

Chapter 1

Introduction to Ambient Air Monitoring

The Environmental Protection Agency (EPA), under the authority of the Clean Air Act, has established National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, particulate matter (PM₁₀ and PM_{2.5}), carbon monoxide, ozone, nitrogen dioxide, and lead. These standards, contained in Title 40 Part 50 of the *Code of Federal Regulations* (CFR), are of two types: *primary standards* and *secondary standards*. As stated in Section 109 of the Clean Air Act, primary standards are those, “the attainment and maintenance of which are requisite to protect the public health.” The section further defines a secondary ambient air quality standard as, “a level of air quality attainment and maintenance of which is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutants in the ambient air.” In other words, primary standards are those promulgated to protect human health; secondary standards are for the protection of the general welfare (e.g., protection of plants, animals, materials, visibility, etc.). In addition, Section 109 of the Act requires the EPA to evaluate, at 5-year intervals, the criteria for which standards have been promulgated and to issue any new standards as may be appropriate.

These primary and secondary ambient air quality standards must be achieved throughout the United States and its possessions. In order to meet the standards, states are required to develop and implement air pollution control strategies through the mechanism of State Implementation Plans (SIPs). The implementation plans may contain control strategies such as industrial and urban zoning, the development or expansion of mass transit systems and vehicle inspection and maintenance programs, and the establishment of stationary source emissions standards for specific industrial categories. Ambient air monitoring plays a vital role in the development and evaluation of these control strategies. During the development phase, air quality data is used to determine if an area is attaining or not attaining the air quality standards. This determination is critical for the proper designing of control strategies for the area in question because attainment areas usually require less stringent control measures than nonattainment areas. Furthermore, air quality data may be used to generate or validate computer models of air pollution dispersion which are then used in the development of control strategies. After the implementation plans containing their various control strategies have been put into force, further ambient air quality monitoring is required in both attainment and nonattainment areas. For areas that have achieved attainment, further monitoring is necessary to assure that attainment is maintained. Additional monitoring is required in nonattainment areas for evaluating progress toward reaching attainment.

In addition to the requirement that the primary and secondary NAAQS be achieved and maintained throughout the country, the Clean Air Act also stipulates that no significant deterioration of existing air quality will be allowed in any portion of any state. In order to comply with this provision, it is necessary to determine the impact on the existing air quality of an area by a planned new emissions source. The estimated emissions contributed by the new source must be compared to the existing air quality to ascertain whether the new source would significantly deteriorate the present air quality.

Ambient air quality monitoring data is used to establish the preexisting air quality of the area in question.

In conjunction with the NAAQS, EPA has established detailed analytical methods for monitoring these pollutants. These methods, termed *reference methods*, are contained in Appendices A through L of 40 CFR 50 (Appendices A through L are also provided in Appendix 1 of this manual). Reference method is defined as “a method of sampling and analyzing the ambient air for an air pollutant that is specified as a reference method in an Appendix of 40 CFR Part 50, or a method that has been designated as a reference method in accordance with 40 CFR Part 53.” (40 CFR Part 53 is included in Appendix 2 of this manual.) A summary of the applicable requirements for reference and equivalent methods for the monitoring of criteria pollutants are provided in Table 1-1.

TABLE 1-1. Summary of Applicable Requirements for Reference and Equivalent Methods for Air Monitoring of Criteria Pollutants (Reproduced from Table A-1 to Subpart A of 40 CFR Part 53).

Pollutant	Reference or Equivalent	Manual or Automated	Applicable Part 50 Appendix	Applicable Subparts of 40 CFR Part 53					
				A	B	C	D	E	F
SO ₂	Reference	Manual	A						
	Equivalent	Manual		✓		✓			
		Automated		✓	✓	✓			
CO	Reference	Automated	C	✓	✓				
	Equivalent	Manual		✓		✓			
		Automated		✓	✓	✓			
O ₃	Reference	Automated	D	✓	✓				
	Equivalent	Manual		✓		✓			
		Automated		✓	✓	✓			
NO ₂	Reference	Automated	F	✓	✓				
	Equivalent	Manual		✓		✓			
		Automated		✓	✓	✓			
Pb	Reference	Manual	G						
	Equivalent	Manual		✓		✓			
PM ₁₀	Reference	Manual	J	✓			✓		
	Equivalent	Manual		✓		✓	✓		
		Automated		✓		✓	✓		
PM _{2.5}	Reference	Manual	L	✓				✓	
	Equivalent Class I	Manual	L	✓		✓		✓	
	Equivalent Class II	Manual	L ₁	✓		✓ ₂		✓	✓ _{1,2}
	Equivalent Class III	Automated	L ₁	✓		✓		✓ ₁	✓ ₁

PM _{10-2.5}	Reference	Manual	O ₂	✓			✓	
	Equivalent Class I	Manual	O ₂	✓			✓	
	Equivalent Class II	Manual	O ₂	✓		✓ ₂	✓ ₁	✓ _{1,2}
	Equivalent Class III	Automated	L ₁ , O _{1,2}	✓		✓	✓ ₁	✓ ₁

¹ Some requirements may apply, based on the nature of each particular candidate method, as determined by the Administrator.

² Alternative Class III requirements may be substituted.

A reference method may be either manual or automated. The *manual reference methods* are detailed analytical procedures, with specifications on all important parameters. The pararosaniline method for SO₂ analysis is an example of a manual method, as are the reference methods for PM₁₀ and PM_{2.5}. *Automated reference methods* depend on specified measurement principles (MP) and calibration procedures (CP). An automated reference method consists of a measurement principle which has been specified as reference by EPA, as well as, an EPA designated reference calibration procedure. Thus, for an automated reference method, any instrument using the reference measurement principle and calibrated by the reference calibration procedure can be designated as a separate reference method. This can be explained using the example of the reference measurement principle and calibration procedure for ozone determination -- chemiluminescence with ethylene and ultraviolet (UV) photometry, respectively. Several manufacturers make ozone analyzers which differ in various aspects, yet they all use the same chemiluminescence process and conform to EPA's specifications. Each manufacturer's instrument is considered a reference method, if it is designated as a reference method per 40 CFR Part 53, meets the performance specifications in Table 1-2, and is calibrated using the UV photometry calibration procedure.

Table 1-2. Performance specifications for automated (gaseous) methods (Reproduced from Table B-1 of 40 CR Part 53 Subpart B).

Performance parameter	Units ¹	Sulfur dioxide	Ozone	Carbon monoxide	Nitrogen dioxide	Definitions & test procedures
Range	ppm	0–0.5	0–0.5	0–50	0–0.5	Sec. 53.23(a)
Noise	ppm	.005	.005	.50	.005	Sec. 53.23(b)
Lower detectable limit	ppm	.01	.01	1.0	.01	Sec. 53.23(c)
Interference equivalent						Sec. 53.23(d)
Each interferant	ppm	±.02	±.02	±1.0	±0.02	
Total interferant	ppm	.06	.06	1.5	.04	
Zero drift, 12 & 24 hour	ppm	±.02	±.02	±1.0	±.02	Sec. 52.23(e)
Span drift, 24 hour						Sec. 52.23(e)
20 % of upper range limit	%	±20.0	±20.0	±10.0	±20.0	
80 % of upper range limit	%	±5.0	±5.0	±2.5	±5.0	
Lag time	mins.	20	20	10	20	Sec. 52.23(e)
Rise time	mins.	15	15	5	15	Sec. 52.23(e)
Fall time	mins.	15	15	5	15	Sec. 52.23(e)

Precision						Sec. 52.23(e)
20 % of upper range limit	ppm	.01	.01	.5	.02	
80 % of upper range limit	ppm	.015	.01	.5	.03	

¹To convert from ppm to ug/m³at 25 °C and 760 mm Hg. Multiply by M/0.02447, where M is the molecular weight of the gas.

Some methods of air pollution analysis are designated *equivalent methods* by EPA. An equivalent method is “a method of sampling the ambient air for an air pollutant that has designated as an method in accordance with 40 CFR Part 53” as stated in 40 CFR Part 50.1. Two types of methods may be considered for equivalent method status: *manual methods and automated methods*. For a manual method to be designated as an equivalent method, it must demonstrate a consistent relationship to the reference method used to measure pollutant concentrations in a real atmosphere. In other words, the reference method and candidate manual method sample the same air in a “field” monitoring situation and the manual method's results must match (with some allowances) the results of the reference method. For automated methods to attain equivalent method status, they must be able to meet or exceed the performance standards specified by EPA in 40 CFR 53B. These specifications are given in Table 1-2. In addition, the candidate method must meet the consistent relationship requirements of Table 1-3. A current list of all reference and equivalent methods is maintained and updated by EPA whenever a new method is designated. This list can be found on the *AMTIC Bulletin Board* at <http://www.epa.gov/ttn/amtic>.

Table 1-3. Test concentration ranges, number of measurements required, and maximum discrepancy specification (Reproduced from Table C-1 to Subpart C of Part 53).

Pollutant	Concentration range (parts per million)	Simultaneous measurements required				Maximum discrepancy specification (parts per million)
		1-hr		24-hr		
		First set	Second set	First set	Second set	
Ozone	Low 0.06 to 0.10.....	5	6	.....	.....	0.02
	Med 0.15 to 0.2.....	5	6	.....	.....	0.03
	High 0.35 to 0.45.....	4	6	.....	.....	0.04
	Total	14	18	.....	.....	.....
Carbon monoxide	Low 7 to 11.....	5	6	.....	.....	1.5
	Med 20 to 30.....	5	6	.....	.....	2.0
	High 35 to 45.....	4	6	.....	.....	3.0
	Total	14	18	.....	.....	.....
Sulfur dioxide	Low 0.02 to 0.05.....	.....	.....	3	3	0.02
	Med 0.10 to 0.1.....	.....	.....	2	3	0.03
	High 0.30 to 0.50.....	7	8	2	2	0.04
	Total	7	8	7	8	.....
Nitrogen dioxide	Low 0.02 to 0.08.....	.....	.....	3	3	0.02
	Med 0.10 to 0.20.....	.....	.....	2	3	0.03
	High 0.25 to 0.35.....	.....	.....	2	2	0.03
	Total.....	.....	.....	7	8	.....

All formal sampler design and performance requirements and the operational requirements applicable to reference methods for PM₁₀ and PM_{2.5} are specified in Appendix J and L of 40 CFR Part 50, respectively. The requirements, for PM_{2.5} federal reference method (FRM) samplers, are quite specific and include explicit design specifications for the type of sampler, the type of filter, the sample flow rate, and the construction of the sample collecting components. However, various designs for the flow-rate control system, the filter holder, the operator interface controls, and the exterior housing are possible. Hence, various reference method samplers from different manufacturers may vary considerably in appearance and operation. Also, a reference method may have a single filter capability (single sample sampler) or a multiple filter capability (sequential sample sampler), provided no deviations are necessary in the design and construction of the sample collection components specified in the reference method regulation. A PM_{2.5} method is not a reference method until it has been demonstrated to meet all the reference method regulatory requirements and has been officially designated by EPA as a reference method for PM_{2.5}.

Equivalent methods for PM_{2.5} have much wider latitude in their design, configuration, and operating principle than reference methods. These methods are not required to be based on filter collection of PM_{2.5}; therefore, continuous or semi-continuous analyzers and new types of PM_{2.5} measurement technologies are not precluded as possible equivalent methods. Equivalent methods are not necessarily required to meet all the requirements specified for reference methods, but they must demonstrate both *comparability* to reference method measurements and similar PM_{2.5} *measurement precision*. The requirements that some (but not all) candidate methods must meet to be designated by EPA as equivalent methods are specified in 40 CFR Part 53. To minimize the difficulty of meeting equivalent method designation requirements, three classes of equivalent methods have been established in the 40 CFR Part 53 regulations based on a candidate method's extent of deviation from the reference method requirements. All three classes of equivalent methods are acceptable for SLAMS or SLAMS-related PM_{2.5} monitoring, but not all types of equivalent methods may be equally suited to various PM_{2.5} monitoring requirements or applications.

In addition to the regulations to reference and equivalent methods described in 40 CFR 50 and 53, 40 CFR 58 contains requirements for reference and equivalent methods used at State Local Air Monitoring Stations (SLAMS) and at Prevention of Significant (PSD) monitoring stations. Appendices A and B of 40 CFR 58 describe quality assurance requirements for SLAMS monitoring networks and PSD monitoring networks, respectively. Appendix C of 40 CFR 58 specifies the use of reference and equivalent methods in SLAMS and PSD monitoring networks. 40 CFR 58 Appendix E specifies probe materials (i.e., FEP Teflon®, borosilicate glass, or their equivalent) and pollutant-sample resident time in probes (i.e., less than 20 seconds) for SO₂, NO₂, and O₃ monitors of SLAMS monitoring networks.

Traditionally, NAAQS pollutants have been monitored because of their deleterious human health effects and due to their ubiquitous distribution nationwide. National and site-specific trends of the NAAQS can be found at <http://www.epa.gov/oar/airtrends/>. On average, substantial reductions have been achieved for each of the NAAQS since 1980. However, ozone and particulate matter remain as pollutants of special concern, particularly, in high population areas.

In addition to NAAQS monitoring, recent efforts have expanded ambient monitoring for other harmful pollutants. Specifically, the EPA Air Toxics program works with state, local, and tribal

governments in order to quantify and reduce emissions of approximately 188 hazardous pollutants found in ambient air, more commonly known as “air toxics”. These “air toxics” are pollutants that are known or suspected to cause cancer or other serious health effects, such as reproductive effects or birth defects, or adverse environmental effects. Additional information, as provided by EPA, on the air toxics program can be found at <http://www.epa.gov/oar/toxicair/newtoxics.html>.

Dramatic and mostly positive changes in air quality have been observed over the last two decades, despite increasing population, vehicle usage, and productivity. Most criteria pollutant measurements read well below national standards. In response to these changes and an increased concern over air toxics a new National Ambient Air Monitoring Strategy (NAAMS) was adopted in 2006. Under the recently adopted NAAMS, monitoring objects have evolved to allow for more flexibility and emphasis on monitoring for those traditional pollutants which continue to persist (i.e., particulate matter, ozone, and constituents of acid deposition) and an expansion and redirection of existing efforts and development of new capacity to monitor for air toxics.

In order to accurately quantify constituents in the ambient air it is necessary to measure sample gas parameters, such as: temperature, pressure, humidity, gas composition, and flow rate. The importance of these parameters and how they are accounted for will be discussed in detail in Chapter 2 of this Manual.

The topics discussed in subsequent chapters include a detailed discussion of the measurement principle and calibration procedures for each of the gaseous *criteria pollutants* (i.e., carbon monoxide, sulfur dioxide, ozone, and nitrogen dioxide) including special considerations for monitoring for precursor gas concentration levels, procedures for the generation of test atmospheres needed to calibrate ambient air monitors, and the framework of the recently adopted National Ambient Air Monitoring Strategy (NAAMS).

In addition to the discussion presented in this manual, hands-on laboratory exercises have been developed to provide the students a realistic experience in the operation and calibration of ambient monitors. These exercises are contained in the accompanying Laboratory Exercise Manual.

References

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