



**A.Lanfranco  
& Associates Inc.**

Environmental Consultants

Prepared for

**METRO VANCOUVER**

**Metrotower III 4730 Kingsway  
Burnaby, BC V5H 0C6**

**WASTE TO ENERGY FACILITY**

**Emissions Test Report  
November 2019 4th Quarter Survey  
Operational Certificate 107051**

## **CERTIFICATION**

The field monitoring for this survey was conducted by certified stack test technicians as required by the British Columbia Ministry of Environment (BC MOE) Field Sampling Manual.

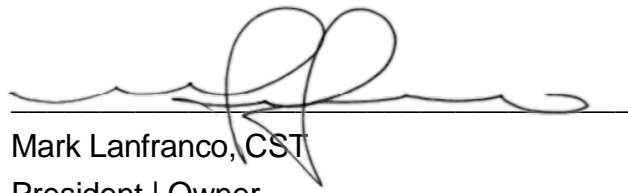
The field crew consisted of:

Mr. S. Harrington (certified), Mr. C. Lanfranco (certified), Mr. S. Ferguson (certified), Mr. J. Gibbs (certified) and Mr. S. Baker.

The report was prepared by Mr. S. Harrington using reporting principles and guidelines generally acceptable to Metro Vancouver (MV).

The field crew and A. Lanfranco and Associates Inc. certify that the test methods used were BC MOE/MV approved reference methods for the parameters investigated.

Report reviewed by:



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Mark Lanfranco, CST  
President | Owner

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## SUMMARY

The following table shows the emission results from the three units located at Metro Vancouver's Waste-To-Energy Facility (WTEF) as well as the current emission limits as defined by the Operational Certificate (OC) issued by BC Ministry of Environment & Climate Change Strategy. This compliance survey represents the fourth quarter of 2019.

**Table 1: Summary Comparison of Emissions Test Results with Limits**

<b>Parameter</b>	<b>Limit</b>	<b>Unit 1</b>	<b>Unit 2</b>	<b>Unit 3</b>	<b>Plant Average</b>
<b>Test Date</b>		4-5-Nov-19	6-7-Nov-19	5-6-Nov-19	
<b>Particulate</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>9.0</b>	1.15	0.50	5.99	<b>2.55</b>
<b>Hydrogen Fluoride</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>1.0</b>	0.01	0.02	2.97E-03	<b>0.01</b>
<b>Trace Metals - OC Class</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )					
Lead (Pb)	-	0.0008	0.0006	0.0071	<b>0.0028</b>
Arsenic (As)	-	0.0003	0.0006	0.0005	<b>0.0005</b>
Chromium (Cr)	-	0.0116	0.0036	0.0020	<b>0.0057</b>
<b>OC Class Sum</b> (Pb, As and Cr)	<b>0.064</b>	0.0128	0.0047	0.0095	<b>0.0090</b>
<b>Mercury</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>0.02</b>	0.0011	0.0007	0.0001	<b>0.0006</b>
<b>Cadmium</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>0.007</b>	0.0001	0.0000	0.0008	<b>0.0003</b>

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All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

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## 1 INTRODUCTION

Metro Vancouver (MV) commissioned an emission survey at the Waste-To-Energy Facility (WTEF) in Burnaby BC, as required by the provincially approved Operational Certificate (OC). This report documents the results of a survey on Units 1, 2 and 3 for the fourth survey of four for the year 2019. This survey includes filterable particulate matter, trace metals, mercury (Hg), hydrogen fluoride (HF), ammonia (NH<sub>3</sub>) and nitrous oxide (N<sub>2</sub>O). A. Lanfranco and Associates Inc., of Surrey, B.C., conducted the sampling program on behalf of MV. The sampling program consisted of, but was not limited to, the planning, execution, analysis, and reporting of three emission sources located at the WTEF.

This report includes a comparison of emission results to limits established in the OC, detailed emission results, a brief outline of methods employed, equipment used, and a discussion of the survey. All supporting data and appendices are presented under separate cover.

The individual sources that were monitored for compliance are identified as Unit 1, Unit 2 and Unit 3 which represent the three distinct processing lines at the WTEF. The three boilers are identified as discharge E300670 in the operational certificate.

Sampling was conducted on November 4, 5, 6, 7, 2019.

## 2 METHODOLOGY

All services provided by A. Lanfranco and Associates Inc. were conducted in accordance with approved reference methods as issued by:

- Metro Vancouver (MV)
- BC Ministry of Environment & Climate Change Strategy (BC MOE)
- Environment Canada (EC)
- US Environmental Protection Agency (EPA)

### 2.1 Sampling and Analytical Methods

The following table lists the test methods used for the different parameters measured. The subsequent paragraphs briefly describe each method.

**Table 2: Reference Methods**

<u>Parameter</u>	<u>Reference Method</u>
Sample and Velocity traverse points	EPS 1/RM/8 A Determination of Sampling Site and Traverse Points
Velocity and flowrate	EPS 1/RM/8 B Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)
Gas molecular weight (O <sub>2</sub> /CO <sub>2</sub> )	EPS 1/RM/8 C Determination of Molecular Weight by Gas Analysis
Flue gas Moisture	EPS 1/RM/8 D Determination of Moisture Content
Particulate Matter	EPS 1/RM/8 E Determination of Particulate Matter Emissions from Stationary Sources
Trace Metals with Mercury	EPA Method 29 Determination of Metals Emissions from Stationary Sources
Hydrogen Fluoride (HF)	EPS1/RM/1 Reference Method for Source Testing: Measurement of Releases of Gaseous Hydrogen Chloride from Stationary Sources
Nitrous Oxide (N <sub>2</sub> O)	WCB Method 1101
Ammonia (NH <sub>3</sub> )	EPA Method CTM 027

Sampling Site and Traverse Points

Primary: EPS 1/RM/8 Method A

Supporting: EPA Method 1

This method is designed to aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source. A measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. Traverse points are then located within each of these equal areas.

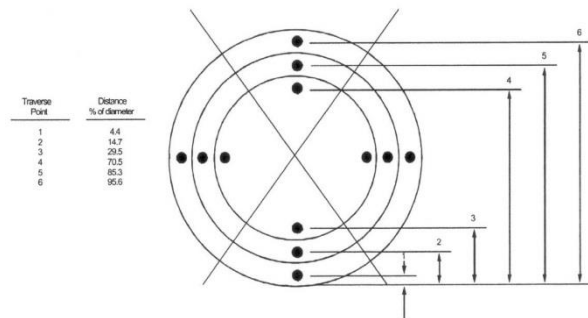


Figure 1. Example showing circular stack cross section divided into 12 equal areas, with location of traverse points.

Stack Gas Velocity and Volumetric Flow Rate

Primary: EPS 1/RM/8 Method B

Supporting: EPA Method 2

The average gas velocity in a stack or duct is determined from the gas density and from the measurement of velocity pressure with an S-type pitot tube. A standard pitot tube may be used where plugging of the tube openings due to particulate matter and/or moisture is not likely to occur. Stack gas volumetric flow rate is determined from measurements of stack gas velocity, temperature, absolute pressure, dry gas composition, moisture content, and stack diameter.

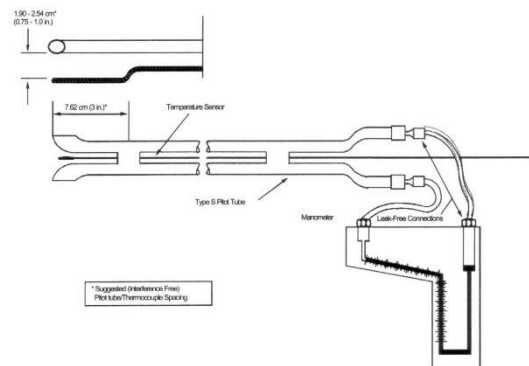


Figure 2. Type S Pitot Tube Manometer Assembly

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Molecular Weight by Gas Analysis

Primary: EPS 1/RM/8 Method C  
Supporting: EPA Method 3

An integrated or grab sample is extracted from a single point in the gas stream and analyzed for its components using a Fyrite analyzer, a gas chromatograph, or calibrated continuous analyzers.

Moisture Content

Primary: EPS 1/RM/8 Method D  
Supporting: EPA Method 4

A gas sample is extracted from a single point in the enclosed gas stream being sampled. The moisture is condensed, and its weight measured. This weight, together with the volume of gas sampled, enables the stack gas moisture content to be calculated.

Particulate Matter

Primary: EPS 1/RM/8 Method E  
Supporting: EPA Method 5

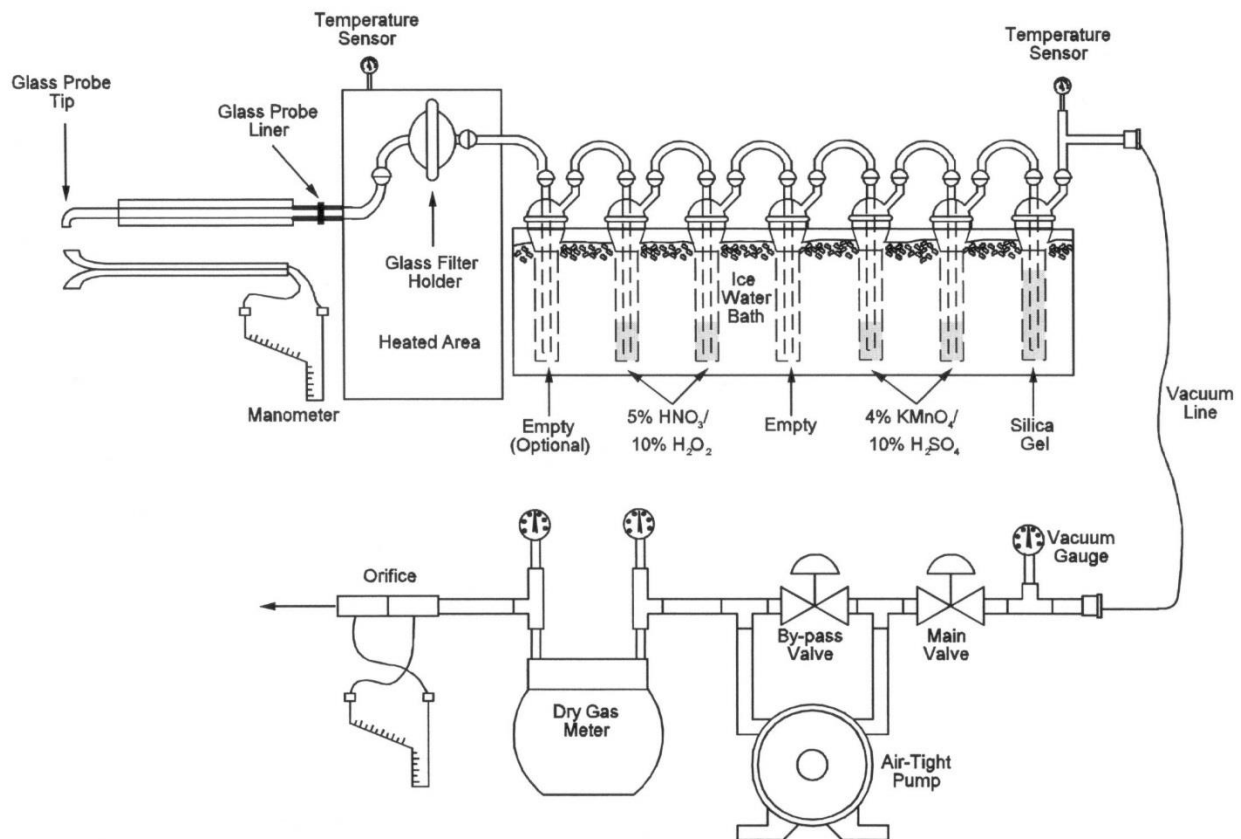
Particulate matter is withdrawn isokinetically from a number of sampling or traverse points in an enclosed gas stream. The particulate sample is collected in the nozzle, probe, and on a glass fibre filter, all maintained at a temperature of  $120 \pm 14^{\circ}\text{C}$  or such other temperature as is necessary to prevent blinding of the filter from condensation. 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 or release rate to be made.



Trace Metal

Primary: EPA Method 29 (modified)

This method is used in conjunction with the above Method 5. A stack sample is withdrawn isokinetically from the source. Particulate emissions are collected in the probe and on a heated filter, and gaseous emissions are then collected in an aqueous acidic solution of hydrogen peroxide (analyzed for all metals including Hg) and an aqueous acidic solution of potassium permanganate (analyzed only for Hg). The recovered samples are digested, and appropriate fractions are analyzed for Hg by cold vapour atomic absorption spectroscopy (CVAAS). The remaining trace metals are analyzed with inductively coupled argon plasma emission spectroscopy (ICAP), atomic absorption spectroscopy (AAS) and graphite furnace atomic absorption spectroscopy (GFAAS). Figure 3 displays the sample train and its configuration.



**Figure 3.** Particulate / Trace Metals Sampling Train

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Hydrogen Fluoride

Primary: EPS 1/RM/1

Supporting: BC Method 7176106 & 7066101

HF is sampled in a four-impinger train consisting of two impingers containing distilled/deionized H<sub>2</sub>O, one empty impinger, and a fourth containing silica gel. A sample of the stack gas is extracted from a single point near the centre of the stack over the sample duration at a constant rate. The collected samples are measured for F by ion chromatography at ALS Environmental in Burnaby, BC.

N<sub>2</sub>O

Primary: WCB Method 1101

Three N<sub>2</sub>O samples were collected from each source using evacuated tedlar bag sampling procedures. Each bag was purged and evacuated on-site with small amounts of stack gas, prior to final stack gas collection. Each bag sample was an integrated type sample where stack gases were collected over sixty minute periods. The bag sampling was conducted over about a four-hour period. The samples were analysed at Maxxam Laboratory, Burnaby B.C. N<sub>2</sub>O analysis was conducted within 24 hours of sample collection using WCB Method 1101.

Ammonia

Primary: EPA Method CTM-027

The absorbing solution in the first two impingers is 0.1 N H<sub>2</sub>SO<sub>4</sub> and the triplicate samples were extracted at a constant rate for 60-minute durations. The collected samples are analyzed at Element Laboratories in Surrey, BC

#### Method Modifications

Three minor method modifications were instituted for this work.

1. Reagent blanks for metals trains were made to the same volumes as all samples. In other words, exactly 100 ml of the various reagents used to recover samples was NOT done, as some sample components (probe washing for example) required more than 100 ml to adequately clean and rinse the probe. Instead, sample recovery was conducted with however much rinsing was deemed adequate. In the laboratory, the blanks and samples were made up with the appropriate reagent so that all samples and blanks were the same volume.
2. Filter and residue weighing were not conducted with the six-hour interval technique. Instead the sample filters and beakers were conditioned with cooling and desiccation and then weighed on two separate laboratory scales after 24 hours. Duplicate or triplicate Blank samples were carried through the gravimetric analysis, and the sample results were adjusted with the Blank data to determine the net filter and probe wash residue weight gain. This is the Environment Canada approved modified approach for weighing probe wash residue.
3. For the purposes of calculating a result, all parameters were given the value of  $\frac{1}{2}$  the detection limit when the analysis yielded 'non-detect' results.

All results are expressed using the metric system and corrected to standard conditions of 20 °C and 101.325 kPa, dry gas (unless otherwise noted).

## 2.2 Calculations

The following sections show the equations and define the variables that were used for this survey. The equations are organized in three sections. Equations 1-11 were used to calculate parameter concentration at standard conditions on a dry basis. Equations 12-26 were used to sample within the  $100 \pm 10\%$  isokinetic variation and to confirm that sampling meets this isokinetic variation threshold. Equations 27-29 were used to calculate the volumetric flowrate of the stack flue gas.

### 2.2.1 Parameter Concentration Calculations

$$c = \frac{m}{V_{std}} \quad \text{Equation 1}$$

$$m_{part} = m_{filter} + m_{pw} \quad \text{Equation 2}$$

$$m_i = m_{ana,i} - m_{blank} \quad \text{Equation 3}$$

$$m_{HF} = \frac{20.006}{18.998} (m_F - m_{blank}) / 1000 \quad \text{Equation 4}$$

$$V_{std} = \frac{V_{std(imp)}}{35.315} \quad \text{Equation 5}$$

$$V_{std(imp)} = \frac{V_{samp} \times y \times P_m \times (T_{std} + 459.67)}{P_{std} \times (T_{m(ave)} + 459.67)} \quad \text{Equation 6}$$

$$V_{samp} = V_{final} - V_{init} \quad \text{Equation 7}$$

$$P_m = P_B + \frac{\Delta H_{ave}}{13.6} \quad \text{Equation 8}$$

$$\Delta H_{ave} = \frac{1}{n} \sum_{i=1}^n \Delta H_{i(act)}, \text{ where } n = \text{the number of points} \quad \text{Equation 9}$$

$$OC = \frac{20.9 - \%O_{2c}}{20.9 - \%O_{2m}} \quad \text{Equation 10}$$

$$\%O_{2m} = \frac{1}{n} \sum_{i=1}^n \%O_{2i}, \text{ where } n = \text{the number of } O_2 \text{ measurements} \quad \text{Equation 11}$$

Where,

$c$	= Parameter concentration
$m$	= Parameter mass
$m_i$	= Net analytical mass (mg, ng, or $\mu\text{g}$ )
$m_{ana,i}$	= Analytical mass (mg, ng, or $\mu\text{g}$ )
$m_{blank}$	= Blank analytical mass (mg, ng, or $\mu\text{g}$ )
$m_{part}$	= Total particulate mass (mg)
$m_{filter}$	= Net particulate gain from filter (mg)
$m_{pw}$	= Net particulate gain from probe wash (mg)
$m_{HF}$	= Net mass of HF (mg)
$m_F$	= Net mass of F ( $\mu\text{g}$ )
$V_{std(imp)}$	= Sample volume at standard conditions ( $\text{ft}^3$ )
$V_{std}$	= Sample volume at standard conditions ( $\text{m}^3$ )
$V_{samp}$	= Sample volume at actual conditions ( $\text{ft}^3$ )
$V_{final}$	= Final gas meter reading ( $\text{ft}^3$ )
$V_{init}$	= Initial gas meter reading ( $\text{ft}^3$ )
$T_{std}$	= Standard temperature (68 °F)
$T_m$	= Gas meter temperature (°F)
$T_{m(ave)}$	= Average gas meter temperature (°F)
$P_m$	= Absolute meter pressure (inches of Hg)
$P_B$	= Barometric pressure (inches of Hg)
$P_{std}$	= Standard barometric pressure (29.92 inches of Hg)
$\Delta H_{ave}$	= Average of individual point orifice pressures (inches of $\text{H}_2\text{O}$ )
$\Delta H_{i(act)}$	= Individual recorded point orifice pressures (inches of $\text{H}_2\text{O}$ )
$OC$	= Oxygen correction factor (dimensionless)
$\%O_{2c}$	= Oxygen concentration to correct to (% dry basis)
$\%O_{2i}$	= Individual oxygen measurements (% dry basis)
$\%O_{2m}$	= Average measured stack gas oxygen concentration (% dry basis)

Equation 1 is the general concentration calculation used for all parameters. The mass,  $m$ , is the net analytic mass for the given parameter. For particulate,  $m$  is the sum of the mass contributed from probe washing and filter particulate.

For trace metals and Hg,  $m$  is the blank corrected (Equation 3) analytical result (Appendix 1) for each metals species and run. If the analytical result was below the detection limit, half of the detection limit (DL) was used for  $m$  in Equation 1.

The HF concentration was calculated from analytic results. Equation 4 was used to convert the F mass to HF, and this result was used as  $m$  in equation 1. As with the trace metals, half the detection limit was substituted for results that were non-detectable.

### 2.2.2 Isokinetic Variation Calculations

$$\Delta H_i = \frac{2.62 \times 10^7 \times c_p \times A_n \times (1 - B_{wo}) \times M_D \times (T_m + 459.67) \times \Delta p_i}{k_o \times M_w \times (T_{Stk} + 459.67)} \quad \text{Equation 12}$$

$$R_m = 85.49 \times c_p \times \sqrt{\Delta p_i} \times \sqrt{\frac{(T_{Stk_i} + 459.67)}{M_w \times P_B}} \times 60 \times A_n \times \frac{(T_{m_i} + 459.67) \times (1 - B_{wo})}{(T_{Stk_i} + 459.67) \times y} \quad \text{Equation 13}$$

$$A_n = \pi \left( \frac{d_n}{24} \right)^2 \quad \text{Equation 14}$$

$$M_w = M_D \times (1 - B_{wo}) + 18 \times B_{wo} \quad \text{Equation 15}$$

$$M_D = 0.44 \times \%CO_2 + 0.32 \times \%O_2 + 0.28 \times (100 - \%CO_2 - \%O_2) \quad \text{Equation 16}$$

$$T_{Stk} = \frac{1}{n} \sum_{i=1}^n T_{Stk_i}, \text{ where } n = \text{the number of points} \quad \text{Equation 17}$$

$$B_{wo} = \frac{V_{cond}}{V_{cond} + V_{std(imp)}} \quad \text{Equation 18}$$

$$V_{cond} = 0.04707 \times V_{gain} \quad \text{Equation 19}$$

$$Iso = \frac{1}{n} \sum_{i=1}^n Iso_i, \text{ where } n = \text{the number of points} \quad \text{Equation 20}$$

$$Iso_i = \frac{v_{nzi}}{v_i} \quad \text{Equation 21}$$

$$v_i = 85.49 \times c_p \times \sqrt{\Delta p_i} \times \sqrt{\frac{(T_{Stk_i} + 459.67)}{(P_{Stk} \times M_w)}} \quad \text{Equation 22}$$

$$v_{nzi} = \frac{(V_i - V_{i-1}) \times y \times (T_{Stk_i} + 459.67) \times (P_B + \frac{\Delta H_{i(act)}}{13.6})}{A_n \times t_i \times 60 \times (T_{m(i)} + 459.67) \times P_{Stk} \times (1 - B_{wo})} \quad \text{Equation 23}$$

$$P_{stk} = P_B + \frac{P_g}{13.6} \quad \text{Equation 24}$$

$$v_{stk} = \frac{1}{n} \sum_{i=1}^n v_i, \text{ where } n = \text{the number of points} \quad \text{Equation 25}$$

$$v_{nz} = \frac{1}{n} \sum_{i=1}^n v_{nzi}, \text{ where } n = \text{the number of points} \quad \text{Equation 26}$$

Where,

$A_n$	= Nozzle area (ft <sup>2</sup> )
$d_n$	= Diameter of nozzle (inches)
$c_p$	= Pitot coefficient (dimensionless)
$\Delta p_i$	= Individual point differential pressures (inches of H <sub>2</sub> O)
$T_{stk}$	= Average flue gas temperature (°F), second subscript <i>i</i> , indicates individual point measurements
$T_m$	= Average gas meter temperature (°F), second subscript <i>i</i> , indicates individual point measurements
$k_o$	= Gas meter calibration constant (dimensionless)
$y$	= Gas meter calibration factor (dimensionless)
$\Delta H_{i(act)}$	= Calculated individual point orifice pressures (inches of H <sub>2</sub> O)
$P_g$	= Stack Static pressure (inches of H <sub>2</sub> O)
$P_{stk}$	= Absolute stack pressure (inches of Hg)
$M_w$	= Wet gas molecular weight (g/gmol)
$M_D$	= Dry gas molecular weight (g/gmol)
%CO <sub>2</sub>	= Stack gas carbon dioxide concentration (% dry basis)
%O <sub>2</sub>	= Stack gas oxygen concentration (% dry basis)
$B_{wo}$	= Stack gas water vapour, proportion by volume
$V_i$	= Gas meter reading at individual point(ft <sup>3</sup> )
$t_i$	= Sample time at each point (minutes)
$V_{cond}$	= Total volume of water vapor collected, corrected to standard conditions (ft <sup>3</sup> )
$V_{gain}$	= Condensate gain of impinger contents (mL)
$P_{std}$	= Standard pressure (29.92 inches of Hg)
$v_{stk}$	= Average flue gas velocity (ft/sec)
$v_i$	= Individual point flue gas velocity (ft/sec)
$v_{nz}$	= Average velocity at nozzle(ft/sec)
$v_{nzi}$	= Individual point velocity at nozzle(ft/sec)
$ISO_i$	= Individual point isokinetic variation (%)
$ISO$	= Average isokinetic variation (%)
$R_m$	= Isokinetic sampling rate (ft <sup>3</sup> /min)

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### 2.2.3 Volumetric Flowrate Calculations

$$Q_S = Q_A \times \frac{(T_{Std} + 459.67)}{(T_{Stk} + 459.67)} \times \frac{P_{Stk}}{P_{Std}} \quad \text{Equation 27}$$

$$Q_A = \frac{v_{stk} \times 60 \times A_{stk}}{35.315} \quad \text{Equation 28}$$

$$A_{stk} = \pi \left( \frac{d}{24} \right)^2 \quad \text{Equation 29}$$

Where,

$Q_A$  = Actual flowrate ( $Am^3/min$ )  
 $Q_S$  = Flowrate ( $m^3/min$ ) at standard conditions on a dry basis  
 $A_{stk}$  = Area of stack ( $ft^2$ )  
 $d$  = Diameter of stack (inches)



### 3 DETAILED TEST RESULTS

The results of stack emissions were calculated using a “STACK” computer program developed by A. Lanfranco and Associates for BC MOE requirements.

Tables 3-11 present the detailed results of all emissions parameters tested for each of the units. Additional data and the computer outputs can be found in the accompanying Appendices.

**Table 3: Unit 1 Summary of Emission Test Results**

Parameter	Run 1	Run 2	Run 3	Average
Test Date - Particulate/Metals	4-Nov-19	5-Nov-19	5-Nov-19	
Test Time - Particulate/Metals	10:44 - 12:50	09:35 - 11:38	12:15 - 14:18	
Duration - Minutes	120	120	120	
Test Date - Acid Gases	5-Nov-19	5-Nov-19	5-Nov-19	
Test Time - Acid Gases	09:40 - 10:40	10:54 - 11:54	12:25 - 12:25	
Duration - Minutes	60	60	60	
Stack Temperature (°C)	149	150	154	151
Average Gas Velocity (m/s)	13.1	13.0	12.9	13
Dry Flow Rate (m <sup>3</sup> /min)	1124	1127	1115	1122
Moisture (Vol. %)	15.7	14.9	14.4	15.0
Oxygen (Vol. %)(dry basis)	10.4	10.4	10.1	10.3
Carbon Dioxide (Vol. %)(dry basis)	10.0	10.0	10.0	10.0
<b>Particulate</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	1.79	0.86	0.81	<b>1.15</b>
<b>Hydrogen Fluoride</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.003	0.017	0.002	<b>0.007</b>
<b>Nitrous Oxide</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )*	2.1	10.3	11.1	<b>7.8</b>
<b>Ammonia</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.9	1.5	3.2	<b>2.0</b>
<b>Trace Metals - Operational Certificate List (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>				
<b>OC Class</b> (Pb, As and Cr)	0.03458	0.00190	0.00189	<b>0.01279</b>
<b>Aluminum</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.01634	0.01086	0.00997	0.01239
<b>Cadmium</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.00008	0.00010	0.00007	0.00008
<b>Lead</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.00107	0.00059	0.00077	0.00081
<b>Mercury</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.00092	0.00047	0.00206	0.00115
<b>Phosphorus</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	0.00238	0.00120	0.00119	0.00159
Isokinetic Variation ( % )	103	102	102	102

\*N<sub>2</sub>O was sampled on November 4, 2019

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 4: Unit 1 Trace Metals Emissions (OC Class)**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
<b>OC Class</b>				
Pb	0.00107	0.00059	0.00077	0.00081
As	0.00020	0.00040	0.00040	0.00033
Cr	0.03330	0.00091	0.00072	0.01164
Sum of OC Class	0.03458	0.00190	0.00189	0.01279
<b>Other</b>				
Al	0.01634	0.01086	0.00997	0.01239
Cd	0.00008	0.00010	0.00007	0.00008
P	0.00238	0.00120	0.00119	0.00159
Hg	0.00092	0.00047	0.00206	0.00115

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 5: Unit 1 Detailed Trace Metals Emissions**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
Pb	0.00107	0.00059	0.00077	0.00081
Sb	0.00129	0.00090	0.00099	0.00106
Cu	0.00100	0.00021	0.00057	0.00059
Mn	0.00167	0.00041	0.00020	0.00076
V	0.00040	0.00040	0.00040	0.00040
Zn	0.00397	0.00112	0.00318	0.00276
As	0.00020	0.00040	0.00040	0.00033
Cr	0.03330	0.00091	0.00072	0.01164
Co	0.00052	0.00009	0.00010	0.00024
Ni	0.01463	0.00092	0.00036	0.00530
Se	0.00060	0.00150	0.00060	0.00090
Te	0.00079	0.00080	0.00079	0.00080
Tl	0.00037	0.00037	0.00037	0.00037
Cd	0.00008	0.00010	0.00007	0.00008
Hg	0.00092	0.00047	0.00206	0.00115

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 6: Unit 2 Summary of Emission Test Results**

<b>Parameter</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
Test Date - Particulate/Metals	6-Nov-19	7-Nov-19	7-Nov-19	
Test Time - Particulate/Metals	12:53 - 14:57	09:45 - 11:47	12:28 - 14:30	
Duration - Minutes	120	120	120	
Test Date - Acid Gases	7-Nov-19	7-Nov-19	7-Nov-19	
Test Time - Acid Gases	10:35 - 11:35	12:38 - 13:38	14:07 - 15:07	
Duration - Minutes	60	60	60	
Stack Temperature (°C)	156	148	151	152
Average Gas Velocity (m/s)	13.3	12.9	13.2	13
Dry Flow Rate (m <sup>3</sup> /min)	1123	1110	1154	1129
Moisture (Vol. %)	16.2	16.0	14.2	15.5
Oxygen (Vol. %)(dry basis)	9.5	9.5	9.8	9.6
Carbon Dioxide (Vol. %)(dry basis)	10.1	10.0	10.3	10.1
<b>Particulate (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.62	0.37	0.53	<b>0.50</b>
<b>Hydrogen Fluoride (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.029	0.017	0.016	<b>0.020</b>
<b>Nitrous Oxide (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)*</b>	7.8	6.9	6.5	<b>7.1</b>
<b>Ammonia (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	2.0	2.3	4.8	<b>3.0</b>
<b>Trace Metals - Operational Certificate List (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>				
<b>OC Class (Pb, As and Cr)</b>	0.00835	0.00187	0.00401	<b>0.00474</b>
<b>Aluminum (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00671	0.00267	0.00442	0.00460
<b>Cadmium (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00004	0.00004	0.00004	0.00004
<b>Lead (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00051	0.00060	0.00070	0.00060
<b>Mercury (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00057	0.00141	0.00005	0.00067
<b>Phosphorus (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00134	0.00140	0.00085	0.00120
Isokinetic Variation ( % )	103	103	101	102

\*N<sub>2</sub>O was sampled on November 4, 2019

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 7: Unit 2 Trace Metals Emissions (OC Class)**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
<b>OC Class</b>				
Pb	0.0005	0.0006	0.0007	0.0006
As	0.0008	0.0005	0.0003	0.0006
Cr	0.0070	0.0007	0.0030	0.0036
Sum of OC Class	0.0083	0.0019	0.0040	0.0047
<b>Other</b>				
Al	0.00671	0.00267	0.00442	0.0046
Cd	0.00004	0.00004	0.00004	0.0000
P	0.00134	0.00140	0.00085	0.0012
Hg	0.00057	0.00141	0.00005	0.0007

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 8: Unit 2 Detailed Trace Metals Emissions**

<b>Metal</b>	<b>Test 1</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 2</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Test 3</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	<b>Average</b> (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
Pb	0.00051	0.00060	0.00070	0.00060
Sb	0.00083	0.00088	0.00085	0.00085
Cu	0.00027	0.00011	0.00014	0.00018
Mn	0.00071	0.00026	0.00034	0.00044
V	0.00033	0.00035	0.00034	0.00034
Zn	0.00227	0.00488	0.00160	0.00292
As	0.00083	0.00053	0.00034	0.00057
Cr	0.00700	0.00074	0.00298	0.00357
Co	0.00011	0.00007	0.00014	0.00011
Ni	0.00409	0.00058	0.00092	0.00186
Se	0.00050	0.00053	0.00138	0.00080
Te	0.00067	0.00070	0.00068	0.00068
Tl	0.00035	0.00040	0.00051	0.00042
Cd	0.00004	0.00004	0.00004	0.00004
Hg	0.00057	0.00141	0.00005	0.00067

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 9: Unit 3 Summary of Emission Test Results**

<b>Parameter</b>	<b>Run 1</b>	<b>Run 2</b>	<b>Run 3</b>	<b>Average</b>
Test Date - Particulate/Metals	5-Nov-19	6-Nov-19	6-Nov-19	
Test Time - Particulate/Metals	12:54 - 14:56	09:13 - 11:15	11:27 - 13:30	
Duration - Minutes	120	120	120	
Test Date - Acid Gases	6-Nov-19	6-Nov-19	6-Nov-19	
Test Time - Acid Gases	09:43 - 10:43	10:55 - 11:55	12:14 - 13:14	
Duration - Minutes	60	60	60	
Stack Temperature (°C)	154	155	158	156
Average Gas Velocity (m/s)	14.3	13.6	14.3	14.0
Dry Flow Rate (m <sup>3</sup> /min)	1229	1171	1203	1201
Moisture (Vol. %)	14.7	14.4	15.7	14.9
Oxygen (Vol. %)(dry basis)	9.6	10.0	10.0	9.9
Carbon Dioxide (Vol. %)(dry basis)	10.0	10.0	10.0	10.0
<b>Particulate (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	5.06	5.92	6.99	<b>5.99</b>
<b>Hydrogen Fluoride (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	3.14E-03	3.12E-03	2.66E-03	<b>2.97E-03</b>
<b>Nitrous Oxide (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)*</b>	10.0	5.4	17.4	<b>11.0</b>
<b>Ammonia (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	2.2	4.2	4.9	<b>3.800</b>
<b>Trace Metals - Operational Certificate List (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00923	0.00919	0.01008	<b>0.00950</b>
<b>OC Class (Pb, As and Cr)</b>	0.01186	0.00948	0.00932	0.01022
<b>Aluminum (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00093	0.00061	0.00078	0.00077
<b>Cadmium (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00766	0.00508	0.00845	0.00706
<b>Lead (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00012	0.00008	0.00018	0.00013
<b>Mercury (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>	0.00500	0.00621	0.00466	0.00529
<b>Phosphorus (mg/m<sup>3</sup> @ 11% O<sub>2</sub>)</b>				
Isokinetic Variation ( % )	102	104	103	<b>103</b>

\*N<sub>2</sub>O was sampled on November 4, 2019

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 10: Unit 3 Trace Metals Emissions (OC Class)**

Metal	Test 1 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 2 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 3 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Average (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
<b>OC Class</b>				
Pb	0.00766	0.00508	0.00845	0.00706
As	0.00000	0.00072	0.00065	0.00046
Cr	0.00157	0.00339	0.00098	0.00198
Sum of OC Class	0.00923	0.00919	0.01008	0.00950
<b>Other</b>				
Al	0.01186	0.00948	0.00932	0.0102
Cd	0.00093	0.00061	0.00078	0.0008
P	0.00500	0.00621	0.00466	0.0053
Hg	0.00012	0.00008	0.00018	0.0001

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

**Table 11: Unit 3 Detailed Trace Metals Emissions**

Metal	Test 1 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 2 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Test 3 (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )	Average (mg/m <sup>3</sup> @ 11% O <sub>2</sub> )
Pb	0.00766	0.00508	0.00845	0.00706
Sb	0.00245	0.00297	0.00403	0.00315
Cu	0.00251	0.00230	0.00337	0.00272
Mn	0.00059	0.00095	0.00054	0.00069
V	0.00025	0.00023	0.00036	0.00028
Zn	0.06191	0.05905	0.07865	0.06654
As	0.00000	0.00072	0.00065	0.00046
Cr	0.00157	0.00339	0.00098	0.00198
Co	0.00007	0.00012	0.00012	0.00010
Ni	0.00042	0.00288	0.00039	0.00123
Se	0.00047	0.00049	0.00054	0.00050
Te	0.00036	0.00052	0.00057	0.00048
Tl	0.00047	0.00049	0.00054	0.00050
Cd	0.00093	0.00061	0.00078	0.00077
Hg	0.00012	0.00008	0.00018	0.00013

All data is corrected to standard conditions (S) of 20 °C, 101.325 kPa (dry) unless otherwise noted.

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## 4 DISCUSSION

All Units were in compliance with limits as set out in the OC.

Relative to other recent surveys, particulate matter was in the low range for Units 1 and 2, but high for Unit 3. Unit 3 is operating with older fabric filters that are due for replacement in 2020.

As stated in Section 2.1, EPA Method 5/29 was modified slightly to accommodate performance based analytical protocols utilized in B.C. for trace metals sampling and analysis. The analytical modification consists of using volumes of recovery reagents different than the method stipulates. In order to validate (ie performance-based QA) the modification, sample Blanks and all samples were made up to the same volume, so that subtraction of the Blank data, was done on equivalent sample sizes. In addition, special Hg spiking of blank filters and peroxide solutions was conducted. This spiking is referred to as a “matrix spike” and is reported in Appendix B, Quality Control for mercury, where the recovery of spiked mercury was calculated to be an acceptable 85 to 115%. It should be noted that independent front half/back half analysis of all trace metals was conducted for this survey. In addition, individual quartz filter blanks were analyzed for each unit.

Sampling was conducted in accordance with their respective reference methods (EPA 29 except as discussed) and passed all appropriate quality assurance and quality control criteria.

All sampling was conducted/supervised by certified emission testing personnel, using calibrated source sampling equipment and quality controlled reagents. It is therefore stated that the survey and this report complies with the MV’s WTEF compliance testing requirements for this fourth survey in 2019.