Source Testing for Vidir Gasifier Air Emissions with Straw Feed Stock

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Source Testing for
Vidir Gasifier Air Emissions
with Straw Feed Stock

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Submitted by

Dillon Consulting Limited

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1 BACKGROUND

Dillon Consulting Limited (Dillon) was retained by Vidir BioMass Inc.(Vidir) to conduct source testing on the Vidir Gasifier using straw feed stock. The source testing program was designed to quantify the total suspended particulate matter (PM) and combustion gas emission rates from the Vidir Gasifier. These measured emission rates were conducted with the Gasifier operating at the maximum system design production rate of approximately 500 pounds (227 kg) of straw per hour.

Dillon provided a letter proposal to Ron Penner, National Sales Manager, Vidir BioMass Inc. dated January 10, 2003, outlining the scope of work required to perform the source testing. Source testing was conducted over the period of January 23 to 29, 2003.

1.1 Disclaimer

This report was prepared by Dillon for the sole benefit of our client. The material in it reflects Dillon's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Dillon accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

3 SAMPLING METHODOLOGIES

Environment Canada's "Reference Methods for Source Testing: Measurement of Releases of Particulate Matter from Stationary Sources (EPS 1/RM/8, December 1993)" was used to collect samples for particulate matter. This method incorporates a 0.3 micron glass fiber filter, followed by water impingers to collect filterable and condensable particulate matter. The condensable particulate matter collected in the water fraction of the sampling train was further analyzed for total chlorides (as chlorine), oxides of nitrogen (as nitrate) and sulphates. All analytical work was performed by Enviro•Test Laboratories, Edmonton, Alberta. A total of three (3) tests were conducted.

Dillon measured the concentration of combustion gases from the exhaust gas stream simultaneously with the particulate matter testing during steady state conditions with a straw feed rate of 500 pounds (227 kg) per hour. Combustion gas emission concentrations were measured with a Telegan Tempest 100 Portable Combustion Gas Analyzer. This instrument allows the following gases to be measured simultaneously:

- Oxygen (O_2);
- Carbon Monoxide (CO);
- Sulphur Dioxide (SO_2) and,
- Oxides of Nitrogen (NO, NO_2, NO_x).
- Carbon Dioxide (CO_2) by calculation;

The Telegan Tempest 100 analyzer sampling unit includes a stainless steel sample probe, a condensate trap, a filter trap, and a housing unit, which contains a series of electrochemical cells. Gas concentrations were manually recorded at approximately one-minute intervals simultaneously with the particulate matter tests.

4 RESULTS

Table 4.1 summarizes the results of isokinetic particulate matter testing performed on the Vidir Gasifier exhaust stack. Appendix A contains the stack data summary sheets for this testing. Appendix B contains the Enviro•Test Laboratories Chemical Analysis Report. The results obtained for total chlorides (as chlorine) have been converted to represent the emissions as hydrogen chloride (HCl).

Table 4.2 summarizes the results of the combustion gas concentrations in the Vidir Gasifier exhaust stream while Table 4.3 provides the combustion gas emission rates. Appendix C contains the combustion gas summary sheets for each of the test periods.

Combustion gas concentrations for carbon monoxide (CO) were not recorded during Test #1 because process interruptions before the start of the test resulted in high CO concentrations which temporarily poisoned the electrochemical cell. It should also be noted that during the first test the concentration of sulphur dioxide was steady at 0 ppm and may also be a result of the temporary electrochemical cell poisoning from the high CO concentrations.

Table 4.1: Particulate Matter Emissions from Vidir Gasifier Exhaust Stack

Location	Date (m/d/y)	Sample Time	Sample Volume $(m^3)_{ref}$	Exhaust Gas Temp. (^0C)	Exhaust Gas Moisture (%)	Exhaust Stack Diameter (m)	Vent Gas Velocity (m/s)	Exhaust Gas Flow Rate $(m^3/s)_{ref}$	Concentration (mg/m^3)		Emission Rate (g/s)	
									PM	HCl	PM	HCl
Vidir Gasifier Exhaust Stack	1/23/03	1315-1345	0.826	205	14.2	0.30	11.6	0.47	168.6	209.6	0.078	0.099
	1/28/03	1304-1340	0.661	247	18.4	0.30	9.20	0.32	221.1	129.5	0.070	0.041
	1/29/03	1259-1347	1.141	218	12.4	0.30	10.5	0.41	193.1	97.11	0.079	0.040
	Average			223	15.0	0.30	10.4	0.40	194.2	145.4	0.076	0.060

Notes:

Reference Conditions = 298 K (25 °C) and 101.325 kPa
PM = Particulate Matter
HCl = Hydrogen Chloride
Feed Rate = 227 kg (500 lbs) of straw per hour.

Table 4.2: Combustion Gas Emission Concentrations from Vidir Gasifier Exhaust Stack

Location	Date (m/d/y)	Sample Time	Exhaust Gas Flow Rate $(m^3/s)_{ref}$	Combustion Gas Concentration									
				O_2		CO_2		CO		NO_x		SO_2	
				%	mg/m^3	%	mg/m^3	ppm	mg/m^3	ppm	mg/m^3	ppm	mg/m^3
Vidir Gasifier Exhaust Stack	1/23/03	1324-1341	0.47	5.9	77,220	11.4	205,200	---	---	849	1597	0	0
	1/28/03	1302-1334	0.32	4.9	64,130	12.2	219,600	6730	7707	421	792	25	65
	1/29/03	1250-1342	0.41	6.8	89,000	10.6	190,800	1461	1673	700	1317	15	39
	Average			5.9	76,780	11.4	205,200	4096	4690	657	1235	13	35

Notes:

Combustion Gas concentrations are the average concentrations from each test period.
Feed Rate = 227 kg (500 lbs) of straw per hour.

Example Calculation: $$\text{Conc. } CO_2 \text{ (mg/m3)} = \frac{\text{ppm} \times MW_{CO2}}{24.45} \quad \text{where } MW_{CO2} = 44 \text{ g/g mole}$$

Table 4.3: Combustion Gas Emission Rates from Vidir Gasifier Exhaust Stack

Location	Date (m/d/y)	Sample Time	Combustion Gas Emission Rate (g/s)				
			O_2	CO_2	CO	NO_x	SO_2
Vidir Gasifier Exhaust Stack	1/23/03	1324-1341	36.3	96.4	---	0.751	0
	1/28/03	1302-1334	20.5	70.3	2.466	0.253	0.021
	1/29/03	1250-1342	36.5	78.2	0.686	0.540	0.016
	Average		31.1	81.6	1.576	0.515	0.019

Note: Combustion Gas emission rates based upon average concentrations from each test period.
Feed Rate = 227 kg (500 lbs) of straw per hour.

Example Calculation: $ER(g/s) = \frac{\text{Conc. } (mg/m^3) \times \text{Flow } (m^3/s)}{1000 \text{ mg/g}}$

5 DISPERSION MODEL

Dispersion models are used to predict the reduction in contaminant concentrations from an emission source as it passes through the atmosphere to a receptor point. The US EPA Industrial Source Complex PRIME (ISC-PRIME) dispersion model[1] was used in this study to model particulate matter and combustion gas emissions for the Vidir Gasifier using straw feed stock at a rate of 500 pounds (227 kg) per hour.

The modeling options employed include concentration output, rural dispersion parameters, flat terrain and simple + complex terrain calculations. The regulatory default modelling options were used which include the use of stack-tip downwash, buoyancy-induced dispersion, final plume rise (except for sources with building downwash), a routine for processing averages when calm winds occur, default values for wind profile exponents and vertical temperature gradients, and the use of upper bound estimates for sources influenced by building downwash from super-squat buildings.

The EPA building profile input program (BPIP) was employed to determine if the stacks are subject to building wake effects, and if so, to calculate the building downwash effects.

Maximum predicted contaminant concentrations were evaluated for 1-hour and 24-hour averaging periods to compare to POI limits and ambient air quality parameters.

5.1 Coordinate System

For this exercise a simple coordinate system was established which defined the stack as the origin. The positive Y-axis was located in the north direction and the positive X-axis was located in the east direction. The stack exit elevation was set at 25 feet (7.62 m).

5.2 Meteorological Data

The dispersion model program requires the input of site-specific meteorological data. Environment Canada hourly meteorological data for the Winnipeg area for the period 1997 to 2001 was used for this modeling exercise.

The hourly wind speed, wind direction, and ambient temperature were used to define the meteorological data file. A neutral atmospheric stability ("D" stability) was assigned as this stability is predominant for the meteorological data for the area.

[1] ISC-AERMOD View - Interface for the US EPA ISCST3, AERMOD and ISC-PRIME, Lakes Environmental Consultants Inc., Version 3.5.1

5.3 Receptors

For the purpose of this exercise, the Vidir Gasifier was not assumed to be in a fixed location and specific receptors have not been identified. This modeling scenario provides a generic example of probable zones of impact from the process.

The receptor grid was set to be circular with an initial radius of 25 m from the stack origin and extending outward from the point of origin to a distance of 1000 m with receptor points located 45° apart. The segments were located 25 m apart near the property line and 100 m apart at the furthest receptor points.

All receptors were assumed to be at the same elevation as the site grade elevation. Appendix D contains computer model-generated drawings which identifies the stack origin, the property line, and the receptor points.

5.4 Dispersion Model Results

Table 5.1 summarizes the maximum predicted 1-hour and 24-hour average POI concentrations of particulate matter and combustion gases. Applicable POI limits for contaminants are provided for comparison. Where no federal or provincial (Manitoba) limits were available, Ontario limits are provided. Appendix D contains the dispersion modeling data.

Table 5.1: POI Summary for 24-hr Averaging Period

Contaminant	Maximum POI Concentrations ($\mu g/m^3$) Property Line/ Off-Property		Province of Manitoba Ambient Air Quality Objectives Maximum Acceptable Level Concentration ($\mu g/m^3$)	
	1-Hour	24-Hour	1-Hour	24-Hour
Particulate Matter	21.1	8.79	N/V	120
Carbon Monoxide	437	182	35000	15000[1]
Oxides of Nitrogen	143	59.6	400	200
Sulphur Dioxide	5.27	2.20	900	300
Hydrogen Chloride	16.7	6.94	100[2]	100 [20][3]

Notes: (1) 8-hour average
(2) 30-min POI Limit (Ontario)
(3) Ontario 24-hour AAQC

6 DISCUSSIONS OF RESULTS

The results of particulate matter emissions testing performed on the Vidir Gasifier exhaust stack indicate that the particulate matter concentrations in this stream range between 168 mg/m^3 and 221 mg/m^3. The corresponding average emission rate is 0.076 g/s. Based upon the chemical analysis of total chlorides (as chlorine) converted to hydrogen chloride the concentrations in this stream range between 97 mg/m^3 and 210 mg/m^3. The corresponding average hydrogen chloride emission rate is 0.060 g/s.

Based on a feed rate of 500 pounds (227 kg) per hour the average mass emission factors are 1206 mg/kg and 952 mg/kg for particulate matter and hydrogen chloride, respectively. These emission factors should remain valid for increased straw production rates provided gasification parameters remain constant.

Dispersion modeling was conducted to calculate the point of impingement concentrations based upon the emission rates measured during this sampling program at a straw feed rate of 500 pounds (227 kg) per hour. The results of the dispersion model indicate that the emissions of all of the measured parameters from the Vidir Gasifier comply with the Ontario and Manitoba regulated Point of Impingement and Ambient Air Quality Criteria Concentrations. The emission rates of oxygen and carbon dioxide are not regulated from process exhausts provided the POI concentrations do not create health or explosive hazards. The POI concentrations for the remaining combustion gases (i.e., CO, NOx, SO2) do not exceed any of the regulated POI limits or AAQC. In general the point of impingement concentrations predicted by the dispersion modeling for all measured pollutants are at least one-half of the regulated levels with no pollution control devices.

7 CLOSURE

This report was prepared exclusively for the purposes, project, and site location outlined in the report. The report is based on information provided to, or obtained by Dillon as indicated in the report, and applies solely to site conditions existing at the time of the site investigation. Although a reasonable investigation was conducted by Dillon, Dillon's investigation was by no means exhaustive and cannot be construed as a certification of the absence of any contaminants from the site. Rather, Dillon's report represents a reasonable review of available information within an agreed work scope, schedule, and budget. It is, therefore, possible that currently unrecognized contamination or potentially hazardous materials may exist at the site, and that the levels of contamination or hazardous materials may vary across the site. Further review and updating of the report may be required as local and site conditions, and the regulatory and planning frameworks, change over time.

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Respectfully submitted,
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