

APPENDIX G.21
2020 Source Testing

2020 Source Testing Report

Eco Waste Incinerators – Milne Port and Mary River
Milne Port and Mary River, Nunavut
Project # OAQS2004

Prepared for:

Baffinland Iron Mines Corporation

2275 Upper Middle Road East, Suite 300, Oakville, ON L6H 0C3

27-Apr-21

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27-Apr-21

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Executive Summary

Baffinland Iron Mines Corporation (Baffinland) retained Wood Environment & Infrastructure Solutions (Wood) to conduct performance source testing on two (2) Eco Waste Incinerators located in Mary River and Milne Port on Baffin Island, Nunavut. The incinerators are used to burn various wastes including personal domestic waste, kitchen waste, dewatered sewage sludge, paper, packaging, lumber and textiles, documents, clinical and medical waste.

Testing was performed as part of Baffinland’s obligations to the Nunavut Government. The program was designed to measure incinerator emissions of dioxins and furans (D/F). In-stack concentrations were calculated and compared against the Canadian Council of Minister of the Environment Canada-Wide Standard (CWS) for the same.

The program was conducted from August 24th, 2020 to August 28th, 2020 at the Milne Port site, and from August 29th, 2020 to September 2nd, 2020 at the Mary River site.

Testing was carried out during normal maximum burns with approximately 2000 kg of pre-sorted camp waste. Each batch incineration was set for 10 to 12 hours with a subsequent approximate 12 hour cool down period. Each test commenced once stable incinerator temperatures were achieved, approximately 2 hours following combustion start up. Baffinland staff provided guidance for when testing was to begin and attended/documentated all tests conducted.

The testing results are summarized in Tables ES.1 to ES.3. Sampling, analysis and reporting procedures were followed as per the Ontario Source Testing Code (OSTC) and U.S. Environmental Protection Agency (U.S. EPA) methods.

The test program gave mixed test results with two out of the three tests for each unit showing levels below the Environment Canada CCME criteria of 80 pg/DRm³ corrected to 11%O₂.

Taking into consideration, issues that occurred during the 3rd Milne Port Test (high level of wet waste) and during the 1st Mary River Test (Process Faults), and excluding them from the test averages, it may be indicated that under normal operating conditions, when operating as specified by the manufacturer, the incinerators can meet the 80 pg TEQ /DRm³ @11% O₂ criteria.

This report is subject to the Appended Statement of Limitations.

Table ES.1: Average Stack Gas Characteristics

Source	Flow (DRm ³ /s)*	Oxygen (% dry)	Carbon Dioxide (% dry)	Carbon Monoxide (ppm dry)	Moisture (%)	Stack Temp. (°C)
Eco Waste – Milne Port	1.33	15.21%	4.63%	2.85	5.69%	494
Eco Waste – Mary River	1.87	16.23%	3.57%	4.05	4.22%	529

*DRm³ = Dry reference cubic metres (25°C, 101.3 kPa)



Table ES2: Summary of In-Stack Dioxin/Furan Concentrations – Milne Port

Test	In-Stack Concentration pg/DRm ^{3*}	Criteria	% Of Criteria
1	60.7		
2	41.2		
3	819**		
Average	51.0 (307)	80	63.7% (384%)

*Corrected to 11% O₂

**On review of the incinerator operations during the third test, which contained the highest level of wet waste, this test may represent an outlier and could be excluded from the average. Averages presented show the average without and with the third test included.

Table ES3: Summary of In-Stack Dioxin/Furan Concentrations – Mary River

Test	In-Stack Concentration pg/DRm ^{3*}	Criteria	% Of Criteria
1	494**		
2	14.4		
3	40.1		
Average	27.3 (183)	80	34.0% (229%)

*Corrected to 11% O₂

**On review of the incinerator operations (note: primary faults) during the first test, this test may represent an outlier and could be excluded. Averages presented show the average without and with the third test included.



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1.0 Introduction

Baffinland Iron Mines Corporation (Baffinland) retained Wood Environment & Infrastructure Solutions (Wood) to conduct performance source testing on two (2) Eco Waste Incinerators located in Mary River and Milne Port on Baffin Island, Nunavut. Testing was conducted on August 24th, 25th, and 28th, 2020 at the Milne Port site, and on August 29th, 31st, and September 2nd, 2020 at the Mary River site.

The incinerator exhausts were tested for the following contaminants:

- Emission flow rates within the duct;
- Dioxins and furans; and
- Combustion gases (O₂, CO₂, CO).

The incinerators are used to burn various wastes including personal domestic waste, kitchen waste, dewatered sewage sludge, paper, packaging, lumber and textiles, documents, clinical and medical waste.

The program was designed to measure the incinerators' emissions once stable operations were obtained. Stable operation was defined as the incinerator achieving primary and secondary temperatures achieved and maintained within the defined temperature zones. Measured dioxin/furan in-stack concentrations were compared against the Canadian Council of Ministers of the Environment Canada-Wide Standard (CWS) of 80 pg per dry reference cubic meter.

Sampling, analysis and reporting procedures were followed as per the Ontario Source Testing Code (OSTC) and Environment Canada Method EPS 1/RM/3.

1.1 Summary of Test Program

The test contaminants included in this program and the corresponding testing protocols are listed below in Table 1.

Table 1: Test Contaminants

Test Contaminant	Sampling Method	Analytical Method
Flow Rate	EPS 1-AP-74-1 Methods A-F	N/A
Dioxins / Furans	Env. Canada EPS 1/RM/2	EPS 1/RM/3 HRMS
Oxygen/Carbon Dioxide (O ₂ /CO ₂)	U.S. EPA Method 3A (modified)	Electrochemical / Non-dispersive Infrared
Carbon Monoxide	U.S. EPA Method 10 (modified)	Non-dispersive Infrared

Note: EPA 40CFR60 – United States Environmental Protection Agency
EPS – Environment Canada's Environmental Protection Series

1.2 Test Program Organization

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Company Address / Plant Location:	Mary River Mine Site Baffin Island, Nunavut
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2) Sampling Company:	Wood Environment & Infrastructure Solutions
Project Coordinator:	Steve McClure
Telephone No.:	(905) 568-2929
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Sampling Team:	Steve McClure, Ozgun Kizilkaya
3) Analytical Laboratory:	ALS Global
Project Coordinator:	Ron McLeod
Telephone No.:	(905) 331-3111

2.0 Source Description

Baffinland operates two dual chambered diesel fired Eco Waste incinerators, one at each of the Milne Port and Mary River sites. Each incinerator consists of a primary and secondary chamber. Waste is manually loaded into the primary chamber whose function is to perform pyrolysis and gasification, and combustion of fixed carbon. The secondary chamber completes the combustion and ensures that black soot is not released from the exhaust stack. The incinerator capacity is approximately 2000 kg per day. The two units are near identical in design.

The stack inner diameter was measured at 0.800 metres (31.5 inches) with a cross-sectional area of 0.503 m² (5.41 sf). Sample ports are located approximately 4 diameters downstream and more than 2 diameters upstream from flow disturbances. On both units, however, opacity meters are located immediately beneath one of the sampling traverses.

Each batch was constructed with a set quantity of materials, including wooden pallets on the bottom, cardboard, and specific quantities of wet and dry camp waste. At the completion of each cycle, the incinerator was allowed to cool to below approximately 45C and was raked out to leave the incinerator empty.

3.0 Test Program

3.1 Objectives

The purpose of the test program was to establish whether the performance of the installed equipment (Eco-Waste incinerators) meets emission guarantees.

Test objectives include the following:

- Measurement of the exhaust gas characteristics and emission rates of the contaminants; and
- Comparing in-stack concentrations to the Canada-Wide Standard for dioxins/furans.

3.2 Test Matrix

The test matrix for this program is provided below in Table 2.

Table 2: Test Matrix

No. of Runs / Unit	Sample/ Pollutant	Method Number	Sample Run (min)	Analytical Method	Analytical Laboratory
3	Dioxins / Furans	EPS 1/RM/2	240	GC/HRMS GC/MS	ALS Global
3	O ₂ and CO ₂	EPA Method 3A (modified)	240	Electrochemical, Non-dispersive Infrared	Wood Analyzer
3	CO	EPA Method 10 (modified)	240	Non-dispersive Infrared	Wood Analyzer

3.3 Operations and Process

Each test commenced once stable operation of the incinerator was obtained, approximately 120 minutes after waste loading and ignition of the burners in the primary chamber. It is our understanding that stable operation was considered achieved when a given temperature range was reached and then maintained in the primary chamber for a period of time.

The decision to commence sampling was given by Baffinland staff. Baffinland staff also documented the loading and operations of the incinerators and any aberrations in the function of the incinerator.

During the program, several process issues occurred resulting from process faults and other combustion issues believed related to the nature of the waste. These were documented by Baffinland staff and are included in the appendix.



4.0 Sampling Locations

Gas streams emitted from the incinerators are discharged through a stack having an exit diameter of 0.80m. Figure 1 shows an example of the sampling pattern across the cross-section of the stack. Figures 2 and 3 show the two incinerator stack sampling locations.

It is noted that 4 diameters ahead of each of the sample locations, is located a dilution damper. These dampers are in a fixed position that is manually set and allow air infiltration into the stacks in order to induce flow in the stack.

Similarly, on both units, opacity meters are located immediately beneath one of the sampling traverses. These are visible in Figures 2 and 3 below as the blue devices on the sides of the stacks. During operation, the opacity meters have air blowing into the stack to maintain clean windows for the opacity measurements.

The isokinetic sampling locations are located as follows:

Milne Port:

ID: 0.80 m

Distance to upstream disturbance: approximately 4 diameters

Distance to downstream disturbance: >2 diameters

Mary River:

ID: 0.80 m

Distance to upstream disturbance: approximately 4 diameters

Distance to downstream disturbance: >2 diameters

For the isokinetic tests, a total of 12 sampling points (six (6) per traverse) were tested. Both traverses were sampled on both stacks for all tests, similar to the configuration shown in Figure 1.

Figure 1: Sampling point pattern

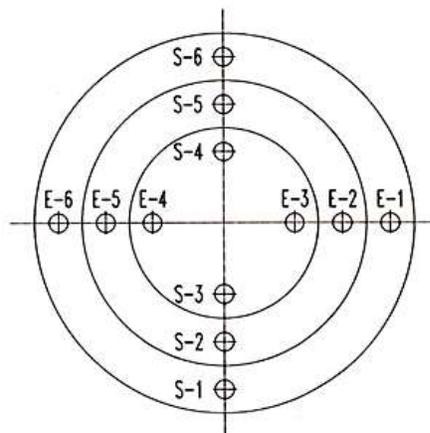




Figure 2: Incinerator Stack, Milne Port



Figure 3: Incinerator Stack, Mary River

5.0 Sampling and Analytical Procedures

5.1 Dioxins/Furans

Sampling for dioxins and furans was conducted using a single isokinetic sampling train in accordance with the "Reference Method for Source Testing: Measurement of Releases of Selected Semi-Volatile Organic Compounds from Stationary Sources", Environment Canada Report EPS 1/RM/2. Performance of the method involved the use of an integrated sampling train consisting of a quartz filter (pre-rinsed with a Hexane/Acetone solution), condenser, polymeric resin trap (XAD-2), and impingers. The use of the condenser ensured that the sample gas passing through the XAD-2 resin trap was maintained at a temperature below 20°C.

All glassware, filters and resin used for this program were cleaned as per the Reference Method prior to equipment mobilization to site. A set of blank samples was collected from a fully assembled sampling train prior to beginning the sampling program. The blank samples were analyzed and are reported in the appendices.

The sampling time per test, excluding port changes, leak checks or process interruptions, was 240 minutes. Testing was commenced once stable operation of the incinerator was obtained, approximately 120 minutes after commencement of incineration in primary chamber.

Triplicate test runs were conducted. The source gas was collected using an air-cooled quartz probe and then passed through the filter, condenser, XAD-2 resin, and impingers in sequence. The following were recorded at five minutes intervals throughout the test:

- Sampling time
- Dry gas meter volume
- Pitot tube pressure
- Stack gas temperature
- Oven and impinger temperatures
- Dry gas meter temperatures
- Control module orifice pressure
- Sampling pump vacuum pressure

Following the conclusion of each test, sampling trains were disassembled and recovered at a clean location on site. The probe, filter, resin, condensate trap and impinger contents were each recovered as per the procedures outlined in the method for subsequent analysis according to the Environment Canada Method EPS 1/RM/3.

The Toxic Equivalency (TEQ) was calculated for dioxins and furans using the World Health Organization 2005 Toxic Equivalency Factors.

5.2 Combustion Gases

For the purpose of determining molecular weight and to correct for oxygen content, testing for O₂, CO₂ and CO was conducted. Sample gas was monitored in the exhaust of the isokinetic sampling train, throughout the sampling period following modified US EPA Methods 3A and 10. Analyzer calibrations for O₂ and CO were conducted with certified calibration gases.

As per the Canada-Wide Standards requirement, the sample concentrations were corrected to 11% oxygen.

6.0 Results

6.1 Schedule of the Test Program

The sampling program was conducted from 24 August 2020 to 2 September 2020 per the following schedules:

Table 3: Milne Port Test Schedule

Test ID	Date	1 st Traverse Start	1 st Traverse Finish	2 nd Traverse Start	2 nd Traverse Finish
ORG-1	24-Aug-20	13:20	15:20	15:44	17:44
ORG-2	25-Aug-20	15:59	17:59	18:12	20:12
ORG-3	28-Aug-20	04:05	06:05	06:22	08:22

Table 4: Mary River Test Schedule

Test ID	Date	1 st Traverse Start	1 st Traverse Finish	2 nd Traverse Start	2 nd Traverse Finish
ORG-1	29-Aug-20	13:43	15:43	16:18	18:18
ORG-2	31-Aug-20	16:05	18:05	18:18	20:18
ORG-3	02-Sep-20	13:53	15:53	16:02	18:02

6.2 Test Results

Results of the sampling program can be found within Tables 5 to 10. Calculations are shown in Appendix A. Field data sheets can be found in Appendix C.

These results are subject to the Appended Statement of Limitations.

Table 5: Summary of Stack Gas Characteristics – Milne Port

Test ID	Flow (DRm ³ /s)*	Oxygen (% dry)	Carbon Dioxide (% dry)	Carbon Monoxide (ppmvd)	Moisture (%)	Stack Temp. (°C)
ORG-1	1.30	15.14%	4.71%	2.71	5.81%	517
ORG-2	1.27	15.21%	4.61%	2.80	5.63%	481
ORG-3	1.41	15.27%	4.57%	3.04	5.64%	486
Average	1.33	15.21%	4.63%	2.85	5.69%	494

*DRm³ = Dry reference cubic metres (25°C, 101.3 kPa)

Table 6: Summary of In-Stack Dioxin/Furan Concentrations – Milne Port

Test	In-Stack Concentration pg/DRm ³ *	Criteria	% Of Criteria
1	60.7		
2	41.2		
3	819**		
Average	51.0 (307)	80	63.7% (384%)

*Corrected to 11% O₂

**On review of the incinerator operations during the third test, which contained the highest level of wet waste, this test may represent an outlier and could be excluded from the average. Averages presented show the average without and with the third test included.

Table 7: Summary of Stack Gas Characteristics – Mary River

Test ID	Flow (DRm ³ /s)*	Oxygen (% dry)	Carbon Dioxide (% dry)	Carbon Monoxide (ppmvd)	Moisture (%)	Stack Temp. (°C)
ORG-1	2.00	17.01%	2.99%	4.49	3.62%	449
ORG-2	1.84	15.88%	3.90%	4.84	4.56%	576
ORG-3	1.78	15.82%	3.84%	2.81	4.49%	561
Average	1.87	16.23%	3.57%	4.05	4.22%	529

*DRm³ = Dry reference cubic metres (25°C, 101.3 kPa)

Table 8: Summary of In-Stack Dioxin/Furan Concentrations – Mary River

Test	In-Stack Concentration pg/DRm ³ *	Criteria	% Of Criteria
1	494**		
2	14.4		
3	40.1		
Average	27.3 (183)	80	34.0% (229%)

*Corrected to 11% O₂

**On review of the incinerator operations (note: primary faults) during the first test, this test may represent an outlier and could be excluded. Averages presented show the average without and with the third test included.



Table 3: Testing Results: Dioxins/Furans – Mary River

Compound	CAS	Test 1 (pg/s)	Test 2 (pg/s)	Test 3 (pg/s)	Average (pg/s)
2,3,7,8-TCDD	1746-01-6	6.25	0.974	1.01	2.75
1,2,3,7,8-PeCDD	40321-76-4	70.9	2.55	4.28	25.9
1,2,3,4,7,8-HxCDD	39227-28-6	77.9	3.24	3.15	28
1,2,3,6,7,8-HxCDD	57653-85-7	157	4.18	5.36	55
1,2,3,7,8,9-HxCDD	19408-74-3	116	3.34	3.19	41
1,2,3,4,6,7,8-HpCDD	35822-46-9	958	43.2	21.7	341
OCDD	3268-87-9	1070	63.1	31.9	388
2,3,7,8-TCDF	51207-31-9	113	3.83	100.7	72.68
1,2,3,7,8-PeCDF	57117-41-6	151	5.57	33.3	63.3
2,3,4,7,8-PeCDF	57117-31-4	361	12.8	43.0	139.1
1,2,3,4,7,8-HxCDF	70648-26-9	278	7.59	17.7	101.2
1,2,3,6,7,8-HxCDF	57117-44-9	279	9.74	13.8	100.8
2,3,4,6,7,8-HxCDF	72918-21-9	569	13.9	16.7	200
1,2,3,7,8,9-HxCDF	60851-34-5	181	4.50	7.90	64.5
1,2,3,4,6,7,8-HpCDF	67562-39-4	1037	34.7	36.8	369
1,2,3,4,7,8,9-HpCDF	55673-89-7	189	5.72	3.26	65.9
OCDF	39001-02-1	588	33.3	22.8	215
Dioxins/Furans (TEQ)	N/A	389	13.4	36.7	147



Table 10: Testing Results: Dioxins/Furans – Milne Port

Compound	CAS	Test 1 (pg/s)	Test 2 (pg/s)	Test 3 (pg/s)	Average (pg/s)
2,3,7,8-TCDD	1746-01-6	1.26	0.692	10.1	4.01
1,2,3,7,8-PeCDD	40321-76-4	7.26	6.46	276	96.6
1,2,3,4,7,8-HxCDD	39227-28-6	9.41	4.31	345	120
1,2,3,6,7,8-HxCDD	57653-85-7	20.7	10.3	737	256
1,2,3,7,8,9-HxCDD	19408-74-3	15.2	8.96	579	201
1,2,3,4,6,7,8-HpCDD	35822-46-9	133	72.1	4387	1531
OCDD	3268-87-9	203	122	3201	1175
2,3,7,8-TCDF	51207-31-9	12.0	5.38	1.21	6.21
1,2,3,7,8-PeCDF	57117-41-6	17.7	8.45	35.0	20.4
2,3,4,7,8-PeCDF	57117-31-4	34.7	22.5	195	84.2
1,2,3,4,7,8-HxCDF	70648-26-9	36.8	20.0	149	68.5
1,2,3,6,7,8-HxCDF	57117-44-9	39.0	21.6	161	73.9
2,3,4,6,7,8-HxCDF	72918-21-9	79.0	50.6	491	207
1,2,3,7,8,9-HxCDF	60851-34-5	17.7	11.7	107	45.4
1,2,3,4,6,7,8-HpCDF	67562-39-4	188	167	897	417
1,2,3,4,7,8,9-HpCDF	55673-89-7	23.8	16.4	123	54.4
OCDF	39001-02-1	122	75.3	386	194
Dioxins/Furans (TEQ)	N/A	46.0	30.1	657	244



7.0 Discussion

The test program gave mixed test results with two out of the three tests for each unit showing levels below the Environment Canada CCME criteria of 80 pg/DRm³ corrected to 11%O₂.

Taking into consideration, issues that occurred during the 3rd Milne Port Test (high level of wet waste) and during the 1st Mary River Test (Process Faults), and excluding them from the test averages, it may be indicated that under normal operating conditions, when operating as specified by the manufacturer, the incinerators can meet the 80 pg TEQ /DRm³ @11% O₂ criteria.

7.1 Observations

1. Primary Burner Faults

During combustion, diesel fired burners maintain the primary and secondary temperatures. Occasionally, the primary burners on the incinerators, had faults occur during the test program. This caused the burner to shut down and would have to be reset by plant staff after a period of time. At times, the reset was immediate and other times it took longer. This would affect chamber temperatures and presumably would affect emissions.

2. Waste Content Uncertainty

During loading, waste was filled by type (e.g. wood, domestic, dry, wet, cardboard, etc.). At Mary River it was weighed and measured out. At Milne Port, the scale was not functioning, and instead waste quantities were estimated. At both sites, for the most part, waste was loaded in closed bags which were not inspected. This would have been difficult as several hundred bags were loaded for each burn. As such, it is unclear whether some items may have been loaded which were not intended for this type of incinerator.

3. Stable Operation

For each test, the incinerator was lit and observed until stable temperatures had been achieved. This was observed by the Wood field team as approximately 800C in the primary chamber and approximately 1000C in the secondary chamber. At times it was difficult for the Baffinland coordinator to determine if stability had been achieved, prior to starting testing, as the temperatures would vary over time.

8.0 Closure

The Wood sampling team is grateful for the cooperation of Baffinland Iron Mines during the execution of this test program. Wood looks forward to future projects together.

Yours truly,

Wood Environment & Infrastructure Solutions
a Division of Wood Americas Limited

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Appendix A
Test Data and Calculations



Appendix B

Laboratory Certificates of Analysis



Appendix C
Raw Sampling Data





wood.

Appendix D
Calibration Sheets

Appendix E

Process Data

(to be supplied by Baffinland)

Appendix F

Statement of Limitations

Limitations

1. The work performed in the preparation of this report and the conclusions presented herein are subject to the following:
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 - c. The limitations stated herein.
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