GOVERNMENT OF
NEWFOUNDLAND AND LABRADOR

Department of Environment and Conservation
Pollution Prevention Division

Guidance Document

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

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Subject

The procedures accepted by the department for source emission testing as per Section 21 of the *Air Pollution Control Regulations NLR 39/04.*

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 industrial facilities.

Background

In the past, when the department required an industrial facility to perform a source emission test, the procedures which the facility followed were often left to the discretion of the facility. As there are several similar but uniquely different procedures available, this discretion often led to inconsistencies in the information that was both collected and reported when facilities employed different contractors.

Having recognized the inconsistencies and the problems associated therein, as an initial step, in 1998 the department developed an interim policy directive which adopted a standard set of analytical procedures which all industrial facilities would follow. Subsequent to this interim policy directive, the department developed a standard set of guidelines which clearly defined the circumstances and conditions under which source emission testing would occur. These guidelines, coupled with the adoption of the standard set of analytical procedures, have cumulated in this guidance document, and replaces the rescinded interim policy directive PPD: 98-02.

Definitions

In this guidance document:

(a) "air contaminant" means any discharge, release, or other propagation into the air and includes, but is not limited to, dust, fumes, mist, smoke, particulate matter, vapours, gases, odours, odorous substances, acids, soot, grime or any combination thereof;

(b) "criteria air contaminants" mean the following specific air contaminants: carbon monoxide, nitrous oxides, particulate matter (including fractions), and sulphur oxides;

(c) "department" means the Department of Environment and it's successors;

(d) "regulations" mean the *Air Pollution Control Regulations NLR 39/04*, as amended from time to time;

(e) "stack" means a stationary chimney, flue, conduit or duct arranged to conduct an air contaminant to the natural environment;

(f) "source emission test" means the sampling of air contaminant emissions from a stack in accordance with this guidance document.

1. 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 effluent gas stream is flowing in a known direction. This procedure cannot be used when:

(1) flow is cyclonic or swirling (see Section 1.4),
(2) a stack is smaller than 0.15 metre (6 in.) in diameter,
(3) the stack has a non-circular or non-rectangular cross-section, or
(4) the measurement site is less than 2 stack diameters downstream or less than 0.5 diameters upstream from a flow disturbance.

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

1.1 SPECIFICATIONS AND LOCATION OF SAMPLING PORTS

Sampling and velocity measurement should ideally 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, or from a visible flame. For conical stacks, i.e. circular stacks which uniformly decrease in diameter with height, an equivalent diameter (D_e) is the diameter at the upstream flow disturbance. For a rectangular cross section, the equivalent diameter (D_e) for determining the upstream and downstream distances, shall be determined by Equation 1.1:

Equation 1.1

$$D_e = \frac{2DW}{D+W}$$

where: D=depth, W=width

Example. For a rectangular stack measuring 0.9 metres by 1.1 metres on the cross-sections, D_e would equal 0.99 metres.

(Reference hereafter to "diameter" includes both diameter of a circular cross-section and an equivalent diameter of a conical and rectangular cross-section.)

For a stack with a circular or conical cross-section, at least 2 sampling ports separated by 90° are required for stacks ≤ 2.50 metres in diameter, and at least 4 sampling ports, each separated by 90° are required for stacks > 2.50 metres in diameter. The ports are to be installed at an equal height such that 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 will be constructed from 6 inch Schedule 40 pipe, threaded on one end and fitted with a cap as detailed in Figure 1.1-2. Assembly of sampling equipment with relation to the sampling ports is shown in Figure 1.1-3.

Figure 1.1-1

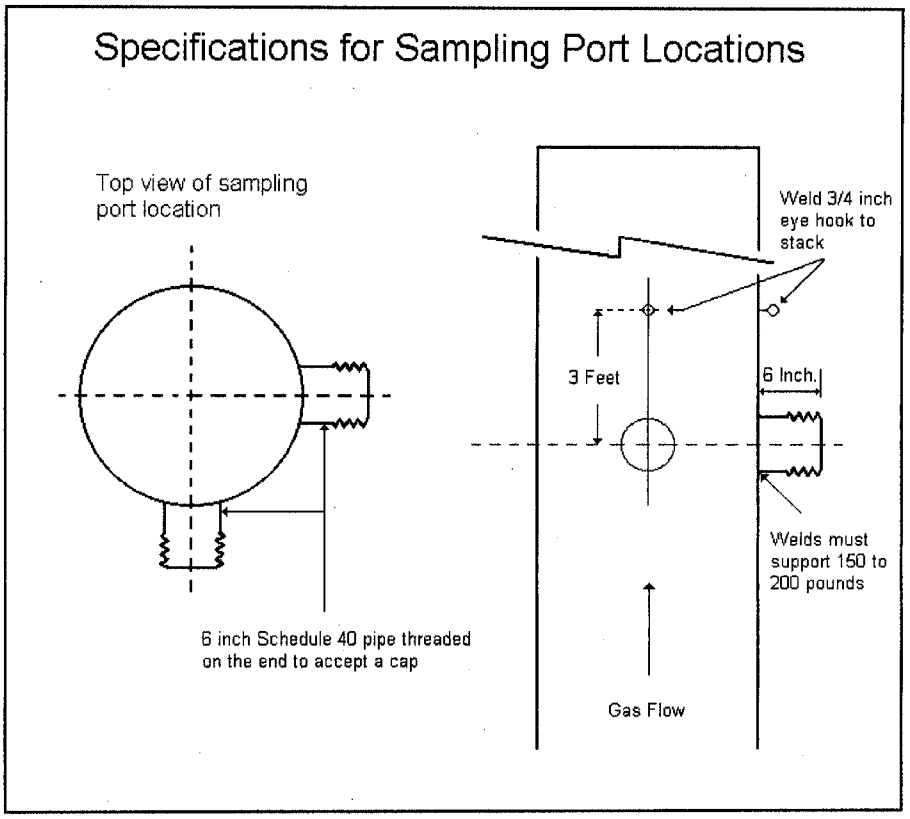


Figure 1.1-2

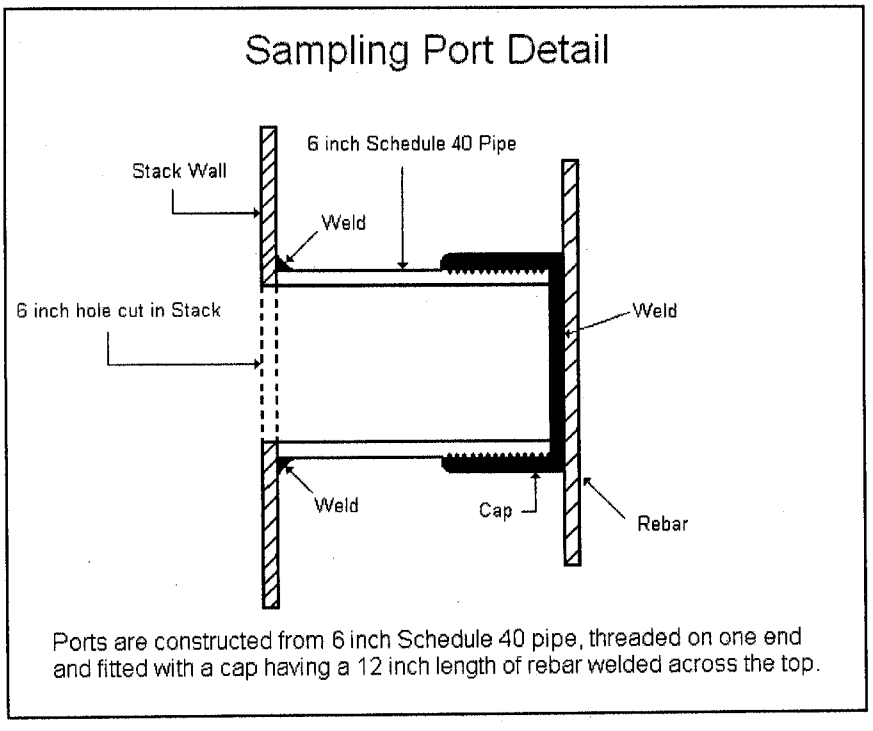
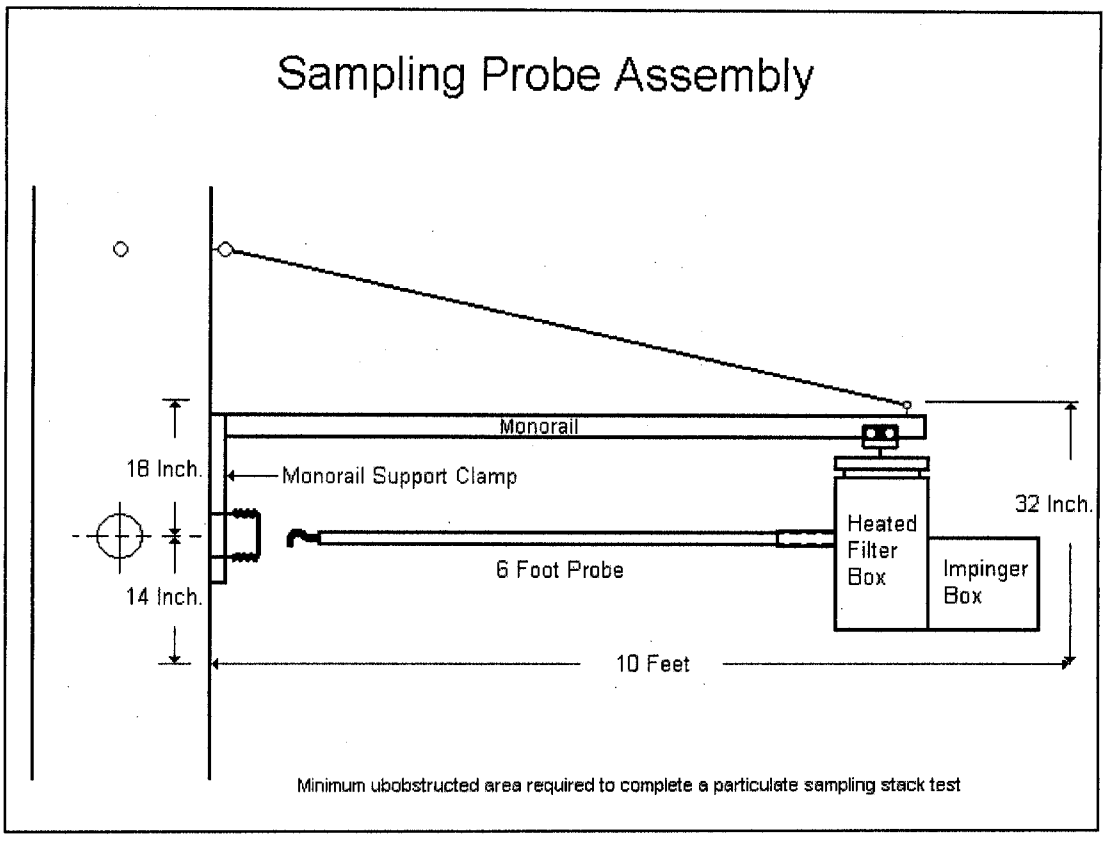


Figure 1.1-3



1.2 DETERMINATION OF THE NUMBER OF SAMPLING POINTS

The minimum number of total traverse points shall be as per Table 1.2-1.

Before referring to the table, determine the distances from the chosen measurement site 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, to determine the distance in terms of the number of stack diameters. Then, determine from Table 1.2-1 the minimum number of traverse points that corresponds to: (X) the number of duct diameters upstream; and (Y) the number of diameters downstream. For circular and conical stacks the number of sampling points will be the larger of the two minimums determined from Table 1.2-1. For rectangular stacks, the number of sampling points will be greater than or equal the larger of the two minimums determined from Table 1.2-1 such that for stacks with a depth to width ratio less than or equal to 1.5, the value is contained in Table 1.2-2, and for stacks with a depth to width ratio greater than 1.5, the matrix is chosen to closely approximate the stack dimensional ratio.

Figure 1.2-1

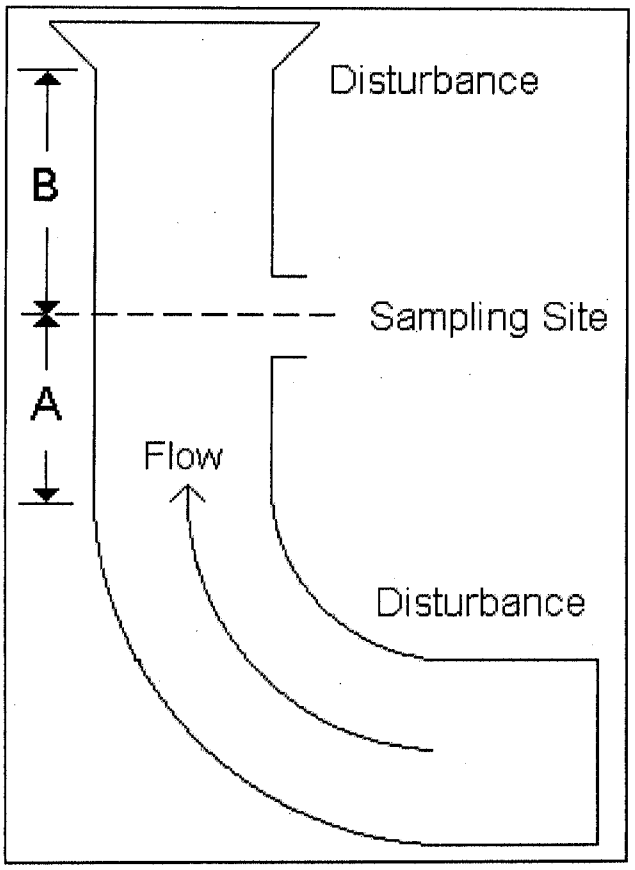


Table 1.2-1

MINIMUM REQUIRED SAMPLING POINTS						
Stack Diameter (m)	1.75 ≤ **Y** < 2.00	1.50 ≤ **Y** < 1.75	1.25 ≤ **Y** < 1.50	1.00≤ **Y** < 1.25	0.75 ≤ **Y** < 1.00	0.50 ≤ **Y** < 0.75
	7 ≤ **X** < 8	6 ≤ **X** < 7	5 ≤ **X** < 6	4 ≤ **X** < 5	3 ≤ **X** < 4	2 ≤ **X** < 3
$0.15 < D_e \leq 0.30$	4	4	4	4	8	8
$0.30 < D_e \leq 0.60$	8	8	8	12	12	12
$0.60 < D_e \leq 1.30$	12	16	20	24	24	24
$1.30 < D_e \leq 2.50$	16	20	24	28	28	28
$2.50 < D_e \leq 5.00$	20	24	28	32	32	32
$5.00 < D_e$	24	28	32	36	36	36

Table 1.2-2

CROSS-SECTIONAL LAYOUT FOR RECTANGULAR STACKS WITH DEPTH TO WIDTH RATIO ≤ 1.5	
Sampling Points	Rectangular Matrix Layout
4	2 x 2
9	3 x 3
12	3 x 4
16	4 x 4
20	4 x 5
25	5 x 5
30	5 x 6
36	6 x 6

1.3 LOCATION OF SAMPLING POINTS

For circular and conical stacks, locate the traverse points on two perpendicular diameters according to the example shown in Figure 1.3-1 and Table 1.3-1.

Figure 1.3-1: Example showing circular stack cross sections divided into 12 equal areas with location of traverse points

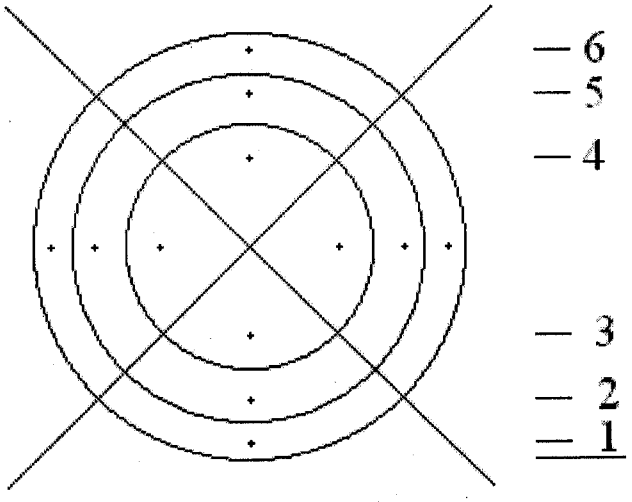


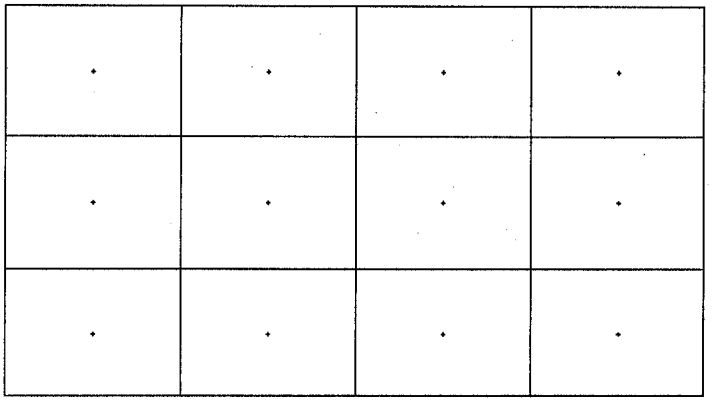
Table 1.3-1

LOCATION OF TRAVERSE POINT IN CIRCULAR STACKS (% of stack diameter from inside wall to traverse point)									
Traverse point number	Number of traverse points on a diameter								
	2	4	6	8	10	12	14	16	18
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4
2	85.4	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 stacks having diameters greater than 0.61 m (24 in.) no traverse points shall be located within 2.5 centimetres (1.00 in.) of the stack wall. When any of the traverse points fall within 2.5 cm (1.00 in.) of the stack wall, relocate them away from the stack wall to either a distance of 2.5 cm (1.00 in.) or a distance equal to the sampling nozzle inside diameter, whichever is larger. For stacks having diameters equal to or less than 0.61 m (24 in.), no traverse points shall be located within 1.3 cm (0.50 in.) of the stack wall. When any of the traverse points fall within 1.3 cm (0.50 in) of the stack wall, relocate them away from the stack walls to either a distance of 1.3 cm (0.50 in.) or a distance equal to the sampling nozzle inside diameter, whichever is larger. These relocated traverse points shall be the "adjusted" traverse points. Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling (or velocity measurement) procedure, and in recording the data.

For rectangular stacks, determine the number of traverse points as explained in Section 1.2 of this procedure. From Table 1.2-3 determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse points, and then locate a traverse point at the centroid of each equal area according to the example in Figure 1.3-2. The situation of traverse points being too close to the stack walls is not expected to arise with rectangular stacks.

Figure 1.3-2: Example showing rectangular stack cross section divided into 12 equal areas with a traverse 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 such devices as cyclones and inertial demisters, following venturi scrubbers, or 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.

The following technique is acceptable for this determination.

Level and zero the manometer. Connect a Type S pitot tube to the manometer. Position the Type S pitot tube at each traverse point, in succession, so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane; when the Type S pitot tube is in this position, it is at "0° reference." Note the differential pressure (Δp) reading at each traverse point. If a null (zero) pitot reading is obtained at 0° reference at a given traverse point, an acceptable flow condition exists at that point. If the pitot reading is not zero at 0° reference, rotate the pitot tube (up to ± 90°), until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree. After the null technique has been applied at each traverse point, calculate the average of the absolute values of α; assign α values of 0° to those points for which no rotation was required, and include these in the overall average. If the average value of α is greater than 20°, the overall flow condition in the stack is unacceptable and alternative methodology must be used to perform accurate sampling.

1.5 NON-STANDARD SAMPLING REGIMES

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

2. SAMPLING TRAIN CONDITIONS AND STANDARDS

2.1 NUMBER OF TESTS

Each stack is required to be tested a minimum of 3 times for every operating scenario. Results from all tests and an average are to be reported to the department.

2.2 SAMPLE TIMES

At each sample point as located in Section 1.3, a minimum of two readings will be taken before the sampling equipment is repositioned to the next point. One set of readings will 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 test shall be 60 minutes.

Table 2.2-1

Minimum Sampling Times and Number of Readings				
Sampling Points	Number of Readings per Sampling Point	Total Number of Readings	Time per Reading	Total Sample Time
4	6	24	2.5 minutes	60 minutes
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	48	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 m^3 (35.3 ft^3) If the minimum sample volume cannot be obtained in the minimum time in Section 2.2, then the sampling time will be adjusted accordingly to collect the required volume.

2.4 ISOKINETIC SAMPLING

The sampling nozzle shall be sized to ensure particulate 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 will not proceed until either a maximum leakage rate of 0.00057 m^3 / minute (0.02 ft^3 / minute) or 4% of the estimated sampling rate is achieved. Leak checks will be performed immediately prior to sampling, immediately after completion of sampling 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. Calibration certificates are required for:

Dry Gas Meter
Magnehelic Pressure Gauges
Nozzles
Orifice Meter
Pitot Tubes
Thermocouples
Rotameter.

2.7 INTERRUPTIONS

If during any sampling test, a facility fails to maintain the source operating conditions as defined under Section 3.5, then an interruption has occurred and the following 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 point where the interrupt occurred once the sampling process conditions are reestablished and leak checks are performed
(5) If such interruption exceeds 10 minutes then the test results will be considered invalid and sampling shall restart once the sampling process conditions are reestablished
(6) Any such interruption must be noted and reported to the department

3. SAMPLE COLLECTION CONDITIONS AND STANDARDS

3.1 PRETEST PLAN

All facilities shall submit a pretest plan to the department, a minimum of 30 days prior to stack emission testing and such plan shall include:

Process Parameters

i) mode of operation (cyclic, batch or continuous)
ii) product / raw material feed rates and composition
iii) fuel feed rates and composition
iv) normal operating temperatures
v) specific process parameters affecting emissions
vi) data verifying source operating conditions as defined in Section 3.5
vii) process flow diagrams identifying all points of emission related to the emission testing program

Stack Parameters

i) physical dimensions and layout of each stack
ii) sample port locations relative to upstream and downstream disturbances
iii) number of sampling points per stack
iv) physical and chemical nature of the pollutants

Test Area Parameters

i) shelter and safety provisions for sampling team
ii) accessibility to sampling site
iii) sampling platform and scaffolding requirements
iv) availability of power sources

General Parameters

i) description of the facility
ii) proposed dates of the sampling program
iii) statement of qualifications and experience of the sampling team
iv) source testing methods, subject to Section 3.3

If the pretest plan is deemed inadequate by department officials, the department shall request the necessary information from the industrial facility a minimum of 20 days prior to the first day of the proposed sampling schedule. The industrial facility shall submit the requested information to the department a minimum of 10 days prior to the first day of the proposed sampling date. All testing will be conducted only after acceptance of the pretest plan by department officials.

The facility shall notify the department of the final source testing schedule, 7 days prior to the actual commencement of source testing.

3.2 CONTAMINANTS TO BE TESTED

All source emission tests will require testing for the criteria air contaminants, carbon dioxide and oxygen as a minimum. The department reserves the right to require testing for other air contaminants in addition to the criteria air contaminants. Stacks that have not previously been tested, will normally require testing for other air contaminants as part of the initial source emission test.

3.3 SOURCE TESTING METHODS

The approved sampling methods are the United States Environmental Protection Agency (US EPA) methods under 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:

Method 2	Determination of stack gas velocity and volumetric flow (Type S pitot tube)
Method 3A	Determination of Oxygen and Carbon Dioxide concentrations in emissions from stationary sources (instrumental analyzer procedure)
Method 4	Determination of Moisture content in stack gases
Method 5	Determination of Particulate emissions from stationary sources
Method 6C	Determination of Sulphur Dioxide emissions from stationary sources (instrumental analyzer procedure)
Method 7E	Determination of Nitrogen Oxide emissions from stationary sources (instrumental analyzer procedure)
Method 10	Determination of Carbon Monoxide emissions from stationary sources
Method 25A*	Determination of Total Gaseous Organic concentration using a flame ionization analyzer
Method 29*	Determination of Metals emissions from stationary sources
Method 201A	Determination of PM_{10} Emissions (Constant Sampling Rate Procedure)

SW-846 Methods:

Method 0010*	Modified Method 5 Sampling Train (Semi-Volatiles)
Method 0023A*	Sampling Method for Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofuran Emissions from Stationary Sources
Method 0030*	Volatile Organic Sampling Train

* when required

The department reserves the right to require sample retesting if the above noted Methods are not adhered to.

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

If required by the department under section 3.2, other air contaminants will be sampled by a method approved by the department.

3.4 PARTICULATE SIZE FRACTIONATION

Particulate emission testing will incorporate size fractionation with the determination of PM_{10} and $PM_{2.5}$ as a minimum. If required, additional fractions will be determined via a cascade impactor yielding a minimum of 6 fractions, using a method approved by the department. Alternate methods of fractionation may also be used upon approval by the department.

3.5 SOURCE OPERATING CONDITIONS

The facility, will operate all sources which feed into the stack being tested, at the rate between the 85th percentile and the 95th percentile of the daily rates from the previous 3 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.

3.6 SOURCE TESTING AUDIT

Notwithstanding Section 3.1, the source testing program shall be subject to an onsite audit by a department official for consistency with the provisions of this document. If the audit shows that the provisions of this document are not met, then the onsite department official shall immediately suspend the source testing program for the affected pollutants. Source testing for such pollutants shall resume when the deficiencies identified during audit are within acceptable tolerances and addressed to the satisfaction of the onsite department official.

4. REPORTING REQUIREMENTS

4.1 FUEL CONSUMPTION

During source emission testing, the facility shall record and report total fuel consumption of all sources which feed into the stack.

4.2 FUEL COMPOSITION

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

i)	% sulphur by weight	ASTM D129-95, ASTM D4294-98
ii)	% ash by weight	ASTM D482-95
iii)	API gravity	ASTM D4052-96
iv)	nickel ppm	AA or ICP
v)	vanadium ppm	AA or ICP
vi)	other parameters as determined 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 75 days of completion of the sampling and shall include:

i) all field data recorded during testing
ii) instrument calibration information
iii) sampling site characteristics
iv) detailed statistics for each sample run
v) fuel consumption and composition data for each sample run
vi) data confirming the required facility operating conditions
vii) all other information required under this document

4.4 REFERENCE CONDITIONS

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