

## 7.0 Sampling Methods

To establish the basic validity of ambient air monitoring data, it must be shown that:

- the proposed sampling method complies with the appropriate monitoring regulations;
- the equipment is accurately sited;
- the equipment was accurately calibrated using correct and established calibration methods; and
- the organization implementing the data collection operation are qualified and competent.

For example, if the only reasonable monitoring site has a less than ideal location, the data collection organization must decide whether a representative sample can be obtained at the site. This determination should be recorded and included in the program's QAPP. Although after-the-fact site analysis may suffice in some instances, good quality assurance techniques dictate that this analysis be made prior to expending the resources required to collect the data.

The purpose of this section is to describe the attributes of the sampling system that will ensure the collection of data of a quality acceptable for the Ambient Air Quality Monitoring Program.

### 7.1 Environmental Control

#### 7.1.1 Monitoring Station Design

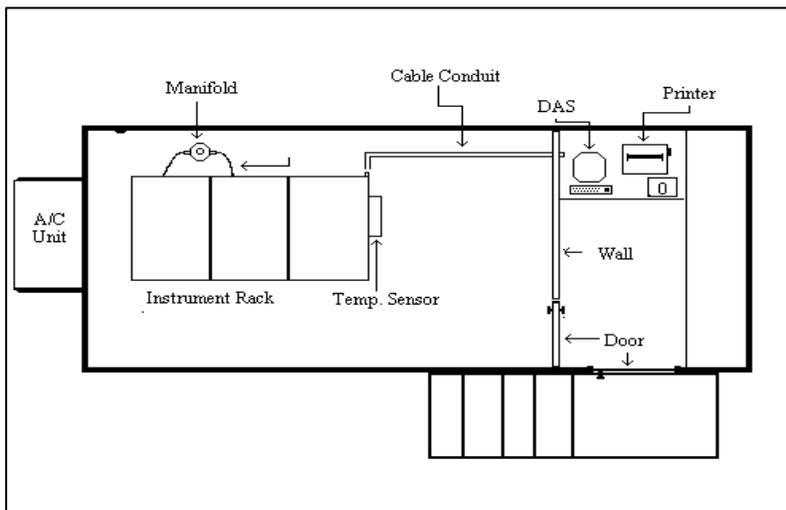
State and local agencies should design their monitoring stations with the station operator in mind. Careful thought to safety, ease of access to instruments and optimal work space should be given every consideration. If the station operator has these issues addressed, then he/she will be able to perform their duties more efficiently and diligently. Having the instruments in an area that is difficult to work in creates frustration and prolongs downtime. The goal is to optimize data collection and quality. This must start with designing the shelter and laboratory around staff needs and requirements.

Monitoring stations may be located in urban areas where space and land are at a premium, especially in large cities that are monitoring for NO<sub>x</sub> and CO. In many cases, the monitoring station is located in a building or school that is gracious enough to allow an agency to locate its equipment. Sometimes, a storage or janitorial closet is all that is available. However, this can pose serious problems. If the equipment is located in a closet, then it is difficult for the agency to control the effects of temperature, humidity, light, vibration and chemicals on the instruments. In addition, security can also be an issue if people other than agency staff have access to the equipment. Monitoring organizations should give serious thought to locating air monitoring equipment in stand-alone shelters with limited access, or modify existing rooms to the recommended station design if funds and staff time are available.

In general, air monitoring stations should be designed for functionality and ease of access for operation, maintenance and repair. In addition, the shelter should be rugged enough to withstand local weather condition extremes. In the past, small utility trailers were the norm in monitoring shelters. However, in some areas, this will not suffice. Recently, steel and aluminum storage containers are gaining wide acceptance as monitoring shelters. It is recommended that monitoring stations be housed in shelters that are fairly secure from intrusion or vandalism. All sites should be located in fenced or secure areas with access only through locked gates or secure pathways. The shelter's design dictates that they be insulated (R-19 minimum) to prevent temperature extremes within the shelter. All structures should be secured to their foundations and protected from damage during natural disasters. All monitoring shelters should be

designed to control excessive vibrations and external light falling on the instruments, and provide 110/220 VAC voltage throughout the year. When designing a monitoring shelter, make sure that enough electrical circuits are secured for the current load of equipment plus other instruments that may be added later or audit equipment (e.g., NPAP/PEP). Every attempt should be made to reduce the environmental footprint of shelters to make them as energy efficient as possible. Some possibilities include venting of excess heat of monitoring instruments to the outside in summer months, use of energy efficient fixtures and HVAC systems, and ensuring that the amount of space devoted to the monitors is not excessive (remembering that space is needed at times for additional QA equipment). Figure 7.1 represents one shelter design that has proven adequate.

The first feature of the shelter is that there are two rooms separated by a door. The reasons for this are twofold. The entry and access should be into the computer/data review area. This allows access to the site without having to open the room that houses the equipment. It also isolates the equipment from cold/hot air that can come into the shelter when someone enters. Also, the Data Acquisition System (DAS)/data review area is isolated from the noise and vibration of the equipment. This area can be a place where the operator can print data, and prepare samples for the laboratory. This also gives the operator an area where cursory data review can take place. If something is observed during this initial review then possible problems can be corrected or investigated at that time. The DAS can be linked through cables that travel through conduit into the equipment area. The conduit is attached to the ceiling or walls and then dropped down to the instrument rack.



**Figure 7.1 Example Design for Shelter**

racks away from the wall, the rear of the instruments are accessible. The trays or rails allow the site operators access to the instruments without removing them from the racks. Most instrument vendors offer sliding rails as an optional purchase.

### 7.1.2 Sampling Environment

A proper sampling environment demands control of all physical parameters external to the samples that might affect sample stability, chemical reactions within the sampler, or the function of sampler components. The important parameters to be controlled are summarized in Table 7-1.

The air conditioning/heating unit should be mounted to heat and cool the equipment room. When specifying the unit, make sure it will cool the room on the warmest and heat on the coldest days of the year. Also, make sure the electrical circuits are able to carry the load. If necessary, keep the door closed between the computer and equipment room to lessen the load on the heating or cooling equipment.

All air quality instrumentation should be located in an instrument rack or equivalent. The instruments and their support equipment are placed on sliding trays or rails. By placing the

**Table 7-1 Environment Control Parameters**

Parameter	Source of specification	Method of Control
Instrument vibration	Manufacturer's specifications	Design of instrument housings, benches, etc., per manufacturer's specifications.
Light	Method description or manufacturer's specifications	Shield chemicals or instruments that can be affected by natural or artificial light
Electrical voltage	Method description or manufacturer's specifications	Constant voltage transformers or regulators; separate power lines; isolated high current drain equipment such as hi-vols, heating baths, pumps from regulated circuits
Temperature	Method description or manufacturer's specifications	Regulated air conditioning system 24-hour temperature recorder; use electric heating and cooling only
Humidity	Method description or manufacturer's specifications	Regulated air conditioning system; 24-hour temperature recorder

With respect to environmental temperature for designated analyzers, most such analyzers have been tested and qualified over a temperature range of 20°C to 30°C; few are qualified over a wider range. This temperature range specifies both the range of acceptable operating temperatures and the range of temperature change which the analyzer can accommodate without excessive drift. The latter, the range of temperature change that may occur between zero and span adjustments, is the most important. When one is outfitting a shelter with monitoring equipment, it is important to recognize and accommodate the instrument with the most sensitive temperature requirement.

To accommodate energy conservation regulations or guidelines specifying lower thermostat settings, designated analyzers located in facilities subject to these restrictions may be operated at temperatures down to 18°C, provided the analyzer temperature does not fluctuate by more than 10°C between zero and span adjustments. Operators should be alert to situations where environmental temperatures might fall below 18°C, such as during night hours or weekends. Temperatures below 18°C may necessitate additional temperature control equipment or rejection of the area as a sampling site.

Shelter temperatures above 30°C also occur, due to temperature control equipment that is malfunctioning, lack of adequate power capacity, or shelters of inadequate design for the environmental conditions. Occasional fluctuations above 30°C may require additional assurances that data quality is maintained. Sites that continually have problems maintaining adequate temperatures may necessitate additional temperature control equipment or rejection of the area as a sampling site. If this is not an option, a waiver to operate beyond the required temperature range should be sought with the EPA Regional Office, if it can be shown that the site can meet established data quality requirements.

In order to detect and correct temperature fluctuations, a 24-hour temperature recorder at the analyzer site is suggested. These recorders can be connected to data loggers and should be considered official documentation that should be filed (see Section 5). Many vendors offer these type of devices. Usually they are thermocouple/thermistor devices of simple design and are generally very sturdy. Reasons for using electronic shelter temperature devices are two-fold: 1) through remote interrogation of the DAS, the agency can tell if values collected by air quality instruments are valid, and 2) that the shelter temperature is within a safe operating range if the air conditioning/heating system fails.

## 7.2 Sampling Probes And Manifolds

### 7.2.1 Design of Probes and Manifolds for Automated Methods

Some important variables affecting the sampling manifold design are the diameter, length, flow rate, pressure drop, and materials of construction. With the development of NCore precursor gas monitoring, various types of probe/manifold designs were reviewed. This information can be found in the *Technical Assistance Document (TAD) for Precursor Gas Measurements in the NCore Multi-pollutant Monitoring Network*<sup>1</sup> and is also included in Appendix F of this Handbook.

Of the probe and manifold material looked at over the years, only Pyrex<sup>®</sup> glass and Teflon<sup>®</sup> have been found to be acceptable for use as intake sampling lines for all the reactive gaseous pollutants. Furthermore, the EPA has specified borosilicate glass or FEP Teflon<sup>®</sup> as the only acceptable probe materials for delivering test atmospheres in the determination of reference or equivalent methods. Therefore, borosilicate glass (which includes Pyrex<sup>®</sup>), FEP Teflon<sup>®</sup> or their equivalent must be the only material in the sampling train (from inlet probe to the back of the analyzer) that can be in contact with the ambient air sample for existing and new SLAMS.

For volatile organic compound (VOC) monitoring at PAMS, FEP Teflon<sup>®</sup> is unacceptable as the probe material because of VOC adsorption and desorption reactions on the FEP Teflon<sup>®</sup>. Borosilicate glass, stainless steel, or its equivalent, are the acceptable probe materials for VOC and carbonyl sampling. Care must be taken to ensure that the sample residence time is kept to 20 seconds or less.

#### Residence Time Determination

No matter how nonreactive the sampling probe material may be, after a period of use, reactive particulate matter is deposited on the probe walls. Therefore, the time it takes the gas to transfer from the probe inlet to the sampling device is also critical. Ozone, in the presence of nitrogen oxide (NO), will show significant losses even in the most inert probe material when the residence time exceeds 20 seconds. Other studies indicate that a 10-second or less residence time is easily achievable.

Residence time is defined as the amount of time that it takes for a sample of air to travel from the opening of the cane to the inlet of the instrument and is required to be less than 20 seconds for reactive gas monitors. The residence time of pollutants within the sampling manifold is also critical. It is recommended that the residence time within the manifold and sample lines to the instruments be less than 10 seconds (of the total allowable 20 seconds). If the volume of the manifold does not allow this to occur, then a blower motor or other device (vacuum pump) can be used to decrease the residence time. The residence time for a manifold system is determined in the following way. First the volume of the cane, manifold and sample lines must be determined using the following equation:

$$Total\ Volume = Cv + Mv + Lv$$

Where:

Cv = Volume of the sample cane and extensions, cm<sup>3</sup>

Mv = Volume of the sample manifold and trap, cm<sup>3</sup>

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<sup>1</sup> <http://www.epa.gov/ttn/amtic/files/ambient/monitorstrat/precursor/tadversion4.pdf>

$L_v$  = Volume of the instrument lines,  $\text{cm}^3$

Each of the components of the sampling system must be measured individually. To measure the volume of the components, use the following calculation:

$$V = \pi i * (d/2)^2 * L$$

Where:

V = volume of the component,  $\text{cm}^3$

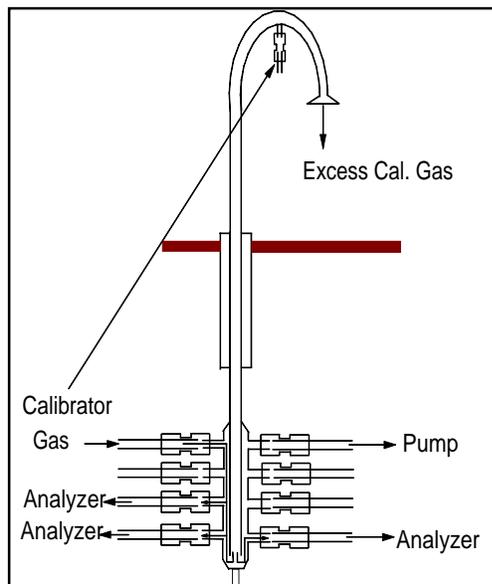
$\pi$  = 3.14159

L = Length of the component, cm

d = inside diameter, cm

Once the total volume is determined, divide the volume by the flow rate of all instruments. This will give the residence time.

It has been demonstrated that there are no significant losses of reactive gas ( $\text{O}_3$ ) concentrations in conventional 13 mm inside diameter sampling lines of glass or Teflon if the sample residence time is 10 seconds or less. This is true even in sample lines up to 38 m in length, which collect substantial amounts of visible contamination due to ambient aerosols. However, when the sample residence time exceeds 20 seconds, loss is detectable, and at 60 seconds the loss is nearly complete.



**Figure 7.2 Positions of calibration line in sampling manifold**

**Placement of tubing on the Manifold:** If the manifold that is employed at the station has multiple ports then placement of the instrument lines can be crucial. If a manifold similar to Figure 7.2 is used, it is suggested that instruments requiring lower flows be placed towards the bottom of the manifold. The general rule of thumb states that the calibration line (if used) placement should be in a location so that the calibration gases flow past the instruments before the gas is evacuated out of the manifold. Figure 7.2 illustrates two potential introduction ports for the calibration gas. The port at the elbow of the sampling cane provides more information about the cleanliness of the sampling system.

### 7.2.2 Placement of Probes and Manifolds

Probes and manifolds must be placed to avoid introducing bias to the sample. Important considerations are probe height above the ground, probe length (for horizontal probes), and physical influences near the probe.

Some general guidelines for probe and manifold placement are:

- probes should not be placed next to air outlets such as exhaust fan openings
- horizontal probes must extend beyond building overhangs
- probes should not be near physical obstructions such as chimneys which can affect the air flow in the vicinity of the probe
- height of the probe above the ground depends on the pollutant being measured

Table 7-2 summarizes the probe and monitoring path siting criteria while Table 7-3 summarizes the spacing of probes from roadways. This information can be found in 40 CFR Part 58, Appendix E<sup>2</sup>. For PM<sub>10</sub> and PM<sub>2.5</sub>, Figure 7.3 provides the acceptable areas for micro, middle, neighborhood and urban samplers, with the exception of microscale street canyon sites.

**Table 7-2 Summary of Probe and Monitoring Path Siting Criteria**

Pollutant	Scale (maximum monitoring path length, meters)	Height from ground to probe, inlet or 80% of monitoring path <sup>1</sup> (meters)	Horizontal and vertical distance from supporting structures <sup>2</sup> to probe, inlet or 90% of monitoring path <sup>1</sup> (meters)	Distance from trees to probe, inlet or 90% of monitoring path <sup>1</sup> (meters)	Distance from roadways to probe, inlet or monitoring path <sup>1</sup> (meters)
SO <sub>2</sub> <sup>3,4,5,6</sup>	Middle (300 m) Neighborhood Urban, and Regional (1 km).	2–15	> 1	> 10	N/A
CO <sup>4,5,7</sup>	Micro, Middle (300 m), Neighborhood (1 km).	3 ± 1/2: 2–15	> 1	> 10	2–10; see Table 7–3 of this section for middle and neighborhood scales.
NO <sub>2</sub> , O <sub>3</sub> <sup>3,4,5</sup>	Middle (300 m) Neighborhood, Urban, and Regional (1 km).	2–15	> 1	> 10	See Table 7-3 of this section for all scales.
Ozone precursors (for PAMS) <sup>3,4,5</sup>	Neighborhood and Urban (1 km)	2–15	> 1	> 10	
PM,Pb <sup>3,4,5,6,8</sup>	Micro: Middle, Neighborhood, Urban and Regional.	2–7 (micro); 2–7 (middle PM10-2.5); 2–15 (all other scales).	> 2 (all scales, horizontal distance only).	> 10 (all scales).	2–10 (micro); see Figure 7.3 of this section for all other scales

N/A—Not applicable.

<sup>1</sup> Monitoring path for open path analyzers is applicable only to middle or neighborhood scale CO monitoring and all applicable scales for monitoring SO<sub>2</sub>, O<sub>3</sub>, O<sub>3</sub> precursors, and NO<sub>2</sub>.

<sup>2</sup> When probe is located on a rooftop, this separation distance is in reference to walls, parapets, or penthouses located on roof.

<sup>3</sup> Should be >20 meters from the dripline of tree(s) and must be 10 meters from the dripline when the tree(s) act as an obstruction.

<sup>4</sup> Distance from sampler, probe, or 90% of monitoring path to obstacle, such as a building, must be at least twice the height the obstacle protrudes above the sampler, probe, or monitoring path. Sites not meeting this criterion may be classified as middle scale (see text).

<sup>5</sup> Must have unrestricted airflow 270 degrees around the probe or sampler; 180 degrees if the probe is on the side of a building.

<sup>6</sup> The probe, sampler, or monitoring path should be away from minor sources, such as furnace or incineration flues. The separation distance is dependent on the height of the minor source's emission point (such as a flue), the type of fuel or waste burned, and the quality of the fuel (sulfur, ash, or lead content). This criterion is designed to avoid undue influences from minor sources.

<sup>7</sup> For microscale CO monitoring sites, the probe must be >10 meters from a street intersection and preferably at a midblock location.

<sup>8</sup> Collocated monitors must be within 4 meters of each other and at least 2 meters apart for flow rates

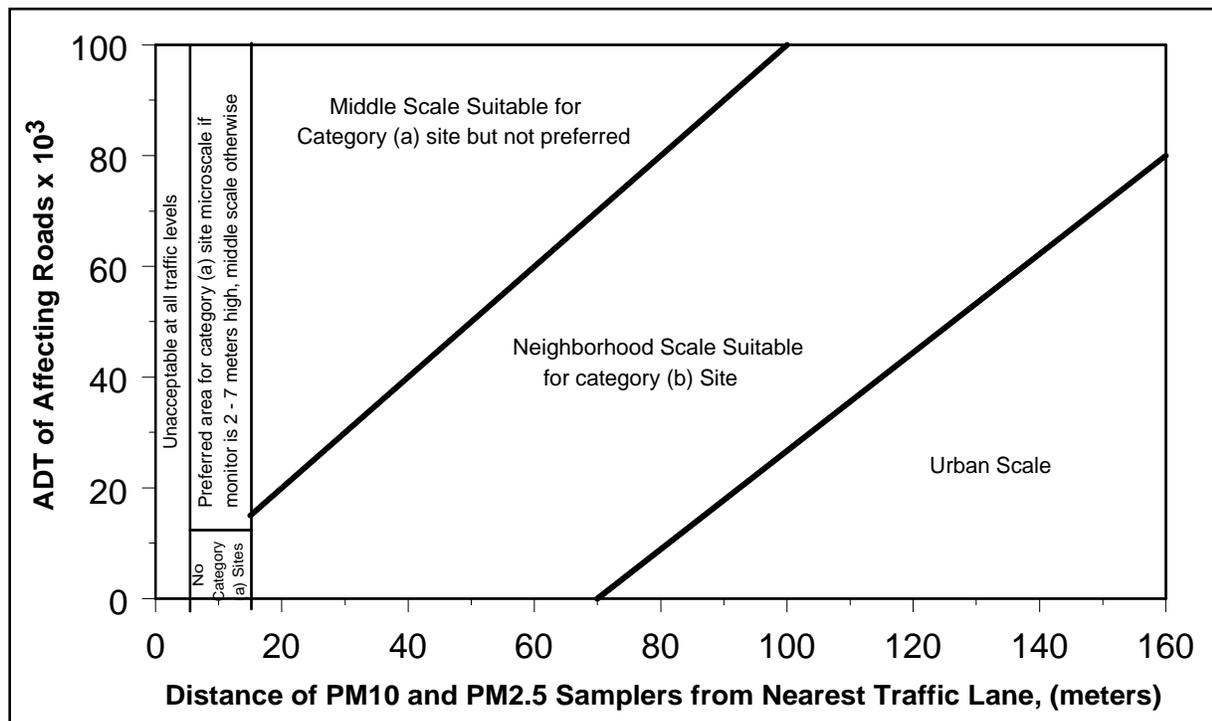
<sup>2</sup> <http://www.access.gpo.gov/nara/cfr/cfr-table-search.html>

**Table 7-3 Minimum Separation Distance Between Roadways and Sampling Probes or Monitoring Paths at Neighborhood and Urban Scales for O<sub>3</sub>, Oxides of Nitrogen (NO, NO<sub>2</sub>, NO<sub>x</sub>, NO<sub>v</sub>) and CO**

Roadway ave. daily traffic vehicles per day	O <sub>3</sub> and Oxides of N Neighborhood & Urban <sup>1</sup>	O <sub>3</sub> and Oxides of N Neighborhood & Urban <sup>1&amp;2</sup>	CO Neighborhood
≤ 1,000	10	10	
10,000	10	20	
≤ 10,000			10
15,000	20	30	25
20,000	30	40	45
30,000			80
40,000	50	60	115
50,000			135
≥ 60,000			150
70,000	100	100	
≥110,000	250	250	

<sup>1</sup> Distance from the edge of the nearest traffic lane. The distance for intermediate traffic counts should be interpolated from the table values based on the actual traffic count.

<sup>2</sup> Applicable for ozone monitors whose placement has not already been approved as of December 18, 2006.

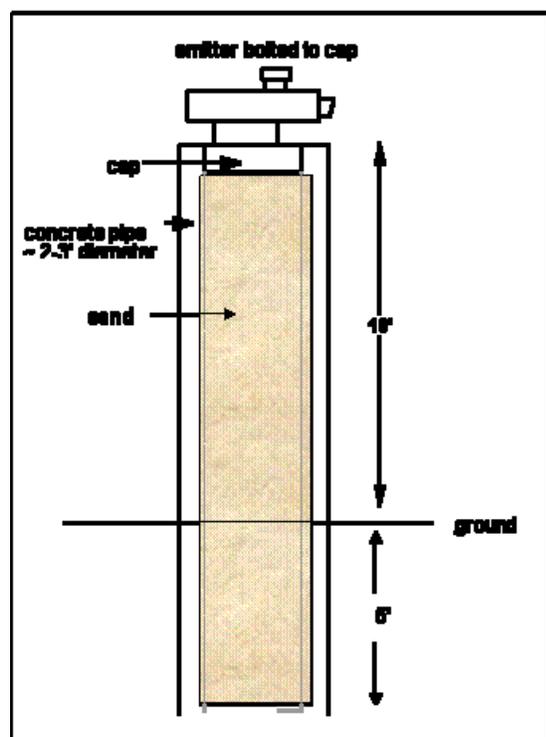


**Figure 7.3 Acceptable areas for PM<sub>10</sub> and PM<sub>2.5</sub> micro, middle, neighborhood, and urban samplers except for microscale street canyon sites**

## Open Path Monitoring

To ensure that open path monitoring data are representative of the intended monitoring objective(s), specific path siting criteria are needed. 40 CFR Part 58, Appendix E, contains specific location criteria applicable to monitoring paths after the general station siting has been selected based on the monitoring objectives, spatial scales of representativeness, and other considerations presented in Appendix D. The new open path siting requirements largely parallel the existing requirements for point analyzers, with the revised provisions applicable to either a "probe" (for point analyzers), a "monitoring path" (for open path analyzers), or both, as appropriate. Criteria for the monitoring path of an open path analyzer are given for horizontal and vertical placement, spacing from minor sources, spacing from obstructions, spacing from trees, and spacing from roadways. These criteria are summarized in Table 7-2.

**Cumulative Interferences on a Monitoring Path:** To control the sum effect on a path measurement from all the possible interferences which exist around the path, the cumulative length or portion of a monitoring path that is affected by obstructions, trees, or roadways must not exceed 10 percent of the total monitoring path length. This limit for cumulative interferences on the monitoring path controls the total amount of interference from minor sources, obstructions, roadways, and other factors that might unduly influence the open path monitoring data.



**Figure 7.4** Optical mounting platform

**Monitoring Path Length:** For  $\text{NO}_2$ ,  $\text{O}_3$  and  $\text{SO}_2$ , the monitoring path length must not exceed 1 kilometer for analyzers in neighborhood, urban, or regional scales, or 300 meters for middle scale monitoring sites. These path limitations are necessary in order to produce a path concentration representative of the measurement scale and to limit the averaging of peak concentration values. In addition, the selected path length should be long enough to encompass plume meander and expected plume width during periods when high concentrations are expected. In areas subject to frequent periods of rain, snow, fog, or dust, a shortened monitoring path length should be considered to minimize the loss of monitoring data due to these temporary optical obstructions.

### Mounting of Components and Optical Path

**Alignment:** Since movements or instability can misalign the optical path, causing a loss of light and less accurate measurements or poor readings, highly stable optical platforms are critical. Steel buildings and wooden platforms should be avoided as they tend to move more than brick buildings when wind and temperature conditions vary. Metal roofing will, for example, expand when heated by the sun in the summer. A concrete pillar with a wide base, placed upon a stable base material, has

been found to work well in field studies. A sketch of an optical platform is included in Figure 7.4.

### 7.2.3 Probe and Manifold Maintenance

After an adequately designed sampling probe and/or manifold has been selected and installed, the following steps will help in maintaining constant sampling conditions:

1. Conduct a leak test. For the conventional manifold, seal all ports and pump down to approximately 1.25 cm water gauge vacuum, as indicated by a vacuum gauge or manometer connected to one port. Isolate the system. The vacuum measurement should show no change at the end of a 15-min period.
2. Establish cleaning techniques and a schedule. A large diameter manifold may be cleaned by pulling a cloth on a string through it. Otherwise the manifold must be disassembled periodically and cleaned with distilled water. Soap, alcohol, or other products that may contain hydrocarbons should be avoided when cleaning the sampling train. These products may leave a residue that may affect volatile organic measurements. Visible dirt should not be allowed to accumulate.
3. Plug the ports on the manifold when sampling lines are detached.
4. Maintain a flow rate in the manifold that is either 3 to 5 times the total sampling requirements or at a rate equal the total sampling requirement plus 140 L/min. Either rate will help to reduce the sample residence time in the manifold and ensure adequate gas flow to the monitoring instruments.
5. Maintain the vacuum in the manifold <0.64 cm water gauge. Keeping the vacuum low will help to prevent the development of leaks.

### 7.2.4 Support Services

Most of the support services necessary for the successful operation of ambient air monitoring networks can be provided by the laboratory. The major support services are the generation of reagent water and the preparation of standard atmospheres for calibration of equipment. Table 7-4 summarizes guidelines for quality control of these two support services.

In addition to the information presented above, the following should be considered when designing a sampling manifold:

- suspending strips of paper in front of the blower's exhaust to permit a visual check of blower operation;
- positioning air conditioner vents away from the manifold to reduce condensation of water vapor in the manifold ;
- positioning sample ports of the manifold toward the ceiling to reduce the potential for accumulation of moisture in analyzer sampling lines, and using borosilicate glass, stainless steel, or their equivalent for VOC sampling manifolds at PAMS sites is to avoid adsorption and desorption reactions of VOC's on FEP Teflon;
- if moisture in the sample train poses a problem (moisture can absorb gases, namely NO<sub>x</sub> and SO<sub>2</sub>), wrap the manifold and instrument lines with "heat wrap", a product that has heating coils within a cloth covering that allows the manifold to be maintained at a constant temperature that does not increase the sampled air temperature by more than 3-5 degrees C above ambient temperature;
- ensuring the manifold has a moisture trap and that it is emptied often; and
- using water resistant particulate filters in-line with the instrument.

**Table 7-4 Techniques for Quality Control of Support Services**

Support	Parameters affecting quality	Control techniques
Laboratory and calibration gases	Purity specifications vary among manufacturers Variation among lots Atmospheric interferences Composition	Develop purchasing guides Overlap use of old and new cylinders Adopt filtering and drying procedures Ensure traceability to primary standard
Reagents and water	Commercial source variation Purity requirements Atmospheric interferences Generation and storage equipment	Develop purchasing guides. Batch test for conductivity Redistillation, heating, deionization with ion exchange columns Filtration of exchange air Maintenance schedules from manufacturers

### 7.3 Reference/Equivalent Methods and Approved Regional Methods

For monitoring in a SLAMS network, either reference or equivalent methods are usually required. This requirement, and any exceptions, are specified in 40 CFR Part 58, Appendix C<sup>3</sup>. In addition, reference or equivalent methods may be required for other monitoring applications, such as those associated with prevention of significant deterioration (PSD). Requiring the use of reference or equivalent methods helps to assure the reliability of air quality measurements including: ease of specification, guarantee of minimum performance, better instruction manuals, flexibility of application, comparability with other data and increased credibility of measurements. However, designation as a reference or equivalent method provides no guarantee that a particular analyzer will always operate properly. 40 CFR Part 58, Appendix A requires the monitoring organization to establish an internal QC program. Specific guidance for a minimum QC program is described in Section 10 of this Handbook.

The definitions and specifications of reference and equivalent methods are given in 40 CFR Part 53. For most monitoring applications, the distinction between reference and equivalent methods is unimportant and either may be used interchangeably.

Reference and equivalent methods may be either manual or automated (analyzers). For SO<sub>2</sub>, particulates, and Pb, the reference method for each is a unique manual method that is completely specified in 40 CFR Part 50 (Appendices A, and G respectively); all other approved methods for SO<sub>2</sub> and Pb qualify as equivalent methods. For CO, NO<sub>2</sub>, and O<sub>3</sub>, Part 50 provides only a measurement principle and calibration procedure applicable to reference methods for these pollutants. Automated methods (analyzers) for these pollutants may be designated as either reference methods or equivalent methods, depending on whether the methods utilize the same measurement principle and calibration procedure specified in Part 50. Because any analyzer that meets the requirements of the specified measurement principle and calibration procedure may be designated as a reference method, there are numerous reference methods for CO, NO<sub>2</sub>, and O<sub>3</sub>. Further information on this subject is in the preamble to 40 CFR Part 53.

<sup>3</sup> <http://www.access.gpo.gov/nara/cfr/cfr-table-search.html> All references to CFR in following section can be found at this site.

Except for the unique reference methods for SO<sub>2</sub>, particulates, and Pb specified in 40 CFR Part 50, all reference and equivalent methods must be officially designated as such by EPA under the provisions of 40 CFR Part 53. Notice of each designated method is published in the *Federal Register* at the time of designation. A current list of all designated reference and equivalent methods is maintained and updated by EPA whenever a new method is designated. This list can be found on AMTIC<sup>4</sup>. Moreover, any analyzer offered for sale as a reference or equivalent method after April 16, 1976 must bear a label or sticker indicating that the analyzer has been designated as a reference or equivalent method by EPA.

Sellers of designated automated methods must comply with the conditions summarized below:

1. A copy of the approved operation or instruction manual must accompany the analyzer when it is delivered to the purchaser.
2. The analyzer must not generate any unreasonable hazard to operators or to the environment.
3. The analyzer must function within the limits of the performance specifications in Table 7-5 for at least 1 year after delivery when maintained and operated in accordance with the operation manual.
4. Any analyzer offered or sale as a reference or equivalent method must bear a label or sticker indicating that it has been designated as a reference or equivalent method in accordance with 40 CFR Part 53.
5. If such an analyzer has one or more selectable ranges, the label or sticker must be placed in close proximity to the range selector and must indicate which range or ranges have been designated as reference or equivalent methods.
6. An applicant who offers analyzers for sale as reference or equivalent methods is required to maintain a list of purchasers of such analyzers and to notify them within 30 days if a reference or equivalent method designation applicable to the analyzers has been canceled or if adjustment of the analyzers is necessary under 40 CFR Part 53.11(b) to avoid a cancellation.

Accordingly, in selecting a designated method for a particular monitoring application, consideration should be given to such aspects as:

- the suitability of the measurement principle;
- the suitability for the weather and/or geographic conditions at the site;
- analyzer sensitivity and available operating ranges suitable for the site;
- susceptibility to interferences that may be present at the monitoring site;
- requirements for support gases or other equipment;
- reliability;
- maintenance requirements;
- initial as well as operating costs;
- features such as internal or fully automatic zero and span checking or adjustment capability, etc.;
- compatibility to your current and future network, i.e. software and connections (RS 232, Ethernet); and
- manual or automated methods.

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<sup>4</sup> <http://www.epa.gov/ttn/amtic/criteria.html>

It is important that the purchase order for a new reference or equivalent analyzer specify the designation by the EPA.

The required performance specifications, terms of the warranty, time limits for delivery and acceptance testing, and what happens in the event that the analyzer falls short of performance requirements should be documented. Aside from occasional malfunctions, consistent or repeated noncompliance with any of these conditions should be reported to EPA. In selecting designated methods, remember that designation of a method indicates only that it meets certain minimum standards. Competitive differences still exist among designated analyzers. Some analyzers or methods may have performance, operational, economic or other advantages over others. A careful selection process based on the individual air monitoring application and circumstances is very important.

Some of the performance tests and other criteria used to qualify a method for designation as a reference or equivalent method are intended only as pass/fail tests to determine compliance with the minimum standards. Test data may not allow quantitative comparison of one method with another.

**Table 7-5 Performance Specifications for Automated Methods**

Performance Parameter	Units	SO <sub>2</sub>	O <sub>3</sub>	CO	NO <sub>2</sub>	Def and Test procedure-CFR Sec
1) Range	ppm	0-0.5	0-0.5	0-50	0-0.5	53.23(a)
2) Noise	ppm	0.005	0.005	0.50	0.005	53.23(b)
3) Lower detectable limit	ppm	0.01	0.01	1.0	0.01	53.23(c)
4) Interference equivalent Each Interferant Total Interferant	ppm	± 0.02 0.06	± 0.02 0.06	± 1.0 1.5	± 0.02 0.04	53.23(d)
5) Zero drift, 14 and 24 hour	ppm	±.02	±.02	±1.0	±.02	53.23(e)
6) Span drift, 24 hour 20% of upper range limit 80% of upper range limit	percent	± 20.0 ± 5.0	± 20.0 ± 5.0	± 10.0 ± 2.5	± 20.0 ± 5.0	53.23(e)
7) Lag time	minutes	20	20	10	20	53.23(e)
8) Rise Time	minutes	15	15	5	15	53.23(e)
9) Fall Time	minutes	15	15	5	15	53.23(e)
10) Precision 20% of upper range limit 80% of upper range limit	ppm	0.01 0.015	0.01 0.01	0.5 0.5	0.02 0.03	53.23(e)

### FRM/FEM Designated Operating Ranges and the Affect of Span Checks

Although all FRM/FEMs are required to meet the range specified in Table 7-5, many instruments are designated for ranges narrower and or broader than the requirement. During the equipment purchase/selection phase, monitoring organizations should select an instrument with ranges most appropriate to the concentration at the site which the instrument will be established and then use the range that is most appropriate for the monitoring situation. Earlier versions of this Handbook suggested that the concentration of the span checks be 70 – 90% of the analyzers measurement range. Using this guidance and the designated ranges of some of the FRM/FEM method being used, a span check might be selected at a concentration that is never found in the ambient air at the site for which the monitoring is operating. The span check concentration should be selected that is more beneficial to the quality control of the routine data at the site and EPA suggests: 1) the selection of an appropriate measurement range and 2) selecting a span that at a minimum is above 120% of the highest NAAQS (for sites used for designation purposes) and above the 99% of the routine data over a 3 year period. The multi-point verification/calibrations that are performed at a minimum annually can be used to challenge the

instrument and confirm linearity and calibration slope of the selected operating range.

### **PM<sub>2.5</sub> Reference and Equivalent Methods**

All formal sampler design and performance requirements and the operational requirements applicable to reference methods for PM<sub>2.5</sub> are specified in 40 CFR Part 50, Appendix L. These requirements 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) or a multiple filter capability (sequential), provided no deviations are necessary in the design and construction of the sample collection components specified in the reference method regulation. A PM<sub>2.5</sub> 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<sub>2.5</sub>.

Equivalent methods for PM<sub>2.5</sub> have a 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<sub>2.5</sub>; therefore, continuous or semi-continuous analyzers and new types of PM<sub>2.5</sub> 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<sub>2.5</sub> **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<sub>2.5</sub> monitoring. But not all types of equivalent methods may be equally suited to various PM<sub>2.5</sub> monitoring requirements or applications.

**Class I** equivalent methods are very similar to reference methods, with only minor deviations, and must meet nearly all of the reference method specifications and requirements. The requirements for designation as Class I equivalent methods are only slightly more extensive than the designation requirements for reference methods. Also, because of their substantial similarity to reference methods, Class I equivalent methods operate very much the same as reference methods.

**Class II** equivalent methods are filter-collection-based methods that differ more substantially from the reference method requirements. The requirements for designation as Class II methods may be considerably more extensive than for reference or Class I equivalent methods, depending on the specific nature of the variance from the reference method requirements.

**Class III** equivalent methods cover any PM<sub>2.5</sub> methods that cannot qualify as reference or Class I or II equivalent methods because of more profound differences from the reference method requirements. This class encompasses PM<sub>2.5</sub> methods such as continuous or semi-continuous PM<sub>2.5</sub> analyzers and potential new PM<sub>2.5</sub> measurement technologies. The requirements for designation as Class III methods are the most extensive, and, because of the wide variety of PM<sub>2.5</sub> measurement principles that could be employed for candidate Class III equivalent methods, the designation requirements are not explicitly provided in 40 CFR Part 53.

## Approved Regional Methods (ARM)

There are some continuous PM<sub>2.5</sub> methods that currently may not be able to meet the national FRM and FEM designation criteria. However, these methods may operate at acceptable levels of data quality in certain regions of the country or under certain conditions. The EPA has expanded the use of alternative PM<sub>2.5</sub> measurement methods through ARMs. A method for PM<sub>2.5</sub> that has not been designated as an FRM or FEM as defined in 40 CFR Part 50.1 may be approved as an ARM. If a monitoring organization feels that a particular method may be suitable for use in its network, it can apply for the method to be designated as an ARM. The following provides a summary of the ARM requirements.

### PM<sub>2.5</sub> ARM Criteria Summary

1. Must meet Class III Equivalency Criteria
  - Precision
  - Correlation
  - Additive and multiplicative bias
2. Tested at site(s) where it will be used
  - 1 site in each MSA/CMSA up to the first 2 highest pop MSA/CMSA
  - 1 site in rural area or Micropolitan Statistical Area
  - Total of 3

If the ARM has been approved by another agency then:

- 1 site in MSA/CMSA and 1 site in rural area or Micropolitan Statistical Area
  - Total of 2
3. 1 year of testing all seasons covered
    - 90 valid sample pairs per site with at least 20 valid sample pairs per season.
    - Values < 3 ug/m<sup>3</sup> may be excluded in bias estimates but this does not affect completeness criteria.
  4. Collocation to establish precision not required
    - peer reviewed published literature or data in AQS that can be presented is enough
  5. ARM must be operated on an hourly sampling frequency providing for aggregation into 24-hour average measurements.
  6. Must use approved inlet and separation devices (Part 50 Appendix L or FEM Part 53)
    - Exception –methods that by their inherent measurement principle may not need an inlet or separation device.
  7. Must be capable of providing for flow audits
    - Exception –that by their inherent measurement principle measured flow is not required.
  8. Monitoring agency must develop and implement appropriate procedures for assessing and reporting precision and bias.

### Routine Monitoring Implementation

9. Collocation of ARM and FRM/FEM at 30% of SLAMS network or at least 1/network
  - At 1 in 6 day sampling frequency
  - Located at design value site among the largest MSA/CMSA
  - Collocated FRM/FEM can be substituted for ARM if ARM is invalidated
10. Collocation ARM with ARM
  - 7.5% of sites or at least 1 site
11. Bias assessment (PEP)
  - Same frequency as Appendix A

### ARM Approval

1. New ARM- EPA NERL, RTP, NC

2. ARM that has been approved by another agency- EPA Regional Administrator