

PART B
AIR AND AIR EMISSIONS TESTING

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HIVOL SAMPLING TO ASSESS CHRONIC HAZARD OF TRACE METALS IN AIR PARTICULATES

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1. Guidelines for the HiVol Sampling Procedure for Assessing Chronic Hazard Associated with Trace Metals in Particulates

Three requirements of the sampling procedure are:

- That the lab provide quality control information to accompany all reported measurements.
- That trip blanks accompany every 5 samples collected, and that 5 blank filters be analyzed prior to field circulation for every new filter type put into use.
- That the Hi Volume sampler draw a sample over a full 7 days per filter, and that the 7 day sampling intervals be contiguous (one interval following immediately after another) over the course of a full year.

These requirements maximize the amount of information obtained from the current sampling equipment and lab methodologies so that a chronic exposure hazard can be calculated with the greatest accuracy without significantly increasing the costs of sample collection and analysis.

Other requirements are:

- That the site meet Ministry standards for particulate sampling.
- That the motor exhaust from the HiVol must be vented away from the sample inlet according to Ministry standards.

Any lab providing analysis services must meet Ministry certification requirements.

2. Background

An assessment of the chronic impact of trace metals involves calculating the average metal concentration found in a sequence of samples. The HiVol sampling method involves drawing particulate onto a filter. Lab analysis of the sample will determine the combination of metals in the sample and metals in the filter.

In calculating an averaged ambient metal concentration, the averaged metal content of the filters must be subtracted from the averaged total (sample and filter) of the metal measured. The greatest source of uncertainty in calculating ambient metals concentrations is generally due to the variability in the metal composition of the filter.

3. Quality Control

Because metal quantities are often present in concentrations which border on the threshold of detection:

- A proper understanding of the uncertainties and statistical distribution of the amounts of metals in the analyzed sample (filter plus collected particulate) is required, as is.
- A proper understanding of the uncertainties and statistical distribution of the amounts of metals in blank filters.

Under no circumstance should data be censored at a detection limit as this destroys the statistical profile.

All information provided from the lab analysis must include the quality control information. The intent is to separate bias and precision from overall uncertainties so that averaged quantities can be accorded an appropriate uncertainty. This also allows us to incorporate information, obtained from a variety of analytic sources (labs) and methodologies, into a statistical analysis, adjusting for bias and precision as required.

To mitigate the costs associated with quality control, samples can be processed in batches. However, to build a base of quality control information, a given batch should not contain more than 5 samples.

As quality control reference samples that contain metals in known quantities which match those found in a typical field sample become available, at least one reference sample must be included with every sample batch analyzed.

Because of the volume of information, all data from the lab analysis must be available electronically in a form that can be easily incorporated into Ministry databases. Labs that seek to provide analysis services must receive approval from the Ministry for the data delivery formats before submitting data.

4. Analysis of Blank Filters

A statistical base of information must be generated for every filter type used in the collection of ambient metal samples. This can be accomplished whenever a new filter type is introduced by having the lab provide an analysis of the metallic composition of 5 filters prior to their type being circulated. At present, only the Pallflex Teflon TX40HI20WW has been approved for metals analysis sampling. Other filter types must receive approval from the Ministry before being used.

The contamination associated with the field analysis can be determined by analyzing trip blanks. A trip blank is a blank filter that is delivered to the field site, placed on the HiVol sampler, removed immediately without activating the sampler, and then repackaged and shipped to the lab for analysis. To develop a base of information, trip blanks must accompany every 5 samples collected in the field. This will allow tracking of contamination and variations between filter batches.

Should a significant trend be noted in the trip blanks, it may be necessary to reanalyze a sequence of blanks (not trip blanks) to ensure that the filter composition has not shifted. If, after this, it is determined that the composition of the filter has not changed, the sampling methodology should be re-examined to ensure contamination is being minimized.

5. Sampling

- (a) The uncertainty introduced from the metal composition of the filter can be reduced if the amount of sample per filter is increased. This can be accomplished by running the HiVol sampler for more than 24 hours per filter.

The limit of how long to run a sample depends on the build-up of particulate on the filter, blocking air flow pathways through the filter and altering its screening properties. The suppliers of filters generally do not have maximum loading limits specified.

- (b) A rough estimate of acceptable loading can be obtained from maximum loadings from past measurements in BC. For TSP, this was 1.3 grams (ambient concentration of 787ug/M³ collected over 24 hours); for PM₁₀, this was 0.7 grams (ambient concentration of 419ug/M³ collected over 24 hours). No failure of equipment was noted for such loadings (over the 24 hours of the sample).

Actual loading limits will depend on the density and size of particulate collected, however, it is anticipated that the HiVol filter should not become overloaded if operated for 7 days in an environment where the ambient concentration rarely exceeds 100ug/m³.

- (c) For quality assurance, the flow rate of the HiVol must be measured at the beginning and end of the sampling interval, and this information must be available for incorporation into Ministry databases.
- (d) The number of days (7) is selected to fit within a normal work week schedule, and is long enough that the relative uncertainty associated with the metallic composition of the Teflon filters (Pallflex EMFAB TX40HI20WW) is less than levels set by current ambient objectives.

The number of days can be extended if it is demonstrated that this will not overload the HiVol sampler. The number of days can be reduced if filters of greater metallic purity (less trace metal composition, or more uniform metallic composition) are used. At present only the Pallflex Teflon TX40HI20WW has been approved for metals analysis sampling, so the sampling period must not be reduced without prior consultation with the Ministry.

- (e) The sampling must be performed over contiguous intervals (the next sample started as soon as the previous sample is finished) so that statistical artifacts associated with high (or low) concentration episodes can be minimized.
- (f) Equipment downtime is tolerable as long as samples are collected over at least 85% of the time for each calendar month. Experience with HiVol samplers that are run continuously shows that the brushes on the motor need to be replaced every month.

6. Revision History

October 10, 2013:	This section republished without change. Appendix 10.3 - Sample Container, Preservation, and Hold Times for Air (Vapours) included.
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1. Introduction

The requirements contained in this document are intended to supplement and update various stack sampling reference methods, and will clarify specific points as well as stating any requirements which may be unique to the Ministry of Environment, Lands and Parks (MELP).

1.1 Acknowledgements

The staff of the Greater Vancouver Regional District (GVRD) prepared the original version of this document which has subsequently been adopted and modified by the Ministry of Environment, Lands and Parks. Publication of the GVRD material is with the permission of the GVRD.

1.2 Purpose and Scope

This document standardizes sampling protocols and methods which may be required by permit, approval, regulation, or bylaw. It also serves as a guideline for stationary emission testing survey reporting for regulatory staff, permittees, and consultants.

Reference to the “Regulatory Body or Agency” means the governing body, Ministry of Environment, Lands and Parks and/or the delegated Greater Vancouver Regional District which regulates the discharge of contaminants into the air, as stated in the Waste Management Act (WMA). “Regulatory Administrator” has the same meaning as Director, District Director and manager, as defined in the WMA and Air Quality Director under Greater Vancouver Regional District Bylaw 725. “Regulatory Officers” has the same meaning as an officer defined in the WMA.

The Regulatory Administrator must be contacted if any deviations from the methods or equipment included in this code are contemplated (Appendix 7.1). Request for testing deviations require prior written approval by the Regulatory Administrator. Any questions with respect to details contained in this document should be directed to the attention of:

Director, Air Resources Branch
Environment and Resource Management
Department
Ministry of Environment, Lands and Parks
Location: 3-2975 Jutland Rd
Victoria, B.C. V8T 5J9
Mail: P.O. Box 9341 Stn Prov Govt
Victoria, B.C. V8W 9M1
Phone: (250) 387-9933 or 387-9932
Fax: (250) 356-7197

Director, Air Quality Department
Greater Vancouver Regional District
4330 Kingsway
Burnaby, B.C. V5H 4G8

Phone: (604) 436-6700
Fax: (604) 436-6707

1.3 Continuous Emission Monitoring

For in-stack continuous emission monitors (CEMs), the Regulatory Agency requires the use of Environment Canada or United States Environmental Protection Agency (U.S. EPA) protocols and performance specifications (as listed in Appendix 7.1), unless otherwise superseded by other Provincial or GVRD requirements.

1.4 Validation of New Methods

The Regulatory Agency may adopt new stationary source test methods that are not used in other jurisdictions provided the requirements of U.S. EPA Method 301 have been met (see Appendix 7.1 listing). The onus is on the source owner or operator proposing the new method to ensure that all the requirements of Method 301 have been met. Before a new method can be accepted, the Regulatory Administrator may require substantial documentation to indicate all the information required under Method 301 is supplied as appropriate.

1.5 Trade Names or Commercial Products

Mention of trade names or commercial products does not constitute endorsement by the Ministry of Environment, Lands and Parks or the Greater Vancouver Regional District.

2. Pre-Test Conditions

The following conditions must be met prior to sampling:

- All manual source testing results submitted to the Regulatory Agency must have been conducted or continuously supervised on-site by at least one individual who has passed relevant stack sampling courses as required by the Regulatory Administrator. Relevant courses include the following:
 - British Columbia Institute of Technology (BCIT), Stack Testing and Sampling;
 - Mount Royal College (Calgary), Stack Sampling Course;
 - University of Windsor, The Windsor Stack Sampling Course;
 - Fanshawe College (London, Ontario), Air Sampling and Evaluation LabII; and
 - United States Environmental Protection Agency (U.S. EPA), Source Sampling for Pollutants.

Note: It may be possible to challenge the above courses. Further information may be obtained by contacting the educational institution.

- It is the responsibility of the owner/operator of a facility to provide safe access to the chosen sampling location and a firm platform for obtaining samples shall be provided following Appendix 1 of this chapter and pertinent Workers' Compensation Board Regulations.
- The chosen sampling site must meet the minimum requirement of two stack diameters downstream and a half a diameter upstream from the last flow disturbance. Note that this requires more sampling points compared to a sampling site that is located eight stack diameters downstream and two diameters upstream from the last flow disturbance.
- The cross-sectional sampling point layout within a rectangular duct must be chosen such that the ratio of the length to the width is between 1.0 and 2.0.
- For particulate sampling, the mean rotational angle for all sampling points must not exceed $\pm 20^\circ$ from the 0° reference position (calculated as outlined in Appendix 2 of this chapter).
- For sources that operate under Provincial permit, approval, regulation or bylaw, the proponent is to provide the Regulatory Administrator with a minimum of five working days advance notice before emission compliance testing is carried out. Alternately, the proponent can provide the Regulatory Administrator with another mutually acceptable minimum advance notice duration, in writing, before emission testing is carried out.
- For sources that operate under GVRD permit, approval or bylaw, the proponent shall provide the Regulatory Administrator with a minimum of three working days advance notice before any emission compliance testing is carried out.
- The results of all air emission testing performed for regulatory compliance requirements under permit, approval, regulation or bylaw shall be retained by the facility, for a period of five years, and be made available to the Regulatory Administrator upon request.
- A detailed test plan must be submitted in writing for approval for any non-routine (e.g., Destruction Removal Efficiency or Special Waste Facility) testing programs 30 days prior to the scheduled sampling.

3. Additional Sampling Requirements

In addition to the requirements of the Reference Method for Source Testing: Measurement of Releases of Particulate from Stationary Sources (EPS 1/RM/8), or U.S. EPA Methods 1 to 5, the following requirements must be fulfilled for all compliance testing:

- A minimum of three test runs constitute a valid stack survey, unless the method being used specifically states otherwise. Where less than three runs are being used, the Stack Emission Survey Report must quote the language and section of the method that allows exception from the three test run requirement.
- For a valid stack survey, the individual test runs should be taken on the same day. The duration, over which the three test runs are extracted, for a valid stack survey, should not exceed two days. Any individual run shall be taken on one given day. Alternately, the proponent can provide the Regulatory Administrator with another mutually acceptable duration for stack sampling, in writing before emission testing is carried out.
- The results of individual test runs and the average of all test runs constituting a valid stack survey shall be reported. The arithmetic average of all test runs taken during a valid stack survey shall be used to assess compliance with the limits stated in permits, approvals, regulations or bylaws.
- The minimum duration of one complete test run must be 60 minutes, except testing for dioxins, furans, PCBs and PAHs which shall be a minimum of 240 minutes per individual test run, unless the method being used states otherwise. Where exception is being made, the language and section of the method that allows for this must be quoted in the Stack Emission Survey Report (see Appendix 9.1).
- The sampling nozzle shall be sized to obtain a sample volume of 1 m³ (as sampled) or greater for particulate testing.
- Sample points shall be calculated using the applicable tables found in EPS 1/RM/8 or the US EPA CFR 40 Part 60. The general guidelines are:
 - stacks with diameters greater than 61 cm - 12 point minimum, 24 point maximum (25 for rectangular stacks)
 - stacks with diameters between 30 and 61 cm - 8 point minimum, 24 point maximum (25 for rectangular stacks)

- Consult the applicable tables for calculating points at locations requiring more than the minimum number of points and less than the maximum.
- In the recovery procedure for a standard particulate test, acetone and deionised water must be used for washing the interior surfaces of the nozzle, probe, cyclone (if used), and filter holder (the front half of the sampling train). Make blank determinations on the acetone and water and subtract the weight from the washing particulate catch. The blank volumes approximate the average amount of water and acetone used for each front half wash.
- In performing grab sampling (e.g., bag, bomb, or container for independent analysis), unless the method being used states otherwise:
 - two grab samples withdrawn one after the other constitute a single test run,
 - a minimum of three test runs are required for each valid stack survey, and
 - an interval of at least one hour is required between the individual test runs.
- For cases where deviations from the above three conditions are applied, the Stack Emission Survey Report must quote the language and section of the method that allows the exception(s).
- High volume particulate sampling is considered to be non-standard and requires prior written approval from the Regulatory Administrator. If sampling by these methods has been approved, the method outlined in Appendix 3 of this chapter must be followed.
- Leak checks are mandatory and should be carried out as outlined in Appendix 4 of this chapter.
- Sampling under adverse conditions may require specialized equipment or procedures. Some of these are listed in Appendix 5 of this chapter.

4. Calibration Requirements

The following table outlines the general requirements for the calibration of source testing equipment:

Equipment	Interval	Recommended Procedure
Dry Gas Meter	Annually when equipment remains at a permitted facility. Every 6 months when equipment is used at various facilities.	Against a: <ul style="list-style-type: none"> • spirometer, • wet test meter, • calibration checked dry gas meter, and/or • critical orifice as indicated in U.S. EPA Method 5.
Magnehelic Gauges	Annually when equipment remains at a permitted facility. Every 6 months when equipment is used at various facilities.	Against an inclined manometer, as indicated in U.S. EPA Method 2.
Nozzles	Calibrate before initial field use. When nozzles become nicked, dented or corroded they are to be reshaped and calibrated prior to use.	Calibrate by measuring with a micrometer. Examine thoroughly prior to each field use. See U.S. EPA Method 5.
Pitot Tubes	After each field use re-examine. For a new pitot tube or in the event of any damage such that the pitot tube does not meet specification, repair and calibration is required.	Calibrate in a wind tunnel using the procedures outlined in U.S. EPA Method 2.
Thermocouples	Every 6 months.	Against a National Institute of Standards & Technology (N.I.S.T) thermometer, with ice, water, and hot oil as indicated in U.S. EPA Method 2.
Rotameters		Need not be calibrated, but should be cleaned and maintained according to the manufacturer's instruction, as indicated in U.S. EPA Method 3.

In addition to the requirements above, if critical orifices are used as a means of checking calibration, they are to be checked once every two years against a spirometer, wet test meter, or calibrated dry gas meter.

The calibration certificate must include all pertinent data, the date of calibration, and the name of the technician who performed the calibrations. Valid calibration certificates for all pertinent equipment used in the emission survey must be included in the report. The calibration sheets to be used are those referenced in Appendix 6 of this chapter, or those which include all the pertinent data outlined in these reference calibration sheets.

All calibrated instruments shall be permanently and uniquely identified for easy reference.

A copy of the most current calibrations shall be carried with the source testing team on all field tests and must be provided to Regulatory Agency audit staff or officer upon request.

Note that the stated interval of either six months or annually should be considered a maximum time frame, as calibrations must be conducted as required.

5. General Reporting Requirements

The stack emission survey reports must be tabulated, summarized, and forwarded to the Regulatory Administrator in the appropriate Region or District either as an attachment to the Permittees' quarterly reports or as a separate report.

All stack emission survey reports shall be clearly legible and contain the necessary detail as specified in the report requirements in Appendix 9 of this chapter. All reports shall include, but not be limited to, the information listed in Appendix 9, unless prior written authorization has been obtained from the Regulatory Administrator.

The electronic reporting of data may be required in the future.

6. Method Specific Reporting Requirements

In addition to the requirements specified in EPS 1/RM/8, or U.S. EPA Methods 1 to 5, the following outlines the minimum reporting requirements for Methods 1 through 5, high volume particulate sampling, and gaseous constant rate sampling.

6.1 Method 1 - Determination of Sampling Site and Traverse Points

- (a) Report all stack dimensions. A diagram of the sampling site must include the following:
 - Measured distance and number of duct diameters upstream and downstream from the last flow disturbance
 - Stack shape and cross sectional distances
 - Stack cross sectional area
 - Number of sample ports
 - Nipple length and diameter
- (b) Include the measured location of all traverse points, along with a notation of any points which have been combined during the testing period [i.e., multiple points within 1.3 to 2.5 cm (0.5 to 1 inch) of the stack wall].

6.2 Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate

- (a) A cyclonic flow check is required at each measurement location. In the report, include the rotational angle for each individual point as well as the calculated mean rotational angle for all sampling points. The cyclonic flow check need not be repeated for each survey provided a previous cyclonic flow check has been performed and no modifications affecting the flow patterns have taken place since that time.
- (b) Report the devices used for velocity measurement along with the range of the instrument used to measure the differential pressure. Calibration data is required for the S-type pitot tubes, standard pitot tubes, and/or magnehelic gauges used during the measurement period.

6.3 Method 3 - Determination of Gas Composition and Molecular Weight

6.3.1 Grab Sampling (Orsat or “Fyrite”)

Take a minimum of three individual samples during each test run - one at the start, midpoint, and conclusion of each test. Report the time the individual tests were carried out and the results of these measurements.

6.3.2 Integrated Sampling

Note the type of collection bag (Tedlar, Mylar, Aluminized Mylar) as well as the sampling time and rate. Report the time lapse between collection and analysis along with results of the leak check procedure performed on the system.

6.3.3 Continuous Sampling (Non-Permanent In-Stack)

- (a) Report the type of analyzer, method of detection, calibration procedure with results, and leak check results.
- (b) Report sample times and any interruptions or problems with the measurement system.

6.4 Method 4 - Determination of Moisture Content of Stack Gas

- (a) The moisture calculations for saturated conditions shall include two values:
 - 1. a moisture value from the condenser method
 - 2. a moisture value from a psychometric chart and/or saturation vapour pressure tables, as found in Appendix 10 of this chapter.
- (b) The lower of the two reported values is to be considered the correct moisture value and is to be used in all subsequent calculations.
- (c) Record the temperature of the last impinger for each sampling interval on the field sheet.
- (d) Record reported weights or volumes of impingers individually including the weight difference of the silica gel.

6.5 Method 5 - Determination of Particulate Emissions

- (a) Calibration sheets are required for the following equipment:
 - 1. Dry Gas Meters
 - 2. Pitot Tubes
 - 3. Magnehelic Gauges
 - 4. Orifice Meters
 - 5. Thermocouples
 - 6. Nozzles
- (b) A flow chart or schematic of the collection system components is required. This schematic shall indicate but not be limited to: the type of sampling probe liner, type and number of impingers, and contents and volume of impingers.
- (c) Leak tests are to be conducted as outlined in Appendix 4 of this chapter. The field sheets must document the time, vacuum reading, and the leakage rate.

- (d) The sampling field sheet must be complete and legible. Readings are taken and recorded for each sampling interval which must be a minimum of 2.5 minutes and a maximum of 5 minutes. This is to include:
 - 1. Stack temperature
 - 2. Velocity pressure (ΔP)
 - 3. Orifice pressure (ΔH)
 - 4. Dry gas meter, probe, hot box, and last impinger temperature
 - 5. Pump vacuum (millimeters of Hg)
 - 6. Dry gas meter volume
- (e) In addition, document all pre-test estimates of moisture, stack temperature, maximum velocity pressure and the nozzle estimate on field sheets.
- (f) Document the sample recovery procedure, including all clean up procedures for the sampling probe, cyclone, filter holder and impingers.

6.6 Continuous Emission Monitoring Survey (Non-Permanent In-Stack)

With the exception of sources covered under the MELP Asphalt Plant Regulation, three one-hour tests with calibrations run between each test are required for a valid continuous emission monitoring survey. Emission calculations for tests of one hour will be based on readings at one minute intervals (a minimum of 60 measurements).

For sources covered under the MELP Asphalt Plant Regulation, a single one hour test is required for a valid emission monitoring survey for organics and carbon monoxide. Calibration runs are to be performed both before and after the test. Emission calculations will be based on readings at one minute intervals (a minimum of 60 measurements).

Reports for continuous emission monitoring surveys shall include:

- (a) A detailed sampling system description and schematic diagram
- (b) Copies of digital or chart recorder printouts labeled with individual test start and finish times, chart speed, pre-and post calibrations, span, drift determination, parameters sampled, number of sample points, and NO_x converter efficiency.

- (c) Tables for:
 1. Analysis of calibration gases
 2. Analyzer calibration data
 3. System calibration bias and drift test
 4. Sample tables are found in Appendix 8 of this chapter.

6.7 High Volume Particulate Sampling Methods

Please note that Method 5 is mandatory and only for unusual circumstances will the use of the high volume procedure for compliance testing be considered. Prior written approval from the Regulatory Administrator is required, as it is a non-standard testing method. Information submitted to the Regulatory Agency shall include but not be limited to:

- (a) A detailed diagram of the sampling site including the duct locations where sampling was conducted.
- (b) A detailed schematic of the sampling apparatus.
- (c) Calibration sheets for the following equipment:
 1. Pitot tubes
 2. Magnehelic Gauges
 3. Thermometers
 4. Calibration curve for the flow orifice.
- (d) The size of the nozzle used.
- (e) The sampling field sheets and all information necessary to conduct the calculations. A sample calculation shall be conducted for one run. The percent isokinetics for each sampling point must be submitted.
- (f) Documentation of the sample recovery procedure which was used.

6.8 Determination of Gaseous Emissions from Stationary Sources

- (a) Sampling and analytical procedures must follow approved methods and be documented. Gas sampling trains shall be operated within the recommended maximum flow rates outlined in the method. Any deviation from recognized procedures will require prior written approval from the Regulatory Administrator.
- (b) A flow chart or schematic of the collection system components is required. This diagram must include the impinger contents and volumes as well as the type of impinger and sequence. Document the type of impinger connections.

- (c) Calibration sheets are required for:
 - 1. Dry Gas Meters
 - 2. Pitot tubes
 - 3. Magnehelics
 - 4. Thermometers
 - 5. Orifice meter

- (d) On the gas sampling field sheet, detail sampling conditions as described in Appendix 9 of this Chapter at an interval not greater than 10 minutes between readings.

- (e) In addition, Determination of Nitrogen Oxides (Flask Method) requires:
 - 1. The volume of the collection flask - flask valve combination must be measured prior to sampling. Record the measured volume on the flask.
 - 2. On the field sheet, include the flask volume and initial and final flask pressure and temperature. An initial and final barometric pressure are also to be included.
 - 3. Enclose the sampling field sheet and all information necessary to conduct the calculations. Include an example calculation for one run.

- (f) The sample recovery procedure must be documented.

7. Sources of Further Information

Alberta Stack Sampling Code. Publication Number: REF. 89 ISBN 0-7732-1406-2, 1995 version effective January 1, 1996.

Air Resources Branch; Source Testing Code (Version #2). Nov. 1980. Province of Ontario, Ministry of Environment, Report # ARB-TDA-66-80.

Asphalt Plant Regulation. BC Regulation 217/97, Deposited June 27, 1997, Province of British Columbia, Ministry of Environment, Lands and Parks.*

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III. 1988. United States Environmental Protection Agency, Environmental Monitoring Laboratory; Stationary Sources Specific Methods.

Standards of Performance for New Stationary Sources, Vol. 40. United States Environmental Protection Agency, Office of the Federal Register; Parts 53-60.

Source Sampling Manual Volume I. August 1981. State of Oregon, Department of Environmental Quality, Air Quality Control Division.

Occupational Health & Safety Regulation, BC Regulation 296/97, effective April 15, 1998, Workers Compensation Board of British Columbia.

Reference Method for Source Testing: Measurement of Releases of Particulate from Stationary Sources. December 1993. Environment Canada, EPS 1/RM/8.

Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation. September 1993. Environment Canada, EPS 1/PG/7.

* Available at http://www.qp.gov.bc.ca/stat_reg/regs/elp/R217_97.htm

8. Revision History

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|--------------------|--|
| October 10, 2013: | This section republished without change. Appendix 10.3 - Sample Container, Preservation, and Hold Times for Air (Vapours) included. |
| February 28, 2001: | The Stationary Air Emissions Testing Section was revised in detail, with the revised draft reviewed by private sector representatives. |
| November 1999: | Initial publication. |

Appendix 1 Platform, Access and Safety Requirements

Appendix 1.1 Additional Platform Access and Safety Requirements for Monitoring Stack Emissions

Appendix 1.2a Sampling Facilities on Circular Stacks

Appendix 1.2b Sampling Facilities on Circular Stacks

Appendix 1.3 Sampling Facilities on Rectangular Stacks

Appendix 1.4 Dimensions of a Stack Sampling Platform

Appendix 1.1 Additional Platform, Access and Safety Requirements for Monitoring Stack Emissions

The Workers' Compensation Board (WCB) of British Columbia helps create a working environment that protects the health, safety and well being of workers. To achieve this, the WCB administers the Occupational Health and Safety Regulation adopted under the authority of the Workers Compensation Act and the Workplace Act.

For platform access and safety requirements related to the monitoring of stack emissions, all applicable WCB requirements should be adhered to. The following section is intended only to serve as guidance for setting up stack sampling platforms, access ladders and other associated works. The latest WCB requirements are to be used in all cases where the following guidelines are in conflict.

- (a) Safe access to the sampling locations and a firm platform for obtaining stack samples shall be provided.
- Access ladders shall be constructed in accordance with the latest Workers' Compensation Board (W.C.B.) requirements. In addition, it is recommended that a "safety climb" with two sets of harnesses be provided.
- The basic platform shall be 1.07 metres (3.5 feet) wide with a 1.07 metre (3.5 foot) high railing. If 2 ports are required at 90°, the stack platform shall serve the quarter of the stack circumference between the ports and shall extend at least 0.91 metres (3 feet) beyond each port. The 1.22 metre (4 foot) section of the top railing in front of the ports (Fig. 1.1 and 2) shall be hinged in such a manner that the top rail can swing upward and over 180 degrees. This facilitates the movement of the sampling box and probe perpendicular to the stack during a traverse without interference from the top railing of the platform.
- The sampling port shall consist of a standard 10 cm (4 inch) male-threaded pipe nipple welded to the stack at the sampling location with a screw cap to cover the opening. The ports shall be installed flush with the interior stack wall and shall extend outward from the exterior stack wall at least 7.6 centimetres (3 inches). Properly grounded electric outlets of 110/120 volts (15-20 amps), near each sampling port, or, spaced in such a manner as to be accessible for sampling at all ports, shall be installed to provide power for the sampling train components and accessories. The sampling port shall be approximately 1.52 metres (5 feet) above the base of the platform. An eyebolt shall be installed 0.91 metres (3 feet) directly above each port. The eyebolt should be hooked

with a 3.2 millimetre (1/8 inch) steel cable of the length indicated in Fig. 3. This cable should be supplied by the platform owner and should remain on the stack for future testing.

- Circular stacks with an inside diameter greater than 1.22 metres (4 feet) or rectangular stacks (Fig. 2) with the largest dimension greater than 1.22 metres (4 feet), shall be equipped with platform extensions as indicated in Fig. 3. The required extensions are in addition to the basic platform width of 1.07 metres (3.5 feet) and must be firmly secured. The 1.22 metre (4 foot) width of the extension shall be centered around the traverse axis. Schematic diagrams showing facilities for circular and rectangular stacks are shown in Figs. 1, 1.1 & 2 respectively.
- Constant rate or gaseous sampling does not require the installation of multiple ports and eyebolts.
- (b) Access to working platform (W.C.B. regulation 30.14 and American National Standards Institute (A.N.S.I.) A143-3 1974);
 - Adequacy of the working platform (A.N.S.I. A14-3 1974);
 - Guardrail system around working platform (W.C.B. regulation 8.70 and 8.78);
 - Transfer of equipment up to the working platform (W.C.B. regulation 30.16).
- (c) The W.C.B. permits the Regulatory Agency to specify platform widths greater than 76 cm (30 inches), if desirable or necessary;
 - The stairs, ladder and platform must be certified by a Professional Engineer;
 - It is the responsibility of the stack owner to comply with Industrial Health and Safety requirements concerning the access to the stack and the platform.

Appendix 1.2a Sampling Facilities on Circular Stacks

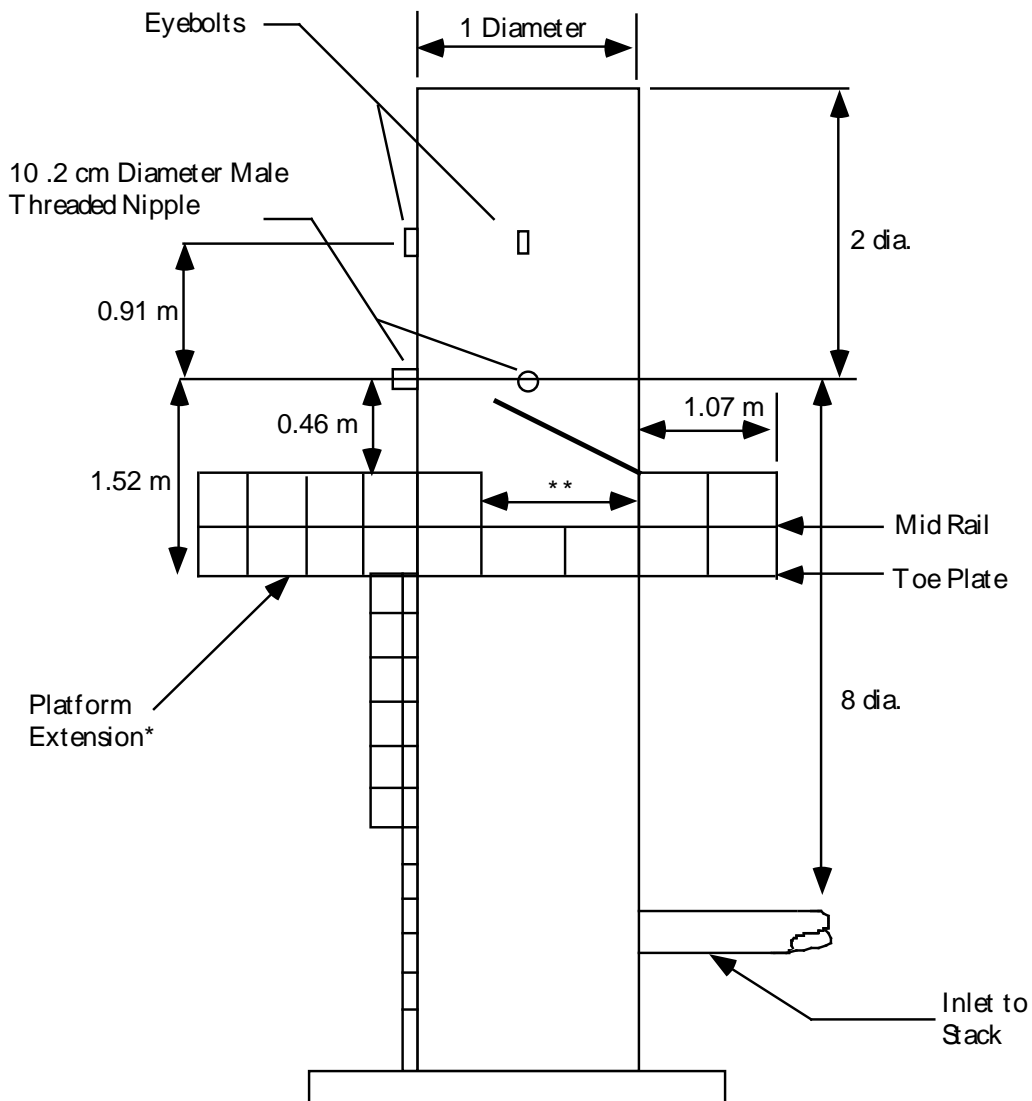


Figure 1

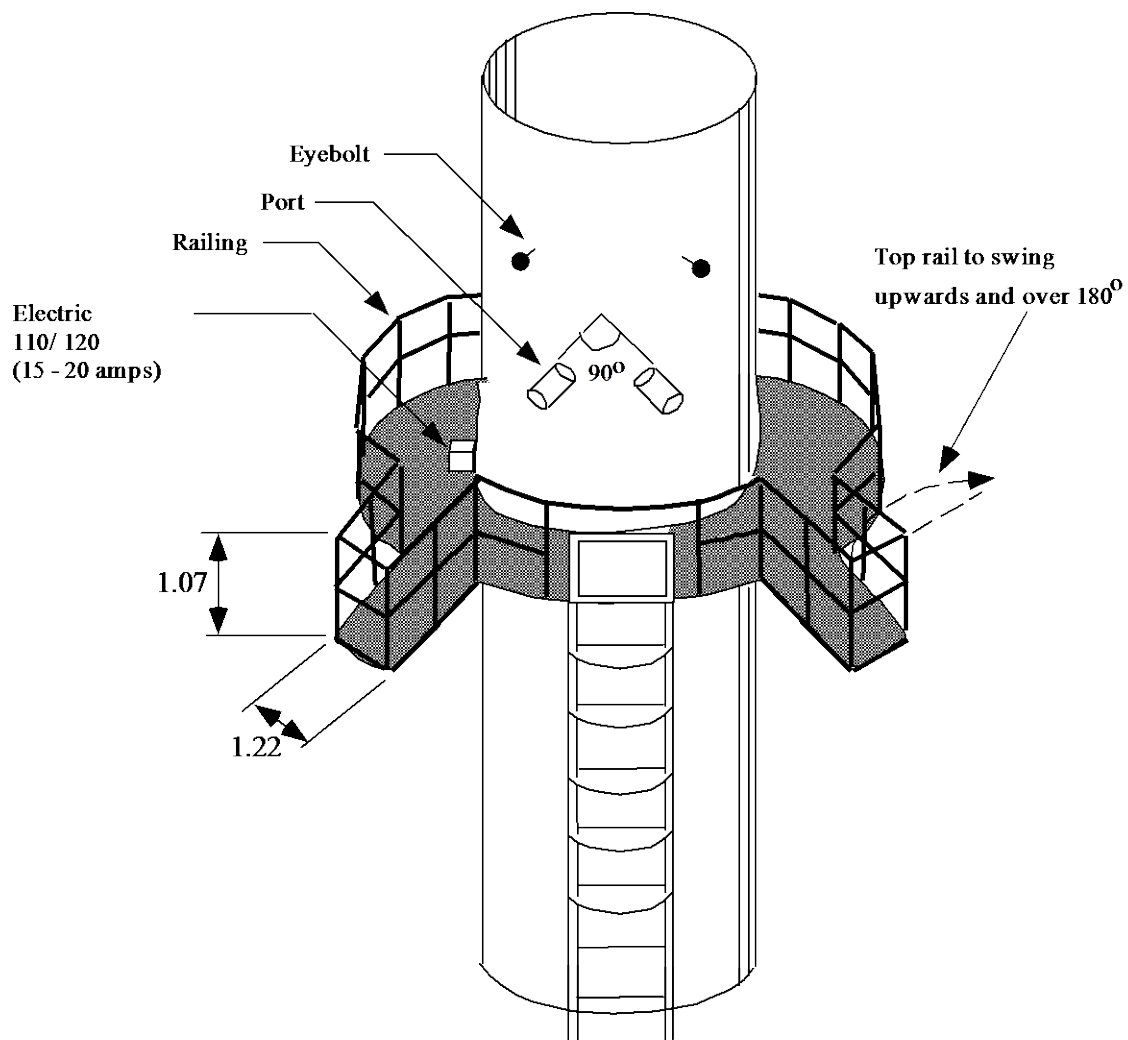
Note:

* Stacks with Inside Diameter (I.D.) less than 1.22 m do not require platform extension. See figure 1.1 for length of platform extension when I.D. is greater than 1.22 m.

** The 1.22 m top rail-guard in front of ports (with or without platform extension) shall be hinged to swing upwards and over 180 degrees when necessary.

All dimensions are in metres unless otherwise noted.

Appendix 1.2b Sampling Facilities on Circular Stacks



Schematic Diagram

Figure 1.1

All dimensions are in metres.

Appendix 1.4 Dimensions of a Stack Sampling Platform

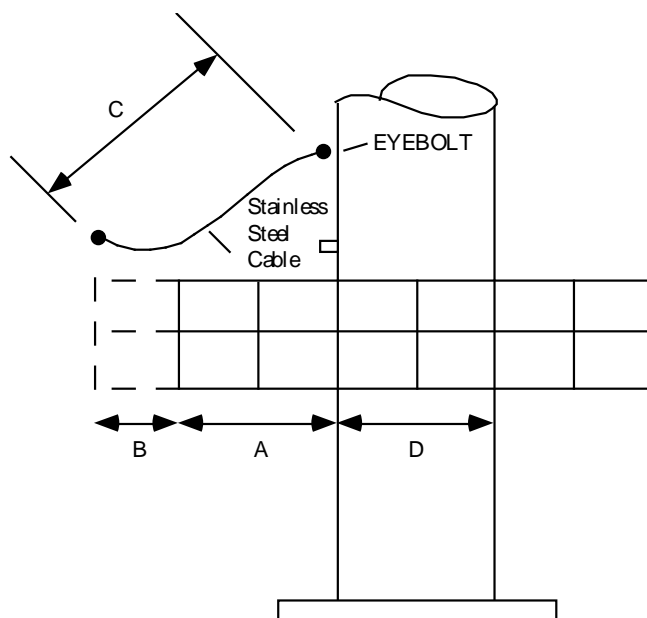


Figure 3

D DIAMETER OR LARGEST DIMENSION OF A STACK (m)	A BASE PLATFORM WIDTH (m)	B PLATFORM EXTENSION (m)	C LENGTH OF STEEL CABLE (m)
≤ 1.22	1.07	0	2.44
$1.22 < D \leq 1.83$	1.07	0.46	3.96
$1.83 < D \leq 2.44$	1.07	0.76	3.96
> 2.44	1.07	1.07	3.96

Appendix 2 Cyclonic Flow Check & Pitot Leak Check Procedure

Cyclonic Flow

Location of a suitable sampling site for velocity measurement or for particulate and mist determinations requires that the gas flow be essentially parallel to the stack walls.

If there is a possibility of cyclonic flow [as determined in Section 6.2 (a)], checks with a pitot tube and draft gauge should be made as follows:

Pitot Leak-Check

- (a) Connect calibrated S-type pitot tube to a manometer.
- (b) Leak check the system by drawing a vacuum of two to four inches of water on the manometer. The manometer reading should not change over a 15 second period.
- (c) Repeat this procedure applying a positive pressure to the system.
- (d) If the system leaks, correct the problem and repeat the leak check procedure.

Cyclonic Flow Check

- (a) Carefully zero the manometer and insert the pitot tube so that the planes of the face openings are perpendicular to the stack area cross sectional plane - that is, parallel to the expected gas flow. The pitot tube is thus rotated 90° from its usual position.
- (b) Traverse the stack area by measuring the velocity head at each sampling point with the pitot tube in this position. Keep the sampling port opening sealed while traversing. Temperature need not be measured at this time.
- (c) When the gas flow is exactly parallel to the stack walls and, therefore, parallel to the pitot tube face openings, no reading will be obtained on the manometer. If a reading is obtained, rotate the pitot tube around its longitudinal axis until a zero reading is indicated on the manometer.
- (d) Record the angle of rotation for each point (starting with 0° in the pitot tubes initial position) required to obtain a zero manometer reading.
- (e) Obtain an arithmetic average of the angles of rotation at each traverse point, including angles of 0°. If the average angle of rotation is < 20°, the gas flow conditions are acceptable. If the average angle is > 20°, the conditions are not acceptable; testing must be halted and the Regulatory Administrator is to be consulted.

To facilitate measurement of pitot tube rotation, a number of devices can be made, depending on the user. Fabrication of a protractor that will fit over the sampling port along with a movable indicating arm clamped to the pitot tube will provide a measurement of the angle of rotation. A level indicator (available at most hardware stores) calibrated in 5° increments can also be mounted on the pitot tube and used to measure rotation.

The preferred device is a degree level (available at most hardware stores) with 1° increments which can be mounted on the end of a pitot tube. Its alignment with the head of the pitot tube can be checked by one of two methods:

1. the use of two indicating levels, one at the front and one at the end or,
2. by placing the pitot on a stable surface then place the indicating level at the front and then at the end and compare readings. The readings do not have to be the same. The differential, using the front as the reference, or true value can be subtracted or added to the corresponding angular determinations of stack flow.

Appendix 3 High Volume Particulate Sampling

Appendix 3.1 Sample Collection Procedures

Appendix 3.2 Sample Recovery

Appendix 3.3 Analytical Procedure

Appendix 3.1 Sample Collection Procedure

- (a) Use a pitot tube to map the velocity distribution across the face of the exhaust. Areas of zero or negative flow should also be included if present. At each point at which the velocity is measured, measure the flow in the direction giving maximum deflection of the pitot pressure gauge.
- (b) Select six or more points of outgoing (positive) flow from the points measured above to sample. The points shall be representative of the flow pattern and should include the point of maximum velocity. If six points of positive flow cannot be obtained, use the maximum number possible. Do not choose any points closer than 5 cm (2 inches) from the wall.
- (c) Measure the average exhaust temperature.
- (d) Determine the nozzle size required for isokinetic sampling. An estimate of the orifice temperature is required. For low temperature exhausts the orifice temperature is usually very close to the exhaust temperature. For higher temperature exhausts, a trial run may be necessary to determine the expected orifice temperature.
- (e) Calculate the required orifice pressure drop for each chosen sampling point to obtain an isokinetic sample. Mount the nozzle so that the nozzle opening is parallel to the cyclone or stack exhaust. This will keep the differential pressure gauge properly positioned to read as it was designed to. With the probe out of the stream, turn on the blower and adjust the flow rate to that calculated for the first sampling point. Locate the probe nozzle at the first sampling point and immediately start the timer. Move the probe around until the velocity pressure matches that calculated for the flow rate which was pre-set. The sample rate may need to be adjusted after entering the gas stream. The probe nozzle must be pointing directly into the flow.
- (f) Continually monitor the velocity during the sampling period (with the pitot tube mounted to the probe) and move the probe around as required to keep it in an area where the velocity matches the original velocity used to calculate the pre-set sampling rate. Record the sampling time, the orifice temperature and pressure drop on the data sheet.
- (g) A survey shall consist of three tests. The minimum sample time per test shall be 15 minutes with a minimum sampling time per point of 3 minutes.
- (h) Repeat the above steps for each sampling point. The blower need not be turned off between points if readjustment to the new sampling rate can be made rapidly.

- (i) Care should be taken so that the nozzle does not touch the walls of the exhaust stack as deposited particulate may be dislodged and enter the train. If there is reason to believe this happened, discontinue the sample, clean the train and restart the test.
- (j) If excessive loading of the filter should occur or the pressure drop should increase such that isokinetic conditions cannot be maintained, replace the filter and continue the test.
- (k) At the conclusion of the sampling period, remove the probe from the exhaust and turn off the blower (do not reverse this order as the filter may be broken and the sample lost). Plug the nozzle to prevent sample loss and transport the sample to the recovery area.
- (l) Measure the moisture content of the stack gas and the barometric pressure (absolute). The moisture may usually be measured by the wet-dry bulb technique.

Appendix 3.2 Sample Recovery

- (a) The probe and nozzle should be brushed with the blower turned on to suck the particulate onto the filter.
- (b) After filter removal and storage, the nozzle, probe and front half of the filter holder must be rinsed with acetone or methanol and brushed until all visible particulate is removed.

Appendix 3.3 Analytical Procedure

The filter must be weighed immediately upon removal from the dessicator because of the relatively large filter and the possibility of a hygroscopic filter catch.

Appendix 4 Sample Train Leak Check Procedures

Leak checks are necessary to assure that the sample has not been biased (low) by dilution air. The method specifies that leak checks be performed at certain intervals as discussed below:

Pre-test - A pre-test leak check should be conducted by plugging the nozzle inlet and pulling a vacuum at 380 mm Hg (15 inches Hg) for at least one minute. The leakage rate must be less than 0.57 L/min. (0.02 ft³/min.) or 4% of the estimate average sampling rate, whichever is less. Sampling cannot proceed until the leakage rate is acceptable.

During Sampling - If a component (e.g., filter assembly or impinger) change is made (including problems due to breakages or cracks) during the sample run, a leak check shall be conducted before the component change. The leak check shall be performed at a vacuum equal to the maximum vacuum reached up until that point in the test. If this test has a leakage rate above the accepted maximum of 0.57 L/min. (0.02 ft³/min.) the sampling shall be considered invalid, and redone. After the component change the pre-test shall be repeated.

Post-test - A leak check is mandatory at the conclusion of each sample run. The leak check should be conducted at 380 mm (15 in.) Hg. If the leak check fails at 380 mm (15 in.), then the test may be repeated at the maximum vacuum reached during any point in the test run. The maximum allowable leakage rate is 0.57 L/min. (0.02 ft³/min.) or 4% of the average sample rate, whichever is less. A correction factor may be applied if the leakage is in excess of the acceptable limits. However, approval for acceptance must be granted by the Regulatory Administrator and each case will be assessed individually.

Appendix 5 Sampling under Adverse Conditions

It is essential that a sample be representative of the source from which it was taken. Various conditions may affect this criterion. The following are some ways which these adverse conditions may be overcome:

- **Corrosive or highly reactive components** - The use of special materials such as Inconel, glass, quartz or Teflon.
- **High vacuum sources** - (found before exhaust fans and high natural draft stacks) - Operation of the sampling train pump before and after probe insertion to avoid the escape of impinger solution into the filter holder; gas drawn before and after should not be included in the sample volume.
- **High pressure sources** - Port sealed tightly yet allow for freedom of movement of the probe; for example, a gas valve and packing gland could be incorporated in the port.
- **High temperature source (> 600°C or 1100°F)** - Quartz or Inconel probe liner or water cooled probe with temperature control to avoid cooling below dew point; shielded thermocouple.
- **High moisture content source** - Probe temperature maintained above the dew point; probe sheathed with insulation layer within an outer layer to prevent droplets from impinging on the actual probe, creating a cooling effect via evaporation; for Method 5 locate a filter between the third and fourth impinger (as specified in the method).
- **High velocity source** - Relocate sampling site or expand duct or stack to reduce the velocity; pumps of sufficient capacity to maintain the required sampling rates can be used.
- **Low velocity source** - Sources with a velocity in the range of 1.5-3.0 m/s (5-10 ft/s) should be measured using an inclined manometer with a scale of 0 to 0.6 kPa (0-2.4 in. H₂O). Sources with velocities below 1.5 m/s (5 ft/s) should have the sampling site relocated or the duct constricted to increase the velocity.

Appendix 6 Calibration Forms

- Appendix 6.1 General Calibration Form**
- Appendix 6.2 Orifice Meter Calibration Form**
- Appendix 6.3 Nozzle Diameter Calibration Form**
- Appendix 6.4 Temperature Calibration Form**
- Appendix 6.5 S-Type Pitot Calibration Form**
- Appendix 6.6 Magnehelic Calibration Form**
- Appendix 6.7 Dry Gas Meter Calibration Form**

Appendix 6.1 General Calibration Form

Equipment	Date Of Calibration	Place Of Calibration	Method
S - Type Pitot			
Orifice Meter			
Temperature Device			
Rotameter			
Nozzle Diameter			
Dry Gas Meter			
Magnehelic Gauge			

Appendix 6.2 Orifice Meter Calibration Form

Technician : _____

Date _____

Signature : _____

Console I.D. : _____

Parameter Summary	Run No. 1	Run No. 2	Run No. 3	Run No. 4	Run No. 5
Md = mol. wet dry air					
Pb = atmospheric press.					
Y = dry gas meter calibration					
ΔH = press. diff. @ orifice					
Ri = initial dry gas vol.					
Rf = final dry gas vol.					
Δt = measured interval (min.)					
$Q_m = Y (R_f - R_i) / \Delta t$					
To = dry gas outlet temp.					
$T_m = T_o + 273$ or 460					
$P_m = P_b + \Delta H / 13.6$					
$K_o = Q_m / (T_m / P_m \cdot \Delta H / M_d)^{1/2}$					
Average K_o					

Appendix 6.3 Nozzle Diameter Calibration Form

Technician : _____

Date : _____

Signature: _____

Nozzle I.D.	Nozzle Diameter (a)			Δ Diameter (b)	Average Diameter (c)
	D1	D2	D3		

Where:

- (a) D1, D2, D3 = three different nozzle diameters; each diameter must be measured with a micrometer to within 0.25 mm (0.001 in.)
- (b) Δ Diameter = maximum difference between any two diameters, must be less than or equal to 1.0 mm (0.004 in.)
- (c) Average Diameter = average of D1, D2 and D3

Appendix 6.4 Temperature Calibration Form

Technician : _____
 Date : _____
 Signature : _____
 Barometric Pressure : _____
 Land Elevation: _____
 Type of Device
 and I.D.: _____

Calibration Medium	Mercury In Glass Thermometer Temp.		Temperature Device Reading
	Actual Reading	Corrected	
ICE BATH			
BOILING WATER			
HOT OIL			

Note: Temperature Device must read within 1.5% of certified mercury in glass thermometer to be acceptable.

Appendix 6.5 S-Type Pitot Calibration Form

Technician: _____

Date : _____

Signature : _____

Pitot I.D. : _____

Nozzle

I.D.: _____

Approx. Wind Vel.	Ref. Pitot Vel. Press		S-Type Pitot Vel. Press		Pitot Coefficient
	Ft/sec.	ΔP_{ref}	$C_{ref}(\Delta P_{ref})^{1/2}$	ΔP_s	

Calibration Equation : $C_p = \frac{C_{ref}(\Delta P_{ref})^{1/2}}{(\Delta P_s)^{1/2}}$

$C_{ref} =$ _____

Where:

ΔP_{ref} = velocity pressure measured by reference pitot

C_{ref} = coefficient of reference pitot

ΔP_s = velocity pressure measured by S-type pitot

C_p = coefficient of S-type pitot

Appendix 6.6 Magnehelic Calibration Form

Technician : _____
 Date : _____
 Signature : _____
 Gauge I.D. : _____
 Scale : _____

Manometer $\Delta P1$	Magnehelic $\Delta P2$	% Pressure Difference

Average Percent Pressure Difference = $(\Delta P1 - \Delta P2) / \Delta P1 \cdot 100$

The magnehelic gauge must read within 5% of the gauge oil manometer (over its usable range) or the calibration and/or magnehelic gauge is not acceptable.

Appendix 6.7 Dry Gas Meter Calibration Form

Technician : _____

Date : _____

Signature : _____

Console _____

I.D.: _____

Parameter Summary	Run No. 1	Run No. 2	Run No. 3
Ta = ambient (wet test meter) temp.			
ΔP = press. diff. @ wet test meter			
Pb = atmospheric pressure			
Pv = vapour pressure			
ΔH = press. diff. @ orifice			
Ti = dry test inlet temp.			
To = dry test outlet temp.			
Ri = initial dry test vol.			
Rf = final dry test vol.			
Vi = initial wet test vol.			
Vf = final wet test vol.			
$P_w = P_b + \Delta P$			
$P_d = P_b + \Delta H$			
$T_w = T_a + 273$ or 460			
$T_d = [(T_i + T_o)/2] + 273$ or 460			
$B_w = P_v/P_b$			
Calibration Equation Result (Y)			
Average (Y)			

Calibration Equation : $Y = [(V_f - V_i)/(R_f - R_i)] [(P_w/P_d)(T_d/T_w)](1 - B_w)$

The calibration factor must be within 2% (0.98-1.02) of the wet test meter or spirometer reading for the meter to be acceptable.

**Appendix 7 Regulatory Agency Approved Test
Methods**

Appendix 7.1 Parameters and Approved Methods

Appendix 7.2 Method Sources

Appendix 7.1 Parameters and Approved Methods

Parameter	Method	Notes
Ammonia	EPA CTM 27	
Arsenic	EPA 108	
Benzene, Toluene, Ethyl benzene, Xylenes	EPA 18	
Beryllium	EPA 104	
Carbon Dioxide (CO ₂)	see Gas composition and molecular	
Carbon Monoxide (CO)	EC c, EPA 10, EPA 10a, EPA 10b	
Chloride (Total)	EPA 26	
Chlorine and Chlorine Dioxide (Cl/ClO ₂)	EPA 40CFR63.457	
Combined Trains (Multi-metals including	EPA 29	
Combined Trains (particulate/metals/gaseous hydrogen	EC f	
Continuous Emission Monitoring (certification/QA/QC)	EC d, EPA PS-1 to PS-7	
Fluoride	Alcan 3010, EPA 13a, EPA 13b	Alcan 3010 only applies to aluminium production facilities
Formaldehyde (HCOH)	NCASI a, SW 0011	NCASI only applies to wood products facilities, use SW 0011 for all other facilities
Gas composition and molecular weight (Orsat or fyrite)	EPA 3	
Gas composition and molecular weight (CO ₂ , O ₂ instrumental)	EPA 3a	
Gas composition and molecular weight (CO ₂ , O ₂ Orsat)	EPA 3b	
Hexavalent Chromium	EPA ALT 014, IC 306	

Stationary Air Emissions Testing

Parameter	Method	Notes
Hydrogen Chloride (HCl) Halides and Halogens	EPA 26, EPA 26a	EPA 26a is to be used when acid particulate matter is present in the emission
Hydrogen Sulphide (H ₂ S)	EPA 11, EPA 15	EPA 15 also includes Carbonyl Sulphide (COS) and Carbon Disulphide (CS ₂)
Lead (Pb)	EPA 12	
Mercury	EPA 101a	
Metals (Ag, As, Cd, Cu, Mn, Ni, Pb, Sn, Tl, Zn)	EPA 29	
Moisture Content	EPA 4	
Nitrogen Oxides (NO _x)	EPA 7, EPA 7a, EPA 7c, EPA 7d, EPA 7e, EPA 20	
Opacity	EPA 9, EPA 9 alternative 1, MELP a, EPA 203	EPA 9 is the observation method; EPA 9 alternative 1 is the lidar method. EPA 203 is a proposed continuous method.
Organics (Total gaseous non-methane as carbon, grab)	EPA 25	
Organics (Total gaseous hydrocarbons as methane, continuous)	EPA 25a	To be used for testing asphalt plants
Organics (Speciation of hydrocarbons, grab)	EPA 18	
Organics (polychlorinated biphenyls (PCBs) and other semi volatile organic compounds)	EC a	

Stationary Air Emissions Testing

Parameter	Method	Notes
Organics (boiling point \geq 100oC, semi-volatile organics (Semi-Vost), polychlorinated dibenzo-para-dioxins (PCDDs), and polychlorinated dibenzofurans (PCDFs))	EC a, EPA 23	
Organics (boiling point \leq 100oC, volatile organics (VOST))	SW 0030	
Oxidants (ozone)	IC 411	With adjustments to impinger volumes*
Oxygen (O ₂)	See Gas composition and molecular weight listing	
Particulates	EC e, EPA 5, EPA 5d, EPA 5f	
Particulates (Cyclonic flow)	Appendix 12	Appendix 12 is contained within this chapter of the B.C. Field Sampling Manual
Particulates (High volume)	EPA CTM 003, Oregon 8	**
Particulates (In-stack)	EPA 17	
Particulates (Sizing)	EPA 201a	
Particulates (PM ₁₀)	EPA 201, EPA 201a	
Particulates (and condensable organics)	EPA 202, Oregon 7	
Sampling site and traverse points	EC e, EPA 1	
Sampling site and traverse points (Stacks/ducts 4-12" diameter)	EPA 1a	
Sulphur	EPA 16	
Sulphuric acid mist and sulphur dioxide (SO ₂)	EPA 8	
Sulphur dioxide (SO ₂)	EPA 6, EPA 6a, EPA 6c	

Stationary Air Emissions Testing

Parameter	Method	Notes
Total Reduced Sulphur (TRS) compounds	Appendix 11, EPA 15a, EPA16, EPA 16a, EPA 16b	Appendix 11 is under review, a revised method is anticipated for the next revision of this manual. .
Validation Protocol	EPA 301	For new methods or the expansion of applicability for existing methods **
Velocity and volumetric flow rate (Stacks/ducts > 12" diameter)	EC e, EPA 2	
Velocity and volumetric flow rate (Direct measurement)	EPA 2a, EPA 2d	
Velocity and volumetric flow rate (3-D probe)	EPA CTM 019	
Vinyl chloride	EPA 106	
Volatile organic compounds (VOCs)	see Organics listing	
For the test methods followed by an asterisk (*) impingers must be analyzed and reported individually to prove that sample breakthrough has not occurred.		
Test methods followed by a double asterisk (**) require prior written approval.		

Testing of any parameters not listed or the altering of any methods listed above requires the approval of the Regulatory Administrator. A minimum of 30 days advance notice by a written request along with the supporting documentation for the Regulatory Administrator's evaluation is required to determine the acceptability or rejection of such proposals. The Regulatory Administrator's written approval is required before non-listed or altered method testing is to proceed.

Appendix 7.2 Method Sources

Alcan ALCAN METHODS

- a. Method 3010-98 Sampling of the Cell Room Roof Vents at the A.S. & C. Aluminum Smelters in Quebec. Measurement of Total Particulates and Total Fluorides (Particulates and Gaseous) Revision: June 1998.

Listed in Appendix 7.1 as “Alcan” followed by the letter “a”.

Alcan test methods can be obtained from Alcan International Limitée, Centre de recherche et de développement, Arvida - Madame Pâquerette Leclerc, 1955, boul. Mellon, C.P. 1250, Janquière Québec, G7S 4K8.

EC ENVIRONMENT CANADA-ENVIRONMENTAL PROTECTION SERVICE TEST METHODS

- a. Reference Method for Source Testing: "Measurement of Releases of Selected Semi-Volatile Organic Compounds from Stationary Sources" EPS 1/RM/2, June 1989.
- b. Reference Method for Source Testing: "Measurement of Releases of Gaseous Hydrogen Chloride from Stationary Sources" EPS 1/RM/1, June 1989.
- c. Reference Method for Source Testing: "Measurement of Releases of Carbon Monoxide from Stationary Sources" EPS 1/RM/4, July 1990.
- d. Report: "Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation" EPS 1/PG/7, September 1993.
- e. Reference Method for Source Testing: "Measurement of Releases of Particulate from Stationary Sources" EPS 1/RM/8, December 1993.
- f. Report: "The National Incinerator Testing and Evaluation Program: Air Pollution Control Technology" EPS 3/UP/2, September 1986.

Listed in Appendix 7.1 as “EC” followed by a letter from a to f to match the above listing.

EC test methods can be ordered through Environment Canada at: Environmental Protection Publications, Technology Development Branch, Conservation and Protection, Environment Canada, Ottawa, Ontario, K1A 0H3.

EPA UNITED STATES ENVIRONMENTAL PROTECTION AGENCY - CODE OF FEDERAL REGULATIONS 40 Parts 60 and 61 -TEST METHODS

Listed in Appendix 7.1 as “EPA” followed by the appropriate method number, or for conditional test methods “EPA CTM” followed by the method number.

Most EPA test methods can be found at the United States Environmental Protection Agency Technology Transfer Network (TTN) Website at <http://www.epa.gov/ttn/emc/>

Methods listed as “EPA 40CFR” are contained in the United States National Archives and Records Administration, Code of Federal Regulations. For downloading see <http://www.access.gpo.gov/nara/about-cfr.html#page1>

IC INTERSOCIETY COMMITTEE - APCA, ACS, AICHE, APWA, ASCE, ASME, AOAC, HPS, IPA - TEST METHODS

Listed in Appendix 7.1 as “IC” followed by the appropriate method number IC test methods are listed in a publication entitled “Methods of Air Sampling and Analysis,” Third Edition, James P. Lodge, Jr., Editor, Intersociety Committee APCA, ACS, AIChE, APWA, ASME, AOAC, HPS, ISA, Lewis Publishers, Inc, 1989.

MELP BRITISH COLUMBIA MINISTRY OF ENVIRONMENT LANDS AND PARKS

Source Testing Code For the Visual Measurement of The Opacity of Emissions From Stationary Sources.

Listed in Appendix 7.1 as “MELP” followed by the letter “a”

Can be found at <http://www.env.gov.bc.ca/epd/cpr/codes/stcvmo.html>

NCASI National Council for Air and Stream Improvement

Chilled Impinger Method for use at Wood Products Mills to Measure Formaldehyde Methanol, and Phenol.

Listed in Appendix 7.1 as “IC” followed by the letter “a”.

NCASI test methods can be obtained from the National Council of the Paper Industry for Air and Stream Improvement (NCASI), Inc., P.O. Box 13318, Research Triangle Park, NC 27709-3318, (919) 558-1999. For general NCASI information see <http://www.ncasi.org/>

Oregon STATE OF OREGON - DEPARTMENT OF ENVIRONMENTAL QUALITY AIR QUALITY DIVISION – SOURCE SAMPLING MANUAL VOLUME 1

Listed in Appendix 7.1 as “Oregon” followed by the appropriate method number.

Oregon test methods can be obtained from the Source Testing Co-ordinator, Department of Environmental Quality, 2020 Southwest 4th Ave, Suite 400, Portland, OR 97201, Tel: (503) 229-5554, Fax (503) 229-5265. Further information is available on the web at: <http://www.deq.state.or.us/>

SW U.S. EPA TEST METHODS FOR EVALUATING SOLID WASTE

Volume IC: Laboratory Manual Physical/Chemical Methods, Publication SW-846.

Listed in Appendix 7.1 as “SW” followed by the appropriate method number.

SW test methods can be obtained from the National Technical Information Service (NTIS), Technology Administration, U.S. Department of Commerce, Springfield, VA 22161, Tel: (703) 605-6000 or 1-800-553-6847, Fax: (703) 605-6900. Further information is available at <http://www.ntis.gov/>

**Appendix 8 Continuous Emission Monitoring
(Non-Permanent In-Stack) Reporting Forms**

Appendix 8.1 Analysis of Calibration Gases

Appendix 8.2 Analyzer Calibration Data

Appendix 8.1 Analysis of Calibration Gases

Analytical method used: _____

Date: _____

Sample Run	Gas Concentration (indicate units)		
	Zero*	Mid-range**	High-range***
1			
2			
3			
Average			
Maximum Percent Deviation			

* Average must be less than 0.25 % of span

** Average must be 50 to 60 % of span

*** Average must be 80 to 90 % of span

Appendix 8.2 Analyzer Calibration Data

Source Identification: _____ Analyzer Calibration Data for Sampling: _____
 Test Personnel: _____ Runs: _____
 Date: _____ Span: _____

	Cylinder Value (Indicate Units)	Analyzer Calibration Response (Indicate Units)	Absolute Difference (Indicate Units)	Difference (Percent of Span)
Zero gas				
Mid-range				
High-range				

Appendix 9 Compliance Testing Report Requirements

Appendix 9.1 Source Emission Survey Report Format

Appendix 9.2 Compliance Testing Report Summary Table

Appendix 9.3 System Calibration Bias and Drift Check

Appendix 9.1 Source Emission Survey Report Format

Stack emission survey reports should contain the information listed below unless mutually acceptable arrangements regarding the report content have been made between the facility and the Regulatory Administrator.

1. Title Page

The title page shall contain:

- (a) plant name,
- (b) plant location,
- (c) permit, approval or registration number,
- (d) date of survey,
- (e) name of the sampling firm, and
- (f) report author(s).

2. Summary

The summary of the source emission survey shall include but not be limited to:

- (a) A compliance testing report summary, which lists the parameters, described in Appendix 9.2.
- (b) An indication of how the source emission survey compares with applicable emission limits and previous emission testing shall be provided.

3. Table of Contents

A table of contents listing the report sections and the appendices shall be provided.

4. Introduction

The introduction shall include, but not be limited to, information on:

- (a) the reason for the survey,
- (b) the name(s) and contact telephone number(s) of the team member(s) which have taken relevant stack sampling courses,
- (c) a list of stack sampling, and plant personnel present during testing with contact telephone numbers,
- (d) the name of the company which prepared the analytical results, and
- (e) a list of analytical personnel and contact telephone numbers.

General comments on:

- how the plant was operating,
- process data (relevant to the operation of the source of emissions and to the performance of pollution abatement equipment), and
- presence of dust/fly ash on and around the plant, or other pertinent observations (such as opacity).

5. Test Methods

This section shall contain:

- (a) a brief outline of the methods and equipment used to collect and analyze the samples.
- (b) a detailed explanation of any deviation from the approved stack sampling methods or from any other accepted sampling methods (prior written approval required).

6. Results

The section shall contain but not be limited to tables which contain the following:

- (a) emission source description with permit appendix number or other identifying information,
- (b) name of pollutant(s),
- (c) pollutant concentration for each run and the average for the survey (mg/m³), corrected to reference conditions as stated in the permit, approval, regulation or bylaw (i.e. specific %O₂ or %CO₂),
- (d) stack emission flow rate (m³/min.) at standard reference conditions of 20°C, 101.325 kPa, dry gas,
- (e) pollutant mass emission rate(s) (kg/hr.),
- (f) process production rate at the time of the survey (tonnes of product/hr. or other units as appropriate),
- (g) average or normal process production rate (same units as (f)) and
- (h) maximum process production rate (same units as (f)).

7. Discussion

A discussion of the survey shall include but not be limited to explanations for any deviations from normal due to problems associated with:

- (a) plant operation,
- (b) pollution control equipment operation,
- (c) inadequate sampling facilities,
- (d) sampling equipment, and
- (e) sample analysis.

For cases where there is a large variation (greater than 20%) between the emission survey conducted and previous surveys, an explanation of probable causes is also required.

8. Data Sheets

- (a) Stack sampling field sheets, or digital or chart recorder outputs. Originals or legible photocopies for each sample run performed as part of the survey are required. Information on the sheets shall include but not be limited to:
 - (i) plant name, location, emission source description, date of survey, and run number (an individual sheet is required for each run),

- (ii) relevant constant parameters for equipment as noted in the sampling method being performed and as stated in this code,
 - (iii) tabulated results that pertain to individual traverse points, grab samples or the specific survey which was performed, or digital or chart recorder outputs (with appropriate labeling),
 - (iv) sample recovery procedures used, if applicable,
 - (v) example calculations as appropriate.
- (b) Laboratory certificates of analysis, if applicable.
 - (c) System calibration bias and drift check, described in Appendix 9.3 if applicable.
9. Appendices
- (a) Stack sampling site diagram (with stack dimensions and measured locations of traverse points).
 - (d) Cyclonic flow check.
 - (e) Completed instrument calibration forms for equipment used during the survey.
 - (f) Detailed sampling system description and schematic diagram.
 - (g) Certificate of completion for relevant stack sampling course.

Stationary Air Emissions Testing

Appendix 9.2 Compliance Testing Report Summary Table

Permit #(if applicable) _____ Facility Name: _____ Location (Legal Address) _____ Reason for test: _____ Test methods used: _____ Process operation: _____ Production rate during test: _____ Fuel consumption rate: _____ Pollution control equipment operating conditions: _____	Compliance: Yes ___ No ___ (attach explanations) Report Complete: Yes ___ No ___ (attach explanations) Test Date: _____ 19___ to _____ 19___ Parameters measured: Part ___ CO ___ SO ₂ ___ NO _X ___ NO ₂ ___ Other: ___ ___ ___ ___ ___ Normal Production rate: _____ Type of fuel: _____
--	--

Test Results:

Emission Source and #	Parameter	Run #1	Run #2	Run #3	Average	Permit Limit

For Regulatory office use only - Reviewed By : _____ - Date : _____	I hereby state that the test results are accurate and the test(s) were conducted in accordance with the procedures stated in the methods used. <div style="display: flex; justify-content: space-around;"> _____ signature _____ _____ date _____ </div>
---	---

Appendix 9.3 System Calibration Bias and Drift Check

Source Identification: _____ Run Number: _____
 Test Personnel: _____ Span: _____
 Date: _____

	Analyzer Calibration Response	Initial Values		Final Values		Drift (% of Span)
		System Calibration Response	System Cal. Bias (% of Span)	System Calibration Response	System Cal. Bias (% of Span)	
Zero gas						
Upscale gas (a)						

(a) As stated in the method being followed.

Appendix 10 Psychrometric Charts and Vapour Pressure Tables

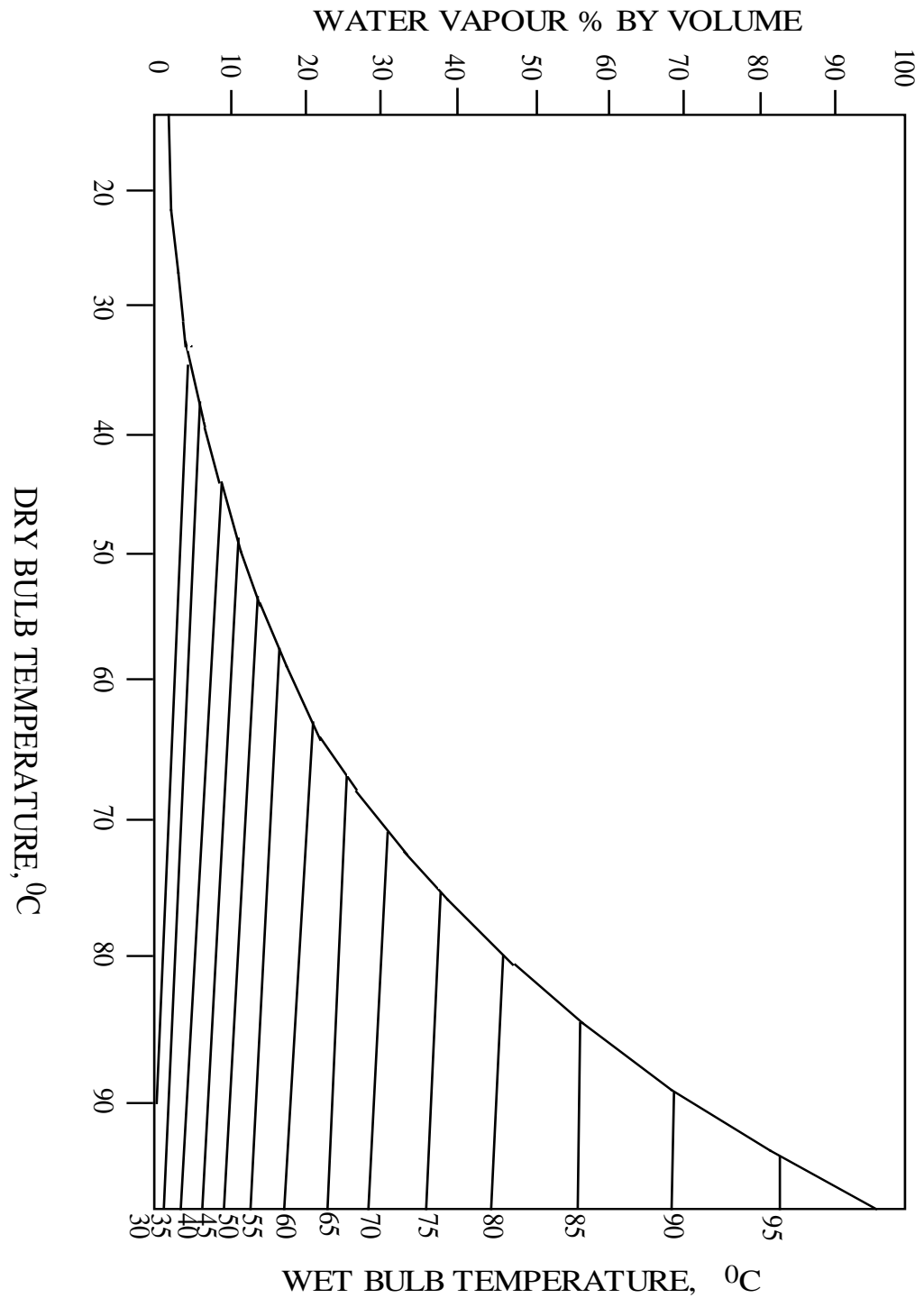
Appendix 10.1 Vapour Pressures of Water in Millimeters of Mercury

Appendix 10.2 High Temperature Psychrometric Chart for Air-Water Vapour Mixtures at 101.3 kPa

Appendix 10.1 Vapour Pressures of Water in Millimeters of Mercury

Temp. (°C)	0	1	2	3	4	5	6	7	8	9
0	4.58	4.93	5.29	5.69	6.10	6.54	7.01	7.51	8.05	8.61
10	9.21	9.84	10.52	11.23	11.99	12.79	13.63	14.53	15.48	16.48
20	17.54	18.65	19.83	21.07	22.38	23.76	25.21	26.74	28.35	30.04
30	31.82	33.70	35.66	37.73	39.90	42.18	44.56	47.07	49.69	52.44
40	55.32	58.34	61.50	64.80	68.26	71.88	75.65	79.60	83.71	88.02
50	92.51	97.20	102.09	107.20	112.51	118.04	123.80	129.82	136.08	142.60
60	149.50	156.43	163.77	171.38	179.31	187.54	196.09	204.96	214.17	223.73
70	233.70	243.90	254.60	265.70	277.20	289.10	301.40	314.10	327.30	341.00
80	355.10	369.70	384.90	400.60	416.80	433.60	450.90	468.70	487.70	506.10
90	525.76	546.05	566.99	588.60	610.90	633.90	657.62	682.07	707.27	733.24
100	760.00	787.57	815.86	845.12	875.06	906.07	937.92	970.60	1004.42	1038.92
110	1074.56	1111.20	1148.74	1187.42	1227.25	1267.98	1309.94	1352.95	1397.18	1442.63
120	1489.14	1536.80	1586.04	1636.36	1687.81	1740.93	1795.12	1850.83	1907.83	1966.35
130	2026.16	2087.42	2150.42	2214.64	2280.76	2347.26	2416.34	2488.16	2560.67	2634.84
140	2710.92	2788.44	2867.48	2948.80	3031.64	3116.76	3203.40	3292.32	3382.76	3476.24
150	3570.48	3667.00	3766.56	3866.88	3970.24	4073.88	4183.80	4293.24	4404.96	4519.72
160	4636.00	4755.32	4876.92	5000.04	5126.96	5256.16	5388.88	5521.40	5658.20	5798.04
170	5940.92	6085.32	6233.52	6383.24	6538.28	6694.08	6852.92	7015.56	7180.48	7349.20
180	7520.20	7694.24	7872.08	8052.96	8236.88	8423.84	8616.12	8809.92	9007.52	9208.16
190	9413.36	9620.08	9831.36	10047.20	10265.32	10488.76	10715.24	10944.76	11179.60	11417.48
200	11659.16									

Appendix 10.2 High Temperature Psychrometric Chart for Air-Water Vapour Mixtures at 101.3 kPa



Appendix 10.3 Sample Container, Preservation, and Hold Times for Air (Vapours)

Type of Analysis	Storage Temp ¹	Container Type	Preservation	Maximum Hold Time ²
Air – Vapours – Organic				
VOCs by Canister Sampling	ambient	SS canister	none	30
VOCs by Thermal Desorption	≤6°C	Thermal desorption tube	none	30 days
VOCs and other Volatile Substances by Charcoal and Miscellaneous Collection Media	≤6°C (or as applicable reference method)	see BC Lab Manual Method	none	30days

¹ Storage temperature applies to storage at the laboratory. For all tests where refrigeration at ≤6°C is required at the laboratory, samples should be packed with ice or cold packs to maintain a temperature of ≤10°C during transport to the laboratory. The storage of ≤8°C for microbiological samples applies during storage at the laboratory and during transport to the laboratory. To prevent breakage, water samples stored in glass should not be frozen. Except where indicated by "do not freeze", test results need not be qualified for frozen samples.

² Hold Times: Single values refer to hold time from sampling to analysis. Where 2 values are given, the first is hold time from sampling to extraction, and the second is hold time from extraction to analysis.

Appendix 11 Determination of Total Reduced Sulphur Compounds Using Grab Sampling

The Ministry test method for total reduced sulphur (TRS) is under review. A revised method is anticipated for the next revision of the B.C. Field Sampling Manual.

For the latest status on the review, contact either:

- Director of the Air Resources Branch, Ministry of Environment, Lands and Parks, or
- Director, Air Quality Department, Greater Vancouver Regional District.

Appendix 12 Method for Measuring Particulate Emissions from Stationary Sources with Cyclonic Flow Pattern (Alignment Method)

The Technical Committee on Cyclonic Flow Sampling (Ministry of Environment, British Columbia, November 31, 1990) originally compiled this method. For the text which follows minor modifications have been made to ensure that this method is consistent with current Ministry stack sampling procedures. Instead of referring to outdated Ministry methods reference is made to adopted U.S. EPA methods as appropriate. The technical content of the method itself has not been altered.

Forward

The method described in this Appendix is used to measure the releases of particulate matter from stationary sources with cyclonic flow pattern. This method is to be used in conjunction with U.S. EPA Methods 1 to 5. The complexity of the sampling and analytical procedures warrants that personnel performing them be trained and experienced.

Application of this method for compliance testing requires strict adherence to the method in all aspects. Deviations from the method may invalidate the test results. Any changes in equipment, reagents, materials, procedures, or calculations from those specified in the method must be approved by the Regulatory Administrator prior to testing.

This method is subject to amendment from time to time. Users should contact the Ministry for the most up-to-date version that is applicable to the source to be tested.

This method was recommended by the Technical Committee on Cyclonic Flow Sampling. The members of this committee were as follows:

Mr. B.B. Manna, P.Eng., Chair, Ministry of Environment (MoE), British Columbia
Mr. T.B. Leung, P.Eng., MoE, British Columbia
Mr. P.K. Leung, P.Eng., Environment Canada
Mr. L. Begoray, P.Eng., Alberta Environment
Mr. P. Tam, P.Eng., B.H. Levelton & Associates

Appendix 12.1 Principle

Particulate matter is withdrawn isokinetically from a number of sampling or traverse points in an enclosed gas stream. At each traverse point, the nozzle is canted directly into the flow at the pre-determined rotational angle where the maximum gas velocity occurs. The isokinetic sampling rate is based on the actual stack gas velocity. The particulate sample is collected in the nozzle, probe, cyclone (if used) and filter, all maintained within a temperature range required by U.S. EPA Method 5. The particulate weight is determined gravimetrically after removal of uncombined water. Simultaneous determinations of the gas stream moisture content, velocity, temperature, and molecular weight allow calculations of the particulate concentration and the particulate mass emission rate to be made.

Appendix 12.2 Applicability

This method is used to determine the concentration of particulates in enclosed gas streams of stationary sources with cyclonic flow pattern. Gas flow inside a stack or flue is considered cyclonic if the average absolute value of the rotational angles, as determined by Section 4.1 of this method, is greater than 10 degrees.

Prior to considering using this method, the tester must evaluate, to the satisfaction of the Regulatory Administrator, the feasibility of eliminating cyclonic flow patterns at the sampling location by one or a combination of the following options:

- Option One: Relocation of the sampling ports
- Option Two: Installation of flow straighteners to minimize the cyclonic flow pattern
- Option Three: Stack extension to minimize cyclonic effects

If none of the above options are feasible, the Regulatory Administrator may determine the applicability of the method for a specific source, taking into consideration pre-test information (to be submitted by the proponent) such as:

- (i) Particulate and stack/flue characteristics (e.g. particle size and particulate concentration profile across stack or flue).
- (ii) Sampling ports location.
- (iii) Rotational (or yaw) and tilt (or pitch) angles.
- (iv) Supersaturation state of the gas stream.
- (v) Stability of the cyclonic flow pattern with respect to time and space.

Proponents must also consult with the Regulatory Administrator prior to using this method to perform a survey.

Appendix 12.3 Apparatus and Reagents

Same as for U.S. EPA Method 5 - 2 and 3.

Appendix 12.4 Procedures

Pre-sampling Preparations

In addition to following the procedures specified in U.S. EPA Method 5 - 4, a preliminary traverse shall be conducted to determine the velocity and rotational angle at each traverse point.

Insert into the stack an S-type pitot tube that is connected to a differential pressure gauge. Position the pitot tube at the first traverse point. Rotate the pitot tube clockwise or anti-clockwise about its longitudinal axis until the pressure taps are equal (i.e. Δp equals zero or null). Determine and record the rotational angle, α , to the nearest degree by rotating the pitot tube ninety degrees about its longitudinal axis and in the opposite direction. Note that the value of α can be zero, positive or negative depending on the direction of the gas velocity in relation to the stack or flue axis (Figure A1). Record the velocity pressure reading, Δp , for this traverse point. Repeat the procedure for all the traverse points. Conduct a second series for measurements by repeating the procedure for the traverse points. The second test should be conducted under the same process conditions as the first test and the two tests should be conducted at least 60 minutes apart. After the rotational angle of each traverse point inside the stack/flue has been determined, recorded and verified, calculate the average of the absolute value of α . If the average α for each series of measurement is less than or equal to 10 degrees, the source is not considered to have a cyclonic flow pattern. Otherwise, submit the pre-sampling test results to the Regulatory Administrator and obtain prior approval to use this method for measuring particulate emissions under cyclonic flow conditions.

Preparation of Collection Train

Follow the procedures described in U.S. EPA Method 5 - 4.1.3.

Sampling Train Operation

If either or both the rotational angles and velocities measured for the same traverse point during the two discrete test runs as described, under Section 4.1, differ by five degrees and five percent or less respectively, the cyclonic flow pattern is deemed to be stable; thus sampling procedures as outlined in Section 4.3.1 should be followed. However, if either or both the rotational angles and velocities differ by more than five degrees or five percent respectively, the cyclonic flow pattern is deemed to be unstable.

Therefore steps must be taken to minimize the time elapsed between the determination of the rotational angle and particulate sampling; sampling procedures are outlined in Section 4.3.2 should be followed.

The basic difference in the sampling procedures for stable and unstable cyclonic flow patterns is that for stable cyclonic flows, isokinetic sampling can be carried out at the pre-determined rotational angle of each traverse point whereas for unstable cyclonic flows, the rotational angle for each traverse point is determined and is used immediately for isokinetic sampling.

Sampling Procedures for Stable Cyclonic Flow Patterns

Prior to sampling, determine the rotational angle of each traverse point by following the procedures described in Section 4.1. Insert the sampling probe into the stack/flue with the nozzle canted directly into the flow at the pre-determined rotational angle of the first traverse point. Immediately start the vacuum pump and adjust the sampling rate to isokinetic conditions. Repeat this procedure for all the other traverse points. The isokinetic sampling rate is based on the actual stack gas velocity. Conduct isokinetic sampling for all the traverse points by following the procedures contained in U.S. EPA Method 5.

Sampling Procedures for Unstable Cyclonic Flow Patterns

Determine the rotational angle of the first traverse point. Adjust the sampling probe with the nozzle canted into the flow at this rotational angle. Immediately start the vacuum pump and adjust the sampling rate to isokinetic conditions. Turn the vacuum pump off at the conclusion of the sampling at the first traverse point. Repeat these procedures for all other traverse points. The isokinetic sampling rate is based on the actual stack gas velocity. Isokinetic sampling for all the traverse points must be conducted by following the procedures described in U.S. EPA Method 5.

Sample Recovery and Sample Analysis

Follow the procedures in U.S. EPA Method 5 - 4.2 and 4.3.

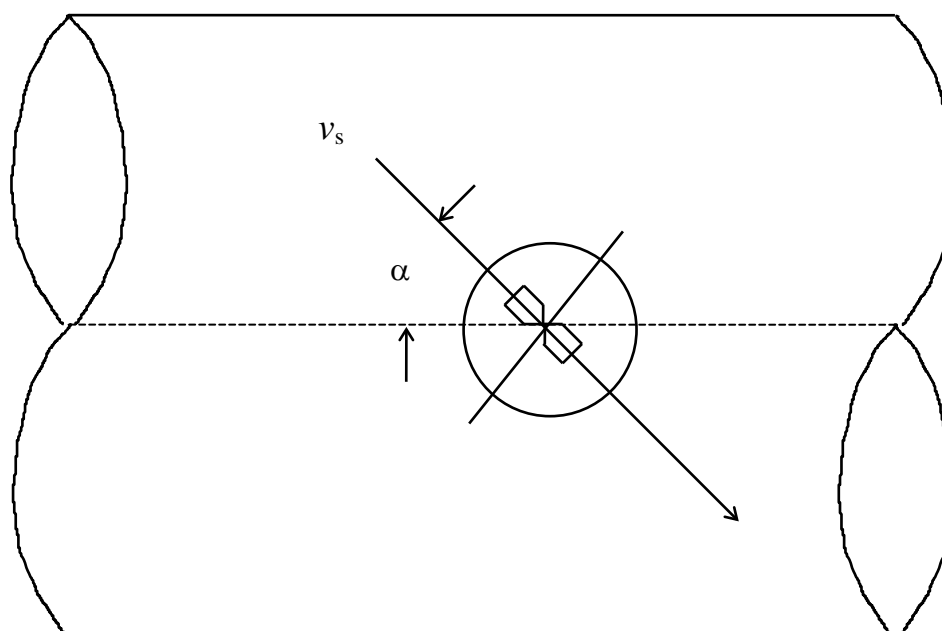
Appendix 12.5 Calculations and Reporting

The following modifications to U.S. EPA Method 5 are required:

To determine the stack/flue gas flow rate, Q_{sp} , use the average of the vertical components of the stack/flue gas velocity, $v_s \cos \alpha$, at each traverse point. Where possible, the calculated Q_{sp} should be verified independently by other means, such as taking flow measurement at another location.

The particulate emission rate, is the production of the concentration, c_s , and the stack/flue gas flow rate, Q_{sp} , from Section 5.1.

To compensate for the potential bias associated with cyclonic sampling, correction factors may be used in calculating and reporting the final particulate emission rate, c_s , and Q_{sp} . Consult with the Regulatory Administrator regarding the values of the correction factors for a specific stationary emission source.



STACK / FLUE

α = Rotational Angle

v_s = Stack Gas Velocity