



# Air Monitoring Guideline for Saskatchewan

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Ministry of  
Environment

goGreen  
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## Air Monitoring Guideline for Saskatchewan

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# 1. INTRODUCTION

The objective of this Guideline is to provide general guidance to industries in Saskatchewan that are required to conduct ambient air monitoring at their facilities. The Guideline explains the specific air monitoring and reporting requirements for measuring ambient air quality in the province.

An operating facility should always rely on the operating approval issued to them by the Saskatchewan Ministry of Environment (the ministry). An operating approval will specify the details of a facility's monitoring and reporting requirements. This Guideline is intended to ensure that air monitoring and reporting requirements outlined in an operating approval, or control order, will be carried out by industries in a consistent manner.

The Guideline will be reviewed periodically to ensure that up to date information is available for measuring and reporting air quality in Saskatchewan. The ministry's Standard Operating Procedures (SOPs) for air monitoring equipment, station maintenance, and data validation are available in a companion document. Source testing methodologies for emissions monitoring are beyond the scope of this Guideline.

## **2. MONITORING REQUIREMENTS**

### **2.1 Site Selection**

The goal of establishing an ambient air monitoring station is to provide the most efficient assessment of the air quality, or of an air pollution problem, that impacts the general population. The location of a monitoring station should be selected based on an objective representation for the geographical area of interest. The most representative monitoring location is typically achieved through the use of an appropriate air dispersion model. Points to consider in this case when selecting specific site locations include:

- past and current monitoring results
- site accessibility
- power accessibility
- topographical effects
- local interferences
- security

Separate networks of stations in a given area should complement each other. If a network is to be established, additional factors in site selection must also be considered, such as:

- distribution of instrumentation or stations within the area of high population density;
- most appropriate location of each station determined by the highest concentration expected to occur;
- separation between stations; and
- to correctly match the spatial scale represented by the sample of monitored air with the spatial scale most appropriate for the monitoring objective of the station.

### **2.2 Sampling System Design**

To ensure data quality, it is essential to properly design the sampling system. In addition to shelter design, consideration should also be given to temperature stability, sampling probe location, manifold system design, sampling line length and composition, and composition of filters and fittings.

#### **2.2.1 Shelter Requirements**

As most of the equipment consists of sensitive electronic devices, the shelter must provide protection for the instrumentation from precipitation, excessive dust and dirt,

corrosive chemicals, intense light, radiation and vibration. A temperature range between 20°C and 30°C should be maintained in the shelter, as excessive temperature fluctuations can lead to analyzer drift.

Other building requirements must also be maintained to meet electrical and building codes and occupational health and safety requirements. A shelter must be equipped with an ABC type fire extinguisher.

### 2.2.2 Probe Siting Criteria

Table 1 lists the standard probe siting criteria that must be met. Table 2 determines the minimum distance the inlet must be from a roadway.

Table 1 Standard Site Criteria

Site Characteristics	Sampling Inlet for Continuous monitoring	Wind Instrumentation	Static Monitors
<b>Height above ground</b>	Sample inlet must be height of shelter plus at least 1m, but less than 2 m above top of shelter. Cannot exceed 15 m above ground.	Anemometer must be a minimum of 10 m above ground and at least 2.5 times shelter height	Greater than or equal to 1 m and less than or equal to 3 m
<b>Other requirements</b>	> 20 m from trees. Distance from inlet to any airflow obstacle must be > 2 times the height of obstacle above inlet. 3 of the 4 wind quadrants must have unrestricted airflow.	Anemometer height must be > 2 times the height of obstacle if horizontal distance is < 10 times the obstacle height.	Elevation angle must be < 30° from sample inlet to top of any obstacle

Table 2 Minimum Distances from Roadways

Average Traffic (Vehicles per day)	≤10,000	15,000	20,000	40,000	70,000	≥ 110,000
<b>Minimum Distance between Roadway and Inlet (meters)</b>	≥ 10	20	30	50	100	≥ 250

### 2.2.3 Manifold

The material used for the inlet manifold must be non-reactive with the pollutants that are being monitored. This usually limits the choices to glass and Teflon. For multi parameters, the preferred inlet system for a monitoring station is the use of a multi-port Pyrex glass manifold, with each instrument drawing a sample from it via a 1/4"

Teflon sampling line. A water trap should be installed in the manifold to remove excess moisture from outside, preventing water from entering the analyzers.

In a conventional manifold, a blower is utilized to provide airflow through the manifold. The residence time of the air within the manifold must be maintained below 20 seconds, but must not be so great to create a vacuum of more than one inch of water below ambient pressure. If an “ARB” type manifold is utilized, there is less of a need for bypass flow and a blower is not typically required if combined flow rates of the monitoring instruments are high enough. The residence time is still required to be less than 20 seconds, and it is recommended that the residence time within the manifold to the instruments be less than 10 seconds. To determine the residence time and other information on manifolds, refer to Appendix A.

### **2.3 Analyzer Selection, Measurement Methods and Operating Specifications**

An analyzer used for an ambient air monitoring program within the province must satisfy the requirements of the US EPA equivalent reference methods for ambient air monitoring. Non-equivalent instruments being used in a monitoring program must have demonstrated proof of the effectiveness and accuracy of the analyzer. The operating characteristics are to be documented and their performance continuously evaluated both in the field and in the laboratory. Appendix B summarizes the minimum performance specifications and the recognized measurement methods for the ambient air gas analyzers. Real time mass measurement of selected size particles in ambient air samples must also satisfy the requirements of the US EPA equivalent reference methods for ambient air monitoring. This is typically achieved by using a Tapered Element Oscillating Microbalance (TEOM), a Beta Attenuation Monitor (BAM), a Synchronized Hybrid Ambient Real-time Particulate (SHARP) monitor, or a GRIMM Dust Monitor. The standard siting criteria in Table 1 is also applicable for these instruments and the operating parameters and instrument configuration for the various detection methods is described in the Standard Operating Procedures. Real time mass measurement of selected size particles that do not satisfy US EPA equivalent method requirements, such as the nephelometer, may be used for an ambient monitoring program, provided the unit has been validated against a reference or equivalent reference method. Refer to the SOP for the Nephelometer for more detailed information on calculation factors for nephelometers.

### **2.4 Ambient Monitoring Station Operations and Guidelines**

Station operations include regularly scheduled station visits, zero and span verifications, calibrations, preventative maintenance and documentation. Standard Operating Procedures (SOP's) should be developed for each specific instrument to ensure operators are aware of all the detailed information and follow the correct installation, operation and detailed calibration and maintenance procedures for each



analyzer. SOP's have been developed for various instrumentation operated by the Ministry and can be made available upon request.

#### 2.4.1 Station Visits

Besides the requirement to change filters and canisters on certain sampling equipment, regular visits to the monitoring station at least once per week are required. The purpose of this is to verify proper operation of the monitoring equipment to ensure the collection of complete and valid data, as well as to verify any other abnormalities to the station or operation that cannot be diagnosed remotely. Site visits and all activities performed should be documented in a site logbook. Activities to be performed during site visits include the following:

- Analyzer zero/span verification. Record values on control chart and note abnormal deviations. Manually adjust zero value as required; calibration is required when span value falls outside of control acceptability.
- Perform preventative maintenance as recommended by operations and maintenance manuals
- Replace span cylinders when pressure drops below 215 psig (1500 kPa)
- Examine manifold and transfer lines for dirt buildup or damage and clean or replace as required. Examine inlet filters for dirt buildup and replace as necessary.
- Examine external and internal station conditions including inlet probe, seals in sampling system, scrubbing and drying agents, replacing or repairing components as required.

If automatic daily zero/span verifications are performed on the analyzers, weekly visits to the monitoring station are not required. Regular remote checks for abnormal deviations of the zero/span verification is required, however, and regular visits to the station should occur on a monthly basis to perform the remainder of the activities to the station, as listed above.

In the case of an Airpointer® that has an automated internal zero/span option, regular station visits are not required, as full diagnostic capabilities of the instruments and operational equipment can be achieved remotely. Remote checks should be performed on a regular basis, as determined by the Ministry of Environment project officer or airshed association Director.

#### 2.4.2 Analyzer Operation

In general, real time instrumentation must be operational at least 90% of the time on a monthly basis. Operating procedures can typically be described in the specific monitoring instruments operations manual. Performance specifications are listed in Table B-1 in Appendix B.

### 2.4.3 Data Acquisition

A data-logging device must be utilized for the collection of data from the monitoring instrumentation and a strip chart recorder should also be used as a backup for recording analyzer response. The graphical display of the strip chart also serves as a diagnostic tool for analyzing unusual analyzer response. All data is to be retained for a period of at least 24 months and made available to Saskatchewan Ministry of Environment upon request.

### 2.4.4 Calibrations

As many variables can affect the calibration of ambient air monitoring instruments resulting in inaccurate data being collected, instrument calibration at regular intervals is necessary. Calibrations are multipoint checks consisting of zero verification and a minimum of three, but preferably four upscale points across the operating range of the analyzer.

Multipoint calibrations are required at maximum intervals of 3 months or following span drifts of greater than  $\pm 10\%$ , whichever comes first. Calibrations are also performed after initial installation, after major repairs, and when decommissioning the analyzer. This calibration frequency is a general guideline and may vary depending on the requirements of an airshed management program or a permit to operate under the Clean Air Act. General calibration procedures can be found in Appendix C, but there may be specific requirements for certain instruments or instrument types and calibration procedures in the analyzer operation manual should be followed.

### 2.4.5 Calibration and Reference Standards Traceability

Materials and devices used for calibrating the various ambient air monitoring equipment must be certified as accurate against reference standards and traceable to recognized national primary standards. With the exception of ozone, Standard Reference Materials (SRMs) for gaseous pollutants are acquired from the United States National Institute of Standards and Technology (NIST). For ozone measurements, traceability of a standard reference photometer (SRP) is typically maintained by direct intercomparison to other equivalent ozone photometers manufactured by NIST. Traceability of other reference standards (temperature, pressure, flow rate and voltage) can be maintained by periodic recertification against higher level standards, such as the corresponding national primary standards at the National Research Council of Canada's Institute for National Measurement Standards (NRC-INMS).

### 2.4.6 Zero and Span Verifications

Analyzer performance and stability can be assessed through zero and span verifications. Verifications should be performed at least weekly on continuous gas analyzers. If automatic daily zero/span verifications are performed, they should be

scheduled every 24 hours at a time when pollutant levels are typically at a minimum, which is usually during early morning hours. Alternatively, a zero/span verification may be performed every 23 hours to obtain a better overall assessment of all hours of the day, or within 15 minutes prior to the end of an hour and ending within 15 minutes prior to the beginning of the next hour, resulting in no data loss. A multipoint calibration is required when a deviation of greater than  $\pm 10\%$  occurs from the control chart of the previous calibration. Zero and Span verifications and control charts are described in more detail in Appendix D.

#### 2.4.7 Site Documentation

Existing and newly established air monitoring sites require documentation of the following site parameters:

- Station name and address
- Station identification number (If required)
- City or municipality or both if applicable
- Analyzer type
- Site description, which would include scale of representativeness, land use, elevation, average building height, air flow restrictions, manifold, and nearest meteorological station
- Site influences, such as localized sources, roadway influences, and major point sources
- Site map or aerial photograph of the area
- Pictures from manifold inlet showing north, east, south and west directions

### **2.5 Data Validation**

The purpose of the validation process is to ensure that recorded data is representative of ambient conditions. Data is subjected to strict scrutiny to ensure that the data set is accurate and scientifically defensible and equipment performance has been assessed and is quantifiably documented.

Validation of continuous ambient and meteorological sensor data occurs several times before data is finally archived. Opportunities to validate the data occur daily, monthly and annually.

#### 2.5.1 Daily Validation

Daily data validation is conducted on the one-hour averages using the following steps:

- Daily validation should consistently be performed at the same time of day, usually in the morning, and may be performed by all levels of technicians and/or supervisors.

- Daily validation involves the review of the previous 30 hours of data from every analyzer in the network. Data is examined for negative baseline, missing data, power failures, rate of change flags or any other data anomalies. Zero/Span calibration data reports are also reviewed.
- If the validation process detects an error, the first step is to verify the 1 minute data averages or strip charts.
- A data error may result in the data point being declared invalid.
- A data error may result in instrument repair followed by a recalibration of the analyzer. If the analyzer is replaced the analyzer must also be recalibrated immediately. In some cases the Zero/Span source may be used to verify the calibration of the analyzer.
- The daily check also involves verifying that all communication systems are operational. Corrections or repairs are carried out as required.
- All technicians responsible for the daily validation must be familiar with the verification process.

### 2.5.2 Monthly Validation

Monthly data validation is conducted on one-hour averages using the following steps:

- Monthly data validation involves examination of manual calibrations, Zero/Span data and calibrations.
- The data set is reviewed for the entire month and reasons for missing data is explained, or the data is replaced if available.
- Zero Offset is identified and corrected as required.
- Instrument span results (automatic and manual) are examined and if the span value exceeds  $\pm 10\%$ , data going back to the previous good span is invalidated.
- A second review of data from all stations should be performed, preferably by another technician.
- After second review, the dataset is checked for minimums, maximums, averages, data recovery, trends, etc.

### 2.5.3 Annual Validation

Annual data validation is conducted on the one-hour averages and is examined using the following steps:

- As part of the annual data validation minimums, maximums, averages, data recovery, trends, etc are calculated and identified. Anomalies are identified and undergo further verification.
- An annual data report is generated and reviewed.
- The dataset is archived.
- The three levels in the verification process coupled with the application of high quality QA/QC standards provide a defensible dataset.

## **2.6 Passive and Intermittent Monitoring**

Standard Operating Procedures (SOP's) should be developed for each specific instrument to ensure that operators are aware of all the detailed information and follow the correct installation, operation and detailed calibration and maintenance procedures for each analyzer. SOP's have been developed for various instrumentation operated by the ministry, which can be made available upon request.

### 2.6.1 Particulates and Speciation

Non-continuous samplers utilized for the collection of particulate matter include high-volume samplers, Partisols and Dichotomous samplers. Appendix E describes the weight determination procedures and requirements for non-continuous sample filters. If speciation of the sample is to be obtained, the use of a speciated sampler equipped with a speciation cartridge will be required. The standard siting criteria in Table 1 is also applicable for these non-continuous samplers.

### 2.6.2 Passive Sampling

Passive (diffusive) sampling provides a good cost-effective indicator of the ambient conditions of an area where there may be no power, only an indicator is required, or an aid in establishing a representative monitoring location.

A passive (or diffusive) sampler is a device that is capable of taking samples of gas or vapor pollutants from the atmosphere at a rate controlled by a physical process such as diffusion through a static air layer or permeation through a membrane. It does not involve the active movement of the air through the sampler. Passive samplers are generally simple in structure and do not require electricity so they are cost effective and very convenient to use.

The major difference between active samplers and passive samplers is that the active sampler has a known sampling rate, which is the pump's flow rate. The passive sampler's sampling rate depends on many factors such as temperature, relative humidity, wind direction, wind speed, sampler's structure and collection media. If a passive sampler is to be used in all climate conditions, there must be a reasonable way to calculate the sampling rate. The key factor for using passive samplers is how to determine their sampling rates.

Technical information and instructions for passive sampling can be found in Appendix F.

## 2.7 Air Quality Standards in Saskatchewan

Saskatchewan's ambient air quality standards are as follows:

Pollutant <sup>(1)</sup>	Average Concentration For Applicable Time Period				
	1 Hour	8 Hours	24 Hours	30 Days	Annual
Suspended Particulates			120 $\mu\text{g}/\text{m}^3$		*70 $\mu\text{g}/\text{m}^3$
Settleable Particulates				2.0 $\text{mg}/\text{cm}^2$	
Soil Index			1.5 COH units		
Sulphur Dioxide	450 (0.17) $\mu\text{g}/\text{m}^3$		150 (0.06) $\mu\text{g}/\text{m}^3$		**30 (0.01) $\mu\text{g}/\text{m}^3$
Sulphation				30 mg of $\text{SO}_3$ per 100 $\text{cm}^2$	
Carbon Monoxide	15 (13) $\text{mg}/\text{m}^3$	6 (5) $\text{mg}/\text{m}^3$			
Oxidants (Ozone)	160 (0.08) $\mu\text{g}/\text{m}^3$				
Nitrogen Dioxide	400 (.2) $\mu\text{g}/\text{m}^3$				**100 (0.05) $\mu\text{g}/\text{m}^3$
Hydrogen Sulphide	15 (10.8) $\mu\text{g}/\text{m}^3$		5 (3.6) $\mu\text{g}/\text{m}^3$		

NOTE: Volume units, in parts per million or parts per billion for  $\text{H}_2\text{S}$ , are in brackets  
\* Geometric Means, \*\*Arithmetic Means

<sup>(1)</sup> Sampling will be in a manner and location specified by the Minister.

The Canada-wide Standards (CWSs) listed below are in addition to the above air quality standards.

- Particulate Matter
  - A CWS for  $\text{PM}_{2.5}$  of  $30 \mu\text{g}/\text{m}^3$ , 24-hour averaging time
  - Achievement to be based on the 98<sup>th</sup> percentile ambient measurement annually, averaged over three consecutive years
- Ozone
  - A CWS for ozone of 65 ppb, eight-hour averaging time
  - Achievement to be based on the 4<sup>th</sup> highest measurement annually, averaged over three consecutive years
- Benzene, Mercury, Dioxins & Furans
  - Information on numerical targets or emission limits for specific facilities or sectors is available from the Canadian Council of Ministers of the Environment website at <http://www.ccme.ca/>

## **3. REPORTING REQUIREMENTS**

### **3.1 Reporting of Data and Results**

- The person responsible for environmental monitoring shall report to the ministry or anyone acting on its behalf (e.g. an airshed association), accurately and clearly and in accordance with this Guideline.
- Data shall be reported as valid only if all required Quality Assurance and Quality Control (QA/QC) requirements have been met.
- Data not meeting the stated QA/QC requirements shall be reported with clearly identifiable data flags in accordance with the requirements of this Guideline.
- The person responsible shall report the monitoring results to the ministry in a written monitoring report, or in electronic format.

### **3.2 Regular Reporting**

- The person responsible shall submit reports to the ministry by the time specified in the Clean Air Permit (Approval to Operate or operating permit) issued pursuant to the Clean Air Act and Regulations, or as required in writing by the ministry.
- If data or reports are sent in electronic format, the electronic files must be sent on one or more CDs via mail, until a formalized mechanism exists to confirm receipt of electronically transferred data and reports. Electronic reports that contain data that cannot be manipulated, such as PDF files, must be accompanied by the data in a form that can be manipulated, such as in an Excel spreadsheet, to allow for further data analysis.

### **3.3 Content of Monitoring Reports**

#### **3.3.1 Quarterly Report**

Unless otherwise specified in this Guideline, the person responsible shall include in each monitoring report all of the following information:

- The name and address of the agency responsible;
- The location where the monitoring activities reported were carried out, if different from the address of the agency responsible;

- A unique identifier of the environmental monitoring report, such as the approval number and date, or another unique identifier when no approval number exists;
- Identification on each page of the report to ensure that the page is recognized as part of the environmental monitoring report, and clear identification of the end of the report;
- Identification of the environmental monitoring method(s) used,
- A description of the condition and unambiguous identification of the sample(s), if applicable;
- The date and time of sample collection;
- The date of analysis of the sample(s), if applicable;
- The time of sample preparation and/or analysis, if the required holding time for either activity is less than or equal to 72 hours;
- Reference to the sampling plan and procedures used by the person responsible for the sampling;
- Maps, diagrams, sketches, or photographs of the sampling location and/or the monitoring station (air quality and meteorology). When there are no changes to the sampling location, maps, diagrams, sketches, or photographs of the sampling location need only be included in the first report;
- Details of any environmental conditions during sampling that may affect the interpretation of the sampling results;
- The environmental monitoring results, with the units of measurement and any QA/QC failures or invalid data identified;
- Identification of the basis (dry or wet weight basis) on which the data are calculated;
- The data value, in the same units as the units stipulated in the Approval to Operate, or, if not specified, as required in the environmental monitoring method specified in this Guideline, or as otherwise required by the ministry;
- The name(s), function(s), and signature(s) or equivalent electronic identification of the person(s) authorizing the environmental monitoring report, and the date of issue;
- The data presented numerically in tables and in a graphical format. Examples of air monitoring summary tables are illustrated in Appendix G;
- An interpretation of the environmental monitoring results, including comparison to applicable standards, guidelines, limits, and a provision of trends, if applicable;
- A summary of ambient air contaminant excursions above the Saskatchewan's Ambient Air Quality Standards, Canadian Ambient Air Quality Standards, or Canada-wide Standards or guidelines with explanation as to why these



excursions occurred and what actions were taken to prevent their reoccurrence;

- A statement of compliance and/or non-compliance with requirements and/or specifications where applicable;
- A statement about the estimated uncertainty of measurement;
- Deviations or exclusions from the method;
- Any non-standard conditions that may have affected the quality of the results, including the use and definitions of data qualifiers;
- Clear identification of numerical results for values outside quantification limits;
- Any additional information that may be required by a specific method or reporting requirement; and
- Any other information requested in writing by the ministry.

In the event that a specified reporting format does not require inclusion of all items listed above, the person responsible shall retain all the required information relevant for interpretation of monitoring data.

### 3.3.2 Annual Report

The agency responsible shall submit an annual written report to the ministry prior to March 31 for the period of twelve (12) calendar months ending the previous December 31.

Annual reports should include the quarterly reporting requirements listed above as well as, but not be limited to, the following:

- Update on the QA/QC program for the field and laboratory procedures performed by both the Company's field staff and their analytical laboratories;
- Results of inspections;
- Stack emission survey results;
- A yearly measurement or estimate of facility emissions. The estimates should include a summary of the calculations and data used to obtain the total emission figures. The estimates should be in tonnes per year;
- A statement assuring that air monitor calibrations were undertaken and a summary of follow-up actions in response to the calibrations. The monitors shall be calibrated at least twice per year;
- A record of air pollution control equipment performance including all scheduled and non-scheduled maintenance;
- A record of any downtime of major air pollution control equipment stating problems experienced and corrective actions taken to prevent reoccurrence;

- Results of the annual review of the environmental monitoring and control systems related to spill control;
- Results of the annual review of the environmental contingency plans;
- A current list of industrial sources, fuel burning equipment, and incinerators. This list shall include the specific make, model, size and associated air pollution abatement equipment, and type and quantity of fuel consumed, as well as purpose for each piece of equipment;
- Documentation of any significant or proposed changes in the works, industrial sources and fuel burning equipment and the operational practice of the works, industrial sources and fuel burning equipment, and comments upon the impact of such changes that could affect the environment;
- A summary of flaring activities including the date, times of flaring, estimate of volume of gas flared as monthly and annual amount, tonnes of sulphur dioxide released and circumstances necessitating flaring, if applicable; and
- A record of all scheduled and non-scheduled maintenance of components of the industrial sources and/or fuel burning equipment.

### **3.4 Accidental, Emergency or Unauthorized Releases**

- Where an accidental, emergency or unauthorized release or discharge of an air contaminant occurs that results in air pollution, the person responsible must as soon as practicable, advise the ministry with preliminary notification of the occurrence describing:
  - the circumstances leading to the air pollution; and
  - the actions took to correct the discharge of air pollution to minimize the resulting air contaminations.
- Whenever a spill occurs as defined in the regulations it must be reported to the Saskatchewan Ministry of Environment's Spill Report Line by calling 1-800-667-7525. If the spill exceeds defined maximum limits, the responsible party will be required to submit a written spill report within seven days. Information required for reporting is available from the Sask Spills website at [www.saskspills.ca](http://www.saskspills.ca).

### **3.5 Reporting Requirements for Air Zone Associations**

An air zone association in Saskatchewan is required to submit annual reports of ambient air quality monitored within the air zone to the ministry. The reporting requirements will be the same as mentioned above.

An air zone association should provide access to the ministry of the real-time ambient air quality data monitored and presented via the internet/web. The data monitored could be presented on the internet in different graphical and tabular formats such as average and summary reports; compliance and exceedance

reports; air quality index; air quality maps; air quality trends; hourly, daily, and monthly average data reports; and instrument operation reports.

### **3.6 Air Monitoring Results Obtained from Subcontractors**

When a person responsible subcontracts air monitoring and/or reporting, the subcontractor(s) performing the subcontracted work shall be specified in the air monitoring report.

### **3.7 Format of Reports**

The person responsible should use the applicable monitoring report formats specified in this Guideline, unless otherwise authorized in writing by the ministry. In the event that no suitable format is included in this Guideline, the person responsible should design the format to accommodate the type of environmental monitoring carried out.

### **3.8 Submissions of Data and Reports**

In the case of submission of monitoring reports or data by facsimile, e-mail, or electronic media submission, the requirements of this Guideline shall be met. Environmental monitoring reports and data should be mailed to the ministry's Environmental Project Officer responsible for the facility.

## REFERENCES

Air Monitoring Directive, 1989, Prepared by Alberta Environment.

AMD 2006, Amendments to the Air Monitoring Directive 1989, Prepared by Alberta Environment.

British Columbia Field Sampling Manual, 2003, Prepared by B.C. Ministry of Water, Land and Air Protection.

Methods and Procedures Document, 2006, Prepared by Greater Vancouver Regional District, Air Quality Policy and Management Division.

Passive Air Sampling System, Technical and Instruction Information, Prepared by Maxxam Analytics Inc.

Quality Assurance and Quality Control Guidelines, Report No. PMD 95-8, revised 2002, Environment Canada.

Quality Assurance and Quality Control Guidelines, Report No. AAQD 2004-1, Environment Canada.

United States Environmental Protection Agency (USEPA), 2008, QA Handbook for Air Pollution Measurement Systems, Volume II, Ambient Air Quality Monitoring Program.

## Appendix A - Manifold Design for Ambient Air Sampling System

*This procedure is an excerpt from Environment Canada's Quality Assurance and Quality Control Guidelines, Report No. AAQD 2004-1. It has been modified where appropriate to suit operations within Saskatchewan.*

The following information is from the US EPA Quality Assurance Handbook (reference 2): Some important variables affecting the sampling manifold design are the diameter, length, flow rate, pressure drop, and materials of construction. Considerations for these parameters are discussed below for both a vertical laminar flow and a conventional manifold design.

### Vertical Laminar Flow Design

By the proper selection of a large diameter vertical inlet probe and by maintaining a laminar flow throughout, the sample air is not permitted to react with the walls of the probe. Numerous materials such as glass, PVC plastic, galvanized steel, and stainless steel, can be used for constructing the probe. Removable sample lines constructed of Teflon or glass can be used to provide each device with sample air. Inlet probe diameters of 15 cm with a flow rate of 150 L/min are necessary if diffusion losses and pressure drops are to be minimized. The sampling rate should be maintained to ensure laminar flow conditions.

This configuration has the following advantages:

- a 15-cm pipe can be cleaned easily by pulling a cloth through it with a string
- sampling ports can be cut into the pipe at any location and, if unused, can be plugged with stoppers of similar composition
- metal poses no breakage hazard < there is less potential for sample contamination than there is with smaller tubes

### Conventional Manifold Design

In practice, it may be difficult to achieve vertical laminar flow because of the elbows within the intake manifold system. Therefore, a conventional horizontal manifold system should be constructed of inert materials such as Pyrex glass and/or Teflon, and in modular sections to enable frequent cleaning. The system consists of a vertical "candy cane" protruding through the roof of the shelter with a horizontal sampling manifold connected by a tee to the vertical section. Connected to the other vertical outlet of the tee is a bottle for collecting heavy particles and moisture before they enter the horizontal section. A small blower, 1700 L/min at 0 cm of water at static pressure, is at the exhaust end of the system to provide a flow through the system of approximately 85 to 140 L/min. Particulate monitoring instruments, such as Beta Attenuation Mass Monitors (BAMs) and TEOMs, each have separate intake probes that are as short and as straight as possible to avoid particulate losses due to impaction on the walls of the probe.

In Figures A-1 and A-2, typical designs for a vertical and a horizontal sampling manifold are shown.

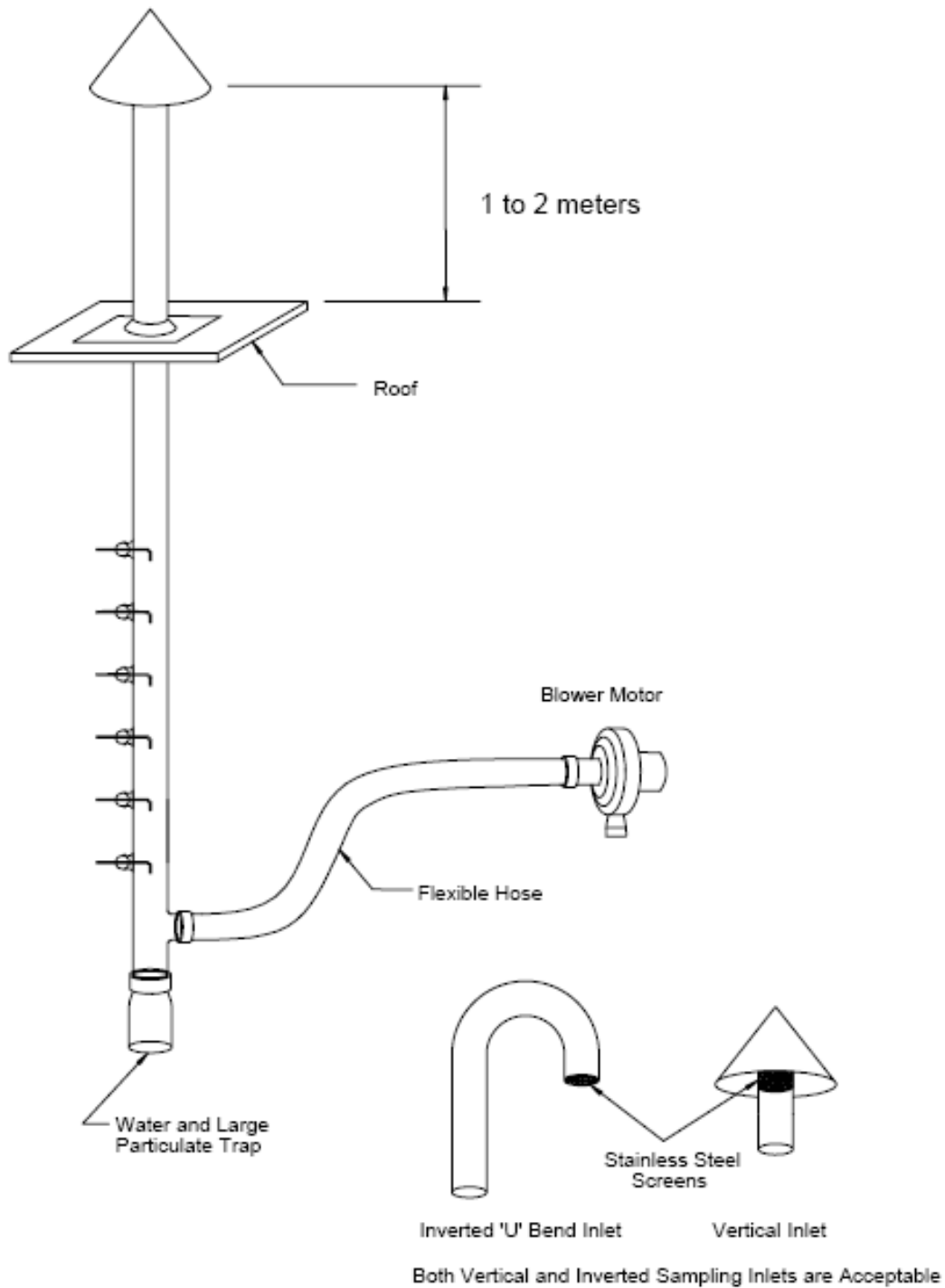
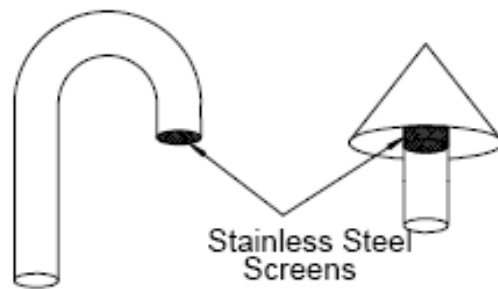
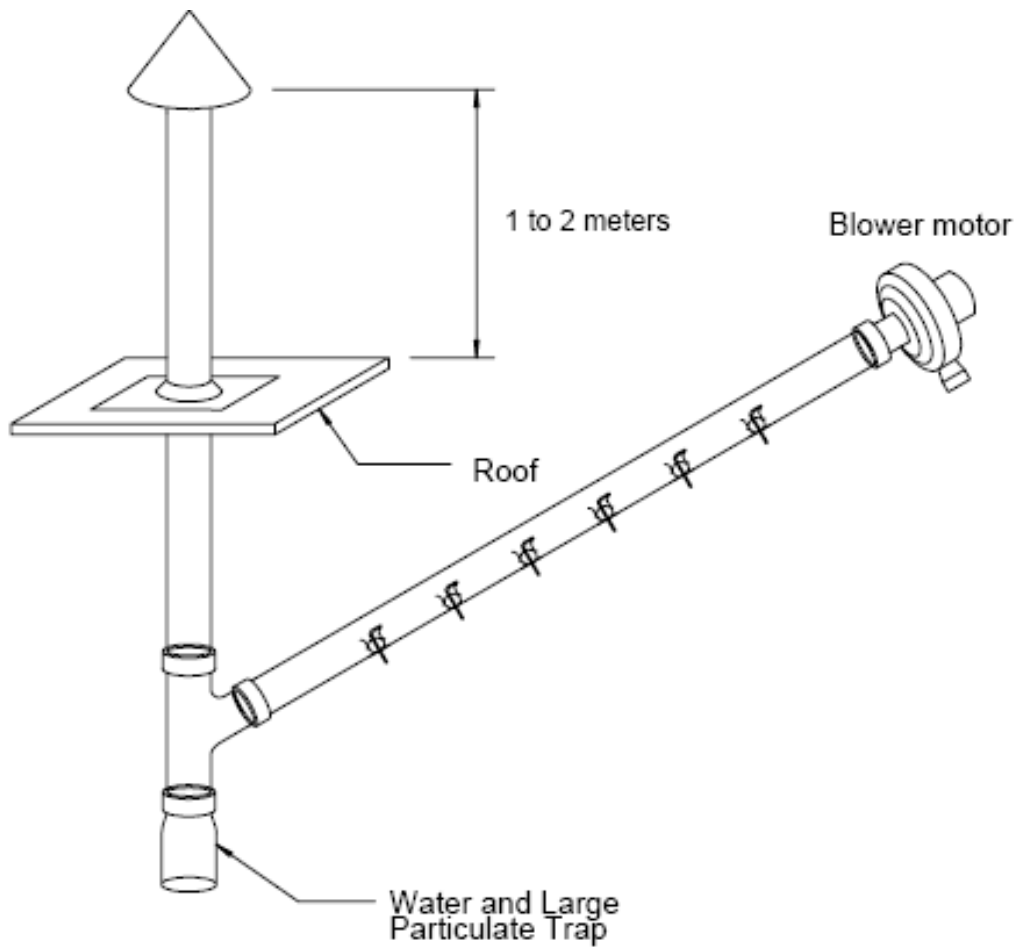


Figure A-1 Typical Vertical Manifold



Inverted 'U' Bend Inlet      Vertical Inlet

Both Vertical and Inverted Sampling Inlets are Acceptable

Figure A-2 Typical Horizontal Manifold

## “ARB” Manifold

Another type of manifold that is widely used is known as the “ARB” style manifold. This manifold has a reduced profile, where there is less volume in the cane and manifold; therefore, less of a need for bypass flow. These manifolds allow the user more options than the other conventional manifolds. If the combined flow rates are high enough with the instruments at the monitoring location, by-pass flow devices such as blower motors are not required.

## Residence Time Determination

The residence time of pollutants within the sampling manifold is critical. 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 twenty seconds for reactive gas monitors. It is recommended that the residence time within the manifold and sample lines to the instruments be less than ten 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:

$$\text{Total Volume} = C_v + M_v + L_v$$

Where:

$C_v$  = Volume of the sample cane and extensions

$M_v$  = Volume of the sample manifold and trap

$L_v$  = Volume of the instrument lines

## Positions of calibration line in sampling manifold

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

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

Where:

$V$  = volume of the component

$\pi$  = 3.14159

$L$  = Length of the component

$d$  = inside diameter

Once the total volume is determined, divide the volume by the flow rate of all instruments. This will give the residence time. If the residence time is greater than ten seconds, attach a blower or vacuum pump to increase the flow rate and decrease the residence time. It has been demonstrated that there are no significant losses of reactive gas ( $O_3$ ) concentrations in conventional 13 mm inside diameter sampling lines of glass or Teflon if the sample residence time is ten 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.

### **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. 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.

### **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.

## Appendix B - Performance Specifications for Ambient Air Gas Analyzers

*This procedure is an excerpt from Environment Canada's Quality Assurance and Quality Control Guidelines, Report No. AAQD 2004-1. It has been modified where appropriate to suit operations within Saskatchewan.*

Where applicable, all analyzers must be approved by the US EPA as an equivalent method of measurement for a specific pollutant. The typical performance specifications and the recognized measurement methods for the ambient air gas analyzers are shown in Table B-1. As the Airpointer® uses US EPA equivalent methodology for SO<sub>2</sub>/H<sub>2</sub>S, CO, O<sub>3</sub> and NO<sub>x</sub>, and meets the performance specifications as listed in Table B-1, the Saskatchewan Ministry of Environment recognizes the Airpointer® as an appropriate method of measuring these pollutants.

Recommended measurement units of the analyzers are parts per million (ppm) or parts per billion (ppb) by volume. For conversion between mass units and volume the reference temperature and pressure are 25° C and 760 mmHg.

The performance parameters are defined as follows:

Minimum Detection Limit	The lowest concentration that can be detected by the air analyzer with confidence. It is defined as twice the noise level of the analyzer. It is used synonymously with the lower detection limit in this document.
Precision	The degree of variation about the mean of repeated measurements of the same pollutant concentration by the analyzer, expressed as standard deviation about the mean.
Linearity	The maximum deviation between the actual analyzer output reading and the predicted analyzer output from a least square fit to the actual readings.
Zero Drift	The change in analyzer output response to a constant zero air input concentration over a period of unadjusted continuous operation.

Span Drift	The percent change in analyzer output response to a constant upscale pollutant concentration over a period of unadjusted continuous operation.
Noise	Spontaneous short duration deviations in the analyzer output, about the mean output, which are not caused by input concentration changes.
Rise Time To 95%	The time interval between initial response (the first observable change in analyzer output) and a level of signal output which is 95% of the steady state output after a step increase in input concentration.
Fall Time To 95%	The time interval between initial response (the first observable change in analyzer output) and a level of signal output which is 95% of the steady state output after a step decrease in input concentration.
Operating Temperature Range	The minimum and maximum ambient temperature, of the environment surrounding the analyzer, in which the analyzer will meet all performance specifications.
Operating Humidity Range	The maximum level of moisture content of the ambient air in the environment surrounding the analyzer, in which the analyzer will meet all performance specifications.
Cycling Time	The time required to complete the active measurement cycle (sample collection, analysis and measurement) and to produce an output.
Operating Ranges	The ranges corresponding to the full scale output of the analyzer.
Operating Voltages	The minimum and maximum line voltages in which the analyzer will meet all performance specifications.

Table B-1 Performance Specifications for Ambient Air Gas Analyzers

Performance Parameter	Pollutant					
	Carbon Monoxide	Ozone	Total Hydrocarbon	Oxides of Nitrogen	Sulphur Dioxide	Ammonia
Measurement Method	Infrared Gas Filter Correlation	UV Absorption	Flame Ionization	Chemiluminescence	UV Fluorescence	Catalytic thermal oxidation followed by NO measurement
Minimum Detection Limit	0.1 ppm	0.002 ppm	0.1 ppm	0.005 ppm	0.002 ppm	0.01 ppm
Precision	± 0.1 ppm	± 0.002 ppm	± 0.1 ppm	± 0.002	± 0.002 ppm	± 0.01 ppm
Linearity	1% F.S.	1% F.S.	1% F.S.	1% F.S.	1% F.S.	1% F.S.
Zero Drift / 24 hours	±0.2 ppm	±0.002 ppm	± 1% F.S.	±0.002 ppm	±0.002 ppm	±0.002 ppm
Span Drift / 24 hours	± 1% F.S.	± 1% F.S.	± 1% F.S.	± 1% F.S.	± 1% F.S.	± 1% F.S.
Noise	± 0.05 ppm	± 0.001 ppm	± 0.5% F.S.	± 0.002 ppm	± 0.001 ppm	± 0.002 ppm
Rise Time ( 95% )	90 sec.	90 sec.	180 sec.	180 sec.	180 sec.	180 sec.
Fall Time ( 95% )	90 sec.	90 sec.	180 sec.	180 sec.	180 sec.	180 sec.
Operating Temperature Range	10° - 40° C	10° - 40° C	10° - 40° C	10° - 40° C	10° - 40° C	10° - 40° C
Operating Humidity Range	100%	100%	100%	100%	100%	100%
Maximum Cycling Time	1 min.	1 min.		3 min.	3 min.	3 min.
Normal Operating Ranges	50 ppm	0.5 ppm or 1.0 ppm	10 ppm, 20 ppm or 50 ppm	0.5 ppm or 1.0 ppm	0.5 ppm or 1.0 ppm	1.0 ppm, 2.0 ppm, 5.0 ppm, or 10.0 ppm
Operating Voltage	105-125 vac / 60 Hz	105-125 vac / 60 Hz		105-125 vac / 60 Hz	105-125 vac / 60 Hz	105-125 vac / 60 Hz

## Appendix C - General Calibration Procedures for Ambient Air Gas Analyzers

*This procedure is an excerpt from Environment Canada's Quality Assurance and Quality Control Guidelines, Report No. AAQD 2004-1. It has been modified where appropriate to suit operations within Saskatchewan.*

These guidelines provide only general calibration procedures for ambient air gas analyzers and are intended as a supplement to the procedures specified in analyzer operation manuals. Certified transfer standards traceable to the (U.S.) National Institute of Standards and Technology (NIST) or the (Canadian) Institute of National Measurement Standards (INMS) must be used for all analyzer calibrations.

1. Allow the calibrator to warm up to its operating temperature prior to calibration. For permeation systems, allow the system to equilibrate at operating conditions, which can take up to 24 hours.
2. When using gas cylinders, purge the pressure regulator and lines as follows:
  - (a) Attach the regulator to the calibration gas cylinder and connect a transfer line of inert material of either stainless steel or Teflon from the regulator to the vacuum side of an air pump. Connect a transfer line to the pressure side of the pump to vent the high concentration calibration gas outside the station.
  - (b) Turn the pump on.
  - (c) Open the regulator valve to evacuate the regulator for 60 seconds.
  - (d) Close the regulator valve and then slowly open the cylinder valve to fill the regulator with calibration gas. (The pump should be left running during this procedure.)
  - (e) Close the cylinder valve then open the regulator valve to evacuate the regulator again for 60 seconds.
  - (f) Repeat steps d, and e, twice.
  - (g) Close the regulator valve.
  - (h) Connect a 1/8" transfer line from the purged regulator to the gas inlet of the calibrator (stainless steel recommended for SO<sub>2</sub>).
  - (i) Slowly open the cylinder valve and verify that the regulator out pressure is within calibrator specifications.
  - (j) Slowly open the regulator valve.
3. Using a reducer, connect a 3/8" transfer line from one of the calibrator manifold ports to the atmosphere, outside the station, to vent the excess gas. For calibrators without manifolds, use a Tee reducer to connect the 3/8" vent line to the calibrator. Venting outside the station minimizes entrainment of ambient air and reduces the risk of exposure to high gas concentrations that could be harmful. The length to diameter ratio of the vent line must be at least ten to prevent entrainment of ambient air.

4. Connect a ¼" transfer line from one of the calibrator ports to the analyzer inlet. Plug extra manifold ports. For calibrators without manifolds, connect a ¼" transfer line from the Tee reducer to the analyzer inlet.
5. Set the calibrator total gas flow output to at least 1.5 times the intake flow rates of the analyzer(s) connected to the calibrator. The level of excess flow rate, and the length and diameter of the vent line affect system pressurization, which must be avoided.
6. Set the calibrator to produce zero gas.
7. Measure the analyzer zero reading and, after verifying stability for 10 minutes, set the analyzer reading to zero.
8. Set the calibrator to generate a concentration equal to about 80% of the selected analyzer range. Measure the analyzer response and, after verifying stability for ten minutes, set the analyzer to read the generated concentration value. Verify that the reading remains stable within  $\pm 1\%$  of the set concentration value.
9. Set the calibrator to produce zero gas and re-verify the analyzer zero setting. If an adjustment of the zero setting is required, repeat step 8. After the zero and the 80% of range responses are set, introduce gas concentrations of 80%, followed by 60%, 40%, and 20% of range, verifying stability for 10 minutes at each point.
10. Document the pertinent calibration results in the calibration report and in the station logbook.
11. After calibration, reconfigure the analyzer for normal operation.
12. Zero and span the analyzer and record the values in the calibration report and station logbook. The span cylinder should be replaced if the span records indicate excessive instability, or if the pressure falls below 300 psi. If a new cylinder is used, its span value should be measured as above and recorded in the calibration report and station logbook. The above also applies when permeation devices are used for zeroing and spanning.

For NO<sub>x</sub> analyzers, the NO<sub>2</sub> channel must also be calibrated, by gas phase titration (GPT) or permeation tube.

Ozone analyzers are calibrated against a UV photometry ozone transfer standard. The above procedure also applies to ozone calibration, except as they relate to gas cylinders. Following calibration, the analyzer's internal span function is used to determine the post-calibration span control value.

## Least Square Regression Analysis for Validation / Correction of Analyzer Data

A regression analysis of calibration or audit results provides a quantitative assessment of analyzer performance. The following summarizes the steps involved in this calculation.

For this analysis, it is necessary to define the dependent and independent variables. The correct form of the regression equation to obtain corrected data values from raw analyzer values is when the true values are set as the dependent variable ( $y$ ), and the analyzer values are set as the independent variable ( $x$ ). The resultant equation is in the form of:

$$y = ax+b$$

Where  $y$  is true value,  $a$  is slope of calibration or audit curve,  $x$  is analyzer value, and  $b$  is intercept of calibration or audit curve.

Defining  $x$  and  $y$  as described above, a slope of 1.10 indicates that the analyzer reading is 10% low, whereas a slope of 0.95 indicates that the analyzer reading is 5% high.

The slope parameter is used to assess the accuracy of the instrument readings. The intercept value is used to assess whether the analyzer zero is within acceptable limits. The regression coefficient,  $R$ , is an indication of the degree of linearity of the calibration or audit points.

In an audit, these three parameters are rated as follows for assessing analyzer performance:

Slope:	Very Good	0.95 to 1.05
	Satisfactory	0.85 to 0.94 or 1.06 to 1.15
	Unsatisfactory	< 0.85 or >1.15
Intercept:	Satisfactory	=< 3% of the full scale
	Unsatisfactory	> 3% of the full scale
Regression Coefficient:	Satisfactory	0.995 to 1.000
	Unsatisfactory	< 0.995

When audit results are unsatisfactory for any of these parameters, appropriate corrective action must be taken, and all data collected subsequent to the last satisfactory audit or calibration must be reviewed. Data determined to be valid with correction must be identified as such, with details of the correction documented. Data that cannot be corrected must be invalidated.

## Appendix D - Zero and Span Verifications for Ambient Air Gas Analyzers

*This procedure is an excerpt from Environment Canada's Quality Assurance and Quality Control Guidelines, Report No. AAQD 2004-1. It has been modified where appropriate to suit operations within Saskatchewan.*

A zero and span verification is an "unofficial" check of an analyzer's response. It may include dynamic checks made with uncertified test concentrations, artificial stimulation of the analyzer's detector, electronic or other types of checks of a portion of the analyzer, etc. Zero and span checks are not to be used as a basis for analyzer zero or span adjustments, calibration updates, or adjustment of ambient data. They are intended as quick, convenient checks to be used between calibrations to check for possible analyzer malfunction or calibration drift. Whenever a zero and span check indicates a possible calibration problem, a multipoint calibration should be carried out before any corrective action is taken. If a zero and span check is to be used in the quality control program, a "reference response" for the check should be obtained immediately following a multipoint calibration while the analyzer's calibration is accurately known. Subsequent check responses should then be compared to the most recent reference response to determine if a change in response has occurred. For automatic zero and span checks, the first scheduled check following the calibration should be used for the reference response. It should be kept in mind that any check that involves only part of the analyzer's system cannot provide information about the portions of the system not checked and therefore cannot be used as a verification of the overall analyzer calibration.

### Physical Zero and Span Adjustments

Almost all ambient monitoring instruments have physical means by which to make zero and span adjustments. These adjustments are used to obtain the desired nominal scale range (within the instruments' specifications), to provide convenient (nominal) scale units, and to periodically adjust the instruments' response to correct for calibration drift. Note: NO/NO<sub>2</sub>/NO<sub>x</sub> analyzers may not have individual zero and span controls for each channel. If that is the case, the zero and span controls must be adjusted only under the conditions specified in the calibration procedure provided in the analyzer's operation/instruction manual. Precise adjustment of the zero and span controls may not be possible because of: (1) limited resolution of the controls, (2) interaction between the zero and span controls, and (3) possible delayed reaction to adjustment or a substantial stabilization period after adjustments are made. Precise adjustments may not be necessary because calibration of the analyzer following zero and span adjustments will define the precise response characteristic (calibration curve). Accordingly, zero and span adjustments must always be followed by a calibration. Allow sufficient time between the adjustments and the calibration for the analyzer to fully stabilize. This stabilization time may be substantial for some analyzers. Also, obtain unadjusted response readings before adjustments are made. Zero and span adjustments do not necessarily need to be



made at each calibration. In fact, where only relatively small adjustments would be made, it is probably more accurate not to make the adjustments because of the difficulty of making precise adjustments mentioned earlier. An appropriate question, then, is how much zero or span drift can be allowed before a physical zero or span adjustment should be made to an analyzer? Ideally, all ambient measurements obtained from an analyzer should be calculated or adjusted on the basis of the most recent multipoint calibration or on the basis of both the previous and subsequent calibrations.

### **Zero and Span Control Charts**

Zero and span control charts are used to monitor the performance of analyzers. Essentially they show analyzer response to zero and span gas, and alert the operator to conditions when corrective action is required. There are many ways to construct control charts. An example of control charts is shown in Figure D-1.

For newly installed analyzers, a more frequent zero and span period is recommended to establish the drift characteristics of the instrument. A daily or biweekly period may be used. Once the drift characteristics are established, a less frequent schedule may be used. A minimum schedule of once per week is recommended for all continuous analyzers.

In order to observe any negative zero drifts, the zero point of the calibration may be offset by a known positive amount.

## Zero and Span Control Chart

Station ID \_\_\_\_\_ Pollutant \_\_\_\_\_ Analyzer ID \_\_\_\_\_ s/n \_\_\_\_\_

DATE																																		
ZERO																																		
SPAN																																		
(SPAN - ZERO)																																		
DRIFT PERIOD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34
Vertical Scale 1 Division = _____ ppb/ppm																																		
Span Drift																																		
Vertical Scale 1 Division = _____ ppb/ppm/%																																		

Span Standard Concentration= \_\_\_\_\_ ppm/ppb

Zero Drift Control Limits ± \_\_\_\_\_ ppb/ppm

Date Analyzer Calibrated \_\_\_\_\_

Span Drift Control Limits ± \_\_\_\_\_ ppb/ppm/%

Operator \_\_\_\_\_

Figure D-1

## **Appendix E - Determination of the Weight of PM10 and PM2.5 Particulate Matter Collected on Filter Media**

*This procedure is an excerpt from Environment Canada's Quality Assurance and Quality Control Guidelines, Report No. PMD 95-8, revised 2002. It has been modified where appropriate to suit operations within Saskatchewan.*

### **1. INTRODUCTION AND SCOPE**

The accurate determination of the weight of particulate matter collected on a filter is essential to the measurement of particulate matter concentration in air. The filters are pre-conditioned in an environment of controlled humidity and temperature before being weighed. The difference in weight before and after the filter has been exposed to a pre-determined volume of air determines the amount of particulate matter collected on the filter.

This standard operating procedure is used to determine the weight of particulate matter collected on filter media after a known volume of ambient air has flowed through it.

### **2. PRINCIPLE OF THE METHOD**

The principle of the method is based on the gravimetric determination of the weight of a specific filter before and after a known volume of air has been drawn through it. The weight gained by the filter after exposure is taken as the weight of the particulate matter collected. Using the known volume of air drawn through the filter, the concentration of particulate matter in air is determined.

### **3. DETECTION LIMIT**

The detection limit of the method is dictated by the accuracy of the analytical balance used in the weighing process. A detection limit of 15µg must be achieved.

### **4. INTERFERENCE**

The most significant interference of this method comes from foreign material accumulated on the filter. This can be water moisture, dust and artifacts due to chemical reactions of the material on the filter and ambient air. Static electricity can also significantly alter the accuracy of the filter weight. Steps in this procedure are designed to minimize these effects.

## **5. FACILITIES, EQUIPMENT AND SUPPLIES**

### **5.1 Facilities**

- 5.1.1 The laboratory where this work is being done must have the temperature controlled at 23°C within a variation of  $\pm 3^\circ\text{C}$ . The humidity must be controlled within the range of 40 % with a variation of  $\pm 5\%$  over a 24 hour period. The temperature and humidity conditions are continuously monitored by a hydrothermograph located in the balance room. The chart paper onto which the conditions are recorded must be retained for a minimum of 12 months. The room temperature and humidity are also recorded in the filter data file at the beginning of each weighing session.
- 5.1.2 The accuracy of the recording device will be verified monthly or when the chart paper is changed using an NIST thermometer and a psychrometer.
- 5.1.3 The air exchange rate in the weighing room must be at least 6 times per hour. A dynamic electronic air filter having an efficiency of 95-99% for particles of 1-3  $\mu\text{m}$  in diameter is installed in the air circulation stream.
- 5.1.4 All working surfaces, shelves, table and floor must be clean and dust free. No aerosol cleaning agents nor vacuum cleaners should be used in this facility. Only isopropyl alcohol with lint free wipers should be used for cleaning work surfaces. Floor should be damp mopped only.
- 5.1.5 Lab coat must be worn by all persons in the laboratory to minimize dust contamination.

### **5.2 Micro Balance**

- 5.2.1 The micro balance must be installed on a proper balance table to minimize any vibration from the floor.
- 5.2.2 The micro balance should have a range of 100 mg with a resolution of 1.0  $\mu\text{g}$ . The micro balance shall be calibrated annually and the standard weight shall be re-certified annually. It will be noted in the balance log book when the weight was re-certified and the balance serviced and/or calibrated. The applicable certificates/paperwork will be maintained on file.
- 5.2.3 A beta emitting radioactive electrostatic eliminator shall be used to neutralize the electrostatic charge that may adhere to the filters. The static eliminator is suspended within the closed chamber approximately 2 cm above the weighing pan. The filter shall be placed in the pan for approximately one minute for static electricity elimination before a reading is to be established.
- 5.2.4 The electrostatic eliminator will be replaced with a new one 12 months after the manufacture date.

### **5.3 Supplies**

- 5.3.1 Only clean dedicated stainless steel or nylon tweezers with non-serrated tips are used to handle the filters.
- 5.3.2 Lint free tissues and isopropyl alcohol must be available for cleaning purposes.
- 5.3.3 Filters for sampling programs must be stored in this laboratory.

## **6. PROCEDURES FOR WEIGHT DETERMINATION**

### **6.1 Handling of Filters**

To avoid contamination, filters must be handled with proper tweezers. Filters must be held only at the edge by the sealing ring. Individual filters should be placed in the container dish and then transferred directly to the weighing pan of the balance. The filter should never be placed on the working surfaces of the laboratory. Once weighed, the filter should be returned to the filter holder, closed and stored.

### **6.2 Micro Balance Stabilization and Calibration Verification**

- 6.2.1 The micro balance is to remain powered up at all times. In the event of power failure, the balance should be permitted to warm up for a minimum of two hours.
- 6.2.2 The precision and accuracy of the micro balance and the weighing system is verified daily prior to a weighing session using both the reference filters and a standard weight.
- 6.2.3 The standard weight is 100 mg referenced to mass standards traceable to the United States National Institute of Standards and Testing.
- 6.2.4 Three filters of each size are kept in the weighing laboratory for the verification of laboratory conditions and the determination of the micro balance precision.
- 6.2.5 At the beginning of a weighing session, weigh and record the weight of the standard reference weight. Enter this weight in the data file.
- 6.2.6 Also, at the beginning of the weighing session, weigh and record the weight of all standard reference filters. Enter the weights into the data file. The weight of the filters must all be within the limit of  $\pm 10\mu\text{g}$  of the weight established previously. These weights must not vary beyond this limit within a 24 hour period. The continuous record of the standard filters serve as a continuous assessment of the weighing system precision and accuracy.

### **6.3 Precondition of Unexposed Filters**

- 6.3.1 Remove the filters from the packaging.
- 6.3.2 Visually inspected each filter prior to weighing. The inspection will look for any defects in the filter, such as tears, holes, distortion, discoloration, integrity of the support ring and any other abnormalities.
- 6.3.3 Defective filters shall be rejected.
- 6.3.4 Place each filter on the bottom half of the container. Place them on shelves in a vented cabinet in the weighing room and in contact with ambient air, i.e. not sealed with the container cover. Filters must be protected from deposition of dust from ambient air movements. Condition filters for a minimum of 24 hours before weighing.

### **6.4 Identification of the Filter**

The filters are identified by a unique numerical code. For High-vol filters, the number is stamped on the back of the filter at least 48 hours prior to pre-sample weighing and for the 37 and 47  $\mu\text{m}$  filters, this code is affixed to the exterior of the container cover that is used to transfer and handle the filter once its pre-sampling weight is determined. Care must be taken when handling the filter to avoid misidentifying the filters. At no time should more than one weighed filter be placed outside of the corresponding container to avoid confusion.

For dichotomous filters the two separate particle streams, the coarse (10  $\mu\text{m}$ ) particles and the fine (less than 2.5  $\mu\text{m}$ ) particles, are further identified by odd and even numbers.

### **6.5 Determination of Filter Weight**

- 6.5.1 After the micro balance is stabilized and verified for accuracy and precision, remove one filter from the container and place it on the weighing pan of the balance. Close the balance pan chamber door and wait for approximately one minute for the elimination of static electricity and reading to stabilize. Observe the reading of the balance and enter it in the corresponding database file as the initial weight ( $m_{initial}$ ) with the identification number of the filter.
- 6.5.2 Remove the filter from the weigh pan and return it immediately to the container and cover. Verify that the identification code on the cover corresponds correctly to the identification code entered in the database file.
- 6.5.3 Store the weighed filters in sets in their appropriate shipping containers for shipping or further processing.

## **6.6 Post Exposure Conditioning of the Filters**

- 6.6.1 Upon receipt of the exposed filters from the field, remove them from the shipping containers. Verify the sample numbers, dates and other particulars on the accompanying data sheet and enter the information in the logbook for the sampling station.
- 6.6.2 To avoid contamination, only filters that are ready to be weighed within 48 hours should be prepared for conditioning. Others are to be kept covered in the containers until ready for weighing.
- 6.6.3 Exposed filters must be weighed within 30 days from receipt.
- 6.6.4 Open the container cover and place it underneath the bottom part. Ensure that the exposed filter is in the dish with the exposed (where particles are collected) side facing upwards.
- 6.6.5 The filters are kept in the ventilated cabinets for 24 hours to acclimatize to the temperature and humidity of the laboratory.

## **6.7 Weight Determination of Exposed Filters**

- 6.7.1 After conditioning for a period of 24 hours, exposed filters are weighed using the micro balance following the procedure in section 6.5 above.
- 6.7.2 Before placing the filter onto the balance for weighing the filter must be visually inspected for defects. The inspection will look for any defects in the filter, such as tears, holes, distortion, discoloration, integrity of the support ring and any other abnormalities.
- 6.7.3 Defective filters are noted in the data file and rejected. The identification and all particulars of the rejected filters are entered into the data file as invalid samples.
- 6.7.4 Enter the final weight ( $m_{final}$ ) of the filter in the appropriate column in the database file. Verify that the identification code is correct.

## **6.8 Exposed Filters Management**

After the final weight has been determined for the exposed filter, replace the filter in the same container with exposed side facing upwards. Store the filters in a designated cabinet in the weighing laboratory. These filters will be held in the weight room until transferred to the analytical laboratory for chemical composition analysis. Exposed filters must be weighed and sent for analysis within 30 days of receipt.

## **6.9 Data Management**

The data relevant to the particular filter are entered directly into the electronic file. This file is copied immediately into a diskette. Diskettes are labeled and stored in the

weight room. The electronic data files on the hard disk of the computer are backed up onto the NAPS network server weekly.

## 6.10 Quality Control

Within twenty-four hours of each weighing session, 10% of the filters of the session will be re-weighed. The difference between the first and the second weight should be within 10 µg for unexposed filters and 25 µg for exposed filters. If this limit is exceeded, the cause for the discrepancy shall be determined. When the cause of the error is corrected, all filters weighed during that session must be re-weighed. The re-weigh data are entered into the data file

## 7. CALCULATION OF PARTICULATE MATTER CONTENT ON THE FILTER

The mass (M) of particulate matter collected on the filter is the difference between initial and final weight as in equation 1.

$$M = m_{final} - m_{initial} \quad (\text{Equation 1})$$

### 7.1 Calculation of Particulate Matter Concentration in the Air Sample

The concentration of particulate matter in an air sample is expressed in micrograms per cubic metre (µg/m<sup>3</sup>). The volume of the air sample passed through the filter must be determined from the field data sheet that should accompany the exposed filter. The actual volume (V<sub>act</sub>) of the air sample is the product of the airflow rate (f<sub>r</sub>) and the sampling time (t).

i.e.  $V_{act} = f_r \times t$  (Equation 2)

The mass concentration (M<sub>c</sub>) is expressed in actual air volumes in units of µg/m<sup>3</sup> is calculated as below:

$$M_c = M/V_{act} \quad (\text{Equation 3})$$

To report the mass concentration in standard conditions, convert the actual mass concentration to standard mass concentration (M<sub>cstd</sub>) as below:

$$M_{cstd} = M_c \times P_a / 760 \times 298.2 / (T_a + 273.2) \quad (\text{Equation 4})$$

Where

P<sub>a</sub> = the averaged ambient local absolute pressure in mmHg

T<sub>a</sub> = the averaged ambient local temperature in °C.



## **Appendix F - Technical Information and Instructions of Passive Air Sampling System**

*This information is an excerpt from the technical and instruction information of the Maxxam passive air sampling system. It has been modified slightly to provide a more general technical and instructional guideline for passive sampling.*

### **1. PRINCIPLE**

The Passive Sampling System can be used to sample various gasses, including SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>S, NH<sub>3</sub> and NO<sub>x</sub> (NO<sub>x</sub> passive samplers are only recommended for warm weather). The passive sampling system uses a specially designed rain shelter to allow the passive sampler to be installed face downwards and to allow air movement across the surface of the diffusion barrier. After exposure, the samplers are analyzed in laboratory. The sampling rates of the passive samplers are calculated using an equation, which takes into account its dependence on associated meteorological factors.

### **2. SPECIFICATION**

The following are the typical measuring ranges of Passive Sampling Systems:

- Detection limit: 0.1 ppb for SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, NO<sub>x</sub> and 0.02 ppb for H<sub>2</sub>S based on one month exposure period
- Capacity: 120 ppb for SO<sub>2</sub>, 140 ppb for O<sub>3</sub> and NO<sub>x</sub>, 50 ppb for NO<sub>2</sub>, and 6 ppb for H<sub>2</sub>S based on one-month exposure period.
- Exposure time: from 4 hours to 60 days.

### **3. SAMPLE COLLECTION**

#### **Passive sampler assembly**

Each passive sampler typically contains one of the following as shown in Figure F-1:

- sampler body
- diffusion barrier
- sampling medium
- support ring
- cover cap

The laboratory conducts the assembly of the passive samplers. After assembly, the passive sampler is sealed in a small resealable plastic bag. The plastic bag is put into a special protective container, which has a Teflon liner in the lid to ensure sampler integrity.

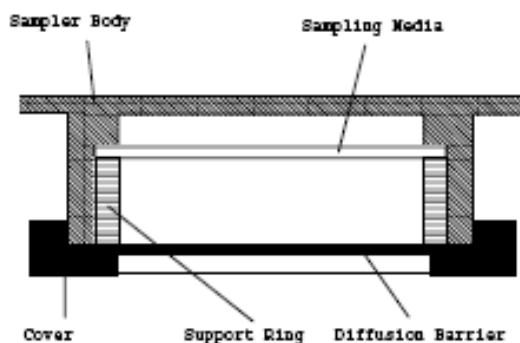


Figure F-1

### Passive sampler shipment

Passive sampler containers (or less) are sealed in a large resealable plastic bag in order to further prevent contamination. The plastic bags are put into any safe container and shipped as non-hazardous goods.

### Passive sampler storage

Unexposed NO<sub>x</sub> passive samplers must be kept at -20°C in a refrigerator. The unexposed SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>S and exposed SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>S and NO<sub>x</sub> passive samplers should be kept at 4°C. At 4°C, the shelf life of SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>S passive samplers is 3 months. At room temperature, one month is recommended. At -20°C, the shelf life of NO<sub>x</sub> passive samplers is 3 months.

## Field sampling

For credible results, it is recommended that triplicate or at least duplicate passive samplers be used for each monitoring location. To validate results, field blanks must be included. The number of field blanks depends on the number of passive samplers used in field studies. Two field blanks are needed for less than 10 passive samplers. For each additional one to 10 passive samplers, one blank is to be added. The passive samplers are installed in a rain shelter (Figure F-2). Each passive sampler is installed in the rain shelter face downward. Using a passive sampler's bottom, push any one of the three buttons up in the rain shelter and then the passive sampler can be easily slid into the center of the rain shelter. Make sure the button falls down after the passive sampler moves to the center.

During installation:

- do not touch diffusion barriers;
- do not let passive samplers fall to the ground.

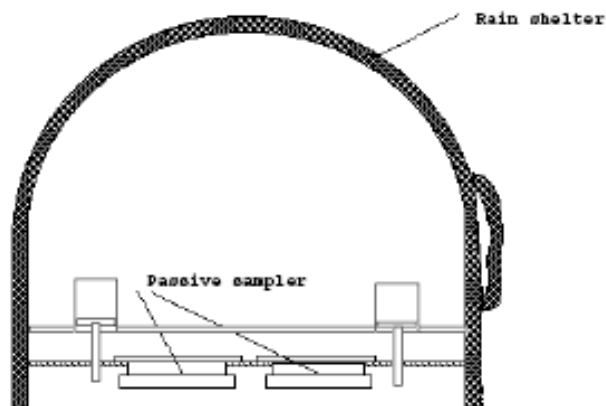


Figure F-2

The installation height of the rain shelter is as follows:

- the rain shelter should be above ground 1 - 3 m;
- election angle should be  $< 30^\circ$  from the diffusion barrier surface of the passive sampler to the top of any obstacle;
- or the distance from the obstacle should be  $> 10$  times the obstacle height.

Figure F-3 provides a pictorial representation of proper siting selection and installation.

In general, the rain shelter must be installed properly to prevent passive samplers from being interfered by animals, human beings, or surroundings. If there are

several rain shelters in one location, it is recommended to keep them separate in order to avoid air movement interference.

Passive samplers' exposure start and end times and date should be recorded on a field-sampling sheet. Average temperature, average relative humidity, and average wind speed during the exposure period can be obtained from local weather station or from nearby monitoring stations.

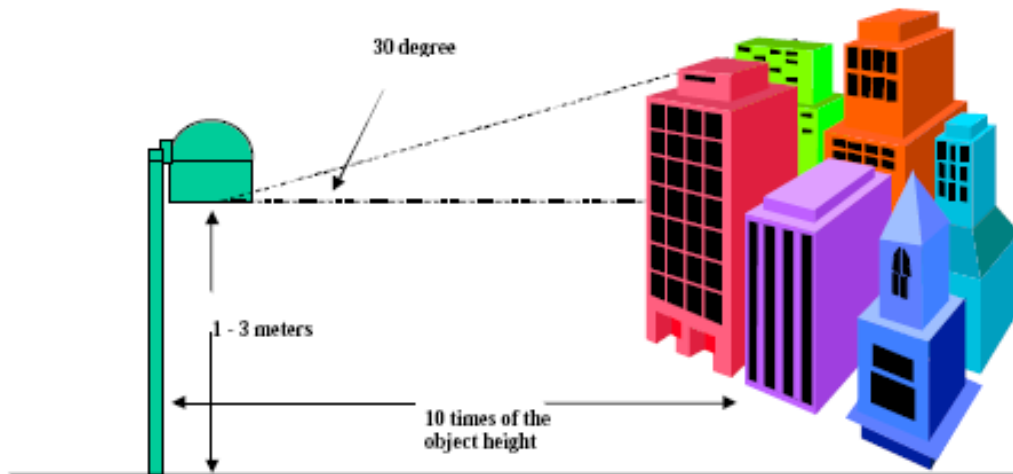


Figure F-3 Removal and disassembly of the passive sampler after exposure

After exposure, the samplers are removed from the rain shelter, sealed in the resealable bags, put back into the protective bottle with the cap sealed using Teflon tape and returned to lab for analysis. The disassembly of the sampler in laboratory is performed in a glove box or a clean room purged with purified air.

#### **4. CALCULATION AND DATA REPORT**

##### **Concentration calculation**

After analysis, final calculations are completed based on analytical results from a lab and information provided by from the field. The concentrations of pollutants detected by the passive sampling system in air are reported as part per billion (ppb). The following information is required from the field personnel:

- Exposure time in hours
- Average temperature, average relative humidity, and average wind speed during an exposure period.

## Appendix G - Example of Air Monitoring Summary Tables

### Continuous Ambient Monitoring

PARAMETER	STATION NUMBER	% TIME MONITOR OPERATIONAL	MAXIMUM VALUE		NUMBER OF SAMPLES ABOVE STANDARD	
			1-HR	24-HR	1-HR	24-HR

### Passive and Intermittent Ambient Monitoring

PARAMETER	NUMBER OF STATIONS IN NETWORK	NUMBER OF SAMPLES	MAXIMUM VALUE	AVERAGE OF NETWORK	NUMBER OF SAMPLES ABOVE STANDARD