Chapter 11

Valid Data and Completeness Requirements

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1.0 Introduction

No monitoring record is ever complete (100% data collection). There are periods of missing data – some planned and necessary (e.g., calibrations, audits, maintenance) – but others that are unforeseen (e.g., power outages, equipment failures). Of the collected data, not all of it is representative of the ambient atmospheric conditions (e.g., collection errors, equipment malfunctions). Data validation ensures the quality and consistency of pollutant and meteorological data collected by the reporting organization for submission to USEPA's Air Quality System (AQS) and for comparison to the National Ambient Air Monitoring Standards (NAAQS).

2.0 Operating Schedules

2.1 Continuous Analyzers

For continuous analyzers (CO, NO_2, SO_2, O_3, continuous $PM_{2.5}$, continuous PM_{10}, and continuous Speciation), consecutive hourly averages must be collected except during:

1. periods of routine maintenance;
2. periods of instrument calibration/audits; or
3. periods or monitoring seasons exempted by the USEPA Regional Administrator.

2.2 Intermittent Samplers

In order to maintain a consistency in sampling, intermittent samplers (Pb-TSP, Pb-PM_{10}, PM_{10}, $PM_{2.5}$, and Speciation-$PM_{2.5}$), at a minimum, operate on USEPA's national sampling schedule (3-day, 6-day, 12-day schedule). The calendar is published annually and can be found on USEPA's AMTIC website, http://www.epa.gov/ttn/amtic/calendar.html.

2.2.1 Manual $PM_{2.5}$ Samplers

State/Local Area Monitoring Stations (SLAMS): Manual $PM_{2.5}$ samplers must operate on at least a 1-in-3 day schedule at sites without a collocated continuously operating $PM_{2.5}$ monitor. For sites with both manual and continuous $PM_{2.5}$ monitors, the monitoring agency may request approval for a reduction to 1-in-6 day $PM_{2.5}$ sampling or for seasonal sampling from the USEPA Regional Administrator. The USEPA Regional Administrator may grant sampling frequency reductions after consideration of factors, including but not limited to the historical $PM_{2.5}$ data quality assessments, the location of current $PM_{2.5}$ design value sites, and other regulatory data needs.

Sites that have design values that are within plus or minus 10% of the NAAQS; and sites where one or more 24-hour concentration values have exceeded the NAAQS for a consecutive period of 3 years are required to maintain at least a 1-in-3 day sampling frequency. Sites that have a design

value within plus or minus 5% of the daily $PM_{2.5}$ NAAQS must have an FRM or FEM operate on a daily schedule.

National Core (NCore) and Regional Background/Regional Transport Sites: Manual $PM_{2.5}$ samplers must operate on at least a 1-in-3 day sampling frequency.

2.2.2 Manual PM_{10} Samplers

A 24-hour sample, taken from midnight to midnight (local standard time), is collected to ensure national consistency. The minimum monitoring schedule for a site in the area of expected maximum concentration shall be based on the relative level of that monitoring site concentration with respect to the 24-hour standard as illustrated in Figure 1 of 40 CFR §58.12. The minimum sampling schedule for all other sites is once every six days.

2.2.3 Lead (Pb) Manual Methods

For Pb manual methods, at least one 24-hour sample is collected every 6 days except during periods or seasons exempted by the USEPA Regional Administrator.

2.2.4 PAMS Samplers

For PAMS VOC samplers, samples must be collected as specified in 40 CFR Part 58, Appendix D Section 5. Area specific PAMS operating schedules must be included as part of the PAMS network description and must be approved by the USEPA Regional Administrator.

2.3 Meteorological Monitors

For meteorological monitors (wind speed, wind direction, vertical wind direction, ambient temperature, relative humidity, barometric pressure, solar/UV radiation, precipitation), consecutive hourly averages must be collected except during:

1. periods of routine maintenance or
2. periods of instrument calibration/audits.

3.0 Valid Data

Prior to releasing data for use by others, continuous monitoring, intermittent particulate, and meteorological data must be verified by the station operator and validated by the Quality Assurance Section.

3.1 Continuous Analyzers

For continuous monitoring data, there are several basic causes for invalidating monitoring data by either the monitor operator or quality assurance personnel. In addition, other analyzer operations (calibrations, audits, operator applied null codes) should be verified while reviewing the data. Additional data validation limits for continuous particulate samplers are detailed in Chapter 7, "Measurement of Suspended Particulates," of the Quality Assurance Manual. Additional data validation information for gas analyzers are detailed in Chapter 12, "Data Reduction and Audit Procedures," of the Quality Assurance Manual.

Data may be rendered invalid and not usable for any purpose if any of the following conditions exist; however, the data reviewer must check with the pertinent sections of 40 CFR Part 50 to determine if the data meets certain exceptions that would render the data as valid:

1. The monitor records less than forty-five (45) minutes for any hour. NOTE: Since various QC checks take time to complete (zero/span/1-point QC), it is suggested that they be implemented in a manner that spans two hours (e.g., at 11:45 PM to 12:15 AM) in order to avoid losing an hour's worth of data.

2. The monitor exhibits excessive zero or span drift. The daily zero and span values must not exceed the maximum amount for a twenty-four (24) hour period and greater than 24 hours up to 14 days. See Table 1 for the zero and span drift limits.

Table 1
Zero and Span Drift Limits

Pollutant	**24 hours**	**>24 hours to 14 days**
	Zero Drift	Zero Drift
	Span Drift	Span Drift
Sulfur Dioxide	≤ ±3.0 ppb	≤ ±5.0 ppb
	Span drift ≤ ± 10%	Span drift ≤ ± 10%
Ozone	≤ ±3.0 ppb	≤ ±5.0 ppb
	Span drift ≤ ± 7%	Span drift ≤ ± 7%
Carbon Monoxide	≤ ±0.4 ppm	≤ ±0.6 ppm
	Span drift ≤ ± 10%	Span drift ≤ ± 10%
Nitrogen Dioxide	≤ ±3.0 ppb	≤ ±5.0 ppb
	Span drift ≤ ± 10%	Span drift ≤ ± 10%

3. The data exhibits evidence of an analyzer malfunction. The analyzer malfunction (e.g., low sample flow, pump failure, lamp burnout) may be detected at any stage of the data handling

procedure.

4. The monitor was not calibrated after on-site installation. The data is invalid until it is calibrated.

5. More than six (6) months have elapsed since the gas monitor's last calibration and one year for continuous particulate monitors (Tapered Element Oscillating Micro-Balance monitor (TEOM), Beta Attenuation Monitor (BAM), Synchronized Hybrid Ambient Real-time Particulate (SHARP) monitor, Aethalometer).

6. If the value for the zero or span exceeds the range of the recording device (i.e., if the zero is less than 0.0% or the span is greater than 100.0%), then that data is invalid until the next zero or span that is within acceptable limits.

7. If the monitor exhibits unusual or excessive trace outputs to the recorder or data logger including:

    a. A straight line trace (other than minimum detectable) for several hours

    b. A wide, solid trace indicating excessive noise or erratic behavior, such as spiking

    c. A long steady increase or decrease in deflection

    d. A cyclic trace pattern with a defined time period

    e. A trace below the zero baseline spiking or signal noise

8. If the zero or span potentiometer is changed between calibrations with no documentation of a calibration, all data is invalid from the time of the change to the time the monitor is properly recalibrated.

9. If the shelter temperature exceeds the predefined limits of 15 °C to 33 °C (0 °C to 40 for Aethalometer), the data collected by the continuous gas analyzers is considered as invalid. Some continuous PM samplers may also have a larger temperature range to collect accurate data. This range would need to be defined and have scientific backing by the entity collecting the data.

10. If a chart recorder is the sole hardware to collect the continuous data, the following information must be present on the start and finish of each raw data segment to ensure that the data can be properly processed:

    - Site name
    - Pollutant(s) or Meteorological Parameter(s)
    - Date
    - Time

- Chart speed
- Initials of operator
- Any remarks (e.g., jammed paper in the chart recorder, chartless recorder media being "full" (full diskette)) that will provide information concerning invalid or missing data.

The Quality Assurance Section Chief may invalidate continuous monitoring data for reasons not specifically noted in this chapter if the data or the collection procedures are of a questionable or improper nature. The Quality Assurance Section Chief will make decisions about these invalidations on a case-by-case basis.

3.2 Intermittent Samplers

For manual particulate samplers (PM_{10}, Pb, $PM_{2.5}$), there are several reasons for invalidating data by either the sampler operator or quality assurance personnel. Data can be considered invalid if any of the listed conditions exist; however, before invalidating data, the reviewer must check with 40 CFR Part 50 to determine if the data meets certain exceptions that may render the data as valid. Additional data validation limits for intermittent particulate samplers are detailed in Chapter 7, "Measurement of Suspended Particulates," of the Quality Assurance Manual. Sections 3.2.1 through 3.2.3 provide potential sources of measurement error for lead (Pb), PM_{10}, and $PM_{2.5}$, respectively.

1. The total sampling time is not within the range of 1,380.0 minutes to 1,500.0 minutes (23 to 25 hours). Samples can still be valid if occur < 1,380 minutes **and** in exceedance of NAAQS from midnight to midnight local standard time.

2. Evidence of a non-ambient filter collection in any post-sampling check. Examples of problematic filter collections include:

   - Particulate bleed off
   - Holes or tears in the filter
   - Pb-TSP filters that have more than 9.0 mm^2 missing, more than 10 insects or insect parts on the filter, bird feces, etc.

3. An audit shows the sampler to be out of the calibration limits of ± 4% of transfer standard or ± 5% of flow rate design value for $PM_{2.5}$ and PM_{10} sequential samplers and ± 7.0% for hi-vol Pb-TSP and hi-vol PM_{10} samplers.

4. The flow transfer standard used for calibrations has not been certified within the twelve (12) preceding months. All sampler motor/pump calibrations done with an orifice that exceeds recertification requirements are invalid, and all data is invalid until the sampler is recalibrated using a properly certified orifice.

5. The sampler is calibrated using either an incorrect method or data (e.g., temperature, pressure, orifice certification information). In these cases, the calibration is invalid and all data is invalidated until the sampler is properly recalibrated.

6. The sample is collected on the same side of the hi-vol glass or quartz filter as the filter number (smooth side). The filter has a rougher texture on one side to improve collection efficiency.

7. The hi-vol sampler has not been properly calibrated within the three (3) preceding months. All data is invalid until the sampler is recalibrated using a properly certified orifice. For some PM and Pb samplers, it may be better to perform the calibration in a laboratory setting then once the sampler is placed at the site, a verification will need to be performed prior to any valid data collection.

8. The initial and/or final flow rate at standard conditions for Pb-TSP and actual conditions for PM_{10} hi-vol is not within the range of 1.1 m^3/min to 1.7 m^3/min for Pb-TSP or 1.02 m^3/min to 1.24 m^3/min for PM_{10} hi-vol, the data may also be invalidated.

9. Data may be invalidated if the difference between initial and final flow meter readings for a TSP or PM_{10} hi-vol sampler is not within the range of plus or minus (±) 10.0%.

10. All necessary information is not recorded on the data sheet for each sample. The following information must be available for each sample:

    - Site
    - Pollutant
    - Date and time started
    - Date and time ended
    - Sampler motor number (and flow controller serial number, if applicable)
    - Filter number
    - Flow meter reading (if applicable) for start and finish
    - Elapsed time meter reading for start and finish
    - Any remarks
    - Operator's signature (not initials)

The Quality Assurance Section Chief may invalidate intermittent monitoring data for reasons not specifically noted in this chapter if the data or the collection procedures are of a questionable or improper nature. The Quality Assurance Section Chief will decide these invalidations on a case-by-case basis.

3.2.1 Lead Sampler Potential Sources of Error

Airflow variation. The mass of material collected on the filter represents the (integrated) sum of the product of the instantaneous flow rate times the instantaneous particle concentration. Therefore, dividing this mass by the average flow rate over the sampling period yields the true particulate matter concentration only when the flow rate is constant over the sampling period. The error resulting from a variable flow rate depends on the magnitude of the instantaneous changes in the flow rate and in the particulate matter concentration. The variation can be greatly

reduced by equipping the sampler with a constant flow controller.

Air volume measurement. If the flow rate changes substantially or non-uniformly during the sampling period, appreciable error in the estimated air volume may result from using the average of the pre-sampling and post-sampling flow rates. Greater air volume measurement accuracy may be achieved by:

(1) equipping the sampler with a constant flow controller,

(2) using a calibrated, continuous flow rate recording device to record the actual flow rate during the sampling period and integrating the flow rate over the period; or

(3) any other means that will accurately measure the total air volume sampled during the sampling period.

Filter handling. Careful handling of the filter between the sample setup and post-sample pickup is necessary to avoid errors due to loss of fibers or particles from the filter. A filter paper cartridge or cassette used to protect the filter can minimize handling errors.

Non-sampled particulate matter. Particulate matter may be deposited on the filter by wind during periods when the sampler is inoperative. It is recommended that errors from this source be minimized with the use of a sample saver, an automatic mechanical device that keeps the filter covered during non-sampling periods, or by timely installation and retrieval of filters to minimize the non-sampling period.

Timing errors. Samplers are normally controlled by timers set to start and stop the sampler at midnight local standard time. Errors in the nominal 1,440-min sampling period may result from a power interruption during the sampling period or from a discrepancy between the start or stop time recorded on the filter information record and the actual start or stop time of the sampler. Such discrepancies may be caused by

(1) poor resolution of the timer set-points,
(2) timer error due to power interruption,
(3) incorrect setting of the timer, or
(4) timer malfunction.

In general, digital electronic timers have much better set-point resolution than mechanical timers, but require a battery backup system to maintain continuity of operation after a power interruption. A continuous flow recorder or elapsed time meter provides an indication of the sampler run-time, as well as indication of any power interruption during the sampling period.

Recirculation of sampler exhaust. Under stagnant wind conditions, sampler exhaust air can be resampled as this does not appear to affect the Pb measurement substantially. This problem can be reduced by ducting the exhaust air well away, preferably downwind, from the sampler.

3.2.2 PM_{10} Sampler Potential Sources of Error

Volatile Particles. Volatile particles collected on filters are often lost during shipment and/or storage of the filters prior to the post-sampling weighing. Although shipment or storage of loaded filters is sometimes unavoidable, filters should be reweighed as soon as practical to minimize these losses.

Speciation Artifacts. Positive errors in PM_{10} concentration measurements can result from the retention of gaseous species on filters, including sulfur dioxide and nitric acid. Retention of sulfur dioxide on filters, followed by oxidation to sulfate, is referred to as artifact sulfate formation, a phenomenon which increases with increasing filter alkalinity. Little or no artifact sulfate formation should occur when using filters that meet USEPA's filter alkalinity specification. Artifact nitrate formation, resulting primarily from retention of nitric acid, occurs to varying degrees on many filter types, including glass fiber, cellulose ester, and many quartz fiber filters. Loss of atmospheric particulate nitrate during or following sampling may occur due to dissociation or chemical reaction. This phenomenon has been observed on Teflon® filters. The magnitude of nitrate artifact errors in PM_{10} mass concentration measurements will vary with location and ambient temperature; however, for most sampling locations, these errors are expected to be small.

Humidity. The effects of ambient humidity on the sample are unavoidable. The filter equilibration procedure is designed to minimize the effects of moisture on the filter medium.

Filter Handling. Careful handling of filters between pre-sampling and post-sampling weighing is necessary to avoid errors due to damaged filters or loss of collected particles from the filters. Use of a filter cartridge or cassette may reduce the magnitude of these errors.

Flow Rate Variation. Variations in the sampler's operating flow rate may alter the particle size discrimination characteristics of the sampler inlet. The magnitude of this error will depend on the sensitivity of the inlet to variations in flow rate and on the particle distribution in the atmosphere during the sampling period. The use of a flow control device is required to minimize this error.

Air Volume Determination. Errors in the air volume determination may result from errors in the flow rate and/or sampling time measurements. The flow control device serves to minimize errors in the flow rate determination, and an elapsed time meter is required to minimize the error in the sampling time measurement.

3.2.3 $PM_{2.5}$ Potential Sources of Error

Sample Recovery. The filter, while still contained in the filter cassette must be carefully removed from the sampler within 177 hours (7 days, 9 hours) of the end of the sample collection.

Post-Sample Weighing. Post-sampling conditioning and weighing must be completed within 240 hours (10 days) after the end of the sample period. If the filter sample is maintained at temperatures below the average ambient temperature during sampling (or at or below

temperatures 4 °C for average sampling temperatures less than 4 °C) during the time between retrieval from the sampler and the start of the conditioning, the post-sampling conditioning and weighing must occur within 30 days.

Sample period. The required sample period for $PM_{2.5}$ concentration measurements must be within 1,380 to 1500 minutes (23 to 25 hours) or if < 1,380 minutes **and** in exceedance of NAAQS from midnight to midnight local standard time.

Sample flow rate. Proper operation of the impactor or cyclone requires that specific air velocities be maintained through the sampler. The design sample air flow rate through the inlet must be 16.67 L/min (1.000 m^3 /hour) measured as actual volumetric flow rate at the temperature and pressure of the sample air entering the inlet. The volumetric flow rate, measured or averaged over intervals of not more than 5 minutes over a 24-hour period, should not vary more than ±5 percent from the specified 16.67 L/min flow rate over the entire sample period.

Temperature audit. Any deviation greater than 2 °C needs to be reported for corrective action.

Barometric Pressure: Any deviation greater than 10 mmHg needs to be reported for corrective action.

Flow audit: The percent difference between the sampler flow rate and the audit flow rate is used to validate the one-point flow rate verification check. The audit results also are used to estimate the sampler bias. If the flow audit result differs by ± 4% of transfer standard or ± 5% of the flow rate design, the deviation should be reported for corrective action.

3.3 Toxics Monitoring

The specific data validation limit for toxic monitoring is detailed in Chapter 8, "Quality Assurance of Ambient Air Toxic Organic Compounds Monitoring," of the Quality Assurance Manual. On a monthly basis, Quality Assurance staff members will randomly select an hour period to quality assure air canister and PAMS ozone precursors data by reprocessing the data file. Differences of 20 ppbC for a particular hour will be invalidated. Also, if such difference(s) are found, reprocessing will be required of the previous 12 hours and the following 12 hours of the selected 24 hour period to confirm accuracy. This will then total 48 hours of reprocessed data. If any 20 ppbC discrepancies are found again, appropriate hourly data will be invalidated. Reprocessing of 12 more hours prior to and following the previously reprocessed 48 hour period will be required, and so on, until no more discrepancies are found. Also, if any values higher than 300% of background is detected for a certain hour, that hour will be reprocessed to make sure it is valid. See Chapter 8, Part 8.0, Data Validation for the detailed technical procedure on data validation.

3.4 Meteorological Monitors

For meteorological monitoring data, there are several basic causes for invalidation of monitoring data by either the monitor operator or quality assurance personnel. Information regarding data

validation limits for meteorological monitors can be found in Chapters 9, "Meteorological Monitoring," and 12, "Data Reduction and Audit Procedures." Additional details on meteorological monitoring are available in the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV: Meteorological Measurements Version 2.0, (EPA-454/B-08-002, March 2008), which is available at the following link:

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

3.5 Invalidation of Collected Data

Collected data that has been determined to be invalid must be identified using a null qualifier code to describe the reason for the invalidation. This is especially important when submitting data into USEPA's Air Quality System (AQS). Table 2 is the latest listing of available AQS null codes. For continuous data, the null qualifier code replaces the invalid data. For intermittent data, the AQS qualifier code is entered into the laboratory information management system as the reason why the sample was invalidated. The qualifier code will follow the sample when particulate data is extracted from the management system.

Table 2
Null Data Codes for Invalid Single Samples

AQS Null Qualifier Description	Qualifier Code
Aberrant Data (Corrupt Files, Aberrant Chromatography, Spikes, Shifts)	DA
Accuracy check	BM
Auto Calibration	BD
Bad Weather	AO
Building/Site Repair	BE
Calibration	AT
Calibration Verification Standard	ST
Collection Error	AQ
Component Check & Retention Time Standard	TC
Construction/Repairs in Area	AC
Detection Limit Analyses	DL
Experimental Data	XX
Filter Damage	AJ
Filter Inspection Flag	FI
Filter Leak	AK
Holding Time Or Transport Temperature Is Out Of Specs.	TS
Insufficient Data (cannot calculate)	AI
Interference/co-elution/misidentification	BH
Lab Error	AR
Laboratory Calibration Standard	CS
Lost or damaged in transit	BI
Machine Malfunction	AN
Maintenance/Routine Repairs	BA
Method Blank (Analytical)	MB

Miscellaneous Void	AM
Missing ozone data not likely to exceed level of standard	BG
Module End Cap Missing	MC
Monitoring Waived	AU
Multi-point Calibration	BC
Operator Error	BJ
Poor Quality Assurance Results	AS
Power Failure	AV
Precision Check	AX
Precision/Zero/Span	BF
Q C Audit	AZ
Q C Control Points (zero/span)	AY
QA Audit	BL
Sample Flow Rate out of Limits	AH
Sample Pressure out of Limits	AA
Sample Time out of Limits	AG
Sample Value Exceeds Media Limit	BN
Sampler Contamination	SC
Scheduled but not Collected	AF
Shelter Storm Damage	AD
Shelter Temperature Outside Limits	AE
Site computer/data logger down	BK
Storm Approaching	SA
Technician Unavailable	AB
Unable to Reach Site	BB
Vandalism	AP
Voided by Operator	AL
Wildlife Damage	AW

4.0 Completeness Requirement

Data required for comparison to the NAAQS have specific completeness requirements, which provide a measure of assurance that the data is statistically complete and representative. These completeness requirements generally start from completeness at hourly and 24-hour concentration values. However, the levels of data aggregation used for NAAQS determinations include 3-hour, 8-hour, quarterly, annual and multiple years. Generally, depending on the calculation of the design value, USEPA requires data to be 75% complete. All continuous measurements come down to what is considered a valid hour and currently all intermittent particulate sampling (manual PM, Pb, speciation) is based on a 24-hour sampling period.

Table 3 provides the completeness goals for the various ambient air program monitoring programs. The data cells in Table 3 that are highlighted in yellow refer to the standards that apply to the specific pollutant. Even though a highlighted cell lists the completeness requirement, 40 CFR Part 50 provides additional detail, on how a design value might be calculated with less data than the stated requirement. Sections 4.1 through 4.7 provide additional detail on data completeness for the criteria pollutants. Therefore, the information provided in Table 3 should be

considered as the initial completeness goal, which should be attempted to be achieved. Completeness goals that are not highlighted, although not covered in CFR, are very important to the achievement of the CFR completeness goals. For example, even though there is only an 8-hour ozone standard, it is important to have complete 1-hour values in order to determine the 8-hour design value.

Table 3
Completeness Goals for Ambient Air Monitoring Data

[Reference Table 6-5 from the Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II: Ambient Air Quality Monitoring Program, (EPA-454/B-013-003 May 2013)]

	Completeness Goals and Associated Standards (highlighted)					
Pollutants	**1-hour**	**3-hour**	**8-hour**	**24-hour**	**Quarterly**	**Annual**
CO	45, 1 min. values*		75% of hourly values	75% of hourly values		75% of hourly values per quarter
O_3	45, 1 min. values*		75% of hourly values			
SO_2	45, 1 min. values*	All 3 hours 75% complete		75% of hourly values		75% of hourly values per quarter
NO_2	45, 1 min. values*					75% of hourly values per quarter
PM_{10} Cont	45, 1 min. values			18 hours		
$PM_{2.5}$ Cont.	45, 1 min. values			18 hours		
PM_{10} Manual				23 Hours**		
$PM_{2.5}$ Manual				23 hours	75% of samples	
Pb				23 Hours	3 mo avg 75% of samples	
PAMS				23 Hours		
STN				23 Hours		
CSN				23 Hours		

***If an hour includes the daily zero/span sequence, the hour is considered valid if at least fifty percent (50.0%) of the hour is valid.**
**** not defined in CFR**

The Indiana Department of Environmental Management, Office of Air Quality, Quality Assurance Section must be contacted and provided with information needed to decide appropriate completeness requirements or sampling intervals other than those listed in Table 3 and 40 CFR Part 50.

4.1 Carbon monoxide

The primary standards for CO are 9 parts per million (ppm) for an 8-hour average, not to be exceeded more than once per calendar year and 35 ppm for a 1-hour average concentration, not to be exceeded more than once per year. The design values for the primary CO NAAQS are the second highest maximum 1-hour concentration and the second highest 8-hour running average for a monitoring site. The 8-hour averages are determined from successive non-overlapping 8-

hour blocks starting at midnight of each calendar day. The 8-hour running average is computed as the sum of the hourly averages divided by eight.

An 8-hour average is considered valid if at least 75% of the hourly averages for the 8-hour period are available. In the event that only six (or seven) hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using six (or seven) as the divisor.
[Reference: 40 CFR § 50.8, National primary ambient air quality standards for carbon monoxide.]

4.2 Nitrogen Dioxide

Data from an ambient air quality monitoring site will meet the primary NO_2 NAAQS when the valid 1-hour primary standard design value is less than or equal to 100 parts per billion (ppb) and when the annual primary standard design value is less than 53 ppb. The design value for the primary 1-hour NO_2 NAAQS is the three-year average of the annual 98^{th} percentile daily maximum 1-hour concentrations for a monitoring site. The annual primary standard is the annual mean value for a monitoring site for one calendar year.

The one hour NO_2 primary standard design value for an ambient air monitoring site is considered valid if the data encompass three consecutive calendar years of complete data. A year meets data completeness requirements when all 4 quarters are complete. A quarter is complete when at least 75% of the sampling days for each quarter have complete data. A sampling day has complete data if 75% of the hourly concentration values are reported for that day.

In the event that one, two, or three years of data do not meet the completeness requirements and would normally not be useable in calculating a valid 3-year 1-hour primary standard design value, exceptions are allowed to attain a valid 3-year 1-hour primary standard design value. Data not meeting the completeness requirement question, but meeting certain conditions outlined in 40 CFR Part 50 Appendix S may be utilized in the calculation of a valid design value.

The annual primary NO_2 standard design value is valid when at least 75% of the hours in the year are reported. An annual NO_2 primary standard design value based on data that does not meet completeness criteria may be considered valid at the initiative or approval of the USEPA Administrator.
[Reference: Appendix S to Part 50—Interpretation of the Primary National Ambient Air Quality Standards for Oxides of Nitrogen (Nitrogen Dioxide)].

4.3 Ozone

Data from an ambient air quality monitoring site will meet the primary O_3 NAAQS when the valid 8-hour primary standard design value is less than or equal to 0.075 parts per million (ppm). The design value for the primary O_3 NAAQS is the three-year average of the annual fourth highest daily maximum 8-hour average concentration for a monitoring site.

The 8-hour running average is computed as the sum of the hourly O_3 averages in an 8-hour period divided by eight. An 8-hour average is considered valid if at least 75% of the hourly averages for the 8-hour period are available. In the event that only six or seven hourly averages are available, the 8-hour average shall be computed on the basis of the hours available using six or seven as the divisor. Periods with three or more missing hours can be considered valid if, after substituting one-half the minimum detectable limit for the missing hourly concentrations, the 8-hour average concentration is greater than the level of the ozone standard.

There are 24 possible running 8-hour average ozone concentrations for each calendar day during ozone monitoring season. (Ozone monitoring seasons vary by geographic location as designated in 40 CFR Part 58, Appendix D.) The daily maximum 8-hour concentration for each calendar day is the highest of the 24 possible 8-hour average concentrations computed for that day. This process is repeated, yielding a daily maximum 8-hour average ozone concentration for each calendar day with ambient ozone monitoring data. Because the 8-hour averages are recorded in the start hour, the daily maximum 8-hour concentrations from two consecutive days may have some hourly concentrations in common. An ozone monitoring day shall be counted as a valid day if valid 8-hour averages are available for at least 75% of possible hours in the day (i.e., at least 18 of the 24 averages). In the event that less than 75% of the 8-hour averages are available, a day shall also be counted as a valid day if the daily maximum 8-hour average concentration for that day is greater than the level of the ambient standard.

The O_3 8-hour primary standard design value for an ambient air monitoring site is considered valid if the data encompass three consecutive calendar years of complete data. The completeness requirement is met for the 3-year period if daily maximum 8-hour average concentrations are available for at least 90% of the days within the O_3 monitoring season, on average for the 3-year period, with a minimum data completeness requirement in any one year of at least 75% of the days. When computing whether the minimum data completeness requirements are met, meteorological or ambient data may be sufficient to demonstrate that meteorological conditions on missing days were not conducive to having concentrations above the level of the standard. Missing days assumed less than the level of the standard may be counted for meeting the data completeness requirement, subject to the approval of the appropriate Regional Administrator.

Years with ozone concentrations greater than the level of the O_3 NAAQS shall be included even if they have less than complete data. Thus, in computing the 3-year average fourth maximum concentration, calendar years with less than 75% data completeness shall be included in the computation if the 3-year average fourth-highest 8-hour concentration is greater than the level of the standard.
[Reference: Appendix P to Part 50—Interpretation of the 8-Hour Primary and Secondary National Ambient Air Quality Standards for Ozone]

4.4 Sulfur Dioxide

4.4.1 Primary Standard

Data from an ambient air quality monitoring site will meet the primary SO_2 NAAQS when the

valid 1-hour primary standard design value is less than or equal to 75 parts per billion (ppb). The design value for the primary SO_2 NAAQS is the three-year average of the annual 99th percentile daily maximum 1-hour concentrations for a monitoring site.

The 1-hour SO_2 primary standard design value for an ambient air monitoring site is considered valid if the data encompass three consecutive calendar years of complete data. A year meets data completeness requirements when all 4 quarters are complete. A quarter is complete when at least 75% of the sampling days for each quarter have complete data. A sampling day has complete data if 75% of the hourly concentration values are reported for that day.

In the event that one, two, or three years of data do not meet the completeness requirements and would normally not be useable in calculating a valid 3-year 1-hour primary standard design value, there are exceptions allowed to attain a valid 3-year 1-hour primary standard design value. Data not meeting the completeness requirement question, but meeting certain conditions outlined in 40 CFR Part 50 Appendix T may be utilized in the calculation of a valid design value. [Reference: Appendix T to Part 50—Interpretation of the Primary National Ambient Air Quality Standards for Oxides of Sulfur (Sulfur Dioxide)]

4.4.2 Secondary Standard

The secondary 3-hour averaged standard for SO_2 is 0.5 parts per million (ppm), not to be exceeded more than once per calendar year. Data from an ambient air quality monitoring site will meet the secondary SO_2 NAAQS when the valid 3-hour secondary standard design value is less than or equal to 0.5 ppm. The design value for the secondary SO_2 NAAQS is the second highest 3-hour block average for a monitoring site. The 3-hour block averages are determined from successive non-overlapping 3-hour blocks starting at midnight of each calendar day. The 3-hour block average is computed as the sum of the hourly averages divided by three.

To demonstrate attainment with the secondary standard, the second-highest 3-hour average is based upon hourly data that are at least 75% complete in each calendar quarter. A 3-hour block average is considered valid only if all three hourly concentrations for the 3-hour block are available.

If only one or two hourly averages are available within the 3-hour block, but the 3-hour average would exceed the secondary standard when zeros are substituted for the missing value(s), then the 3-hour average is considered valid.
[Reference: 40 CFR § 50.5, National secondary ambient air quality standard for sulfur oxides (sulfur dioxide).]

4.5 PM_{10}

Data requirements in 40 CFR 58.12 specify the required minimum frequency of sampling for PM_{10}. For the purposes of making comparisons with the PM_{10} NAAQS of 150 µg/m^3, all data produced by State and Local Air Monitoring Stations (SLAMS) and other sites submitted to USEPA in accordance with the part 58 requirements must be used, and a minimum of 75% of the

scheduled PM_{10} samples per quarter are required. Under 40 CFR 50.6(a), the 24-hour primary and secondary standards are attained when the expected number of exceedances per year at each monitoring site is less than or equal to one. In the simplest case of everyday sampling, the number of expected exceedances at a site is determined by recording the number of exceedances in each calendar year and then averaging them over the past 3 calendar years. If PM_{10} sampling is scheduled less frequently than every day, or if some scheduled samples are missed, a PM_{10} value will not be available for each day of the year. To account for the possible effect of incomplete data, an adjustment is made to the data collected at each monitoring site to estimate the number of exceedances in a calendar year. Appendix K of 40 CFR Part 50 provides the procedure for calculating the expected number of exceedances.
[Reference: Appendix K to Part 50—Interpretation of the National Ambient Air Quality Standards for Particulate Matter]

4.6 $PM_{2.5}$

The annual $PM_{2.5}$ NAAQS is met when the annual standard design value is less than or equal to 12.0 micrograms per cubic meter ($\mu g/m^3$). For single sites, three years of valid annual means are required to produce a valid annual standard design value, which is the average of the three annual means. A year meets data completeness requirements when at least 75% of the scheduled sampling days for each quarter have valid data. Quarterly data capture rates (expressed as a percentage) are specifically calculated as the number of creditable samples for the quarter divided by the number of scheduled samples for the quarter, the result then multiplied by 100 and rounded to the nearest integer. However, years with at least 11 samples in each quarter are considered valid if the resulting annual standard design value concentration is greater than the level of the standard.

The 24-hour $PM_{2.5}$ NAAQS is met when the 24-hour standard design value at each monitoring site is less than or equal to 35 $\mu g/m^3$. This comparison is based on three consecutive, complete years of air quality data. A year meets data completeness requirements when at least 75% of the scheduled sampling days for each quarter have valid data. However, years shall be considered valid, notwithstanding quarters with less than complete data (even quarters with less than 11 samples), if the resulting annual 98th percentile value 24-hour standard design value is greater than the level of the standard.
[Reference: Appendix N to Part 50—Interpretation of the National Ambient Air Quality Standards for $PM_{2.5}$]

4.6.1 Intermittent $PM_{2.5}$

The required sample period for a valid $PM_{2.5}$ concentration measurement is 1,380 to 1500 minutes (23 to 25 hours). If a sample period is less than 1,380 minutes, a measured concentration is calculated from the collected $PM_{2.5}$ mass divided by the actual sampled air volume, multiplied by a correction factor of the actual number of minutes in the sample period and divided by 1,440. This revised concentration may be used as if it were a valid concentration measurement for the specific purpose of determining a violation of the NAAQS. This value assumes that the $PM_{2.5}$ concentration is zero for the remaining portion of the sample period and therefore represents the

minimum concentration that could have been measured for the full 24-hour sample period.

Creditable samples are samples that are given credit for data completeness. They include valid samples collected on required sampling days and valid "make-up" samples taken for missed or invalidated samples on required sampling days. Make-up samples are samples taken to supplant missed or invalidated required scheduled samples. Make-up samples are taken either before the next required sampling day or exactly one week after the missed (or voided) sampling day. Extra samples are non-creditable samples. They are daily values that do not occur on scheduled sampling days and that cannot be used as make-ups for missed or invalidated scheduled samples, but are used in mean calculations and are subject to selection as a 98th percentile.
[Reference: Appendix N to Part 50—Interpretation of the National Ambient Air Quality Standards for $PM_{2.5}$]

4.6.2 Continuous $PM_{2.5}$

Block 24-hour averages are calculated from the available hourly $PM_{2.5}$ concentration data for each day. A 24-hour average is considered valid if at least 75% (i.e., 18) of the hourly averages for the 24-hour period are available. In the event that less than 24 hourly averages are available (i.e., less than 24, but at least 18), the 24-hour average shall be computed based on the hours available using the number of available hours as the divisor. A 24-hour period with seven or more missing hours is considered valid if, after substituting zero for all missing hourly concentrations, the 24-hour average concentration is greater than the level of the standard.
[Reference: Appendix N to Part 50—Interpretation of the National Ambient Air Quality Standards for $PM_{2.5}$]

4.7 Lead

The national primary and secondary ambient air quality standards for Pb are met when the maximum arithmetic 3-month mean concentration for a 3-year period is less than or equal to 0.15 micrograms per cubic meter.
[Reference: 40 CFR § 50.16 – National primary and secondary ambient air quality standards for lead.]

A 3-month parameter mean is considered valid (i.e., meets data completeness requirements) if the average of the data capture rate of the three consecutive monthly means is greater than or equal to 75%. Monthly data capture rates (expressed as a percentage) are calculated as the number of creditable samples for the month divided by the number of scheduled samples for the month, the result then multiplied by 100 but not rounded. (Creditable samples include any make-up samples taken the subsequent month for missed samples in the month in question, and exclude any make-up samples taken in the month in question for missed samples in the previous month.) The 3-month data capture rate is the sum of the three corresponding unrounded monthly data capture rates divided by three and the result rounded to the nearest integer (zero decimal places). For purposes of assessing data capture, Pb-TSP and Pb-PM_{10} data collected before January 1, 2009 will be treated with an assumed scheduled sampling frequency of every sixth day.

A 3-month parameter mean that does not have at least 75% data capture and thus is not considered valid can be considered valid (and complete) if it passes either of two "data substitution" tests, which are highlighted in 40CFR Part 50 Appendix R.
[Reference: Appendix R to Part 50—Interpretation of the National Ambient Air Quality Standards for Lead]

5.0 Data Classification

In accordance with the IDEM Quality Assurance Project Plan, ambient air monitoring data are classified into three different categories according to its representativeness.

5.1 Continuous Data

- Category A Data: Audit results that are within ± 7.5% of the nominal value,
- Category B Data: Audit results that are within ± 7.5% to ±15.0% of the nominal value, and
- Category C Data: Audit results that are beyond ± 15.0% of the nominal value, which designate the data from the analyzer as invalid.

A level one check (70-90 % of analyzer range) detects how much a continuous sampler is out of tolerance.

5.2 Intermittent Data (Pb-TSP and hi-vol PM_{10})

- Category A. Audit flow that is within ± 5.0% of the nominal value,
- Category B. Audit flow that is within ± 5.0% to ±7.0% of the nominal value, and
- Category C. Audit flow that is beyond ± 7.0% of the nominal value; data from this sampler is considered as invalid until the sampler is recalibrated.

For intermittent samplers, any flow during the run date that deviates from 1.1 to 1.7 m^3/min at SRC for Pb-TSP and 1.02 to 1.24 m^3/min at actual conditions for hi-vol PM10 is considered out of tolerance.

5.3 USEPA QA Handbook Critical Criteria

The USEPA reference for nearly all ambient air monitoring - 40 CFR Part 58, Appendix A - identifies a number of quality control features that must be implemented for SLAMS and PSD networks. For the gaseous criteria pollutants (SO_2, CO, O_3, and NO_2), the principle quality control test is the one-point QC check, which is performed at least once every two weeks (40 CFR Part 58 Appendix A, Section 3.2.1). The QC check is made by challenging the analyzer with a QC check gas of known concentration between 0.01 and 0.10 ppm for SO_2, NO_2, and O_3, and between 1 and 10 ppm for CO analyzers. The cumulative results of the one-point QC checks are used to evaluate the monitoring site and network's precision and bias statistics. The formulae for determining precision and bias can be found in Section 4 of 40 CFR Part 58 Appendix A and in Chapter 13, Quality Assessment and Statistical Analysis of Air Monitoring Data, of the

Quality Assurance Manual. USEPA's Quality Assurance Handbook for Air Pollution Measurement Systems Vol. 2, (EPA-454/B-08-003) identifies the measurement quality objectives (MQOs) for the criteria gas pollutants, based on information found in 40 CFR Part 58, Appendix A. Table 4 provides a summary of that information.

Table 4
Ambient Air Monitoring Measurement Quality Samples for Gases
[Reference: Table 10-3 and Appendix D, Quality Assurance Handbook for Air Pollution Measurement Systems Vol. II, EPA-454/B-13-003 (May 2013)]

Method	Reference (40CFR58, Appendix A)	Coverage	Minimum Frequency	Measurement Quality Objectives
One-point Quality Control Checks				
SO_2, CO	Section 3.2.1	Each analyzer	Once per 2 weeks	Precision: ≤10%, Bias: ± ≤10%
NO_2	Section 3.2.1	Each analyzer	Once per 2 weeks	Precision: ≤15%, Bias: ± ≤15%
O_3	Section 3.2.1	Each analyzer	Once per 2 weeks	Precision: ≤7%, Bias: ≤± 7%
Annual Performance Evaluation				
SO_2, NO_2, CO, O_3	Section 3.2.2	Each analyzer	Once per year	≤15% for each audit concentration

The main QC checks for particulate monitors are the one-point flow rate verification of the sampler and the semi-annual flow rate audits. The flow rate verification is performed using a certified flow transfer standard to check the operational flow rate of the analyzer or sampler. The percent differences between the audit and measured flow rates when compared to the measurement quality objectives is an indicator of how well the samplers are operating.

Table 5
Ambient Air Monitoring Measurement Quality Samples for Particulates
[Reference: Appendix D, Quality Assurance Handbook for Air Pollution Measurement Systems Vol. II, EPA-454/B-13-003 (May 2013)]

Parameter	Measurement Quality Objective	Minimum Frequency
One – Point Flow Rate Verification		
$PM_{2.5}$ filter based	± 4% of transfer standard ± 5% of flow rate design value	1/month
$PM_{2.5}$ continuous	± 4% of transfer standard ± 5% of flow rate design value	1/month
PM_{10c} for $PM_{10-2.5}$ filter based	± 4% of transfer standard; ± 5% of flow rate design value	1/month
PM_{10} filter based (low-volume)	± 4% of transfer standard ± 5% of flow rate design value	1/month
PM_{10} filter based (hi-volume)	± 7% of transfer standard ± 5% of flow rate design value	Once per quarter

PM_{10} continuous	± 4% of transfer standard	1/month
Pb-High Volume	± 7% of transfer standard	Once per quarter
Semi-annual Flow rate audit		
$PM_{2.5}$ filter based	± 4% of transfer standard ± 5% of flow rate design value	1/6 months
$PM_{2.5}$ continuous	± 4% of transfer standard ± 5% of flow rate design value	1/6 months
PM_{10c} for $PM_{10-2.5}$ filter based	± 4% of transfer standard ± 5% of flow rate design value	1/6 months
PM_{10} filter based (low volume)	± 4% of transfer standard ± 5% of flow rate design value	1/6 months
PM_{10} filter based (hi-volume)	± 7% of transfer standard ± 10% of flow rate design value	1/6 months
PM_{10} continuous	± 4% of audit standard	1/6 months
Pb-High Volume	± 7% of audit standard	1/6 months

In order to meet the parameter MQOs, USEPA developed validation templates for the criteria pollutants (reference: Quality Assurance Handbook for Air Pollution Measurement Systems Vol. 2, EPA-454/B-13-003, Appendix D). The validation templates contain several criteria that the USEPA working group considered as having a direct effect or potential effect on the measured concentration. The validation template includes:

- Critical Criteria: standards deemed critical to maintaining the integrity of a sample or a group of samples. Samples not meeting each and every critical criterion should be invalidated unless there are compelling reasons or justifications for not doing so.
- Operational Criteria: standards that are important for maintaining and evaluating the quality of the data collection system. A violation of an operational criterion may be cause for invalidation.
- Systematic Criteria: standards, which are important for interpreting the data but do not usually affect the validity of the data.

Site operators and quality assurance staff members are encouraged to review the validation templates and apply the validation criteria to the ambient monitoring program to ensure the collection of consistent, complete, and representative ambient data.