Government of Newfoundland and Labrador
Department of Environment and Climate Change
Pollution Prevention Division

Guidance Document

Title: **Procedural Guide for Source Emission Testing**

Prepared By: **Barrie Lawrence, Senior Environmental Scientist**

Issue Date: **December 6, 2001**

1st Revision Date: May 28, 2004

2nd Revision Date: April 13, 2023

Approved By: _____

Robert Locke, Director

Source Emission Testing

GD-PPD-016.2

SUBJECT

The procedures accepted by the department for source emission testing per Section 19 of the *Air Pollution Control Regulations, 2022*.

OBJECTIVE

To define the required analytical procedures for compliance source emission testing. In so doing, the department ensures that the quality of all results obtained and submitted to the department are complete and consistent across all facilities.

BACKGROUND

Facilities in the province which emit an air contaminant in excess of a predefined provincial and/or national level are required to verify their emissions on a regular basis via a source emission test. A source emission test may be required annually, biennially or every four years depending on the state of compliance and the air contaminant being sampled. Specific details on the source emission testing frequency can be found in guidance document: *Determination of Compliance with the Ambient Air Quality Standards* (GD-PPD-009.4) as amended from time to time, available at:

https://www.gov.nl.ca/ecc/publications/env-protection/

This is the 2nd revision to the guidance document. In this revision updates were made to:

- definitions;
- methods;
- timelines;
- operating conditions;
- reporting requirements; and
- references to outdated legislation.

LEGISLATIVE AUTHORITY

Air Pollution Control Regulations, 2022, Sections 9 and 19:

Performance testing facilities

9. (1) The owner or operator of an emission source shall provide the following performance testing facilities:

(a) sampling ports adequate for testing devices and applicable methods;

(b) safe sampling platforms;

(c) safe access to sampling platforms; and

(d) utilities for sampling and testing devices.

(2) Notwithstanding subsection (1), the minister may exempt an owner or operator of an emission source from providing the performance testing facilities referred to in subsection (1).

Manner of measurements, recording and analyses

19. All measurements, recordings and analysis conducted under these regulations shall be

(a) performed at locations and by devices and methods acceptable to the department; and

(b) made readily accessible to the department in a time and manner acceptable to the department.

DEFINITIONS

a) “air contaminant” means any discharge, release, or other propagation into the air and includes dust, fumes, mist, smoke, particulate matter, vapours, gases, odours, odorous substances, acids, soot, grime or any combination of them;

b) “department” means the department presided over by the minister;

c) “emission source” means any combustion process equipment, installation, machinery, appliance, equipment or tanks from which air contaminants may be discharged, released or propagated;

d) “facility” means any stationary property, real or personal, taken as a whole, which has an emission source;

e) “source emission test” means the sampling of air contaminant emissions from a stack in accordance with this guidance document; and

f) “stack” means a chimney, flue, conduit or duct arranged to conduct an air contaminant into the air.

1.0 SAMPLE AND VELOCITY TRAVERSES

This procedure is used to determine representative measurement sites for air contaminant emissions and/or total volumetric flow rate from a stack, where the gas stream is flowing in a known direction. This procedure cannot be used when:

- flow is cyclonic or swirling (see Section 1.4 of this guidance document);
- a stack is smaller than 0.30 metre in diameter; or
- the measurement site is less than 2 stack diameters downstream or less than 0.5 stack diameters upstream from a flow disturbance.

The requirements of this procedure must be considered before construction of a new facility or new stack from which emissions shall be measured; failure to do so may require subsequent alterations to the stack.

1.1 SPECIFICATIONS AND LOCATION OF SAMPLING PORTS

Sampling and velocity measurements should be performed at a port located at least eight stack diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack. For conical stacks, i.e. circular stacks which uniformly decrease in diameter with height, the stack diameter for calculation purposes shall be the diameter at the upstream flow disturbance. For a rectangular stack, a stack equivalent diameter (D_e) for determining the upstream and downstream distances, shall be determined by Equation 1.1.

Equation 1.1 Calculation of Equivalent Diameter for Rectangular Stacks

$$D_e = \frac{2LW}{L + W}$$

where: L = length
W = width

For example, a rectangular stack measuring 0.90 metres (L) by 1.20 metres (W) has an equivalent diameter (D_e) = (2 x 0.90 x 1.20) / (0.90 + 1.20) = 1.03 metres.

For circular or conical stacks, at least 2 sampling ports, separated by 90 degrees, are required when the stack diameter is less than or equal to 2.50 metres. At least 4 sampling ports, each separated by 90 degrees are required when the stack diameter is greater than 2.50 metres. The ports are to be installed at an equal height such that the centreline of each port intersects the others and the centrelines are perpendicular to the upstream flow disturbance as outlined in Figure 1.1.1.

For rectangular cross-sections, ports are located on the most convenient side of the stack.

The sampling ports shall be constructed from 6 inch Schedule 40 pipe, threaded on one end and fitted with a cap with rebar or like material attached as detailed in Figure 1.1.2. Assembly of sampling equipment and required clearances with relation to the sampling ports is shown in Figure 1.1.3.

Sampling port caps are to be install and tightly secured at all times; only removed on the port in use for source emission testing. Upon completion of the source emission testing through a particular port, the cap is to be re-installed and tightly secured.

Figure 1.1.1 Specifications for Sampling Port Locations

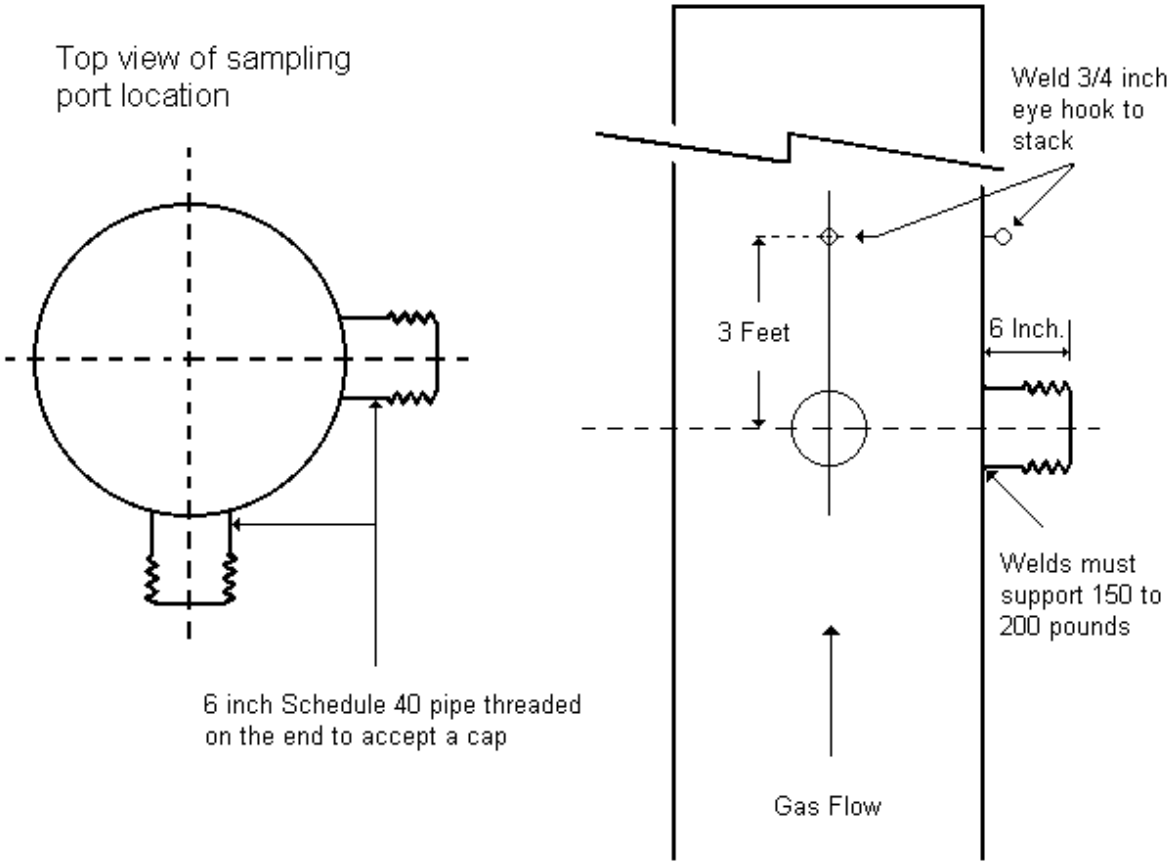


Figure 1.1.2 Sampling Port Details

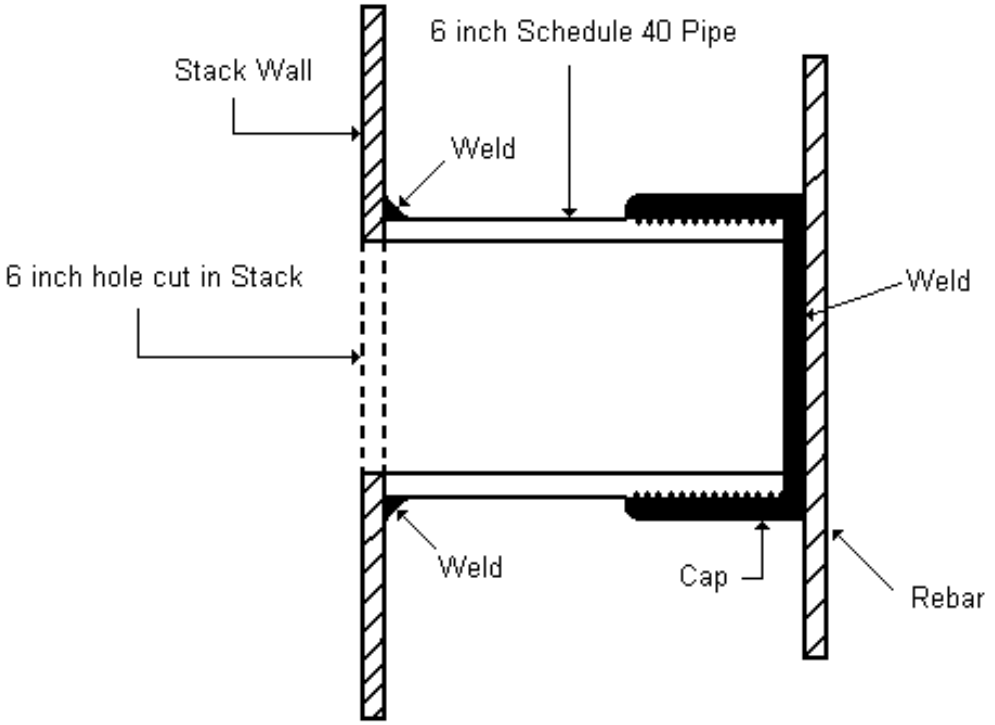
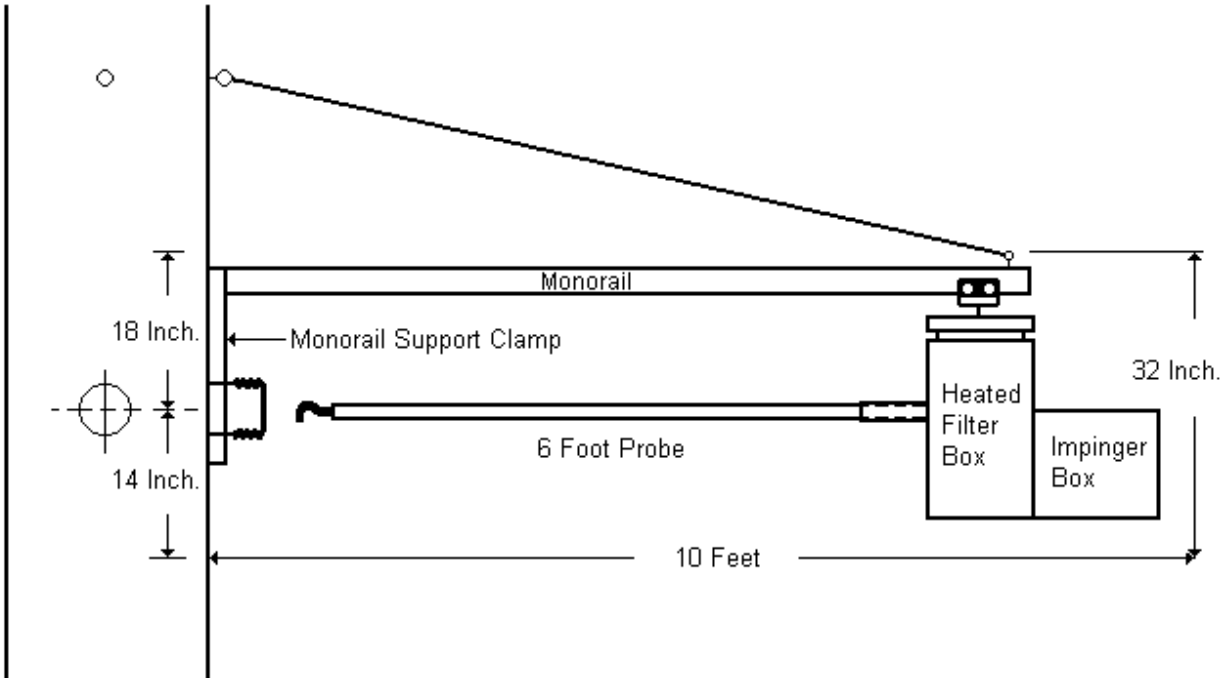


Figure 1.1.3 Minimum Clearances for Sample Probe Assembly



1.2 DETERMINATION OF THE NUMBER OF TRAVERSE SAMPLING POINTS

The minimum number of traverse sampling points shall be as per Table 1.2.1.

Before referring to the table, determine the distances from the chosen sampling port centreline to the nearest upstream and downstream disturbances, (A and B as shown in Figure 1.2.1 respectively), and divide each distance by the stack diameter (D) or in the case of rectangular stacks, the equivalent stack diameter (D_e), to determine the distance in terms of the number of stack diameters such that for circular and conical stacks:

$$X = A / D \qquad Y = B / D$$

and for rectangular stacks:

$$X = A / D_e \qquad Y = B / D_e$$

From Table 1.2.1 determine the minimum number of traverse sampling points that corresponds to X duct diameters upstream and Y duct diameters downstream. The number of traverse sampling points shall be the larger of the two minimums determined from Table 1.2.1.

Figure 1.2.1 Upstream and Downstream Measurement Sites

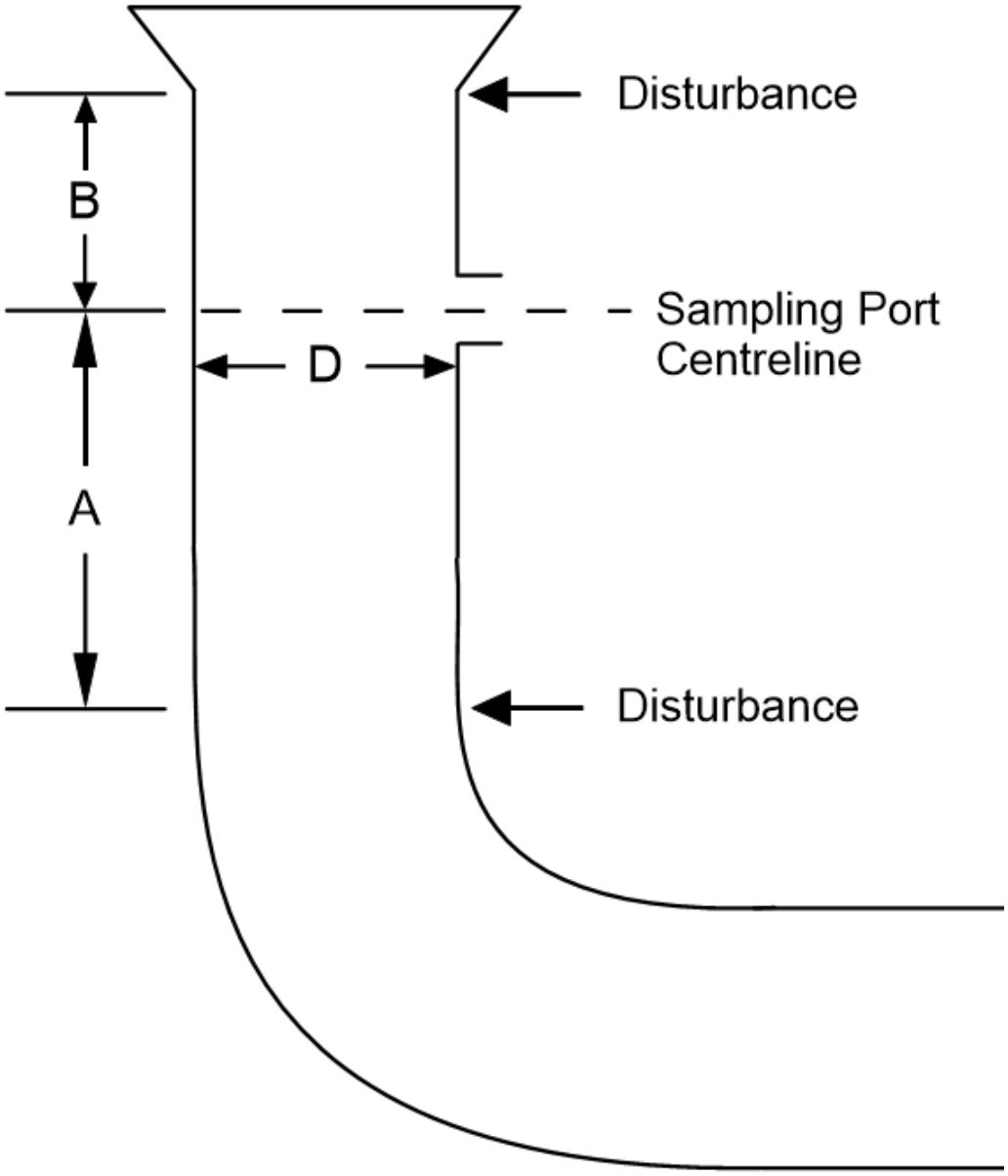


Table 1.2.1 Minimum Required Traverse Sampling Points

Stack Diameter (m)	Upstream (**X**) and Downstream (**Y**) Stack Diameters			
	0.50 ≤ **Y** < 1.25	1.25 ≤ **Y** < 1.50	1.50 ≤ **Y** < 1.75	1.75 ≤ **Y** < 2.00
	2 ≤ **X** < 5	5 ≤ **X** < 6	6 ≤ **X** < 7	7 ≤ **X** < 8
0.30 < **D** ≤ 0.60	12	8	8	8
0.60 < **D** ≤ 1.30	24	20	16	12
1.30 < **D** ≤ 2.50	28	24	20	16
2.50 < **D** ≤ 5.00	32	28	24	20
D > 5.00	36	32	28	24

1.3 LOCATION OF TRAVERSE SAMPLING POINTS

For circular and conical stacks, locate the traverse sampling points on two perpendicular diameters according to the example shown in Figure 1.3.1. Each traverse sampling point defines an equal area within the stack. Table 1.3.1 provides the relative distance of the traverse sampling points within the stack.

Figure 1.3.1 Example Showing Locations of 12 Traverse Sampling Points

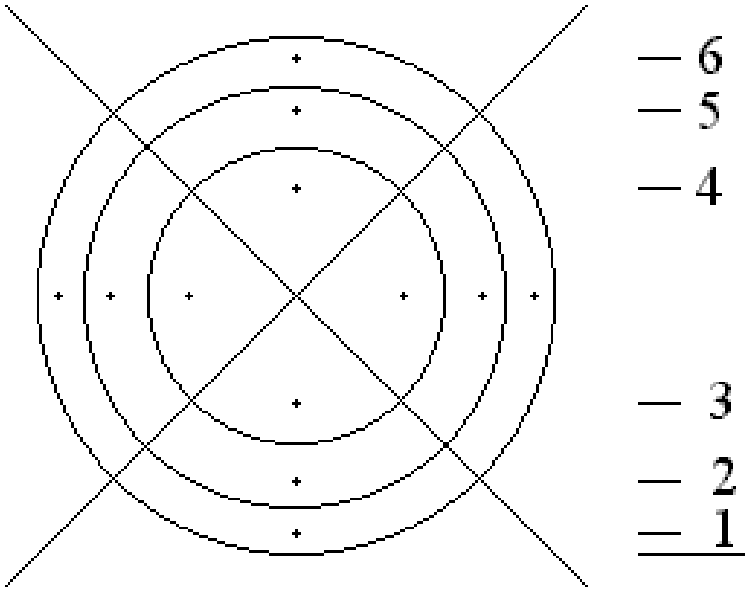


Table 1.3.1 Location of Traverse Sampling Points in a Circular Stack

(% of Stack Diameter From Inside Wall to Traverse Sampling Point)								
Traverse Sampling Point Number	Number of Traverse Sampling Points on a Diameter							
	4	6	8	10	12	14	16	18
1	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4
2	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4
3	75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5
4	93.3	70.4	32.3	22.6	17.7	14.6	12.5	10.9
5		85.4	67.7	34.2	25.0	20.1	16.9	14.6
6		95.6	80.6	65.8	35.6	26.9	22.0	18.8
7			89.5	77.4	64.4	36.6	28.3	23.6
8			96.8	85.4	75.0	63.4	37.5	29.6
9				91.8	82.3	73.1	62.5	38.2
10				97.4	88.2	79.9	71.7	61.8
11					93.3	85.4	78.0	70.4
12					97.9	90.1	83.1	76.4
13						94.3	87.5	81.2
14						98.2	91.5	85.4
15							95.1	89.1
16							98.4	92.5
17								95.6
18								98.6

For example, if there are 12 traverse sampling points in a circular or conical stack and the stack diameter is 3.00 metres, then the location of the traverse sampling points are calculated in Table 1.3.2.

Table 1.3.2 Locations of 12 Traverse Sampling Points With a Circular of Conical Stack Diameter of 3 Metres

Traverse Sampling Point Number	% of Stack Diameter From Inside Wall to Traverse Sampling Point (from Table 1.3.1)	Traverse Sampling Point Location (metres)
1	2.1	0.063
2	6.7	0.201
3	11.8	0.354
4	17.7	0.531
5	25.0	0.750
6	35.6	1.068
7	64.4	1.932
8	75.0	2.250
9	82.3	2.469
10	88.2	2.646
11	93.3	2.799
12	97.9	2.937

For circular or conical stacks having diameters greater than 0.60 metres, no traverse sampling points shall be located within 2.50 centimetres of the stack wall. When any of the traverse sampling points fall within 2.50 centimetres of the stack wall, relocate them away from the stack wall to either a distance of 2.50 centimetres or a distance equal to the sampling nozzle inside diameter, whichever is larger. For stacks having diameters equal to or less than 0.60 metres, no traverse sampling points shall be located within 1.25 centimetres of the stack wall. When any of the traverse sampling points fall within 1.25 centimetres of the stack wall, relocate them away from the stack wall to either a distance of 1.25 centimetres or a distance equal to the sampling nozzle inside diameter, whichever is larger. If after the relocation of traverse sampling points there are two successive traverse sampling points at the same location, consider these sampling points to be combined into a single adjusted traverse sampling point. Sample and take readings at the adjusted traverse sampling point for twice the the sample time otherwise defined in Section 2.2.

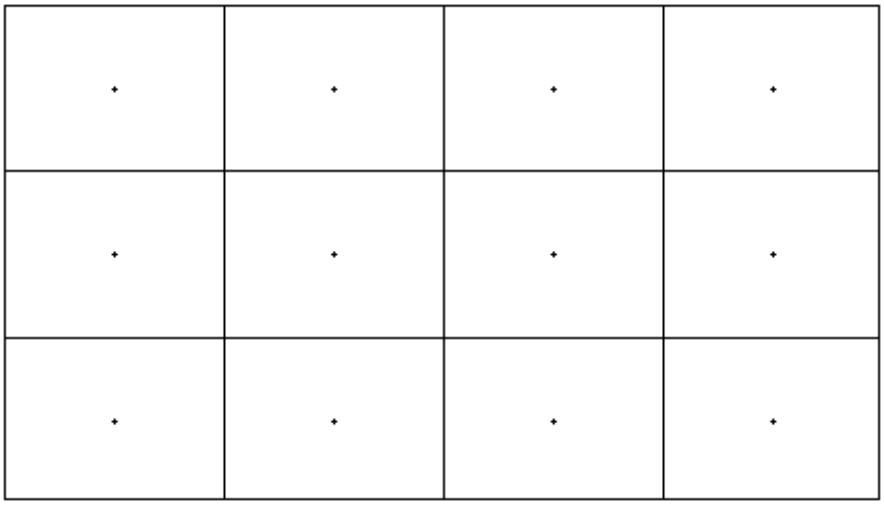
For rectangular stacks, determine the number of traverse sampling points as explained in Section 1.2 of this guidance document. From Table 1.3.3 determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse sampling points, and then locate a traverse sampling point at the centroid of each equal area according to the example in Figure 1.3.2. The situation of traverse sampling points being too close to the stack walls is not expected to arise with rectangular stacks.

Table 1.3.3 Cross-Sectional Traverse Sampling Point Layout for Rectangular Stacks

Number of Traverse Sampling Points	Rectangular Matrix Layout
8	2 X 4
9 *	3 X 3
12	3 X 4
15 *	3 X 5
16	4 X 4
20	4 X 5
24	4 X 6
25 *	5 X 5
28	4 X 7
32	4 X 8
36	6 X 6

* For instances where the number of traverse sampling points is not included in Table 1.2.1.

Figure 1.3.2 Example Showing Rectangular Stack Divided Into 12 Equal Areas With a Traverse Sampling Point at Centroid of Each Area



1.4 VERIFICATION OF ABSENCE OF CYCLONIC FLOW

In most stacks, the direction of gas flow is essentially parallel to the stack wall. However, cyclonic flow may exist after devices such as cyclones, inertial demisters, or venturi scrubbers. Cyclone flow may also exist in stacks having tangential inlets or other duct configurations which tend to induce swirling. In these instances, the presence or absence of cyclonic flow at the sampling location must be determined.

To determine the absence or presence of cyclonic flow, level and zero the manometer. Connect a Type S pitot tube to the manometer. Position the Type S pitot tube at the first traverse sampling point so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane. When the pitot tube is in this position, it is at 0 degrees reference. Note the differential pressure (Δp) reading. If a null (zero) pitot reading is obtained at 0 degrees reference, an acceptable flow condition exists at that traverse sampling point. If the pitot reading is not zero at 0 degrees reference, rotate the pitot tube (up to ± 90 degrees), until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree. Repeat this procedure for each traverse sampling point. After the null technique has been applied at each traverse sampling point, calculate the average of the absolute values of α using all traverse sampling points, including those traverse sampling points were no rotation was required. If the average value of α is greater than 20 degrees, the overall flow condition in the stack is unacceptable and the department is to be consulted to determine an alternative methodology of sampling.

1.5 NON-STANDARD SAMPLING REGIMES

For sampling or velocity measurement regimes that do not conform to the procedures stated herein, the department shall be consulted prior to the implementation of the sampling or velocity measurement program to determine an alternate methodology of sampling.

2.0 SAMPLING TRAIN CONDITIONS AND STANDARDS

2.1 NUMBER OF SAMPLES

Each stack is required to be sampled a minimum of three times for every operating scenario defined in the pretest plan per Section 3.1 of this guidance document. Results from all three samples, and an average or all three samples, are to be reported to the department.

2.2 SAMPLE TIMES

At each traverse sampling point as located per Section 1.3 of this guidance document, a minimum of two readings shall be taken before the sampling equipment is repositioned to the next traverse sampling point. One set of readings shall be taken immediately after the assembly is positioned, and the subsequent reading(s) at the time defined in Table 2.2.1. The minimum total sampling time for each sample shall be 64 minutes.

Table 2.2.1 Minimum Sampling Times and Number of Readings

Traverse Sampling Points	Number of Readings per Traverse Sampling Point	Total Number of Readings	Time per Reading	Total Sample Time
8	4	32	2 minutes	64 minutes
12	3	36	2 minutes	72 minutes
16	2	32	2.5 minutes	80 minutes
20	2	40	2 minutes	80 minutes
24	2	28	2 minutes	96 minutes
28	2	56	2 minutes	112 minutes
32	2	64	2 minutes	128 minutes
36	2	72	2 minutes	144 minutes

2.3 SAMPLE VOLUMES

The sampling nozzle shall be sized to obtain a minimum sample volume of 1 cubic metre. If the minimum sample volume cannot be obtained in the minimum time per Section 2.2 of this guidance document, then the sampling time shall be extended accordingly to collect the required volume.

2.4 ISOKINETIC SAMPLING

The sampling nozzle shall be sized to ensure sampling is isokinetic. The acceptable isokinetic deviation per reading is 100% +/- 10%. For size fractionation, the acceptable isokinetic deviation per reading is 100% +/- 20%.

2.5 LEAK CHECKS

Leak checks are mandatory to ensure that the sample has not been diluted by excess air. Sampling shall not proceed until either a maximum leakage rate of 0.00057 cubic metres / minute or 4% of the estimated sampling rate is achieved. Leak checks shall be performed immediately prior to the collection of each sample, immediately after the collection of each sample, and immediately before and after a component change during sampling.

2.6 CALIBRATIONS

Equipment used in the sampling train shall be calibrated within the 6 months prior to the start of sampling. The sampling team must carry current copies of the calibration certificates for all calibrated equipment used in the sampling train. Such certificates must include all pertinent data, date of calibration and the name of the person who performed the calibration. All calibrated equipment shall be permanently and uniquely identified for easy reference.

Continuous gas analyzers are to meet the performance specifications detailed in US EPA Method 7E as referenced in Section 3.3 of this guidance document.

2.7 INTERRUPTIONS

If during any source emission test, a facility fails to maintain the emission source operating conditions as defined under Section 3.4 of this guidance document, then an interruption has occurred and the following steps shall apply:

1. The sampling is immediately discontinued upon such interruption;
2. The sampling probe is removed and sealed;
3. The sampling train temperature is maintained;
4. If such interruption is less than 10 minutes, then sampling can resume at the traverse sampling point where the interruption occurred once the sampling process conditions are re-established and leak checks are performed;
5. If such interruption exceeds 10 minutes then the source emission test results shall be considered invalid and sampling shall restart once the sampling process conditions are re-established;
6. Any such interruption must be noted, detailed and reported to the department.

3.0 SAMPLE COLLECTION CONDITIONS AND STANDARDS

3.1 PRETEST PLAN

All facilities shall submit a pretest plan to the department, a minimum of thirty days prior to stack emission testing and such plan shall include:

Process Parameters

- mode of operation (cyclic, batch, continuous, etc);
- product / raw material feed rates and composition;
- fuel feed rates and composition;
- normal operating temperatures;
- specific process parameters affecting emissions;
- data verifying emission source operating conditions as defined in Section 3.4 of this guidance document;
- process flow diagrams identifying all emission sources related to the emission testing program.

Stack Parameters

- physical dimensions and layout of each stack;
- sample port locations relative to upstream and downstream disturbances;
- number of traverse sampling points per stack;
- physical and chemical nature of the air contaminants.

Test Area Parameters

- shelter and safety provisions for sampling team;
- accessibility issues to the stack sampling locations;
- sampling platform and scaffolding requirements;
- availability of power sources.

General Parameters

- description of the facility;
- proposed dates of the sampling program;
- statement of qualifications and experience of the sampling team;
- source emission testing methods, subject to Section 3.3 of this guidance document.

If the pretest plan is deemed inadequate by department officials, the department shall request the necessary information from the facility a minimum of fifteen days prior to the first day of the proposed sampling schedule. The facility shall submit the requested information to the department a minimum of seven days prior to the first day of the proposed sampling date. All sampling shall be conducted only after acceptance of the pretest plan by department officials.

The facility shall notify the department of the final source emission testing schedule, seven days prior to the actual commencement of source emission testing.

3.2 AIR CONTAMINANTS TO BE SAMPLED

All source emission tests shall include the measurement of oxygen, carbon dioxide and moisture. The air contaminants to be sampled for, as a minimum, during source emission tests are detailed in Table 3.2.1. The department reserves the right to require sampling for other air contaminants in addition to those noted in Table 3.2.1. Stacks that have not previously been sampled, shall normally be required to be sampled for other air contaminants as part of the initial source emission test.

Table 3.2.1 Air Contaminants to be Sampled

Air Contaminant	Combustion Emission Sources	Non-Combustion Emission Sources	Incinerators
Sulphur Dioxide (SO_2)	✓		✓
Oxides of Nitrogen (including nitric oxide and nitrogen dioxide) (NO and NO_2)	✓		✓
Carbon Monoxide (CO)	✓		✓
Total Particulate Matter (TPM)	✓	✓	✓
Particulate Matter less than or equal to 10 microns (PM_{10})	✓	✓	✓
Particulate Matter less than or equal to 2.5 microns ($PM_{2.5}$)	✓	✓	✓
Condensable Particulate Matter	✓	✓	✓
Metals	✓	✓	✓
Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans			✓

3.3 SOURCE EMISSION TESTING METHODS

The approved sampling methods, as amended time to time, are the United States Environmental Protection Agency (US EPA) methods under Title 40, Codes of Regulations (CFR) Part 60 Appendix A and US EPA Test Methods for Evaluating Solid Wastes Physical / Chemical Methods (SW-846) and specifically are:

CFR Part 60 Methods:

2	Determination Of Stack Gas Velocity And Volumetric Flow (Type S Pitot Tube)
3A	Determination Of Oxygen And Carbon Dioxide Concentrations In Emissions From Stationary Sources (Instrumental Analyzer Procedure)
4	Determination Of Moisture Content In Stack Gases
5	Determination Of Particulate Emissions From Stationary Sources
6C	Determination Of Sulfur Dioxide Emissions From Stationary Sources (Instrumental Analyzer Procedure)
7E	Determination Of Nitrogen Oxides Emissions From Stationary Sources (Instrumental Analyzer Procedure)
10	Determination Of Carbon Monoxide Emissions From Stationary Sources (Instrumental Analyzer Procedure)
25A	Determination Of Total Gaseous Organic Concentration Using A Flame Ionization Analyzer
29	Determination Of Metals Emissions From Stationary Sources
201A	Determination Of PM_{10} And $PM_{2.5}$ Emissions From Stationary Sources (Constant Sampling Rate Procedure)
202	Dry Impinger Method For Determining Condensable Particulate Emissions From Stationary Sources

CFR Part 60 methods can be located at:

https://www.epa.gov/emc/emc-promulgated-test-methods

SW-846 Methods:

0010	Modified Method 5 Sampling Train
0023A	Sampling Method For Polychlorinated Dibenzo-p-Dioxins And Polychlorinated Dibenzofuran Emissions From Stationary Sources
0030	Volatile Organic Sampling Train

SW-846 methods can be located at:

https://www.epa.gov/hw-sw846/sw-846-compendium

The department reserves the right to require resampling if the above noted Methods are not followed.

Upon request, the department may allow source emission testing to occur via other methods. Such request shall be made in the pretest plan and shall include the rationale and justification of using the alternate method.

If required by the department under Section 3.2 of this guidance document, other air contaminants shall be sampled by a method approved by the department.

3.4 EMISSION SOURCE OPERATING CONDITIONS

The facility, shall operate all emission sources which feed into the stack being sampled, at the rate between the 75th percentile and the 95th percentile of the daily rates from the previous three years. Such rate shall be confirmed by departmental officials prior to the start of the source emission testing. Failure to maintain such a rate during sampling shall constitute an interruption under Section 2.7 of this guidance document.

3.5 SOURCE EMISSION TESTING AUDIT

The source emission testing program may be subject to an onsite audit by a department official for consistency with the provisions of this guidance document and the pretest plan. If the audit shows that the provisions of this guidance document or pretest plan are not being met, then the onsite department official may immediately suspend the source emission testing program for the affected air contaminants. Source emission testing for such air contaminants shall resume when the deficiencies identified during audit are within acceptable tolerances and addressed to the satisfaction of the onsite department official.

3.6 REFERENCE CONDITIONS

All source emission testing results, irrespective of the method specification, shall be reported based at reference conditions, defined as a dry gas temperature of 25° Celsius and a gas pressure of 101.325 kilopascals.

4.0 REPORTING REQUIREMENTS

4.1 PROCESSES

During source emission testing, the facility shall record all process information pertinent to the operation of the emission source which may impact emissions. This may include, but is not limited to:

- fuel consumption rate of all emission sources which feed into the stack;
- production rates per product;
- burners in operation;
- damper positioning;
- operating status of pollution control equipment.

4.2 FUEL COMPOSITION

During source emission testing, as necessary, the facility shall sample and report the feed fuel of the stack being sampled, and have such sample independently analyzed for:

- sulphur content ASTM D4294
- ash content ASTM D482
- API gravity ASTM D4052
- metals ICP
- gross heat of combustion ASTM D240
- water content ASTM D95
- other parameters as specified by the department

4.3 REPORTING RESULTS

The source emission testing results, irrespective of any other requirements placed on the facility such as a dispersion model report, shall be submitted to the department within 120 days of completion of the sampling and shall clearly and legibly include:

- all records noted in Sections 4.1 and 4.2 of this guidance document
- all field data recorded during sampling in chronological order;
- instrument calibration information;
- sampling site characteristics;
- detailed statistics for each sample run;
- data confirming the required facility operating conditions;
- all other information required under this guidance document.

In circumstances where a source emission testing campaign occurs over two or more distinct phases and the phases are at least one month apart, separate reports shall be submitted to the department within 120 days of the completion of each phase of source emission testing.

For example, if phase one of a stack sampling campaign commences on July 1st of a given year, and is completed on July 15th, and phase two commences on August 30th and is completed on September 15th, then a report for phase one would be due on November 12th, and the phase two report would be due on January 13th of the subsequent year.