percent O2, or 12 percent CO2) appropriate adjustments to the recommended requirements should be made. It is assumed that the HCl measurement range for controlled emissions would be approximately 250 ppm and that the measurement range for uncontrolled emissions would be approximately 1500=ppm.

1. Use of Calibration Gases

A design specification should be added to require that HCL monitors be able to accept calibration gases for daily calibration checks, performance specification tests, and periodic quality assurance audits. In addition, the recommendations regarding where the gases are introduced to the measurement system, the application to dilution sampling systems, and the requirements for demonstrating the adequacy of alternate calibration techniques are the same as described above for SO2 CEMS. Because of the higher cost for HCl calibration gases and the amount of gas used by some of the currently available monitors, it is expected that a demonstration of an alternate calibration technique would be attempted for most HCL CEMS applications.

2. Data Availability and Back-Up Data Recording Devices

All CEMS must operate continuously without repairs, unscheduled maintenance, or non-routine adjustments during the performance specification tests to determine calibration drift, linearity, and relative accuracy. In addition, minimum data availability specifications are included as QA requirements and are applicable to the operation of the CEMS after completion of the performance specification tests. (See Section 5, Quality Assurance Requirements for SO2, NOx, CO, and HCL CEMS, 8. Minimum Data Availability Requirements of this document.)

Recommendations and suggestions regarding the use and performance testing of back-up recording devices for HCl CEMS are the same as described in Section 2 for SO2 CEMS.

3. Calibration Drift Test and Reference Values

A calibration drift specification for HCl monitors restricting drift to 5 percent of span for 7 consecutive days should be established. The drift test procedures in Performance Specification 2 should be used except that (1) the calibration drift tests must be performed using calibration gases or other prior approved alternate calibration procedure, and (2) the value of the calibration gases must be obtained from the vendors certified analysis (within three months of the performance test) or by performing triplicate analysis of the gases using proposed EPA Method 26. The suggestion that the source owner or operator identify application problems that may affect the stability of the monitor is also the same as for SO2 CEMS.

4. Linearity Test

A performance specification and test procedure should be added to require a three-point cylinder gas audit to demonstrate the linearity of each HCl monitor. The linearity specification and test procedure apply to the entire monitoring channel, including the data acquisition system, as installed and operated at the particular facility. (A non-linear analyzer used in conjunction with appropriate adjustments by the data acquisition system is acceptable.) This test should use the zero and upscale calibration gas used for the daily calibration checks and an additional audit point at 20 to 30 percent of span. The recommended procedures for performing the test are the same as described above for SO2 CEMS except that Protocol 1 gases are not available for HCl. Therefore, the concentration value of all three calibration gases should be determined as described above in Item 3. The linearity specification should require that the mean difference between the calibration gas value and the monitor responses at each of the three points be calculated from the three measurements. The mean difference at all three test points must be less than 5 percent of span for HCl monitors.

5. Relative Accuracy Test

The recommended procedures and conditions for the relative

accuracy test are the same as those described above for SO2 CEMS. The following accuracy specifications are also recommended: relative accuracy less than 20 percent of the mean reference value, relative accuracy less than 10 percent of the standard, or mean difference less than 5 ppm, whichever is least restrictive. For cases where the emission standard is expressed in units of lb/MM Btu or corrected to a specified O2 or CO2 concentration, an absolute accuracy specification equivalent to 5 ppm should be calculated using an average or typical diluent concentration and applicable conversion factors. The appropriate procedures for use in cases where a percent removal standard is more restrictive than the emission standard are the same as for SO2 CEMS. The relative accuracy test should be performed using proposed EPA Method=26.

6. Alternate Accuracy Test Procedure

The same considerations apply to the alternate accuracy test procedure for HCl monitors as were described above for SO2 CEMS. In essence, the alternate accuracy test procedure is not needed since the more elaborate linearity test is required for all HCl CEMS installed at MWC facilities. The agency may decide to waive the relative accuracy test requirement if the emissions are consistently very low as indicated by source performance test results (i.e., "compliance tests") or other independent effluent measurements. However, the relative accuracy test should not be waived based on low concentrations indicated by the HCl CEMS because of the possibility of significant or total loss of HCl in the effluent samples within the sample acquisition/sample conditioning equipment.

7. Cycle Time and Response Time Test

A specification should be included that requires all HCl CEMS to complete at least one cycle of operation (sampling, analyzing, and data recording) for each successive 15-minute period, (i.e., a minimum of four samples per hour). The same considerations apply to time-sharing of HCl monitors as are described above for SO2 CEMS. A response time test should be conducted according to the procedures described above for SO2 CEMS.

8. Data Reporting Equipment Specifications

Additional equipment or design specifications may be added by states to facilitate the specific record keeping and reporting requirements that may apply. Various state agencies are currently considering a wide range of alternatives including: automated data reporting using magnetic media, telecommunication systems that allow agency representatives to obtain or review data on-demand from remote locations, and real-time or intermittent telemetry systems for CEM data and information. No additional guidance is included because of the diversity of state requirements and approaches.

SECTION 5
QUALITY ASSURANCE REQUIREMENTS FOR
SO2, NOx, CO, HCl CEMS

This section describes the NESCAUM workgroup recommendations for quality assurance requirements applicable to SO2, NOx, CO, and HCl CEMS installed at MWC facilities. The NESCAUM workgroup recommendations are similar to and adopt specific parts of 40 CFR 60, APPENDIX F, PROCEDURE 1. QUALITY ASSURANCE REQUIREMENTS FOR GAS CONTINUOUS MONITORING SYSTEMS USED FOR COMPLIANCE DETERMINATION revised July 1, 1988. The QA requirements that are adopted must also be consistent with the applicable performance specifications and test procedures. Therefore, the specific NESCAUM workgroup recommendations for QA requirements and procedures described in Items 1 through 8 below reference the corresponding performance specification recommendations in Sections 2, 3, and 4 of this document.

The following definition is used:
Quality assurance consists of the activities and procedures that are performed by the source owner or operator to ensure that CEM data meet certain criteria with respect to accuracy, precision, availability, and representativeness after the successful completion of the initial performance specification test.
Specific QA requirements for gas CEMS installed at MWC facilities for the measurement of SO2, NOx, CO, and HCl emission levels and percent removal are presented in Items 1 through 7 below.

1. Preliminary Monitoring Plan

Each source owner or operator required to install a CEMS for the measurement of one or more gaseous pollutants or diluent concentrations should submit a preliminary monitoring plan to the agency prior to the installation of the monitoring equipment. The preliminary monitoring plan need not be submitted if a draft CEMS QA plan is submitted to the agency prior to the installation of the monitoring equipment.

Submission of the preliminary monitoring plan is required to provide an opportunity for identification of misunderstandings between the agency and the source owners or operators with respect to the applicable CEMS requirements and acceptable monitoring approaches during the planning phase of the monitoring program. It is hoped that the submission of such a plan and review by the agency will (1) resolve problems attributable to ambiguous regulations, (2) minimize the likelihood of the purchase and installation of unacceptable monitoring equipment, and (3) avoid the need for development of a detailed quality assurance plan before actual operating experience with the monitoring equipment is obtained.

The preliminary monitoring plan should very briefly set forth

the basic approach that will be used to comply with the applicable CEMS requirements. It should include:

a. The identification, location, and description of the specific combustor unit(s) (e.g., plant name, unit number, unit size or capacity, general type of control system, etc.)

b. Identification of the applicable regulations and continuous monitoring requirements (e.g., EPA NSPS, state regulations, permit requirements, etc.)

c. Identification of the type of monitor (e.g., extractive, point in-situ, etc.) the CEMS manufacturer or vendor, and the model number or other identifying feature of the equipment to be installed

d. Identification of the analytical technique for each analyzer that will be used (e.g., NDIR, UV absorption, chemiluminescence, etc.)

e. Identification and description of the proposed monitoring location(s) (i.e., position along the effluent path) and identification of the specific measurement point(s) at each monitoring location from which samples will be obtained

f. Discussion of plans for time-sharing of extractive monitoring systems between two or more monitoring locations either as a permanent installation or as a back-up provision when a particular monitor is inoperative

g. Identification of the procedures that will be used to convert measurement data to units of the standard, including specific conversion factors, assumptions, and equations as applicable

h. Description of any mathematical procedures that will be used to correct emission measurement data for calibration drift, interference of other constituents, quenching, or other measurement phenomena applicable to the proposed measurement system

i. Brief description of the data acquisition system and data recording devices

j. Identification of any exceptions to the performance specifications or other applicable monitoring requirements and any alternate procedures that may require the approval of the agency

2. CEMS Quality Assurance Plan

Each source owner or operator should develop a CEMS quality assurance plan for each facility. The quality assurance plan should be submitted to the agency no later than 90=days after completing the initial successful performance specification test of the CEMS. At a minimum the quality assurance plan must address the following specified quality control and quality assessment subjects:

a. Background information. - - This should include:

· Identification and description of the specific combustor unit(s)

· Identification of the applicable regulations and monitoring requirements

· Identification and description of the monitoring instrumentation

· Description of the measurement location(s) and sampling points

· Description of the data recording devices and data handling system

This information is a reiteration and update of information contained in the preliminary monitoring plan and information that is usually included in the performance specification test report(s). It is included to assure that both the user and the agency are aware of changes to the original plan and the current status of the monitoring program at the facility.

b. Procedures used to establish proper calibration of the CEMS. - - These procedures should explain how the monitoring equipment is adjusted to provide the correct responses both initially and after repairs or corrective action. The procedures should address the calibration of both the components and the overall measurement system. The procedures should also identify assumed parameters (i.e., conversion factors, effluent moisture content, etc.) that are important to the fundamental calibration of the monitoring equipment. Procedures for verifying the validity of mathematical procedures used to correct or adjust the monitoring data should also be included.

c. Procedures used for the routine (daily) zero and upscale calibration checks and criteria for adjustment of the CEMS for excessive drift. - - For monitoring systems that use calibration gases for the daily checks, these procedures should describe:

· Where the gases are introduced to the measurement system
· How the correct flow rate and pressure for the gas injections are determined and maintained
· The length of time the gases are injected
· The data display device(s) used to determine the monitor response
· Any procedures necessary for the interpretation of the data

· The criteria for deciding if adjustments to the monitoring system are necessary
· The action to be taken when adjustments are needed

These procedures should include specification of the supplier and type of calibration materials used for the daily calibration checks and the method used to establish the concentration values of these materials.

For monitoring systems that use an alternate method for performing the routine zero and upscale checks, similar information describing the procedures is required. The specific requirements should be addressed in the written plan submitted when applying for approval of the alternate procedure during the performance specification test [See also "Item 1. Use of Calibration Gases" in the recommended performance specifications.]

d. Procedures used for cylinder gas audits (linearity tests) and relative accuracy tests. - - These procedures should detail how the accuracy assessments are conducted at the specific facility. The values of the two Protocol 1 calibration gases used for the linearity test, the supplier, and the steps taken to ensure that

the certification is current should be described. The specific procedures for introducing the gases to the monitoring system as described in Item 2. c (above) for the daily checks should also be included. For relative accuracy tests, the test methods to be used, sampling location/sampling points, duration of sampling runs, procedures for converting the reference data to units of the standard, and CEMS data interpretation/calculation procedures should be specified.

e. Quality control procedures including daily and periodic checks of system or component performance, preventive maintenance procedures, spare parts inventory, etc. - - These types of procedures are inherently monitor- and source-specific. However, detailed written procedures and corresponding data forms have been found to be effective for identifying developing problems and promoting consistency and thoroughness in performing daily and periodic checks of CEMS. Minimum preventive maintenance procedures are usually specified by the monitor manufacturer and should be included in the quality assurance plan. The spare parts that should be available on site depends on the data availability requirements, delivery time from suppliers or other sources, and the likelihood of failure of individual components; historical performance is the best indicator of the parts that may be needed. The quality control procedures should explain the organization of QA responsibilities among the various departments/groups or individuals at the facility.

f. Corrective action procedures for repair, adjustment, or replacement of the CEMS or its components. - - Corrective action procedures are often trouble-shooting efforts and are therefore difficult to describe in sufficient detail to be useful. However, clear objective criteria for determining when corrective action is needed based on the results of the required daily checks and periodic accuracy tests should be included. Additional criteria related to procedures or checks included as quality control procedures may also be helpful in resolving developing problems. This section should also include alternative monitoring procedures for use when minimum data availability requirements cannot be met by the CEMS.

g. Procedures used for data reduction, record keeping, and reporting of CEMS information. - - These procedures should detail exactly how the CEMS data is handled including:

· methods for correcting data for calibration drift
· specific averaging procedures
· methods of excluding invalid data and calibration data from emission averages
· equations, constants, and assumptions used to convert concentration measurements to units of the standard
· provisions for recording process/control system data and reasons for excess emissions
· provisions for recording CEMS downtime, adjustments, and repairs
· procedures for review and editing of data

The media, format, and location of all records and all reports to be submitted to the agency should be specified. The individuals or groups responsible for maintenance of records, development of reports, and review of reports should be identified.

3. Quality Assurance Plan Revision

Each source owner or operator should review the QA plan and all data generated by its implementation at least once each year and revise or update the plan, as necessary, based on the results of the annual review. The revised plan must be available for on-site review by the agency at any time. Within thirty days of completion of the annual QA plan review, the source owner or operator must submit a written explanation of all changes (or lack of changes) to the agency.

The agency may request revision of the QA plan at any time based on the results of emission report reviews, inspections, audits, review of the QA plan, or any other information available to the agency.

4. Routine Zero and Upscale Calibration Checks

Each source owner or operator should perform a zero (or low-level value between 0=and 20 percent of span) and upscale (50 to 90 percent of span) calibration drift check at least once daily in accordance with a written procedure contained in the CEMS QA plan. The daily check procedure must provide a check of the entire measurement system including sample acquisition equipment, sample lines, conditioning systems, analyzers, and data recording devices. The procedure must be accomplished by introducing calibration gases of the required concentrations in the sampling probe or at the sampling probe outlet. For measurement systems employing dilution probes or similar devices, the calibration gases must be introduced prior to the dilution point and in such a manner that they are diluted to the same extent as the sample gases from the effluent stream. Similarly, for sample acquisition systems using aspirators or eductors, the calibration gases must be introduced prior to these devices even if these components are part of the sample probe assembly. The values of the calibration gases may be established through the use of certified reference materials (CRMS), standard reference materials (SRMS), or EPA Protocol 1 gases. Alternatively, calibration gas values determined by the gas manufacturer's certified analysis (i.e., + 2 % of tag value) may be used if the concentration is checked by direct comparison with Protocol 1 gases, or by triplicate analysis using an appropriate EPA test method or an equivalent procedure. (See recommended Performance Specifications for SO2 CEMS, Item 3 for specific procedures for establishing the gas concentrations.)

Source owners or operators may conduct a demonstration of an alternate calibration check procedure subject to the approval of the agency. This demonstration may be conducted during the initial performance specification test or at a later time. (See Section 2,

Performance Specifications for SO2 and NOx CEMS[6], "Item 1. Use of Calibration Gases" for guidance on demonstration of an alternate method.)

The monitoring system must allow the amount of positive and negative drift (difference between the analyzer response and correct value of the calibration gas) to be quantified. At a minimum, the monitoring system shall be adjusted when the drift exceeds two times the performance specification limit. (The recommended calibration drift performance specifications are 2.5 percent of span for SO2 and NOx monitors, 0.5=percent O2 or CO2 for diluent monitors, 3 percent of span for CO monitors, and 5=percent of span for HCl monitors.) When adjustments are made, the drift check should be repeated after the adjustments are completed to verify that the monitor responds correctly.

The data acquisition system software in some monitoring systems automatically applies a mathematical correction to the CEMS emissions data based on the routine zero and span check results. Some other CEMS utilize an automatic control system for calibration drift adjustments. Manual adjustment of systems using automatic adjustments is not required until the drift based on the unadjusted responses is equivalent to 10 percent of span for the monitoring channel. These systems must allow determination of (1) the amount of drift in the unadjusted values, (2) the magnitude of the correction factor or adjustment that is applied, and (3) the adjusted system response to the daily zero and upscale calibration values.

5. Cylinder Gas Audit

A cylinder gas audit (linearity test) should be performed each calendar quarter using the same procedures and gas specifications that were used during the initial performance specification test. The audit should use the two audit points specified by Appendix F, Procedure 1 in conjunction with the zero and upscale calibration points used for the daily checks. If the high range audit point (i.e., 50 to 60 percent of the pollutant monitor span) of Procedure 1 is used for the daily upscale checks, an audit gas of 80 to 90 percent of span should be substituted for the high range audit point. A three-point audit check is required for HCl monitors. The same specification used in the performance specification test should also apply for the quarterly audits. Acceptable performance is indicated if the mean difference between the monitor responses and the value of the calibration gas is less than 5 percent of span at each of the four audit points for SO2, NOx, CO, and HCl monitors. The acceptance criteria for diluent monitors is 0.5 percent O2 or CO2. If the system fails the cylinder gas audit, take corrective action and repeat the audit until successful. The results of the cylinder gas audit should be reported to the agency with the emissions report for the period during which the audit is conducted.

6. Relative Accuracy Tests

A relative accuracy test (minimum of nine sampling runs) should be performed at least once per year using the same procedures and specifications used in the initial performance specification test. The relative accuracy test should be conducted as soon as practical before or after one of the quarterly cylinder gas audits to demonstrate the validity of the gas calibration technique and verify assumptions about the calibration procedure. No adjustments or repairs to the monitoring system other than the routine calibration drift adjustment according to the written procedure contained in the QA plan can occur between the cylinder gas audit and the relative accuracy test. To be considered working properly, the CEMS must satisfy both the relative accuracy and cylinder gas audit specifications. If the system fails to meet either specification, take corrective action and repeat both tests until successful. The results of the relative accuracy test should be reported to the agency with the emissions report for the period during which the test is conducted.

7. Out-of-Control Periods

Criteria for "out-of-control" periods are similar to those defined in Appendix F, Procedure 1. Specifically, the monitor is out-of-control if (a) the calibration drift exceeds two times the performance specification drift limit for five consecutive days, (b)=the calibration drift exceeds five times the performance specification limit on any day, (c) the system fails a relative accuracy test, or (d) the monitor fails a cylinder gas audit described above in Item 5. Data collected during out-of-control periods cannot be used to satisfy minimum data availability requirements.

8. Minimum Data Availability Requirements

Source owners and operators subject to continuous monitoring requirements should properly operate and maintain all monitoring equipment at all times that the source is operational. For sources where gas CEMS are required for the measurement of controlled or uncontrolled emissions of SO2, NOx, CO, or HCl, continuous monitoring data in units of the standard should be available for a minimum of 90 percent of the source operating hours for each reporting period (e.g., quarterly). For the purpose of determining conformance with this requirement, the time required to perform routine (e.g., daily) zero and upscale calibration checks, and quarterly linearity tests is included as CEM operating time. The time required for scheduled or unscheduled CEMS maintenance or other quality assurance activities is not included as operating time in the determination of CEMS availability except as may be specifically allowed in a QA plan approved by the agency. Some states may require higher levels of CEMS data availability or may require the use of redundant monitoring devices for all or some monitoring parameters.

In the event that the installed CEMS can not achieve the minimum data availability requirement, the source owner or operator should use alternate monitoring procedures (e.g., back-up monitors, parameter monitoring, performance testing, etc.) subject to the approval of the agency. The alternate monitoring procedures are required to be described in the QA plan. (See Section 5, 2 Quality Assurance Plan Item f.)

SECTION 6
EQUIPMENT AND PERFORMANCE SPECIFICATIONS FOR OPACITY CEMS AT MUNICIPAL WASTE COMBUSTION FACILITIES

This section describes the NESCAUM workgroup recommendations for monitor location requirements, design specifications, performance specifications, and corresponding test procedures for opacity CEMS installed at MWC facilities. Specifically, the NESCAUM workgroup recommends that states consider adopting the EPA requirements contained in "PERFORMANCE SPECIFICATION 1 - SPECIFICATION AND TEST PROCEDURES FOR OPACITY CONTINUOUS EMISSION MONITORING SYSTEMS IN STATIONARY SOURCES" of 40 CFR 60, Appendix B revised July 1, 1988, with the changes detailed in Items 1 through 5 below.

1. Performance Specification 1 Design Specifications

The design specifications in Performance Specification 1 should be adopted for: peak and mean spectral response, angle of view, angle of projection, optical alignment sight, simulated zero and upscale calibration checks, access to external optics, and automatic zero compensation indicator. In addition, "Section 6. Design Specification Verification Procedure" of Performance Specification 1 should be used to determine conformance with the above design requirements. The optional requirement in Performance Specification 1, "Section=5.1.9 External Calibration Filter Access" should be changed to a mandatory requirement to ensure the capability of auditing the monitor using external calibration attenuators.

(Note: The EPA Atmospheric Research and Exposure Assessment Laboratory, Quality Assurance Division has initiated an evaluation of the procedures used for the manufacturer's certification of conformance with the design specifications for opacity monitors. Revision of Performance Specification 1 requirements or test procedures may also result from this effort. Among others, future revisions may include (1) test procedure clarifications, (2) specifications for uniformity of light beam, (3) specific procedures for checking the photopic response.)

2. Cycle Time and Measurement Frequency

An additional design specification should be added to require that all opacity monitors complete a minimum of one cycle of sampling and analyzing for each successive 10-second period and one cycle of data recording for each successive 6-minute period or other period as specified in applicable regulations during normal operation. This requirement is similar to the requirement in 40 CFR 60.13 (e) (1) and is also consistent with the response time specification in Performance Specification 1. The

specification should require that the opacity monitoring system have the capability to display measurements for 1-minute periods or shorter intervals to facilitate monitor performance evaluations.

3. Data Availability and Back-Up Data Recording Devices

All opacity CEMS must operate continuously without repairs, unscheduled maintenance, or non-routine adjustments during the performance specification tests. In addition, minimum data availability specifications are included as a quality assurance requirements and are applicable to the operation of the CEMS after completion of the performance specification tests. (See Section 7, Quality Assurance Requirements for Opacity CEMS, 8. Minimum Data Availability Requirements.)

It is recognized that most MWC CEMS will include a computer data acquisition system and that when the data acquisition system is inoperative, many vital CEMS functions are suspended and data availability is immediately affected. Source owners and operators are encouraged, but not required, to include a back-up recording device or other appropriate redundancy within the data acquisition system in order to maximize data availability.

4. Performance Specification 1 Performance Test Procedures and Acceptance Criteria

The Performance Specification 1 criteria should be adopted for calibration error, response time, conditioning period, operational test period, and zero and calibration drift. In addition, Section 7,. Performance Specification Verification Procedure should be used to determine conformance with these criteria. However, the requirement that allows the calibration error test to be performed either at the manufacturer's facility or in the field should be changed. The regulation should allow the source owner or operator to choose either (1) to conduct the calibration error tests in the field, or (2) to conduct a performance audit of the monitor during the operational test period to ensure that calibration error test results obtained at the manufacturer's facility are representative of installed CEMS performance. Procedures for conducting a performance audit are included with the opacity monitor quality assurance requirements.

5. Data Reporting Equipment Specifications

Additional equipment or design specifications may be added by states to facilitate the specific record keeping and reporting requirements that may apply. Various state agencies are currently considering a wide range of
alternatives including: automated data reporting using magnetic media, telecommunication systems that allow agency representatives to obtain or review data on-demand from remote locations, and real-time or intermittent telemetry systems for CEM data and information. No additional guidance is included because of the diversity of state requirements and approaches.

SECTION 7
QUALITY ASSURANCE REQUIREMENTS
OPACITY CEMS

This section describes the NESCAUM workgroup recommendations for QA requirements applicable to opacity CEMS installed at MWC facilities. The QA requirements that are adopted should be consistent with the applicable performance specifications and test procedures. Therefore, the specific NESCAUM workgroup recommendations for QA requirements and procedures described in Items 1 through 7 below reference the performance specification recommendations in Section 6 of this document.

The following definition is used:
Quality assurance consists of the activities and procedures that are performed by the source owner or operator to ensure that CEM data meet certain criteria with respect to accuracy, precision, availability, and representativeness after the successful completion of the initial performance specification test.

The following QA requirements are recommended for opacity CEMS:
1. Preliminary Monitoring Plan

Each source owner or operator required to install an opacity CEMS should submit a preliminary monitoring plan to the agency prior to the installation of the monitoring equipment. The preliminary monitoring plan need not be submitted if a draft CEMS quality assurance plan is submitted to the agency prior to the installation of the monitoring equipment.

Submission of the preliminary monitoring plan is required to provide an opportunity for identification of misunderstandings between the agency and the source owners or operators with respect to the applicable CEMS requirements and acceptable monitoring approaches during the planning phase of the monitoring program. It is hoped that the submission of such a plan and review by the agency will (1) resolve problems attributable to ambiguous regulations, (2) minimize the likelihood of the purchase and installation of unacceptable monitoring equipment, and (3) avoid the need for development of a detailed quality assurance plan before actual operating experience with the monitoring equipment is obtained.

The plan should very briefly set forth the basic approach that will be used to comply with the applicable monitoring requirements. It should include:
a. The identification, location, and description of the specific combustor unit(s) (e.g., plant name, unit number, unit size or capacity, general type of control system, etc.)

b. Identification of the applicable regulations and continuous monitoring requirements (e.g., EPA NSPS, state regulations, permit requirements, etc.)
c. Identification of the CEMS manufacturer or vendor, the model number or other identifying feature of the equipment to be installed
d. Identification of the proposed monitoring location(s) (i.e., position along the effluent path), description of the transmissometer measurement path orientation at each monitoring location, measurement path length, and stack exit diameter
e. Discussion of procedures and equipment that will be used to calculate the opacity of emissions discharged to the atmosphere where two or more transmissometers are installed in multiple ducts for a single unit or where emissions from multiple units are exhausted through a common stack
f. Description of any automatic procedures that will be used to correct or adjust opacity measurement results for calibration drift
g. Description of the data recording devices that will be used
h. Identification of any exceptions to the performance specifications or other applicable monitoring requirements and any alternate procedures that may require the approval of the agency

2. CEMS Quality Assurance Plan

Each source owner or operator should develop a CEMS QA plan for each facility. The QA plan should be submitted to the agency not later than 90=days after completing the initial successful performance specification test of the CEMS. At a minimum the QA plan must address the following quality control and quality assessment subjects:
a. Background information. - - This should include:
· Identification and description of the specific combustor unit(s)
· Identification of the applicable regulations and monitoring requirements
· Identification and description of the monitoring instrumentation
· Description of the measurement location(s) and monitor paths
· Description of the data recording devices and data handling system.
This information is a reiteration and update of information contained in the preliminary monitoring plan and information that is usually included in the performance specification test report(s). It is included to assure that both the user and the agency are aware of changes to the original plan and the current status of the monitoring program at the facility.
b. Procedures used to establish proper calibration of the CEMS. - - These procedures should explain how the monitoring equipment is adjusted to provide the correct responses both initially and after repairs or corrective action. The procedures should address the calibration of the transmissometer(s), the data recording devices, and the overall measurement system. Procedures for verifying the validity of mathematical corrections or other automatic adjustments

to the monitoring data should be included.

c. Procedures used for the routine (daily) zero and upscale calibration checks and criteria for adjustment of the CEMS for excessive drift. - - These procedures should explain:

· How the daily calibration checks are initiated

· The data display device(s) used to determine the monitor responses,

· The criteria for deciding if adjustments to the monitoring system are necessary

· The action to be taken when adjustments are needed

It is particularly important that any assumptions associated with the calibration check procedure be understood and that any auxiliary monitor parameters necessary to assess monitor performance be identified.

d. Procedures for performance audits and zero alignment checks. - - These procedures should provide any special information necessary for the conduct of performance audits or the interpretation of the audit results. Zero alignment procedures should explain how the monitor is removed from the stack and set up under clear path conditions or how the test is performed on the installed monitor during source outages. The specific procedures used to adjust the simulated zero device and the records of the zero alignment results and adjustments should be explained.

e. Quality control procedures including daily and periodic checks of system or component performance, preventive maintenance procedures, spare parts inventory, etc. - - These procedures are inherently monitor- and source-specific. However, detailed written procedures and corresponding data forms have been found to be effective for identifying developing problems and promoting consistency and thoroughness in performing daily and periodic checks of monitoring systems. Minimum preventive maintenance procedures are usually specified by the monitor manufacturer and should be included in the quality assurance plan. The spare parts that should be available on site depends on the data availability requirements, delivery time from suppliers or other sources, and the likelihood of failure of individual components; historical performance is the best indicator of the parts that may be needed. The quality control procedures should explain the organization of QA responsibilities among the various departments/groups or individuals at the facility.

f. Corrective action procedures for repair, adjustment, or replacement of the CEMS or its components. - - Corrective action procedures are often trouble-shooting efforts and are therefore difficult to describe in sufficient detail to be useful. However, clear objective criteria for determining when corrective action is needed based on the results of the required daily checks and periodic audits should be included.

g. Procedures used for data reduction, record keeping, and reporting of CEMS information. - - These procedures should detail

exactly how the CEMS data is handled including:

· methods for correcting data for calibration drift, if applicable
· criteria for identifying invalid data
· provisions for recording process/control system data and reasons for excess emissions;
· provisions for recording and tracking CEMS downtime adjustments and repairs.

The media, format, and location of all records and all reports to be submitted to the agency should be specified. The individuals or groups responsible for maintenance of records, development of reports, and review of reports should be identified.

3. Quality Assurance Plan Revision

Each source owner or operator should review the QA plan and all data generated by its implementation at least once each year and revise or update the plan, as necessary, based on the results of the annual review. The revised plan must be available for on-site review by the agency at any time. Within thirty days of completion of the annual QA plan review, the source owner or operator must submit a written explanation of all changes (or lack of changes) to the agency.

The agency may request revision of the QA plan at any time based on the results of emission report reviews, inspections, audits, review of the QA plan, or any other information available to the agency.

4. Routine Zero and Upscale Calibration Checks

Each source owner or operator should perform a zero (or low-level value between 0=and 20 percent of span) and upscale (50 to 90 percent of span) calibration drift check at least once daily in accordance with a written procedure contained in the CEMS QA plan. (This requirement is the same as that contained in 40 CFR 60.13 (d)=(1).) The daily check procedure must provide a system check of the analyzer internal optical surfaces and all electronic circuitry including the lamp and photodetector assembly.

The monitoring system must allow the amount of positive and negative drift (difference between the analyzer response and correct value of the calibration check devices) to be quantified. At a minimum, the monitoring system shall be adjusted when the drift exceeds the performance specification limit, i.e., 2 percent opacity. (This criteria is twice as restrictive as the criteria in 40 CFR 60.13.) The transmissometer optical surfaces exposed to the effluent should be cleaned prior to performing the zero and calibration drift adjustments except for systems using automatic zero adjustments. When calibration adjustments are made, the drift check should be repeated after the adjustments are completed to verify that the monitor responds correctly.

Some opacity monitors use an automatic zero compensation device to offset dust accumulation on the optical surfaces or other changes in the electro-optical components. Also, the data

acquisition system software in some monitoring systems automatically applies a mathematical correction to the monitoring data based on the zero and upscale calibration check results. Manual adjustment of systems using automatic adjustments should be performed when the drift based on the unadjusted responses (or the magnitude of the adjustment) is equivalent to 4 percent opacity. These systems must allow determination of the amount of drift in the unadjusted values or the magnitude of the correction factor/adjustment that is applied.

5. Performance Audit

A performance audit of each opacity CEMS should be performed each calendar quarter according to the procedures contained in "Performance Audit Procedures for Opacity Monitors" EPA-600/8-87-025, April 1987, or equivalent procedures subject to the approval of the agency. The criteria contained in the referenced document for stack exit correlation error, system faults, zero and span errors, monitor alignment, dust accumulation, and calibration error should be used to determine acceptable performance. The results of the performance audit should be reported to the agency with the emissions report for the period during which the audit is conducted.

The values of the optical filters used in performance audits should be checked at least once per year according to the procedures in Performance Specification 1.

6. Zero Alignment

A zero alignment should be performed at least once per year unless a particular facility can submit data showing that a different frequency is appropriate. The zero alignment procedure involves adjustment of the monitor so that the response to the simulated zero device coincides with the monitor response to clear path conditions. The check may be accomplished if clear path conditions are present during a source outage or by removing the transmissometer from the stack and setting up the instrument at the operating pathlength in a clean environment. (General procedures for performing zero alignment checks are described in Section 9 of "Performance Audit Procedures for Opacity Monitors.") The amount of adjustment necessary to accomplish the zero alignment (expressed as percent opacity) should be reported to the agency with the emissions report for the period during which the procedure is conducted.

An external, removable, zero-jig may be used as an alternate procedure to the zero alignment provided that (1) the zero-jig setting is established for the specific monitor by comparison of monitor responses to the zero-jig and to the clear path condition, (2) the zero-jig is demonstrated to be capable of producing a consistent zero response when it is repeatedly reinstalled on the monitor, and (3) the zero-jig is protected when not in use to ensure that the setting equivalent to the zero condition does not

change. Source owners or operators that use a zero-jig should perform a zero alignment and check of the zero-jig at least once every three years.

7. Out-of-Control Periods

Criteria for "out-of-control" periods are similar to those defined for gas CEMS. Specifically, an opacity monitor should be considered out-of-control if (a) the calibration drift exceeds the performance specification drift limit (i.e., 2 percent opacity) for five consecutive days, (b) the calibration drift exceeds five percent opacity on any day, or (c) the opacity monitoring system fails a performance audit. Data collected during out-of-control periods cannot be used to satisfy minimum data availability requirements.

8. Minimum Data Availability Requirements

Source owners and operators subject to continuous monitoring requirements should properly operate and maintain all monitoring equipment at all times that the source is operational. For sources where opacity CEMS are required, continuous monitoring data should be available for a minimum of 90 percent of the source operating hours for each reporting period (e.g., quarterly). For the purpose of determining conformance with this requirement, the time required to perform routine (e.g., daily) zero and upscale calibration checks, and quarterly performance audits is included as CEM operating time. The time required for scheduled or unscheduled CEMS maintenance or other QA activities is not included as operating time in the determination of CEMS availability except as may be specifically allowed in a QA plan approved by the agency. Some states may require higher levels of CEMS data availability.

In the event that the installed CEMS can not achieve the minimum data availability requirement, the source owner or operator should use alternate monitoring procedures subject to the approval of the agency.

APPENDIX

Comparison of Accuracy Specifications

The two basic relative accuracy specifications of Performance Specification 2 are illustrated in Figure 1. It can be seen that "20 percent of the reference value" is the least restrictive criterion when the emission level is greater than 50 percent of the standard; "10 percent of the standard" becomes the less restrictive criterion when the emissions are below 50 percent of the standard. For both of these specifications, the relative accuracy calculation includes the sum of the mean difference plus 95% confidence coefficient.

The recommended 5 ppm mean difference criterion is an absolute accuracy specification similar to the "10 percent of the standard" specification. The 5 ppm criterion is less restrictive than the "10 percent of the standard" criterion when the emission standard is 50 ppm because the confidence coefficient is eliminated. At lower emission standards the difference between the two criteria becomes more significant and the 5 ppm criterion is the less restrictive. The various relative accuracy specifications are illustrated in Figure 2 for emission standards of 50=ppm and 30 ppm. The recommended 5 ppm mean difference accuracy specification attempts to reflect the limitations associated with the reference test procedures, the CEMS measurement capability, and the relative accuracy tests at sources with fluctuating emission levels. These technical limitations are independent of the level of the emission standard. Similarly, the 5 ppm criterion is also independent of the level of the emission standard.

It can be shown that the proposed NSPS MWC SO2 emission limit of 30 ppm corrected to 7 percent O2 corresponds to about 0.07 lbs. SO2/MM Btu. Thus, the alternate "20 percent of the standard" accuracy specification of Performance Specification 2 could be applied. However for the proposed NSPS standard, this limit corresponds to 6 ppm and includes the confidence coefficient. This is probably more restrictive than the recommended 5 ppm mean difference criterion without the confidence coefficient and it is also dependent on the emission standard. The "average" or "typical" contribution of the confidence coefficient to the relative accuracy result could be determined by statistical analysis of test results at MWC facilities. However, it seems unlikely that the confidence coefficient contribution is less than 1 ppm. Thus, the 5 ppm mean difference limit is less restrictive than the "20 percent of the standard" criteria.

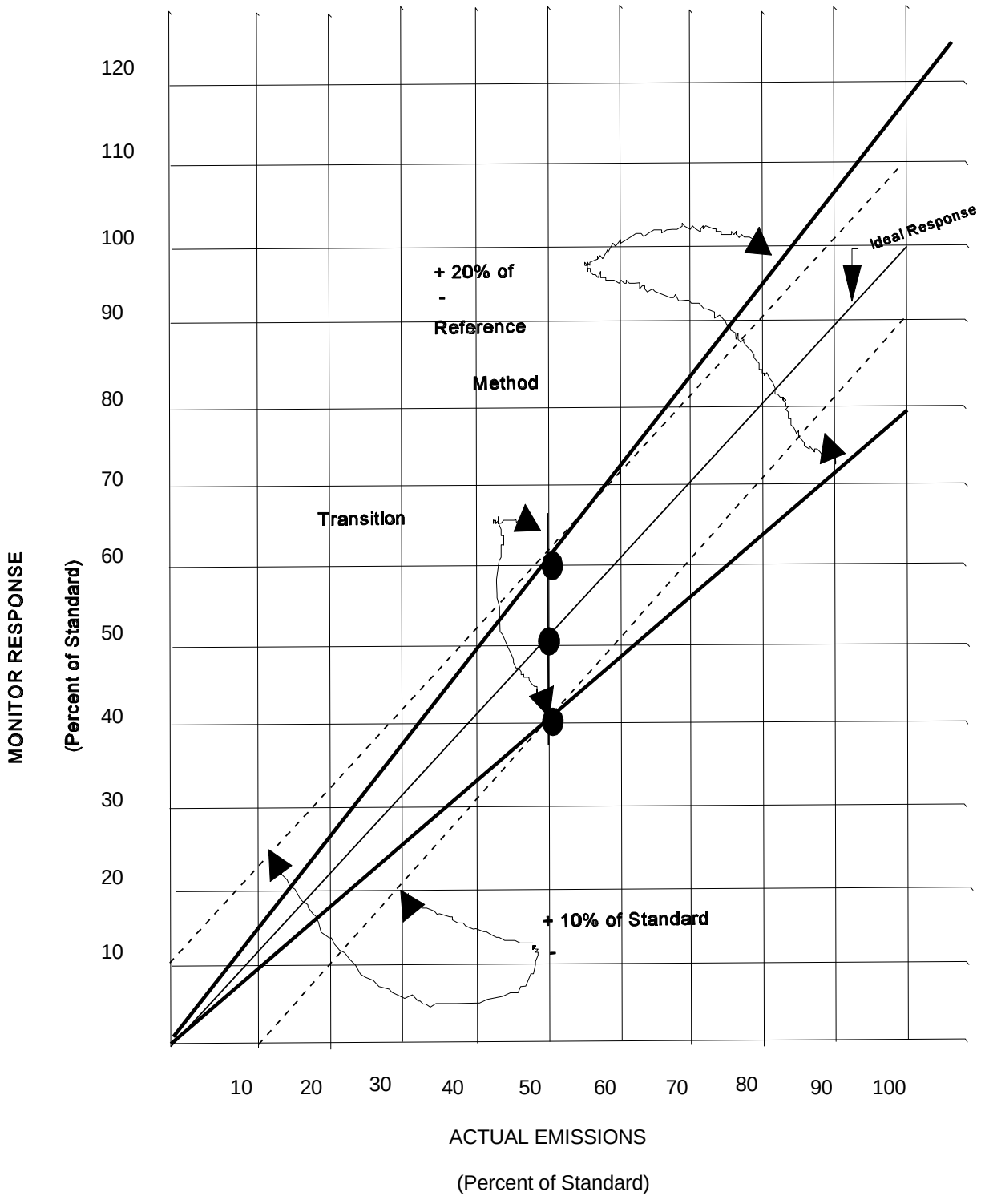

Figure 1. Performance Specification 2,Relative Accuracy Specifications

Figure 1 Redrawn to be compatible with Wordperfect file

NOTE: I had to redraw the following figures because they were done orginally on a MAC. They are not quite as precise as they should be. If you want a hard copy of the orginals, send me a Message on the BBS . Terry Harrison

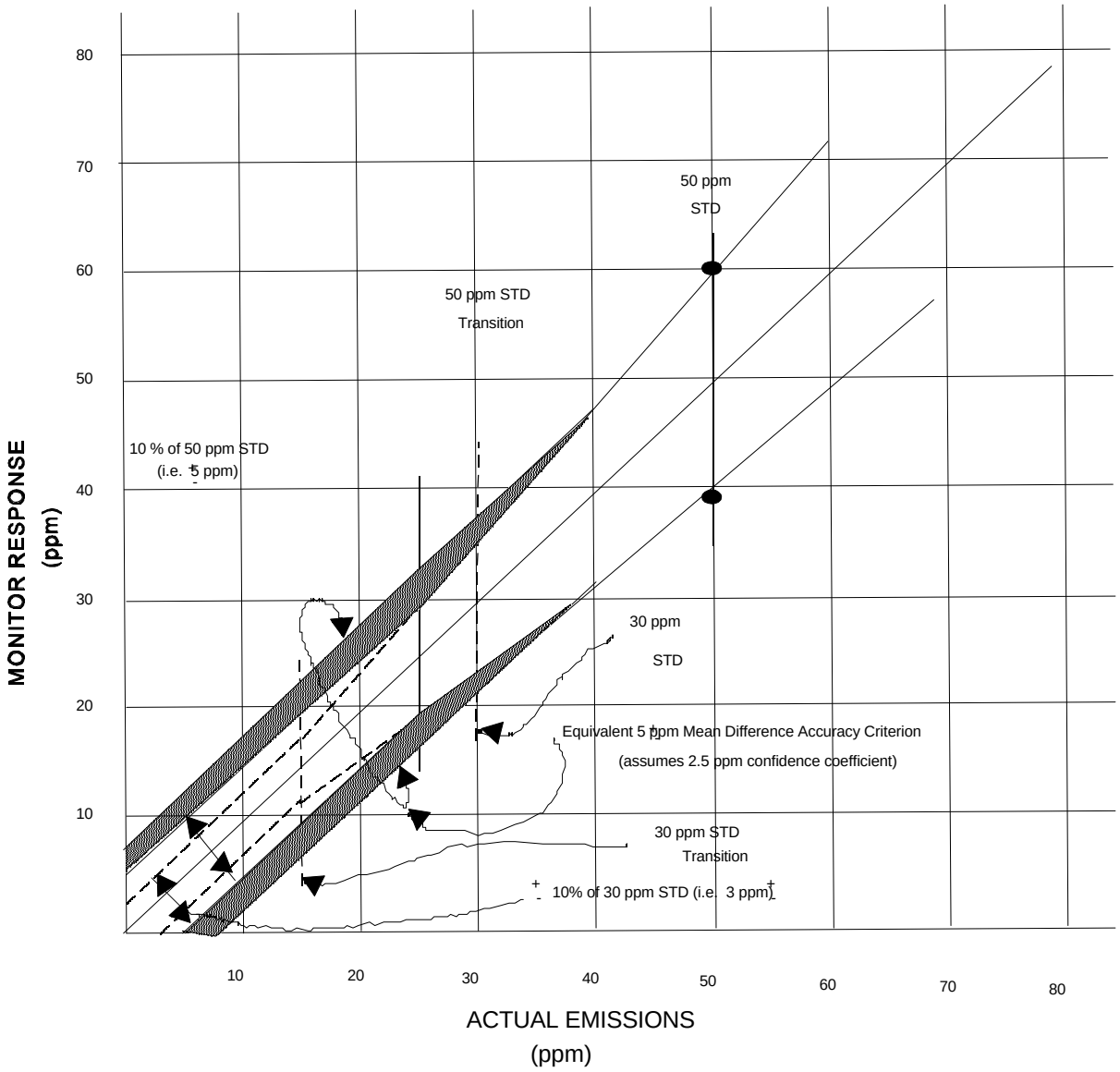

Figure 2. Example Accuracy Specifications for 30 ppm and 50 ppm Standards

Figure 2 Redrawn to be compatilbe with Wordperfect file.