REPORT

Carbon Dioxide Emission Intensity Report

Votorantim Cimentos North America

Submitted to:

St Marys Cement, a Company of Votorantim Cimentos North America

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Submitted by:

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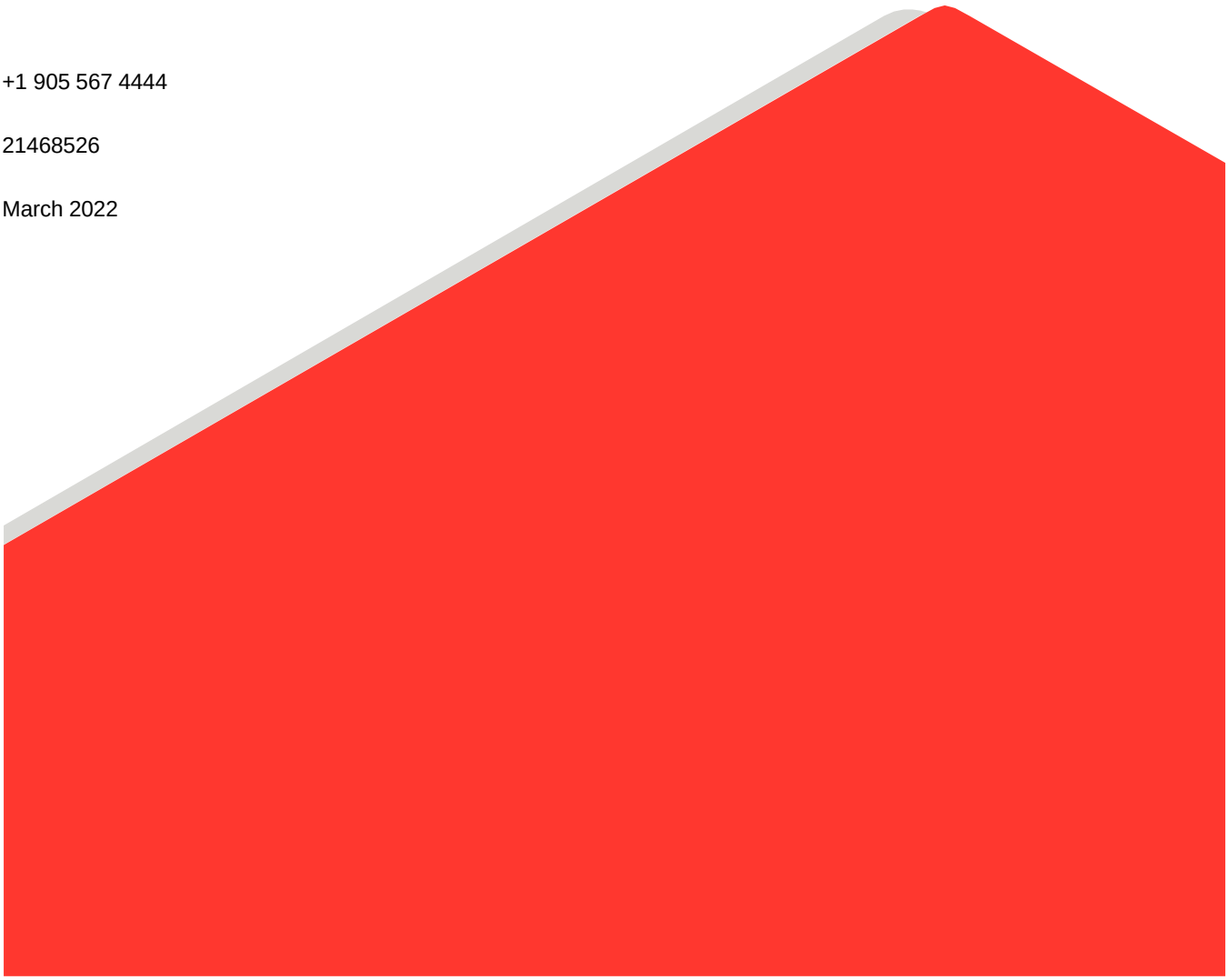
March 2022



Distribution List

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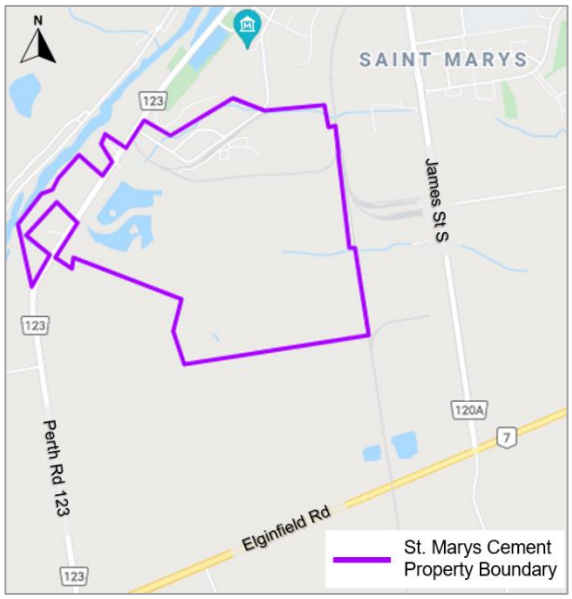
1.0 INTRODUCTION

St Marys Cement (SMC), a company of Votorantim Cimentos North America (VCNA) is proposing to use Alternative Low Carbon Fuels (ALCFs) as an energy source for their cement plant located at 585 Water Street South, in St. Marys, Ontario (the Site).



As part of SMC's strategy to reduce greenhouse gas (GHG) emissions and in keeping with best practices implemented around the world, SMC has retained Golder Associates Ltd. (Golder) to undertake a study to support the ALCF Application for a Non-Demonstration (Permanent) Project under Ontario Regulation (O. Reg.) 79/15 (as amended by O. Reg. 54/21 and 824/21) of the Environmental Protection Act for an amendment to Environmental Compliance Approval (ECA) number 4546-AQ9GMB, issued on August 31, 2017 to proceed with regular use of ALCFs at the Site (the Amendment ECA Application).

The purpose of this report is to demonstrate that the carbon dioxide (CO_2) emission intensities of the proposed ALCFs are less than the CO_2 emission intensity of the conventional fuel currently used at the Site as required by O. Reg. 79/15.

The CO_2 emission intensity is a form of measurement that allows different fuel types to be compared and is an indicator of the amount of carbon dioxide (CO_2), which is a GHG, that is emitted into the atmosphere when the fuel is combusted. A lower CO_2 emission intensity value means that a given material will release less CO_2.

As part of the Amendment ECA Application, SMC is requesting approval to:

- operate with a daily throughput of ALCFs at the Site of up to 175 tonnes per day;
- use ALCFs that may include the following example ALCF materials that are grouped into the associated baskets as noted in parathesis:
  - Shredded wood from post construction waste (Construction & Demolition By-Products and Biomass Materials baskets);
  - Nested plastics and paper and Shredded caps, labels and bags (Non-Recyclable Plastics and Non-Recyclable Paper Fiber/Wood/Plastic Composites baskets);
  - Shredded conveyor belt rubber and Shredded conveyor skirt rubber (Rubber materials (non-tire derived) basket);
- install new equipment to feed ALCFs; and
- install ALCF storage using enclosed containers and buildings.

The Site will target approximately 40% thermal replacement by using mixtures of ALCFs to replace petroleum coke.

The above noted ALCFs would meet the following criteria:

- be used as mixtures of non-recyclable and non-odorous materials;
- not be derived from or composed of any material set out in Schedule 1 of O. Reg. 79/15;
- wholly derived from or composed of materials that are biomass, municipal waste, or a combination of both;
- have a high heat value of at least 10 megajoules per kilogram.

2.0 SITE DESCRIPTION

The cement plant produces Portland cement by combining materials bearing calcium carbonate, silica, alumina and iron oxide at high temperatures to produce cement clinker. The clinker is subsequently ground with finishing materials such as gypsum and limestone to produce cement. The Site has a maximum permitted production rate of 1.1 million tonnes of clinker per year and operates 24 hours per day, 7 days a week, 12 months per year with the exception of scheduled plant shut-downs.

The primary North American Industrial Classification System (NAICS) code for the Site is 327310 (cement manufacturing).

2.1 Portland Cement Production Process

The production process described below was reproduced from the Site's Emission Summary and Dispersion Modelling Report (BCX, 2022), which was updated to support the Amendment ECA Application.

2.1.1 Raw Material / Conventional Fuel Delivery and Storage

The main raw material (limestone) is supplied by an off-site quarry and kept in a storage pile on-site. Limestone is transferred from the storage pile via an enclosed conveyor system to a secondary crusher/screen system which uses baghouses to control emissions. Processed limestone is then fed via enclosed conveyors to a limestone storage silo.

Other raw materials (e.g., sand, iron, silica, alumina, clay, ash) and additives (gypsum) are delivered by truck and solid fuels (i.e., petroleum coke) are delivered by tanker. Most raw materials are stored at the Site in storage silos or storage buildings. Conventional solid fuels are pneumatically transferred from tanker trucks into silos.

2.1.2 ALCF Delivery and Storage (Proposed)

Sorted and pre-processed (size-reduced) ALCFs will be delivered by enclosed trucks and off-loaded directly from the truck into the proposed ALCF storage building through a completely enclosed process.

2.1.3 Raw Material Preparation

Limestone, silica (sand and clay), alumina and iron oxide sources are proportionately fed from the raw material storage silos and storage building via an enclosed conveyor belt system to a raw mill. Emissions from the raw mill are controlled by the main kiln baghouse, venting through the main kiln stack. In the raw mill, the raw materials are ground and mixed to uniform particle size and dried. The raw mill uses the hot exhaust gases from the pre-heater tower/kiln to dry the raw meal. The dried raw meal is stored in the kiln feed silo.

2.1.4 Fuel Preparation

Conventional solid fuels are fed to the fuel milling system from the storage silos. Emissions are controlled by the fuel mill baghouse venting through the main kiln stack. Milled conventional fuel (fuel meal) is fed to the kiln burner or the back-end firing system burner through the conventional fuel feed system.

Once the Site is approved to use ALCFs, the homogenized fuel from the ALCF storage building will be fed into the main kiln burner and the back-end firing system burner through a series of conveyors. The ALCF feed system will be fully integrated with the plant control system to regulate and limit the fuel substitution rates into the kiln to maintain the required temperature profile and system conditions. ALCF will not be used during kiln start-up or shut down.

As hydrogen technologies become available, the Site is proposing to use H_2 as a fuel to reduce greenhouse emissions from the Site. The Site is planning to install a technology (UC3 system) that will integrate an automatic electrolyte production unit which will produce H_2 and O_2 using fresh water through an electrolysis process. These gases will then be injected in the burning zone of the kiln during normal clinker production to improve the combustion efficiency of the kiln.

2.1.5 Clinker Production

Calcination (Preheater Tower and Kiln)

Dried raw meal is fed, via air slides and bucket elevators, up to a dual string pre-heater tower consisting of a series of cyclones. As the raw meal progressively passes through a pre-heater string and its cyclones, it is preheated using the hot gases from the kiln. The pre-heated material is fed into the kiln, where the flame temperature reaches 1,600 to 1,800°C, gas temperature is above 1,200°C and the raw meal temperature is raised to 950°C. Heat input for the calcination process is currently provided by the main kiln burner using conventional fuels (i.e., petroleum coke) and the dual fuel-fired (solid fuel or natural gas) back-end firing stem (located at the feed input end of the kiln) using natural gas. The rotation speed of the kiln is controlled to gradually move the raw materials towards the burning zone/backend which provides a long residence time ensuring complete combustion/calcination.

The chemical reactions and physical processes under high temperatures and with a long residence time transform the raw meal into clinker. The high temperatures, long residence times and the oxidizing atmosphere in the kiln system result in the complete destruction of the organic components of the fuels (conventional/ALCF) and raw materials. The clinker formed inside the kiln retains the majority of the inorganic components of the fuels and raw materials including heavy metals.

Under normal operating conditions, approximately 90% of the flue gases from the kiln pass through the pre-heater strings and raw mill to the kiln baghouse, while the remaining 10% of the kiln flue gases goes through the bypass system (i.e., “bypassing” the preheater strings and the raw mill) which includes the electrostatic precipitator. The purpose of the bypass system is to remove fines containing alkalis (e.g., sodium and potassium oxides), chlorine and sulphur from the kiln system to ensure compliance with the concrete ASTM and CSA standards.

Flue gases from the pre-heater strings are cooled by the conditioning towers (high pressure water sprays) before being treated by the main baghouse for particulate control. The temperature of the flue gases is rapidly reduced to prevent damage to the baghouse and the formation of organics. Both the kiln baghouse and the bypass electrostatic precipitator exhaust to the atmosphere via the main kiln stack.

The Site also uses a Selective Non-Catalytic NO_x Reduction (SNCR) ammonia solution injection system to reduce NO_x emissions from the kiln stack.

Continuous Process Monitoring and Continuous Emissions Monitoring for the Kiln System

Process parameters including burning zone temperature, residence time and residual O_2 in the kiln and pressure differential in the kiln, preheater tower and raw mill are monitored through the Site’s continuous process monitoring system (CPM) to maintain optimal process conditions and product quality. Raw material, natural gas, conventional fuel, H_2 and ALCF feed rates and clinker production rates are/will also be monitored by CPM.

In addition, the Site uses and continuous emissions monitoring (CEM) system to monitor kiln stack emissions including nitrogen oxides (NO_x), sulphur dioxide (SO_2) and opacity at all times.

Clinker Cooling

The clinker product is cooled by passing ambient air across the product in the clinker cooler. Part of this pre-heated air is directed into the kiln for use as combustion air. The air passes through the clinker cooler baghouse prior to being exhausted to the atmosphere though the cooler stack.

Clinker exits the clinker cooler at an average temperature of 350°C onto an enclosed conveyor system. The conveyor system either sends clinker to storage in the fully enclosed storage building, or clinker is shipped offsite without further processing.

2.1.6 Cement Production

Cement finishing is accomplished in the finish mill building. Clinker, limestone, gypsum and silica fume are milled together to produce Portland cement. Wet additives are also incorporated. Emissions from the finish mill are controlled by a baghouse venting though the finish mill stack. The finished cement product is transferred into product storage silos. Product can be dispatched in bulk via tanker trucks or packaged in bags for shipment.

3.0 CONVENTIONAL FUELS

The thermal requirements of the cement manufacturing process at the Site have been provided by the combustion of petroleum coke. While natural gas may be used for combustion, this assessment only evaluated the replacement of petroleum coke. Fuel fed to the main kiln burner is approximately 288 tonnes of conventional fuel per day at a maximum permitted production rate of 3,000 tonnes of clinker per day or 1.1 million tonnes of clinker per year.

The required heat input for the maximum clinker production is approximately 9,500 gigajoules/day (or 33 gigajoules/tonne).

4.0 ALTERNATIVE LOW-CARBON FUELS

Under O. Reg. 79/15, ALCFs are fuels that have a CO_2 emission intensity that is less than the CO_2 emission intensity of the conventional fuel in the place of which the fuel is combusted. In addition, an ALCF proposed for use must meet one of the following two descriptions:

1. The fuel:
   - is not derived from or composed of any material set out in Schedule 1;
   - is wholly derived from or composed of materials that are biomass or municipal waste or a combination of both; and
   - Must have a high heat value of at least 10,000 megajoules per tonne if it is not derived from or composed of materials that are solid biomass.
2. The fuel must be derived from or composed of organic matter, not including peat or peat derivatives, derived from a plant or micro-organism and grown or harvested for the purpose of being used as a fuel.

As part of the Amendment ECA Application, the Site is proposing to utilize up to 175 tonnes per day of ALCFs. The Site proposes to use ALCF materials from five ALCF material baskets. The ALCF materials include, but are not limited to:

ALCF Material Basket	■ Construction & Demolition By-Products ■ Biomass Materials	■ Non-Recyclable Plastics ■ Non-Recyclable Paper Fiber/Wood/Plastic Composites		■ Rubber materials (non-tire derived)	
Example of ALCF	Shredded wood from post construction waste	Nested plastics and paper	Shredded caps, labels and bags	Shredded conveyor belt rubber	Shredded conveyor skirt rubber

It is anticipated that the ALCF materials will be blended at the Site prior to their combustion in the kiln. The proportion of individual ALCF materials will depend on availability of material which would result in different amount of required petroleum coke to achieve the total required heat input for clinker production.

5.0 CARBON DIOXIDE EMISSION INTENSITY CALCULATIONS

In accordance with O. Reg. 79/15, the CO_2 emission intensity calculations must be based on chemical analysis data of the conventional fuel and proposed ALCFs. The sections below describe the sampling requirements, chemical analysis results and carbon dioxide emission intensity calculations.

It should be noted chemical analysis results are based on the chemical analysis data that were obtained for the purposes of the ALCF Application under O. Reg. 79/15. As the carbon content of ALCFs may vary depending on the fuel supplier, the Site plans to develop and implement a fuel testing program to regularly monitor the CO_2 intensity of the ALCF used at the Site.

5.1 Fuel Sampling

5.1.1 Conventional Fuel Sampling

Samples of petroleum coke were submitted for chemical analysis to estimate the total carbon content and high heat value as follows:

- the Site: three samples for the months of September 2021 to December 2021;
- SMC Bowmanville: six samples for the months of August 2021 to January 2022.

CO_2 emission intensity calculations were completed in February 2022.

These samples met the following criteria listed in Section 9(3) of O. Reg. 79/15:

a) only include samples taken and analyzed during the most recent six-month period during which the facility was operating before the determination is made;

b) include at least one sample taken and analyzed during each month of the six-month period mentioned in clause (a);

c) not include any samples taken more than 36 months before the determination is made; and

d) be representative of the coal or coke in the place of which alternative low-carbon fuel is proposed to be combusted.

In accordance with O. Reg. 79/15, only prescribed chemical analysis methods were used to determine the total carbon content and high heat value of each fuel. The chemical analysis methods and sampling results are summarized in Table 1. A copy of the conventional fuel chemical analysis data is provided in Appendix A.

5.1.2 ALCF Sampling

The Site requested SMC Bowmanville to submit samples of ALCF materials for chemical analysis from suppliers the Site is considering using, with the exception of rubber materials which were submitted by the Site. The materials were submitted for chemical analysis to estimate the biological carbon content, total carbon content and high heat value of each ALCF material. The chemical analysis methods and sampling results are summarized in Table 2. A copy of the ALCF chemical analysis data is provided in Appendix A.

These samples met the following criteria listed in Section 10(2) of O. Reg. 79/15:

1) Only samples taken within 36 months before the determination is made shall be used.

2) One of the following methods shall be applied:

   i. Analysis in accordance with a prescribed chemical analysis method of at least one sample of the fuel.

   ii. Analysis in accordance with a prescribed chemical analysis method of at least one sample of each of the individual materials that the fuel is composed of or derived from, using a weighted average of the carbon content and high heat value of the individual materials.

The number of samples analyzed must provide results that are sufficiently representative of the fuel or individual materials and must allow for adequate characterization of the fuel or individual materials.

Biological carbon content data for the ALCF samples were obtained from analytical testing using the ASTM D 6866 “Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis” biobased carbon testing methodology required by O. Reg. 79/15.

Table 1: Conventional Fuel Sampling Results

Submitted by SMC Site			St. Marys			Bowmanville					
Lab No.			491-2108978-001	491-2108828-001	491-2109700-001		16729-2	16904-2	17085-2	17221-2	17467-2
Client Sample ID			SAR090-21-3988 Petcoke-1	SAR090-21-2606 Petcoke-2	SAR090-21-5348 Petcoke-3	Aug PETCOKE Petcoke-4	Sept PETCOKE Petcoke-5	Oct PETCOKE Petcoke-6	Nov PETCOKE Petcoke-7	Dec PETCOKE Petcoke-8	Jan PETCOKE Petcoke-9
Date of Sample Collection			September 29, 2021	October 2021	November 30, 2021	August 2021	September 30, 2021	October 31, 2021	November 30, 2021	December 31, 2021	January 31, 2022
Test	ASTM Method	Unit									
HHV, Calorific Value, As Received	E870	BTU/lb	14168	14194	14086	13938	13907	14148	14498	14684	14759
		MJ/kg	32.955	33.015	32.764	32.419	32.347	32.908	33.722	34.154	34.329
Carbon, As Received	D3178	% wt.	87.12	87.09	86.79	79.82	78.98	78.30	83.26	85.36	79.03

Table 2: ALCF Sampling Results

Submitted by SMC Site			Bowmanville					St. Marys	
Supplier ID			Supplier-1	Supplier-2	Supplier-3	Supplier-4	Supplier-5	SMC St. Marys - Conveyor Belt	
ALCF Basket			- Construction & Demolition By-Products - Biomass Materials			- Non-Recyclable Plastics - Non-Recyclable Paper Fiber/Wood/Plastic Composites		Rubber materials (non-tire derived)	
ALCF Material			Shredded wood from post construction waste			Nested plastics and paper	Shredded caps, labels and bags	Shredded conveyor belt rubber	Shredded conveyor skirt rubber
Test	ASTM Method	Unit							
HHV, Calorific Value	E870	[MJ/kg]	15.61	17.18	17.57	18.34	28.28	33.026	23.111
Carbon, As Received	D3178	[% wt]	39.07%	43.62%	44.71%	37.83	56.45	66.17%	55.82%
Biological Carbon	D6866	[% wt]	99%	98%	100%	47%	10%	2%	42%

5.2 Sample Calculations

5.2.1 Conventional Fuel Sample Calculation

The following formula was used to calculate the carbon dioxide emission intensity for each conventional fuel sampling result. An example calculation is presented below using the chemical analysis results for conventional fuel sample 491-2108828-001.

$$\textbf{Carbon dioxide emission intensity } \left[\frac{\textbf{kg } CO_2}{\textbf{MJ}}\right]$$

$$= \text{Total carbon content [\%]} \times \text{C to } CO_2 \text{ conversion } \left[\frac{\text{kg } CO_2}{\text{kg C}}\right] \div \text{High heat value } \left[\frac{\text{MJ}}{\text{kg fuel}}\right]$$

Where:

$$\textbf{Total carbon content} = 87.09\% \text{ (value from chemical analysis result for sample } 491-2108828-001)$$

$$\textbf{C to } CO_2 \textbf{ conversion} = 3.67$$

$$\textbf{High heat value} = 33.015 \frac{MJ}{kg} \text{ (value from chemical analysis result for sample } 491-2108828-001)$$

Therefore:

$$\text{Carbon dioxide emission intensity} = 87.09\% \times 3.67 \frac{\text{kg } CO_2}{\text{kg C}} \times \frac{1}{33.015} \frac{\text{kg fuel}}{\text{MJ}}$$

$$\text{Carbon dioxide emission intensity} = 0.0968 \frac{\text{kg } CO_2}{\text{MJ}}$$

5.2.2 ALCF Example Calculation

In accordance with O. Reg. 79/15, the following formula was used to calculate the carbon dioxide emission intensity for each ALCF sampling result. An example calculation is presented below using the chemical analysis results for sample 905W-01.

$$\textbf{Carbon dioxide emission intensity } \left[\frac{\textbf{kg } CO_2}{\textbf{MJ}}\right]$$

$$= \text{Non} - \text{biological carbon content [\%]} \times \text{C to } CO_2 \text{ conversion } \left[\frac{\text{kg } CO_2}{\text{kg C}}\right] \div \text{High heat value } \left[\frac{\text{MJ}}{\text{kg fuel}}\right]$$

Where:

$$\textbf{Non} - \textbf{biological carbon content [\%]} = \text{Total carbon content [\%]} \times (100\% - \text{Biological carbon content [\%]})$$

$$\textbf{Total carbon content} = 39.54\% \text{ (value from chemical analysis result for sample } 905W-01)$$

$$\textbf{Biological carbon content} = 99\% \text{ (value from chemical analysis result for sample } 905W-01)$$

$$\textbf{C to } CO_2 \textbf{ conversion} = 3.67$$

$$\textbf{High heat value} = 15.605 \frac{\text{MJ}}{\text{kg}} \text{ value from chemical analysis result for sample } 905W-01)$$

Therefore:

$$\text{Non} - \text{biological carbon content} = 39.54\% \times (100\% - 99\%)$$

$$\text{Non} - \text{biological carbon content} = 0.39\%$$

And,

$$\text{Carbon dioxide emission intensity} = 0.39\% \times 3.67 \frac{\text{kg CO}_2}{\text{kg C}} \times \frac{1}{15.605} \frac{\text{kg fuel}}{\text{MJ}}$$

$$\text{Carbon dioxide emission intensity} = 0.0009 \frac{\text{kg CO}_2}{\text{MJ}}$$

5.3 Summary of Assessment

5.3.1 Conventional Fuel Assessment

CO_2 emission intensity values were calculated for each petroleum coke sampling result, as presented in Table 3. Detailed sample calculations for the other fuels are provided in Appendix B.

Table 3: Petroleum Coke CO_2 Emission Intensity Calculation

Sample ID	Petcoke-1	Petcoke-2	Petcoke-3	Petcoke-4	Petcoke-5	Petcoke-6	Petcoke-7	Petcoke-8	Petcoke-9
Source of Sample	SMC	SMC	SMC	BW	BW	BW	BW	BW	BW
CO2 Emission Intensity [kg CO2/MJ]	0.0968	0.0970	0.0972	0.0904	0.0896	0.0873	0.0906	0.0917	0.0845

The average CO_2 Emission Intensity of petroleum coke based presented in Table 3 is 0.0917 kg CO_2/MJ.

The average High Heat Value of petroleum coke based on the results presented in Table 1 is 33.2 MJ/kg.

Based on the average High Heat Value and the maximum petroleum coke input of 288 tonnes/day, the required heat input is estimated at 9,556 GJ/day.

5.3.2 ALCFs Assessment

The CO_2 emission intensity values were calculated for each ALCF material, as presented in Table 4. Detailed sample calculations for the other fuels are provided in Appendix B.

Table 4: ALCFs CO_2 Emission Intensity Calculation

Supplier ID	Supplier-1	Supplier-2	Supplier-3	Supplier-4	Supplier-5	Conveyor Belt Rubber	Conveyor Skirt Rubber
ALCF Material Basket	▪ Construction & demolition by-products ▪ Biomass materials			▪ Non-recyclable plastics ▪ Non-recyclable paper fiber/wood/plastic composites		Rubber materials (non-tire derived)	
Example of ALCF	Shredded wood from post construction waste			Nested plastics and paper	Shredded caps, labels and bags	Shredded conveyor belt rubber	Shredded conveyor skirt rubber
Non-Biological Carbon [%wt]	0.39%	0.87%	0.00%	20.05%	50.81%	64.85%	32.38%
CO2 Emission Intensity [kg CO2/MJ]	0.0009	0.0019	0.0000	0.0401	0.0659	0.0721	0.0514
Percent Reduction in CO2 Emission Intensity from Petcoke to ALCF	99%	98%	100%	56%	28%	21%	44%

The results demonstrate that the ALCFs have significantly lower CO_2 emission intensity values than conventional fuel. For example, the carbon dioxide emission intensity value of nested plastics and paper (Supplier 4) represents a decrease of approximately 56% when compared to the carbon dioxide emission intensity of petroleum coke. Combustion of Shredded wood from post construction waste (Supplier 3) results in 100% decrease in carbon dioxide emission intensity when compared to the carbon dioxide emission intensity of petroleum coke.

5.3.3 Use of ALCFs and Conventional Fuel

It is anticipated that the ALCF materials will be blended at the Site prior to their combustion in the kiln. The proportion of individual ALCF materials will depend on availability of material and will result in different overall CO_2 emission intensity of the ALCFs as well as different amount of required petroleum coke to achieve the required heat input.

As the Site will be blending ALCF materials into a mixture prior to their use in the kiln, the overall High Heat Value of the blended ALCF materials will vary depending on the proportion of ALCF materials in the mixture which are difficult to predict. This also impacts the variability in required amounts of conventional fuel to supplement ALCFs and achieve the required heat input. A scenario assessment was conducted where it was assumed that 175 tonne/day of each ALCF material would be used in the kiln (i.e., no blending of ALCF materials). Please note that

it is unlikely that the Site will use 175 tonnes/day of only one ALCF material due to availability. The following information was used for this scenario assessment, with results presented in Table 5:

Maximum Conventional Fuel Use =	288	tonnes/day
Maximum ALCF Use =	175	tonnes/day
Maximum Required Heat Input =	9556	GJ/day

Table 5: Required Amount of Conventional Fuel When Using 100% of Each ALCF Material.

Fuel	Parameter	Supplier-1	Supplier-2	Supplier-3	Supplier-4	Supplier-5	Conveyor Belt Rubber	Conveyor Skirt Rubber
ALCF (100% of each ALCF, 175 tonne/day)	ALCF Material Basket	▪ Construction & demolition by-products ▪ Biomass materials			▪ Non-recyclable plastics ▪ Non-recyclable paper fiber/wood/plastic composites		Rubber materials (non-tire derived)	
	Example of ALCF	Shredded wood from post construction waste			Nested plastics and paper	Shredded caps, labels and bags	Shredded conveyor belt rubber	Shredded conveyor skirt rubber
	HHV, Calorific Value [MJ/kg]	15.61	17.18	17.57	18.34	28.28	33.03	23.11
	Heat Input [GJ/day]	2731	3007	3075	3210	4949	5780	4044
	Thermal Replacement [%]	29%	31%	32%	34%	52%	60%	42%
Conventional Fuel	Required Amount of Conventional Fuel with [tonne/ day]	206	197	195	191	139	114	166
	Heat Input [GJ/day]	6825	6548	6480	6346	4606	3776	5511
	Displaced Amount [tonne/day]	82	91	93	97	149	174	122
	Displaced Percentage [%]	29%	31%	32%	34%	52%	60%	42%

Blending the proposed ALCF materials will result in a variable amount of petroleum coke in place of which ALCFs would be combusted at the Site. The required amounts of petroleum coke will vary between the values presented in Table 5, up to the currently approved maximum throughput of 288 tonnes/day.

6.0 CONCLUSION

As part of SMC's strategy to reduce GHG emissions and in keeping with best practices implemented around the world, SMC proposes to use ALCFs at the Site. The results of this CO_2 emission intensity report support this strategy, with estimated ALCF CO_2 emission intensity values lower than the conventional fuel value. This report was prepared in accordance with the requirements outlined in Section 11 in O. Reg. 79/15.

The results presented in this report are solely based on the chemical analysis data that were obtained for the purposes of the Amendment ECA Application under O. Reg. 79/15. The Site plans to develop and implement a fuel testing program to regularly monitor the composition and CO_2 emission intensity of the ALCFs to be used at the Site.

7.0 LICENSED ENGINEERING PRACTITIONER STATEMENT

Ontario Regulation 79/15 requires that this Carbon Dioxide Intensity Report be prepared by a licensed engineering practitioner (LEP) as part of an ALCF approval application.

As the LEP who prepared this Carbon Dioxide Intensity Report, I confirm that, in accordance with Section 11.(1) of Ontario Regulation 79/15,

i) the carbon dioxide emission intensities of the coal or coke and of the alternative low carbon fuel have been determined in accordance with Ontario Regulation 79/15, and

ii) the carbon dioxide emission intensity of the alternative low-carbon fuel proposed to be combusted is less than the carbon dioxide emission intensity of the coal or coke in the place of which the alternative low-carbon fuel is proposed to be combusted.

Bonnie Field (Choi), P.Eng., 100219538

8.0 PROPONENT STATEMENT

Ontario Regulation 79/15 requires that this Carbon Dioxide Intensity Report be certified by the proponent or a person who is authorized by the proponent.

By signing below, Ruben Plaza, Corporate Environmental Manager, North America of Votorantim Cimentos North America, certifies that the information given to the licensed engineering practitioner to prepare the report is complete and accurate.

Ruben Plaza, Corporate Environmental Manager, North America

9.0 REFERENCES

BCX Environmental Consulting, 2022. Emission Summary and Dispersion Modelling Report, St. Marys Cement Inc. (Canada) – St Marys Plant, March 2022.

Signature Page

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https://golderassociates.sharepoint.com/sites/147511/project files/6 deliverables/1000 - co2 intensity report/21468526-r-rev0 vcna st marys co2 emission intensity report 28mar2022.docx

APPENDIX A

Chemical Analysis Results

Sampling Results for Conventional Fuel – St Marys Cement, St. Marys, ON

Analysis Report

October 08, 2021

IMPERIAL OIL
453 CHRISTINA STREET
SARNIA ONTARIO N7T 8C8
CANADA

ATTN: Katelyn Charman

Client Sample ID:	SAR090-21-2606*	Sample ID By:	Imperial Oil
Date Sampled:	N/A	Sample Taken At:	Sarnia-CCIS*
Date Received:	Oct 1, 2021	Sample Taken By:	Submitted
Product Description:	PETCOKE	P. O. #:	4510474206*

SGS Minerals Sample ID: 491-2108828-001

	Method	As Received	Dry
Moisture, Total %	ASTM D4931	1.09	
Ash %	ASTM D4422 (Mod)	0.44	0.45
Sulfur %	ASTM D1552	6.48	6.55
Carbon %	ASTM D5373	87.09	88.05
Hydrogen %	ASTM D5373	2.12	2.15
Nitrogen %	ASTM D5373	1.83	1.85
Oxygen (by diff) %	ASTM D5373 (by diff)	0.95	0.95

Tests	Result	Unit	Method
UOM, Sample Weight	g	---	
Sample Weight	3777.0	---	

Vanessa Chambliss
Branch Manager

SGS North America Inc. | Minerals Services Division
16130 Van Drunen Road South Holland IL 60473 **t** (708) 331-2900 **f** (708) 333-3060 www.sgs.com/minerals

Analysis Report

November 24, 2021

IMPERIAL OIL
453 CHRISTINA STREET
SARNIA ONTARIO N7T 8C8
CANADA

ATTN: Heather. M. Brown
Research Technologist

Client Sample ID:	SAR090-21-2606	Sample ID By:	Imperial Oil
Date Sampled:	N/A	Sample Taken At:	Imperial Oil
Date Received:	Nov 4, 2021	Sample Taken By:	Imperial Oil
Product Description:	PETCOKE	P. O. #:	4540166218

SGS Minerals Sample ID: 491-2109332-001

	Method	As Received	Dry
Moisture, Total %	ASTM D4931	1.09	
Volatile Matter %	ASTM D3175	5.56	5.62
Sulfur %	ASTM D1552	6.48	6.55
Gross Calorific Value Btu/lb	ASTM D5865	14194	14350

Tests	Result	Unit	Method
Calcium, Ca	50	µg/g	ASTM D5600 (Mod)
Iron, Fe	776	µg/g	ASTM D5600 (Mod)
Nickel, Ni	462	µg/g	ASTM D5600 (Mod)
Silicon, Si	58	µg/g	ASTM D5600 (Mod)
Sodium, Na	81	µg/g	ASTM D5600 (Mod)
Vanadium, V	1147	µg/g	ASTM D5600 (Mod)

Vanessa Chambliss
Branch Manager

Analysis Report

October 20, 2021

IMPERIAL OIL
453 CHRISTINA STREET
SARNIA ONTARIO N7T 8C8
CANADA

ATTN: Katelyn Charman

Client Sample ID:	SAR090-21-3988*	Sample ID By:	Imperial Oil
Date Sampled:	Sep 29, 2021	Sample Taken At:	
Date Received:	Oct 11, 2021	Sample Taken By:	Submitted
Product Description:	PETCOKE	P. O. #:	4510474206*

SGS Minerals Sample ID: 491-2108978-001

	Method	As Received	Dry
Moisture, Total %	ASTM D4931	1.17	
Ash %	ASTM D4422 (Mod)	0.49	0.50
Sulfur %	ASTM D1552	6.48	6.56
Carbon %	ASTM D5373	87.18	88.22
Hydrogen %	ASTM D5373	1.97	1.99
Nitrogen %	ASTM D5373	2.07	2.09
Oxygen (by diff) %	ASTM D5373 (by diff)	0.64	0.64

Tests	Result	Unit	Method
UOM, Sample Weight	g	---	
Sample Weight	3075.1	---	

Vanessa Chambliss
Branch Manager

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Analysis Report

November 24, 2021

IMPERIAL OIL
453 CHRISTINA STREET
SARNIA ONTARIO N7T 8C8
CANADA

ATTN: Heather. M. Brown
Research Technologist

Client Sample ID:	SAR090-21-3988	Sample ID By:	Imperial Oil
Date Sampled:	N/A	Sample Taken At:	Imperial Oil
Date Received:	Nov 4, 2021	Sample Taken By:	Imperial Oil
Product Description:	PETCOKE	P. O. #:	4540166218

SGS Minerals Sample ID: 491-2109332-002

	Method	As Received	Dry
Moisture, Total %	ASTM D4931	1.17	
Volatile Matter %	ASTM D3175	4.89	4.95
Sulfur %	ASTM D1552	6.48	6.56
Gross Calorific Value Btu/lb	ASTM D5865	14168	14336

Tests	Result	Unit	Method
Calcium, Ca	38	µg/g	ASTM D5600 (Mod)
Iron, Fe	514	µg/g	ASTM D5600 (Mod)
Nickel, Ni	478	µg/g	ASTM D5600 (Mod)
Silicon, Si	53	µg/g	ASTM D5600 (Mod)
Sodium, Na	62	µg/g	ASTM D5600 (Mod)
Vanadium, V	1174	µg/g	ASTM D5600 (Mod)

Vanessa Chambliss
Branch Manager

Analysis Report

December 13, 2021

IMPERIAL OIL
453 CHRISTINA STREET
SARNIA ONTARIO N7T 8C8
CANADA

ATTN: Heather. M. Brown
Research Technologist

Client Sample ID:	SAR090-21-5348*	Sample ID By:	Imperial Oil
Date Sampled:	Nov 30, 2021	Sample Taken At:	Sarnia-CCIS*
Date Received:	Dec 6, 2021	Sample Taken By:	NA*
Product Description:	PETCOKE	P. O. #:	4510474206*

SGS Minerals Sample ID: 491-2109700-001

	Method	As Received	Dry	DAF
Moisture, Total %	ASTM D4931	1.77		
Ash %	ASTM D4422 (Mod)	0.58	0.59	
Volatile Matter %	ASTM D3175	5.87	5.98	6.01
Fixed Carbon (by diff) %	ASTM D3172 (by diff)	91.78	93.43	
Sulfur %	ASTM D1552	6.42	6.54	
Gross Calorific Value Btu/lb	ASTM D5865	14086	14340	14425
Carbon %	ASTM D5373	86.79	88.35	
Hydrogen %	ASTM D5373	2.03	2.07	
Nitrogen %	ASTM D5373	2.28	2.32	
Oxygen (by diff) %	ASTM D5373 (by diff)	0.13	0.13	

Tests	Result	Unit	Method
HARDGROVE GRINDABILITY			
Hardgrove Grindability Index	40	---	ASTM D5003
Hardgrove Grindability Moisture	0.49	%	ASTM D5003
Trace Metals in Petroleum Coke			
Basis	Dry	---	ASTM D5600
Calcium, Ca	37.00	µg/g	ASTM D5600
Iron, Fe	549.00	µg/g	ASTM D5600
Nickel, Ni	497.00	µg/g	ASTM D5600
Silicon, Si	75.00	µg/g	ASTM D5600
Sodium, Na	61.00	µg/g	ASTM D5600
Vanadium, V	1193.00	µg/g	ASTM D5600

Vanessa Chambliss
Branch Manager

Sampling Results for Conventional Fuel – St Marys Cement, Bowmanville, ON

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 16572-1 to 3
Date Report: Sept 15, 2021
Sample in: Sept 7, 2021
PO. No.: 6300286816

Attention: Jason Schultz

Re: Coal and Coke samples - Aug 31 , 2021 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	16572-1	16572-2	16572-3
		Sample ID	August Coal	August PETCOKE	August FLUID COKE
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	12431 28.914	13938 32.419	13597 31.626
2. Moisture content, As Received	E870	% wt.	6.28	6.59	3.55
3. Carbon, As Received	D3178	% wt.	69.17	79.82	83.07

Tested by : P.S.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

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E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 16729-1 to 3
Date Report: Oct 14, 2021
Sample in: Oct 6, 2021
PO. No.: 6300286816

Attention: Jason Schultz

Re: Coal and Coke samples - Sept 30 , 2021 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	16729-1	16729-2	16729-3
		Sample ID	Sept Coal	Sept PETCOKE	Sept FLUID COKE
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	13093 30.454	13907 32.347	13794 32.084
2. Moisture content, As Received	E870	% wt.	5.23	8.92	2.53
3. Carbon, As Received	D3178	% wt.	73.27	78.98	84.87

Tested by : P.S.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

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Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 16904-1 to 3
Date Report: Nov 16, 2021
Sample in: Nov 5, 2021
PO. No.: 6300286816

Attention: Jason Schultz

Re: Coal and Coke samples - Oct 31 , 2021 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	16904-1	16904-2	16904-3
		Sample ID	Oct Coal	Oct PETCOKE	Oct FLUID COKE
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	12977 30.184	14148 32.908	13720 31.912
2. Moisture content, As Received	E870	% wt.	4.07	6.14	1.76
3. Carbon, As Received	D3178	% wt.	72.75	78.30	84.11

Tested by : P.S.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

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Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 17085-1 to 3
Date Report: Dec 17, 2021
Sample in: Dec 8, 2021
PO. No.: 6300286816

Attention: Jason Schultz

Re: Coal and Coke samples - Nov 30 , 2021 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	17085-1	17085-2	17085-3
		Sample ID	Nov Coal	Nov PETCOKE	Nov FLUID COKE
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	11657 27.114	14498 33.722	13951 32.449
2. Moisture content, As Received	E870	% wt.	6.51	4.01	3.68
3. Total Carbon, As Received	D3178	% wt.	69.60	83.26	84.07

Tested by : P.S.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

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Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 17221-1 to 3
Date Report: Jan 20, 2022
Sample in: Jan 7, 2022
PO. No.: 6300286816

Attention: Jason Schultz

Re: Coal and Coke samples - Dec 31 , 2021 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	17221-1	17221-2	17221-3
		Sample ID	Dec Coal	DEC PETCOKE	DEC FLUID COKE
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	13690 31.842	14684 34.154	13976 32.507
2. Moisture content, As Received	E870	% wt.	3.50	3.34	2.83
3. Total Carbon, As Received	D3178	% wt.	76.54	85.36	85.47

Tested by : P.S.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

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E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 17467-1 to 3
Date Report: Feb 17, 2022
Sample in: Feb 7, 2022
PO. No.: 6300349848

Attention: Jason Schultz

Re: Coal and Coke samples - Jan 31, 2022 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	17467-1	17467-2	17467-3
		Sample ID	Jan Coal	Jan PETCOKE	Jan FLUID COKE
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	11779 27.397	14759 34.329	14019 32.607
2. Moisture content, As Received	E870	% wt.	4.56	1.63	2.23
3. Total Carbon, As Received	D3178	% wt.	66.85	79.03	85.21

Tested by : P.S.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Sampling Results for ALCF – St Marys Cement, St. Marys, ON

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement Inc (Canada)
585 Water St. South,
St. Marys, Ontario
N4X 1B6
Attention: Kara Terpstra

Lab no.: 17459-1 ,2 (B)
Date Report: Feb 10, 2022
Sample in: Feb 7, 2022

Re: 2 Rubber powder from Skirting and Conveyor Belts Feb 4, 2022 for analysis.

Lab no.	17459-1	17459-2
Sample no,	Skirting	Conveyor Belts
Test - Metal analsis in ug/g by ICP scan		
Metals	**Results**	
Antimony (Sb)	<0.1	<0.1
Arsenic (As)	<0.1	<0.1
Barium (Ba)	15.5	4.1
Beryllium (Be)	<0.1	<0.1
Cadmium (Cd)	<0.1	<0.1
Chromium (Cr)	<0.1	<0.1
Cobalt (Co)	2.1	<0.1
Iron (Fe)	326.0	124.9
Lead (Pb)	<0.1	<0.1
Manganese (Mn)	86.9	24.8
Nickel (Ni)	<0.1	<0.1
Selenium (Se)	<0.1	<0.1
Silver (Ag)	<0.1	<0.1
Tin (Sn)	<0.1	<0.1
Vanadium (V)	<0.1	<0.1
Mercury (Hg)	<0.01	<0.01

Detection for metals is 0.1 ug/g

Tested by : J,X.(Chemist)

Approved By: James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
585 Water Street,
St. Marys, Ontario
N4X 1B6

17459-1,2
Date Report: Feb 10, 2022
Sample in: Feb 7, 2022

Attention: Kara Terpstra

Re: 2 rubber powder samples Skirting and Conveyor Belts , Feb 4,2022 for testing.

		Lab no..:	17459-1	17459-2
		Sample ID.	Skirting,	Conveyor Belts
Test	**Method ASTM**	**Unit**	**Results**	
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	9936 23.111	14199 33.026
2. Moisture content, As Received	E870	% wt.	0.56	0.90
3. Total Chlorine, As Received	D808	% wt.	0.03	0.04
4. Sulfur, As Received	D1552	% wt.	1.68	0.82
5. Total Carbon, As Received	D3178	% wt.	55.82	66.17
6. Total Organic Carbon	D4129	% wt.	54.15	62.86
7. Ash content, As Received	D482	% wt.	32.45	12.71

Tested by : P.S / A.C.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

February 01, 2022

Bonnie Field
Golder Associates Ltd.
6925 Century Avenue
Suite 100
Mississauga
L5N 7K2
Canada
Dear Mrs. Field

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as “percent modern carbon (pMC)”. This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited under Summary of Results. The standard version used is the latest available as of the date reported (unless otherwise noted). The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Digital signature on file

Ronald E. Hatfield President

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

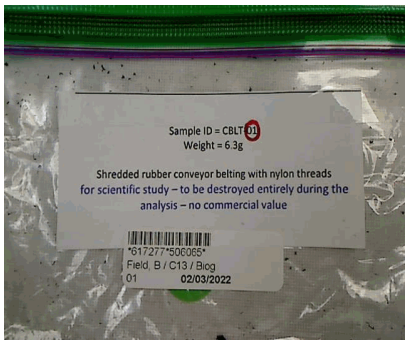
Certificate Number: 506065617277126076

Validation:

Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	January 25, 2022
Date Reported	February 01, 2022
Submitter Label	CBLT-01

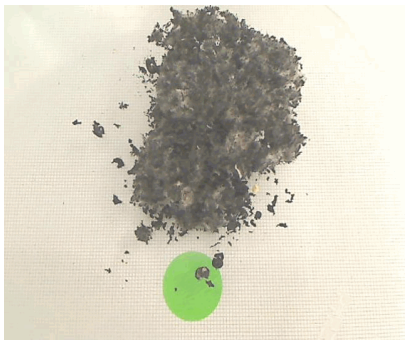
RESULT: 2 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-617277
Percent modern carbon (pMC)	2.08 +/- 0.04 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC

View of content (1mm x 1mm scale)



2547.7mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO_2 in the air and/or from fossil carbon (more than 40,000 years old) such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report

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Miami, FL 33155 USA
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ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

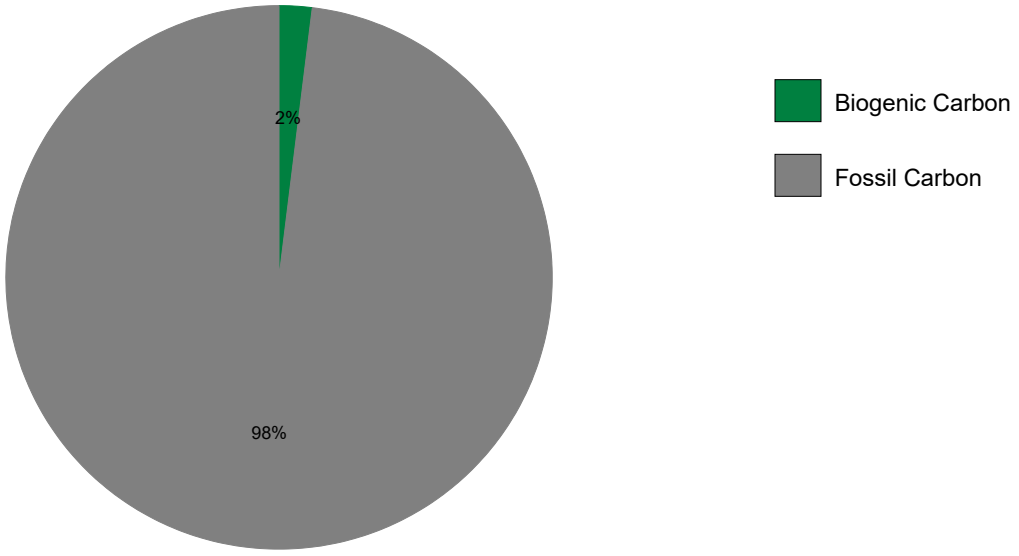
Certificate Number: 506065617277126076

Validation:

Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	January 25, 2022
Date Reported	February 01, 2022
Submitter Label	CBLT-01

RESULT: 2 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-617277
Percent modern carbon (pMC)	2.08 +/- 0.04 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO_2 in the air and/or from fossil carbon (more than 40,000 years old) such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NISTSRM-1990C and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: February 02, 2022
Submitter: Mrs. Bonnie Field

QA MEASUREMENTS

Reference 1

Expected Value:	0.42 +/- 0.04 pMC
Measured Value:	0.46 +/- 0.03 pMC
Agreement:	Accepted

Reference 2

Expected Value:	129.41 +/- 0.06 pMC
Measured Value:	129.29 +/- 0.37 pMC
Agreement:	Accepted

Reference 3

Expected Value:	96.69 +/- 0.50 pMC
Measured Value:	96.10 +/- 0.29 pMC
Agreement:	Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Digital signature on file

Date: February 02, 2022

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

February 01, 2022

Bonnie Field
Golder Associates Ltd.
6925 Century Avenue
Suite 100
Mississauga
L5N 7K2
Canada
Dear Mrs. Field

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as “percent modern carbon (pMC)”. This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited under Summary of Results. The standard version used is the latest available as of the date reported (unless otherwise noted). The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Digital signature on file

Ronald E. Hatfield President

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Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

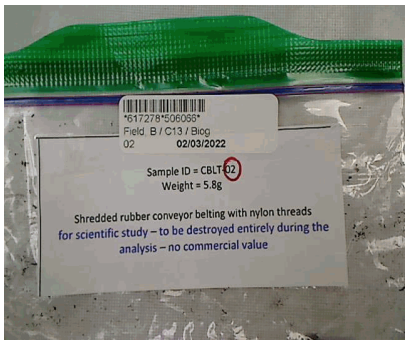
Certificate Number: 506066617278126076

Validation:

Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	January 25, 2022
Date Reported	February 01, 2022
Submitter Label	CBLT-02

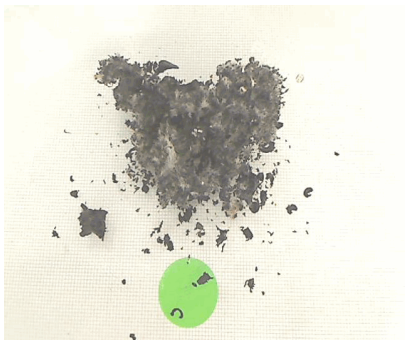
RESULT: 2 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-617278
Percent modern carbon (pMC)	1.89 +/- 0.04 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC

View of content (1mm x 1mm scale)



2535.7mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO_2 in the air and/or from fossil carbon (more than 40,000 years old) such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report

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Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

Certificate Number: 506066617278126076

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Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	January 25, 2022
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Submitter Label	CBLT-02

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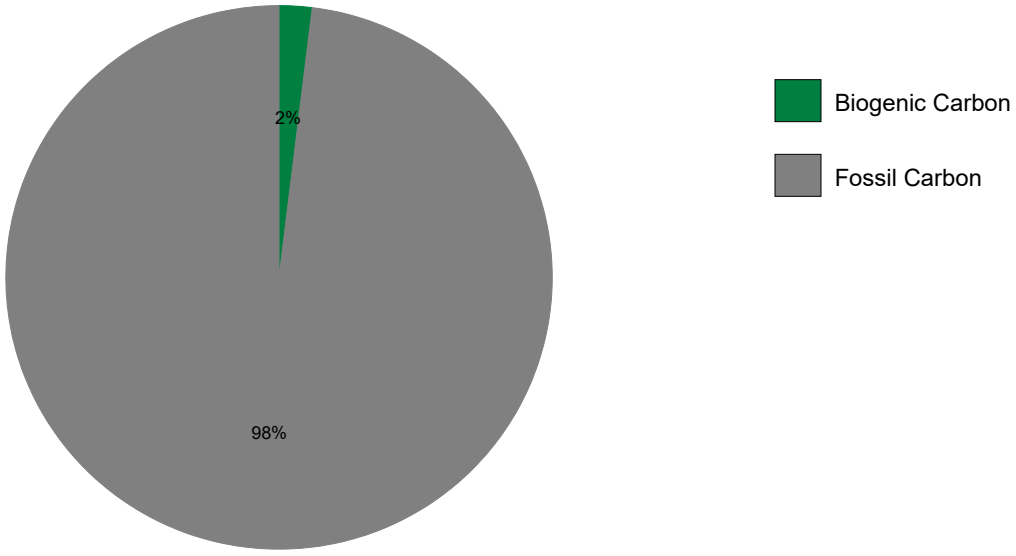

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NISTSRM-1990C and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: February 02, 2022
Submitter: Mrs. Bonnie Field

QA MEASUREMENTS

Reference 1

Expected Value:	0.42 +/- 0.04 pMC
Measured Value:	0.46 +/- 0.03 pMC
Agreement:	Accepted

Reference 2

Expected Value:	129.41 +/- 0.06 pMC
Measured Value:	129.29 +/- 0.37 pMC
Agreement:	Accepted

Reference 3

Expected Value:	96.69 +/- 0.50 pMC
Measured Value:	96.10 +/- 0.29 pMC
Agreement:	Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Digital signature on file

Date: February 02, 2022

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Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

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Sincerely,

Digital signature on file

Ronald E. Hatfield President

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ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

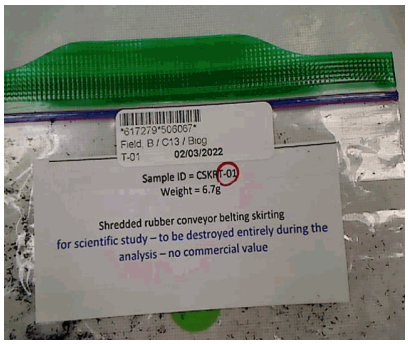
Certificate Number: 506067617279126076

Validation:

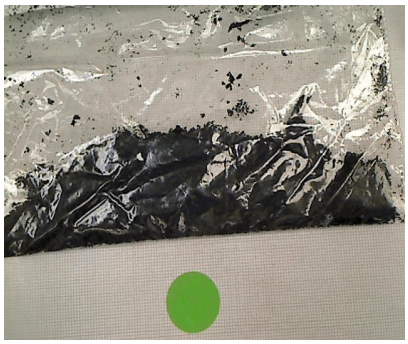
Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	January 25, 2022
Date Reported	February 01, 2022
Submitter Label	CSKRT-01

RESULT: 42 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-617279
Percent modern carbon (pMC)	41.91 +/- 0.14 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC



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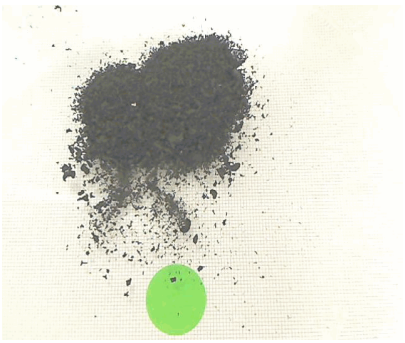

2578.2mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

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Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

Certificate Number: 506067617279126076

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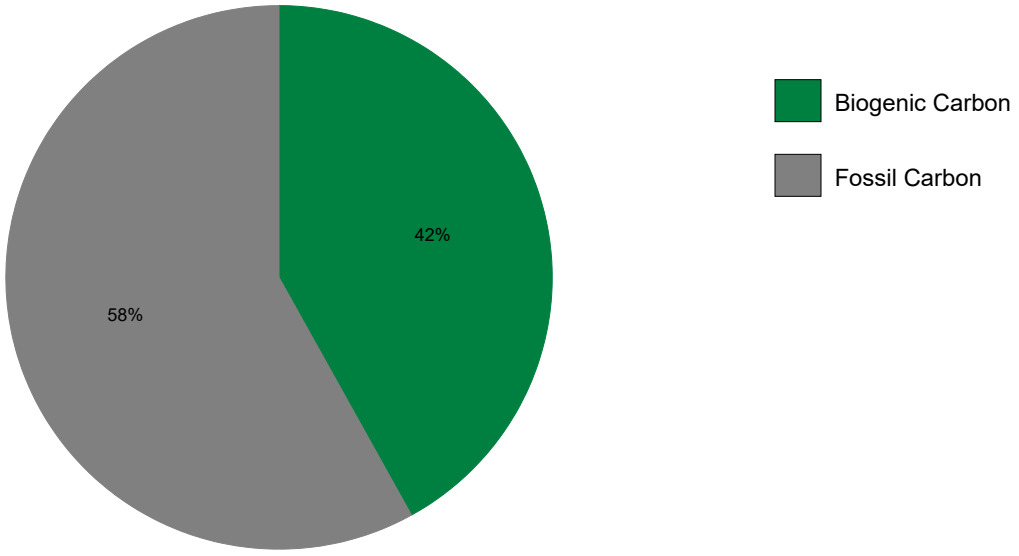

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

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Report Date: February 02, 2022
Submitter: Mrs. Bonnie Field

QA MEASUREMENTS

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Measured Value:	0.46 +/- 0.03 pMC
Agreement:	Accepted

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Expected Value:	96.69 +/- 0.50 pMC
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COMMENT: All measurements passed acceptance tests.

Validation: Digital signature on file

Date: February 02, 2022

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ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

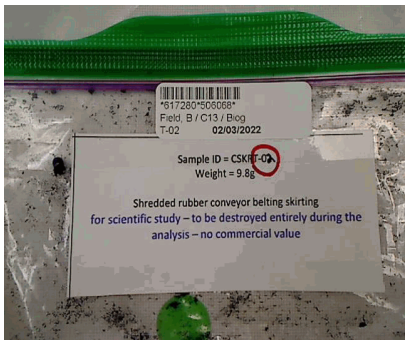
Certificate Number: 506068617280126076

Validation:

Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	January 25, 2022
Date Reported	February 02, 2022
Submitter Label	CSKRT-02

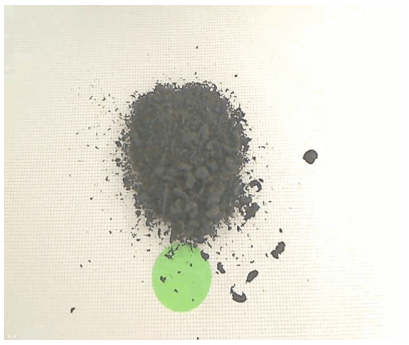
RESULT: 42 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-617280
Percent modern carbon (pMC)	41.61 +/- 0.12 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC

View of content (1mm x 1mm scale)



2574.8mg analyzed (1mm x 1mm scale)

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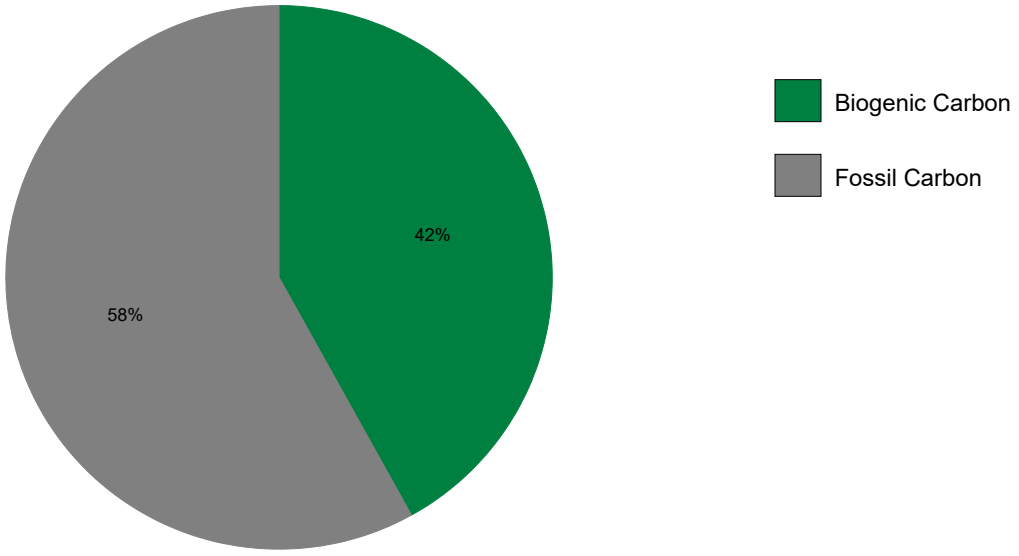

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4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Quality Assurance Report

This report provides the results of reference materials used to validate radiocarbon analyses prior to reporting. Known-value reference materials were analyzed quasi-simultaneously with the unknowns. Results are reported as expected values vs measured values. Reported values are calculated relative to NISTSRM-1990C and corrected for isotopic fractionation. Results are reported using the direct analytical measure percent modern carbon (pMC) with one relative standard deviation. Agreement between expected and measured values is taken as being within 2 sigma agreement (error x 2) to account for total laboratory error.

Report Date: February 02, 2022
Submitter: Mrs. Bonnie Field

QA MEASUREMENTS

Reference 1

Expected Value:	0.42 +/- 0.04 pMC
Measured Value:	0.42 +/- 0.03 pMC
Agreement:	Accepted

Reference 2

Expected Value:	129.41 +/- 0.06 pMC
Measured Value:	129.54 +/- 0.35 pMC
Agreement:	Accepted

Reference 3

Expected Value:	96.69 +/- 0.50 pMC
Measured Value:	97.23 +/- 0.29 pMC
Agreement:	Accepted

COMMENT: All measurements passed acceptance tests.

Validation: Digital signature on file

Date: February 02, 2022

Sampling Results for ALCF – St Marys Cement, Bowmanville, ON

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 17086-1 to 5
Date Report: Dec 17, 2021
Sample in: Dec 8, 2021
PO no.: 6300286815

Attention: Jason Schultz

Re: 3 Wood chip & 2 Plastics samples from: Nov 30,2021
for St. Mary Low Carbon Fuel project.

		Lab no..:	17086-1	17086-2	17086-3	17086-4	17086-5
		Sample ID.	Upak Nov Wood	GFL Nov Wood	905 Nov Wood	Atlantic Nov Plastic	EFS Nov Plastic
Test	**Method ASTM**	**Unit**	**Results**				
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	7388 17.184	7555 17.573	6709 15.605	7885 18.340	12159 28.281
2. Moisture content, As Received	E870	% wt.	15.51	10.74	23.57	21.78	10.20
3. Total Chlorine, As Received	D808	% wt.	0.07	0.02	0.07	0.36	3.36
4. Sulfur, As Received	D1552	% wt.	0.28	0.28	0.35	0.25	0.25
5. Total Carbon, As Received	D3178	% wt.	43.62	44.71	39.07	37.83	56.45
6. Total Organic Carbon	D4129	% wt.	42.14	43.39	37.12	35.56	55.04
7. Ash content, As Received	D482	% wt.	3.69	4.49	3.93	3.08	7.39

Tested by : P.S / A.C.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

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January 03, 2022

Bonnie Field
Golder Associates Ltd.
6925 Century Avenue
Suite 100
Mississauga
L5N 7K2
Canada
Dear Mrs. Field

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as “percent modern carbon (pMC)”. This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited under Summary of Results. The standard version used is the latest available as of the date reported (unless otherwise noted). The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick
Vice President of Laboratory Operations

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ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

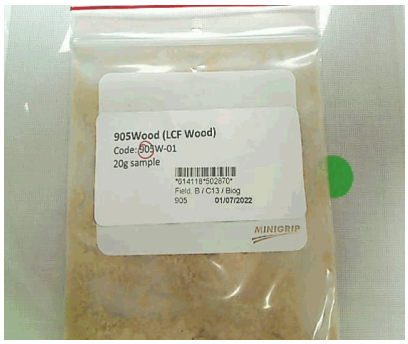
Certificate Number: 502870614118125234

Validation: Chris Patrick
Digital signature on file

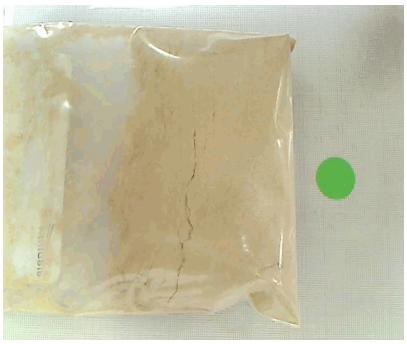
Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	December 20, 2021
Date Reported	January 03, 2022
Submitter Label	905W-01

RESULT: 99 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-614118
Percent modern carbon (pMC)	110.92 +/- 0.5 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



Package received - labeling COC


View of content (1mm x 1mm scale)


3030.7mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO_2 in the air and/or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

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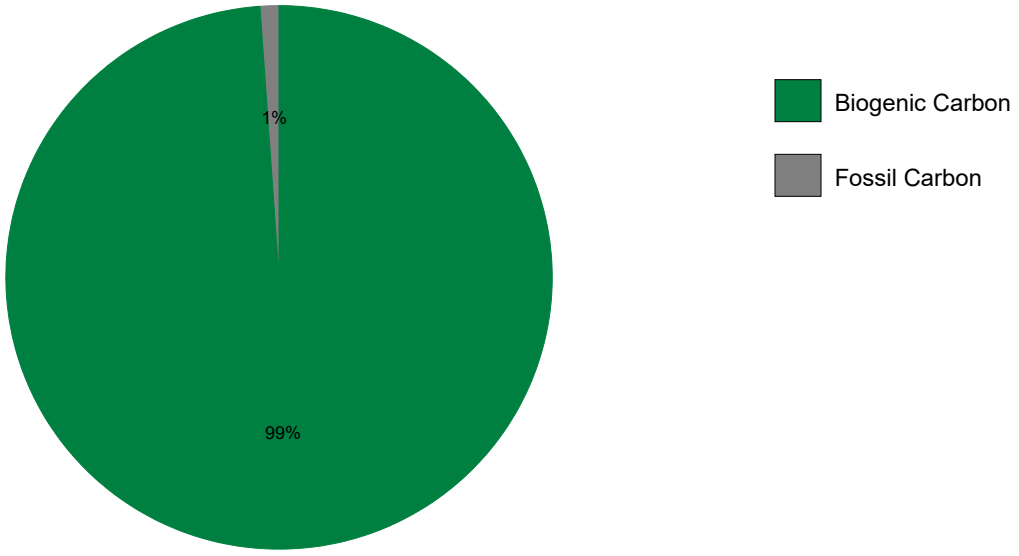

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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Golder Associates Ltd.
6925 Century Avenue
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Canada
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Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

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Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick
Vice President of Laboratory Operations

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Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

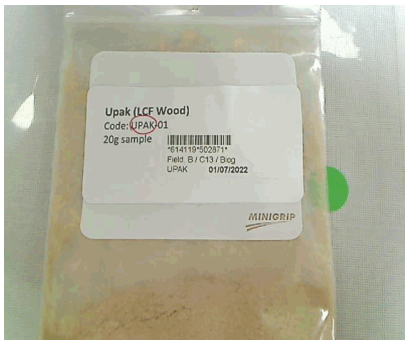
Certificate Number: 502871614119125234

Validation: Chris Patrick
Digital signature on file

Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	December 20, 2021
Date Reported	January 03, 2022
Submitter Label	UPAK-01

RESULT: 98 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-614119
Percent modern carbon (pMC)	110.21 +/- 0.52 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



Package received - labeling COC


View of content (1mm x 1mm scale)


3017.2mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

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Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

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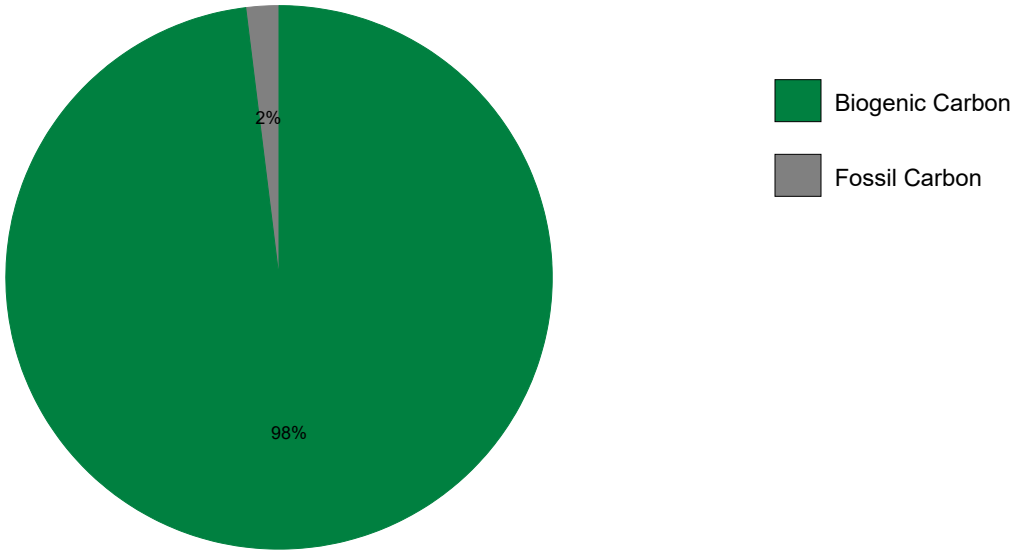

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

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Dear Mrs. Field

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Sincerely,

Chris Patrick
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Vice President of Laboratory Operations

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Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

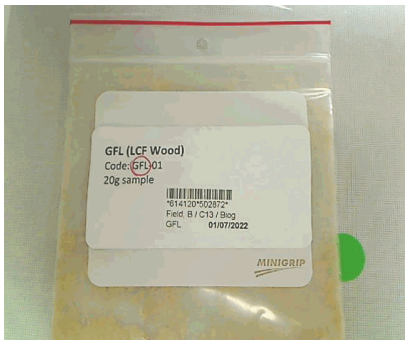
Certificate Number: 502872614120125234

Validation: Chris Patrick
Digital signature on file

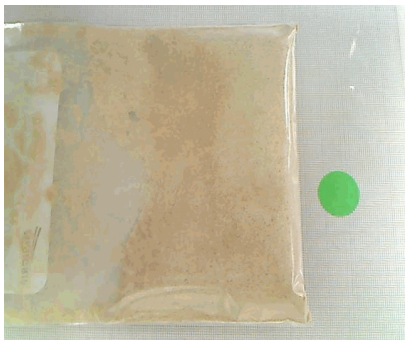
Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	December 20, 2021
Date Reported	January 03, 2022
Submitter Label	GFL-01

RESULT: 100 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-614120
Percent modern carbon (pMC)	118.47 +/- 0.52 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



Package received - labeling COC


View of content (1mm x 1mm scale)


3022.8mg analyzed (1mm x 1mm scale)

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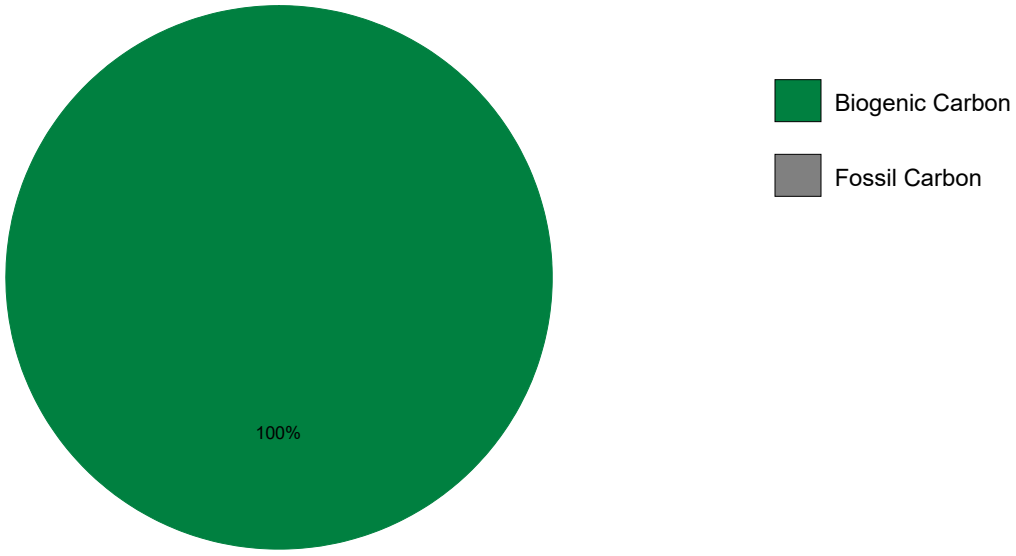

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

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L5N 7K2
Canada
Dear Mrs. Field

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as “percent modern carbon (pMC)”. This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited under Summary of Results. The standard version used is the latest available as of the date reported (unless otherwise noted). The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick
Vice President of Laboratory Operations

Beta Analytic, Inc.
4985 SW 74th Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

Certificate Number: 502873614121125234

Validation: Chris Patrick
Digital signature on file

Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	December 20, 2021
Date Reported	January 03, 2022
Submitter Label	ATLPL-01

RESULT: 47 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-614121
Percent modern carbon (pMC)	46.78 +/- 0.3 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000

Package received - labeling COC


View of content (1mm x 1mm scale)


3038.8mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO_2 in the air and/or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

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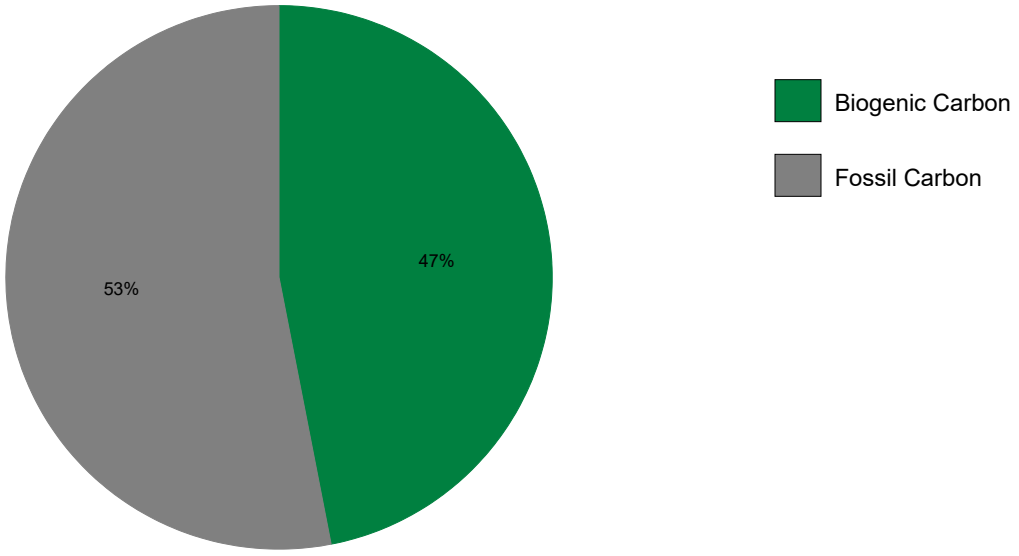

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% Biogenic Carbon Content ASTM D6866-21 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

Beta Analytic
TESTING LABORATORY

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ISO/IEC 17025:2017-Accredited Testing Laboratory

December 31, 2021

Bonnie Field
Golder Associates Ltd.
6925 Century Avenue
Suite 100
Mississauga
L5N 7K2
Canada
Dear Mrs. Field

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

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Reported results are accredited to ISO/IEC 17025:2017 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

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ISO/IEC 17025:2017-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-21 Method B (AMS)

Certificate Number: 502874614122125234

Validation: Chris Patrick
Digital signature on file

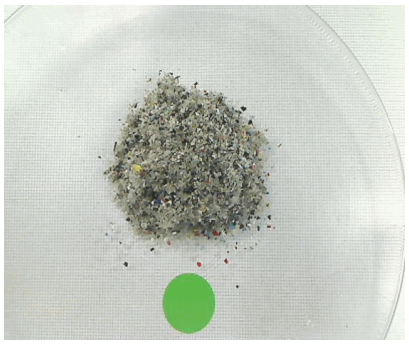
Submitter	Bonnie Field
Company	Golder Associates Ltd.
Date Received	December 20, 2021
Date Reported	December 31, 2021
Submitter Label	EFSPL-01

RESULT: 10 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-614122
Percent modern carbon (pMC)	10.01 +/- 0.06 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000

Package received - labeling COC


View of content (1mm x 1mm scale)


3078.0mg analyzed (1mm x 1mm scale)

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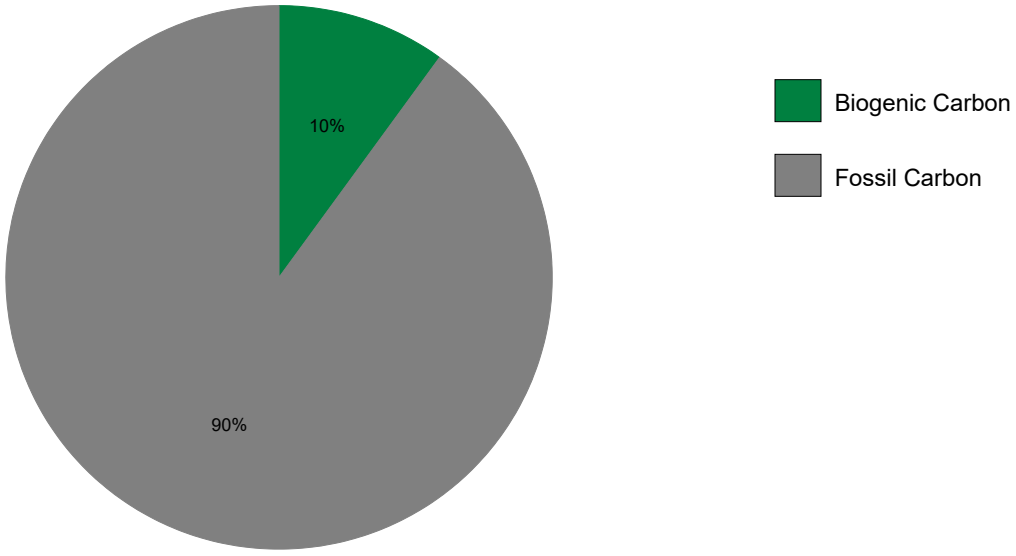

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APPENDIX B

Carbon Dioxide Emission Intensity Calculations

Carbon Dioxide Emission Intensity Calculation for ALCF

Description

VCNA proposes to use up to 175 tonnes per day of alternative low carbon fuels in place of conventional fuels (petroleum coke).

Material baskets: Construction & Demolition By-Products
Biomass

Methodology

As per O.Reg. 79/15 section 9.(1) (amended by O. Reg. 824/21) the carbon dioxide emission intensity of a fuel, in this case shredded wood from post construction waste (biomass), proposed to be combusted as an alternative low carbon fuel is calculated using the following formula:

Carbon dioxide emission intensity = $CC_{non\text{-}bio}$ x 3.67/HHV

where,

$CC_{non\text{-}bio}$ = non-biological carbon content of fuel [kg C / tonne fuel]
HHV = high heat value of fuel [MJ / tonne fuel]

A non-biological carbon value was calculated for each of the individual materials for wood fuel by subtracting the biological carbon portion from total carbon. The non-biological carbon content value was used to calculate a carbon dioxide emission intensity for each individual material.

Sample Calculation

$CC_{non\text{-}bio}$ = total carbon [%wt] x (1 - biological carbon [% wt])
$CC_{non\text{-}bio}$ = 39.07% x (100% - 99%)
$CC_{non\text{-}bio}$ = 0.39%

Carbon dioxide emission intensity = of sample 905W-01

$$0.39\%\ \text{C} \times \frac{3.67\ \text{kg CO}_2}{\text{kg C}} \times \frac{1}{15.605\ \text{MJ}}\ \text{kg}$$

Carbon dioxide emission intensity = of sample 905W-01

$$0.0009\ \frac{\text{kg CO}_2}{\text{MJ}}$$

Summary of Carbon Dioxide Intensity

		Sample ID	905W-01	UPAK-01	GFL-01
		Source of Material	905Wood	UPAK	GFL
Test	ASTM Method	Date of Sample Collection	November 30, 2021	November 30, 2021	November 30, 2021
Biological Carbon	D6866	% wt.	99%	98%	100%

Notes: Samples were collected on November 30, 2021 at BWM (one sample of each type of material) and submitted to Beta Analytic.
Results were reported on January 3, 2022 by Beta Analytic.

		Sample ID	905W-01	UPAK-01	GFL-01
		Source of Material	905Wood	UPAK	GFL
		Date of Sample Collection	November 30, 2021	November 30, 2021	November 30, 2021
Test	ASTM Method	Unit	Results		
HHV, Calorific Value As Received	E870	BTU/lb	6709	7388	7555
		MJ/kg	15.605	17.184	17.573
Carbon, As Received	D3178	% wt.	39.07	43.62	44.71

Notes: Samples were collected on November 30, 2021 (one sample of each type of material) and submitted to Petro Laboratories Inc.
Results were reported on December 17,2021 by Petro Laboratories.

Summary of Carbon Dioxide Intensity

		Sample ID	905W-01	UPAK-01	GFL-01
		Source of Material	905Wood	UPAK	GFL
		Date of Sample Collection	November 30, 2021	November 30, 2021	November 30, 2021
Test	ASTM Method	Unit	Results		
Biological Carbon	D6866	% wt.	99%	98%	100%
Non-biological Carbon	—	% wt.	0.39%	0.87%	0.00%
CO_2 Intensity	—	kg CO_2/MJ	**0.0009**	**0.002**	**0.000**

Carbon Dioxide Emission Intensity Calculation for ALCF

Description

VCNA proposes to use up to 175 tonnes per day of alternative low carbon fuels in place of conventional fuels (petroleum coke).

Material baskets: Non-Recyclable Plastics
Non-Recyclable Paper Fiber/Wood/Plastic Composites

Methodology

VCNA proposes to use nested plastics and paper, as well as shredded plastic caps, labels and bags as alternative fuels.
As per O.Reg. 79/15 section 10.(1) (amended by O. Reg. 824/21) the carbon dioxide emission intensity of a fuel proposed to be combusted as an alternative low carbon fuel is calculated using the following formula:

Carbon dioxide emission intensity = $Cc_{non\text{-}bio}$ x 3.67/HHV

where,

$CC_{non\text{-}bio}$ = non-biological carbon content of fuel [kg C / tonne fuel]
HHV = high heat value of fuel [MJ / tonne fuel]

A non-biological carbon value was calculated for each individual material for plastic fuel by subtracting the biological carbon portion from total carbon. The non-biological carbon content value was used to calculate a carbon dioxide emission intensity for each individual material.

Sample Calculation

$CC_{non\text{-}bio}$ = total carbon [%wt] x (1 - biological carbon [% wt])
$CC_{non\text{-}bio}$ = 37.83% x (100% - 47%)
$CC_{non\text{-}bio}$ = 20%

Carbon dioxide emission intensity = of sample ATLPL-01	20.0%	C	3.67	$kg\ CO_2$ / kg C	1	kg / 18.340	MJ
Carbon dioxide emission intensity = of sample ATLPL-01	0.0401	$kg\ CO_2$ / MJ					

Summary of Carbon Dioxide Intensity

Biogenic Carbon Results

		Sample ID	ATLPL-01	EFSPL-01
		Source of Material	Atlantic	EFS
		Material Description	Nested plastics and paper	Shredded caps, labels and bags
Test	ASTM Method	Date of Sample Collection	November 30, 2021	November 30, 2021
Biological Carbon	D6866	% wt.	47%	10%

Notes: Samples were collected on November 30, 2021 at BWM (one sample of each type of material) and submitted to Beta Analytic.
Results were reported on January 3, 2022 by Beta Analytic.

HHV and Total Carbon Results

		Sample ID	ATLPL-01	EFSPL-01
		Source of Material	Atlantic	EFS
		Material Description	Nested plastics and paper	Shredded caps, labels and bags
		Date of Sample Collection	November 30, 2021	November 30, 2021
Test	ASTM Method	Unit	Results	
HHV, Calorific Value As Received	E870	BTU/lb	7885	12159
		MJ/kg	18.340	28.281
Carbon, As Received	D3178	% wt.	37.83	56.45

Notes: Samples were collected on November 30, 2021 (one sample of each type of material) and submitted to Petro Laboratories Inc.
Results were reported on December 17,2021 by Petro Laboratories.

Summary of Carbon Dioxide Intensity

		Sample ID	ATLPL-01	EFSPL-01
		Source of Material	Atlantic	EFS
		Material Description	Nested plastics and paper	Shredded caps, labels and bags
		Date of Sample Collection	November 30, 2021	November 30, 2021
Test	ASTM Method	Unit	Results	
Biological Carbon	D6866	% wt.	47%	10%
Non-biological Carbon	—	% wt.	20.05%	50.81%
CO_2 Intensity	—	$kg\ CO_2/MJ$	**0.0401**	**0.0659**

Carbon Dioxide Emission Intensity Calculation for ALCF

Description

VCNA proposes to use up to 175 tonnes per day of alternative low carbon fuels in place of conventional fuels (petroleum coke).

Material baskets: Rubber materials (non-tire derived)

Methodology

VCNA proposes to use shredded rubber conveyor belt material as an alternative fuel. There are two types of shredded rubber conveyor belt material: belting with nylon threads and skirting without nylon threads.
As per O.Reg. 79/15 (amended by O. Reg. 824/21) section 10.(1) the carbon dioxide emission intensity of a fuel proposed to be combusted as an alternative low carbon fuel is calculated using the following formula:

Carbon dioxide emission intensity = $Cc_{non\text{-}bio}$ x 3.67/HHV

where,

$CC_{non\text{-}bio}$ = non-biological carbon content of fuel [kg C / tonne fuel]
HHV = high heat value of fuel [MJ / tonne fuel]

A non-biological carbon value was calculated for each individual material for rubber fuel by subtracting the biological carbon portion from total carbon. The non-biological carbon content value was used to calculate a carbon dioxide emission intensity for each individual material.

Sample Calculation

$CC_{non\text{-}bio}$ = total carbon [%wt] x (1 - biological carbon [% wt])
$CC_{non\text{-}bio}$ = 66.17% x (100% - 2.00%)
$CC_{non\text{-}bio}$ = 64.85%

Carbon dioxide emission intensity = $\frac{64.85\%\ C}{}$ | $\frac{3.67\ kg\ CO_2}{kg\ C}$ | $\frac{1\ kg}{33.026\ MJ}$

Carbon dioxide emission intensity = $\frac{0.0721\ kg\ CO_2}{MJ}$

Summary of Chemical Analysis Results

Biogenic Carbon Results

		Sample ID	CBLT-01	CBLT-02	CSKRT-01	CSKRT-02
		Source of Material	SMC	SMC	SMC	SMC
		Material Description	Shredded rubber conveyor belting with nylon threads	Shredded rubber conveyor belting with nylon threads	Shredded rubber conveyor skirting without nylon threads	Shredded rubber conveyor skirting without nylon threads
Test	ASTM Method	Date of Sample Collection	January 20, 2022	January 20, 2022	January 20, 2022	January 20, 2022
Biological Carbon	D6866	% wt.	2.00%	2.00%	42.00%	42.00%

Notes: Duplicate samples of conveyor belting and skirting were collected at SMC on January 20, 2022 and submitted to Beta Analytic.
Results were reported on February 1, 2022 by Beta Analytic.

HHV and Total Carbon Results

		Sample ID	17459-2	17459-1
		Source of Material	SMC	SMC
		Material Description	Shredded rubber conveyor belting with nylon threads	Shredded rubber conveyor skirting without nylon threads
Test	ASTM Method	Unit	Results	
HHV, Calorific Value, As Received	E870	BTU/lb	14199	9936
		MJ/kg	33.026	23.111
Carbon, As Received	D3178	% wt.	66.17%	55.82%

Notes: Two samples were collected at SMC on February 4, 2022 (one sample of each type of conveyor material) and submitted to Petro Laboratories Inc.
Results were reported on February 10, 2022 by Petro Laboratories Inc.

Summary of Carbon Dioxide Intensity

		Source of Material	SMC	SMC
		Material Description	Shredded rubber conveyor belting with nylon threads	Shredded rubber conveyor skirting without nylon threads
Test	ASTM Method	Unit	Results	
Biological Carbon (Average)	D6866	% wt.	2.00%	42.00%
Non-biological Carbon	—	% wt.	64.85%	32.38%
CO_2 Intensity	—	kg CO_2/MJ	**0.0721**	**0.0514**

Notes: Biological Carbon results were averaged for the duplicate samples of conveyor belting and skirting.

Carbon Dioxide Emission Intensity Calculation for Conventional Fuels

Description

VCNA proposes to replace conventional fuels (petroleum coke) with up to 175 tonnes per day of alternative low carbon fuels (ALCFs). Due to the ALCFs' variability in high heat value, the amount of conventional fuels that would be replaced will vary. The facility will target a 40% thermal replacement.

Methodology

As per O.Reg. 79/15 section 9.(1) (amended by O. Reg. 824/21) the CO_2 emission intensity of coal or petroleum coke (coke) is calculated using the following formula:

CO_2 emission intensity = CC_{total} x 3.67/HHV

where,

CC_{total} = total carbon content of coal or coke [kg C / tonne fuel]
HHV = high heat value of coal or coke [MJ / tonne fuel]

The following conventional fuel samples were sent for analysis:
- Bowmanville facility: August to December 2021 and January 2022
- St. Marys: Q4 2021 (September to November 2021)

A carbon intensity value was calculated for each of the test results. The results were then averaged over the number of total tests to obtain an average carbon intensity of the fuel.

Sample Calculation

CO_2 emission intensity = CC_{total} x 3.67/HHV

CO_2 emission intensity = 87.09 % C | 3.67 kg CO_2 / kg C | 1 kg / 33.015 MJ

CO_2 emission intensity = 0.0968 kg CO_2 / MJ

Summary of Carbon Dioxide Intensity

		Submitted by SMC Site	St. Marys			Bowmanville					
		Laboratory	SGS North America Inc.			Petro Laboratories Inc.					
		Lab No.	491-2108978-001	491-2108828-001	491-2109700-001	16572-2	16729-2	16904-2	17085-2	17221-2	17467-2
		Client Sample ID	SAR090-21-3988	SAR090-21-2606	SAR090-21-5348	Aug PETCOKE	Sept PETCOKE	Oct PETCOKE	Nov PETCOKE	Dec PETCOKE	Jan PETCOKE
		Date of Sample Collection	**September 29, 2021**	**October 2021**	**November 30, 2021**	**August 31, 2021**	**September 30, 2021**	**October 31, 2021**	**November 30, 2021**	**December 31, 2021**	**January 31, 2022**	
Test	**ASTM Method**	**Unit**										**Average**
HHV, Calorific Value, As Received	E870	BTU/lb	14168	14194	14086	13938	13907	14148	14498	14684	14759	14264.667
		MJ/kg	32.955	33.015	32.764	32.419	32.347	32.908	33.722	34.154	34.329	33.18
Carbon, As Received	D3178	% wt.	87.12	87.09	86.79	79.82	78.98	78.30	83.26	85.36	79.03	82.86
CO_2 Intensity	—	kg CO_2/MJ	0.0970	0.0968	0.0972	0.0904	0.0896	0.0873	0.0906	0.0917	0.0845	0.0917

golder.com