



**Air Monitoring Directive Chapter 4:  
Monitoring Requirements and Equipment  
Technical Specifications**

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August 3, 2016

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## Table of Contents

<b>List of Tables .....</b>	<b>4</b>
<b>1.0 Purpose.....</b>	<b>5</b>
1.1 Amendments .....	5
1.2 General Monitoring Requirements .....	7
<b>2.0 Continuous Ambient Monitoring .....</b>	<b>7</b>
2.1 Performance Specification Standards Sheets.....	8
2.2 Operation and Maintenance .....	8
2.3 Reporting and Notification .....	9
2.4 Continuous Ambient Air Analyzers.....	9
2.5 Meteorological Sensors.....	10
<b>3.0 Integrated Sampling .....</b>	<b>13</b>
3.1 Passive Sampling .....	17
3.1.1 Passive Sampler Validation .....	17
3.1.2 Installation.....	18
3.1.3 Quality Control Samples for Field Sampling.....	19
3.1.4 Sampling Period.....	21
3.1.5 Determination of the Time-Weighted Average Pollutant Concentration ..	21
3.2 Intermittent Sampling .....	22
3.2.1 Filtration Sampling .....	23
3.2.2 Active Sorbent Sampling .....	24
3.2.3 Canister Sampling.....	25
3.3 Static Sampling .....	27
<b>4.0 Mobile Air Monitoring .....</b>	<b>28</b>
4.1 Personnel.....	29
4.2 Vehicle Configuration and Specifications .....	30
4.2.1 Platform.....	30
4.2.2 Layout and Design .....	30
4.2.3 Instrumentation and Specifications.....	31
4.2.4 Power System(s) .....	31
4.2.5 Heating, Ventilation and Air Conditioning System.....	32
4.2.6 Meteorological (Mast) .....	32
4.2.7 Global Positioning System.....	33
4.2.8 Instrument Pumps and Housing .....	33
4.2.9 Data Acquisition .....	33
4.3 Instrument Calibration .....	34
4.3.1 Timing.....	34
4.3.2 Zero and Span .....	34

4.4	Monitoring Plan .....	35
4.4.1	Siting Criteria.....	35
4.5	Data Storage and Records.....	36
<b>5.0</b>	<b>Precipitation Chemistry Monitoring.....</b>	<b>36</b>
5.1	Site Selection .....	37
5.2	Sampling Equipment Selection.....	37
5.3	Sampling Equipment Installation.....	38
5.4	Sampling Equipment Operation and Weekly Maintenance.....	38
5.5	Sample Collection Supplies .....	40
5.6	Precipitation Depth Measurement.....	40
5.7	Precipitation Sample Preparation and Shipment.....	41
5.8	Analytical Laboratory .....	43
5.9	Precipitation Chemistry Data Handling .....	44
5.10	Precipitation Chemistry Network Monitoring Plan .....	44
<b>6.0</b>	<b>Vegetation Monitoring.....</b>	<b>45</b>
6.1	Fluoride Analysis .....	45
<b>7.0</b>	<b>Industrial Source Monitoring .....</b>	<b>45</b>
7.1	Sampling Procedures .....	46
7.2	Notification of Planned Stack Surveys .....	46
7.3	Industrial Source Monitoring Reports .....	47
<b>8.0</b>	<b>References.....</b>	<b>47</b>
<b>Appendix</b>	<b>Guidance on the Determination of Precision and Accuracy for Passive Samplers.....</b>	<b>49</b>

## List of Tables

Table 1	Minimum performance specifications and operating principles for continuous ambient air analyzers .....	11
Table 2	Minimum performance specifications and operating principles for meteorological sensors .....	13
Table 3	Parameters measured in precipitation samples.....	43

## 1.0 Purpose

This Monitoring Requirements and Equipment Technical Specifications document forms a part (Chapter 4) of Alberta's Air Monitoring Directive (Alberta Environment and Parks 2016, as amended from time to time) and will hereafter be referred to as the Monitoring Chapter. Refer to Chapter 1 (the AMD Introduction) for requirements and definitions that apply to all parts of the AMD, a list of what components constitute the AMD, and details on review of and revisions to the AMD.

The purpose of the Monitoring Chapter is to outline the minimum requirements for air monitoring methods and equipment specifications to ensure that monitoring is conducted consistently across the province, using robust methods, resulting in representative data that are comparable and of known quality.

*ME 1-A The person responsible must comply with the requirements set out in the Monitoring Chapter on or before July 30, 2017, unless otherwise specified in the Monitoring Chapter.*

The Monitoring Chapter is organized into the following sections:

- 2.0 Continuous Ambient Monitoring – minimum instrument specifications for continuous ambient air analyzers and meteorological sensors.
- 3.0 Integrated Sampling – minimum requirements for the use of integrated samplers, including passive and intermittent samplers, and the phase out of static samplers.
- 4.0 Mobile Air Monitoring – minimum requirements for monitoring ambient air quality using a mobile air monitoring unit or vehicle.
- 5.0 Precipitation Chemistry Monitoring – minimum requirements for selecting precipitation chemistry sampling equipment; sample collection and handling; sample preparation; and laboratory analysis of precipitation samples.
- 6.0 Vegetation Monitoring – minimum requirements for the analysis of vegetation samples when monitoring for fluoride.
- 7.0 Industrial Source Monitoring – provides clarification and guidance for industrial source monitoring requirements which are mandated in codes and approval conditions.

## 1.1 Amendments

August 3, 2016

- 1. Update to document design/branding.
- 2. Clarified and added guidance in section 3.1.1 Passive Sampler Validation.

3. Changed “diffusive barrier surface” to “diffusion barrier surface” in section 3.1.2 guidance and clause ME 3-R (c) to match terminology in ME 3-O, in regards to passive sampling.
4. Clarified that ME 3-P applies when a protective shelter is used in passive sampling.
5. Added guidance below ME 3-Q on deployment of method blanks for passive sampling.
6. Clarified guidance below ME 3-R on what is meant by method blanks being deployed in the same manner as the corresponding passive samples.
7. Added guidance below ME 3-S on deployment of replicate passive samplers.
8. Added guidance below ME 3-Y, linking to ME 3-M for validating passive samplers for the sampling period to which they will be exposed.
9. In section 3.1.5, changed “sampling rate” to “time-weighted average pollutant concentration” and clarified guidance to ensure applicability to all methods for determining sampling rate and ultimately concentration.
10. Amended clauses ME 3-Z, 3-AA and 3-BB to replace “sampling rate” with “time-weighted average pollutant concentration” and added bullets for passive sample, replicate sample and method blank for clarity.
11. In clause ME 3-BB, removed requirement to record rationale for source of meteorological data when determining time-weighted average pollutant concentration as this is addressed by record keeping required in ME 3-AA.
12. Minor edits to the Appendix on determination of passive sampler precision and accuracy.
13. In section 5, changed “chain of custody form” to “precipitation sampling field sheet” and added guidance on sample shipment.
14. In section 5.7, clarified that a precipitation sample collection period is seven days or 168 hours.
15. Amended clause ME 5-DD by decreasing the number of days after precipitation sample collection by which the laboratory must receive the sample (from 14 to 7 days).
16. In section 5.8, added “conductivity” to the parameters analyzed, changed the title of Table 3, deleted Table 4 (Laboratory flags for precipitation sample) and removed reference to “chain of custody form”.

## 1.2 General Monitoring Requirements

*ME 1-B When the person responsible (a) conducts any monitoring outside of that which is specified in the AMD, and (b) will be submitting the results of this monitoring to the Regulator, the person responsible must have written authorization from the Director prior to commencing the following:*

- (i) the use of monitoring methods not specified in the AMD;*
- (ii) the use of monitoring equipment not specified in the AMD; and*
- (iv) monitoring for ambient parameters not specified in the AMD.*

Monitoring in ME 1-U may include special air studies. Chapter 9 of the AMD (Reporting) provides more details on special air studies and submitting results to the Regulator.

## 2.0 Continuous Ambient Monitoring

The Continuous Ambient Monitoring section provides the performance specifications and requirements for both continuous ambient air analyzers and meteorological sensors to ensure the appropriate selection, installation and operation of continuous ambient air monitoring technologies.

Performance specifications referenced in this section for continuous ambient air analyzers and meteorological sensors are based on the current state of technology. These specifications were compiled as a result of a technology assessment of a wide range of commercially available instrumentation, including those developed by various manufacturers. The final results of the technology assessment are contained in a report entitled Development of Performance Specifications for Continuous Ambient Air Monitoring Analyzers (Alberta Environment and Sustainable Resource Development 2014), available on the AMD website.

The Regulator does not directly or indirectly endorse the use of any specific:

- continuous ambient air analyzer;
- meteorological sensor;
- manufacturer;
- individual commercial product; or
- named technology.

*ME 2-A All (a) continuous ambient air analyzer(s) or (b) meteorological sensor(s) operated by the person responsible for collecting ambient air monitoring data for submission to the Regulator shall be subject to the provisions and specifications prescribed in Section 2.0 of the Monitoring Chapter.*

## 2.1 Performance Specification Standards Sheets

The performance specifications for continuous ambient air analyzers and meteorological sensors are not intended to exclude instruments with operating principles and/or performance specifications other than those provided. Instead, they represent the minimum required performance specifications based on currently accepted technologies. Some performance specifications are based on well-established methods with long histories of successful field monitoring applications, while others may still be evolving. Alternative methods or specifications for an analyzer or sensor may be used if authorization is received from the Regulator. The Regulator may also periodically review and revise specifications to reflect the most current technologies as they are continually refined, developed and evaluated.

*ME 2-B The person responsible must comply, at a minimum, with all the terms and conditions on the performance specification standards sheets for all:*

- (a) continuous ambient air analyzer(s); and*
- (b) meteorological sensor(s).*

Performance specification standards sheets providing operational requirements and minimum performance specifications are available on the AMD website. The performance specification standards sheets are organized by monitored parameter and include the following:

- field of application;
- principles of operation;
- performance specifications;
- operational requirements;
- calibration requirements;
- reporting requirements; and
- additional information.

*ME 2-C Any discrepancy between the terms and conditions of the AMD and an individual performance specification standards sheet for (a) continuous ambient air analyzer(s) and (b) meteorological sensor(s) shall be resolved in favour of the AMD.*

## 2.2 Operation and Maintenance

*ME 2-D The person responsible must (a) operate and (b) maintain all:*

- (i) continuous ambient air analyzer(s); and*
- (ii) meteorological sensor(s) in accordance with:*
  - (1) the Monitoring Chapter; and*
  - (2) the manufacturer's specifications.*



Performance specifications provided by a manufacturer do not guarantee that an instrument will perform as expected in the field during routine operations. Most published performance specifications assume appropriate instrument maintenance and operation.

The Calibration Chapter (Chapter 7) of the AMD specifies calibration requirements for the maintenance of continuous ambient air analyzers and the Site Selection Chapter (Chapter 3) specifies requirements for cleaning the manifold and sampling tubing of continuous ambient air analyzers. The Data Quality Chapter (Chapter 6) of the AMD specifies the required operational time for continuous ambient monitoring instruments.

*ME 2-E Any conflict between the Monitoring Chapter and the manufacturer's specifications in ME 2-D(i) and (ii) shall be resolved in favour of the Monitoring Chapter, unless otherwise authorized in writing by the Director.*

*ME 2-F The person responsible shall keep a copy of the manufacturer's manual available at all times at a given monitoring station for each individual:*  
*(a) continuous ambient air analyzer; and*  
*(b) meteorological sensor.*

### **2.3 Reporting and Notification**

Refer to the Reporting Chapter (Chapter 9) of the AMD for reporting requirements associated with continuous ambient air analyzers and meteorological sensors, including notification requirements.

### **2.4 Continuous Ambient Air Analyzers**

*ME 2-G If the person responsible purchases a new continuous ambient air analyzer after July 30, 2015, the new continuous ambient air analyzer must comply with the minimum performance specifications in Table 1 unless use of an equivalent, alternative analyzer is authorized in writing by the Director.*

*ME 2-H Commencing no later than July 30, 2017, the person responsible must operate all existing continuous ambient air analyzers in accordance with the minimum performance specifications as specified in Table 1 unless use of an equivalent, alternative analyzer is authorized in writing by the Director.*

Written authorization from the Director allows for the use of alternative analyzers demonstrating equivalency. For example, continuous ambient air analyzer(s) that do not publish all the minimum performance specifications in Table 1 are subject to authorization from the Director prior to use. Any equipment incapable of meeting the specified requirements in Table 1 will need to be upgraded or replaced.

When multiple methodologies are provided in Table 1, selection of the appropriate method for a particular monitoring application may require that the person responsible consider various factors, such as: the requirements of support gases or other equipment, maintenance requirements, capital costs, and operating costs.

## 2.5 Meteorological Sensors

- ME 2-I If the person responsible purchases a new meteorological sensor after July 30, 2015, the new meteorological sensor must comply with the minimum performance specifications in Table 2 unless use of an equivalent, alternative sensor is authorized in writing by the Director.*
- ME 2-J Commencing no later than July 30, 2017, the person responsible must operate all existing meteorological sensors in accordance with the minimum performance specifications in Table 2 unless use of an equivalent, alternative sensor is authorized in writing by the Director.*

Written authorization from the Director allows for the use of alternative sensors demonstrating equivalency. For example, meteorological sensor(s) that do not publish all the minimum performance specifications in Table 2 are subject to authorization from the Director prior use. Any equipment incapable of meeting the specified requirements in Table 2 will need to be upgraded or replaced.

When multiple methodologies are provided in Table 2, selection of the appropriate method for a particular monitoring application may require that the person responsible consider various factors, such as: the requirements of support gases or other equipment, maintenance requirements, capital costs, and operating costs.

**Table 1 Minimum performance specifications and operating principles for continuous ambient air analyzers<sup>1</sup>**

Criteria	Ammonia	VOCs (BTEX and Styrene)	Carbon Monoxide		Ethylene	Hydrocarbons	Hydrogen Sulphide and Total Reduced Sulphur
			Routine Monitoring	Trace-Level			
<b>Required Operating Range (Full Scale):</b>	5 ppm	1 ppm	50 ppm	5 ppm or 50 ppm	1 ppm or 10 ppm	10 ppm, 20 ppm, or 50 ppm	0.1 ppm*, 0.5 ppm or 1.0 ppm
<b>Zero Noise:</b>	0.5 ppb RMS	-	25 ppb RMS	20 ppb RMS	-	1% of full scale	0.25 ppb RMS
<b>Lower Detection Limit:</b>	1 ppb	2.0 ppb	50 ppb	40 ppb	10 ppb	60 ppb	0.5 ppb
<b>Zero Drift (24-hr):</b>	1 ppb	-	100 ppb	100 ppb	-	1% of full scale	1.0 ppb
<b>Span Drift (24-hr):</b>	1% of full scale	-	1% of full scale	1% of full scale	-	1% of full scale	1% of full scale
<b>Linearity:</b>	1% of full scale	-	1% of full scale	1% of full scale	1% of full scale	1% of full scale	1% of full scale
<b>Accuracy:</b>	-	-	-	-	-	-	-
<b>Precision:</b>	0.4 ppb or 0.5% of reading	3% of reading	100 ppb or 1% of reading	0.5% of reading	-	1% of full scale	1.0 ppb or 1% of reading
<b>Rise time:</b>	Maximum 120 s	-	Maximum 60 s	Maximum 60 s	-	Maximum 70 s	Maximum 120 s
<b>Fall time:</b>	Maximum 120 s	-	Maximum 60 s	Maximum 60 s	-	Maximum 70 s	Maximum 120 s
<b>Cycle time:</b>	-	15 minutes	-	-	5 minutes	-	-
<b>Operating Principle(s)</b>	Chemiluminescence	Gas Chromatography (GC); or GC/Flame Ionization Detector (FID)	Non-dispersive Infrared (NDIR); or Gas Filter Correlation		Gas Chromatography (GC)/Reduction Gas Detector (RGD); or GC/Photo Ionization Detector (PID); GC/Flame Ionization Detector (FID); or Laser Adsorption Spectroscopy	Flame Ionization Detector (FID); Gas Chromatography (GC)/FID; or Oxidizer/FID	Ultraviolet (UV) pulsed fluorescence

**Table 1 Minimum performance specifications and operating principles for continuous ambient air analyzers<sup>1</sup> (continued)**

Criteria	Ozone	Oxides of Nitrogen		PM <sub>2.5</sub> and PM <sub>10</sub>	Sulphur Dioxide	
		Routine Monitoring	Trace Level		Routine Monitoring	Trace Level
<b>Required Operating Range (Full Scale):</b>	0.5 or 1 ppm	0.5 ppm or 1.0 ppm	0.2 ppm, 0.5 ppm or 1.0 ppm	500 µg m <sup>-3</sup> or 1000 µg m <sup>-3</sup>	0.5 ppm or 1.0 ppm	0.1 ppm, 0.5 ppm or 1.0 ppm
<b>Zero Noise:</b>	0.5 ppb RMS	0.25 ppb RMS	0.025 ppb RMS	-	1.0 ppb RMS	0.1 ppb RMS
<b>Lower Detection Limit:</b>	1.0 ppb	0.5 ppb	0.05 ppb	4.8 µg m <sup>-3</sup>	2.0 ppb	0.2 ppb
<b>Zero Drift (24-hr):</b>	1.0 ppb	0.5 ppb	0.1 ppb	-	1.0 ppb	0.2 ppb
<b>Span Drift (24-hr):</b>	1% of full scale	1% of full scale	1% of full scale	-	1% of full scale	1% of full scale
<b>Linearity:</b>	1% of full scale	1% of full scale	1% of full scale	-	1% of full scale	1% of full scale
<b>Accuracy:</b>	-	-	-	5% of reading	-	-
<b>Precision:</b>	1.0 ppb or 1% of reading	0.5 ppb or 1% of reading	0.05 ppb or 0.5% of reading	2.0 µg m <sup>-3</sup>	1.0 ppb or 1% of reading	0.2 ppb or 2% of reading
<b>Rise time:</b>	Maximum 60 s	Maximum 60 s	Maximum 60 s	-	Maximum 120 s	Maximum 120 s
<b>Fall time:</b>	Maximum 60 s	Maximum 60 s	Maximum 60 s	-	Maximum 120 s	Maximum 120 s
<b>Cycle time:</b>	-	-	-	1-hour**	-	-
<b>Operating Principle(s)</b>	Ultraviolet (UV) Photometry; or Chemiluminescence	Chemiluminescence		Beta Attenuation Monitor (BAM); Light Scattering/BAM; Tapered Element Oscillating Microbalance (TEOM); or US EPA Equivalent <sup>†</sup>	Ultraviolet (UV) pulsed fluorescence	

<sup>1</sup>Concentration measured at Standard Temperature and Pressure (25°C, 760 mmHg).

- Indicates no set specifications.

\*The typical operating range is 0.1 ppm with 0.5 ppm or 1.0 ppm used in unique circumstances such as emergency monitoring.

\*\* Cycle time is only applicable for semi-continuous (e.g., BAM) analyzers.

<sup>†</sup> US EPA equivalent methods will be accepted for continuous monitoring of ambient levels of PM<sub>2.5</sub> and PM<sub>10</sub>.

ppm is parts per million by volume.

ppb is parts per billion by volume.

RMS is the root mean square.

µg m<sup>-3</sup> is the mass, in micrograms, of the substance in one cubic metre of air.

**Table 2 Minimum performance specifications and operating principles for meteorological sensors**

Criteria	Ambient Temperature		Barometric Pressure	Relative Humidity	Solar Radiation	Surface Wetness	Wind Direction	Wind Speed
	AT	$\Delta T$						
<b>Required Operating Range (Full Scale):</b>	-30 – 50°C	-30 – 50°C	600–1000 hPa	0–100% RH	0–1300 W m <sup>-2</sup>	0 – 60°C	0 – 360°	0.0 – 50.0 m s <sup>-1</sup>
<b>Accuracy:</b>	0.6°C	0.1°C	1.5 hPa	7% of reading	-	-	3°	0.25 m s <sup>-1</sup> or 2% of reading
<b>Resolution:</b>	0.1°C	0.1°C	0.5 hPa	0.5% RH	-	-	1°	0.1 m s <sup>-1</sup>
<b>Spectral Range:</b>	-	-	-	-	400–1100 nm	-	-	-
<b>Precision:</b>	-	-	-	-	5% of reading	-	-	-
<b>Linearity:</b>	-	-	-	-	2.5% of full scale	-	-	-
<b>Starting Threshold:</b>	-	-	-	-	-	-	0.5 m s <sup>-1</sup>	0.5 m s <sup>-1</sup>
<b>Distance Constant</b>	-	-	-	-	-	-	-	< 3 m
<b>Operating Principle(s)</b>	Thermal Resistor or Thermocouple		Aneroid/ Electronic Barometer	Hygrometer	Pyranometer	Sensing Grid or Dielectric	Cup/Prop Anemometer and Vane System or Heated Sonic Anemometer	

AT is ambient temperature.

$\Delta T$  is delta temperature.

- indicates no set specifications.

°C is degrees Celsius.

° is to degrees.

hPa is hectopascal.

RH is relative humidity.

m s<sup>-1</sup> is metres per second.

nm is wavelength of incident radiation, in units of nanometres.

W m<sup>2</sup> is energy flux measured in watts per metre squared.

### 3.0 Integrated Sampling

The purpose of the Integrated Sampling section is to provide guidance and consistent requirements for conducting integrated sampling in Alberta, including passive and intermittent sampling and the phasing out of static sampling.

Integrated sampling provides a time-weighted average measurement of a gas, a vapour, or particulate matter over a set period. The integrated sample is analyzed in a laboratory to determine the ambient concentration or mass loading per sample. There are different types of integrated samplers, including passive samplers, intermittent samplers, and static samplers.

The sampling period varies depending on the integrated sampler and monitoring objectives. Common periods include a 24-hour sample every 6 days, a calendar month, or a grab sample (e.g., short-term duration of seconds or a minute). Shorter-term periods may reflect temporary spikes in ambient air quality data, whereas spikes would be averaged out in longer-term periods. Long term periods are suitable for providing information on long-term air quality trends.

Mention of trade names or commercial products does not constitute endorsement nor recommendation for use.

*ME 3-A The person responsible shall comply with Section 3.0 Integrated Sampling of the Monitoring Chapter for all integrated sampling data that the person responsible submits to the Regulator.*

Training requirements for personnel conducting air quality monitoring, reporting and maintenance activities are outlined in the Quality System Chapter (Chapter 5) of the AMD. For the reporting requirements for integrated sampling, refer to the Reporting Chapter (Chapter 9) of the AMD.

*ME 3-B The person responsible shall only use integrated samplers that are commercially available, unless otherwise authorized in writing by the Director.*

As an example, the person responsible may be authorized to use an alternative integrated sampler if the commercially-available integrated samplers are not suited to the intended application.

*ME 3-C The person responsible shall (a) develop, (b) document, and (c) implement, SOPs for each integrated sampler that is used, in accordance with the following at a minimum:*

- (i) the manufacturer's specifications; and*
- (ii) the AMD.*

There should be clear and unambiguous instructions available for the use of each integrated sampler, including any special considerations for the monitoring method.

*ME 3-D Any conflict between the Monitoring Chapter and the manufacturer's specifications for integrated sampling in ME 3-C shall be resolved in favour of the Monitoring Chapter, unless otherwise authorized in writing by the Director.*

*ME 3-E The person responsible shall include in the SOPs in ME 3-C the following, at a minimum:*

- (a) monitoring method description, including (i) limitations, (ii) interferences, (iii) sampling period, and (iv) sampling frequency;*
- (b) list of required equipment and materials;*
- (c) integrated sampler set-up procedures;*

- (d) *integrated sampler operating or exposure procedures;*
- (e) *integrated sample handling procedures;*
- (f) *integrated sample identification procedures;*
- (g) *integrated sample shipping procedures;*
- (h) *integrated sampler cleaning, inspection and maintenance procedures; and*
- (i) *record keeping procedures.*

For general requirements and guidance on documenting sampling plans and handling samples, refer to the Quality System Chapter (Chapter 5) of the AMD.

The manufacturer may specify methods to protect the integrity of the integrated sample, such as the type of gloves that must be worn during sample handling, methods for sealing and packaging the sample, and methods for cleaning sampling equipment to prevent contamination. Interference with the integrated sample could occur if directly exposed to an emission source such as a solvent or idling vehicle. Interference could also occur if the integrated sample is not maintained at an appropriate temperature post-exposure, causing condensation on the sample or influencing reaction rates. Air pressure, such as when shipping by airplane, may also cause interference with some monitoring methods.

*ME 3-F In addition to ME 3-E, the person responsible shall include in the SOPs in ME 3-C the following sample handling procedures, at a minimum, to protect the integrity of the integrated sample:*

- (a) *integrated sample storage requirements including:*
  - (i) *range of acceptable storage temperatures;*
  - (ii) *maximum acceptable storage duration of each integrated sampling medium prior to the sampling period;*
  - (iii) *maximum acceptable storage duration of each integrated sampling medium after the end of the sampling period, prior to the laboratory analysis;*
  - (iv) *methods to prevent contamination; and*
  - (v) *methods to prevent damage;*
- (b) *integrated sample deployment and collection requirements including:*
  - (i) *methods to prevent contamination; and*
  - (ii) *methods to prevent damage; and*
- (c) *integrated sample shipping requirements including:*
  - (i) *range of acceptable temperatures during shipping;*
  - (ii) *methods to prevent contamination; and*
  - (iii) *methods to prevent damage.*

*ME 3-G The person responsible shall keep integrated samples that are susceptible to photochemical reactions out of direct sunlight.*

*ME 3-H The person responsible shall (a) complete a chain of custody form for each integrated sample, (b) retain a copy of each completed chain of custody form, and*

*(c) ship to the laboratory each completed chain of custody form with the corresponding sample.*

Chain of custody forms are provided by the laboratory. Prior to the sampling period, the person responsible should confirm with the laboratory the maximum recommended integrated sample storage duration. The storage duration (holding time) is constrained by the type of laboratory analysis required. At the end of the sampling period, the integrated samples should be shipped to the laboratory as soon as practicable to minimize possible sample degradation.

*ME 3-I The person responsible shall:*

- (a) complete a field sheet for each integrated sample taken;*
- (b) retain a copy of each completed field sheet; and*
- (c) ship to the laboratory each completed field sheet with the corresponding integrated sample, unless the origins of the sample are to be blind to the laboratory.*

Meteorological conditions and any unusual observations may also be included on field sheets. Pollutant concentrations may vary with time of day, temperature, humidity, and wind speed and direction. The field sheet records can help with determination of the integrated sample concentration and interpretation of the data.

*ME 3-J The person responsible shall record on the field sheet in ME 3-I the following, at a minimum, for each integrated sample:*

- (a) identification of the integrated sample;*
- (b) identification of the integrated sampling site;*
- (c) date and time of the start of the sampling period;*
- (d) date and time of the end of the sampling period; and*
- (e) date the integrated sample is shipped to the laboratory.*

*ME 3-K When recording the time in ME 3-J, the person responsible shall use the 24-hour clock and Mountain Standard Time.*

Refer to the Quality System Chapter (Chapter 5) of the AMD for laboratory data quality assurance requirements. As additional considerations, the laboratory should consider any special instructions from the integrated sampler manufacturer on the laboratory analysis, as well as any published methods such as those provided by Environment Canada, the US EPA, or the National Institute for Occupational Safety and Health (NIOSH).

*ME 3-L The person responsible shall select a laboratory which meets the following criteria, at a minimum, when conducting integrated sample analysis:*

- (a) operates under current ISO standard governing procedures in all measurement and calibration associated with each analysis required by the person responsible;*
- (b) documents the methods used for (i) extraction, and (ii) analysis;*



- (c) documents any deviations from published methods for (i) extraction, and (ii) analysis, that can be referenced;
- (d) reports measured values with appropriate significant digits to reflect the true certainty of the analytical method; and
- (e) uses data quality flags for each data point to indicate the quality of the result.

Data quality flags should indicate, for example, if the integrated sample received by the laboratory was contaminated, if there was insufficient sample collected for analysis, and if the analyzed parameter was below the method detection limit.

Refer to the Reporting Chapter (Chapter 9) of the AMD for reporting requirements for integrated sampling.

### **3.1 Passive Sampling**

Refer also to clauses ME 3-A to ME 3-L for general requirements and guidance that pertain to all integrated samplers.

Passive sampling is a diffusive sampling method used to determine the concentration of a gas or vapour in ambient air. Passive samplers have no moving parts and do not require electricity to operate, and are therefore suitable for remote locations. Passive sampling may be used to monitor pollutants such as sulphur dioxide, hydrogen sulphide, nitrogen dioxide, ozone, or VOCs. These samplers are common tools for determining spatial and temporal trends of time-weighted average pollutant concentrations. Further discussion on passive sampling is provided in the Appendix.

#### **3.1.1 Passive Sampler Validation**

Validation is used to confirm that a monitoring method is suitable for the intended use, as noted in the Quality System Chapter (Chapter 5) of the AMD. With passive sampling, the performance of a passive sampler is influenced by a variety of factors such as the passive sampling medium, meteorological factors, and the method of determining the sampling rate. As such, there may be disparity in the performance of different passive sampler designs. Validation may be used to quantify the level of uncertainty of measurement. Having an understanding of the precision and accuracy of a particular passive sampler design can assist in evaluating the suitability of the sampler for a given monitoring purpose, and subsequently assist with the interpretation of time-weighted average pollutant concentrations from field sampling.

The validation conditions should reflect the anticipated use of the passive sampler (i.e., the intended application). The passive sampler validation should include validation in the field in addition to any controlled laboratory experiments. The validation may be performed by a party other than the person responsible. The validation only needs to be performed once for the same application, unless there is a change to the passive sampler (e.g., sampling medium) or to the exposure conditions.

*ME 3-M The person responsible shall only conduct passive sampling with passive samplers that have been validated for the following conditions at a minimum:*

- (a) a representative range of ambient air concentrations to which the passive sampler is to be exposed;*
- (b) a representative range of sampling periods over which the passive sampler is to be exposed; and*
- (c) a representative range of meteorological factors including (i) wind speed, (ii) ambient temperature, and (iii) humidity, to which the passive sampler is to be exposed.*

For example, a minimum of 12 months of consecutive sampling periods in the field may enable validation in representative conditions for passive samplers that will be exposed to seasonal variability. Further to ME 3-M (c), atmospheric pressure should be taken into consideration when sampling at different altitudes.

The validation should include a comparison of replicate passive samples for the determination of precision, and a comparison of passive samples co-located with a reference method monitor for the determination of accuracy. The reference method monitor should meet the requirements of the AMD, including calibration, to prevent errors from being induced into the comparison.

The greater the number of validation samples, the more robust the estimate of precision and accuracy. Guidance on the determination of precision and accuracy for passive samplers is provided in the Appendix.

### **3.1.2 Installation**

The siting requirements for passive samplers are provided in the Site Selection Chapter (Chapter 3) of the AMD. The manufacturer's specifications may provide additional requirements or recommendations for installation. A passive sampler is typically installed within a protective shelter that houses the diffusion barrier surface of the sampler in a vertically downward-facing position.

*ME 3-N The person responsible shall orient each passive sampler in accordance with the manufacturer's specifications.*

*ME 3-O The person responsible shall deploy each passive sampler in a manner that:*

- (a) prevents the diffusion barrier surface of the passive sampler from becoming wet;*
- (b) protects the diffusion barrier surface of the passive sampler from the ingress of particulates; and*
- (c) protects the diffusion barrier surface from high wind speeds.*

Some considerations in protecting the diffusion barrier surface of a passive sampler may include siting, orientation of the diffusion barrier surface, and use of a protective shelter. Recommendations may be provided by the manufacturer of the passive sampler.

*ME 3-P When a protective shelter is used, the person responsible shall only use a protective shelter that (a) does not interfere with the diffusive uptake rate of the passive sampler, and (b) minimizes temperature rise of the passive sampler due to direct solar radiation.*

The design of the protective shelter, including the surface and colour, may affect the temperature of the passive sampling environment.

### 3.1.3 Quality Control Samples for Field Sampling

Quality control samples such as method blanks, replicate passive samples (e.g., duplicates or triplicates), and passive samples co-located with a reference method monitor in the field can help quantify and identify sources of systematic and random error associated with the passive monitoring method.

Method blanks may indicate field sampling and laboratory sources of contamination of a passive sample. The purpose of replicate and co-located passive samples is to provide an estimate of precision and accuracy, respectively, of the monitoring method. This can assist in the interpretation of passive sampling data, or ambient air quality, over a period of time or over a particular area where passive sampling is conducted.

*ME 3-Q The person responsible shall deploy the following number of method blanks whenever conducting passive sampling:*  
*(a) at least one method blank during each sampling period; and*  
*(b) the number of method blanks equal to at least 10% of the passive samples deployed during the sampling period.*

At least one method blank needs to be deployed for each batch of 1 to 10 passive samples. ME 3-Q provides the minimum requirements; the deployment of additional method blanks can provide a more accurate value for the correction of data.

*ME 3-R The person responsible shall (a) deploy each method blank in ME 3-Q over the same sampling period as the corresponding passive samples, and (b) handle and deploy each method blank in ME 3-Q in the same manner as the corresponding passive samples, excluding exposure of the passive sampler's diffusion barrier surface to ambient air.*

The method blanks and the corresponding passive samples should be treated the same, to the extent possible based on the passive sampler design. As an example, since the chemical reaction rate of the passive sampling medium may be affected by temperature, the method blank should

be exposed to the same temperature as the corresponding passive sample throughout the sampling period. However, method blanks may need to be deployed within a different type of protective shelter than the corresponding passive samples if the diffusion barrier surface of the method blanks would not otherwise be able to remain sealed.

*ME 3-S The person responsible shall deploy the following number of replicate passive samples whenever conducting passive sampling:*

- (a) at least one replicate passive sample during each sampling period; and*
- (b) the number of replicate passive samples corresponding to at least 10% of the passive samples deployed during the sampling period.*

At least one replicate passive sample needs to be deployed for each batch of 1 to 10 passive samples. ME 3-S provides the minimum requirements; the deployment of additional replicates can provide more accurate results. The independence of different passive sampling sites should also be considered in the interpretation of sampling results.

*ME 3-T The person responsible shall (a) deploy each replicate passive sample in ME 3-S at the same site as the corresponding passive sample, (b) deploy each replicate passive sample in ME 3-S over the same sampling period as the corresponding passive sample, and (c) handle each replicate passive sample in ME 3-S in the same manner as the corresponding passive sample.*

The replicate passive samples and the corresponding passive samples should be treated the same. The location of replicate passive samplers may be rotated throughout a monitoring network.

*ME 3-U The person responsible shall deploy at least one passive sample co-located with a reference method monitor whenever conducting passive sampling in a monitoring network that includes:*

- (a) at least one reference method monitor; and*
- (b) at least five passive sampling sites.*

*ME 3-V The person responsible shall deploy each co-located passive sample in ME 3-U (a) at the same site as the corresponding reference method monitor, and (b) over a sampling period during which the corresponding reference method monitor is expected to be operating.*

*ME 3-W The person responsible shall (a) conduct and (b) record the following comparisons:*

- (i) time-weighted average pollutant concentrations from each replicate passive sample in ME 3-S compared to the corresponding passive sample; and*
- (ii) time-weighted average pollutant concentrations from each passive sample co-located with a corresponding reference method monitor in ME 3-U compared to the reference method monitor pollutant concentration data averaged over the same period as the corresponding passive sampling period.*

It is important for the reference method monitor to meet the requirements of the AMD, including calibration, to prevent errors from being induced into the comparison.

The greater the number of quality control samples, the more robust the estimate of precision and accuracy. Guidance on the determination of precision and accuracy for passive samplers is provided in the Appendix.

### 3.1.4 Sampling Period

The sampling period for passive sampling may be specified by an EPEA approval or other authorization in writing from the Director. It is important for the actual sampling period to be as close as practicable to the prescribed sampling period for representativeness. Maintaining an appropriate deployment and collection schedule for a sampling period also minimizes interference with consecutive sampling schedules.

*ME 3-X When the person responsible deploys a passive sampler for a monthly sampling period, the person responsible shall deploy that passive sampler for 30 days  $\pm$  4 days unless otherwise authorized in writing by the Director.*

*ME 3-Y When the person responsible deploys a passive sampler for a specified sampling period other than a monthly sampling period, the person responsible shall deploy that passive sampler for a sampling period of  $\pm$ 10% of the specified sampling period unless otherwise authorized in writing by the Director.*

Further to ME 3-X and 3-Y, the passive sampler needs to have been validated for the particular sampling period (monthly or other) as per ME 3-M.

### 3.1.5 Determination of the Time-Weighted Average Pollutant Concentration

Determination of the time-weighted average pollutant concentration of a passive sample needs to take into account the sampling period, mass uptake and sampling rate of the passive sampler. Since the mechanism for passive sampling is diffusion rather than active air pumping, the sampling rate (i.e., diffusive uptake rate) for a passive sampler must be determined. Passive sampling involves a driving force described by Fick's first law of diffusion, and may be influenced by many factors. There are a variety of methods for determining the sampling rate, such as by using Fick's law (Feigley and Lee 1988), a laboratory method (Hendricks 1998), meteorological parameters (Tang et al. 1997, 1999, 2002; Tang and Lau 2000), and an integrative data application (Tang 2013).

*ME 3-Z The person responsible shall determine the time-weighted average pollutant concentration of each (a) passive sample, (b) replicate sample and (c) method blank in accordance with the manufacturer's specifications.*

*ME 3-AA Where meteorological data are incorporated into the determination of the time-weighted average pollutant concentration of each (a) passive sample, (b) replicate sample and (c) method blank, the person responsible shall use the most representative meteorological data that are available.*

There can be local variation in meteorology. If site-specific meteorological data are unavailable, which is common in remote areas, appropriate meteorological data could be obtained from a nearby monitoring station, airport, or Alberta Agriculture and Rural Development's Agro-Climatic Information Service. Considerations for choosing representative meteorological data are not limited to proximity to the passive sampling site, but also include topography and land use for example.

*ME 3-BB The person responsible shall record for each (a) passive sample, (b) replicate sample and (c) method blank, the following at a minimum:*

- (i) the mass uptake of the passive sampler as determined by the laboratory analysis; and*
- (ii) where meteorological data are incorporated into the determination of the time-weighted average pollutant concentration of the sample, the specific source of the meteorological data.*

These records assist with data tracking and recalculation of time-weighted average pollutant concentrations if needed.

### **3.2 Intermittent Sampling**

Refer also to clauses ME 3-A to ME 3-L for general requirements and guidance that pertain to all integrated samplers.

Intermittent sampling technologies are used to monitor substances such as particulate matter, VOCs, semi-volatile organic compounds (e.g., polycyclic aromatic hydrocarbons), dioxins, furans, metals and some sulphur compounds. Intermittent samplers are typically deployed for 24 hours over a given sampling frequency such as every 6 days. They may also be deployed for shorter terms, such as a grab sample (e.g., seconds or a minute), or an hour.

The appropriate sampling system is chosen based on the pollutant of interest and monitoring objectives. For further details on intermittent sampling equipment and intermittent sampling methodologies, the person responsible should refer to reference documents such as the manufacturer's specifications, the US EPA list of designated reference and equivalent methods, NAPS reference methods, and ASTM methods.

Refer to the Quality System Chapter (Chapter 5) of the AMD for requirements and guidance related to calibrating air monitoring equipment, as well as the Calibration Chapter (Chapter 7) of the AMD for specifics on the HiVol.

The following requirements and guidance apply to all intermittent sampling methods as applicable. The subsequent requirements provide additional, minimum, method-specific requirements and guidance for filtration sampling, active sorbent sampling, and canister sampling.

*ME 3-CC The person responsible shall only operate an intermittent sampler in accordance with the manufacturer's specifications for (a) ambient temperature, (b) barometric pressure, and (c) flow rate.*

*ME 3-DD When the person responsible uses a (a) high-volume air sampling pump or (b) low-volume air sampling pump as part of an intermittent sampler, the person responsible shall maintain a linear air flow rate over the intermittent sampling period.*

An air flow controller, also called a flow restrictor or regulator, is used to adjust for an appropriate range of air flow rates. The flow rate is set to draw in a sufficient air volume over the sampling period. A constant, stable (linear) flow rate allows for the sampled air volume to be calculated over the sampling period. Therefore, calibration is also important.

The person responsible should verify that all of the equipment, e.g., air pumps or pressure gauges, are working properly prior to use.

### **3.2.1 Filtration Sampling**

Filtration sampling is an active monitoring method that requires an air pump to sample particulate matter. Particulate matter is commonly monitored in terms of TSP, PM<sub>10</sub>, or PM<sub>2.5</sub>, and may include speciation for metals or other inorganic substances during the laboratory analysis. An appropriate sampler must be chosen to meet the particular monitoring objective.

A HiVol collects TSP and may be equipped with a size-selective inlet head for PM<sub>10</sub> or PM<sub>2.5</sub>. A low-volume sampler such as a dichotomous sequential sampler (dichot) does not sample TSP but separates particles into PM<sub>2.5-10</sub> (coarse fraction) and PM<sub>2.5</sub> (fine fraction) by its dual-filter design. A Partisol sampler may sample TSP, PM<sub>10</sub>, and PM<sub>2.5</sub>.

An intermittent sampler may include both filters and sorbents to simultaneously collect pollutants of interest in the particulate and gas phases, therefore the filtration sampling and active sorbent sampling requirements may apply. For sampling methods related to sorbents, refer to Section 3.2.2.

The mass determination of particulate matter is by gravimetric analysis. Therefore the sample filters should not be shaken, dropped, or touched by a foreign object, including fingerprints and dirt.

*ME 3-EE When conducting filtration sampling, the person responsible shall use particulate matter filters consisting of the following:*

- (a) *the (i) material and (ii) pore size needed to sample the pollutant of interest; and*
- (b) *the filter diameter needed to prevent sample air from bypassing the particulate matter filter.*

The filter material should be compatible with the required laboratory analysis and the pore size should collect the particulate matter size fraction of interest. Examples of particulate matter filters include quartz fibre, Teflon-coated glass fibre or Teflon filters. A filter with visible defects such as pin holes should not be used.

The person responsible should ensure that filter cassettes are cleaned before reuse to prevent sample contamination. The person responsible should also perform regular leak checks. Leaks could be caused by a damaged O-ring, gasket or rubber seal, or an improperly seated filter.

*ME 3-FF When conducting filtration sampling, the person responsible shall monitor the air flow rate representative of the (a) start and (b) end of the filtration sampling period, at a minimum.*

*ME 3-GG In addition to ME 3-J, when conducting filtration sampling, the person responsible shall record the following information on the filtration sampling field sheet in ME 3-I, at a minimum:*

- (a) *identification of the filtration sampler;*
- (b) *the type of filter; and*
- (c) *(i) the average air flow rate of the sampling period or (ii) the total air volume collected during the sampling period.*

### **3.2.2 Active Sorbent Sampling**

Active sorbent sampling is a monitoring method that typically samples VOCs or semi-volatile organic compounds using sorbent tubes or sorbent cartridges, respectively. For a sorbent tube, including multi-bed tubes, an air pump may be used to pull sample air across the sorbent material to sample pollutants such as formaldehyde and other carbonyl compounds (e.g., aldehydes and ketones). A high-volume or low-volume sampler may be equipped with a sorbent cartridge consisting of a sorbent or sorbent mix including polyurethane foam (PUF), XAD or XAD-2, or Tenax sorbent media to sample pollutants such as polycyclic aromatic hydrocarbons, polychlorinated biphenyls (PCBs), pesticides, or dioxins/furans.

An intermittent sampler may be designed to simultaneously collect pollutants of interest in the gas and particulate phases, therefore the active sorbent sampling and filtration sampling requirements may apply. For requirements and guidance related to filtration sampling, refer to Section 3.2.1.



*ME 3-HH When conducting active sorbent sampling, the person responsible shall use a sorbent sampling medium of the appropriate (a) material, and (b) capacity to sample the pollutant of interest.*

The sorbent needs to be compatible with the laboratory analysis for the pollutant of interest and be of sufficient volume to not lead to sorbent breakthrough. An alternative to increasing the sorbent volume could include a lower air flow rate or shorter sampling period.

*ME 3-II Where multi-bed sorbent tubes are used for active sorbent sampling, the person responsible shall orient multi-bed sorbent tubes so that the sample air passes through the sequence of sorbents in order of increasing sorbent strength.*

This multi-bed sorbent tube orientation prevents contamination of the stronger sorbent with less volatile components.

*ME 3-JJ The person responsible shall conduct active sorbent sampling with a sorbent cartridge only when the system is equipped with a particulate filter.*

While a sorbent is used to collect pollutants in the vapour phase, a filter is used to collect the sample in the particulate phase or protect the sorbent by trapping dust and preventing deterioration.

*ME 3-KK When conducting active sorbent sampling, the person responsible shall monitor the air flow rate representative of the (a) start and (b) end of the active sorbent sampling period, at a minimum.*

*ME 3-LL In addition to ME 3-J, when conducting active sorbent sampling, the person responsible shall record the following information on the active sorbent sampling field sheet in ME 3-I, at a minimum:*

- (a) identification of the active sorbent sampler;*
- (b) the type of sorbent sampling medium; and*
- (c) (i) the average air flow rate of the sampling period or (ii) the total air volume collected during the sampling period.*

### **3.2.3 Canister Sampling**

Whole air sampling involves drawing air into a sampling container or vessel. Whole air sampling with canisters generally enables a low detection limit and is most suitable for ambient conditions.

Canister sampling is a monitoring method that may be used to sample VOCs, such as selected hydrocarbons, and sulphur-containing compounds. Canisters such as Restek™, SilcoSteel® or SUMMA® electroplated or interior-coated stainless steel canisters are specially prepared (i.e., virtually inert, cleaned and evacuated) by the laboratory before use.

Canister sampling involves opening the canister valve to draw in a whole air sample by the differential pressure (vacuum) and closing the valve once the desired air volume is reached. The flow into the canister is controlled through a flow-restrictive inlet such as a critical orifice device or mass flow controller. Sub-atmospheric (negative pressure) or pressurized (above atmospheric pressure) sampling methods may be used.

*ME 3-MM When conducting canister sampling, the person responsible must use a canister that is inert to the chemicals being sampled.*

Inert material for canister sampling lines, tubing, connectors and valves may include stainless steel, glass, silica coated stainless steel, perfluoroalkoxy (PFA), or polytetrafluoroethylene (PTFE, e.g., Teflon). Other materials may induce error in the canister sampling results. The canister interior surface may be coated with Teflon or silica glass.

The interior of canisters should be cleaned and evacuated by the laboratory, and there may be an expiry date associated with that cleaning. Other canister sampling equipment to be cleaned includes tubing and flow controllers, when used.

*ME 3-NN The person responsible shall conduct canister sampling only when the canister is equipped with a particulate filter.*

A particulate filter is used to protect the canisters from contamination by micro-organisms and particles.

*ME 3-OO When conducting canister sampling through the sub-atmospheric method, the person responsible must keep the canister vacuum at the pressure needed for sampling with linear flow throughout the sampling period.*

In the sub-atmospheric method, adequate vacuum is needed to capture sufficient sample volume for a representative sample. When conducting canister sampling through the pressurized method, linear flow is achieved throughout the sampling period with a pump and flow controller.

*ME 3-PP When conducting canister sampling, the person responsible shall prevent the pressure in the canister from exceeding the manufacturer-specified limit.*

*ME 3-QQ When conducting canister sampling, the person responsible shall measure the canister vacuum at the (a) start and (b) end of the sampling period, at a minimum.*

A gauge built into the air flow controller may be used for measuring the initial and final vacuums; this gauge may also be used to check that the canister is filling linearly over time, rather than filling too slowly or too quickly, during the sampling period.

*ME 3-RR The person responsible shall only use a canister that has no detectable leaks.*

Proper maintenance is important. Leaks in the canister sampling train could occur at the connections, leading to a diluted sample and a faster fill rate than desired. The person responsible should ensure all connections are tight, including properly seating flow controllers but not over-tightening the valve which could damage the seal.

*ME 3-SS In addition to ME 3-J, when conducting canister sampling, the person responsible shall record the following information on the canister sampling field sheet in ME 3-I, at a minimum:*

- (a) identification of the canister;*
- (b) the type of canister sampling surface;*
- (c) the volume of the canister; and*
- (d) the canister vacuum reading at the (i) start, and (ii) end of the sampling period.*

The canister identification should include the canister serial number. The type of canister sampling surface should include the canister material (e.g., stainless steel) and any internal coating.

### **3.3 Static Sampling**

Refer also to clauses ME 3-A to ME 3-L for general requirements and guidance that pertain to all integrated samplers.

Static samplers have no moving parts, do not require electricity to operate, and are typically deployed for a one month period. This type of ambient air monitoring was historically used as a simple, inexpensive indicator of trends, however static sampling is a virtually obsolete technology that is being phased out. Passive and intermittent sampling technologies are preferred replacements and their selection would depend on the pollutant of interest and the monitoring objectives.

Existing requirements for static sampling in Alberta may apply until the phase out is complete.

*ME 3-TT The person responsible shall analyze all static samples in accordance with the Methods Manual for Chemical Analysis of Atmospheric Pollutants, as amended, unless otherwise authorized in writing by the Director.*

*ME 3-UU The person responsible shall not install any new static sampling stations unless otherwise authorized in writing by the Director.*

In the case of ambient monitoring at industrial operations, such as oil and gas facilities, static sampling was commonly used for monitoring total sulphation and hydrogen sulphide. The static

sampling of total sulphation and hydrogen sulphide is being replaced by passive sampling of sulphur dioxide and hydrogen sulphide, respectively.

*ME 3-VV Commencing no later than July 30, 2017, the person responsible shall cease monitoring of total sulphation using the static sampling method.*

*ME 3-WW Commencing no later than July 30, 2017, the person responsible shall cease monitoring of hydrogen sulphide using the static sampling method.*

Bulk particulate sampling is a rough method of sampling nuisance dust, often referred to as dustfall. Total and fixed (non-combustible) dustfall stations are containers that collect suspended particulate matter that settles by gravity over a given area and time. It is considered a crude monitoring method that is susceptible to interference, such as from insects and debris. While this method has been used to monitor general nuisance dust from roads, for example at coal mines, an intermittent sampling method for TSP or PM<sub>10</sub> would provide more representative results. For human health concerns, monitoring for finer particulate fractions (e.g., PM<sub>2.5</sub>) would be appropriate. These dust monitoring stations may be upgraded over time, in accordance with the approval requirements for the plant or facility.

The sampling period for static monitoring may be specified in an approval or other authorization in writing from the Director. It is important for the actual sampling period to be as close as practicable to the prescribed sampling period for representativeness. Maintaining an appropriate deployment and collection schedule for a sampling period also minimizes interference with consecutive sampling schedules.

*ME 3-XX When the person responsible deploys a static sampler for a monthly sampling period, the person responsible shall deploy that static sampler for a sampling period having a range of 30 days ± 4 days unless otherwise authorized in writing by the Director.*

## **4.0 Mobile Air Monitoring**

The purpose of the Mobile Air Monitoring section is to establish a set of consistent requirements for monitoring ambient air quality using a mobile air monitoring unit or vehicle.

Mobile air monitoring includes monitoring of ambient air contaminants using instruments contained within a mobile vehicle or monitoring unit. These mobile units are self-contained laboratories. Data collection takes place through all seasons, in both stationary and moving scenarios. Mobile air monitoring units can collect data in areas where permanent air monitoring stations are not located, or where permanent air monitoring stations do not have the required capability.

Mobile air monitoring may be applied to a number of scenarios, including:

- short-term data collection;
- data collection in areas of concern that do not have permanent air monitoring stations;
- evaluating the need for a permanent air monitoring station;
- responding to public concerns or complaints about air quality;
- emergency air monitoring;
- monitoring the effects of short-lived events such as wild fires or prescribed burns;
- enhancing air quality research through comparative studies with permanent air monitoring stations, validation of existing monitoring, evaluating air quality model predictions, etc.;
- collecting a snapshot of baseline ambient air quality data;
- routine area sweeps;
- industrial fence-line monitoring for inspection or issues surveillance purposes; and
- assessing the local, downwind impact of point or area emission sources.

#### **4.1 Personnel**

Training requirements for personnel conducting air quality monitoring, reporting and maintenance activities are outlined in the Quality System Chapter (Chapter 5) of the AMD. Personnel operating instrumentation housed in a mobile air quality monitoring unit are required to have adequate training and proficiency for the monitoring, maintenance and reporting tasks required.

For mobile air monitoring, training may include either factory or in-house training, and should cover instrument operation, maintenance, calibration, as well as the vehicle's internal framework and support systems.

Some suggested personnel qualifications are as follows:

- vehicle specific training on maintenance and operation of all systems including vehicle platform, generators, etc.;
- experience and familiarity with all instruments in the vehicle, including their calibration, maintenance and operation;
- assisted completion of at least two projects with the vehicle;
- driver training for larger vehicles (e.g., RV driver training);
- data reduction and handling associated training (i.e., Microsoft Excel training);
- data logger training; and
- operator safety training in accordance with related Occupational Health and Safety regulations (e.g., hazardous materials training).

## 4.2 Vehicle Configuration and Specifications

### 4.2.1 Platform

When choosing a platform upon which to build the mobile air monitoring vehicle, the following should be considered:

- safety of operator(s) and passengers;
- monitoring purpose;
- instrumentation required;
- support systems required;
- adequate size and space;
- weight distribution;
- four wheel drive, if needed;
- chassis weight capacity;
- power generation requirements;
- fuel capacity for both the vehicle and generator(s);
- fuel type(s) for vehicle and generator(s);
- capacity to expand monitoring equipment;
- meteorological mounting and hardware;
- sample manifold mounting and hardware;
- adequate storage for other air sampling gear and consumables; and
- operator conveniences like microwave, wash sink or coffee maker.

### 4.2.2 Layout and Design

*ME 4-A The person responsible shall locate instrumentation within a mobile air monitoring unit to promote proper operating conditions as follows:*

- (a) temperature sensitive instrumentation must be shielded from areas of temperature fluctuation;*
- (b) instrument racks must be located away from doors;*
- (c) cylinder gases must be mounted in a structurally sound area with ventilation in the event of a gas leak;*
- (d) analyzers that are installed inside the mobile air monitoring unit must be secured against movement;*
- (e) the sampling manifold intake must be configured as far from the vehicle's exhaust and power generation system exhaust as practicable; and*
- (f) the sampling manifold must be (i) inert to substances being monitored and (ii) mounted securely in order to withstand the type of vibrations and shocks that are specific to mobile air monitoring activities.*

Refer to Chapter 3 of the AMD (Site Selection Chapter) for specifications on suitable manifold and tubing material.

It is recommended that a sampling manifold be chosen over a sampling line in units that are equipped with two or more monitoring instruments.

#### 4.2.3 Instrumentation and Specifications

<i>ME 4-B</i>	<i>The person responsible shall select (a) continuous ambient air analyzers and (b) meteorological sensors for use in the mobile air monitoring unit that comply with Section 2.0 of the Monitoring Chapter.</i>
<i>ME 4-C</i>	<i>The person responsible shall operate all (a) continuous ambient air analyzers and (b) meteorological sensors contained within the mobile air monitoring unit according to the Section 2.0 of the Monitoring Chapter.</i>
<i>ME 4-D</i>	<i>Any other analyzers or instruments, in addition to ME 4-C, used by the person responsible in a mobile air monitoring unit shall be operated as per the manufacturer's specifications, using validated methods.</i>
<i>ME 4-E</i>	<i>The person responsible shall keep all monitoring instruments within the manufacturer's specified operating temperature range while the mobile air monitoring unit is actively monitoring ambient air quality.</i>

#### 4.2.4 Power System(s)

<i>ME 4-F</i>	<i>The person responsible shall minimize interference from the mobile air monitoring unit's power generation system and the vehicle's exhaust system on the pollutants being monitored.</i>
<i>ME 4-G</i>	<i>The person responsible shall flag any data collected from a mobile air monitoring unit that have been affected by the mobile air monitoring unit's vehicle or generator exhaust.</i>

For mobile air monitoring units outfitted with CO, NO/NO<sub>2</sub>/NO<sub>x</sub> and hydrocarbon monitoring capabilities, it is recommended that natural gas or propane-fueled power generation systems be used. Exhaust from gasoline and diesel fueled engines interferes with monitoring results for these pollutants.

It is recommended that the following be considered when setting up the power system for the mobile air monitoring unit:

- using a clean burning fuel, such as natural gas or propane, for the generator;
- addition of catalytic convertor to exhaust stream to further reduce interference from generator/vehicle exhaust;
- using a redundant or backup generator for the unit;

- allowing for easy connection to standard, readily available 110 VAC 15A shore power.

Shore power refers to external electrical land power that provides the mobile air monitoring unit energy when its engine and generator are turned off. An automatic transfer switch may be installed to eliminate the risk of power disruption when switching between shore power and generator power. In order to run all equipment on board on shore power, a higher current connection may be necessary.

#### 4.2.5 Heating, Ventilation and Air Conditioning System

*ME 4-H The person responsible shall equip the mobile air monitoring unit with a heating and cooling system with sufficient capacity to maintain a stable operating temperature that is within the manufacturer's specifications for all of the instruments on board.*

*ME 4-I When (a) actively monitoring or (b) calibrating instruments, the person responsible must maintain a constant and stable temperature within the mobile air monitoring unit that is within the operating range of the instruments.*

*ME 4-J In addition to ME 4-I, the person responsible must (a) measure the temperature within the mobile air monitoring unit and (b) log the data in the data acquisition system.*

#### 4.2.6 Meteorological (Mast)

*ME 4-K The person responsible shall report all wind data with respect to true north.*

This can be accomplished by using additional hardware, such as wind instruments with internal compasses, or corrections in the data system, or a combination of both. Local interferences with recorded wind data should be noted in subsequent data reports.

*ME 4-L The person responsible shall record wind direction measured with the mobile air monitoring unit in numerical degrees.*

In addition to numerical degrees, wind direction may also be reported as compass points.

*ME 4-M The person responsible shall flag all wind data that has been collected while the mobile air monitoring unit is in motion as invalid.*

*ME 4-N The person responsible must keep the wind mast on the mobile air monitoring unit at a minimum height of 2 metres above the surface of the unit's roof top while conducting stationary monitoring.*



#### 4.2.7 Global Positioning System

- ME 4-O The person responsible must install a global positioning system on the mobile air monitoring unit that is connected to the data acquisition system.*
- ME 4-P The person responsible must record the following information with every monitored data point using the mobile air monitoring unit's global positioning system and data acquisition system:*
- (a) latitude;*
  - (b) longitude;*
  - (c) time;*
  - (d) mobile air monitoring unit speed; and*
  - (e) (i) direction the mobile air monitoring unit is travelling when in motion, or  
(ii) direction the front of the mobile air monitoring unit is facing when stationary.*

With the parameters required in ME 4-P, elevation may also be recorded.

#### 4.2.8 Instrument Pumps and Housing

- ME 4-Q The person responsible must vent each instrument's exhaust stream outside of the mobile air monitoring unit so that instrument exhaust does not interfere with the unit's manifold intake air.*
- ME 4-R The person responsible must house external analyzer sampling pumps (a) in a location on the mobile air monitoring unit that allows for adequate ventilation, and (b) where the temperature is maintained within the manufacturer's operating specifications for the sample pump.*

Pumps can be external from the instruments and mounted in an outer compartment to maximize cooling.

#### 4.2.9 Data Acquisition

Chapter 6 of the AMD (Data Quality) provides requirements for data acquisition system use.

### 4.3 Instrument Calibration

The Calibration Chapter (Chapter 7) of the AMD provides requirements for the calibration of continuous analyzers.

In the case of an emergency event where mobile air monitoring is required, an audit may be conducted to determine whether the operator is capable of doing the work and if the mobile air monitoring unit is sufficiently prepared and maintained to be used for monitoring. An onsite full calibration should be conducted if any deficiencies are noted, before any monitoring occurs.

Calibration systems used for calibrating instruments within the mobile air monitoring units are subject to the requirements in the Audit Chapter (Chapter 8) of the AMD. The mobile air monitoring unit should be parked indoors whenever practicable prior to the start of an audit.

Ideally, cylinder gases for calibration purposes should be in a sealed cabinet or in a compartment that is vented to outside the mobile air monitoring unit.

#### 4.3.1 Timing

- ME 4-S* Prior to commencing any mobile air monitoring, the person responsible must complete a multipoint calibration for all instruments if the mobile air monitoring unit and instruments therein have been powered off for more than three days.
- ME 4-T* Upon completion of a mobile air monitoring survey, the person responsible shall either:
- (a)* calibrate the mobile air monitoring unit's instruments before powering off for over three days; or
  - (b)* connect the mobile air monitoring unit to shore power and calibrate monthly.

#### 4.3.2 Zero and Span

- ME 4-U* Excluding meteorological sensors, the person responsible must conduct a valid zero-span test for all instruments contained within a mobile air monitoring unit for which a test concentration can be generated:
- (a)* daily if the monitoring equipment on board the mobile air monitoring unit is powered and maintained in a ready state;
  - (b)* prior to commencing monitoring, on the same day that a mobile air monitoring survey commences, while on the generator power supply system that will be used during the monitoring;
  - (c)* after a mobile air monitoring survey is complete, on the same day that monitoring ceases, while on the generator power supply system that was used during the monitoring; and

(d) *in the case where the monitoring episode is greater than 24 continuous hours, a zero-span test must be completed every 12 hours at a minimum;*

More frequent zero-span tests may be performed if the unit operator detects that an instrument baseline has shifted.

*ME 4-V In addition to ME 4-U, the zero-span test must be conducted by the person responsible according to the following criteria:*

- (a) a minimum of 10 minutes stability must be achieved to be considered a valid response;*
- (b) prior to commencing monitoring, the zero value from the zero-span test must be within  $\pm 3\%$  of the full scale range of the analyzer; and*
- (c) when a span deviates greater than  $\pm 15\%$  from the previous span, corrective action must be carried out according to the Calibration Chapter (Chapter 7) of the AMD.*

In an emergency monitoring scenario, zeros or spans should not be initiated during active emergency monitoring.

## **4.4 Monitoring Plan**

Mobile air monitoring is variable in nature. Although monitoring plans can change from moment to moment, it is recommended that a monitoring plan be completed for pre-planned surveys (including emergency monitoring, where possible) with the mobile air monitoring unit including the following components:

- the scope of the survey, including the monitoring period start and completion dates;
- the objective and purpose of the survey;
- what parameters will be measured and reported;
- the methods of data collection;
- the location of the survey;
- the specific vehicle and power requirements;
- the required training or certification for staff who operate the unit (e.g., WHMIS, First Aid, etc.); and
- post data processing and reporting considerations.

### **4.4.1 Siting Criteria**

Depending on the monitoring objectives and purpose when conducting mobile air monitoring, standard ambient air monitoring siting criteria may not apply. Mobile air monitoring units often cannot be located at sites that meet the AMD requirements in Chapter 3 (Site Selection Chapter). However the mobile air monitoring unit operator should select the best available monitoring location whenever practicable.

Characteristics of ideal siting for a mobile air monitoring unit include, but are not limited to:

- (1) Monitoring sites that are open and allow for un-influenced monitoring of wind direction. If possible the mobile air monitoring unit should be positioned as far away from buildings, treelines, and other structures that could potentially influence measured wind values.
- (2) Monitoring sites that are not subject to localized interference with pollutants of interest (i.e., areas that are not influenced by the exhaust of nearby vehicles).
- (3) Positioning such that the sample inlet of the mobile air monitoring unit is facing into the wind and the vehicle and generator exhaust is carried away from the mobile air monitoring unit.
- (4) Safety considerations such that the mobile air monitoring unit does not block roadways or create unsafe traffic conditions for the operator or other people in the area.

This is not a comprehensive list – selection of monitoring locations for mobile air monitoring projects requires a great deal of professional judgment on the part of the operator.

#### **4.5 Data Storage and Records**

For requirements on data capture and storage for continuous ambient air monitoring, refer to the Data Quality Chapter (Chapter 6) of the AMD. Requirements on records retention can be found in the Quality System Chapter (Chapter 5) of the AMD.

*ME 4-W The person responsible must (a) retain and (b) store the following records on board the mobile air monitoring unit at all times:*

- (i) calibration documents for continuous ambient air analyzers and meteorological sensors;*
- (ii) instrument maintenance records; and*
- (iii) zero and span reports for the last six months.*

#### **5.0 Precipitation Chemistry Monitoring**

The requirements contained in the Precipitation Chemistry Monitoring section apply to those persons responsible who operate a precipitation chemistry sample collection site(s); the person responsible for the design, deployment and operation of Alberta's precipitation chemistry monitoring network; and the person responsible for the handling and preparation of precipitation chemistry data under Alberta's precipitation chemistry monitoring network.

The purpose of the Precipitation Chemistry Monitoring section is to outline minimum requirements for:

- the selection of precipitation sampling equipment;

- precipitation sample collection and handling;
- precipitation sampling site operations;
- precipitation sample preparation and laboratory analysis;
- precipitation data handling; and
- preparation of a precipitation chemistry network monitoring plan.

*ME 5-A The person responsible must (a) develop, (b) document and (c) implement a Standard Operating Procedure for the operation of precipitation sampling site(s), in accordance with the requirements of Section 5.0 of the Monitoring Chapter.*

## 5.1 Site Selection

Precipitation sample collection sites may be located independently or co-located with an ambient air monitoring station. Additional requirements for the selection of precipitation sample collection sites are outlined in the Site Selection Chapter (Chapter 3) of the AMD.

*ME 5-B The person responsible shall evaluate a precipitation sampling site against all the criteria for a background monitoring site as outlined in the Site Selection Chapter of the AMD.*

A precipitation sampling site may meet all the background precipitation siting criteria or it may fail to meet at least one of the criterions. The results of the evaluation form a part of the site description required in a precipitation chemistry monitoring plan.

## 5.2 Sampling Equipment Selection

The primary goal of precipitation sample collection is to measure the chemistry of wet deposition. Precipitation sampling equipment set up to collect wet deposition is equipped with a wetness sensor that activates a motor to uncover the sample collection container during a precipitation event. During periods of no precipitation, the sample collection container remains covered. The sensor is slightly heated to prevent false openings as a result of dew and snow or ice melt. In addition to precipitation sample collection, a standard precipitation gauge will be used to provide an accurate calculation of wet deposition quantity for the sample period and provide information on sample completeness.

*ME 5-C The person responsible for collecting precipitation samples must use a standard precipitation gauge with a maximum detection limit of 0.2 mm.*

*ME 5-D The person responsible for collecting precipitation samples must use automated precipitation sampling equipment with a movable cover to collect precipitation samples from ambient air.*

*ME 5-E The precipitation sampling equipment in ME 5-D must:*

- (a) *be equipped with a wetness sensor;*
- (b) *have sampling surfaces that are chemically inert for the constituents measured;*
- (c) *seal and protect the sample from contamination during dry periods;*
- (d) *have a precipitation sample container with sufficient volume to hold all precipitation collected during the sampling period; and*
- (e) *have a housing of stainless steel construction with splash screens.*

All surfaces that the precipitation sample comes into contact with are considered the sampling surface. This can include precipitation sample containers and funnels if used. Polyethylene, polypropylene, and Teflon (or a Teflon coating) are satisfactorily inert to the precipitation constituents being measured and therefore are recommended materials for the precipitation sample container or funnel. The container height should be at least twice its diameter to reduce the potential for snow to blow out of the container. Splash screens prevent sample contamination from the instrument surface.

To facilitate cleaning and routine maintenance, it is recommended that precipitation sampling equipment used have an option for manual activation. When individual components such as the sensor are removable, it is easier to repair sampling equipment.

### **5.3 Sampling Equipment Installation**

The appropriate installation of equipment is important to limit sample contamination and allow for optimal functioning of the equipment.

- ME 5-F The person responsible must install precipitation sampling equipment as specified by (a) the manufacturer's specifications and (b) the Site Selection Chapter (Chapter 3) of the AMD.*
- ME 5-G The person responsible must install a standard precipitation gauge at every precipitation sampling site.*
- ME 5-H The standard precipitation gauge in ME 5-G must be installed as specified by (a) the manufacturer's specifications and (b) the Site Selection Chapter (Chapter 3) of the AMD.*

The standard precipitation gauge may need to be sited away from other precipitation sampling equipment in order to appropriately locate the equipment.

### **5.4 Sampling Equipment Operation and Weekly Maintenance**

- ME 5-I The person responsible must (a) operate and (b) maintain the precipitation sampling equipment in accordance with the manufacturer's specifications.*

*ME 5-J The person responsible must (a) operate and (b) maintain the standard precipitation gauge in accordance with the manufacturer's specifications.*

*ME 5-K During weekly visits to the precipitation sampling site, the person responsible must:*

- (a) clean any ice, snow, or other debris build up on the wetness sensor of precipitation sampling equipment;*
- (b) check that the wetness sensor of the precipitation sampling equipment is functioning properly;*
- (c) clean the sensor grids;*
- (d) check that the sensor grid heater is functioning properly;*
- (e) check that the moving cover of the precipitation sampling equipment is clean of any debris;*
- (f) check that the moving cover mechanism of the precipitation sampling equipment moves freely during open and close cycles; and*
- (g) check that all other components of (a) the precipitation sampling equipment and (b) standard precipitation gauge are operating according to the manufacturer's specifications.*

The sensor grids are exposed to weather, dust, dirt and pollutants and can malfunction if they are not kept clean. To clean sensor grids, turn the power off and wipe using a damp sponge or cloth and mild detergent, if necessary. Wipe away any dry film that may appear on the grid.

Operation of the wetness sensor can be tested by touching the sensor with a damp finger with the power to the precipitation sampling equipment turned on. The cover should move within 5 seconds and close 120 seconds after the sensor has been activated. Consult the manufacturer's manual for trouble shooting steps if the cover does not open during this test.

The operation of the heater can be tested by placing a hand just slightly above the surface of each grid, with the power to the precipitation sampling equipment turned on and feeling the warmth from the grid.

Every week, after the precipitation sample has been prepared for shipment according to Section 5.5, the precipitation sampling equipment is prepared for another sampling period.

*ME 5-L Prior to commencing each sampling period, the person responsible shall prepare the precipitation sampling equipment by rinsing the sample collection container and other surfaces that come into contact with precipitation twice with deionized water.*

*ME 5-M The person responsible shall install the precipitation sample container onto the precipitation sampling equipment according to the manufacturer's specification.*

*ME 5-N The person responsible must (a) operate and (b) maintain the precipitation sampling site, precipitation sampling equipment, and standard precipitation gauge in accordance with the documented Standard Operating Procedure as per ME 5-A.*

## **5.5 Sample Collection Supplies**

The dissolved substances in the precipitation sample are in low concentration and any contamination will yield erroneous results (World Meteorological Organization Global Atmosphere Watch 2004). To prevent contamination, it is important to carefully handle sampling equipment and samples.

*ME 5-O The person responsible shall have the following supplies available for sample collection, handling and shipment at a precipitation sampling site:*

- (a) field sheets to record sample and sampling period information;*
- (b) sterilized sample bottles with lids to hold sample for shipment to the laboratory;*
- (c) deionized water of known quality to rinse the sample collection surfaces;*
- (d) shipping cooler with laboratory address; and*
- (e) sterile disposable gloves.*

Sample bottles, deionized water and the shipping cooler are typically provided by the laboratory. The sample bottles are labelled with laboratory identification and other information required for the completion of precipitation sampling field sheets.

The potential for sample deterioration increases with increased time between collection and analysis (World Meteorological Organization Global Atmosphere Watch 2004). Thus, it is important that the precipitation samples are shipped promptly to the laboratory.

Avoid removing samples during precipitation events. If the precipitation has not paused after a few hours, the sample should be collected and a note made on the field sheets.

## **5.6 Precipitation Depth Measurement**

Precipitation depth is used in calculating the mass of deposited chemicals associated with wet deposition. Standard precipitation gauges are the most representative method of determining precipitation depth; of these, manual gauges are recommended (World Meteorological Organization Global Atmosphere Watch 2004). A manual gauge may require the transfer of collected precipitation into a measuring cylinder to determine precipitation depth. In the case of solid precipitation, the collection would be allowed to melt prior to transferring to measuring cylinder.



*ME 5-P At the end of each sampling period, the person responsible shall read the precipitation depth from a standard precipitation gauge using the manufacturer's specified method.*

*ME 5-Q The person responsible shall note the precipitation depth from ME 5-P onto a precipitation sampling field sheet.*

## **5.7 Precipitation Sample Preparation and Shipment**

A precipitation sample collection period is seven days or 168 hours. A sampling period may run over two calendar years.

*ME 5-R The person responsible must collect a precipitation sample every seven days.*

*ME 5-S The person responsible must remove all snow from the body of the sample collector before opening the collector to remove the precipitation sample.*

*ME 5-T When preparing precipitation samples for shipment to the laboratory, the person responsible shall use a clean heated indoor space at the precipitation sampling site(s).*

*ME 5-U At the end of each seven day sampling period, the person responsible shall:*  
*(a) remove the precipitation sample container from the precipitation sampling equipment;*  
*(b) take the precipitation sample container indoors;*  
*(c) transfer all contents of the precipitation sample container into sample bottle(s), including any debris found in the precipitation sample.*

Debris that may be found in a precipitation sample includes windblown organic matter (e.g., leaves, bugs) and dust. All debris should be transferred with the sample into sample bottle(s) and shipped to the laboratory conducting the precipitation analysis.

*ME 5-V If the sample in ME 5-U is frozen it must be allowed to melt at room temperature before transferring to the sample bottle(s).*

In cases where the amount of precipitation sample collected exceeds the capacity of one sample bottle, the remaining sample amount may be transferred into additional sample bottle(s). Additional sample bottles should be indicated on the precipitation sampling field sheet.

*ME 5-W The person responsible must wear sterile disposable gloves when handling the precipitation sample or the inside surface of the precipitation sample container or sample bottle(s).*

*ME 5-X The person responsible must complete, without omission, a precipitation sampling field sheet (a) for every seven-day sampling period, (b) for each precipitation sampling site.*

*ME 5-Y The person responsible must record (a) all equipment malfunction and (b) any sample spillage that occurs during a sample week, in the comments section of the field sheet.*

Equipment malfunction may include inoperable wetness sensor or sample collector lid.

Every year, 52 field sheets will be completed and submitted for each precipitation sampling site; one for every sample week. Field sheets need to be completed for sampling periods with precipitation and for dry sampling periods. An example of a precipitation sampling field sheet is provided on the AMD website. The field sheet has a check box to indicate when there was no precipitation for the sampling period and therefore no sample was collected (dry sampling period).

*ME 5-Z The field information entered into the precipitation sampling field sheet in ME 5-X must be (a) complete and (b) written legibly.*

*ME 5-AA For the precipitation sampling field sheet in ME 5-X, all time references must be made using the 24-hour clock and Mountain Standard Time.*

*ME 5-BB If the person responsible fails to collect the sample as per ME 5-R, the sample field sheet for each sample week shall be submitted with appropriate comment(s) to explain the reason(s) behind the missed sample week.*

*ME 5-CC In preparing a precipitation sample for shipment to a laboratory, the person responsible must:*

- (a) fill in the required field(s) in the precipitation sampling field sheet from ME 5-X;*
- (b) place the (i) completed precipitation sampling field sheet, and (ii) sample bottle(s) into a shipping cooler;*
- (c) pack the shipping cooler with ice packs; and*
- (c) ship the cooler to the laboratory.*

*ME 5-DD The person responsible must ship all precipitation samples to the laboratory promptly so that the precipitation samples are received by the laboratory no later than 7 days following the precipitation sample collection end date.*

Some level of sample degradation will occur during sample collection and shipment. In order to minimize sample degradation, precipitation samples should have short storage and shipment times. If the sample needs to be stored at the sample site for a short period of time, it should be refrigerated at 4°C.

*ME 5-EE In the case where there was no precipitation during the sampling period, the person responsible shall ship the completed precipitation sampling field sheets in ME 5-X and an empty sample bottle to the laboratory.*

## **5.8 Analytical Laboratory**

The quality assurance requirements for a laboratory used to conduct precipitation chemistry analysis are outlined in the Quality System Chapter of the AMD (Chapter 5).

*ME 5-FF The person responsible must select a laboratory to conduct the analysis of precipitation samples which complies with the quality assurance requirements for a laboratory outlined in the Quality System Chapter of the AMD (Chapter 5).*

*ME 5-GG The person responsible must have the precipitation sample collected in ME 5-R analyzed, at a minimum, for the parameters listed in Table 3.*

*ME 5-HH The person responsible must select a laboratory which meets the following criteria to conduct the precipitation sample analysis:*

- (a) operates under current ISO standard governing procedures in all measurement and calibration associated with each analysis required by the person responsible;*
- (b) uses the analytical approaches recommended in the Global Atmospheric Watch Precipitation Chemistry Programme for the parameters listed in Table 3;*
- (c) reports measured values with appropriate significant digits to reflect the true certainty of the analytical method; and*
- (d) uses data quality flags to indicate quality of analysis results.*

A link to Global Atmospheric Watch Precipitation Chemistry Programme (World Meteorological Organization Global Atmosphere Watch 2004) can be found on the AMD website.

*ME 5-II The person responsible must instruct the laboratory conducting the precipitation sample analysis to clean sample bottles with deionized water of known quality prior to sending them to the sampling site.*

*ME 5-JJ The person responsible must request that the shipping cooler in ME 5-O (d):*

- (a) be labelled with the laboratory address;*
- (b) contain (i) two cleaned and labelled sample bottles and (ii) one bottle of deionized water; and*
- (c) be shipped in a timely manner so as to be available for sample collection.*

**Table 3 Parameters measured in precipitation samples**

pH
specific conductance
acidity (by Gran's plot)
sulphate
nitrate
ammonium
sodium
chloride
potassium
calcium
magnesium
orthophosphate
conductivity (25°C)

## 5.9 Precipitation Chemistry Data Handling

*ME 5-KK The person responsible for handling laboratory analysis results in preparation for publishing or reporting of precipitation chemistry data must use the Precipitation Chemistry Data Handling and Preparation document to prepare and analyze precipitation chemistry data.*

The Precipitation Chemistry Data Handling and Preparation document can be found on the AMD website.

## 5.10 Precipitation Chemistry Network Monitoring Plan

A precipitation chemistry network monitoring plan is documentation of precipitation monitoring program(s) proposed or in place for a particular area.

*ME 5-LL The person responsible for the design, deployment and operation of Alberta's precipitation chemistry monitoring network shall (a) develop and (b) maintain a current monitoring plan for the provincial precipitation chemistry monitoring network.*

*ME 5-MM The monitoring plan in ME 5-LL shall at a minimum include:*

- (a) responsible authorities for the monitoring plan;*
- (b) monitoring objectives;*
- (c) description of sensitive receptors;*
- (d) description of the provincial precipitation chemistry monitoring network;*

- (e) description of each monitoring site including site evaluation results as per ME 5-B;*
- (f) description of equipment deployed;*
- (g) responsible or delegated authorities for the operation of each site; and*
- (h) contingency plans or risk management for ongoing operations of the monitoring program.*

## **6.0 Vegetation Monitoring**

Monitoring for fluoride content in vegetation is required in circumstances where fluoride might accumulate in vegetation or forage as a result of industrial emissions. Fluoride accumulation in vegetation could result in adverse effects on plants or the health of grazing animals. This section applies to industrial operations which are required by an approval to monitor fluoride levels in vegetation samples.

### **6.1 Fluoride Analysis**

It is important that the analytical method used to determine the level of fluoride in vegetation gives an accurate quantitative determination of fluoride so as to determine any potential effects on the vegetation or grazing animals.

*ME 6-A The person responsible shall submit to the Director in writing the proposed vegetation fluoride analysis method for authorization prior to conducting any vegetation fluoride monitoring.*

*ME 6-B The person responsible shall use only the vegetation fluoride analysis method that has been authorized in writing by the Director.*

*ME 6-C The person responsible shall collect all vegetation samples for fluoride analysis after rain and dew drops have dried to limit dissolution of fluorides.*

*ME 6-D The person responsible shall have all vegetation samples analyzed for fluoride on an unwashed basis.*

## **7.0 Industrial Source Monitoring**

The purpose of the Industrial Source Monitoring section is to provide clarification and guidance on industrial source monitoring that is required through industrial approval conditions and Alberta legislation (Alberta Stack Sampling Code, CEMS Code and other reference sources).

This section applies to industrial operations which are required to conduct source emissions monitoring as part of their approval requirements.

## 7.1 Sampling Procedures

- ME 7-A The person responsible shall conduct manual stack surveys, and analyze samples, in accordance with (a) the Alberta Stack Sampling Code, as amended, and (b) the following, as applicable:*
- (i) the Methods Manual for Chemical Analysis of Atmospheric Pollutants, as amended;*
  - (ii) US EPA promulgated methodologies, as amended; and*
  - (iii) other methods, if authorized in writing by the Director.*
- ME 7-B The person responsible shall conduct RATAs and CGAs, and analyze samples, in accordance with (a) the CEMS Code and (b) the following, as applicable:*
- (i) the Alberta Stack Sampling Code, as amended;*
  - (ii) the Methods Manual for Chemical Analysis of Atmospheric Pollutants, as amended;*
  - (iii) US EPA promulgated methodologies, as amended; and*
  - (iv) other methods, if authorized in writing by the Director.*
- ME 7-C When conducting (a) manual stack surveys, (b) RATAs, and (c) CGAs, the person responsible must obtain written authorization from the Director prior to making any modifications to the methods prescribed by ME 7-A and ME 7-B.*

Prior written authorization by the Director is required for any methodologies which are not approved EPA methodology or included in the Alberta Stack Sampling Code or Methods Manual for Chemical Analysis of Atmospheric Pollutants.

Note: Alberta winter conditions can pose safety risks associated with source sampling during cold weather conditions. Where the sampling location or access is unsheltered, it is recommended to schedule source sampling according to weather conditions.

- ME 7-D When conducting (a) RATAs or (b) CGAs, the person responsible must ensure all measurements are representative of the CEMS operation and performance at the time of testing.*

## 7.2 Notification of Planned Stack Surveys

The Reporting Chapter (Chapter 9) of the AMD provides requirements for notifying the Director in advance of any source survey or RATA, including the process and format for notification.

### 7.3 Industrial Source Monitoring Reports

For requirements on preparing source monitoring reports, refer to the Reporting Chapter (Chapter 9) of the AMD.

### 8.0 References

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Any comments, questions, or suggestions regarding the content of this document may be directed to:

[ESRD.AMDFeedback@gov.ab.ca](mailto:ESRD.AMDFeedback@gov.ab.ca)

Air Policy  
Alberta Environment and Parks  
Main Floor, Oxbridge Place  
9820 – 106 Street  
Edmonton, Alberta T5K 2J6

Website: [AEP.alberta.ca/](http://AEP.alberta.ca/)

Original signed by: \_\_\_\_\_  
Hamid Namsechi, Director  
Air Policy  
Environment and Parks

Date: August 3, 2016



## **Appendix                      Guidance on the Determination of Precision and Accuracy for Passive Samplers**

Passive samplers (also called diffusive samplers) are devices for measuring time-weighted average concentrations of air pollutants. A passive sampler collects gas or vapour from the atmosphere at a rate controlled by a physical process, such as diffusion through a static air layer or permeation through a membrane. There is no active movement of the air through the device and concentration values are obtained by laboratory analysis of the exposed sampler (HSE 1994). It is a less expensive way to monitor with greater spatial coverage than continuous monitoring methods, where integrated sampling data are suitable for the monitoring goal.

In Alberta, a passive monitoring network may supplement (not replace) continuous monitoring for industrial or regional ambient air reporting. The major purposes are:

- to provide information on overall spatial patterns and temporal trends of selected air pollutants;
- to provide a basis for regional reporting, and for analyses for public information; and
- to compare with available ambient air quality criteria.

This Appendix includes guidance on a) passive sampler validation and b) precision and accuracy determination for field sampling, including associated calculations. The specific level of precision and accuracy desired will depend on the monitoring objectives.

### **Passive Sampler Validation Guidance**

Refer also to Section 3.1.1, Passive Sampler Validation, of the Monitoring Chapter.

Existing standards and protocols for passive sampling mainly focus on human health exposure in the indoor environment (HSE 1994 and Hull 1984), with the exception of the European Standards EN 13528-1, 13528-2, and 13528-3 which are for ambient air (CEN 2002a, 2002b, 2003). However, these available protocols are very comprehensive and detailed, which may not be practical to follow in many applications. For Alberta, a passive sampling protocol should focus on the purpose and practical application of passive sampling in the field. This portion of the Appendix is intended to provide guidance for performing passive sampler validation in Alberta.

### **General**

Passive samplers for validation should be installed in triplicate. The exposure period must be consistent with the period the sampler is to be used in accordance with manufacturer's recommendations (e.g., 30 days). Use for a period other than the recommended time must be validated.

The AMD outlines passive sampling siting requirements (Site Selection Chapter, Chapter 3) and requirements for installation and determination of sampling rate (Monitoring Chapter, Chapter 4). In addition, records should be kept on the determination of the sampling rates, the

determination of accuracy and precision of passive samplers, and the sampler detection limits for the sampling periods in accordance with the Quality System Chapter (Chapter 5) of the AMD. Analysis of passive samplers should be done only by accredited laboratories, as described in the Quality System Chapter (Chapter 5) of the AMD, preferably by the same laboratory, for the same pollutant, from all passive samplers to reduce inter-laboratory variability.

### **Detection limits**

For passive samplers, the detection level (DL) is calculated as 3 times the standard deviation in the blank samples. Blank samples should be determined by analyzing unexposed laboratory blanks, in replicates of six, for the mean and standard deviation of blank values. DL depends on sampling time, so the appropriate DL is to be used for a given sampling period.

Values below the detection limit are called “non-detects” or Less Than Values (LTVs). For the purpose of data entry, consistency in coding LTVs is necessary as these contain important information. The LTVs should not be discarded and should be coded as <DL with the DL value specified, and not as zeroes or any other values. For example, for a detection limit of 0.1 ppb, a value of <0.1 ppb should be entered when the measurement is below detection. It is possible to have more than one DL in a data set. In that case, <DL should be entered, with the appropriate DL values specified.

### **Bias, precision, correlation and accuracy**

For validation, bias should be within  $\pm 25\%$  of the true value at 95 % confidence limits (CL). Precision, represented by the coefficient of variation (CV), should be  $\leq 10\%$ . See Part A in the Calculations section of this Appendix for the determination of bias and precision.

For determination of accuracy, there should be at least one site where passive samplers are co-located with a reference method monitor in the field (referred to as a “validation site”). This co-location provides a means of assessing the relative performance of passive samplers, i.e., comparing the passive sample result to the “true value” from the reference method monitor under actual field conditions.

The passive sampler and reference method monitor measurements should have a significant correlation coefficient at the 5 percent level, over at least 12 consecutive months, and have a mean error within 25% (ideally within 10%). See Part B in the Calculations section for the determination of correlation and accuracy.

When co-locating at the validation site, 7 passive samplers should be used for exposure and 2 passive samplers as blanks. The measurements from passive samplers are to be compared with the reference method monitor measurements to determine the relative performance of the passive samplers in the field.

To determine the blank-adjusted passive sampler value for the validation period, average the passive sampler values then subtract the average blank values from the validation site. When comparing passive sampler and reference method monitor measurements, the data from the

reference method monitor must be integrated over the same sampling period as the passive samplers so that comparisons can be made.

Similar calculations to those provided in Part A and Part B may be used with field sampling data, as described below.

## **Precision and Accuracy Determination Guidance for Field Sampling**

Refer also to Section 3.1.3, Quality Control Samples for Field Sampling, of the Monitoring Chapter.

This portion of the Appendix is intended to provide guidance on determining the precision and accuracy of passive sampling results. The suggested calculations would provide some basic information as a preliminary analysis. Depending on the results, other approaches may be used to provide more detailed information or more representative results.

### **Precision**

See Part A in the Calculations section of this Appendix; precision may be determined by calculating the coefficient of variation (CV) using replicate (e.g., duplicate) passive sample pairs where in this case, in contrast to validation,  $\bar{x}$  is the mean of absolute differences between each pair. Each pair is considered a data point. Over a monitoring year for example, all data points from each sampling period (e.g., each month) may be included in the calculation; where sampling occurs year round, the minimum sample size would be 12 per year. For a larger dataset, resulting in a more robust estimation, multiple years of data could be included where available.

In addition, the mean absolute difference between replicates, or for skewed data the median absolute difference between replicates data, could provide a more practical reference for precision (i.e., in ppb rather than percent) where the ambient concentrations are low.

### **Accuracy**

See Part B in the Calculations section; accuracy may be determined by calculating the mean error using co-located inter-comparisons (co-located pairs). Each co-located pair (one passive sampler with a corresponding reference method monitor) is considered a data point. Where duplicate passive samplers are co-located with a reference method monitor, each duplicate (rather than an average of the duplicates) should be compared to the monitor resulting in 2 data points. Over a monitoring year for example, all data points from each sampling period (e.g., each month) may be included in the calculation; where sampling occurs year round, the minimum sample size would be 12 per year. For a larger dataset, resulting in a more robust estimation, multiple years of data could be included or additional co-located pairs could be deployed.

In addition, the mean absolute difference between co-located pairs, or for skewed data the median absolute difference between co-located pairs, could provide a more practical reference for accuracy (i.e., in ppb rather than percent) where the ambient concentrations are low. Furthermore, if the mean difference, or for skewed data the median difference, is also calculated,

any trend in overestimation (+ sign) or underestimation (- sign) relative to the reference method monitor may be observed.

## Calculations

### Part A: Calculation of bias and precision

Bias is the difference between the sample mean and the known value. For validation, this may be determined in the laboratory. It is defined as:

$$Bias = \frac{\bar{x} - x_0}{x_0} \times 100$$

where  $\bar{x}$  is the mean of sample data and  $x_0$  is the known value at level tested (e.g., specific concentrations set in laboratory). For validation, the sample consists of seven passive samplers ( $n = 7$ ) exposed under the same conditions for a given concentration level. The 95% confidence limit of the bias, in percent, is computed as follows:

$$\left[ \frac{\bar{x}_L - x_0}{x_0} \times 100, \frac{\bar{x}_U - x_0}{x_0} \times 100 \right]$$

where the first and second quantity in the above interval are the lower and upper confidence limit respectively. These should be within 25%. The following are used in the calculation.

$$\bar{x} = \sum_{i=1}^n x_i / n \quad \text{is the sample mean;}$$

$$\bar{x}_L = \bar{x} - t_{\alpha/2, n-1} \times s_{\bar{x}} \quad \text{is the upper confidence limit of the sample mean;}$$

$$\bar{x}_U = \bar{x} + t_{\alpha/2, n-1} \times s_{\bar{x}} \quad \text{is the lower confidence limit of the sample mean;}$$

$$s = \sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 / (n-1)} \quad \text{is the sample standard deviation;}$$

$$s_{\bar{x}} = s / \sqrt{n} \quad \text{is the standard deviation of the sample mean; and}$$

$$t_{\alpha/2, n-1} = 2.447 \text{ for 95\% confidence interval } (\alpha = 0.05) \text{ and a sample of seven.}$$

The median (e.g., of absolute differences between each pair of replicates) is the numerical value separating the higher half of data from the lower half of data, when the results are arranged in numerical order (i.e., the middle value). If there is an even number of data, then there is no single middle value in the list, so the median is calculated by summing the two middle values and

dividing by two. The greater the difference between the mean and the median, the more skewed the data may be; this can be used as a quick check on how skewed the data distribution is.

Precision may be represented by the coefficient of variation (CV), the same as the percent relative standard deviation, and is defined as

$$CV = \frac{s}{\bar{x}} \times 100$$

where  $s$  is the standard deviation of sample data and  $\bar{x}$  is the mean of sample as defined before. For validation, this may be determined in the laboratory. The CV should be less than 10%, which is a precision of over 90%.

A scatter plot (passive sampler concentration versus corresponding replicate passive sampler concentration) is recommended to assist with interpretation of the data.

### Part B: Calculation and test of correlation coefficient

Let  $x$  be the observation from the passive sampler and  $y$  the observation from the reference method monitor (as the true value) over the same time period in the field. The correlation coefficient is calculated as:

$$r_{xy} = \frac{\frac{1}{n-1} \sum_{i=1}^n [(x - \bar{x})(y - \bar{y})]}{\left[ \frac{1}{n-1} \sum_{i=1}^n (x - \bar{x})^2 \right]^{0.5} \left[ \frac{1}{n-1} \sum_{i=1}^n (y - \bar{y})^2 \right]^{0.5}}$$

where  $\bar{x}$  is the mean of passive sampler data,  $\bar{y}$  is the mean of reference method monitor data, and  $n$  is the number of data pairs.

The significance of the correlation coefficient is assessed using the following statistic:

$$t = r \sqrt{\frac{n-2}{1-r^2}}$$

This statistic should be greater than the 95%  $t$  value with  $n-2$  degrees of freedom ( $t_{\alpha=0.05, n-2}$ ) to give a significant correlation. This is a one-tailed situation since negative correlation is not expected. For  $n = 12$  (e.g., based on 1 co-located sample per month over 12 months),  $t_{\alpha=0.05, 10}$  is 1.812.

Accuracy may be represented by the mean error from the inter-comparison of a passive sampler ( $x$ ) and corresponding reference method monitor (as the true value,  $y$ ). Error  $e$  is defined as the percentage difference of each co-located pair as described by

$$e = \frac{x - y}{y} \times 100.$$

The mean error is the mean of all  $e$  computed. The mean error should be within 25% (ideally within 10%), which is an accuracy of over 75% (ideally over 90%). A scatter plot (passive sampler concentration versus corresponding reference method monitor value) is recommended to assist with interpretation of the data.

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