Chapter 14

Prevention of Significant Deterioration

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1.0 Introduction

The Prevention of Significant Deterioration (PSD) permitting program is a Clean Air Act program for new and modified major sources of air pollution (e.g., power plants, manufacturing facilities) where the area the source is located is classified as either in attainment or unclassifiable with the National Ambient Air Quality Standards (NAAQS). The NAAQS establishes maximum pollution concentration levels to protect public health and welfare from harmful levels of nitrogen oxides, ozone, sulfur dioxide, particulates, carbon monoxide, and lead. A PSD increment is the maximum allowable increase in concentration that is allowed to occur above a baseline concentration for a pollutant. The baseline concentration is defined for each pollutant and is the ambient concentration existing at the time that the first complete PSD permit application affecting the area is submitted. PSD increments prevent the air quality in clean areas from deteriorating to the level set by the NAAQS.

The PSD program does not prevent new or modified pollutant sources from increasing emissions, but is designed primarily to achieve the following:

- Prevent violations of the Clean Air Act NAAQS and protect the environment
- Protect the air quality and visibility in National Parks, National Wilderness areas, and other areas of special natural, recreational, scenic or historic value
- Insure that economic growth will occur in a manner consistent while limiting the impacts on air quality
- Assure that any decision to permit increased air pollution is made only after careful evaluation of all the consequences of such a decision and after adequate opportunities for informed public participation in the decision making process

The PSD permitting program requires the following:

1. Installation of Best Available Control Technology (BACT)
2. An air quality analysis
3. An additional impacts analysis
4. Public involvement

Best Available Control Technology is an emissions limitation that is based on the maximum degree of control that can be achieved at a major stationary source. It is a case-by-case decision that considers energy, environmental, and economic impact. It can be add-on control equipment or modification of the production processes or methods.

The air quality analysis is a study of the effect of air pollution emissions from a proposed major stationary source or major modification, in conjunction with other applicable emissions increases and decreases from existing sources, to determine if the emissions will cause or contribute to a violation of any applicable NAAQS or PSD increment. The air quality analysis involves an assessment of existing air quality and may include ambient monitoring data and air quality dispersion modeling results based on current emission inventories. It should also include

predictions, using dispersion modeling, that may result from the applicants proposed project and future growth associated with the project.

The additional impacts analysis assesses the impacts of air, ground, and water pollution on soil, vegetation, and visibility caused by any increase in emissions of any regulated pollutant from the source or modification under review, and from associated growth. Associated growth is growth (industrial, commercial, and residential) that may occur in the area due to the source.

The PSD application process must include adequate public participation. The regulations solicit and encourage participation by the general public, industry, and other affected persons impacted by the proposed major source or major modification. Specific public notice requirements and a public comment period are required before the PSD review agency takes final action on a PSD application. The public notice must indicate the reviewing authority proposed action (permit approval, denial, or conditional approval) on the proposed major source or major modification. Consideration is given to all comments received, provided they are relevant to the scope of the review. Where requested, or at its own discretion, the reviewing authority may conduct a public hearing to help clarify the issues and obtain additional information to assist in making a final permit decision.

No source or modification, subject to Clean Air Act regulations, may be constructed without a permit that states that the stationary source or modification must meet applicable PSD or National Ambient Air Quality Standards (NAAQS) requirements. Requirements for PSD monitoring can be found in the Clean Air Act of 1977, Part C and in 40 CFR § 52.21.

The PSD permit will state the ambient air monitoring requirements:

- Duration of monitoring
- Parameters to be monitored
- Number of monitoring sites

Pollutant dispersion modeling is performed to determine the areas of maximum impact. The air-monitoring sites must be located in the maximum impact areas and be approved by the OAQ prior to start-up. All groups that conduct PSD monitoring within the state of Indiana must follow the requirements outlined in 40 CFR Part 58 Appendix A and in this chapter. The PSD data (ambient monitoring and quality assurance data) submitted to the OAQ Air Monitoring Branch will be submitted to the U.S. USEPA Air Quality System (AQS) database.

2.0 General Requirements for PSD Monitoring

2.1 General Information

“Revisions to Ambient Air Monitoring Regulations” (Federal Register, vol. 71, no. 200, October 17, 2006 pp. 61236 – 61328) initiated several quality assurance reference changes to PSD monitoring. Appendix B – Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring of 40 CFR Part 58 was removed and the contents of that

appendix were incorporated into the revised Appendix A – Quality Assurance Requirements for SLAMS, SPMs and PSD Air Monitoring. Similarities and differences between SLAMS and PSD monitoring (40 CFR Part 58 Appendix A, Section 1.1) are summarized in the following sections.

Similarities of PSD and SLAMS monitoring programs

- Requires the development, documentation, and implementation of an approved quality system
- Assessment of data quality
- Use of reference, equivalent or approved monitoring methods
- Use of calibration and audit standards traceable to NIST or other primary standard
- Performance evaluation and systems audits of the monitoring system

Differences between PSD and SLAMS monitoring programs

Topic	PSD Monitoring	SLAMS Monitoring
Monitoring and Quality Assurance Responsibilities	Owner/operator seeking the permit	State or Local Agency
Monitoring Duration	Defined in the PSD permit	Indefinite
Quarterly Performance Evaluation Rate	100% of the PSD samplers and monitors	25% of the SLAMS samplers and monitors
Performance Evaluation Staffing	Must be conducted by personnel different from those who perform routine span checks and calibrations	Should be conducted by personnel different from those personnel who perform routine span checks and calibrations
Precision, Accuracy, and Bias Data Reporting	Reported separately for each monitor/sampler	May be reported for each monitor/sampler or by primary quality assurance organization (PQAO)
Data Reporting Requirements	Reported to the permit-granting authority	Reported to USEPA's Air Quality System (AQS)

[NOTE: "Revisions to Ambient Monitoring Quality Assurance and Other Requirements" (Federal Register, vol. 79, no. 176, September 11, 2014 pp. 54356 – 54395) proposed several quality assurance reference changes to PSD monitoring. The major proposal affecting PSD monitoring is the reinstatement of Appendix B – Quality Assurance Requirement for Prevention of Significant Deterioration (PSD) Air Monitoring. When the proposed rule becomes final, references to PSD quality assurance requirements will need to reflect the new authority.]

2.2 Ambient Monitoring and Quality Assurance Project Plan Requirements

Ambient air monitoring and quality assurance responsibilities lie with the owner/operator seeking the PSD permit. The organization must develop and implement an ambient monitoring and a quality assurance program consisting of policies, procedures, specifications, and standard documentation necessary to:

1. Provide data of adequate quality to meet monitoring objectives and quality assurance requirements of the permit granting authority, and

2. Minimize loss of air quality data due to malfunctions or exceeding quality control conditions.

These programs must be described in detail and suitably documented in an ambient monitoring and quality assurance plan (AMQAPP). The monitoring/quality assurance plans should be submitted to the Office of Air Quality, Air Monitoring Branch, for review and approval prior to the initial start date for any monitoring program. The quality assurance activities and ambient monitoring activities will be reviewed during the annual system/performance audits.

Chapter 15, "Systems Audit Criteria and Procedures for Evaluating Ambient Air Monitoring Networks," of the QA Manual provides more in-depth information on the requirements for an AMQAPP. At a minimum, the AMQAPP must include information and operational procedures for each of the following activities:

- Analyzers, samplers, or analytical methodology
- Description of equipment, shelters, terrain, probe material, height of the sample inlet, and mapping/photographs of the monitoring area
- Selection and control of calibration standards
- Calibration procedures
- Zero/span checks and adjustments of automated analyzers
- Quality control checks and their frequency
- Independent performance evaluation audits
- Control limits for zero, span, and other control checks, and respective corrective actions when such limits are surpassed
- Preventive and remedial maintenance
- Recording and validating data
- Data quality assessment
- Documentation of quality control information

2.3 PSD Monitoring Requirements

2.3.1 Monitoring/Sampling Methods

The methods employed to perform PSD monitoring require the use of Federal Reference Method (FRM), Federal Equivalent Method (FEM), or other USEPA-approved monitoring methods. USEPA's list of designated reference and equivalent methods can be found at the following USEPA link:

http://www.epa.gov/ttn/amtic/files/ambient/criteria/reference-equivalent-methods-list.pdf

2.3.2 Pollutant/Flow Standards

Gaseous pollutant concentration standards (permeation devices or compressed gas cylinders) used to obtain calibration or test concentrations for CO, SO_2, and NO must be traceable to a National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) or an available Certified Reference Material (CRM). All calibration systems using standards must be certified by the Quality Assurance Certification Facility (QACF) prior to instrument calibrations and audits.

Test concentrations for ozone must be obtained in accordance with the UV photometric calibration procedure specified in Appendix D of 40 CFR Part 50, or by means of a certified ozone transfer standard. These systems must be certified by the QACF prior to instrument calibrations or audits.

Flow rate measurements must be made by a flow-measuring instrument that is traceable to a NIST volume standard.

Chapter 6, "Certification Methods of Transfer Standards," of the OAQ Quality Assurance Manual provides additional information on the transfer standard certification procedures. Prior arrangements must be made before standards are taken to the QA certification facility. Pollutant standards must not be used unless their certification and traceability is current.

2.3.3 Particulate Pollutant Frequency of Measurements

For areas where particulate pollutants may have significant pollutant variability, continuous sampling is preferred to capture the changing pollutant concentrations. In areas where significant pollutant variability is not expected, manual methods may be employed. If intermittent particulate sampling is permitted, the sampling must adhere to the USEPA national sampling schedule. The current USEPA annual sampling schedule can be found at the following website:

http://www.epa.gov/ttn/amtic/calendar.html

Collocated particulate sampling at PSD sites is required to meet the data quality indicators of precision, bias, and accuracy. Collocated particulate sampling at a PSD site operates on a 6-day schedule or a 3-day schedule for PSD daily monitors.

2.3.4 Meteorological Parameters and Measurement Methods

The calibration and audit procedures in Chapter 9 "Meteorological Systems" of the OAQ Quality Assurance Manual and in the “Quality Assurance Handbook for Air Pollution Measurement Systems, volume IV: Meteorological Measurements, version 2.0” (EPA-454/B-08-002, March 2008) must be followed to maintain the integrity of the meteorological data.

2.3.5 Network Siting and Probe Siting

The procedures to follow are found in Chapter 1, “Quality Assurance of Air Monitoring,” of the OAQ Quality Assurance Manual and 40 CFR Part 58 Appendix E – Probe and Monitoring Path Siting Criteria for Ambient Air Quality Monitoring. While somewhat dated, the following references can provide additional site selection information.

- Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD), EPA-450/4-87-007, May 1987
- Selecting Sites for Carbon Monoxide Monitoring, EPA-450/3-75-077, September 1975
- Optimum site Exposure Criteria for SO2 Monitoring, EPA-450/3-77-013, April 1977
- Site Selection for the Monitoring of Photochemical Air Pollutants, EPA-450/3-77-013, April 1978
- Guidance for Siting Ambient Air Monitors around Stationary Lead Sources, EPA-454/R-92-009, August 1997
- Guideline on Ozone Monitoring Site Selection, EPA-454/R-98-002, August 1998
- Network Design and Optimum Site Exposure Criteria for Particulate Matter, EPA-450/4-87-009, May 1987

2.3.6 Calibration

Information regarding monitor/sampler calibration procedures can be found in the monitor or sampler operating manual and in the following chapters of the OAQ Quality Assurance Manual:

- Chapter 2, “Continuous Monitoring of Ozone”
- Chapter 3, “Continuous Monitoring of Sulfur Dioxide”

- Chapter 4, “Continuous Monitoring of Carbon Monoxide”
- Chapter 5, “Continuous Monitoring of Nitrogen Dioxide”
- Chapter 7, “Measurements of Particulates”
- Chapter 9, “Meteorological Systems”

2.3.7 Validation/Invalidation of Data

Information regarding the data validation/invalidation can be found in Chapter 11, “Valid Data Requirements,” of the OAQ Quality Assurance Manual.

If monitoring data is invalidated during the period represented by a given validation check for automated or manual methods, the results of the precision level check must be excluded from the quarterly precision and accuracy data report.

2.3.8 Data Reporting

The Air Monitoring Branch intends to make public all available monitoring data. As such, all PSD monitoring data and its associated quality assurance data is reported to the USEPA Air Quality System (AQS). All PSD monitoring sites must have USEPA approved Air Quality System (AQS) identification numbers and the data must be formatted for submittal to AQS. These sites must meet USEPA AQS reporting requirements for the ambient air quality data and quality assurance data as outlined in 40 CFR § 58.16.

2.3.9 Data Assessment

The quarterly and annual data assessment procedures for the determination of precision, bias, and accuracy for each analyzer and/or monitor are outlined in Chapter 13, “Quality Assessment and Statistical Analysis of Air Monitoring Data,” of the OAQ Quality Assurance Manual and in Sections 5 and 6 of this chapter.

2.3.10 External Review

Each organization operating a PSD monitoring network shall be subject to an annual systems/ performance evaluation performed by the Office of Air Quality (OAQ) Quality Assurance Section (see Chapter 15). In addition, each network is required to participate in the USEPA’s National Performance Audit Program (NPAP) Section 2.4 of 40 CFR, Part 58, Appendix A.

3.0 Quality Assurance Requirements for PSD Monitoring

Quality assurance of air monitoring systems includes two distinct and important interrelated functions. One function is the control of the measurement process through the implementation of policies, procedures, and corrective actions. The other function is the assessment of the quality of the monitoring data. The principal thought is that a greater effort and effectiveness of control usually results in better quality of the monitoring data. Therefore, data quality assessment is used to determine the effectiveness of the control efforts. Documentation of the monitoring system assessment is important to data users, who can then consider the impact of the data quality in specific applications. Accordingly, assessments of PSD monitoring data quality are required to be made and reported quarterly by the monitoring organization to the OAQ. The data must be submitted no later than that required for AQS data submittal.

Additional guidance for the requirements reflected in this chapter can be found in the "Quality Assurance Handbook for Air Pollution Measurement Systems, volume II: Ambient Air Quality Monitoring Program," (EPA-454/B-13-003, May 2013), available on the web through the following link:

http://www.epa.gov/ttn/amtic/files/ambient/pm25/qa/QA-Handbook-Vol-II.pdf

Guidance for the quality assurance requirements for meteorological parameters can be found in the "Quality Assurance Handbook for Air Pollution Measurement Systems, volume IV: Meteorological Measurements, version 2.0" (EPA-454/B-08-002, March 2008), available through the following link:

http://www.epa.gov/ttn/amtic/files/ambient/met/Volume%20IV_Meteorological_Measurements.pdf

3.1 Measurement Quality Assessment Requirements

All ambient monitoring samplers or analyzers used in PSD monitoring shall be tested periodically to quantitatively assess the quality of the data being routinely collected. The results of these tests shall be reported each quarter to the OAQ, Air Monitoring Branch. Concentration measurements reported from analyzers or analytical systems being tested must be derived by means of the same calibration curve and data processing system used to obtain the routine air monitoring data.

Table l provides a summary of the minimum data quality assessment requirements.

Table 1
Minimum PSD Data Assessment Requirements

Precision				
Method	**Assessment Method**	**Coverage**	**Parameter Frequency**	**Reported**
Automated methods for SO_2, NO_2, O_3	Response check at concentration between 0.01 and 0.1 ppm	Each analyzer	Once per 2 weeks	Actual concentration and measured concentration
Automated methods for CO	Response check at concentration between 1 and 10 ppm	Each analyzer	Once per 2 weeks	Actual concentration and measured concentration
Particulate Matter or Lead	Collocated Sampler	Highest conc. in monitoring network	Once per 6 day or every 3rd day for continuous sampling	Both measurement concentrations per site
Bias				
Method	**Assessment Method**	**Coverage**	**Parameter Frequency**	**Reported**
Particulate Matter or Lead	Sampler flow	Each sampler	Once/Month	Standard flow rate and observed flow rate
Performance Evaluation				
Method	**Assessment Method**	**Coverage**	**Parameter Frequency**	**Reported**
Automated methods for SO_2, NO_2, O_3, CO	See Section 3.3	Each analyzer in network	Once/Quarter	Actual concentration and measured concentration for each level
Particulate Matter PM_{10}, $PM_{2.5}$	Sampler flow	Each sampler	Once/Quarter	Standard flow rate and observed flow rate
Lead (Pb)	Check of sampler flow	Each Sampler	Once/Quarter	Standard flow rate and observed flow rate
	Check of analytical system with Pb audit strips	Analytical	Each Quarter	Measured and Actual Pb concentrations

3.2 One-point Quality Control Check of Gaseous Methods

A one-point quality control check (previously known as a precision check) must be carried out a minimum of once every two weeks on each automated analyzer used to measure SO_2, NO_2, O_3 and CO. The precision check is made by challenging the analyzer with a check gas of known concentration between 0.01 and 0.10 ppm for SO_2, NO_2, and O_3 analyzers, and between 1 and 10 ppm for CO analyzers. Ideally, the precision gas concentration selected should be related to the routine concentration normally measured at sites in the network.

Analyzers must operate in their normal sampling mode during the precision check, and the test atmosphere must pass through all filters, scrubbers, conditioners or other components used during normal ambient sampling and as much of the ambient air inlet system as practicable. If a precision check is made in conjunction with a zero or span adjustment, it must be made prior to such zero or span adjustments. [Note: some models of CO analyzers can be temporarily modified during the precision check to reduce vent or purge flows, or the test atmosphere may enter the analyzer at a point other than the normal sample inlet, provided that the analyzer's response is not likely to be altered by these deviations from the normal operation mode.]

The actual concentration of the precision check gas and the corresponding indicated concentration (analyzer response) are reported and will be used in calculations of the measurement quality objectives. The percent difference between these concentrations is used to assess the precision and bias of the monitoring data.

3.3 Quarterly Performance Evaluation of Gaseous Methods

Each calendar quarter, a performance evaluation (also known as an accuracy audit) is conducted on all network analyzers that monitor for SO_2, NO_2, O_3, or CO. A trained experienced auditor other than the site operator who performs routine monitoring, calibration, or analysis must conduct the performance evaluation. Transfer standards and equipment used for the performance evaluation must not be the same as the standards and equipment used for calibration and spans, but they may be referenced to the same NIST SRM, CRM, or primary UV photometer.

The audit is made by challenging the analyzer with audit gas concentrations from at least three audit levels shown in Table 2. The selected audit levels should represent or bracket 80 percent of ambient concentrations measured by the analyzer. An additional fourth level is encouraged for those analyzers that have the potential to exceed the concentration ranges described by the initial three audit levels selected. The new audit levels in Table 2 were promulgated in the following USEPA document:

http://www.epa.gov/ttn/amtic/files/ambient/pm25/datamang/TechMemoforPEAuditLevels.pdf

Table 2
Accuracy Audit Levels

	Concentration Range, ppm			
Audit Level	**O_3**	**SO_2**	**NO_2**	**CO**
1	0.004 – 0.0059	0.0003 – 0.0029	0.0003 – 0.0029	0.020 – 0.059
2	0.006 – 0.019	0.0030 – 0.0049	0.0030 – 0.0049	0.060 – 0.199
3	0.020 – 0.039	0.0050 – 0.0079	0.0050 – 0.0079	0.200 – 0.899
4	0.040 – 0.069	0.0080 – 0.0199	0.0080 – 0.0199	0.900 – 2.999
5	0.070 – 0.089	0.0200 – 0. 0499	0.0200 – 0. 0499	3.000 – 7.999
6	0.090 – 0.119	0.0500 – 0.0999	0.0500 – 0.0999	8.000 – 15.999
7	0.120 – 0.139	0.1000 – 0.1499	0.1000 – 0.2999	16.000 – 30.999
8	0.140 – 0.169	0.1500 – 0.2599	0.3000 – 0.4999	31.000 – 39.999
9	0.170 – 0.189	0.2600 – 0.7999	0.5000 – 0.7999	40.000 – 49.999
10	0.190 – 0.259	0.8000 – 1.000	0.8000 – 1.000	50.000 – 60.000

The analyzer should be audited through its normal sampling mode such that the test atmosphere passes through all filters, scrubbers, conditioners, and other sample inlet components used during normal ambient sampling and as much of the ambient air inlet system as is practicable. The exception given for certain CO analyzers in precision checks does not apply for accuracy audits. [Note: NO_2 audit gas for chemiluminescence-type NO_2 analyzers must also contain residual NO gas concentration of at least 0.080 ppm and not greater than 0.120 ppm.]

Both the audit test concentrations and the corresponding concentration measurements indicated by the analyzer for each concentration level being tested shall be reported. The percent differences between these concentrations are used to assess the quality of the monitoring data.

3.4 Precision of Particulate Methods ($PM_{2.5}$, PM_{10}, Pb)

For a given PSD particulate monitoring network, one sampling site must have a collocated sampler. The site with the highest expected 24-hour pollutant concentration must be selected. The two samplers must be within 4 meters of each other (inlet to inlet) but at least 2 meters apart for samplers having flow rates greater than 200 l/min or at least 1 meter apart for samplers having a flow rate less than 200 l/min to preclude air flow interference. In addition, the inlets should be at the same height above ground or within 1 meter of each other as measured in the vertical direction. Calibration, sampling, and analysis must be conducted the same for both samplers as well as for all similar samplers within the network. For each pair of collocated samplers, one sampler is designated as the sampler that will report the air quality for the site (“reporting”) and the other is designated as the duplicate sampler (“collocated”). At a minimum,

the collocated sampler must be operated on a six-day schedule or every third day for PSD daily samplers.

3.5 Flow Rate Bias and Accuracy of Particulate Methods ($PM_{2.5}$, PM_{10}, Pb)

The bias and accuracy of manual sampling methods is assessed by verifying and auditing the sampler flow rate using a certified flow transfer standard. A one-point flow rate verification check must be performed at least once every month. The accuracy of manual sampling methods is assessed by auditing the sampler flow rate at least once per quarter using a different flow transfer standard and a trained experienced technician other than the site operator. The flow transfer standard used for the accuracy audit must not be the same one used for calibration or verification, although both transfer standards may be referenced to the same primary flow or volume standard. The differences in flow rate (lpm or m^3/min) between the audit flow measurement and the flow indicated by the sampler's normal flow indicator is used to calculate the flow bias and accuracy statistics. For further information regarding particulate monitoring, refer to Chapter 7, “Measurement of Particulates,” of the OAQ Quality Assurance Manual.

3.6 Accuracy of Pb Analytical Method

In addition to accounting for the flow accuracy of lead (Pb) samplers, the accuracy of the Pb analytical method must be accounted. For each month in a sampling quarter, the Pb analysis is evaluated by analyzing glass fiber strips containing a known quantity of lead. Audit samples are prepared by depositing a Pb solution on 1.9 cm by 20.3 cm. (3/4 inch by 8 inch) unexposed glass fiber filter strip and allowing it to dry thoroughly. An additional audit strip, a “zero” Pb concentration strip is prepared using deionized distilled water. The audit samples must be prepared using reagents different from those used to calibrate the Pb analytical equipment. Prepare audit samples in the following concentration ranges:

Level	Pb Concentration TSP (µg/strip)	Equivalent Ambient Pb Concentration *µg/m^3
0	0	0% of NAAQS
1	9 – 30	30 – 100% of NAAQS
2	60 – 90	200 – 300% of NAAQS

*Equivalent ambient Pb concentration in µg/m^3 is based on sampling at 1.30 m^3 /min for 24 hours on a 20.3 cm X 25.4 cm (8 inch X 10 inch) glass fiber.

Audit samples must be extracted using the same extraction procedure used for exposed filters and analyzed using the same analytical methodology used for exposed filters. The difference between the audit concentration (µg Pb/strip) and the analyst's measured concentration (µg Pb/strip) at each level is used to determine the lead analytical method accuracy.

4.0 Data Quality Objectives

Data quality objectives (DQO) are statements that define the appropriate type of data to collect and specify the tolerable levels of potential decision errors that will be used as a basis for establishing the quality and quantity of data needed to support the objectives of the monitoring program. In 2006, USEPA amended its air quality monitoring requirements; this rule changed a number of requirements in 40 CFR Part 58 Appendix A. One important change was the statistical techniques used to estimate the precision and bias of the quality control and performance evaluation checks in Appendix A. To ensure a commonality of definition, USEPA defined the following terms:

> **Precision –** a measure of the mutual agreement among individual measurements of the same property usually under prescribed similar conditions. Precision can be considered as the random component of error and is estimated by various statistical techniques involving a derivation of the standard deviation.
>
> **Bias –** the systematic or persistent distortion of a measurement process which causes errors in one direction (e.g., positive or negative, high or low). Bias is determined by estimating the positive and negative deviation from the true value as a percentage of the true value.
>
> **Accuracy –** the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) which is due to sampling and analytical operations.

The measurement uncertainty requirements presented in Sections 4.1 to 4.7 were collected from 40 CFR Part 58 Appendix A, Section 2.3 and from the validation templates found in "Quality Assurance Handbook for Air Pollution Measurement Systems, volume II: Ambient Air Quality Monitoring Program," (EPA-454/B-13-003, May 2013).

To assist organizations with an understanding of the assessment of the collected data, USEPA provided a data assessment calculator, a Microsoft Excel spreadsheet, to simplify the calculations. The spreadsheet titled "Data Assessment Statistical Calculator (DASC) – The software to assist those in calculating the new precision and bias statistics" and the guideline titled "Guideline on the Meaning and the Use of Precision and Bias Required by 40 CFR Part 58 Appendix A – Version 1.1" are available at the following web link:

http://www.epa.gov/ttn/amtic/qareport.html

4.1 Measurement Uncertainty for Ozone (O_3) Methods

The goal for acceptable measurement uncertainty is defined for precision as an upper 90 percent confidence limit for the coefficient variation (CV) of 7 percent and for bias as an upper 95 percent confidence limit for the absolute bias of 7 percent.

4.2 Measurement Uncertainty for Nitrogen Dioxide (NO_2)

The goal for acceptable measurement uncertainty is defined for precision as an upper 90 percent confidence limit for the coefficient of variation (CV) of 15 percent and for bias as an upper 95 percent confidence limit for the absolute bias of 15 percent.

4.3 Measurement Uncertainty for Sulfur Dioxide (SO_2)

The goal for acceptable measurement uncertainty for precision is defined as an upper 90 percent confidence limit for the coefficient of variation (CV) of 10 percent and for bias as an upper 95 percent confidence limit for the absolute bias of 10 percent.

4.4 Measurement Uncertainty for Carbon Monoxide (CO)

The goal for acceptable measurement uncertainty for precision is defined as an upper 90 percent confidence limit for the coefficient of variation (CV) of 10 percent and for bias as an upper 95 percent confidence limit for the absolute bias of 10 percent.

4.5 Measurement Uncertainty for Automated and Manual $PM_{2.5}$ and PM_{10} Methods

The goal for acceptable measurement uncertainty for precision is defined as a coefficient of variation (CV) of 10 percent and an absolute bias of less than 10 percent.

4.6 Measurement Uncertainty for Lead (Pb) Methods

The goal for acceptable measurement uncertainty is defined for precision as an upper 90 percent confidence limit for the coefficient variation (CV) of 20 percent and for bias as an upper 95 percent confidence limit for the absolute bias of 15 percent.

4.7 Quarterly Performance Evaluation Results for Gases (O_3, NO_2, SO_2, CO)

The goal for acceptable measurement uncertainty at each accuracy audit level is a percent difference of less than or equal to 15 percent.

4.8 Quarterly Performance Evaluation Results for Particulate Methods ($PM_{2.5}$, PM_{10}, TSP)

The goal for acceptable flow measurement uncertainty depends on the particulate parameter. For $PM_{2.5}$ (continuous and intermittent), PM_{10} (continuous and low-flow intermittent), and Pb

(low volume sampler), the goal for acceptable flow measurement uncertainty is a percent difference within ±4% of the audit standard and within ± 5% of the design flow rate. For PM_{10} (high volume), the goal for acceptable flow measurement uncertainty is a percent difference within ± 7% of the transfer standard and within ± 10% of the design flow. For Pb (high volume sampler), the goal for acceptable flow measurement uncertainty is a percent difference within ± 7% of the transfer standard.

5.0 Statistics for the Assessment of Gaseous Criteria Pollutants

At the end of each sampling quarter, the PSD organization shall calculate and report precision and bias statistics for each analyzer. If monitoring data are invalidated during the period represented by a given precision check, the results of any precision check during that same period shall be excluded from the calculations. The precision and bias statistics are based on the percentage difference (**d_i**) for each precision check as calculated using Equation 1. In addition, the quarterly performance evaluation result for each audit level is calculated using Equation 1. [Note: Each equation noted in Sections 5 and 6 is numbered and matches the numbering convention in 40 CFR 58 appendix A.]

Equation 1

$$d_i = \frac{meas_i - audit_i}{audit_i} \times 100$$

Where:

meas = analyzer's indicated concentration from the i-th precision check
audit = known concentration of the test gas used for the i-th precision check

5.1 Single Analyzer Precision for Gases

The precision estimate is the 90% upper confidence limit of the coefficient of variation (CV) and is calculated using Equation 2.

Equation 2

$$CV = \sqrt{\frac{\sum_{i=1}^{n} d_i^2 - \left(\sum_{i=1}^{n} d_i\right)^2}{n(n-1)}} \cdot \sqrt{\frac{n-1}{X^2_{0.1,n-1}}}$$

Where:

n = the number of precision checks on the instrument made during the sampling quarter
$X^2_{0.1,n-1}$ = the 10th percentile of a chi-squared distribution with n-1 degrees of freedom

5.2 Single Analyzer Bias

The bias estimate is calculated using the results of the one-point QC percentage differences calculated by Equation 1. The bias estimator is the upper bound 95% confidence limit on the mean absolute value of the percent differences as described in Equation 3.

Equation 3

$$|\text{bias}| = AB + t_{0.95,\,n-1} * \frac{AS}{\sqrt{n}}$$

Where

n = number of precision point checks collected during the sampling quarter
$t_{0.95,\,n-a}$ = 95th quantile of a t-distribution with n-1 degrees of freedom
AB = mean of the absolute values of d_i values, as shown in Equation 4
AS = standard deviation of the absolute value of the d_i's, as shown in Equation 5

Equation 4

$$AB = \frac{1}{n} \cdot \sum_{i=1}^{n} |d_i|$$

Equation 5

$$AS = \sqrt{\frac{n \cdot \sum_{i=1}^{n} |d_i|^2 - \left(\sum_{i=1}^{n} |d_i|\right)^2}{n(n-1)}}$$

Since the bias estimator is calculated using absolute values, a tendency (positive, negative, or none) needs to be associated with it, by giving the bias a sign. To determine the bias sign perform a rank ordering of the percent differences (d_i's) and then determine the 25th and 75th percentiles values. The bias should be flagged as positive (+) if both the 25th and 75th percentile values are positive; likewise if both the 25th and 75th percentile values are negative, the bias should be flagged as negative. The bias is flagged with the ± symbol if the 25th and 75th percentile values are of different signs.

5.3 Validation of Bias using one-point QC Checks

The quarterly performance evaluations for the criteria gases are used to verify the results obtained from the one-point QC checks and to validate those results across a range of concentrations. Probability limits can be calculated from the one-point QC checks using Equations 6 and 7 to quantify this annually at the site level.

Equation 6

$$\text{Upper Probability Limit} = m + 1.96 \cdot S$$

Equation 7

$$\text{Lower Probability Limit} = m - 1.96 \cdot S$$

Where

m = the mean of the percent differences, as given by Equation 8
S = standard deviation of the percent differences, as given by Equation 9

Equation 8

$$m = \frac{1}{k} \cdot \sum_{i=1}^{k} d_i$$

Equation 9

$$S = \sqrt{\frac{k \cdot \sum_{i=1}^{k} d_i^2 - \left(\sum_{i=1}^{k} d_i\right)^2}{k(k-1)}}$$

Where

k = the total number of one-point QC checks for the evaluation time period

Percent differences for the performance evaluations, calculated using Equation 1 can be compared to the probability intervals for the respective site or at the primary quality assurance organization level. Ninety-five percent of the individual percent differences (all audit concentration levels) for the performance evaluations should be captured within the probability intervals established for the analyzer.

6.0 Statistics for the Assessment of Particulate Criteria Pollutants

The calculations in this section are for particulate matter single instrument precision as measured by a comparison of reporting and collocated monitors and single instrument bias measured by a comparison of flow rate verifications and in the case of lead (Pb) bias, comparison of flow verifications and Pb strip analysis.

6.1 Precision Estimates for Collocated Samples

Estimates of precision for ambient air quality measurements from the particulate matter and Pb methods are calculated from the concentration results obtained from the collocation of two samplers at one sampling site. At the end of each sampling quarter, calculate and report a precision probability interval using collocated sampler concentration assessments. The equations in this section are applicable for the following:

- precision estimate for $PM_{2.5}$ and PM_{10}
- precision estimate for lead

At low concentrations, the percent difference agreement between collocated samplers may be relatively poor. USEPA has determined that only data pairs in which both measurements are equal to or above the following limits are to be used in calculating precision and bias:

(1) Pb: 0.02 $\mu g/m^3$
(2) PM_{10} (Hi-Vol): 15 $\mu g/m^3$
(3) PM_{10} (Lo-Vol): 3 $\mu g/m^3$
(4) $PM_{10-2.5}$ and $PM_{2.5}$: 3 $\mu g/m^3$

For the paired measurements, calculate the percent difference (d_i) using Equation l0,

Equation 10

$$d_i = \frac{X_i - Y_i}{(X_i + Y_i)/2} \times 100$$

Where

X_i = particulate or lead concentration from the primary sampler (e.g., the sampler reporting air quality for the site)
Y_i = particulate or lead concentration measured by the audit sampler (collocated sampler)

The precision upper bound statistic, coefficient of variation upper bound, is calculated using Equation 11.

Equation 11

$$CV = \sqrt{\frac{n \cdot \sum_{i=1}^{n} d_i^{\,2} - \left(\sum_{i=1}^{n} d_i\right)^2}{2n(n-1)}} \cdot \sqrt{\frac{n-1}{X^2_{0.1,n-1}}}$$

Where

n = the number of valid data pairs being aggregated
$X^2_{0.1,n-1}$ = the 10th percentile of a chi-squared distribution with n-1 degrees of freedom

6.2 One-Point Flow Rate Bias Estimate

For each one-point flow rate verification, calculation of the flow rate bias begins with the percent difference in flow rate using Equation 1.

Equation 1

$$d_i = \frac{\text{meas - audit}}{\text{audit}} \times 100$$

Where:

meas = value indicated by the sampler's flow measurement
audit = value indicated by the auditing flow meter

The absolute bias estimator is an upper bound value based on the percent differences as described in Equation 3.

Equation 3

$$|\text{bias}| = AB + t_{0.95,\,n-1} * \frac{AS}{\sqrt{n}}$$

Where

n = number of flow audits collected during the sampling quarter or year
$t_{0.95,\,n-a}$ = 95th quantile of a t-distribution with n-1 degrees of freedom
AB = mean of the absolute values of d_i values, as shown in Equation 4
AS = standard deviation of the absolute value of the d_i's, as shown in Equation 5

Equation 4

$$AB = \frac{1}{n} \cdot \sum_{i=1}^{n} |d_i|$$

Equation 5

$$AS = \sqrt{\frac{n \cdot \sum_{i=1}^{n} |d_i|^2 - \left(\sum_{i=1}^{n} |d_i|\right)^2}{n(n-1)}}$$

Since the bias estimator is calculated using absolute values, a tendency (positive, negative, or none) needs to be associated with it. To determine the bias sign perform a rank ordering of the percent differences (d_i's) and then determine the 25th and 75th percentiles values. The bias should be flagged as positive (+) if both the 25th and 75th percentile values are positive; likewise if both the 25th and 75th percentile values are negative, the bias should be flagged as negative. The bias is not flagged if the 25th and 75th percentile values are of different signs.

6.3 Lead (Pb) Bias Assessment

The bias estimation is a combination of flow rate verifications (vol bias) and the lead (Pb) strip analysis (mass bias) and is expressed as a percent using Equation 12.

Equation 12

$$|\text{bias}| = \frac{|\text{mass bias}| + |\text{vol bias}|}{100 - |\text{vol.bias}|} \cdot 100$$

Where

mass bias = bias determined from Pb strip analysis
vol bias = bias determined from flow rate verifications

The mass bias calculation begins with Equation 1 to determine the percent difference, d_i, between value indicated by the mass measurement, meas, and the actual lead mass on the lead strip, audit. The absolute mass bias upper bound is calculated using Equation 3 of this chapter, in a similar manner as that used in determination of single analyzer bias. The volume bias calculations are similar to those of the one-point flow rate bias determination of Section 6.2. It begins with Equation 1 to determine the percent difference, d_i, between the value indicated by the sampler's flow rate measurement, and the actual flow rate indicated. The absolute vol bias is calculated using Equation 3 of this chapter.

7.0 PSD Organization Reporting Requirements

At the end of each sampling quarter, the PSD organization must report the collected gas and particulate parameter concentrations and the following data assessment information to the permit-granting authority within 60 days after the end of the quarter.

1. For gas analyzers – measured concentration and actual concentration from the biweekly precision checks and measured concentration and actual concentration from the quarterly performance evaluation audits.

2. For particulate methods – instrument flow measurement and transfer standard flow measurement from monthly flow rate verifications and the instrument flow measurement and transfer standard flow measurement from the quarterly flow rate performance evaluation.

Air monitoring data must be submitted in a format suitable for submission to USEPA's Air Quality System (AQS). Most data loggers will output hourly data in a format suitable for AQS submission (check with the data logger vendor regarding data output formats). USEPA has developed the AQS Transaction Generator that may be used to create AQS data input transactions for one-point quality control and performance evaluation audits for gas parameters and flow rate verification and monthly flow rate verification and quarterly flow rate audits for particulate parameters. The AQS Transaction Generator is a stand-alone Microsoft program workbook that creates accuracy and precision files in the pipe delimited format suitable for uploading to AQS. A guide to using the program is available within the program by clicking on the HELP button.

The file can be found on the following webpage:

http://www.epa.gov/ttn/airs/airsaqs/downloads.htm