TECHNICALREPORT

June 1, 2014 Trace Air Contaminants Study of Combustion Sources

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EXECUTIVE SUMMARY

Alberta Environment is currently re-evaluating the ambient air quality objectives (AAQOs) for the province. This initiative includes reviewing the values of currently targeted substance and potentially adding additional substances to the list. A Stakeholder Advisory Committee (SAC) has been established to participate in this review and evaluation process. The first two substances to be reviewed are Acrolein and Arsenic.

The purpose of this study is to provide upstream oil and natural gas (UOG) industry with facility-related data that can facilitate defensible science-based decisions in this matter, and allow potential risks to the UOG industry to be assessed.

Accordingly, a series of source emission tests were conducted at facilities in various operational regions of Alberta covering a range of different UOG industry subsectors. The emission tests were conducted on a wide range of source types. Operational regions included the south east, central, north east and north. Industry subsectors included sweet gas, sour gas, conventional oil, cold heavy oil and thermal heavy oil production facilities. In total, thirteen combustion source samples were collected from six different combustion source types located at seven different facilities across Alberta.

Source sampling was completed using two types of sampling trains. Organic substances and inert gases were sampled using a canister sampling train and inorganics (metals) were sampled using a two stage impinger train. Canisters contents and impinger solutions were analyzed by Alberta Innovates. The sample line for the the impinger train was not rinsed at the end of the measurements; however, sample residue in the sample line was deemed to be minimal. The organics protocol quantified the target substance Acrolein, and approximately 187 other secondary substances. The specific organic compounds targeted by the analytical method are listed in Section 11 (Appendix D). Compounds targeted by the applied analytical method but not detected are not specifically highlighted in this report, but include 1,3-Butadiene (it was not detected in any of the samples). If a target compound was not detected in means that its concentration was below the lower detection limit of the applied analytical method (e.g., <10 μg/m^3 for C_{5+} compounds).

The inorganics protocol quantified Arsenic, and approximately 35 other substances; however, the protocol is applicable to non-volatile inorganic substances and while it is able to detect some volatile inorganic substances such as mercury, those results will understate actual values of volatile inorganic substances due to inefficiencies of the

sampling system in capturing the gaseous phase of inorganic substances. Accordingly, the results for mercury should be considered qualitative screening level results. Mercury was detected in most of the samples collected so this simply confirms it is generally present in detectable levels. For non-volatile inorganic compounds the results are accurate and quantitative.

The fuel gas associated with each combustion source was sampled for organic substances and inert gases using the same organics analytical protocol.

A rigorous material balance, considering all fuel and flue gas substances identified, was conducted for each combustion source to determine the actual air to fuel ratio, combustion efficiency and flue gas to fuel gas ratio. Based on the results of this material balance, emission factors for all compounds expressed in terms of mass emission per unit of energy input were determined.

Acrolein was observed in only one combustion source emission test and the determined emission factor was 9.09E-5 kg/GJ. This value is well above the detection limit of 7.91E-10 kg/GJ. The emission was associated with a compressor engine that was operating with a combustion efficiency of 95.6%, well below the average efficiency of 99.5% for all of the combustion devices samples. The emission factor determined for Acrolein was within the published range for 4-cycle Rich Burn, Natural Gas Internal Combustion Engines (1.13E-3 to 2.65 E-6 kg/GJ).

Based on these tests, it is appears that acrolein formation and emission from combustion sources may be associated with poor combustion efficiency and a follow up sampling program is recommended to potentially confirm this hypothesis. For combustion sources operating within the design specifications of good to excellent combustion efficiency, acrolein formation and emission does not appear to be an issue.

Arsenic was observed in all combustion source emission tests and the average emission factor was determined to be 4.16E-06 kg/GJ, approximately two orders of magnitude above the lower detection limit of 3.24E-08 kg/GJ. Based on evaluations of combustion air and fuel gas as the potential source of arsenic in the flue gases, it was concluded that fuel gas was the most likely source. Calculated theoretical concentrations of arsenic in the fuel gas were within the range noted by others for arsenic in natural gas.

A sampling program to quantify arsenic and potentially other metal substances in raw natural gas, process fuel gas and sales gas in various Canadian regions is recommended.

In addition to acrolein and arsenic, numerous other organic and inorganic substances were identified and quantified. Each source was characterized by its own suite of substances with some substances being associated with several sources. Emission factors were determined for all substances for each source sampled. These results serve as a database for future assessments of trace contaminant emissions.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRYNOMS

AAQO	Ambient air quality objectives
AAAQO	Alberta ambient air quality objectives
AFR	Air to fuel ratio (Volume basis)
AI	Alberta Innovates Laboratory
As	Arsenic
C1C4	C_1 to C_4 hydrocarbon identification and quantification
CAPP	Canadian Association of Petroleum Producers
CE	Combustion efficiency
CEL	Clearstone Engineering Ltd.
CEMS	Continuous Emission Monitoring System
CH4	Methane
GC	Gas chromatograph
GC/MS	Gas chromatograph/mass spectrometer
GJ	Giga Joule
kg	kilogram
L	Litre
LDL	Lower detection limit
mg	milligram
NA	Not applicable
ppm	part per million
ppb	part per billion
PTAC	Petroleum Technology Alliance Canada
RSC	Reduced sulphur compounds
SAC	Stakeholder Advisory Committee
THC	Total hydrocarbon
TOC	Total organic carbon
ug	microgram
UOG	Upstream oil and gas
VOC	Volatile organic compound

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1 INTRODUCTION

Provincial ambient air quality objectives (AAQOs) are currently being re-evaluated by Alberta Environment. This initiative includes reviewing the values of currently targeted substance and potentially adding additional substances to the list. A Stakeholder Advisory Committee (SAC) has been established to participate in this review and evaluation process and the first two substances to be reviewed are Acrolein and Arsenic.

The upstream oil and natural gas (UOG) industry strives to prepare objective input regarding the technical achievability of a proposed/lowered standard for both substances and the purpose of this study is to establish relevant UOG facility data that can facilitate defensible science-based decisions in this matter, and allow potential risks to the UOG industry to be assessed.

Acrolein may be formed from the breakdown of certain pollutants found in outdoor air, from the burning of organic matter including tobacco, or from the burning of fuels such as gasoline or oil (http://www.epa.gov/ttn/atw/hlthef/acrolein.html).

Inorganic arsenic is found throughout the environment; it is released into the air by volcanoes, the weathering of arsenic-containing minerals and ores, and by commercial or industrial processes (http://www.epa.gov/ttn/atw/hlthef/arsenic.html). Mining, metal smelting and burning of fossil fuels are the major industrial processes that contribute to arsenic contamination of air, water and soil.

The objective of the proposed study was to conduct a screening-level assessment of acrolein and arsenic emissions by the upstream oil and gas industry for use by stakeholders in discussions with Alberta Environment regarding new or revised AAQOs.

2 SCOPE OF WORK

The proposed work consisted of a screening-level measurement program designed to determine emission factors for a range of fossil-fuel/waste-gas combustion sources and a range of waste-gas and fossil-fuel qualities and geological sources in the UOG industry. The types of combustion sources considered included natural gas-fuelled reciprocating compressor engines, natural gas-fueled turbine engines, small and large process heaters and boilers, tail gas incinerators and flares. For practical purposes, flare testing needed to be restricted to enclosed flares where safe access to the post-flame combustion products was achievable. The range of fuel-gas and waste-gas types included raw field gas at conventional and heavy oil production facilities; produced gas used as fuel, and processed natural gas from sweet and sour gas fields.

An allowance was made for up to 16 sources to be sampled as indicated in the Proposed Sample column in **Table 1**. Final results presented are indicated in the Actual Sample column. The proposed sample included the noted ranges of fossil fuel/waste gas combustion sources, waste-gas combustion sources, waste gas and fossil fuel qualities and geological sources in upstream oil and gas industry. However, due to the safety issues and weather constraint, some of the sources were eliminated.

Table 1: Proposed and actual sources surveyed for trace air contaminants.

	Industry Subsector	Source	Proposed Sample	Actual Sample
Location 1	Sweet Gas Gathering System (Plains Region)	Reciprocating Engine	X	√
		Process Heater	X	√
Location 2	Sweet Gas Gathering System (Foothills Region)	Reciprocating Engine	X	√
		Process Heater	X	√
Location 3	Sweet Gas Processing Plant	Reciprocating Engine	X	√
		Process Heater	X	√
Location 4	Thermal Heavy Oil Production	Treaters	X	√
		Steam Generators	X	√
Location 5	Cold Heavy Oil Production	Tank Heaters	X	√
		Screw Pump Engine	X	√
Location 6	Sour Processing Plant	Tail Gas Incinerator	X	X
		Turbine Engine	X	X
		Steam Boiler	X	√
Location 7	Conventional Oil Production	Treater	X	√
		Reciprocating Engine	X	√
		Enclosed Flare	X	X

3 STUDY METHODOLOGY

Sampling, analyzing and assessing these sources required the application of appropriate sampling systems and the use of appropriate tools to analyze the samples. The results generated were used to develop the applicable emission factors.

3.1 SAMPLING SYSTEMS

Two sampling methods were required to achieve the objectives of the study. For arsenic and other metals, an impinger sampling train was employed with an acid solution added to the first impinger. For acrolein, other organic compounds and inert gases, an evacuated canister sampling train was employed. In both cases, the field collected samples were returned to the laboratory for detailed analyses. The two methods are briefly described below and detailed sampling protocols are presented in Appendix C

3.1.1 IMPINGER METALS SAMPLING TRAIN

The impinger sampling train is shown in **Figure 1**. It includes a sample probe for insertion into the source, followed by two impingers, immersed in an ice bath. Each impinger contained a 1.0 %vol nitric acid solution. After the metals are removed in the acid solution, the gas flows through a meter and vacuum pump, and is discharged to the atmosphere. The initial and final volumes of the nitric acid solution are measured in order to assess the moisture content of the sampled gas stream. Gas temperature and pressure are measured at the meter location to provide for volume corrections to standard conditions.

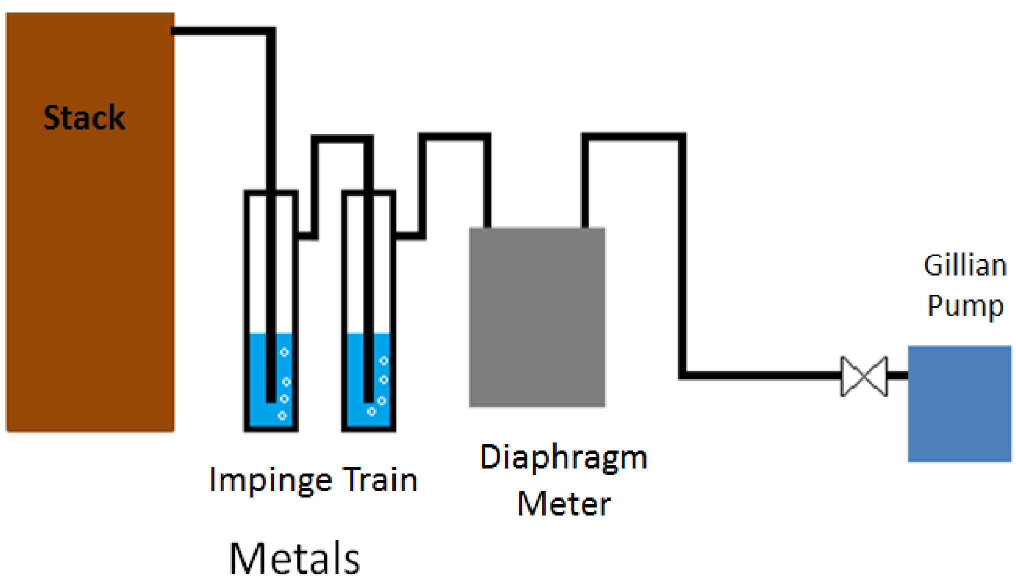

Figure 1. Schematic diagram of impinger sampling train used for metals.

3.1.2 ORGANICS SAMPLING TRAIN

The canister organics sampling train is shown in **Figure 2**. It includes a probe, for insertion into the source and an evacuated canister. The whole canister is returned to the laboratory for analytical work based upon the prescribed protocol. The sample train is based upon NCASI Method IM/CAN/WP-99.02 but does not include the impinger gas conditioning components.

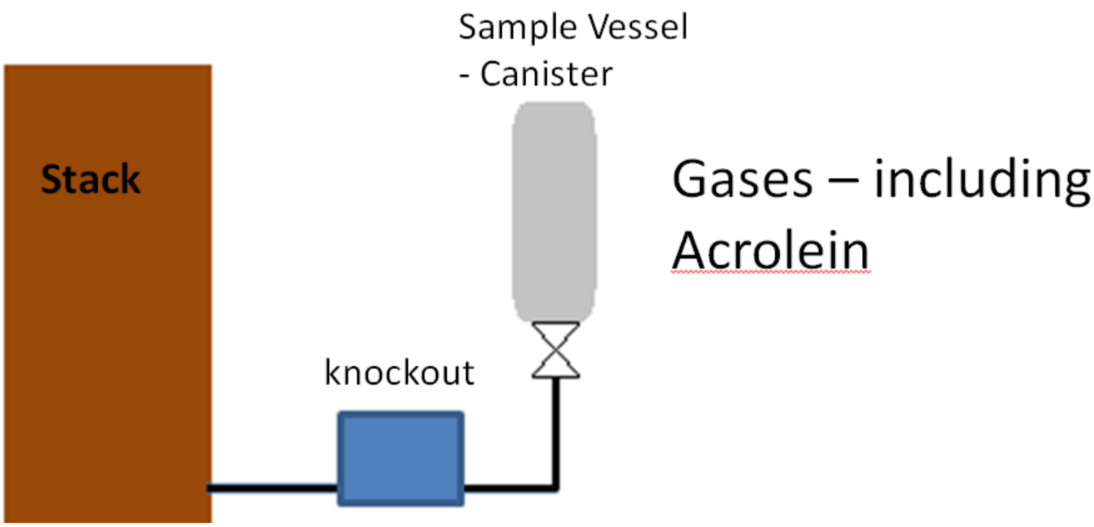

Figure 2. Schematic diagram of canister sampling train used for organics.

3.1.3 FIELD SAMPLE PROTOCOL

In general, fuel gas and flue gas were sampled at each of the selected sources. Fuel gas was sampled for gaseous organic compounds and inert gases using the organics sampling train and flue gas was sampled for organics and metals using both sampling trains.

For each site visited method blanks were also collected for quality control purposes.

- Travel Blanks remained with the project cooler from the laboratory to the sampling site and back to the laboratory without being opened. Sample train travel blanks were included for all applications of the metals sampling train.
- Method Blanks were used for each source. The method blank was handled similar to the actual sample with the same reagents being added, with contact to the same type of vessels and with the same handling procedure. The method blank was used to address potential contamination associated with every step in the procedure not related to the actual sample collected. The method blank analytical results were used to correct sample analytical results.

Actual sample collection at each location and relevant field information pertaining to the source, sampling conditions and or field issues encountered are summarized in **Table 47** of Appendix B.

3.2 ANALYTICAL PROTOCOLS

Analytical work completed by Alberta Innovates followed prescribed protocols as outlined below.

3.2.1 METALS PROTOCOL

The metals analytical work included the quantification of arsenic and numerous other metals. The analytical procedure applied a full metals scan by ICP-MS quantification. The LDL specified for Arsenic was 0.1 µg/L (of impinger solution) and for the remaining compounds the LDL values were between 0.1 µg/L to 2.0 mg/L. **Table 2** summarized the inorganic components LDL values in the impinger solution and the LDL when converted to an emission factor. The later varies by source specifics and the nominal values shown are based on average volumes of gas sampled.

Table 2: Summary of the inorganic components LDL values.

Component	LDL	LDL for Emission Factor
	µg/L	kg/GJ (Fuel)
Aluminum	3	2.10E-06
Antimony	0.05	3.50E-08
Arsenic	0.1	6.99E-08
Barium	0.1	6.99E-08
Beryllium	0.1	6.99E-08
Bismuth	0.1	6.99E-08
Boron	0.8	5.59E-07
Cadmium	0.01	6.99E-09
Calcium	100	6.99E-05
Chlorine	300	2.10E-04
Chromium	0.3	2.10E-07
Cobalt	0.1	6.99E-08
Copper	0.1	6.99E-08
Iron	4	2.80E-06
Lead	0.1	6.99E-08
Lithium	0.2	1.40E-07
Magnesium	10	6.99E-06

Table 2: Summary of the inorganic components LDL values.		
Component	**LDL**	**LDL for Emission Factor**
	µg/L	**kg/GJ (Fuel)**
Manganese	0.1	6.99E-08
Mercury	0.05	3.50E-08
Molybdenum	0.1	6.99E-08
Nickel	0.1	6.99E-08
Phosphorus	5	3.50E-06
Potassium	20	1.40E-05
Selenium	0.3	2.10E-07
Silicon	0.8	5.59E-07
Silver	0.01	6.99E-09
Sodium	20	1.40E-05
Strontium	0.1	6.99E-08
Sulphur	2000	1.40E-03
Thallium	0.1	6.99E-08
Thorium	0.1	6.99E-08
Tin	0.1	6.99E-08
Titanium	0.1	6.99E-08
Uranium	0.1	6.99E-08
Vanadium	0.1	6.99E-08
Zinc	0.2	1.40E-07
Notes: The LDL Emission Factors were calculated using the following conditions: Impinger solution : 21.62 ± 0.81 ml, STP Gas volume: 0.018 ± 0.0011m^3, Estimated Dry Flue Gas Flow rate: 21.84 ± 13.84 m^3/h, Dry Fuel Gas: 1.00 m^3/h, and High Heating Value: 37.51 ± 1.85 GJ/ (m^3fuel).		

3.2.2 ORGANICS PROTOCOL

The organic compound analytical work included the quantification of acrolein and numerous other organic compounds. The organic components LDL are shown in, **Table 9** of Appendix A. The analytical procedure used RSC/VOC/C1C4/Inert scans.

- RSC scans identified and quantifies reduced sulphur compounds by GC
- VOC scans identified volatile organic compounds with by GC/MS
- C1C4 scans identified and quantified C1 to C4 hydrocarbons by GS/MS
- Inerts scan identified and quantified all inert gases by GC

3.2.3 RAW ANALYTICAL DATA PROCESSING

All fuel gas results reported by AI were corrected for potential air in leakage by subtracting out the appropriate quantities of nitrogen and oxygen in order to make the oxygen content of the final analytical result equal to zero. Flue gas samples were reviewed and where independent flue gas oxygen content was available, appropriate corrections were applied.

Table 3 compares the typical fuel gas composition provided by the facility operators at each location and the fuel gases results reported by AI (after appropriate corrections were applied) based on samples collected at the device indicated. The gases analysis reported by AI after appropriate corrections agreed reasonably well with the typical analysis provided by operators at different sources. However, differences were noted between typical results and the AI results and between AI results for more than one fuel gas sample taken at the same facility.

The methane content in the Location 7, a conventional oil production site was determined to be 66 mole percent considerably lower than all other locations. Location 6 also exhibited a relatively low methane concentration. For the remaining locations methane concentrations were greater than 90 mole percent.

Table 3: Comparison typical fuel gas analysis and extended gases analysis for samples at specific device locations.								
	Sources	**Methane mole%**	**Ethane mole%**	**Propane mole%**	**Butane mole%**	**Carbon Dioxide mole%**	**Nitrogen mole%**	**Total[3] mole%**
Location 1	Typical Gas analysis[1]	96.23	0.26	0.03	0.00	0.11	3.25	99.88
	Reciprocating Engine[2]	95.29	0.27	0.03	0.00	0.23	4.18	100.00
	Reboiler[2]	95.39	0.27	0.03	0.00	0.24	4.07	100.00
Location 2	Typical Gas analysis[1]	93.76	0.45	0.20	0.12	1.11	3.91	99.55
	Reciprocating Engine[2]	93.78	0.78	0.27	0.09	0.94	3.82	99.67
	Reboiler[2]	93.76	0.74	0.21	0.06	1.20	3.79	99.75
Location 3	Typical Gas analysis[1]	93.43	0.34	0.05	0.01	0.08	5.87	99.78
	Reciprocating Engine[2]	92.38	0.44	0.06	0.01	0.08	7.02	99.98
	Reboiler[2]	93.71	0.44	0.06	0.01	0.06	5.70	99.98
Location 4	Typical Gas analysis for Steam Generator[1]	92.98	1.81	0.66	0.31	1.77	1.06	98.59
	Steam Generator[2]	93.03	3.20	0.99	0.31	1.71	0.15	99.38
	Typical Gas analysis for Treater[1]	94.86	2.22	0.68	0.14	0.97	0.90	99.77
	Treater[2]	93.46	3.72	1.14	0.21	0.85	0.30	99.68
Location 5	Typical Gas analysis[1]	95.01	0.60	0.20	0.03	3.59	0.35	99.78
	Tank Heater[2]	94.16	0.72	0.00	0.04	4.60	0.21	99.73
	Pump Engine[2]	95.25	0.72	0.24	0.04	3.20	0.28	99.73
Location 6	Typical Gas analysis[1]	87.82	5.43	2.12	0.60	0.01	3.41	99.39
	Steam Boiler[2]	88.44	5.88	2.15	0.53	0.00	2.30	99.30
Location 7	Typical Gas analysis[1]	66.25	7.89	4.50	1.53	13.83	3.03	97.03
	Treater[2]	68.71	9.16	0.00	1.71	16.21	0.81	96.61
	Reciprocating Engine[2]	66.28	8.84	4.90	1.65	15.63	0.19	97.50
Note:	[1] Typical Gas analysis provided by operator and included: argon, hydrogen, helium, nitrogen, oxygen, carbon dioxide, hydrogen sulphide, methane, ethane, propane, butane, iso-butane, pentane, iso-pentane, hexane, heptane, octane, nonane. [2] Extended gas analysis obtained by sampling fuel at location of device indicated. [3] The sum of top 6 components in fuel.							

3.3 EMISSION FACTOR DEVELOPMENT

For all simple combustion processes, a material balance methodology was applied to develop emission factors based on energy input. This methodology was applied to all sources except the tail gas incinerator. Through the material balance methodology, the flue gas emission was explicitly linked to the fuel gas input and emission factors were determined for all organic and inorganic contaminants. These were expressed in terms of mass emission per unit of higher heating value energy input.

The tail gas incinerator is a complex combustion process as it includes additional input streams other than fuel gas and combustion air. Tail gas incinerator input streams include one or more waste gas streams and, in some cases, process generated waste gas or flash gas that is used as fuel in the incinerator. The tail gas contains combustible compounds as well as oxygen, nitrogen and carbon dioxide. A material balance would require relative or actual flow rates of all input streams and stream analyses. Although preparations were made to meet these requirements, a tail gas incinerator was not sampled and no calculations were performed for tail gas incinerator.

3.3.1 SIMPLE COMBUSTION PROCESS MATERIAL BALANCE

A simple combustion process was defined as one where the only input streams were fuel gas and combustion air and the only output was a single flue gas stream. For this process a material balance calculation was completed for all organic compounds identified in the fuel gas and the flue gas. Typically the fuel gas contained 25 to 50 compounds, some of which were present in the flue gas. Typically the flue gas contained 30 to 60 compounds, some of which were not present in the fuel gas and assumed to be manufactured in the combustion process. Air was assumed to be pure oxygen and nitrogen with no organic or metal compound contamination.

The EXCEL spreadsheet based material balance program balanced flue gas oxygen content with measured oxygen content. The material balance program allowed for partial destruction of all fuel gas compounds and the creation of new compounds measured in the flue gas. The program was manually managed though two or more iterations to produce the final material balance.

3.3.1.1 EMISSION FACTOR RESULTS

Once the balance was established, organic compound emission factors were automatically determined. Subsequently, metal substance emissions factors were determined using the material balance established from the organics data material balance.

3.3.1.2 OTHER RESULTS

Other relevant information including flue gas THC and combustion efficiency were determined by the material balance program and presented for each source assessed.

3.3.2 COMPLEX COMBUSTION PROCESS

As noted, the tail gas incinerator was considered to be a complex combustion process.

To facilitate an assessment of this type of emission source, the following supplemental field data collection is required.

- CEMS data
- Tail Gas flow and composition data from a recent sulphur plant test
- Incinerator discharge temperature
- Supplemental waste and flash gas fuel input compositions

As noted in section 2, the tail gas incinerator was not sampled due to safety issues and proposed calculations related to this source were not completed.

4 STUDY RESULTS

Although the study was focused on acrolein and arsenic, the methodology resulted in the identification and quantification of numerous other organic and metallic substances in addition to acrolein and arsenic. Acrolein and arsenic results are analyzed in some detail while the results for the other substances are simply noted as screening level results for further consideration.

4.1 ACROLEIN AND ARSENIC

Table 4 provides a summary the combustion efficiency and emission factors for acrolein and arsenic for all sources sampled. Emission factors determined for all other components observed in the flue gases for each device are presented individually for each source in the detailed results tables in Appendix A.

Of the 13 sources evaluated, only the compressor at Location 1, with a combustion efficiency of 95.6 %, exhibited acrolein in the flue gas. The determined acrolein emission factor for this source was 9.09E-5 kg/GJ. The average combustion efficiency of the other 12 sources was greater than 99.0% and none exhibited acrolein in the flue gas. The lower detection limit of acrolein, in terms of an emission factor, was determined to be 7.91E-10 kg/GJ. This corresponds to an analytical LDL of 0.2 ppbv in the flue gas. The low LDL of acrolein suggests that the result for the compressor at Location 1 was real and not just measurement noise. The potential relationship between the emission of acrolein and combustion efficiency of the compressor engine is noted as a possible reason for acrolein formation in the combustion process.

Arsenic was detected in all sources and the average emission factor for all sources tested was 4.16E-06 kg/GJ. The average LDL of arsenic, expressed in terms of emission factors, was determined to be 3.24E-08 kg/GJ. This value corresponds to 11.1 $\mu g/m^3$ in the dry flue gas. For all emission sources, the calculated emission factor was one to three orders of magnitude higher than the LDL.

Arsenic is not typically released from the materials, such as mild and stainless steel, used to manufacture the combustion devices. Therefore, the source of arsenic must originate from the combustion air or from the fuel gas or both. Based on the material balance method, theoretical arsenic concentrations in the combustion air and the fuel gas were calculated based on the air to fuel ratio (AFR) determined for each sample and the concentration of arsenic measured in the flue gas. AFR is expressed on a volume basis for these calculations. No estimates were made for the option of arsenic being present in both input streams.

The results of these calculations are presented in **Table 6**. Considering all locations and all thirteen sources sampled, the theoretical concentrations of arsenic in the combustion air were slightly more than the concentration in the dry flue gas based on the ratio of (1+AFR)/AFR. The theoretical concentrations of arsenic in the fuel gas were determined to be significantly more than in the dry flue gas by the ratio of (AFR-1)/1. The calculated average theoretical concentration of arsenic in combustion air is 18.3 µg/m^3 with a standard deviation (STDEV) of 19.5 µg/m^3 while the calculated average theoretical concentration of arsenic in fuel gas is 546.3 µg/m^3 with a STDEV of 767.6 µg/m^3.

Comparing the results, source to source at the same location, calculated theoretical arsenic concentrations in combustion air and fuel gas showed considerable variability at Locations 1 and 5. At Location 5, the reason is most probably due to a suspect low emission associated with sample line freezing associated with the Tank Heater source. At locations 2, 3, 4 and 7, the variability source to source is minor. At Location 6 only one sample was analysed. One result at Location 5 and both results at Location 7 exhibit very high arsenic concentrations relative to all other location results. Adjusting the averages, by removing the one high result and one suspect result at Location 5 and both high values at Location 7, yields average arsenic concentrations of 10.3 µg/m^3 for combustion air, and 165.1 µg/m^3 for fuel gas.

Other noteworthy observations include:

- At Location 5, the high arsenic result was associated with a screw pump engine even though the fuel gas contained 95% methane for both sources and appeared to be typical. The tank heater emission exhibited low arsenic results and this is most likely associated with sample line freezing problems experienced during source sampling.
- At Location 7, the high arsenic concentrations were associated with a fuel gas that contained about 67% methane and 9% ethane. This fuel gas composition was quite different from all others samples and appears to be characterized with higher than normal arsenic concentrations.

Table 4: Combustion efficiency and determined emission factors for acrolein and arsenic for different types of sources.							
Industry Subsector	**Source**	**Combustion Efficiency**	**Acrolein Emission Factor**	**Acrolein Emission Factor LDL**	**Arsenic Emissions Factor**	**Arsenic Emissions Factor LDL**	**Comments**
		%	**kg/GJ (fuel)**	**kg/GJ (fuel)**	**kg/GJ (fuel)**	**kg/GJ (fuel)**	
Location 1 Sweet Gas Gathering system	Reciprocating Engine	95.649	9.09E-05	8.62E-10	1.70E-05	3.58E-08	White Superior; Engine Model: 8GT-825
	Reboiler	99.999	0	1.16E-09	3.32E-06	2.77E-08	Flameco Industries - FAH24-XXA2C; Serial #: 1109 82E
Location 2 Sweet Gas Gathering system	Reciprocating Engine	99.782	0	1.45E-09	8.63E-07	2.21E-08	Caterpillar; Model: G3512TAW; Serial #:4KL00571; Rated: 810 HP
	Reboiler	99.933	0	5.58E-10	2.68E-06	5.51E-08	Well-Hall Fabrication; PO #: F94P621;Work Order:94-7620/112/3;
Location 3 Sweet Gas Processing Plant	Reciprocating Engine	99.03+	0	1.15E-09	8.80E-07	2.92E-08	Waukesha; Model F3521GS1; Serial : 317511; Rate Power:738 HP
	Reboiler	99.997	0	1.15E-09	1.72E-06	2.94E-08	Rated Capacity: 429,000BTU
Location 4 Thermal Heavy Oil Production	Steam Generator	99.994	0	1.21E-09	4.38E-06	2.16E-08	COEN Canada Inc; Model 795 R; Rated Capacity: 316 MMBTU/hr
	Treater	99.960	0	6.25E-10	4.38E-06	4.11E-08	Eclipse Combustion Canada; Rated Capacity 6.25 MMBTU/hr
Location 5 Cold Heavy Oil Production	Tank Heater	99.734	0	2.74E-10	1.96E-06[1]	9.80E-08	CLM Tank & Equipment Ltd: Rated Capacity :0.5 MM BTU
	Screw Pump Engine	99.894	0	2.67E-10	5.50E-05	9.89E-08	Ford 300 Engine
Location 6 Sour Processing Plant	Steam Boiler	99.818	0	8.29E-10	2.28E-06	2.96E-08	Toronto Iron Works; Rated Steam:31750 kg/hr; Rated Capacity:29.2 E3 m3/day
Location 7 Conventional Oil Production	Treater	99.977	0	4.02E-10	3.90E-05	5.98E-08	Superior Propane; Serial # 9801665; Duty 1.4 MMBTU
	Reciprocating Engine	99.891	0	3.57E-10	4.70E-05	5.95E-08	Cameron CFA34 - 432KW; 1800 RPM; Model 12SGTB

[1] Sample line freezing problems were experienced and result was most probably affected.

Table 5: Average and standard deviation for combustion efficiency and acrolein and arsenic emission factors for equipment subcategories sampled.							
Equipment Subcategory	**Sources Sampled**	**Combustion Efficiency**		**Acrolein Emission Factor**		**Arsenic Emission Factor**	
		Average	**STDEV**	**Average**	**STDEV**	**Average**	**STDEV**
		%	**%**	**kg/GJ (fuel)**	**kg/GJ (fuel)**	**kg/GJ (fuel)**	**kg/GJ (fuel)**
Compressor	5	98.85%	0.018 %	1.82E-05	4.07E-05	3.16E-11	2.74E-11
Reboiler	3	99.98%	0.00037 %	0.0	0.0	1.50E-11	1.05E-11
Treater	2	99.97%	0.00012 %	0.0	0.0	2.62E-11	2.02E-11
Boiler/Generator	2	99.91%	0.0012 %	0.0	0.0	2.81E-11	2.33E-11
Tank Heater	1	99.73%	NA	0.0	NA	8.69E-13	NA
All Sources	13	99.51%	0.012 %	6.99E-06	2.52E-05	2.40E-11	2.10E-11

Table 6: Arsenic concentrations measured in the flue gas and calculated for combustion air and fuel gas for the 13 sources sampled.														
	Location 1		Location 2		Location 3		Location 4		Location 5		Location 6	Location 7		Ave All Sources	ST DEV
	Process Heater	Recip Engine	Process Heater	Recip Engine	Process Heater	Recip Engine	Steam Gen	Treater	Tank Heater	Pump Engine	Steam Boiler	Treater	Recip Engine		
Flue Gas, μg/m^3	10.6	40.3	4.2	3.5	5.6	2.6	17.4	9.0	1.5	42.5	6.6	47.6	57.4	19.2	20.1
Combustion Air, μg/m^3	9.7	37.8	4.0	3.2	5.1	2.4	15.8	8.6	1.5	41.7	6.2	46.1	55.7	18.3	19.5
Fuel Gas, μg/m^3	129.9	646.1	101.6	34.9	66.4	33.2	190.7	182.5	72.7	2077.1	100.1	1521.0	1945.8	546.3	767.6

[1] Sample line freezing most likely affected the results for this source.

[2] Removal of Location 5 Tank Heater and Pump Engine, and Location 7 Treater and Recip Compressor results in significantly reduced concentrations for :

- Dry Flue Gas: Average = 11.1 μg/m^3; STDEV = 11.9 μg/m^3
- Combustion Air: Average = 10.3 μg/m^3; STDEV = 11.1 μg/m^3
- Fuel Gas: = Average 165.1 μg/m^3; STDEV = 189.0 μg/m^3.

4.2 OTHER SUBSTANCES

Numerous other organic and metallic substances were identified and quantified. For each case, the emission factor was determined.

4.2.1 OTHER ORGANIC SUBSTANCES

A total of 184 of organic and inert substances were identified during the analytical work and, in general, were source specific in terms of the number identified. Many were common to all sources and a few were noted in only one or two sources.

Table 7 summarized the frequency of occurrence for those substances with a ratio measured to LDL emission factor greater than 1000. Although methane only occurred at concentrations greater than 1000 times LDL with a frequency slightly greater than 50% (7 of 13 sources), it was present at lower concentrations in all sources.

No attempt was made to explain the reason for a compounds presence at a specific source type. Measured and LDL emission factors and the ratio for all substances for each source sampled are tabulated in **Table 43** of Appendix A.

Table 7: Frequency of occurrence for compounds where the measured to LDL emission factor ratio is greater than 1000.

Component	CAS Number	Frequency in 13 Sources	Maximum Value of the Ratio	Emission Factor LDL, kg/(GJ fuel)
Methane	74-82-8	7	133,580	5.82E-06
2-Methylpentane	107-83-5	2	94,197	6.35E-08
Pentane	109-66-0	2	70,230	5.32E-08
Nonane	111-84-2	1	57,772	9.46E-08
3-Methylpentane	96-14-0	2	47,099	6.35E-08
Heptane	142-82-5	1	36,230	7.39E-08
Hexane	110-54-3	2	28,984	6.35E-08
Cyclopentane	287-92-3	1	24,525	5.17E-08
Decane	124-18-5	1	21,795	1.05E-07
Methylcyclopentane	96-37-7	1	16,749	6.21E-08
Undecane	1120-21-4	1	10,898	1.15E-07
Octane	111-65-9	1	7,539	8.42E-08
Methylcyclohexane	108-87-2	1	6,103	4.42E-04
Isopentane	78-78-4	1	5,464	5.32E-08
Cyclobutane, isopropyl-	872-56-0	1	4,372	2.41E-06
Cyclopentane, 1,3-dimethyl-	2453-00-1	1	3,129	2.41E-06
Cyclohexane, 1,3-dimethyl-, cis-	638-04-0	1	2,641	2.76E-06
Methane, nitro-	75-52-5	1	2,248	4.51E-08
Butane	106-97-8	1	2,013	5.82E-06
Cyclopentane, ethyl-	1640-89-7	1	1,769	2.41E-06

Table 7: Frequency of occurrence for compounds where the measured to LDL emission factor ratio is greater than 1000.				
Component	**CAS Number**	**Frequency in 13 Sources**	**Maximum Value of the Ratio**	**Emission Factor LDL, kg/(GJ fuel)**
Phthalic anhydride	85-44-9	1	1,723	1.09E-07
Cyclopentane, 1,2,4-trimethyl-	2815-58-9	1	1,651	2.76E-06
Dodecane	112-40-3	2	1,597	1.26E-07
Cyclopentane, 1,1-dimethyl-	1638-26-2	1	1,380	2.41E-06
Camphor	76-22-2	1	1,182	3.74E-06
Benzene, 1,3,5-trimethyl-	108-67-8	1	1,171	2.96E-06
Cyclohexane, 1,2-dimethyl-, trans-	6876-23-9	1	1,103	2.76E-06
Notes: The LDL Emission factor is calculated based on the following conditions: Estimated Dry Flue Gas Flow rate: 21.84 ± 13.84 m^3/h and High Heating Value: 37.51 ± 1.85 GJ/ (m^3fuel)				

4.2.2 OTHER METAL SUBSTANCES

Metallic substances were identified and quantified for each source based on a specific suite of 36 substances. Thus, emission factors for all inorganic substances are presented for all sources. The detailed results are presented in Appendix A. All metallic substance emission factors were determined to be very small and within one or two orders of magnitude of the lower detection limit. In addition, it is noted that the metallic substances are reported as if they were pure metal substances but in most cases these emissions would be tied up as one or more salts of the noted substance.

4.3 COMBUSTION EFFICIENCY

Combustion efficiency was considered to be an important indicator of performance and was determined in various ways for each source sampled. Combustion efficiency not only indicated the fuel efficiency but may be an indicator of poor substance destruction or the potential formation of unwanted substances in the flue gas emissions.

The calculation methods for the three combustion efficiencies are:

$$CE_{TOC} = \frac{(C_{inlet,nonCO2}) - (C_{outlet,nonCO2})}{(C_{inlet,nonCO2})} \; x100\% \qquad \text{(Equation 4.1)}$$

Where:

CE_{TOC} is the total organic carbon based combustion efficiency

$C_{inlet,nonCO2}$ is the TOC in the inlet fuel gas excluding carbon dioxide

$C_{outlet,nonCO2}$ is the TOC in the outlet flue gas excluding carbon dioxide

This method was used to make sure that all compounds identified in the fuel and flue gases were accounted for in the combustion efficiency calculation.

$$CE_{CH4} = \frac{(CH4_{inlet})-(CH4_{outlet})}{(CH4_{inlet})} x100\% \quad \text{(Equation 4.2)}$$

Where:

CE_{CH4}	is the total methane based combustion efficiency
$CH4_{inlet}$	is the methane in the inlet fuel gas
$CH4_{outlet}$	is the methane in the outlet flue gas

This method considered methane to be a basic indicator of combustion efficiency.

$$CE_{THC} = \frac{(C_{inlet,non\ CO2})-(THC_{outlet})}{(C_{inlet,non\ CO2})} x100\% \quad \text{(Equation 4.3)}$$

Where:

CE_{THC}	is the total hydrocarbon based combustion efficiency
$C_{inlet,nonCO2}$	is the inlet gas without carbon dioxide
THC_{outlet}	is the outlet total hydrocarbon

This method approximates the traditional use of a THC combustion analyzer to determine combustion efficiency.

These different combustion efficiencies were calculated and the results are included with the detailed organic substance results tables for each source in Appendix A. The methods used to calculate combustion efficiency do not show any large differences for any of the sources. Even for Location 1, where the combustion efficiency was only 95.65%, the difference between the three methods was very small.

5 RELEVANT PUBLISHED EMISSION FACTORS

Published emission factors for acrolein and arsenic were identified through a literature search of US EPA and European jurisdictions. The only results identified were those reported by the US EPA and published in WebFIRE.

For acrolein, emission factors are published for two categories of natural gas-fired internal combustion sources: Rich Burn 4-cycle Engines and Boilers. The emission factor determined for the compressor at Location 1 is between the two values shown in **Table 8** for Internal Combustion Engines.

Table 8: Literature values of published emission factors of acrolein.		
	Internal Combustion Engines: 4-cycle Rich Burn - Natural Gas[1]	**External Combustion Engines: Boilers < 100 MM Btu/hr Natural Gas**[2]
Emission Factor, kg/GJ (fuel)	1.13E-3 – 2.65 E-6	1.13E-03
[1] US EPA 2000b. [2] US EPA 2000a.		

For arsenic, the only emission factor identified was for combustion boilers used in the power generation sector and the details are presented in **Table 9**. The average arsenic emission factor determined for the sampled sources was 4.16E-06 kg/GJ and this value is 1 order of magnitude less than the published value reported for external combustion boilers.

Table 9: Literature value of published emission factor for arsenic.	
	Electric Generation[1]**/External Combustion Boilers**[2, 3]
Emission Factor, kg/GJ (fuel)	8.60E-05
[1] Tangentially Fired Units and Boilers = 0 - 100 Million Btu/hr except Tangential [2] 10-100 and >100 Million Btu/hr [3] US EPA 1998.	

Alberta ambient air quality objectives for arsenic were published in 2005 as noted in **Table 10**. In addition, ambient air concentrations of arsenic were reported for the Edmonton Central AQM station. The observed concentrations were well below the AAAQO values. Ambien air concentrations reported by others for remote, rural and urban areas are noted in **Table 10**. These values appear to be comparable to the values reported for Edmonton Central. As noted in **Table 11**, theoretical values calculated for combustion air at the seven locations sampled appear to be significantly higher that AAAQO or observed values in Alberta.

In addition, research results for organic arsenic in a number of natural gas samples from wells in several unspecified gas fields in USA are included in **Table 10**. As noted in **Table 11**, theoretical values calculated for fuel gas at the seven locations sampled appear to be in line with concentrations observed in natural gas samples at locations in USA.

Table 10: Arsenic concentrations reported in selected literature for ambient air and natural gas.

	μg/m³	μg/m³
Alberta Ambient Air Quality Objective[1]	1-hour Average	Annual Average
	0.1	0.01
Edmonton Central AQM Station[1]	Range for period of 1993-2003	
	Low	High
	0.03E-03	4.48E-03
	Average	1.02E-3
Ambient Air[2]	Low	High
Rural area	1.00E-03	1.00E-02
Non-contaminated urban areas	3.00E-03	3.00E-02
Ambient Air[3]		
Remote areas	0.007E-03	1.9E-03
Rural area	1E-03	28E-03
Urban areas	2E-03	2320E-03
Natural Gas[4]	Range	
Numerous US field samples of natural gas	10	63000

[1] Alberta Environment 2005.
[2] WHO 2000.
[3] Schroeder et al (1987) in UK Environment Agency 2008.
[4] Irgolic et al 1991.

Table 11: Comparison of theoretical values calculated for arsenic in combustion air and fuel gas with values reported in selected literature.

	μg/m³	μg/m³
Alberta Ambient Air Quality Objective[1]	1-hour Average	Annual Average
	0.1	0.01
Edmonton Central AQM Station[1] (Range for period of 1993-2003)	Low	High
	0.03E-03	4.48E-03
Combustion Air (Table 6) (Theoretical)		
Range	1.5	55.82
Average	18.3	
Natural Gas[2]	Range	

Table 11: Comparison of theoretical values calculated for arsenic in combustion air and fuel gas with values reported in selected literature.		
	μg/m[3]	**μg/m[3]**
Numerous US field samples of natural gas; Range	10	63000
Fuel Gas (Table 6) (Theoretical) Range	33.2	2077.1
Fuel Gas (Table 6) (Theoretical) Average	546.3	
[1] Alberta Environment 2005. [2] Irgolic et al 1991.		

6 CONCLUSIONS AND RECOMMENDATIONS

A measurement campaign was conducted that included thirteen samples from six different combustion source types at seven different locations in Alberta. The intended use of the field data collected was to determine the emission factors of acrolein and arsenic. The final outcome was to provide updated and credible emission factor values pertinent to the UOG industry considering:

1. a range of fossil fuel and waste gas combustion sources,
2. a range of waste gas and fossil fuel gas qualities, and
3. a range of geographical locations.

Acrolein was detected in one compressor engine emission which had a combustion efficiency of 96%. The emission factor was comparable to the values reported in literature. All other sources, including those of the same type with combustion efficiencies greater than 99.0%, did not exhibit any acrolein emissions.

The fact that acrolein was detected at one source with relatively low combustion efficiency, and not at any others locations, suggests a possible link between combustion efficiency and acrolein formation in the combustion process. It is recommended that this potential link by investigated with additional testing. The following test program is recommended.

- Check the combustion efficiency of the compressor engine at Location 1 and, if it is observed to be about the same (96%), repeat testing of the compressor engine without any changes to the engine.
- Tune the engine to a combustion efficiency of at least 99% and repeat the emission test.
- Consider including in the test program one or more another engines operating with an abnormally low combustion efficiency.

Arsenic was detected in all thirteen samples at levels equal to approximately two orders of magnitude above the lower detection limit. Of noteworthy significance is the fact that the arsenic emission factors developed from this study are five orders of magnitude lower than the value reported in the literature for a gas-fired combustion source.

Although arsenic was present in the flue gas associated with all combustion devices sampled, arsenic cannot be created through the combustion process. Organic and non-organic arsenic may be present in the fuel gas or in the combustion air. Therefore, the potential source of the arsenic detected in the flue gas was examined. The theoretical concentrations of arsenic in either the combustion air or in the fuel gas were calculated based on the concentrations of arsenic measured in the flue gas. The results of these calculations indicated that combustion air can be excluded as the potential source of arsenic based on the high calculated theoretical concentrations of arsenic required in the combustion air. The theoretical concentrations are considerably higher than those observed in Edmonton and higher than the AAAQO, and are not likely to be present in rural Alberta air. Conversely, fuel gas was determined to be the most likely source of arsenic as the calculated theoretical concentrations of arsenic in the fuel gas were well within the lower end of the range observed in natural gas wells located in the USA.

It is recommended that consideration be given to quantifying arsenic in Canadian natural gas fields, in plant fuel systems and sales gas delivery networks. A study of this type would provide a baseline for raw gas and address concentration changes as the gas is processed and delivered for consumption.

Emission factors of other organic and inorganic substances identified and quantified in either the fuel gas or flue gas are reported and included in Appendix A. These results were not assessed regarding their potential source, association with source type, relationship to combustion efficiency or any other potential reasons for their presence in the flue gas.

7 REFERENCES

Alberta Environment 2005. Alberta Ambient Air Quality Objectives: Arsenic, Effective May 1, 2005. http://environment.alberta.ca/01025.html

UK Environment Agency 2008. A review of the toxicity of arsenic in air, Science Report – SC020104/SR4, May 2008. http://cdn.environment-agency.gov.uk/scho0508bodr-e-e.pdf

Irgolic et al 1991. Determination of arsenic and arsenic compounds in natural gas samples. Irgolic, K. J., Llger, D., Zingaro, R. A., Spall, D. and Puri, B. K. Appl. Organometal. Chem., 5: 117–124 (1991). doi: 10.1002/aoc.590050209.

US EPA 1998. Section 1.4, Natural Gas Combustion. In: Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, AP-42, Supplement D. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. Research Triangle Park, North Carolina.

US EPA 2000a. Section 3.1, Stationary Gas Turbines for Electricity Generation. In: Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, AP-42. U.S. Environmental Protection Agency.

US EPA 2000b. Section 3.2, Natural Gas-fired Reciprocating Engines. In: Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources, Fifth Edition, AP-42. U.S. Environmental Protection Agency.

WHO 2000. Air Quality Guidelines for Europe: Second Edition (WHO Regional Publications, European Series, No 91) Copenhagen, Denmark, World Health Organization, Regional Office for Europe. http://www.euro.who.int/__data/assets/pdf_file/0014/123071/AQG2ndEd_6_1_Arsenic.PDF

8 APPENDIX A - DETAILED SAMPLE RESULTS

Table 12: Summary of organic compound analytical and emission factor LDL values.

Component	MW	LDL	LDL Emission Factor
		$\mu g/m^3$	kg/ GJ (Fuel)
1,2,3-Trimethylbenzene	120	5.08	2.96E-06
1,2,4-Trimethylbenzene	120	100	5.82E-05
1,2,4-Trimethylcyclopentane	86	3.64	2.12E-06
1,2-Propadiene	40	1.69	9.85E-07
1,3,5-Trimethylbenzene	120	100	5.82E-05
1,3-Butadiyne	50	2.11	1.23E-06
1,3-Hexadiene, 3-ethyl-2-methyl-, (Z)-	124	5.24	3.05E-06
1,3-Pentadiene, (Z)-	68	2.88	1.67E-06
1,4-Pentadiene, 3,3-dimethyl-	96	4.06	2.36E-06
1-Buten-3-yne	52	2.20	1.28E-06
1-Butene	56	118	6.90E-05
1-Cyclohexyl-2-methyl-prop-2-en-1-one	152	6.43	3.74E-06
1-Heptene, 2-methyl-	112	0.14	8.28E-08
1-Heptene, 3-methyl-	112	0.14	8.28E-08
1-Hexene	84	3.55	2.07E-06
1H-Indene, octahydro-, trans-	124	0.16	9.16E-08
1-Methyl-2-n-hexylbenzene	86	3.64	2.12E-06
1-Pentene	70	0.09	5.17E-08
1-Pentene, 3-methyl-	84	0.11	6.21E-08
1-trans-2-cis-3-trans-trimethylcyclopent	84	3.55	2.07E-06
2,2,4-Trimethylpentane	114	0.14	8.42E-08
2,2-Dimethylbutane	86	0.11	6.35E-08
2,3,4-Trimethylpentane	114	0.14	8.42E-08
2,3-Dimethylbutane	86	0.11	6.35E-08
2,3-Dimethylpentane	100	0.13	7.39E-08
2,5-dimethyl Thiophene	112	4.74	2.76E-06
2-Ethyl-3-methylcyclopentene	110	4.65	2.71E-06
2-methyl Thiophene	98	4.14	2.41E-06
2-Methylheptane	114	0.14	8.42E-08
2-Methylhexane	100	0.13	7.39E-08
2-Methylpentane	86	0.11	6.35E-08
2-Pentanone, 4-methyl-4-phenyl-	86	3.64	2.12E-06
2-Propanone	58	2.45	1.43E-06
3-CYCLOHEXYL-PROPANOL	142	6.01	3.50E-06
3-methyl Thiophene	98	4.14	2.41E-06
3-Methylheptane	114	0.14	8.42E-08
3-Methylhexane	100	0.13	7.39E-08
3-Methylpentane	86	0.11	6.35E-08
4-Nonene, 3-methyl-, (Z)-	140	0.18	1.03E-07
Acetaldehyde	44	0.37	2.17E-07
Acetic Acid	60	2.54	1.48E-06

Table 12: Summary of organic compound analytical and emission factor LDL values.			
Component	**MW**	**LDL**	**LDL Emission Factor**
		μg/m^3	**kg/ GJ (Fuel)**
Acetone	58	0.49	2.86E-07
Acrolein	56	0.47	2.76E-07
Allyl sulphide	114	4.82	2.81E-06
Benzene	78	100	5.82E-05
Benzene, (1-methyl-1-propenyl)-, (Z)- (C	132	5.58	3.25E-06
Benzene, 1,2,3,4-tetramethyl-	134	5.67	3.30E-06
Benzene, 1,2,3,5-tetramethyl-	134	5.67	3.30E-06
Benzene, 1-ethyl-2,3-dimethyl-	134	5.67	3.30E-06
Benzene, 1-methyl-2-(1-methylethyl)- (CA	134	5.67	3.30E-06
Benzene, 1-methyl-2-(phenylmethyl)-	84	3.55	2.07E-06
Benzene, 1-methyl-2-propyl-	134	5.67	3.30E-06
Bicyclo[3.3.1]nonane	124	0.16	9.16E-08
Bicyclo[4.1.0]heptane, 3-methyl-	110	4.65	2.71E-06
Butane	58	10	5.82E-06
Butane, 2-methyl-	72	3.05	1.77E-06
Butyl mercaptan	98	4.14	2.41E-06
Carbon dioxide	44	1000000	5.80E-01
Carbon disulfide	76	3.21	1.87E-06
Carbon disulphide	76	3.21	1.87E-06
Carbonyl sulphide	60	2.54	1.48E-06
Chlorobenzene-d5	112	4.74	2.76E-06
cis-2-Butene	56	118	6.90E-05
CYCLOBUTANE, ISOPROPYL-	98	4.14	2.41E-06
Cyclobutanone, 3-ethyl-	98	0.12	7.24E-08
Cycloheptane	98	0.12	7.24E-08
Cyclohexane	84	0.11	6.21E-08
Cyclohexane, 1,1,3-trimethyl-	126	5.33	3.10E-06
Cyclohexane, 1,1-dimethyl-	84	4.74	2.76E-06
Cyclohexane, 1,2,4-trimethyl-, (1.alpha.	126	0.16	9.31E-08
Cyclohexane, 1,2-diethyl-3-methyl-	154	6.51	3.79E-06
Cyclohexane, 1,2-dimethyl-, cis-	112	4.74	2.76E-06
Cyclohexane, 1,2-dimethyl-, trans-	112	4.74	2.76E-06
Cyclohexane, 1,3,5-trimethyl-	126	0.16	9.31E-08
Cyclohexane, 1,3-dimethyl-, cis-	112	4.74	2.76E-06
Cyclohexane, 1,3-dimethyl-, trans-	112	4.74	2.76E-06
Cyclohexane, 1,4-dimethyl-	112	4.74	2.76E-06
Cyclohexane, ethyl-	112	4.74	2.76E-06
Cyclohexanone, 2-(2-methylpropylidene)-	152	6.43	3.74E-06
Cyclopentane	70	0.09	5.17E-08
Cyclopentane, 1,1-dimethyl-	98	4.14	2.41E-06
Cyclopentane, 1,2,3-trimethyl-, (1.alpha	112	0.14	8.28E-08
Cyclopentane, 1,2,4-trimethyl-	112	4.74	2.76E-06
Cyclopentane, 1,2-dimethyl-, cis-	98	0.12	7.24E-08

Table 12: Summary of organic compound analytical and emission factor LDL values.			
Component	MW	LDL	LDL Emission Factor
		μg/m^3	kg/ GJ (Fuel)
Cyclopentane, 1,3-dimethyl-	98	4.14	2.41E-06
Cyclopentane, 1-ethyl-3-methyl-	112	4.74	2.76E-06
Cyclopentane, 1-ethyl-3-methyl-, trans-	112	0.14	8.28E-08
Cyclopentane, ethyl-	98	4.14	2.41E-06
Cyclopentanol	86	3.64	2.12E-06
Cyclopentene-3-carboxylic acid, 1-(trime	214	9.05	5.27E-06
Cyclopropane, 1-methyl-1-isopropenyl-	96	4.06	2.36E-06
Cyclopropane, ethyl-	70	0.09	5.17E-08
Cyclotrisiloxane, hexamethyl-	100	4.23	2.46E-06
Decane	142	0.18	1.05E-07
Dimethyl disulphide	94	3.98	2.32E-06
Dimethyl sulphide	62	2.62	1.53E-06
Dimethyl trisulphide	126	5.33	3.10E-06
Dodecane	170	0.22	1.26E-07
Dodecane, 4,6-dimethyl-	98	4.14	2.41E-06
Dodecane, 4-methyl-	184	0.23	1.36E-07
Endo-tricyclo[5.2.1.0(2.6)]decane	136	5.75	3.35E-06
Ethane	30	10	5.82E-06
Ethyl benzene	106	100	5.82E-05
Ethyl mercaptan	62	2.62	1.53E-06
Ethyl sulphide	90	3.81	2.22E-06
Ethylene	28	10	5.82E-06
Ethyne, dichloro-	94	0.12	6.95E-08
Formaldehyde	30	2.54	1.48E-06
Formic acid	46	1.95	1.13E-06
Furan, 2,3-dihydro-	70	0.09	5.17E-08
Heptane	100	0.13	7.39E-08
Heptane, 2,3-dimethyl-	128	5.41	3.15E-06
Heptane, 2,6-dimethyl-	128	5.41	3.15E-06
Heptane, 3-ethyl-2-methyl-	114	4.82	2.81E-06
HEXA-4,5-DIENE CARBOXYLIC ACID	112	4.74	2.76E-06
Hexanal	100	4.23	2.46E-06
Hexane	86	0.11	6.35E-08
Hexane, 2,3-dimethyl-	92	3.89	2.27E-06
Hexane, 2,4-dimethyl-	114	4.82	2.81E-06
Hexane, 2,5-dimethyl-	114	4.82	2.81E-06
Hydrogen sulphide	34	1.44	8.37E-07
Isobutane	58	10	5.82E-06
Isobutyl mercaptan	90	3.81	2.22E-06
Isobutylene	56	118	6.90E-05
Isopentane	72	0.091	5.32E-08
Isopropyl mercaptan	76	3.21	1.87E-06
Isopropylbenzene	120	100	5.82E-05

Table 12: Summary of organic compound analytical and emission factor LDL values.			
Component	MW	LDL	LDL Emission Factor
		μg/m^3	kg/ GJ (Fuel)
m,p-Xylene	106	100	5.82E-05
m-Diethylbenzene	134	5.67	3.30E-06
Methane	16	10	5.82E-06
Methane, nitro-	61	0.07	4.51E-08
Methyl Alcohol	32	1.35	7.88E-07
Methyl ethyl disulfide	108	4.57	2.66E-06
Methyl mercaptan	48	2.03	1.18E-06
Methylcyclohexane	98	0.12	7.24E-08
Methylcyclopentane	84	0.11	6.21E-08
Methylene chloride	84	2000	1.16E-03
m-Ethyltoluene	120	5.08	2.96E-06
Naphthalene, 2,6-dimethyl-	112	4.74	2.76E-06
Naphthalene, 2-methyl-	142	6.01	3.50E-06
Naphthalene, decahydro-, trans-	138	5.84	3.40E-06
Nitrogen	28	6000000	3.49E+00
Nitrous acid, methyl ester	61	2.58	1.50E-06
Nonadecane	106	4.48	2.61E-06
Nonane	128	0.16	9.46E-08
Nonanol	144	6.09	3.55E-06
n-Propylbenzene	120	100	5.82E-05
Octane	114	0.14	8.42E-08
Octane, 2,6-dimethyl-	104	4.40	2.56E-06
Octane, 2-methyl-	106	4.48	2.61E-06
o-Ethyltoluene	120	5.08	2.96E-06
Oxygen	32	6000000	3.49E+00
o-Xylene	106	100	5.82E-05
Pentadecane	212	8.97	5.22E-06
Pentane	72	0.09	5.32E-08
p-Ethyltoluene	120	5.08	2.96E-06
Phthalic anhydride	148	0.19	1.09E-07
Propane	44	10	5.82E-06
Propane, 2,2-dimethyl-	72	3.05	1.77E-06
Propane, 2-methyl-	58	2.45	1.43E-06
Propene	42	0.05	3.10E-08
Propyl mercaptan	76	3.21	1.87E-06
Propylene	42	89	5.17E-05
Propylidencyclohexane	124	0.16	9.16E-08
Propyne	40	85	4.93E-05
Pyridine, 3,5-dimethyl-	107	0.14	7.91E-08
s-Dichloroethyl ether	142	6.01	3.50E-06
Silane, chlorotrimethyl-	108	4.57	2.66E-06
Styrene	104	100	5.82E-05
Sulfur dioxide	64	0.08	4.73E-08

Table 12: Summary of organic compound analytical and emission factor LDL values.			
Component	**MW**	**LDL**	**LDL Emission Factor**
		µg/m^3	**kg/ GJ (Fuel)**
tert-Butyl mercaptan	90	3.81	2.22E-06
tert-Pentyl mercaptan	104	0.13	7.68E-08
Tetradecane	198	8.37	4.88E-06
Tetrahydro thiophene	88	0.11	6.50E-08
Thiophene	84	3.55	2.07E-06
Toluene	92	100	5.82E-05
trans-2-Butene	56	118	6.90E-05
trans-4-Decene	140	0.18	1.03E-07
Tridecane	184	0.23	1.36E-07
Undecane	156	0.20	1.15E-07
Undecane, 2-methyl-	170	0.22	1.26E-07
Undecane, 3-methyl-	170	0.22	1.26E-07
Undecane, 4,6-dimethyl-	184	7.78	4.53E-06
Undecane, 5-methyl-	170	0.22	1.26E-07
The LDL Emission Factors were calculated using the following conditions: Estimated Dry Flue Gas Flow rate: 21.84 ± 13.84 m^3/h and High Heating Value: 37.51 ± 1.85 GJ/ (m^3 fuel)			

Table 13: Laboratory results and material balance determined emission factors and combustion efficiency for Location 1 – Sweet Gas Gathering System (Foothills Region) – Reciprocating Engine.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**(ppmv)**	**(µg/m^3)**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Methane	6.23E+08	16	9.53E+01	9.53E+01	2.73E+03	1.85E+06	2.81E+07	7.78E+05	7.78E-01	9.53E-01	4.15E-02
Ethyl benzene	6.00E+00	106	1.30E-07	1.30E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.07E-08	0.00E+00
Butane	6.82E+04	58	2.88E-03	2.88E-03	1.43E-01	3.50E+02	5.32E+03	1.47E+02	1.50E-04	1.15E-04	8.67E-06
1-Butene	0.00E+00	56	0.00E+00	0.00E+00	6.11E-02	1.45E+02	2.20E+03	6.10E+01	6.10E-05	0.00E+00	3.72E-06
Acrolein	0.00E+00	56	0.00E+00	0.00E+00	9.12E-02	2.16E+02	3.29E+03	9.10E+01	9.10E-05	0.00E+00	4.16E-06
Heptane, 2,6-dimethyl-	3.00E+01	128	5.70E-07	5.70E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.11E-08	0.00E+00
2-Methylpentane	6.72E+03	86	1.90E-04	1.90E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-05	0.00E+00
m,p-Xylene	1.40E+01	106	3.30E-07	3.30E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-08	0.00E+00
Methylcyclohexane	1.69E+03	98	4.20E-05	4.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.95E-06	0.00E+00
Toluene	1.30E+01	92	3.50E-07	3.50E-07	3.21E-03	1.30E+01	1.90E+02	5.00E+00	5.30E-06	2.48E-08	3.42E-07
Pentane	1.67E+04	72	5.70E-04	5.70E-04	4.05E-02	1.23E+02	1.88E+03	5.20E+01	5.20E-05	2.84E-05	3.08E-06
1-Pentene	0.00E+00	70	0.00E+00	0.00E+00	9.13E-03	2.70E+01	4.11E+02	1.10E+01	1.10E-05	0.00E+00	6.94E-07
Hexane	2.71E+03	86	7.70E-05	7.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.62E-06	0.00E+00
Cyclohexane	4.92E+02	84	1.40E-05	1.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.60E-07	0.00E+00
Nonane	1.60E+01	128	3.00E-07	3.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.74E-08	0.00E+00
Undecane	6.00E+00	156	8.90E-08	8.90E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.81E-09	0.00E+00
Dodecane	1.40E+01	170	2.00E-07	2.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-08	0.00E+00
Propene	1.00E+01	42	6.00E-07	6.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.81E-08	0.00E+00
Cyclopropane, ethyl-	1.60E+01	70	5.50E-07	5.50E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.75E-08	0.00E+00
Cyclopentane, 1,2-dimethyl-, cis-	2.78E+02	98	6.90E-06	6.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.86E-07	0.00E+00
Decane	6.00E+00	142	1.10E-07	1.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-08	0.00E+00
Heptane	4.99E+02	100	1.20E-05	1.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.54E-07	0.00E+00
Cyclopentane, ethyl-	9.80E+01	98	2.50E-06	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.72E-07	0.00E+00
Cyclohexane, 1,3,5-trimethyl-	4.20E+01	126	8.10E-07	8.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.31E-08	0.00E+00
trans-4-Decene	4.30E+01	140	7.50E-07	7.50E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.52E-08	0.00E+00
Cyclohexane, 1,2-dimethyl-, cis-	2.32E+02	112	5.10E-06	5.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.06E-07	0.00E+00
Cyclohexane, 1,3-dimethyl-, trans-	6.70E+01	112	1.50E-06	1.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-07	0.00E+00
Cyclopentane, 1,3-dimethyl-	2.68E+02	98	6.70E-06	6.70E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.68E-07	0.00E+00
Cyclopentane, 1-ethyl-3-methyl-, trans-	2.60E+01	112	5.60E-07	5.60E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.47E-08	0.00E+00

Table 13: Laboratory results and material balance determined emission factors and combustion efficiency for Location 1 – Sweet Gas Gathering System (Foothills Region) – Reciprocating Engine.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**(ppmv)**	**(µg/m^3)**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Bicyclo[3.3.1]nonane	6.60E+01	124	1.30E-06	1.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-07	0.00E+00
Cyclopentane, 1,2,4-trimethyl-	2.02E+02	112	4.40E-06	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.53E-07	0.00E+00
Cyclopentane	1.77E+03	70	6.20E-05	6.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.09E-06	0.00E+00
Cycloheptane	6.76E+02	98	1.70E-05	1.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-06	0.00E+00
Cyclohexane, 1,1,3-trimethyl-	3.82E+02	126	7.40E-06	7.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.68E-07	0.00E+00
Cyclopentane, 1-ethyl-3-methyl-	3.70E+01	112	8.10E-07	8.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.48E-08	0.00E+00
Carbonyl sulphide	0.00E+00	60	0.00E+00	0.00E+00	1.06E-02	2.70E+01	4.10E+02	1.10E+01	1.10E-05	0.00E+00	1.61E-07
Propane, 2,2-dimethyl-	2.99E+02	72	1.00E-05	1.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.08E-07	0.00E+00
Formaldehyde	0.00E+00	30	0.00E+00	0.00E+00	3.06E-02	3.90E+01	5.90E+02	1.60E+01	1.60E-05	0.00E+00	4.65E-07
2,3-Dimethylpentane	5.40E+02	100	1.30E-05	1.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.25E-07	0.00E+00
2,3,4-Trimethylpentane	5.90E+01	114	1.30E-06	1.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.01E-07	0.00E+00
3-Methylhexane	5.24E+02	100	1.30E-05	1.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.97E-07	0.00E+00
3-Methylheptane	4.00E+01	114	8.50E-07	8.50E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.82E-08	0.00E+00
2-Methylhexane	3.26E+02	100	8.00E-06	8.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.59E-07	0.00E+00
2-Methylheptane	1.54E+02	114	3.30E-06	3.30E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-07	0.00E+00
1-Hexene	0.00E+00	84	0.00E+00	0.00E+00	4.95E-03	1.80E+01	2.68E+02	7.00E+00	7.40E-06	0.00E+00	4.52E-07
4-Nonene, 3-methyl-, (Z)-	1.08E+02	140	1.90E-06	1.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.88E-07	0.00E+00
Cyclohexane, 1,2-dimethyl-, trans-	1.66E+02	112	3.60E-06	3.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-07	0.00E+00
Benzene	2.50E+01	78	7.80E-07	7.80E-07	1.70E-02	5.60E+01	8.53E+02	2.40E+01	2.40E-05	4.69E-08	1.55E-06
Ethane	3.27E+06	30	2.66E-01	2.66E-01	8.85E+00	1.12E+04	1.71E+05	4.72E+03	4.72E-03	5.33E-03	2.69E-04
Ethylene	0.00E+00	28	0.00E+00	0.00E+00	2.85E+00	3.38E+03	5.13E+04	1.42E+03	1.42E-03	0.00E+00	8.67E-05
Propane	4.63E+05	44	2.57E-02	2.57E-02	5.90E-01	1.10E+03	1.67E+04	4.62E+02	4.60E-04	7.72E-04	2.69E-05
Ethyl mercaptan	1.70E+01	62	6.60E-07	6.60E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-08	0.00E+00
Dimethyl sulphide	3.70E+01	62	1.50E-06	1.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-08	0.00E+00
Isobutane	2.09E+04	58	8.80E-04	8.80E-04	1.08E-01	2.65E+02	4.03E+03	1.12E+02	1.10E-04	3.53E-05	6.58E-06
Methane, nitro-	0.00E+00	61	0.00E+00	0.00E+00	9.34E-02	2.41E+02	3.66E+03	1.01E+02	1.00E-04	0.00E+00	1.42E-06
2,2-Dimethylbutane	1.91E+02	86	5.40E-06	5.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.26E-07	0.00E+00
Hydrogen sulphide	1.46E+02	34	1.00E-05	1.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	3.29E+04	72	1.12E-03	1.12E-03	3.30E-02	1.01E+02	1.53E+03	4.20E+01	4.20E-05	5.59E-05	2.51E-06
2,3-Dimethylbutane	1.36E+03	86	3.90E-05	3.90E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.31E-06	0.00E+00

Table 13: Laboratory results and material balance determined emission factors and combustion efficiency for Location 1 – Sweet Gas Gathering System (Foothills Region) – Reciprocating Engine.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	(ppmv)	(µg/m^3)	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
o-Xylene	7.00E+00	106	1.60E-07	1.60E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-08	0.00E+00
1,2,4-Trimethylbenzene	3.00E+00	120	6.60E-08	6.60E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.92E-09	0.00E+00
3-Methylpentane	1.77E+03	86	5.00E-05	5.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.03E-06	0.00E+00
Methylcyclopentane	3.56E+03	84	1.00E-04	1.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.22E-06	0.00E+00
Nitrogen	1.30E+08	28	1.13E+01	4.18E+00	8.76E+05	1.04E+09	1.58E+10	4.36E+08	4.36E+02	0.00E+00	0.00E+00
Carbon dioxide	4.15E+06	44	2.31E-01	2.31E-01	4.11E+04	7.65E+07	1.16E+09	3.22E+07	3.22E+01	0.00E+00	0.00E+00
										Comb Eff =	**95.63%**
										CH4 Comb Eff =	**95.64%**
										THC Comb Eff =	**95.65%**

Table 14: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 1 - Sweet Gas Gathering System (Foothills Region) – Reciprocating Engine.							
Excess Air	84%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
			Wet Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	0.92	1.83	1.53	13	17
2226	0	**percentage, %**	5.40	11	9.01	75	100
			Dry Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	0.92		1.53	13	15
2745	0	**percentage, %**	6.05		10	84	100

Table 15: Laboratory results and material balance determined emission factors and combustion efficiency for Location 1 – wet Gas Gathering System (Foothills Region) – Process Heater.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	$\mu g/m^3$	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	$\mu g/m^3$	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	6.24E+08	16	9.54E+01	9.54E+01	1.28E+00	8.65E+02	9.79E+03	2.71E+02	2.70E-04	9.54E-01	1.45E-05
Undecane, 3-methyl-	8.20E+01	170	1.20E-06	1.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-07	0.00E+00
Ethyl benzene	6.00E+00	106	1.40E-07	1.40E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-08	0.00E+00
Butane	5.88E+04	58	2.48E-03	2.48E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.90E-05	0.00E+00
2-Methylpentane	6.44E+03	86	1.80E-04	1.80E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-05	0.00E+00
m,p-Xylene	1.40E+01	106	3.20E-07	3.20E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.50E-08	0.00E+00
Methylcyclohexane	1.70E+03	98	4.20E-05	4.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-06	0.00E+00
Toluene	1.20E+01	92	3.10E-07	3.10E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-08	0.00E+00
Pentane	1.52E+04	72	5.20E-04	5.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-05	0.00E+00
Hexane	2.78E+03	86	7.90E-05	7.90E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-06	0.00E+00
Cyclohexane	5.17E+02	84	1.50E-05	1.50E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.00E-07	0.00E+00
Nonane	1.40E+01	128	2.70E-07	2.70E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-08	0.00E+00
Undecane	6.00E+00	156	9.90E-08	9.90E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-08	0.00E+00
Dodecane	2.42E+02	170	3.50E-06	3.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.20E-07	0.00E+00
Propene	1.20E+01	42	6.90E-07	6.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.10E-08	0.00E+00
Cyclopentane, 1,2-dimethyl-, cis-	2.72E+02	98	6.80E-06	6.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-07	0.00E+00
Decane	6.00E+00	142	1.00E-07	1.00E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-08	0.00E+00
Heptane	5.28E+02	100	1.30E-05	1.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.00E-07	0.00E+00
Undecane, 5-methyl-	6.10E+01	170	8.80E-07	8.80E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-07	0.00E+00
Cyclopentane, ethyl-	1.00E+02	98	2.50E-06	2.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E-07	0.00E+00
Cyclohexane, ethyl-	6.30E+01	112	1.40E-06	1.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-07	0.00E+00
Propylidencyclohexane	5.50E+01	124	1.10E-06	1.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.70E-08	0.00E+00
Cyclohexane, 1,3-dimethyl-, trans-	6.90E+01	112	1.50E-06	1.50E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-07	0.00E+00
Cyclopentane, 1,3-dimethyl-	2.83E+02	98	7.10E-06	7.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.90E-07	0.00E+00
Cyclopentane, 1,2,4-trimethyl-	2.03E+02	112	4.40E-06	4.40E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-07	0.00E+00
Cyclopentane	1.82E+03	70	6.40E-05	6.40E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E-06	0.00E+00
Cycloheptane	6.72E+02	98	1.70E-05	1.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-06	0.00E+00
Cyclohexane, 1,1,3-trimethyl-	3.73E+02	126	7.20E-06	7.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-07	0.00E+00
1H-Indene, octahydro-, trans-	8.10E+01	124	1.60E-06	1.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.40E-07	0.00E+00
Propane, 2,2-dimethyl-	2.97E+02	72	1.00E-05	1.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.00E-07	0.00E+00
2,3-Dimethylpentane	5.40E+02	100	1.30E-05	1.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.30E-07	0.00E+00

Table 15: Laboratory results and material balance determined emission factors and combustion efficiency for Location 1 – wet Gas Gathering System (Foothills Region) – Process Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
2,3,4-Trimethylpentane	5.10E+01	114	1.10E-06	1.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.70E-08	0.00E+00
Cyclohexane, 1,2-dimethyl- (cis/trans) $	1.65E+02	112	3.60E-06	3.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-07	0.00E+00
3-Methylhexane	4.86E+02	100	1.20E-05	1.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.30E-07	0.00E+00
3-Methylheptane	3.40E+01	114	7.40E-07	7.40E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.90E-08	0.00E+00
Cyclohexane, 1,4-dimethyl-	2.32E+02	112	5.10E-06	5.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-07	0.00E+00
cis-2-Butene	2.40E+01	56	1.00E-06	1.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-08	0.00E+00
2-Methylhexane	3.33E+02	100	8.10E-06	8.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-07	0.00E+00
2-Methylheptane	1.51E+02	114	3.20E-06	3.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.60E-07	0.00E+00
Dodecane, 4-methyl-	2.18E+02	184	2.90E-06	2.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-07	0.00E+00
Tridecane	6.00E+02	184	8.00E-06	8.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-06	0.00E+00
Tetradecane	1.60E+02	198	2.00E-06	2.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E-07	0.00E+00
Acetone	0.00E+00	58	0.00E+00	0.00E+00	3.93E-03	9.64E+00	1.09E+02	3.02E+00	3.00E-06	0.00E+00	1.34E-07
Undecane, 2-methyl-	6.90E+01	170	9.90E-07	9.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-07	0.00E+00
Benzene	2.90E+01	78	9.00E-07	9.00E-07	9.80E-04	3.24E+00	3.67E+01	1.02E+00	1.00E-06	5.40E-08	6.68E-08
Ethane	3.32E+06	30	2.71E-01	2.71E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.41E-03	0.00E+00
Propane	4.70E+05	44	2.61E-02	2.61E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.80E-04	0.00E+00
Ethyl mercaptan	2.90E+01	62	1.10E-06	1.10E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-08	0.00E+00
Dimethyl sulphide	3.00E+01	62	1.20E-06	1.20E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-08	0.00E+00
Isobutane	1.74E+04	58	7.30E-04	7.30E-04	2.86E-03	7.02E+00	7.95E+01	2.20E+00	2.20E-06	2.90E-05	1.30E-07
2,2-Dimethylbutane	2.07E+02	86	5.90E-06	5.90E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.50E-07	0.00E+00
1-Pentene, 3-methyl-	3.40E+01	84	9.90E-07	9.90E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.90E-08	0.00E+00
Cyclohexane, 1,2,4-trimethyl-, (1.alpha.	4.40E+01	126	8.60E-07	8.60E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.70E-08	0.00E+00
Hydrogen sulphide	1.43E+02	34	1.00E-05	1.00E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	2.85E+04	72	9.70E-04	9.70E-04	1.05E-03	3.20E+00	3.63E+01	1.00E+00	1.00E-06	4.80E-05	5.96E-08
2,3-Dimethylbutane	1.43E+03	86	4.10E-05	4.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-06	0.00E+00
o-Xylene	6.00E+00	106	1.50E-07	1.50E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-08	0.00E+00
1,2,4-Trimethylbenzene	3.00E+00	120	5.70E-08	5.70E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-09	0.00E+00
3-Methylpentane	1.83E+03	86	5.20E-05	5.20E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-06	0.00E+00
Methylcyclopentane	3.60E+03	84	1.00E-04	1.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.30E-06	0.00E+00

Table 15: Laboratory results and material balance determined emission factors and combustion efficiency for Location 1 – wet Gas Gathering System (Foothills Region) – Process Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Nitrogen	1.29E+08	28	1.12E+01	4.07E+00	8.91E+05	1.10E+09	1.20E+10	3.30E+08	3.31E+02	0.00E+00	0.00E+00
Carbon dioxide	4.26E+06	44	2.37E-01	2.37E-01	8.55E+04	1.60E+08	1.80E+09	5.00E+07	4.98E+01	0.00E+00	0.00E+00
										Comb Eff =	**99.99%**
										CH4 Comb Eff =	**99.99%**
										THC Comb Eff =	**99.99%**

Table 16: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 1 - Sweet Gas Gathering System (Foothills Region) –Process Heater.

Excess Air	34%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	0.96	1.92	0.65	9.71	13
1.00	0	**percentage, %**	7.27	14	4.92	73	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	0.96		0.65	9.71	11
1.30	0	**percentage, %**	8.50		5.76	86	100

Table 17: Gas analysis for determine the metals emission factor in flue gas for Location 1 - Sweet Gas Gathering System (Foothills Region) – Process Heater and Reciprocating Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Aluminum	634.00	483.00	221.00	413.00	262.00	1.63E-04	1.34E-04
Antimony	0.35	0.11	0.08	0.26	0.03	1.03E-07	1.47E-08
Arsenic	28.70	53.50	20.30	8.40	33.20	3.32E-06	1.70E-05
Barium	183.00	276.00	143.00	40.00	133.00	1.58E-05	6.79E-05
Beryllium	0.01	0.02	0.01	0.00	0.01	1.07E-09	5.93E-09
Bismuth	0.03	0.02	0.00	0.02	0.02	8.18E-09	1.04E-08
Boron	548.00	673.00	286.00	262.00	387.00	1.04E-04	1.98E-04
Cadmium	0.25	11.60	0.07	0.17	11.53	6.85E-08	5.89E-06
Calcium	1,800.00	1,950.00	185.00	1,615.00	1,765.00	6.39E-04	9.02E-04
Chlorine	3,210.00	2,810.00	138.00	3,072.00	2,672.00	1.21E-03	1.36E-03
Chromium	2.88	3.35	0.53	2.35	2.82	9.29E-07	1.44E-06
Cobalt	0.26	0.33	0.00	0.25	0.33	9.94E-08	1.67E-07
Copper	36.10	105.00	4.08	32.02	100.92	1.27E-05	5.16E-05
Iron	85.50	117.00	12.00	73.50	105.00	2.91E-05	5.36E-05
Lead	2.73	12.30	0.65	2.08	11.65	8.22E-07	5.95E-06
Lithium	0.05	0.96	0.02	0.03	0.94	1.34E-08	4.79E-07
Magnesium	330.00	335.00	6.90	323.10	328.10	1.28E-04	1.68E-04
Manganese	4.43	10.90	0.36	4.07	10.54	1.61E-06	5.39E-06
Mercury	0.01	0.04	0.01	0.00	0.03	1.23E-09	1.55E-08
Molybdenum	12.90	0.28	0.03	12.87	0.26	5.09E-06	1.31E-07
Nickel	62.10	54.80	0.14	61.96	54.66	2.45E-05	2.79E-05
Phosphorus	0.80	0.80	0.80	0.00	0.00	0.00E+00	0.00E+00

Table 17: Gas analysis for determine the metals emission factor in flue gas for Location 1 - Sweet Gas Gathering System (Foothills Region) – Process Heater and Reciprocating Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Potassium	20,900.00	1,090.00	143.00	20,757.00	947.00	8.21E-03	4.84E-04
Selenium	0.10	0.10	0.10	0.00	0.00	0.00E+00	0.00E+00
Silicon	86.20	178.00	16.00	70.20	162.00	2.78E-05	8.28E-05
Silver	0.27	1.80	0.02	0.25	1.78	9.74E-08	9.10E-07
Sodium	2,010.00	3,990.00	1,360.00	650.00	2,630.00	2.57E-04	1.34E-03
Strontium	26.80	14.50	0.90	25.90	13.60	1.02E-05	6.95E-06
Sulphur	486.00	200.00	200.00	286.00	0.00	1.13E-04	0.00E+00
Thallium	0.01	0.01	0.00	0.00	0.01	7.91E-10	2.55E-09
Thorium	0.06	0.04	0.02	0.05	0.03	1.85E-08	1.38E-08
Tin	1.21	2.00	0.10	1.11	1.90	4.39E-07	9.71E-07
Titanium	1.32	2.02	0.68	0.64	1.34	2.52E-07	6.83E-07
Uranium	0.02	0.03	0.02	0.00	0.02	1.94E-09	8.94E-09
Vanadium	0.09	0.10	0.01	0.08	0.09	3.27E-08	4.62E-08
Zinc	47.40	102.00	1.26	46.14	100.74	1.82E-05	5.15E-05

Table 18: Laboratory results and material balance determined emission factors and combustion efficiency for Location 2 – Sweet Gas Processing Plant – Reciprocating Engine.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Methane	6.50E+08	16	9.94E+01	9.38E+01	2.23E+02	1.51E+05	1.35E+06	3.67E+04	3.67E-02	9.38E-01	1.99E-03
Ethyl benzene	0.00E+00	106	0.00E+00	0.00E+00	1.46E-03	7.00E+00	5.90E+01	2.00E+00	1.60E-06	0.00E+00	1.04E-07
Butane	2.21E+06	58	9.33E-02	8.80E-02	2.76E-02	6.80E+01	6.04E+02	1.60E+01	1.60E-05	3.52E-03	9.85E-07

Table 18: Laboratory results and material balance determined emission factors and combustion efficiency for Location 2 – Sweet Gas Processing Plant – Reciprocating Engine.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
1-Butene	0.00E+00	56	0.00E+00	0.00E+00	6.35E-02	1.50E+02	1.34E+03	3.70E+01	3.70E-05	0.00E+00	2.26E-06
2-Methylpentane	1.75E+05	86	4.98E-03	4.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E-04	0.00E+00
m,p-Xylene	0.00E+00	106	0.00E+00	0.00E+00	1.23E-03	6.00E+00	4.90E+01	1.00E+00	1.30E-06	0.00E+00	8.76E-08
Methylcyclohexane	4.28E+04	98	1.07E-03	1.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E-05	0.00E+00
Toluene	0.00E+00	92	0.00E+00	0.00E+00	4.12E-02	1.60E+02	1.43E+03	3.90E+01	3.90E-05	0.00E+00	2.57E-06
Pentane	4.04E+05	72	1.37E-02	1.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-04	0.00E+00
Hexane	1.78E+05	86	5.07E-03	4.79E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.90E-04	0.00E+00
Cyclohexane	4.57E+04	84	1.33E-03	1.26E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.50E-05	0.00E+00
Furan, 2,3-dihydro-	7.74E+03	70	2.70E-04	2.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-05	0.00E+00
Heptane	3.65E+04	100	8.90E-04	8.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.90E-05	0.00E+00
Cyclopentane, 1,3-dimethyl-	7.37E+03	98	1.80E-04	1.70E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.20E-05	0.00E+00
Cyclopentane	4.86E+04	70	1.70E-03	1.60E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.00E-05	0.00E+00
2,3-Dimethylpentane	5.03E+04	100	1.23E-03	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.10E-05	0.00E+00
3-Methylhexane	3.50E+04	100	8.60E-04	8.10E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.70E-05	0.00E+00
Pyridine, 3,5-dimethyl-	0.00E+00	107	0.00E+00	0.00E+00	3.18E-03	1.40E+01	1.28E+02	4.00E+00	3.50E-06	0.00E+00	1.99E-07
2-Methylhexane	1.86E+04	100	4.60E-04	4.30E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.00E-05	0.00E+00
Formic acid	0.00E+00	46	0.00E+00	0.00E+00	7.65E-03	1.50E+01	1.33E+02	4.00E+00	3.60E-06	0.00E+00	6.81E-08
Benzene	0.00E+00	78	0.00E+00	0.00E+00	3.64E-01	1.20E+03	1.07E+04	2.92E+02	2.90E-04	0.00E+00	1.95E-05
Ethane	1.01E+07	30	8.22E-01	7.76E-01	4.32E+00	5.49E+03	4.89E+04	1.33E+03	1.33E-03	1.55E-02	7.71E-05
Ethylene	0.00E+00	28	0.00E+00	0.00E+00	1.20E+01	1.42E+04	1.27E+05	3.45E+03	3.45E-03	0.00E+00	2.14E-04
Propane	5.19E+06	44	2.89E-01	2.73E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.18E-03	0.00E+00
Propyne	5.60E+05	40	3.43E-02	3.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.70E-04	0.00E+00
Isobutane	4.48E+06	58	1.89E-01	1.79E-01	3.44E-02	8.40E+01	7.52E+02	2.10E+01	2.10E-05	7.14E-03	1.23E-06
Methane, nitro-	0.00E+00	61	0.00E+00	0.00E+00	1.33E-03	3.00E+00	3.10E+01	1.00E+00	8.30E-07	0.00E+00	1.18E-08
Ethyne, dichloro-	0.00E+00	94	0.00E+00	0.00E+00	3.71E-03	1.50E+01	1.31E+02	4.00E+00	3.60E-06	0.00E+00	6.60E-08
2,2-Dimethylbutane	6.44E+04	86	1.83E-03	1.73E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-04	0.00E+00
Hydrogen sulphide	3.80E+01	34	2.70E-06	2.60E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	2.14E+06	72	7.26E-02	6.85E-02	7.39E-03	2.30E+01	2.01E+02	5.00E+00	5.50E-06	3.43E-03	3.29E-07
2,3-Dimethylbutane	1.69E+05	86	4.82E-03	4.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.70E-04	0.00E+00
Phthalic anhydride	0.00E+00	148	0.00E+00	0.00E+00	1.24E-01	7.75E+02	6.91E+03	1.88E+02	1.90E-04	0.00E+00	8.83E-06
3-Methylpentane	2.97E+05	86	8.46E-03	7.99E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.80E-04	0.00E+00

Table 18: Laboratory results and material balance determined emission factors and combustion efficiency for Location 2 – Sweet Gas Processing Plant – Reciprocating Engine.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methylcyclopentane	8.03E+04	84	2.34E-03	2.21E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.30E-04	0.00E+00
Isopropylbenzene	0.00E+00	120	0.00E+00	0.00E+00	8.84E-03	4.50E+01	4.00E+02	1.10E+01	1.10E-05	0.00E+00	7.09E-07
Nitrogen	8.64E+07	28	4.05E+00	3.82E+00	8.58E+05	1.02E+09	9.06E+09	2.47E+08	2.47E+02	0.00E+00	0.00E+00
Carbon dioxide	1.79E+07	44	9.94E-01	9.38E-01	1.10E+05	2.05E+08	1.83E+09	4.98E+07	4.98E+01	0.00E+00	0.00E+00
Combustion Efficiency =											**99.76%**
CH4 Combustion Efficiency =											**99.79%**
THC Combustion Efficiency =											**99.78%**

Table 19: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 2 - Sweet Gas Processing Plant –Reciprocating Engine.							
Excess Air	6.34%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	0.99	1.93	0.12	7.80	11
195	0	**percentage, %**	9.10	18	1.14	72	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	0.99		0.12	7.80	8.91
240	0		11		1.38	88	100

Table 20: Laboratory results and material balance determined emission factors and combustion efficiency for Location 2 – Sweet Gas Processing Plant – Process Heater.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet

Table 20: Laboratory results and material balance determined emission factors and combustion efficiency for Location 2 – Sweet Gas Processing Plant – Process Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	5.47E+08	16	8.37E+01	9.38E+01	2.77E+01	1.88E+04	4.37E+05	1.20E+04	1.20E-02	9.40E-01	6.50E-04
Butane	1.41E+06	58	5.90E-02	5.90E-02	2.10E-02	5.10E+01	1.19E+03	3.30E+01	3.27E-05	2.40E-03	1.94E-06
1-Butene	0.00E+00	56	0.00E+00	0.00E+00	4.30E-03	1.00E+01	2.36E+02	6.00E+00	6.48E-06	0.00E+00	3.99E-07
2-Methylpentane	1.35E+05	86	3.90E-03	3.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-04	0.00E+00
Methylcyclohexane	3.85E+04	98	9.60E-04	9.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.72E-05	0.00E+00
Toluene	0.00E+00	92	0.00E+00	0.00E+00	1.92E-02	7.50E+01	1.74E+03	4.80E+01	4.77E-05	0.00E+00	3.13E-06
Pentane	2.61E+05	72	8.90E-03	8.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.40E-04	0.00E+00
Hexane	1.35E+05	86	3.90E-03	3.90E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E-04	0.00E+00
Cyclohexane	3.98E+04	84	1.20E-03	1.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.96E-05	0.00E+00
Cyclopentane, 1,2-dimethyl-, cis-	9.90E+03	98	2.50E-04	2.50E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.73E-05	0.00E+00
Heptane	2.90E+04	100	7.10E-04	7.10E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.97E-05	0.00E+00
1-Heptene, 2-methyl-	0.00E+00	112	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cyclopentane	3.58E+04	70	1.30E-03	1.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.25E-05	0.00E+00
Cyclopropane, 1-methyl-1-isopropenyl-	0.00E+00	96	0.00E+00	0.00E+00	3.30E-03	1.40E+01	3.17E+02	9.00E+00	8.71E-06	0.00E+00	5.47E-07
Propane, 2,2-dimethyl-	1.15E+04	72	3.90E-04	3.90E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.95E-05	0.00E+00
2,3-Dimethylpentane	5.32E+04	100	1.30E-03	1.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.11E-05	0.00E+00
3-Methylhexane	3.34E+04	100	8.17E-04	8.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.72E-05	0.00E+00
2-Methylhexane	1.80E+04	100	4.40E-04	4.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.08E-05	0.00E+00
trans-2-Butene	3.73E+03	56	1.63E-04	1.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.51E-06	0.00E+00
Benzene	6.74E+03	78	2.10E-04	2.10E-04	4.40E-03	1.50E+01	3.40E+02	9.00E+00	9.32E-06	1.27E-05	6.17E-07
Ethane	9.07E+06	30	7.40E-01	7.40E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-02	0.00E+00
Propane	3.69E+06	44	2.10E-01	2.10E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E-03	0.00E+00
Propyne	3.97E+05	40	2.40E-02	2.40E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.30E-04	0.00E+00
Isobutane	3.26E+06	58	1.30E-01	1.40E-01	1.70E-02	4.30E+01	9.95E+02	2.70E+01	2.73E-05	5.50E-03	1.62E-06
2,2-Dimethylbutane	5.58E+04	86	1.70E-03	1.60E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.52E-05	0.00E+00
Hydrogen sulphide	2.60E+02	34	1.87E-05	1.87E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	1.37E+06	72	4.70E-02	4.70E-02	9.60E-03	2.90E+01	6.83E+02	1.90E+01	1.87E-05	2.30E-03	1.12E-06
2,3-Dimethylbutane	1.41E+05	86	4.00E-03	4.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.40E-04	0.00E+00
3-Methylpentane	2.26E+05	86	6.40E-03	6.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.80E-04	0.00E+00
Methylcyclopentane	6.84E+04	84	2.00E-03	1.90E-03	7.80E-04	3.00E+00	6.50E+01	2.00E+00	1.78E-06	1.20E-04	1.10E-07

Table 20: Laboratory results and material balance determined emission factors and combustion efficiency for Location 2 – Sweet Gas Processing Plant – Process Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Nitrogen	1.84E+08	28	1.61E+01	3.79E+00	7.96E+05	9.43E+08	2.20E+10	6.04E+08	6.03E+02	0.00E+00	0.00E+00
Carbon dioxide	2.16E+07	44	1.20E+00	1.20E+00	4.49E+04	8.36E+07	1.95E+09	5.35E+07	5.30E+01	0.00E+00	0.00E+00
										Comb Eff =	**99.99%**
										CH4 Comb Eff =	**99.99%**
										THC Comb Eff =	**99.99%**

Table 21: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 2 - Sweet Gas Processing Plant –Reciprocating Engine.

Excess Air	163.5%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
			Wet Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	0.98	1.92	3.15	19	25
23	0	**percentage, %**	3.89	7.61	13	76	100
			Dry Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	0.98		3.16	19	23
28	0	**percentage, %**	4.22		1.54	82	100

Table 22: Gas analysis for determine the metals emission factor in flue gas for Location 2 - Sweet Gas Processing Plant – Process Heater and Reciprocating Engine.

Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**

Table 22: Gas analysis for determine the metals emission factor in flue gas for Location 2 - Sweet Gas Processing Plant – Process Heater and Reciprocating Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Aluminum	274.00	209.00	143.00	131.00	66.00	1.03E-04	2.09E-05
Antimony	0.05	0.05	0.01	0.04	0.04	2.81E-08	1.18E-08
Arsenic	9.34	8.66	5.93	3.41	2.73	2.68E-06	8.63E-07
Barium	69.00	57.40	41.80	27.20	15.60	2.14E-05	4.93E-06
Beryllium	0.02	0.01	0.01	0.01	0.00	6.06E-09	1.26E-09
Bismuth	0.00	0.00	0.02	0.00	0.00	0.00E+00	0.00E+00
Boron	154.00	141.00	97.50	56.50	43.50	4.45E-05	1.37E-05
Cadmium	6.14	167.00	0.51	5.63	166.49	4.43E-06	5.26E-05
Calcium	863.00	13000.00	104.00	759.00	12896.00	5.97E-04	4.07E-03
Chlorine	100.00	146.00	100.00	0.00	46.00	0.00E+00	1.45E-05
Chromium	0.85	0.87	0.23	0.62	0.64	4.84E-07	2.02E-07
Cobalt	0.50	9.34	0.03	0.47	9.31	3.71E-07	2.94E-06
Copper	76.80	254.00	2.55	74.25	251.45	5.84E-05	7.95E-05
Iron	308.00	304.00	10.90	297.10	293.10	2.34E-04	9.26E-05
Lead	30.20	155.00	1.39	28.81	153.61	2.27E-05	4.85E-05
Lithium	0.02	0.02	0.02	0.00	0.00	0.00E+00	0.00E+00
Magnesium	81.90	131.00	5.80	76.10	125.20	5.99E-05	3.96E-05
Manganese	9.41	103.00	0.44	8.97	102.56	7.06E-06	3.24E-05
Mercury	0.01	0.02	0.01	0.00	0.01	0.00E+00	2.46E-09
Molybdenum	0.30	2.99	0.02	0.28	2.97	2.20E-07	9.38E-07
Nickel	24.30	296.00	1.02	23.28	294.98	1.83E-05	9.32E-05
Phosphorus	6.82	11.80	0.80	6.02	11.00	4.74E-06	3.48E-06
Potassium	184.00	306.00	55.80	128.20	250.20	1.01E-04	7.91E-05
Selenium	0.10	0.10	0.10	0.00	0.00	0.00E+00	0.00E+00

Table 22: Gas analysis for determine the metals emission factor in flue gas for Location 2 - Sweet Gas Processing Plant – Process Heater and Reciprocating Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Silicon	123.00	414.00	10.00	113.00	404.00	8.89E-05	1.28E-04
Silver	0.34	0.56	0.06	0.28	0.49	2.18E-07	1.56E-07
Sodium	750.00	611.00	396.00	354.00	215.00	2.79E-04	6.79E-05
Strontium	1.69	9.83	0.29	1.40	9.54	1.10E-06	3.01E-06
Sulphur	200.00	10900.00	200.00	0.00	10700.00	0.00E+00	3.38E-03
Thallium	0.00	0.02	0.00	0.00	0.02	2.60E-09	6.29E-09
Thorium	0.00	0.00	0.00	0.00	0.00	0.00E+00	2.84E-10
Tin	0.31	0.26	0.05	0.26	0.21	2.04E-07	6.59E-08
Titanium	2.99	3.80	1.65	1.34	2.15	1.05E-06	6.79E-07
Uranium	0.01	0.02	0.00	0.01	0.01	7.48E-09	4.01E-09
Vanadium	0.16	0.18	0.02	0.14	0.16	1.09E-07	4.97E-08
Zinc	85.20	1300.00	4.74	80.46	1295.26	6.33E-05	4.09E-04

Table 23: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Process Heater.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Methane	6.45E+08	16	9.90E+01	9.40E+01	1.87E+00	1.26E+03	1.39E+04	3.88E+02	3.88E-04	9.37E-01	2.05E-05
Ethyl benzene	0.00E+00	106	0.00E+00	0.00E+00	1.67E-02	7.50E+01	8.22E+02	2.30E+01	2.30E-05	0.00E+00	1.47E-06
Butane	1.83E+05	58	7.73E-03	7.34E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-04	0.00E+00
2-Methylpentane	9.26E+03	86	2.63E-04	2.50E-04	3.28E-03	1.40E+01	1.53E+02	4.00E+00	4.27E-06	1.50E-05	2.52E-07

Table 23: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Process Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
m,p-Xylene	0.00E+00	106	0.00E+00	0.00E+00	4.61E-02	2.07E+02	2.27E+03	6.40E+01	6.35E-05	0.00E+00	4.05E-06
Methylcyclohexane	2.90E+03	98	7.24E-05	6.88E-05	8.54E-03	3.50E+01	3.89E+02	1.10E+01	1.09E-05	4.81E-06	6.56E-07
Toluene	0.00E+00	92	0.00E+00	0.00E+00	2.63E-02	1.02E+02	1.13E+03	3.20E+01	3.15E-05	0.00E+00	2.02E-06
Pentane	2.54E+04	72	8.62E-04	8.19E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.10E-05	0.00E+00
Hexane	2.65E+03	86	7.55E-05	7.17E-05	2.31E-03	8.00E+00	9.20E+01	3.00E+00	2.58E-06	4.30E-06	1.52E-07
Cyclohexane	0.00E+00	84	0.00E+00	0.00E+00	2.83E-03	1.00E+01	1.10E+02	3.00E+00	3.09E-06	0.00E+00	1.86E-07
Nonane	0.00E+00	128	0.00E+00	0.00E+00	2.42E-03	1.30E+01	1.44E+02	4.00E+00	4.02E-06	0.00E+00	2.39E-07
Undecane	0.00E+00	156	0.00E+00	0.00E+00	2.61E-03	1.70E+01	1.89E+02	5.00E+00	5.30E-06	0.00E+00	3.16E-07
Dodecane	0.00E+00	170	0.00E+00	0.00E+00	1.46E-03	1.00E+01	1.15E+02	3.00E+00	3.21E-06	0.00E+00	1.92E-07
Decane	0.00E+00	142	0.00E+00	0.00E+00	3.97E-03	2.40E+01	2.62E+02	7.00E+00	7.33E-06	0.00E+00	4.36E-07
Heptane	0.00E+00	100	0.00E+00	0.00E+00	2.64E-03	1.10E+01	1.23E+02	3.00E+00	3.44E-06	0.00E+00	2.03E-07
Cyclohexane, ethyl-	0.00E+00	112	0.00E+00	0.00E+00	1.27E-03	6.00E+00	6.60E+01	2.00E+00	1.85E-06	0.00E+00	1.11E-07
Cyclohexane, 1,2-dimethyl-, cis-	0.00E+00	112	0.00E+00	0.00E+00	1.55E-03	7.00E+00	8.10E+01	2.00E+00	2.26E-06	0.00E+00	1.36E-07
Cyclohexane, 1,3-dimethyl-, trans-	0.00E+00	112	0.00E+00	0.00E+00	8.46E-04	4.00E+00	4.40E+01	1.00E+00	1.23E-06	0.00E+00	7.43E-08
Cyclopentane	2.19E+03	70	7.64E-05	7.25E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.63E-06	0.00E+00
Carbonyl sulphide	0.00E+00	60	0.00E+00	0.00E+00	6.15E-02	1.56E+02	1.71E+03	4.80E+01	4.80E-05	0.00E+00	6.75E-07
Formaldehyde	0.00E+00	30	0.00E+00	0.00E+00	2.00E-02	2.50E+01	2.78E+02	8.00E+00	7.78E-06	0.00E+00	2.19E-07
2,3-Dimethylpentane	0.00E+00	100	0.00E+00	0.00E+00	4.80E-03	2.00E+01	2.23E+02	6.00E+00	6.23E-06	0.00E+00	3.69E-07
2,3,4-Trimethylpentane	0.00E+00	114	0.00E+00	0.00E+00	4.02E-03	1.90E+01	2.13E+02	6.00E+00	5.96E-06	0.00E+00	3.53E-07
3-Methylhexane	0.00E+00	100	0.00E+00	0.00E+00	4.25E-03	1.80E+01	1.97E+02	6.00E+00	5.52E-06	0.00E+00	3.26E-07
3-Methylheptane	0.00E+00	114	0.00E+00	0.00E+00	2.12E-03	1.00E+01	1.12E+02	3.00E+00	3.15E-06	0.00E+00	1.86E-07
cis-2-Butene	0.00E+00	56	0.00E+00	0.00E+00	4.61E-03	1.10E+01	1.20E+02	3.00E+00	3.36E-06	0.00E+00	2.02E-07
2-Methylhexane	0.00E+00	100	0.00E+00	0.00E+00	2.94E-03	1.20E+01	1.36E+02	4.00E+00	3.82E-06	0.00E+00	2.26E-07
2-Methylheptane	0.00E+00	114	0.00E+00	0.00E+00	1.21E-03	6.00E+00	6.40E+01	2.00E+00	1.79E-06	0.00E+00	1.06E-07
Benzene	0.00E+00	78	0.00E+00	0.00E+00	5.02E-03	1.70E+01	1.82E+02	5.00E+00	5.09E-06	0.00E+00	3.31E-07
Ethane	5.72E+06	30	4.67E-01	4.43E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.87E-03	0.00E+00
Propane	1.17E+06	44	6.50E-02	6.17E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-03	0.00E+00
Isobutane	3.28E+05	58	1.38E-02	1.31E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.26E-04	0.00E+00
Hydrogen sulphide	3.90E+01	34	2.83E-06	2.69E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	6.79E+04	72	2.31E-03	2.19E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.10E-04	0.00E+00

Table 23: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Process Heater.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
2,3-Dimethylbutane	1.27E+03	86	3.61E-05	3.43E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.06E-06	0.00E+00
o-Xylene	0.00E+00	106	0.00E+00	0.00E+00	5.93E-02	2.66E+02	2.92E+03	8.20E+01	8.17E-05	0.00E+00	5.20E-06
1,2,4-Trimethylbenzene	0.00E+00	120	0.00E+00	0.00E+00	1.19E-01	6.04E+02	6.63E+03	1.86E+02	1.86E-04	0.00E+00	1.17E-05
3-Methylpentane	4.04E+03	86	1.15E-04	1.09E-04	2.53E-03	9.00E+00	1.01E+02	3.00E+00	2.82E-06	6.55E-06	1.66E-07
Methylcyclopentane	7.68E+03	84	2.24E-04	2.13E-04	2.54E-03	9.00E+00	9.90E+01	3.00E+00	2.77E-06	1.28E-05	1.67E-07
trans-2-Butene	0.00E+00	56	0.00E+00	0.00E+00	1.63E-02	3.90E+01	4.24E+02	1.20E+01	1.19E-05	0.00E+00	7.16E-07
Acetaldehyde	2.38E+03	44	1.32E-04	1.26E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-06	0.00E+00
1,2,3-Trimethylbenzene	0.00E+00	120	0.00E+00	0.00E+00	4.06E-02	2.06E+02	2.26E+03	6.30E+01	6.33E-05	0.00E+00	4.01E-06
1,3,5-Trimethylbenzene	0.00E+00	120	0.00E+00	0.00E+00	4.44E-02	2.25E+02	2.48E+03	6.90E+01	6.93E-05	0.00E+00	4.39E-06
1,4-Pentadiene, 3,3-dimethyl-	0.00E+00	96	0.00E+00	0.00E+00	5.06E-03	2.10E+01	2.26E+02	6.00E+00	6.32E-06	0.00E+00	3.89E-07
2,2,4-Trimethylpentane	0.00E+00	114	0.00E+00	0.00E+00	6.41E-03	3.10E+01	3.39E+02	9.00E+00	9.50E-06	0.00E+00	5.63E-07
Acetic Acid	0.00E+00	60	0.00E+00	0.00E+00	1.76E-03	4.00E+00	4.90E+01	1.00E+00	1.37E-06	0.00E+00	3.86E-08
Benzene, (1-methyl-1-propenyl)-, (Z)- (C	0.00E+00	132	0.00E+00	0.00E+00	3.84E-02	2.15E+02	2.36E+03	6.60E+01	6.59E-05	0.00E+00	4.22E-06
Benzene, 1,2,3,4-tetramethyl-	0.00E+00	134	0.00E+00	0.00E+00	2.13E-02	1.21E+02	1.33E+03	3.70E+01	3.71E-05	0.00E+00	2.34E-06
Benzene, 1-ethyl-2,3-dimethyl-	0.00E+00	134	0.00E+00	0.00E+00	2.74E-02	1.55E+02	1.71E+03	4.80E+01	4.78E-05	0.00E+00	3.01E-06
Benzene, 1-methyl-2-(1-methylethyl)- (CA	0.00E+00	134	0.00E+00	0.00E+00	2.58E-02	1.46E+02	1.60E+03	4.50E+01	4.49E-05	0.00E+00	2.83E-06
Benzene, 1-methyl-2-propyl-	0.00E+00	134	0.00E+00	0.00E+00	1.15E-02	6.50E+01	7.15E+02	2.00E+01	2.00E-05	0.00E+00	1.26E-06
Carbon disulfide	0.00E+00	76	0.00E+00	0.00E+00	1.64E-02	5.30E+01	5.79E+02	1.60E+01	1.62E-05	0.00E+00	1.80E-07
Dimethyl disulphide	0.00E+00	94	0.00E+00	0.00E+00	3.57E-03	1.40E+01	1.56E+02	4.00E+00	4.36E-06	0.00E+00	7.83E-08
Endo-tricyclo[5.2.1.0(2.6)]decane	0.00E+00	136	0.00E+00	0.00E+00	2.52E-02	1.45E+02	1.59E+03	4.40E+01	4.45E-05	0.00E+00	2.76E-06
m-Diethylbenzene	0.00E+00	134	0.00E+00	0.00E+00	4.73E-03	2.70E+01	2.94E+02	8.00E+00	8.23E-06	0.00E+00	5.19E-07
Methyl ethyl disulfide	0.00E+00	108	0.00E+00	0.00E+00	1.66E-03	8.00E+00	8.30E+01	2.00E+00	2.33E-06	0.00E+00	5.47E-08
m-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	5.17E-02	2.62E+02	2.88E+03	8.10E+01	8.06E-05	0.00E+00	5.11E-06
Naphthalene, 2-methyl-	0.00E+00	142	0.00E+00	0.00E+00	1.71E-02	1.03E+02	1.13E+03	3.20E+01	3.16E-05	0.00E+00	2.06E-06
Naphthalene, decahydro-, trans-	0.00E+00	138	0.00E+00	0.00E+00	8.77E-03	5.10E+01	5.62E+02	1.60E+01	1.57E-05	0.00E+00	9.62E-07
n-Propylbenzene	0.00E+00	120	0.00E+00	0.00E+00	1.52E-02	7.70E+01	8.49E+02	2.40E+01	2.38E-05	0.00E+00	1.51E-06
Octane	0.00E+00	114	0.00E+00	0.00E+00	3.98E-03	1.90E+01	2.11E+02	6.00E+00	5.90E-06	0.00E+00	3.50E-07
o-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	2.97E-02	1.51E+02	1.65E+03	4.60E+01	4.63E-05	0.00E+00	2.93E-06
p-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	1.29E-02	6.50E+01	7.17E+02	2.00E+01	2.01E-05	0.00E+00	1.27E-06

Table 23: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Process Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Sulfur dioxide	0.00E+00	64	0.00E+00	0.00E+00	8.48E-04	2.00E+00	2.50E+01	1.00E+00	7.06E-07	0.00E+00	0.00E+00
Nitrogen	1.66E+08	28	6.00E+00	5.70E+00	8.35E+05	9.89E+08	1.09E+10	3.04E+08	3.04E+02	0.00E+00	0.00E+00
Carbon dioxide	1.23E+06	44	6.81E-02	6.47E-02	8.34E+04	1.55E+08	1.70E+09	4.77E+07	4.80E+01	0.00E+00	0.00E+00
										Comb Eff =	**99.99%**
										CH4 Comb Eff =	**99.99%**
										THC Comb Eff =	**99.99%**

Table 24: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 3 - Sweet Gas Gathering System (Plains Region)– Process Heater.

Excess Air	32%	Item	CO_2	H_2O	O_2	N_2	Total
Wet Basis							
THC (ppm)	**CO (ppm)**	**m3/h**	0.95	1.89	0.60	9.43	13
2.2	0	**percentage, %**	7.38	4.64	4.64	73	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m3/h**	0.95		0.59	9.43	11
2.7	0	**percentage, %**	8.65		5.44	86	100

Table 25: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Reciprocating Engine.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet

Table 25: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Reciprocating Engine.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	6.03E+08	16	9.20E+01	9.24E+01	7.50E+02	5.07E+05	5.95E+06	1.69E+05	1.69E-01	9.24E-01	8.79E-03
Ethyl benzene	0.00E+00	106	0.00E+00	0.00E+00	1.55E-03	7.00E+00	8.20E+01	2.00E+00	2.32E-06	0.00E+00	1.46E-07
Butane	1.86E+05	58	7.90E-03	7.90E-03	2.46E-02	6.00E+01	7.07E+02	2.00E+01	2.01E-05	3.15E-04	1.15E-06
1-Butene	0.00E+00	56	0.00E+00	0.00E+00	2.00E-01	4.80E+02	5.62E+03	1.60E+02	1.60E-04	0.00E+00	9.50E-06
2-Methylpentane	9.90E+03	86	2.80E-04	3.00E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.69E-05	0.00E+00
m,p-Xylene	0.00E+00	106	0.00E+00	0.00E+00	3.70E-03	1.70E+01	1.96E+02	6.00E+00	5.56E-06	0.00E+00	3.49E-07
Methylcyclohexane	2.91E+03	98	7.26E-05	7.28E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.10E-06	0.00E+00
Toluene	0.00E+00	92	0.00E+00	0.00E+00	6.20E-02	2.41E+02	2.83E+03	8.00E+01	8.02E-05	0.00E+00	5.08E-06
Pentane	2.66E+04	72	9.00E-04	9.10E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.53E-05	0.00E+00
1-Pentene	0.00E+00	70	0.00E+00	0.00E+00	3.70E-02	1.08E+02	1.27E+03	3.60E+01	3.60E-05	0.00E+00	2.14E-06
Hexane	1.91E+03	86	5.43E-05	5.44E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.27E-06	0.00E+00
Cyclopentane	2.04E+03	70	7.13E-05	7.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.57E-06	0.00E+00
cis-2-Butene	0.00E+00	56	0.00E+00	0.00E+00	9.40E-03	2.20E+01	2.62E+02	7.00E+00	7.43E-06	0.00E+00	4.42E-07
1-Hexene	0.00E+00	84	0.00E+00	0.00E+00	3.00E-02	1.21E+02	1.42E+03	4.00E+01	4.02E-05	0.00E+00	2.39E-06
Benzene	0.00E+00	78	0.00E+00	0.00E+00	2.90E-01	9.53E+02	1.12E+04	3.17E+02	3.17E-04	0.00E+00	2.03E-05
Ethane	5.41E+06	30	4.40E-01	4.40E-01	5.01E+00	6.36E+03	7.46E+04	2.12E+03	2.10E-03	8.90E-03	1.18E-04
Ethylene	0.00E+00	28	0.00E+00	0.00E+00	1.11E+01	1.32E+04	1.54E+05	4.38E+03	4.40E-03	0.00E+00	2.60E-04
Propane	1.12E+06	44	6.20E-02	6.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.90E-03	0.00E+00
Isobutane	3.42E+05	58	1.40E-02	1.40E-02	5.20E-02	1.26E+02	1.48E+03	4.20E+01	4.21E-05	5.80E-04	2.42E-06
Hydrogen sulphide	1.10E+01	34	7.84E-07	7.86E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	7.15E+04	72	2.40E-03	2.40E-03	8.80E-03	2.70E+01	3.15E+02	9.00E+00	8.94E-06	1.20E-04	5.17E-07
2,3-Dimethylbutane	1.44E+03	86	4.11E-05	4.12E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.47E-06	0.00E+00
o-Xylene	0.00E+00	106	0.00E+00	0.00E+00	1.60E-03	7.00E+00	8.20E+01	2.00E+00	2.32E-06	0.00E+00	1.46E-07
3-Methylpentane	4.15E+03	86	1.20E-04	1.20E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.10E-06	0.00E+00
Methylcyclopentane	7.82E+03	84	2.30E-04	2.30E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-05	0.00E+00
Formic acid	0.00E+00	46	0.00E+00	0.00E+00	8.90E-02	1.73E+02	2.03E+03	5.80E+01	5.76E-05	0.00E+00	1.04E-06
trans-2-Butene	0.00E+00	56	0.00E+00	0.00E+00	2.20E-02	5.10E+01	6.01E+02	1.70E+01	1.71E-05	0.00E+00	1.01E-06
Acetaldehyde	2.78E+03	44	1.60E-04	1.60E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.10E-06	0.00E+00
1,3-Pentadiene, (Z)-	0.00E+00	68	0.00E+00	0.00E+00	1.10E-03	3.00E+00	3.70E+01	1.00E+00	1.06E-06	0.00E+00	6.51E-08
Acetic Acid	0.00E+00	60	0.00E+00	0.00E+00	1.70E-03	4.00E+00	5.20E+01	1.00E+00	1.47E-06	0.00E+00	4.08E-08

Table 25: Laboratory results and material balance determined emission factors and combustion efficiency for Location 3 – Sweet Gas Gathering System (Plains Region) – Reciprocating Engine.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	**μg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**μg/m^3**	**μg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Cyclobutanone, 3-ethyl-	1.78E+03	98	4.45E-05	4.47E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.68E-06	0.00E+00
Cyclopentene-3-carboxylic acid, 1-(trime	0.00E+00	214	0.00E+00	0.00E+00	1.10E-02	1.02E+02	1.20E+03	3.40E+01	3.41E-05	0.00E+00	1.33E-06
m-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	1.60E-03	8.00E+00	9.50E+01	3.00E+00	2.71E-06	0.00E+00	1.69E-07
Nonanol	0.00E+00	144	0.00E+00	0.00E+00	1.10E-03	7.00E+00	7.70E+01	2.00E+00	2.17E-06	0.00E+00	1.13E-07
s-Dichloroethyl ether	0.00E+00	142	0.00E+00	0.00E+00	3.20E-03	1.90E+01	2.28E+02	6.00E+00	6.49E-06	0.00E+00	1.52E-07
Silane, chlorotrimethyl-	0.00E+00	108	0.00E+00	0.00E+00	5.00E-03	2.30E+01	2.70E+02	8.00E+00	7.65E-06	0.00E+00	1.77E-07
Nitrogen	1.20E+08	28	7.00E+00	7.00E+00	8.32E+05	9.85E+08	1.15E+10	3.28E+08	3.28E+02	0.00E+00	0.00E+00
Carbon dioxide	1.37E+06	44	7.60E-02	7.60E-02	8.63E+04	1.61E+08	1.88E+09	5.35E+07	5.35E+01	0.00E+00	0.00E+00
										Comb Eff =	**99.04%**
										CH4 Comb Eff =	**99.04%**
										THC Comb Eff =	**99.04%**

Table 26: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 3 - Sweet Gas Gathering System – Reciprocating Engine.

Excess Air	43%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	0.93	1.85	0.79	9.99	14
622	0	**percentage, %**	6.83	14	5.82	74	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	0.93		0.79	9.99	12
767	0	**percentage, %**	7.91		6.74	85	100

Table 27: Gas analysis for determine the metals emission factor in flue gas for Location 3 - Sweet Gas Gathering System – Process Heater and Reciprocating Engine.

Component	Lab Analysis			Method Blank Corrected		Emission Factor	
	Process Heater, Flue Gas	Reciprocating Engine, Flue Gas	Method blank	Process Heater, Flue Gas	Reciprocating Engine, Flue Gas	Process Heater, Flue Gas	Reciprocating Engine, Flue Gas
	µg/L	µg/L	µg/L	µg/L	µg/L	kg/GJ (Fuel)	kg/GJ (Fuel)
Aluminum	155.00	68.30	3.48	151.52	64.82	6.36E-05	2.70E-05
Antimony	0.06	0.03	0.00	0.06	0.03	2.52E-08	1.05E-08
Arsenic	4.12	2.13	0.02	4.10	2.11	1.72E-06	8.80E-07
Barium	41.10	18.00	0.34	40.76	17.66	1.71E-05	7.37E-06
Beryllium	0.02	0.01	0.00	0.01	0.00	4.53E-09	1.79E-09
Bismuth	0.00	0.00	0.00	0.00	0.00	0.00E+00	0.00E+00
Boron	129.00	69.90	21.20	107.80	48.70	4.52E-05	2.03E-05
Cadmium	3.09	2.25	0.29	2.81	1.97	1.18E-06	8.20E-07
Calcium	671.00	662.00	16.50	654.50	645.50	2.75E-04	2.69E-04
Chlorine	679.00	719.00	100.00	579.00	619.00	2.43E-04	2.58E-04
Chromium	1.22	1.60	0.12	1.10	1.48	4.62E-07	6.17E-07
Cobalt	0.12	0.21	0.01	0.11	0.21	4.81E-08	8.62E-08
Copper	14.90	11.20	1.58	13.32	9.62	5.59E-06	4.01E-06
Iron	45.90	33.20	2.41	43.49	30.79	1.83E-05	1.28E-05
Lead	2.49	3.43	0.38	2.11	3.05	8.87E-07	1.27E-06
Lithium	0.02	0.02	0.02	0.00	0.00	0.00E+00	0.00E+00
Magnesium	63.50	71.20	2.70	60.80	68.50	2.55E-05	2.86E-05
Manganese	3.12	1.68	0.07	3.05	1.61	1.28E-06	6.73E-07
Mercury	0.01	0.03	0.01	0.00	0.02	0.00E+00	8.34E-09
Molybdenum	0.12	0.11	0.01	0.10	0.10	4.35E-08	4.20E-08
Nickel	11.00	7.66	0.63	10.38	7.04	4.35E-06	2.94E-06
Phosphorus	0.80	5.28	0.80	0.00	4.48	0.00E+00	1.87E-06

Table 27: Gas analysis for determine the metals emission factor in flue gas for Location 3 - Sweet Gas Gathering System – Process Heater and Reciprocating Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Potassium	257.00	213.00	15.50	241.50	197.50	1.01E-04	8.24E-05
Selenium	0.10	0.10	0.10	0.00	0.00	0.00E+00	0.00E+00
Silicon	10.00	10.00	10.00	0.00	0.00	0.00E+00	0.00E+00
Silver	0.69	1.40	0.14	0.55	1.26	2.31E-07	5.27E-07
Sodium	911.00	663.00	51.60	859.40	611.40	3.61E-04	2.55E-04
Strontium	2.32	2.58	0.12	2.20	2.46	9.25E-07	1.03E-06
Sulphur	200.00	200.00	200.00	0.00	0.00	0.00E+00	0.00E+00
Thallium	0.00	0.00	0.00	0.00	0.00	8.39E-11	0.00E+00
Thorium	0.00	0.00	0.00	0.00	0.00	1.72E-09	0.00E+00
Tin	0.41	0.69	0.11	0.30	0.58	1.24E-07	2.42E-07
Titanium	0.99	0.53	0.14	0.85	0.39	3.55E-07	1.62E-07
Uranium	0.01	0.00	0.00	0.01	0.00	3.02E-09	7.93E-10
Vanadium	0.04	0.03	0.01	0.04	0.03	1.62E-08	1.16E-08
Zinc	21.60	33.90	1.32	20.28	32.58	8.51E-06	1.36E-05

Table 28: Laboratory results and material balance determined emission factors and combustion efficiency for Location 4 – Thermal Heavy Oil Production – Steam Generator.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Methane	6.10E+08	16	9.33E+01	9.30E+01	5.90E+00	3.99E+03	3.96E+04	1.00E+03	1.01E-03	9.30E-01	5.85E-05
Ethane	3.93E+07	30	3.21E+00	3.20E+00	1.00E-01	1.27E+02	1.26E+03	3.19E+01	3.19E-05	6.39E-02	1.98E-06

Table 28: Laboratory results and material balance determined emission factors and combustion efficiency for Location 4 – Thermal Heavy Oil Production – Steam Generator.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Ethylene	3.55E+03	28	3.10E-04	3.09E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.19E-06	0.00E+00
Propane	1.79E+07	44	9.95E-01	9.92E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-02	0.00E+00
Propylene	1.46E+04	42	8.48E-04	8.46E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.54E-05	0.00E+00
Isobutane	4.15E+06	58	1.75E-01	1.74E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.97E-03	0.00E+00
Butane	7.29E+06	58	3.07E-01	3.06E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-02	0.00E+00
trans-2-Butene	1.47E+04	56	6.42E-04	6.39E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.56E-05	0.00E+00
1-Butene	3.32E+03	56	1.45E-04	1.44E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.78E-06	0.00E+00
Isobutylene	3.55E+03	56	1.55E-04	1.55E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.19E-06	0.00E+00
cis-2-Butene	7.82E+03	56	3.41E-04	3.40E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.36E-05	0.00E+00
Hydrogen sulphide	2.07E+05	34	1.49E-02	1.49E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbonyl sulphide	3.32E+02	60	1.36E-05	1.35E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-07	0.00E+00
Methyl mercaptan	3.76E+04	48	1.91E-03	1.91E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.91E-05	0.00E+00
Ethyl mercaptan	7.55E+03	62	2.98E-04	2.97E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E-06	0.00E+00
Dimethyl sulphide	5.51E+03	62	2.17E-04	2.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.33E-06	0.00E+00
Carbon disulphide	4.82E+01	76	1.55E-06	1.55E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.55E-08	0.00E+00
Isopropyl mercaptan	4.63E+03	76	1.49E-04	1.49E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.46E-06	0.00E+00
tert-Butyl mercaptan	3.88E+02	90	1.06E-05	1.05E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.21E-07	0.00E+00
Propyl mercaptan	1.01E+03	76	3.24E-05	3.23E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.68E-07	0.00E+00
Thiophene	1.28E+03	84	3.71E-05	3.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-06	0.00E+00
Isobutyl mercaptan	1.52E+03	90	4.12E-05	4.10E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.64E-06	0.00E+00
Ethyl sulphide	2.31E+02	90	6.29E-06	6.27E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.51E-07	0.00E+00
Butyl mercaptan	6.55E+02	98	1.63E-05	1.63E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.52E-07	0.00E+00
Dimethyl disulphide	7.95E+03	94	2.07E-04	2.06E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-06	0.00E+00
2-methyl Thiophene	8.17E+03	98	2.04E-04	2.03E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.02E-05	0.00E+00
3-methyl Thiophene	4.68E+03	98	1.17E-04	1.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.83E-06	0.00E+00
Tetrahydro thiophene	1.85E+03	88	5.15E-05	5.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.05E-06	0.00E+00
Allyl sulphide	5.98E+03	114	1.28E-04	1.28E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.67E-06	0.00E+00
2,5-dimethyl Thiophene	6.11E+03	112	1.33E-04	1.33E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.98E-06	0.00E+00
Dimethyl trisulphide	2.65E+04	126	5.14E-04	5.13E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.03E-05	0.00E+00
Isopentane	6.27E+06	72	2.13E-01	2.12E-01	2.60E-02	7.92E+01	7.84E+02	1.99E+01	1.99E-05	1.06E-02	1.29E-06
Pentane	3.84E+06	72	1.30E-01	1.30E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.50E-03	0.00E+00

Table 28: Laboratory results and material balance determined emission factors and combustion efficiency for Location 4 – Thermal Heavy Oil Production – Steam Generator.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
2,2-Dimethylbutane	9.35E+04	86	2.66E-03	2.65E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.59E-04	0.00E+00
Methylene chloride	3.55E-03	84	1.03E-10	1.03E-10	1.00E-06	3.55E-03	3.52E-02	8.94E-04	8.94E-10	1.03E-12	9.91E-12
2,3-Dimethylbutane	1.03E+05	86	2.94E-03	2.93E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.76E-04	0.00E+00
Cyclopentane	1.87E+05	70	6.54E-03	6.52E-03	7.83E-04	2.32E+00	2.30E+01	5.83E-01	5.83E-07	3.26E-04	3.88E-08
2-Methylpentane	7.57E+05	86	2.15E-02	2.15E-02	3.61E-03	1.31E+01	1.30E+02	3.30E+00	3.30E-06	1.29E-03	2.15E-07
3-Methylpentane	3.49E+05	86	9.93E-03	9.90E-03	1.78E-03	6.47E+00	6.41E+01	1.63E+00	1.63E-06	5.94E-04	1.06E-07
Hexane	6.77E+05	86	1.92E-02	1.92E-02	8.70E-04	3.16E+00	3.14E+01	7.96E-01	7.96E-07	1.15E-03	5.17E-08
Methylcyclopentane	1.62E+05	84	4.73E-03	4.71E-03	6.93E-04	2.46E+00	2.44E+01	6.20E-01	6.20E-07	2.83E-04	4.12E-08
Cyclohexane	1.41E+05	84	4.12E-03	4.11E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.46E-04	0.00E+00
Benzene	1.48E+05	78	4.64E-03	4.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.77E-04	0.00E+00
2-Methylhexane	6.18E+04	100	1.51E-03	1.51E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.05E-04	0.00E+00
2,3-Dimethylpentane	2.06E+04	100	5.04E-04	5.02E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.52E-05	0.00E+00
3-Methylhexane	7.19E+04	100	1.76E-03	1.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-04	0.00E+00
Heptane	0.00E+00	100	0.00E+00	0.00E+00	1.35E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.36E-08
Toluene	0.00E+00	92	0.00E+00	0.00E+00	1.97E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-08
Chlorobenzene-d5	0.00E+00	112	0.00E+00	0.00E+00	1.00E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E-11
Dodecane	0.00E+00	170	0.00E+00	0.00E+00	3.47E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.13E-07
Acetaldehyde	0.00E+00	44	0.00E+00	0.00E+00	4.96E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Nitrogen	1.69E+06	28	1.48E-01	1.47E-01	8.63E+05	1.02E+09	1.01E+10	2.57E+08	2.57E+02	0.00E+00	0.00E+00
Carbon dioxide	3.09E+07	44	1.72E+00	1.71E+00	1.10E+05	2.05E+08	2.03E+09	5.15E+07	5.15E+01	0.00E+00	0.00E+00
Oxygen	0.00E+00	32	0.00E+00	0.00E+00	2.04E+04	2.76E+07	2.74E+08	6.95E+06	6.95E+00	0.00E+00	0.00E+00
										Comb Eff =	**99.99%**
										CH4 Comb Eff =	**99.99%**
										THC Comb Eff =	**99.99%**

Table 29: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 4 – Thermal Heavy Oil Production – Steam Generator.							
Excess Air	9.75%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							

Table 29: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 4 – Thermal Heavy Oil Production – Steam Generator.

Excess Air	9.75%	Item	CO_2	H_2O	O_2	N_2	Total
THC (ppm)	CO (ppm)	m^3/h	1.08	2.04	0.20	8.62	12
4.9	0	percentage, %	9.05	17	1.70	72	100
Dry Basis							
THC (ppm)	CO (ppm)	m^3/h	1.08		0.20	8.62	9.91
6.0	0	percentage, %	11		2.05	87	100

Table 30: Laboratory results and material balance determined emission factors and combustion efficiency for Location 4 – Thermal Heavy Oil Production – Treater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	5.45E+08	16	8.34E+01	9.35E+01	7.40E+00	5.01E+03	9.62E+04	2.44E+03	2.44E-03	9.35E-01	1.42E-04
Ethane	4.07E+07	30	3.32E+00	3.72E+00	2.00E-01	2.54E+02	4.88E+03	1.24E+02	1.24E-04	7.44E-02	7.69E-06
Propane	1.82E+07	44	1.01E+00	1.14E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.41E-02	0.00E+00
Isobutane	3.63E+06	58	1.53E-01	1.72E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.87E-03	0.00E+00
Butane	4.49E+06	58	1.89E-01	2.12E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.49E-03	0.00E+00
Carbonyl sulphide	7.16E+01	60	2.92E-06	3.27E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.27E-08	0.00E+00
Dimethyl sulphide	7.29E+01	62	2.88E-06	3.22E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.45E-08	0.00E+00
Carbon disulphide	2.60E+01	76	8.38E-07	9.39E-07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.39E-09	0.00E+00
Dimethyl disulphide	2.46E+02	94	6.40E-06	7.18E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-07	0.00E+00
Unknown Sulphur (MW=32)	0.00E+00	32	0.00E+00	0.00E+00	5.76E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	1.95E+06	72	6.62E-02	7.42E-02	2.77E-02	8.44E+01	1.62E+03	4.11E+01	4.11E-05	3.71E-03	2.66E-06
Pentane	1.13E+06	72	3.85E-02	4.31E-02	2.52E+00	7.67E+03	1.47E+05	3.74E+03	3.74E-03	2.16E-03	2.42E-04
2,2-Dimethylbutane	2.99E+04	86	8.49E-04	9.52E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.71E-05	0.00E+00
Methylene chloride	3.55E-03	84	1.03E-10	1.16E-10	1.00E-03	3.55E+00	6.83E+01	1.73E+00	1.73E-06	1.16E-12	1.92E-08
2,3-Dimethylbutane	3.24E+04	86	9.22E-04	1.03E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.20E-05	0.00E+00
Cyclopentane	3.38E+04	70	1.18E-03	1.32E-03	8.80E-01	2.61E+03	5.01E+04	1.27E+03	1.27E-03	6.61E-05	8.46E-05
2-Methylpentane	2.87E+05	86	8.15E-03	9.14E-03	3.38E+00	1.23E+04	2.36E+05	5.99E+03	5.99E-03	5.48E-04	3.90E-04
3-Methylpentane	1.21E+05	86	3.46E-03	3.87E-03	1.69E+00	6.15E+03	1.18E+05	2.99E+03	2.99E-03	2.32E-04	1.95E-04
Hexane	2.58E+05	86	7.33E-03	8.21E-03	1.04E+00	3.78E+03	7.27E+04	1.84E+03	1.84E-03	4.93E-04	1.20E-04

Table 30: Laboratory results and material balance determined emission factors and combustion efficiency for Location 4 – Thermal Heavy Oil Production – Treater.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**μg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**μg/m^3**	**μg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Methylcyclopentane	4.65E+04	84	1.36E-03	1.52E-03	6.01E-01	2.14E+03	4.10E+04	1.04E+03	1.04E-03	9.11E-05	6.93E-05
Cyclohexane	4.23E+04	84	1.23E-03	1.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.28E-05	0.00E+00
Benzene	2.52E+04	78	7.91E-04	8.86E-04	2.29E+00	7.55E+03	1.45E+05	3.68E+03	3.68E-03	5.32E-05	2.64E-04
2-Methylhexane	2.98E+04	100	7.29E-04	8.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.72E-05	0.00E+00
2,3-Dimethylpentane	8.88E+03	100	2.17E-04	2.44E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.70E-05	0.00E+00
3-Methylhexane	3.27E+04	100	8.00E-04	8.96E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.27E-05	0.00E+00
Heptane	3.38E+04	100	8.27E-04	9.26E-04	1.30E+00	5.50E+03	1.06E+05	2.68E+03	2.68E-03	6.49E-05	6.49E-11
Methylcyclohexane	3.21E+04	98	8.01E-04	8.97E-04	2.19E-01	9.08E+02	1.74E+04	4.42E+02	4.42E-04	6.28E-05	6.28E-11
Toluene	6.15E+03	92	1.63E-04	1.83E-04	6.28E-01	2.44E+03	4.70E+04	1.19E+03	1.19E-03	0.00E+00	0.00E+00
Octane	4.45E+03	114	9.55E-05	1.07E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Chlorobenzene-d5	4.74E-03	112	1.03E-10	1.16E-10	1.00E-03	4.74E+00	9.10E+01	2.31E+00	2.31E-06	0.00E+00	0.00E+00
Nitrogen	3.06E+06	28	2.68E-01	3.00E-01	8.30E+05	9.83E+08	1.89E+10	4.79E+08	4.79E+02	0.00E+00	0.00E+00
Carbon dioxide	1.36E+07	44	7.57E-01	8.49E-01	5.83E+04	1.08E+08	2.08E+09	5.28E+07	5.28E+01	0.00E+00	0.00E+00
										Comb Eff =	**99.86%**
										CH4 Comb Eff =	**99.98%**
										THC Comb Eff =	**99.96%**

Table 31: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 4 – Thermal Heavy Oil Production - Treater.							
Excess Air	102%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	1.07	2.05	2.15	16	21
22	0	**percentage, %**	5.04	9.65	10	75	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	1.07		2.15	16	19
22	0	**percentage, %**	5.58		11	83	100

Table 32: Gas analysis for determine the metals emission factor in flue gas for Location 4 – Thermal Heavy Oil Production – Steam Generator and Treater.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Aluminum	796	366	219	577	147	1.78E-04	8.63E-05
Antimony	0.226	0.0378	0.0321	0.1939	0.0057	5.99E-08	3.35E-09
Arsenic	20	13.3	5.83	14.17	7.47	4.38E-06	4.38E-06
Barium	418	133	166	252	0	7.79E-05	0.00E+00
Beryllium	0.0272	0.0059	0.0154	0.0118	0	3.65E-09	0.00E+00
Bismuth	0.0563	0.0232	0.0094	0.0469	0.0138	1.45E-08	8.10E-09
Boron	938	304	300	638	4	1.97E-04	2.35E-06
Cadmium	2.35	0.0949	0.0293	2.3207	0.0656	7.17E-07	3.85E-08
Calcium	0.986	0.371	0.293	0.693	0.078	2.14E-07	4.58E-08
Chlorine	0.204	0.1	0.1	0.104	0	3.22E-08	0.00E+00
Chromium	278	0.583	0.17	277.83	0.413	8.59E-05	2.42E-07
Cobalt	2.45	0.0341	0.0033	2.4467	0.0308	7.56E-07	1.81E-08
Copper	29.7	4.34	2.74	26.96	1.6	8.34E-06	9.39E-07
Iron	5570	74.5	10.7	5559.3	63.8	1.72E-03	3.74E-05
Lead	19.5	0.733	0.203	19.297	0.53	5.97E-06	3.11E-07
Lithium	0.161	0.02	0.02	0.141	0	4.36E-08	0.00E+00
Magnesium	0.0808	0.0786	0.0452	0.0356	0.0334	1.10E-08	1.96E-08
Manganese	150	0.76	0.289	149.711	0.471	4.63E-05	2.76E-07
Mercury	0.0113	0.01	0.01	0.0013	0	4.02E-10	0.00E+00
Molybdenum	5.62	0.138	0.025	5.595	0.113	1.73E-06	6.63E-08
Nickel	139	0.714	0.121	138.879	0.593	4.29E-05	3.48E-07
Phosphorus	5.93	0.8	0.8	5.13	0	1.59E-06	0.00E+00
Potassium	284	109	86.2	197.8	22.8	6.12E-05	1.34E-05

Table 32: Gas analysis for determine the metals emission factor in flue gas for Location 4 – Thermal Heavy Oil Production – Steam Generator and Treater.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Selenium	0.1	0.1	0.1	0	0	0.00E+00	0.00E+00
Silicon	0.59	0.293	0.141	0.449	0.152	1.39E-07	8.92E-08
Silver	0.121	0.285	0.0346	0.0864	0.2504	2.67E-08	1.47E-07
Sodium	2510	697	801	1709	0	5.28E-04	0.00E+00
Strontium	7.92	3.24	3.31	4.61	0	1.43E-06	0.00E+00
Sulphur	13.7	0.2	0.2	13.5	0	4.17E-06	0.00E+00
Thallium	0.0125	0.0027	0.0014	0.0111	0.0013	3.43E-09	7.63E-10
Thorium	0.163	0.0458	0.0191	0.1439	0.0267	4.45E-08	1.57E-08
Tin	0.78	0.494	0.136	0.644	0.358	1.99E-07	2.10E-07
Titanium	12.6	3.43	0.479	12.121	2.951	3.75E-06	1.73E-06
Uranium	0.0277	0.017	0.0076	0.0201	0.0094	6.21E-09	5.52E-09
Vanadium	0.005	0.005	0.0138	0	0	0.00E+00	0.00E+00
Zinc	1110	2.65	1.79	1108.21	0.86	3.43E-04	5.05E-07

Table 33: Laboratory results and material balance determined emission factors and combustion efficiency for Location 5 – Cold Heavy Oil Production – Tank Heater.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Methane	4.42E+08	16	6.76E+01	9.42E+01	4.30E+00	2.91E+03	1.38E+05	3.79E+03	3.79E-03	9.42E-01	2.04E-04
Ethane	6.32E+06	30	5.17E-01	7.18E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-02	0.00E+00
Propane	0.00E+00	44	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isobutane	1.53E+06	58	6.47E-02	9.01E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-03	0.00E+00

Table 33: Laboratory results and material balance determined emission factors and combustion efficiency for Location 5 – Cold Heavy Oil Production – Tank Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Acetylene	0.00E+00	26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Butane	6.55E+05	58	2.77E-02	3.85E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.54E-03	0.00E+00
Propyne	3.01E+05	40	1.87E-02	2.57E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.70E-04	0.00E+00
Isopentane	7.03E+05	72	2.37E-02	3.33E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-03	0.00E+00
1-Pentene	0.00E+00	70	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pentane	4.05E+05	72	1.37E-02	1.92E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.59E-04	0.00E+00
2,2-Dimethylbutane	4.95E+04	86	1.47E-03	1.96E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-04	0.00E+00
2,3-Dimethylbutane	1.11E+05	86	3.20E-03	4.41E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.65E-04	0.00E+00
Cyclopentane	1.24E+05	70	4.31E-03	6.04E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.02E-04	0.00E+00
2-Methylpentane	3.08E+05	86	8.80E-03	1.22E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.34E-04	0.00E+00
3-Methylpentane	2.16E+05	86	6.10E-03	8.58E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.15E-04	0.00E+00
Acrolein	0.00E+00	56	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Hexane	1.52E+05	86	4.30E-03	6.03E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.62E-04	0.00E+00
Methylcyclopentane	2.59E+05	84	7.50E-03	1.05E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.30E-04	0.00E+00
Cyclohexane	3.38E+05	84	9.80E-03	1.37E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.23E-04	0.00E+00
Benzene	1.84E+04	78	5.70E-04	8.03E-04	3.39E-03	1.12E+01	5.31E+02	1.46E+01	1.46E-05	4.82E-05	9.66E-07
2-Methylhexane	4.53E+04	100	1.10E-03	1.54E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.08E-04	0.00E+00
2,3-Dimethylpentane	6.34E+04	100	1.60E-03	2.16E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-04	0.00E+00
3-Methylhexane	8.63E+04	100	2.10E-03	2.94E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.06E-04	0.00E+00
2,2,4-Trimethylpentane	0.00E+00	114	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Heptane	1.15E+04	100	2.80E-04	3.91E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.74E-05	0.00E+00
Methylcyclohexane	3.94E+05	98	9.84E-03	1.37E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.60E-04	0.00E+00
2,3,4-Trimethylpentane	6.99E+03	114	1.50E-04	2.09E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.67E-05	0.00E+00
2-Methylheptane	0.00E+00	114	0.00E+00	0.00E+00	4.98E-03	2.40E+01	1.14E+03	3.13E+01	3.13E-05	0.00E+00	1.89E-06
Toluene	7.12E+04	92	1.90E-03	2.64E-03	1.84E-03	7.16E+00	3.40E+02	9.34E+00	9.34E-06	1.85E-04	6.12E-07
3-Methylheptane	9.40E+03	114	2.00E-04	2.81E-04	3.30E-03	1.59E+01	7.55E+02	2.07E+01	2.07E-05	2.25E-05	1.25E-06
Octane	0.00E+00	114	0.00E+00	0.00E+00	1.01E-01	4.87E+02	2.31E+04	6.35E+02	6.35E-04	0.00E+00	3.84E-05
Chlorobenzene-d5	4.74E-03	112	1.03E-10	1.44E-10	1.00E-06	4.74E-03	2.25E-01	6.18E-03	6.18E-09	8.65E-12	2.85E-10
Ethyl benzene	1.53E+04	106	3.50E-04	4.93E-04	2.41E-02	1.08E+02	5.13E+03	1.41E+02	1.41E-04	3.95E-05	9.15E-06
m,p-Xylene	3.06E+04	106	7.10E-04	9.83E-04	2.07E-01	9.28E+02	4.41E+04	1.21E+03	1.21E-03	7.87E-05	7.86E-05
o-Xylene	9.73E+03	106	2.20E-04	3.13E-04	1.13E-01	5.07E+02	2.41E+04	6.61E+02	6.61E-04	2.50E-05	4.29E-05

Table 33: Laboratory results and material balance determined emission factors and combustion efficiency for Location 5 – Cold Heavy Oil Production – Tank Heater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Nonane	1.07E+03	128	2.05E-05	2.86E-05	7.74E-01	4.19E+03	1.99E+05	5.46E+03	5.46E-03	2.57E-06	3.31E-04
n-Propylbenzene	2.03E+03	120	4.14E-05	5.77E-05	5.14E-02	2.61E+02	1.24E+04	3.40E+02	3.40E-04	5.19E-06	2.20E-05
m-Ethyltoluene	3.73E+03	120	7.61E-05	1.06E-04	1.82E-01	9.24E+02	4.39E+04	1.20E+03	1.20E-03	0.00E+00	0.00E+00
p-Ethyltoluene	1.83E+03	120	3.74E-05	5.21E-05	1.31E-01	6.65E+02	3.16E+04	8.67E+02	8.67E-04	4.68E-06	5.60E-05
1,3,5-Trimethylbenzene	1.48E+03	120	3.01E-05	4.20E-05	1.39E-01	7.05E+02	3.35E+04	9.20E+02	9.20E-04	3.78E-06	5.94E-05
o-Ethyltoluene	2.36E+03	120	4.81E-05	6.71E-05	1.13E-01	5.74E+02	2.72E+04	7.48E+02	7.48E-04	6.03E-06	4.83E-05
Decane	8.47E+02	142	1.46E-05	2.03E-05	2.92E-01	1.75E+03	8.33E+04	2.29E+03	2.29E-03	2.03E-06	1.39E-04
										Comb Eff =	**99.72%**
										CH4 Comb Eff =	**99.98%**
										THC Comb Eff =	**99.73%**

Table 34: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 5 – Cold Heavy Oil Production – Tank Heater.

Excess Air	415%	Item	CO_2	H_2O	O_2	N_2	Total
			Wet Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	1.01	1.92	8.20	38	49
46	0	**percentage, %**	2.05	3.89	16	77	100
			Dry Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	0.95		8.20	38	47
54	0	**percentage, %**	8.65		17	81	100

Table 35: Laboratory results and material balance determined emission factors and combustion efficiency for Location 5 – Cold Heavy Oil Production – Screw Pump Engine.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	4.42E+08	16	6.86E+01	9.52E+01	1.14E+01	7.71E+03	3.69E+05	9.97E+03	9.97E-03	9.58E-01	5.40E-04
Ethane	6.32E+06	30	5.10E-01	7.16E-01	1.00E-01	1.26E+02	6.08E+03	1.63E+02	1.64E-04	1.40E-02	9.57E-06
Propane	3.15E+06	44	1.70E-01	2.40E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.20E-03	0.00E+00
Isobutane	1.53E+06	58	6.40E-02	8.90E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.60E-03	0.00E+00
Butane	6.55E+05	58	2.70E-02	3.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.50E-03	0.00E+00
Propyne	3.01E+05	40	1.80E-02	2.50E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.60E-04	0.00E+00
Hydrogen sulphide	1.03E+05	34	7.40E-03	1.00E-02	9.47E-03	1.30E+01	6.52E+02	1.70E+01	1.75E-05	0.00E+00	0.00E+00
Methyl mercaptan	5.00E+01	48	2.56E-06	3.55E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.55E-08	0.00E+00
Ethyl mercaptan	2.08E+02	62	8.23E-06	1.14E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.28E-07	0.00E+00
Isopropyl mercaptan	3.63E+02	76	1.17E-05	1.62E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.87E-07	0.00E+00
Thiophene	4.19E+02	84	1.22E-05	1.70E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.78E-07	0.00E+00
2-methyl Thiophene	6.30E+01	98	1.56E-06	2.17E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.09E-07	0.00E+00
3-methyl Thiophene	3.32E+02	98	8.28E-06	1.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.75E-07	0.00E+00
Allyl sulphide	1.21E+02	114	2.59E-06	3.59E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.16E-07	0.00E+00
2,5-dimethyl Thiophene	4.40E+01	112	9.65E-07	1.34E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.05E-08	0.00E+00
Dimethyl trisulphide	3.75E+02	126	7.28E-06	1.01E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E-07	0.00E+00
Cyclohexane, 1,4-dimethyl-	5.64E+03	112	1.23E-04	1.71E-04	5.65E-04	2.68E+00	1.28E+02	3.46E+00	3.46E-06	1.37E-05	2.16E-07
HEXA-4,5-DIENE CARBOXYLIC ACID	0.00E+00	112	0.00E+00	0.00E+00	4.49E-04	2.13E+00	1.02E+02	2.75E+00	2.75E-06	0.00E+00	1.29E-07
Heptane, 2,6-dimethyl-	0.00E+00	128	0.00E+00	0.00E+00	1.28E-03	6.93E+00	3.32E+02	8.96E+00	8.96E-06	0.00E+00	5.52E-07
Cyclohexane, ethyl-	2.05E+04	112	4.47E-04	6.21E-04	7.54E-04	3.57E+00	1.71E+02	4.62E+00	4.62E-06	4.97E-05	2.89E-07
Cyclohexane, 1,1,3-trimethyl-	2.50E+04	126	4.86E-04	6.76E-04	9.47E-04	5.05E+00	2.42E+02	6.52E+00	6.52E-06	6.08E-05	4.08E-07
Heptane, 2,3-dimethyl-	0.00E+00	128	0.00E+00	0.00E+00	1.31E-03	7.09E+00	3.40E+02	9.17E+00	9.17E-06	0.00E+00	5.65E-07
Cyclohexane, 1,2-diethyl-3-methyl-	0.00E+00	154	0.00E+00	0.00E+00	3.47E-03	2.26E+01	1.08E+03	2.90E+01	2.92E-05	0.00E+00	1.83E-06
3-CYCLOHEXYL-PROPANOL	6.43E+03	142	1.11E-04	1.54E-04	1.95E-03	1.17E+01	5.61E+02	1.50E+01	1.51E-05	1.38E-05	8.40E-07
Cyclopentane, 1-ethyl-3-methyl-	4.88E+03	112	1.07E-04	1.48E-04	2.29E-03	1.08E+01	5.19E+02	1.40E+01	1.40E-05	1.18E-05	8.77E-07
2-Ethyl-3-methylcyclopentene	0.00E+00	110	0.00E+00	0.00E+00	2.61E-03	1.21E+01	5.81E+02	1.60E+01	1.57E-05	0.00E+00	1.00E-06
1,3-Hexadiene, 3-ethyl-2-methyl-, (Z)-	0.00E+00	124	0.00E+00	0.00E+00	3.17E-03	1.66E+01	7.96E+02	2.10E+01	2.15E-05	0.00E+00	1.37E-06
Bicyclo[4.1.0]heptane, 3-methyl-	0.00E+00	110	0.00E+00	0.00E+00	4.77E-03	2.22E+01	1.06E+03	2.90E+01	2.87E-05	0.00E+00	1.83E-06
1-Cyclohexyl-2-methyl-prop-2-en-	0.00E+00	152	0.00E+00	0.00E+00	7.72E-03	4.96E+01	2.38E+03	6.40E+01	6.41E-05	0.00E+00	3.70E-06

Table 35: Laboratory results and material balance determined emission factors and combustion efficiency for Location 5 – Cold Heavy Oil Production – Screw Pump Engine.												
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
1-one											
Cyclohexanone, 2-(2-methylpropylidene)-	0.00E+00	152	0.00E+00	0.00E+00	3.75E-03	2.41E+01	1.15E+03	3.10E+01	3.12E-05	0.00E+00	1.80E-06
Benzene, 1,2,3,5-tetramethyl-	0.00E+00	134	0.00E+00	0.00E+00	3.48E-03	1.97E+01	9.44E+02	2.50E+01	2.55E-05	0.00E+00	1.67E-06
Unresolved Hydrocarbons (C12+)	0.00E+00	150	0.00E+00	0.00E+00	8.00E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Isopentane	7.03E+05	72	2.39E-02	3.32E-02	1.52E-03	4.63E+00	2.22E+02	5.98E+00	5.98E-06	1.66E-03	3.64E-07
Pentane	4.05E+05	72	1.38E-02	1.91E-02	6.84E-04	2.08E+00	9.97E+01	2.69E+00	2.69E-06	9.56E-04	1.64E-07
2,2-Dimethylbutane	4.95E+04	86	1.41E-03	1.95E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2,3-Dimethylbutane	1.11E+05	86	3.17E-03	4.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.64E-04	0.00E+00
Cyclopentane	1.24E+05	70	4.34E-03	6.02E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.01E-04	0.00E+00
2-Methylpentane	3.08E+05	86	8.77E-03	1.22E-02	4.60E-04	1.67E+00	8.01E+01	2.16E+00	2.16E-06	7.31E-04	1.32E-07
3-Methylpentane	2.16E+05	86	6.16E-03	8.55E-03	2.74E-04	9.97E-01	4.77E+01	1.29E+00	1.29E-06	5.13E-04	7.87E-08
										Comb Eff =	**99.60%**
										CH4 Comb Eff =	**99.94%**
										THC Comb Eff =	**99.89%**

Table 36: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 5 – Cold Heavy Oil Production – Screw Pump Engine.							
Excess Air	415%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
			Wet Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	1.02	1.95	8.27	39	50
18	0	**percentage, %**	2.04	3.91	17	77	100
			Dry Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	1.02		8.27	39	48
22	0	**percentage, %**	2.12		17	81	100

Table 37: Gas analysis for determine the metals emission factor in flue gas for Location 5 – Cold Heavy Oil Production – Tank Heater and Screw Pump Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Process Heater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Process Heater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Aluminum	337	804	241	96	563	1.34E-04	7.96E-04
Antimony	0.0864	0.123	0.062	0.0244	0.061	3.42E-08	8.62E-08
Arsenic	20.6	58.1	19.2	1.40	38.9	1.96E-06	5.50E-05
Barium	133	387	85	48	302	6.72E-05	4.27E-04
Beryllium	0.0277	0.0347	0.0192	0.0085	0.0155	1.19E-08	2.19E-08
Bismuth	0.0085	0.0323	0.001	0.0075	0.0313	1.05E-08	4.42E-08
Boron	532	997	533	0	464	0.00E+00	6.56E-04
Cadmium	0.436	4.58	0.0119	0.4241	4.5681	5.94E-07	6.46E-06
Calcium	0.33	0.722	0.185	0.145	0.537	2.03E-07	7.59E-07
Chlorine	0.1	0.491	0.1	0	0.391	0.00E+00	5.53E-07
Chromium	15.9	5.86	0.295	15.605	5.565	2.18E-05	7.86E-06
Cobalt	0.158	0.156	0.0054	0.1526	0.1506	2.14E-07	2.13E-07
Copper	4.78	34.4	1.86	2.92	32.54	4.09E-06	4.60E-05
Iron	398	155	18.8	379.2	136.2	5.31E-04	1.92E-04
Lead	3.58	4.81	0.287	3.293	4.523	4.61E-06	6.39E-06
Lithium	0.02	0.955	0.02	0	0.935	0.00E+00	1.32E-06
Magnesium	0.0262	0.0621	0.0056	0.0206	0.0565	2.88E-08	7.98E-08
Manganese	6.48	7.77	0.496	5.984	7.274	8.38E-06	1.03E-05
Mercury	0.01	0.0381	0.01	0	0.0281	0.00E+00	3.97E-08
Molybdenum	0.258	0.323	0.0266	0.2314	0.2964	3.24E-07	4.19E-07
Nickel	9.67	41.4	0.213	9.457	41.187	1.32E-05	5.82E-05
Phosphorus	0.8	3.04	0.8	0	2.24	0.00E+00	3.17E-06
Potassium	161	356	99.7	61.3	256.3	8.58E-05	3.62E-04

Table 37: Gas analysis for determine the metals emission factor in flue gas for Location 5 – Cold Heavy Oil Production – Tank Heater and Screw Pump Engine.

Component	Lab Analysis			Method Blank Corrected		Emission Factor,	
	Process Heater, Flue Gas	Reciprocating Engine, Flue Gas	Method Blank	Process Heater, Flue Gas	Reciprocating Engine, Flue Gas	Process Heater, Flue Gas	Reciprocating Engine, Flue Gas
	μg/L	μg/L	μg/L	μg/L	μg/L	kg/GJ (Fuel)	kg/GJ (Fuel)
Selenium	0.1	0.1	0.1	0	0	0.00E+00	0.00E+00
Silicon	0.361	0.553	0.285	0.076	0.268	1.06E-07	3.79E-07
Silver	0.291	0.787	0.0542	0.2368	0.7328	3.31E-07	1.04E-06
Sodium	994	3150	943	51	2207	7.14E-05	3.12E-03
Strontium	2.72	4.41	3.54	0	0.87	0.00E+00	1.23E-06
Sulphur	1.23	10.5	0.2	1.03	10.3	1.44E-06	1.46E-05
Thallium	0.0016	0.01	0.001	0.0006	0.009	8.40E-10	1.27E-08
Thorium	0.0325	0.0875	0.0095	0.023	0.078	3.22E-08	1.10E-07
Tin	0.439	1.38	0.39	0.049	0.99	6.86E-08	1.40E-06
Titanium	2.96	3.61	0.782	2.178	2.828	3.05E-06	4.00E-06
Uranium	0.0099	0.0454	0.0045	0.0054	0.0409	7.56E-09	5.78E-08
Vanadium	0.128	0.128	0.015	0.113	0.113	1.58E-07	1.60E-07
Zinc	46.3	52.3	2.31	43.99	49.99	6.16E-05	7.06E-05

Table 38: Laboratory results and material balance determined emission factors and combustion efficiency for Location 6 – Sour Processing Plant– Steam Boiler.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	5.45E+08	16	8.33E+01	8.84E+01	1.26E+02	8.53E+04	1.20E+06	2.93E+04	2.93E-02	8.84E-01	1.77E-03
Ethane	6.79E+07	30	5.54E+00	5.88E+00	1.70E+00	2.16E+03	3.02E+04	7.41E+02	7.42E-04	1.18E-01	4.77E-05
Ethylene	0.00E+00	28	0.00E+00	0.00E+00	1.70E+00	2.01E+03	2.82E+04	6.92E+02	6.92E-04	0.00E+00	4.77E-05
Propane	3.65E+07	44	2.03E+00	2.15E+00	6.00E-01	1.12E+03	1.57E+04	3.83E+02	3.84E-04	6.46E-02	2.52E-05

Table 38: Laboratory results and material balance determined emission factors and combustion efficiency for Location 6 – Sour Processing Plant– Steam Boiler.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**μg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**μg/m^3**	**μg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Isobutane	8.81E+06	58	3.70E-01	3.90E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.58E-02	0.00E+00
Butane	1.18E+07	58	5.00E-01	5.30E-01	1.39E+01	3.41E+04	4.78E+05	1.17E+04	1.17E-02	2.12E-02	7.80E-04
cis-2-Butene	7.51E+04	56	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.39E-04	0.00E+00
Propyne	1.98E+06	40	1.20E-01	1.30E-01	8.00E-01	1.35E+03	1.90E+04	4.65E+02	4.65E-04	3.86E-03	3.36E-05
Isopentane	2.52E+06	72	9.00E-02	9.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.54E-03	0.00E+00
Pentane	1.68E+06	72	6.00E-02	6.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.03E-03	0.00E+00
2,2-Dimethylbutane	2.30E+04	86	6.55E-04	6.95E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.17E-05	0.00E+00
2,3-Dimethylbutane	2.18E+04	86	6.20E-04	6.58E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.95E-05	0.00E+00
Cyclopentane	7.99E+04	70	2.79E-03	2.97E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.48E-04	0.00E+00
2-Methylpentane	2.03E+05	86	1.00E-02	1.00E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.67E-04	0.00E+00
3-Methylpentane	9.28E+04	86	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.68E-04	0.00E+00
Hexane	1.62E+05	86	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.94E-04	0.00E+00
Methylcyclopentane	2.85E+04	84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.28E-05	0.00E+00
Cyclohexane	2.73E+04	84	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.06E-05	0.00E+00
Benzene	1.61E+04	78	0.00E+00	0.00E+00	5.48E-02	1.81E+02	2.54E+03	6.20E+01	6.22E-05	5.37E-06	7.68E-07
2-Methylhexane	7.06E+03	100	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.28E-05	0.00E+00
Heptane	7.83E+03	100	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.42E-05	0.00E+00
Methylcyclohexane	6.63E+03	98	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.23E-05	0.00E+00
Toluene	0.00E+00	92	0.00E+00	0.00E+00	6.01E-03	2.34E+01	3.28E+02	8.04E+00	8.04E-06	0.00E+00	5.90E-07
Chlorobenzene-d5	0.00E+00	112	1.03E-10	1.10E-10	1.00E-06	4.74E-03	6.64E-02	1.63E-03	1.63E-09	6.59E-12	8.41E-11
Ethyl benzene	0.00E+00	106	0.00E+00	0.00E+00	7.05E-04	3.16E+00	4.43E+01	1.09E+00	1.09E-06	0.00E+00	7.91E-08
m,p-Xylene	0.00E+00	106	0.00E+00	0.00E+00	2.18E-03	9.77E+00	1.37E+02	3.36E+00	3.36E-06	0.00E+00	2.45E-07
o-Xylene	0.00E+00	106	0.00E+00	0.00E+00	2.20E-03	9.86E+00	1.38E+02	3.39E+00	3.39E-06	0.00E+00	2.47E-07
m-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	8.79E-04	4.46E+00	6.25E+01	1.53E+00	1.53E-06	0.00E+00	1.11E-07
p-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	4.15E-04	2.11E+00	2.95E+01	7.24E-01	7.24E-07	0.00E+00	5.24E-08
o-Ethyltoluene	0.00E+00	120	0.00E+00	0.00E+00	3.10E-04	1.57E+00	2.21E+01	5.41E-01	5.41E-07	0.00E+00	3.91E-08
Decane	0.00E+00	142	0.00E+00	0.00E+00	4.03E-04	2.42E+00	3.39E+01	8.32E-01	8.32E-07	0.00E+00	5.65E-08
1,2,4-Trimethylbenzene	0.00E+00	120	0.00E+00	0.00E+00	2.02E-03	1.03E+01	1.44E+02	3.53E+00	3.53E-06	0.00E+00	2.55E-07
1,2,3-Trimethylbenzene	0.00E+00	120	0.00E+00	0.00E+00	7.21E-04	3.66E+00	5.13E+01	1.26E+00	1.26E-06	0.00E+00	9.10E-08
Undecane	0.00E+00	156	0.00E+00	0.00E+00	3.79E-04	2.50E+00	3.51E+01	8.60E-01	8.60E-07	0.00E+00	5.84E-08
Dodecane	0.00E+00	170	0.00E+00	0.00E+00	4.66E-04	3.35E+00	4.70E+01	1.15E+00	1.15E-06	0.00E+00	7.84E-08

Table 38: Laboratory results and material balance determined emission factors and combustion efficiency for Location 6 – Sour Processing Plant– Steam Boiler.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	$\mu g/m^3$	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	$\mu g/m^3$	$\mu g/(m^3$ fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Hydrogen sulphide	1.50E+01	34	1.05E-06	1.11E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Carbonyl sulphide	9.08E+02	60	3.70E-05	3.93E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.93E-07	0.00E+00
Methyl mercaptan	1.81E+03	48	9.21E-05	9.78E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Ethyl mercaptan	2.18E+03	62	8.62E-05	9.15E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-06	0.00E+00
Dimethyl sulphide	7.60E+01	62	2.99E-06	3.18E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.35E-08	0.00E+00
Isopropyl mercaptan	1.74E+03	76	5.60E-05	5.94E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.78E-06	0.00E+00
tert-Butyl mercaptan	1.31E+02	90	3.58E-06	3.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.52E-07	0.00E+00
Propyl mercaptan	8.30E+01	76	2.68E-06	2.84E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.53E-08	0.00E+00
Thiophene	3.60E+01	84	1.05E-06	1.12E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.48E-08	0.00E+00
Dimethyl disulphide	9.42E+02	94	2.45E-05	2.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.20E-07	0.00E+00
1,2-Propadiene	0.00E+00	40	0.00E+00	0.00E+00	2.22E-03	3.75E+00	5.27E+01	1.29E+00	1.29E-06	0.00E+00	9.33E-08
1,3-Butadiyne	0.00E+00	50	0.00E+00	0.00E+00	1.52E-03	3.21E+00	4.51E+01	1.10E+00	1.10E-06	0.00E+00	8.52E-08
1-Buten-3-yne	0.00E+00	52	0.00E+00	0.00E+00	7.19E-04	1.58E+00	2.22E+01	5.40E-01	5.43E-07	0.00E+00	4.03E-08
2-Propanone	0.00E+00	58	0.00E+00	0.00E+00	4.32E-03	1.06E+01	1.49E+02	3.64E+00	3.64E-06	0.00E+00	1.81E-07
Butane, 2-methyl-	0.00E+00	72	0.00E+00	0.00E+00	3.78E-03	1.15E+01	1.61E+02	3.95E+00	3.95E-06	0.00E+00	2.64E-07
Cyclopentanol	0.00E+00	86	0.00E+00	0.00E+00	3.80E-04	1.38E+00	1.94E+01	4.70E-01	4.75E-07	0.00E+00	2.66E-08
Hexanal	0.00E+00	100	0.00E+00	0.00E+00	1.51E-03	6.38E+00	8.95E+01	2.19E+00	2.19E-06	0.00E+00	1.27E-07
Methyl Alcohol	0.00E+00	32	0.00E+00	0.00E+00	6.11E-03	8.26E+00	1.16E+02	2.84E+00	2.84E-06	0.00E+00	8.57E-08
Nitrous acid, methyl ester	0.00E+00	61	0.00E+00	0.00E+00	5.44E-03	1.40E+01	1.96E+02	4.82E+00	4.82E-06	0.00E+00	7.63E-08
Pentadecane	0.00E+00	212	0.00E+00	0.00E+00	1.14E-02	1.02E+02	1.43E+03	3.51E+01	3.51E-05	0.00E+00	2.40E-06
Propane, 2-methyl-	0.00E+00	58	0.00E+00	0.00E+00	9.03E-03	2.22E+01	3.10E+02	7.61E+00	7.61E-06	0.00E+00	5.06E-07
Nitrogen	2.47E+07	28	2.16E+00	2.29E+00	7.42E+05	8.79E+08	1.23E+10	3.02E+08	3.02E+02	0.00E+00	0.00E+00
Carbon dioxide	0.00E+00	44	0.00E+00	0.00E+00	7.28E+04	1.35E+07	1.90E+08	4.66E+07	4.66E+01	0.00E+00	0.00E+00
Oxygen	0.00E+00	32	0.00E+00	0.00E+00	6.30E+04	8.53E+07	1.20E+09	2.93E+07	2.90E+01	0.00E+00	0.00E+00
										Comb Eff =	**99.76%**
										CH4 Comb Eff =	**99.80%**
										THC Comb Eff =	**99.82%**

Table 39: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 6 – Sour Processing Plant – Steam Boiler.							
Excess Air	47%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	1.11	2.09	1.00	11.90	16
118	0	**percentage, %**	6.91	13	6.25	74	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	1.11		1.01	12	14
145	0	**percentage, %**	7.94		7.18	85	100

Table 40: Gas analysis for determine the metals emission factor in flue gas for Location 6 – Sour Processing Plant – Steam Boiler.				
Component	**Lab Analysis**		**Method Blank Corrected**	**Emission Factor**
	Steam Boiler, Flue Gas	**Method Blank**	**Steam Boiler, Flue Gas**	**Steam Boiler, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**kg/GJ (Fuel)**
Aluminum	172	0.5	1.72E+02	3.69E-10
Antimony	0.0968	0.0028	9.40E-02	2.02E-13
Arsenic	5.39	0.002	5.39E+00	1.16E-11
Barium	56.4	0.191	5.62E+01	1.21E-10
Beryllium	0.013	0.0062	6.80E-03	1.46E-14
Bismuth	0.0044	0.001	3.40E-03	7.32E-15
Boron	132	0.11	1.32E+02	2.84E-10
Cadmium	5.07	0.0087	5.06E+00	1.09E-11
Calcium	2.53	0.0134	2.52E+00	5.42E-12
Chlorine	0.243	0.1	1.43E-01	3.08E-13
Chromium	1.7	0.0493	1.65E+00	3.55E-12
Cobalt	0.152	0.001	1.51E-01	3.25E-13
Copper	22.7	0.05	2.27E+01	4.87E-11
Iron	102	2	1.00E+02	2.15E-10
Lead	3.43	0.0033	3.43E+00	7.38E-12

Table 40: Gas analysis for determine the metals emission factor in flue gas for Location 6 – Sour Processing Plant – Steam Boiler.				
Component	**Lab Analysis**		**Method Blank Corrected**	**Emission Factor**
	Steam Boiler, Flue Gas	**Method Blank**	**Steam Boiler, Flue Gas**	**Steam Boiler, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**kg/GJ (Fuel)**
Lithium	0.02	0.02	171.5	7.25E-05
Magnesium	0.0939	0.0021	0.094	3.98E-08
Manganese	13.1	0.0832	5.388	2.28E-06
Mercury	0.0484	0.01	56.209	2.38E-05
Molybdenum	3.55	0.0141	0.0068	2.88E-09
Nickel	6.84	0.0426	0.0034	1.44E-09
Phosphorus	1.83	0.8	131.89	5.58E-05
Potassium	169	3.77	5.0613	2.14E-06
Selenium	0.1	0.1	2.5166	1.06E-06
Silicon	0.147	0.01	0.143	6.05E-08
Silver	0.117	0.0221	1.6507	6.98E-07
Sodium	701	3.2	0.151	6.39E-08
Strontium	3.51	0.004	22.65	9.58E-06
Sulphur	0.689	0.2	100	4.23E-05
Thallium	0.0025	0.0003	3.4267	1.45E-06
Thorium	0.0096	0.0003	0	0.00E+00
Tin	2.02	0.03	0.0918	3.88E-08
Titanium	2.85	0.04	13.0168	5.51E-06
Uranium	0.0119	0.0009	0.0384	1.62E-08
Vanadium	0.0717	0.005	3.5359	1.50E-06
Zinc	259	0.245	6.7974	2.88E-06

Table 41: Laboratory results and material balance determined emission factors and combustion efficiency for Location 7 – Conventional Oil Production – Treater.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	4.07E+08	16	6.20E+01	6.90E+01	7.00E+00	4.53E+03	1.41E+05	3.71E+03	3.71E-03	6.87E-01	2.08E-04
Ethane	1.02E+08	30	8.00E+00	9.00E+00	0.00E+00	3.81E+02	1.18E+04	3.12E+02	3.12E-04	1.83E-01	1.86E-05
Propane	8.28E+07	44	2.48E-03	2.74E-03	1.00E-01	1.86E+02	5.78E+03	1.52E+02	1.52E-04	8.21E-05	9.32E-06
Isobutane	1.73E+07	58	7.31E-01	8.06E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.22E-02	0.00E+00
Butane	3.68E+07	58	1.55E+00	1.71E+00	1.00E-01	2.45E+02	7.62E+03	2.01E+02	2.01E-04	6.85E-02	1.24E-05
Propyne	1.14E+07	40	6.97E-01	7.69E-01	2.00E-01	3.38E+02	1.05E+04	2.77E+02	2.77E-04	2.31E-02	1.86E-05
Isopentane	1.30E+07	72	4.41E-01	4.86E-01	4.44E-03	1.35E+01	4.20E+02	1.11E+01	1.11E-05	2.43E-02	6.89E-07
Pentane	1.02E+07	72	3.47E-01	3.82E-01	3.79E-03	1.15E+01	3.58E+02	9.45E+00	9.45E-06	1.91E-02	5.89E-07
2,2-Dimethylbutane	1.59E+05	86	4.51E-03	4.98E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.99E-04	0.00E+00
2,3-Dimethylbutane	4.29E+05	86	1.22E-02	1.35E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.08E-04	0.00E+00
Cyclopentane	6.13E+05	70	2.14E-02	2.36E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.18E-03	0.00E+00
2-Methylpentane	2.71E+06	86	7.70E-02	8.49E-02	7.23E-04	2.63E+00	8.17E+01	2.15E+00	2.15E-06	5.09E-03	1.35E-07
3-Methylpentane	1.69E+06	86	4.80E-02	5.30E-02	3.49E-04	1.27E+00	3.94E+01	1.04E+00	1.04E-06	3.18E-03	6.50E-08
Hexane	3.26E+06	86	9.27E-02	1.02E-01	6.77E-04	2.46E+00	7.65E+01	2.02E+00	2.02E-06	6.14E-03	1.26E-07
Methylcyclopentane	6.08E+05	84	1.77E-02	1.95E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.17E-03	0.00E+00
Cyclohexane	5.97E+05	84	1.74E-02	1.92E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.15E-03	0.00E+00
Benzene	1.83E+05	78	5.74E-03	6.33E-03	5.50E-04	1.81E+00	5.63E+01	1.49E+00	1.49E-06	3.80E-04	1.02E-07
2-Methylhexane	4.27E+05	100	1.05E-02	1.15E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.07E-04	0.00E+00
2,3-Dimethylpentane	1.68E+05	100	4.11E-03	4.53E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.17E-04	0.00E+00
3-Methylhexane	4.82E+05	100	1.18E-02	1.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.11E-04	0.00E+00
Heptane	7.99E+05	100	1.96E-02	2.16E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.51E-03	0.00E+00
Methylcyclohexane	4.52E+05	98	1.13E-02	1.24E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.71E-04	0.00E+00
2-Methylheptane	9.79E+04	114	2.10E-03	2.32E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-04	0.00E+00
Toluene	2.24E+05	92	5.96E-03	6.57E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E-04	0.00E+00
3-Methylheptane	5.30E+04	114	1.14E-03	1.26E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-04	0.00E+00
Octane	1.89E+05	114	4.07E-03	4.49E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.59E-04	0.00E+00
Chlorobenzene-d5	0.00E+00	112	1.03E-10	1.14E-10	1.00E-06	4.74E-03	1.47E-01	3.88E-03	3.88E-09	6.85E-12	1.86E-10
Ethyl benzene	1.82E+04	106	4.20E-04	4.63E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.71E-05	0.00E+00
m,p-Xylene	3.37E+04	106	7.77E-04	8.57E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.86E-05	0.00E+00
Styrene	0.00E+00	104	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
o-Xylene	1.17E+04	106	2.70E-04	2.98E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E-05	0.00E+00

Table 41: Laboratory results and material balance determined emission factors and combustion efficiency for Location 7 – Conventional Oil Production – Treater.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Nonane	2.30E+04	128	4.40E-04	4.85E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.37E-05	0.00E+00
Decane	0.00E+00	142	0.00E+00	0.00E+00	7.03E-04	4.22E+00	1.31E+02	3.46E+00	3.46E-06	0.00E+00	2.18E-07
Undecane	0.00E+00	156	0.00E+00	0.00E+00	1.32E-02	8.71E+01	2.70E+03	7.13E+01	7.13E-05	0.00E+00	4.51E-06
Dodecane	0.00E+00	170	0.00E+00	0.00E+00	2.53E-02	1.82E+02	5.65E+03	1.49E+02	1.49E-04	0.00E+00	9.43E-06
2-Propanone	0.00E+00	58	0.00E+00	0.00E+00	2.01E-04	4.93E-01	1.53E+01	4.04E-01	4.04E-07	0.00E+00	1.87E-08
Formaldehyde	0.00E+00	30	0.00E+00	0.00E+00	5.03E-03	6.38E+00	1.98E+02	5.23E+00	5.23E-06	0.00E+00	1.56E-07
Uknown Sulfur	2.71E+04	64	1.03E-03	1.14E-03	3.96E-01	1.07E+03	3.33E+04	8.78E+02	8.78E-04	0.00E+00	0.00E+00
Undecane, 4,6-dimethyl-	0.00E+00	184	0.00E+00	0.00E+00	2.31E-03	1.80E+01	5.58E+02	1.47E+01	1.47E-05	0.00E+00	9.33E-07
Hydrogen sulphide	6.72E+06	34	4.83E-01	5.33E-01	6.46E-02	9.29E+01	2.88E+03	7.61E+01	7.61E-05	0.00E+00	0.00E+00
Methyl mercaptan	2.88E+04	48	1.47E-03	1.62E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.62E-05	0.00E+00
Ethyl mercaptan	6.06E+03	62	2.39E-04	2.64E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.27E-06	0.00E+00
Dimethyl sulphide	2.78E+03	62	1.10E-04	1.21E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.42E-06	0.00E+00
Isopropyl mercaptan	3.47E+03	76	1.12E-04	1.23E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.70E-06	0.00E+00
tert-Butyl mercaptan	5.06E+03	90	1.38E-04	1.52E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.07E-06	0.00E+00
Propyl mercaptan	1.05E+03	76	3.37E-05	3.72E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-06	0.00E+00
Thiophene	4.41E+02	84	1.28E-05	1.42E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.66E-07	0.00E+00
Isobutyl mercaptan	1.10E+03	90	2.99E-05	3.30E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.32E-06	0.00E+00
Ethyl sulphide	1.28E+02	90	3.48E-06	3.83E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.53E-07	0.00E+00
tert-Pentyl mercaptan	1.28E+03	104	3.01E-05	3.32E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.66E-06	0.00E+00
Dimethyl disulphide	5.50E+01	94	1.43E-06	1.58E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.15E-08	0.00E+00
2-methyl Thiophene	1.35E+02	98	3.36E-06	3.71E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.85E-07	0.00E+00
3-methyl Thiophene	2.11E+02	98	5.28E-06	5.82E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.91E-07	0.00E+00
Allyl sulphide	2.34E+02	114	5.03E-06	5.55E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.33E-07	0.00E+00
2,5-dimethyl Thiophene	6.30E+01	112	1.38E-06	1.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.11E-08	0.00E+00
Dimethyl trisulphide	2.07E+02	126	4.03E-06	4.44E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.88E-08	0.00E+00
1-Heptene, 3-methyl-	1.32E+04	112	2.88E-04	3.17E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.54E-05	0.00E+00
CYCLOBUTANE, ISOPROPYL-	6.47E+04	98	1.61E-03	1.78E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.25E-04	0.00E+00
Cyclohexane, 1,1,3-trimethyl-	1.36E+04	126	2.65E-04	2.92E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.63E-05	0.00E+00
Cyclohexane, 1,3-dimethyl-, cis-	2.42E+04	112	5.28E-04	5.82E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.66E-05	0.00E+00
Cyclohexane, ethyl-	1.65E+04	112	3.60E-04	3.97E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.18E-05	0.00E+00

Table 41: Laboratory results and material balance determined emission factors and combustion efficiency for Location 7 – Conventional Oil Production – Treater.											
	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Cyclopentane, 1,1-dimethyl-	1.50E+04	98	3.74E-04	4.12E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-05	0.00E+00
Cyclopentane, 1,2,3-trimethyl-, (1.alpha	1.54E+04	112	3.37E-04	3.72E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.98E-05	0.00E+00
Cyclopentane, 1,3-dimethyl-	4.31E+04	98	1.08E-03	1.19E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.31E-05	0.00E+00
Cyclopentane, ethyl-	1.69E+04	98	4.21E-04	4.65E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.25E-05	0.00E+00
Hexane, 2,4-dimethyl-	1.05E+04	114	2.25E-04	2.48E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.98E-05	0.00E+00
Unknown Sulfur	1.40E+04	32	1.07E-03	1.18E-03	3.96E-01	5.36E+02	1.66E+04	4.39E+02	4.39E-04	0.00E+00	0.00E+00
Nitrogen	8.42E+06	28	7.36E-01	8.11E-01	7.86E+05	9.31E+08	2.89E+10	7.62E+08	7.62E+02	0.00E+00	0.00E+00
Carbon dioxide	2.64E+08	44	1.50E+01	1.60E+01	5.67E+03	1.06E+07	3.28E+08	8.64E+06	9.00E+00	0.00E+00	0.00E+00
										Comb Eff =	**99.97%**
										CH4 Comb Eff =	**99.97%**
										THC Comb Eff =	**99.98%**

Table 42: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 7 – Conventional Oil Production - Treater.							
Excess Air	234%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
Wet Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	1.23	1.88	4.68	25	33
6.5	0	**percentage, %**	3.72	5.7	14	76	100
Dry Basis							
THC (ppm)	**CO (ppm)**	**m^3/h**	1.23		4.68	25	31
7.9	0	**percentage, %**	3.94		15	81	100

Table 43: Laboratory results and material balance determined emission factors and combustion efficiency for Location 7 – Conventional Oil Production – Reciprocating engine.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	µg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	µg/m^3	µg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
Methane	4.07E+08	16	6.23E+01	6.63E+01	2.74E+01	1.85E+04	6.11E+05	1.52E+04	1.52E-02	6.63E-01	9.02E-04
Ethane	1.02E+08	30	8.31E+00	8.84E+00	3.00E+00	3.81E+03	1.25E+05	3.11E+03	3.11E-03	1.77E-01	1.98E-04
Propane	5.27E+07	28	4.60E+00	4.90E+00	1.60E+00	1.90E+03	6.24E+04	1.55E+03	1.55E-03	1.47E-01	1.58E-04
Isobutane	1.31E+07	44	0.00E+00	0.00E+00	2.00E-01	3.72E+02	1.23E+04	3.05E+02	3.05E-04	1.06E-04	2.63E-05
Butane	2.66E+07	42	1.55E+00	1.65E+00	6.00E-01	1.07E+03	3.51E+04	8.72E+02	8.72E-04	6.61E-02	7.90E-05
Propyne	1.60E+07	56	7.00E-01	7.40E-01	4.00E-01	9.47E+02	3.12E+04	7.75E+02	7.75E-04	2.23E-02	3.95E-05
Isopentane	8.65E+06	48	4.40E-01	4.70E-01	1.75E-01	3.55E+02	1.17E+04	2.91E+02	2.91E-04	2.35E-02	2.88E-05
Pentane	8.78E+06	62	3.50E-01	3.70E-01	1.88E-01	4.93E+02	1.62E+04	4.03E+02	4.03E-04	1.84E-02	3.10E-05
2,2-Dimethylbutane	1.40E+05	76	0.00E+00	0.00E+00	2.54E-03	8.00E+00	2.69E+02	7.00E+00	6.68E-06	2.88E-04	5.02E-07
2,3-Dimethylbutane	3.79E+05	76	1.00E-02	1.00E-02	6.16E-03	2.00E+01	6.52E+02	1.60E+01	1.62E-05	7.80E-04	1.22E-06
Cyclopentane	7.88E+05	90	2.00E-02	2.00E-02	1.35E-02	5.10E+01	1.69E+03	4.20E+01	4.20E-05	1.14E-03	2.22E-06
2-Methylpentane	2.39E+06	76	8.00E-02	8.00E-02	5.20E-02	1.67E+02	5.50E+03	1.37E+02	1.37E-04	4.91E-03	1.03E-05
3-Methylpentane	1.49E+06	76	5.00E-02	5.00E-02	3.28E-02	1.05E+02	3.47E+03	8.60E+01	8.63E-05	3.07E-03	6.48E-06
Hexane	3.18E+06	84	9.00E-02	1.00E-01	6.64E-02	2.36E+02	7.77E+03	1.93E+02	1.93E-04	5.92E-03	1.31E-05
Methylcyclopentane	6.51E+05	90	2.00E-02	2.00E-02	1.27E-02	4.80E+01	1.59E+03	4.00E+01	3.96E-05	1.13E-03	2.51E-06
Cyclohexane	6.39E+05	90	2.00E-02	2.00E-02	1.23E-02	4.70E+01	1.54E+03	3.80E+01	3.83E-05	1.11E-03	2.43E-06
Benzene	2.11E+05	90	1.00E-02	1.00E-02	4.65E-03	1.80E+01	5.83E+02	1.40E+01	1.45E-05	3.67E-04	9.19E-07
2-Methylhexane	4.19E+05	98	1.00E-02	1.00E-02	8.51E-03	3.50E+01	1.16E+03	2.90E+01	2.89E-05	7.78E-04	1.96E-06
2,3-Dimethylpentane	1.75E+05	104	0.00E+00	0.00E+00	3.21E-03	1.40E+01	4.65E+02	1.20E+01	1.16E-05	3.06E-04	7.40E-07
3-Methylhexane	4.53E+05	94	1.00E-02	1.00E-02	1.02E-02	4.10E+01	1.34E+03	3.30E+01	3.32E-05	8.79E-04	2.35E-06
Heptane	7.83E+05	98	2.00E-02	2.00E-02	2.12E-02	8.80E+01	2.89E+03	7.20E+01	7.19E-05	1.46E-03	4.89E-06
Methylcyclohexane	4.52E+05	98	1.00E-02	1.00E-02	1.29E-02	5.30E+01	1.76E+03	4.40E+01	4.37E-05	8.40E-04	2.97E-06
2-Methylheptane	7.56E+04	88	0.00E+00	0.00E+00	4.52E-03	1.70E+01	5.54E+02	1.40E+01	1.38E-05	1.79E-04	1.19E-06
Toluene	2.53E+05	104	1.00E-02	1.00E-02	8.46E-03	3.70E+01	1.23E+03	3.00E+01	3.04E-05	4.44E-04	1.95E-06
3-Methylheptane	5.21E+04	112	0.00E+00	0.00E+00	2.56E-03	1.20E+01	3.99E+02	1.00E+01	9.92E-06	9.69E-05	6.74E-07
Octane	1.89E+05	114	0.00E+00	0.00E+00	1.24E-02	6.00E+01	1.97E+03	4.90E+01	4.89E-05	3.46E-04	3.27E-06
Chlorobenzene-d5	0.00E+00	126	0.00E+00	0.00E+00	1.00E-06	0.00E+00	0.00E+00	0.00E+00	4.36E-09	6.61E-12	1.98E-10
Ethyl benzene	1.92E+04	112	0.00E+00	0.00E+00	1.96E-03	9.00E+00	3.06E+02	8.00E+00	7.60E-06	3.58E-05	5.16E-07
m,p-Xylene	3.75E+04	118	0.00E+00	0.00E+00	4.53E-03	2.30E+01	7.44E+02	1.80E+01	1.85E-05	6.61E-05	1.19E-06
o-Xylene	1.39E+04	126	0.00E+00	0.00E+00	1.80E-03	1.00E+01	3.16E+02	8.00E+00	7.85E-06	2.30E-05	4.74E-07
Nonane	1.76E+04	98	0.00E+00	0.00E+00	9.97E-03	4.10E+01	1.36E+03	3.40E+01	3.38E-05	4.21E-05	2.95E-06

Table 43: Laboratory results and material balance determined emission factors and combustion efficiency for Location 7 – Conventional Oil Production – Reciprocating engine.

	Fuel Gas C_i (Lab Analyses)			Norm Fuel Gas C_i	Flue Gas C_i (Lab Analyses)		C_i Emission factor			Combustion Efficiency Calculation	
Based on 1 m^3 of fuel gas	μg/m^3	MW	Vol% C_i/m^3	Norm Vol% C_i/m^3	ppmv	μg/m^3	μg/ (m^3 fuel)	ug /(MJ fuel)	kg /(GJ fuel)	Non CO_2 C inlet	Non CO_2 C outlet
n-Propylbenzene	0.00E+00	98	0.00E+00	0.00E+00	9.80E-04	4.00E+00	1.34E+02	3.00E+00	3.32E-06	0.00E+00	2.90E-07
m-Ethyltoluene	0.00E+00	112	0.00E+00	0.00E+00	2.99E-03	1.40E+01	4.66E+02	1.20E+01	1.16E-05	0.00E+00	8.86E-07
p-Ethyltoluene	0.00E+00	72	0.00E+00	0.00E+00	1.54E-03	5.00E+00	1.54E+02	4.00E+00	3.84E-06	0.00E+00	4.56E-07
1,3,5-Trimethylbenzene	0.00E+00	70	0.00E+00	0.00E+00	1.34E-03	4.00E+00	1.31E+02	3.00E+00	3.25E-06	0.00E+00	3.97E-07
o-Ethyltoluene	0.00E+00	72	0.00E+00	0.00E+00	2.01E-03	6.00E+00	2.02E+02	5.00E+00	5.01E-06	0.00E+00	5.96E-07
Decane	0.00E+00	68	0.00E+00	0.00E+00	1.45E-02	4.20E+01	1.37E+03	3.40E+01	3.41E-05	0.00E+00	4.77E-06
1,2,4-Trimethylbenzene	0.00E+00	70	0.00E+00	0.00E+00	5.57E-03	1.60E+01	5.43E+02	1.30E+01	1.35E-05	0.00E+00	1.65E-06
1,2,3-Trimethylbenzene	0.00E+00	70	0.00E+00	0.00E+00	2.74E-03	8.00E+00	2.67E+02	7.00E+00	6.64E-06	0.00E+00	8.12E-07
m-Diethylbenzene	0.00E+00	86	0.00E+00	0.00E+00	9.01E-04	3.00E+00	1.08E+02	3.00E+00	2.68E-06	0.00E+00	2.97E-07
Undecane	0.00E+00	86	0.00E+00	0.00E+00	1.35E-02	4.90E+01	1.62E+03	4.00E+01	4.02E-05	0.00E+00	4.89E-06
Dodecane	0.00E+00	70	0.00E+00	0.00E+00	4.51E-02	1.34E+02	4.40E+03	1.09E+02	1.09E-04	0.00E+00	1.78E-05
1,2,4-Trimethylcyclopentane	0.00E+00	86	0.00E+00	0.00E+00	4.78E-04	2.00E+00	5.70E+01	1.00E+00	1.42E-06	0.00E+00	1.26E-07
1-Methyl-2-n-hexylbenzene	0.00E+00	86	0.00E+00	0.00E+00	2.56E-02	9.30E+01	3.07E+03	7.60E+01	7.62E-05	0.00E+00	1.10E-05
1-trans-2-cis-3-trans-trimethylcyclopent	0.00E+00	84	0.00E+00	0.00E+00	3.64E-04	1.00E+00	4.30E+01	1.00E+00	1.06E-06	0.00E+00	9.59E-08
2-Pentanone, 4-methyl-4-phenyl-	0.00E+00	86	0.00E+00	0.00E+00	3.03E-02	1.10E+02	3.63E+03	9.00E+01	9.02E-05	0.00E+00	1.20E-05
Benzene, 1-methyl-2-(phenylmethyl)-	0.00E+00	84	0.00E+00	0.00E+00	2.05E-02	7.30E+01	2.40E+03	6.00E+01	5.96E-05	0.00E+00	9.45E-06
CYCLOBUTANE, ISOPROPYL-	6.60E+04	100	0.00E+00	0.00E+00	1.28E-03	5.00E+00	1.78E+02	4.00E+00	4.43E-06	1.20E-04	2.95E-07
Cyclohexane, 1,1-dimethyl-	0.00E+00	84	0.00E+00	0.00E+00	1.64E-04	1.00E+00	1.90E+01	0.00E+00	4.77E-07	0.00E+00	4.32E-08
Cyclohexane, 1,4-dimethyl-	0.00E+00	78	0.00E+00	0.00E+00	1.04E-03	3.00E+00	1.13E+02	3.00E+00	2.81E-06	0.00E+00	2.74E-07
Cyclohexane, ethyl-	1.47E+04	100	0.00E+00	0.00E+00	1.28E-03	5.00E+00	1.78E+02	4.00E+00	4.43E-06	3.07E-05	3.37E-07
Cyclopentane, 1,1-dimethyl-	1.53E+04	100	0.00E+00	0.00E+00	2.67E-04	1.00E+00	3.70E+01	1.00E+00	9.24E-07	2.78E-05	6.15E-08
Cyclopentane, 1,3-dimethyl-	4.40E+04	100	0.00E+00	0.00E+00	9.74E-04	4.00E+00	1.36E+02	3.00E+00	3.37E-06	8.02E-05	2.24E-07
Cyclopentane, ethyl-	1.96E+04	114	0.00E+00	0.00E+00	5.74E-04	3.00E+00	9.10E+01	2.00E+00	2.26E-06	3.14E-05	1.32E-07
Cyclotrisiloxane, hexamethyl-	0.00E+00	100	0.00E+00	0.00E+00	2.04E-03	9.00E+00	2.84E+02	7.00E+00	7.06E-06	0.00E+00	4.03E-07
Dodecane, 4,6-dimethyl-	0.00E+00	98	0.00E+00	0.00E+00	1.82E-02	7.50E+01	2.48E+03	6.20E+01	6.17E-05	0.00E+00	8.39E-06
Heptane, 2,3-dimethyl-	0.00E+00	114	0.00E+00	0.00E+00	3.28E-04	2.00E+00	5.20E+01	1.00E+00	1.29E-06	0.00E+00	9.72E-08
Heptane, 3-ethyl-2-methyl-	0.00E+00	114	0.00E+00	0.00E+00	6.29E-04	3.00E+00	1.00E+02	2.00E+00	2.48E-06	0.00E+00	2.07E-07
Hexane, 2,3-dimethyl-	0.00E+00	92	0.00E+00	0.00E+00	1.83E-04	1.00E+00	2.30E+01	1.00E+00	5.83E-07	0.00E+00	4.82E-08
Hexane, 2,4-dimethyl-	1.05E+04	114	0.00E+00	0.00E+00	3.43E-04	2.00E+00	5.40E+01	1.00E+00	1.35E-06	1.91E-05	9.04E-08

Table 43: Laboratory results and material balance determined emission factors and combustion efficiency for Location 7 – Conventional Oil Production – Reciprocating engine.											
	Fuel Gas C_i (Lab Analyses)			**Norm Fuel Gas C_i**	**Flue Gas C_i (Lab Analyses)**		**C_i Emission factor**			**Combustion Efficiency Calculation**	
Based on 1 m^3 of fuel gas	**µg/m^3**	**MW**	**Vol% C_i/m^3**	**Norm Vol% C_i/m^3**	**ppmv**	**µg/m^3**	**µg/ (m^3 fuel)**	**ug /(MJ fuel)**	**kg /(GJ fuel)**	**Non CO_2 C inlet**	**Non CO_2 C outlet**
Hexane, 2,5-dimethyl-	0.00E+00	114	0.00E+00	0.00E+00	2.16E-04	1.00E+00	3.40E+01	1.00E+00	8.52E-07	0.00E+00	5.69E-08
Naphthalene, 2,6-dimethyl-	0.00E+00	112	0.00E+00	0.00E+00	1.56E-02	7.40E+01	2.43E+03	6.00E+01	6.05E-05	0.00E+00	6.16E-06
Naphthalene, 2-methyl-	0.00E+00	106	0.00E+00	0.00E+00	2.98E-02	1.34E+02	4.40E+03	1.09E+02	1.09E-04	0.00E+00	1.08E-05
Nonadecane	0.00E+00	106	0.00E+00	0.00E+00	4.89E-02	2.19E+02	7.22E+03	1.79E+02	1.79E-04	0.00E+00	3.06E-05
Octane, 2,6-dimethyl-	0.00E+00	104	0.00E+00	0.00E+00	2.75E-03	1.20E+01	3.98E+02	1.00E+01	9.90E-06	0.00E+00	9.05E-07
Octane, 2-methyl-	0.00E+00	106	0.00E+00	0.00E+00	7.97E-04	4.00E+00	1.18E+02	3.00E+00	2.92E-06	0.00E+00	2.36E-07
Tetradecane	0.00E+00	128	0.00E+00	0.00E+00	2.28E-02	1.23E+02	4.06E+03	1.01E+02	1.01E-04	0.00E+00	1.05E-05
Unresolved Hydrocarbons (C12+)	0.00E+00	120	0.00E+00	0.00E+00	3.70E+00	1.88E+04	6.18E+05	1.54E+04	1.54E-02	0.00E+00	0.00E+00
Hydrogen sulphide	2.37E+07	120	4.80E-01	5.10E-01	2.44E-02	1.24E+02	4.08E+03	1.01E+02	1.01E-04	0.00E+00	0.00E+00
Methyl mercaptan	7.21E+04	120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.56E-05	0.00E+00
Ethyl mercaptan	1.17E+04	120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.09E-06	0.00E+00
Dimethyl sulphide	5.38E+03	120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.33E-06	0.00E+00
Isopropyl mercaptan	5.48E+03	120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.57E-06	0.00E+00
Isopropyl mercaptan	5.48E+03	120	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.57E-06	0.00E+00
Nitrogen	8.42E+06	113	1.80E-01	1.90E-01	7.79E+05	9.23E+08	3.04E+10	7.55E+08	7.55E+02	0.00E+00	0.00E+00
Carbon dioxide	2.64E+08	44	1.47E+01	1.56E+01	1.49E+03	2.77E+06	9.13E+07	2.27E+06	2.27E+00	0.00E+00	0.00E+00
Oxygen	0.00E+00	32	0.00E+00	0.00E+00	2.19E+05	2.96E+08	9.76E+09	2.43E+08	2.43E+02	0.00E+00	0.00E+00
										Comb Eff =	**99.85%**
										CH4 Comb Eff =	**99.86%**
										THC Comb Eff =	**99.89%**

Table 44: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 7 – Conventional Oil Production – Reciprocating Engine.							
Excess Air	234%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
			Wet Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	1.30	1.96	4.97	27	35
31	0	**percentage, %**	3.72	5.63	14	76	100

Table 44: Wet and dry flue gas analyses and flow rates based on 1 m^3/h of fuel gas at excess air rate determined by material balance and flue gas oxygen content for the Location 7 – Conventional Oil Production – Reciprocating Engine.							
Excess Air	234%	**Item**	**CO_2**	**H_2O**	**O_2**	**N_2**	**Total**
			Dry Basis				
THC (ppm)	**CO (ppm)**	**m^3/h**	1.30		4.97	27	33
38	0	**percentage, %**	3.94		15	81	100

Table 45: Gas analysis for determine the metals emission factor in flue gas for Location 7 – Conventional Oil Production – Treater and Reciprocating Engine.

Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Treater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Treater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Treater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Aluminum	869	812	0.5	868.5	811.5	7.42E-04	6.90E-04
Antimony	0.278	0.156	0.005	0.273	0.151	2.33E-07	1.28E-07
Arsenic	45.7	55.3	0.0209	45.6791	55.2791	3.90E-05	4.70E-05
Barium	461	437	0.0192	460.9808	436.9808	3.94E-04	3.71E-04
Beryllium	0.0305	0.0278	0.0109	0.0196	0.0169	1.67E-08	1.44E-08
Bismuth	0.0211	0.0093	0.001	0.0201	0.0083	1.72E-08	7.05E-09
Boron	922	871	0.822	921.178	870.178	7.87E-04	7.39E-04
Cadmium	47.6	1.07	0.0067	47.5933	1.0633	4.06E-05	9.04E-07
Calcium	1.56	3.37	0.0095	1.5505	3.3605	1.32E-06	2.86E-06
Chlorine	0.725	0.418	0.1	0.625	0.318	5.34E-07	2.70E-07
Chromium	2.91	2.27	0.03	2.88	2.24	2.46E-06	1.90E-06
Cobalt	0.0992	0.0788	0.001	0.0982	0.0778	8.39E-08	6.61E-08
Copper	32.5	19.4	0.05	32.45	19.35	2.77E-05	1.64E-05
Iron	71.3	62.9	2	69.3	60.9	5.92E-05	5.18E-05
Lead	5.74	2.56	0.0045	5.7355	2.5555	4.90E-06	2.17E-06
Lithium	0.847	0.149	0.02	0.827	0.129	7.06E-07	1.10E-07

Table 45: Gas analysis for determine the metals emission factor in flue gas for Location 7 – Conventional Oil Production – Treater and Reciprocating Engine.							
Component	**Lab Analysis**			**Method Blank Corrected**		**Emission Factor,**	
	Treater, Flue Gas	**Reciprocating Engine, Flue Gas**	**Method Blank**	**Treater, Flue Gas**	**Reciprocating Engine, Flue Gas**	**Treater, Flue Gas**	**Reciprocating Engine, Flue Gas**
	µg/L	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**kg/GJ (Fuel)**	**kg/GJ (Fuel)**
Magnesium	0.0731	0.132	0.0014	0.0717	0.1306	6.12E-08	1.11E-07
Manganese	3.77	5.43	0.03	3.74	5.4	3.19E-06	4.59E-06
Mercury	0.0455	0.01	0.01	0.0355	0	3.03E-08	0.00E+00
Molybdenum	0.825	1.43	0.116	0.709	1.314	6.05E-07	1.12E-06
Nickel	13.6	7.46	0.0915	13.5085	7.3685	1.15E-05	6.26E-06
Phosphorus	23	2.3	0.8	22.2	1.5	1.90E-05	1.27E-06
Potassium	506	403	2.73	503.27	400.27	4.30E-04	3.40E-04
Selenium	0.111	0.1	0.1	0.011	0	9.39E-09	0.00E+00
Silicon	0.604	0.575	0.01	0.594	0.565	5.07E-07	4.80E-07
Silver	0.172	0.0488	0.0142	0.1578	0.0346	1.35E-07	2.94E-08
Sodium	3270	3080	2	3268	3078	2.79E-03	2.62E-03
Strontium	6.88	9.46	0.0263	6.8537	9.4337	5.85E-06	8.02E-06
Sulphur	0.351	0.2	0.2	0.151	0	1.29E-07	0.00E+00
Thallium	0.0085	0.0059	0.0005	0.008	0.0054	6.83E-09	4.59E-09
Thorium	0.099	0.0573	0.0003	0.0987	0.057	8.43E-08	4.84E-08
Tin	0.681	0.568	0.03	0.651	0.538	5.56E-07	4.57E-07
Titanium	4.31	2.98	0.0584	4.2516	2.9216	3.63E-06	2.48E-06
Uranium	0.039	0.0317	0.0005	0.0385	0.0312	3.29E-08	2.65E-08
Vanadium	0.148	0.107	0.0062	0.1418	0.1008	1.21E-07	8.57E-08
Zinc	79.9	90.8	0.299	79.601	90.501	6.80E-05	7.69E-05

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 1	Compressor	Methane	7.78E-01	5.82E-06	133,580
Location 1	Compressor	Methane, nitro-	1.01E-04	4.51E-08	2,248
Location 1	Compressor	Pentane	5.19E-05	5.32E-08	975
Location 1	Compressor	Ethane	4.72E-03	5.82E-06	811
Location 1	Compressor	Isopentane	4.23E-05	5.32E-08	795
Location 1	Compressor	Acrolein	9.09E-05	2.76E-07	329
Location 1	Compressor	Ethylene	1.42E-03	5.82E-06	244
Location 1	Compressor	1-Pentene	1.14E-05	5.17E-08	220
Location 1	Compressor	Nitrogen	4.36E+02	3.49E+00	125
Location 1	Compressor	Propane	4.62E-04	5.82E-06	79
Location 1	Compressor	Carbon dioxide	3.22E+01	5.82E-01	55
Location 1	Compressor	Butane	1.47E-04	5.82E-06	25
Location 1	Compressor	Isobutane	1.12E-04	5.82E-06	19
Location 1	Compressor	Formaldehyde	1.63E-05	1.48E-06	11
Location 1	Compressor	Carbonyl sulphide	1.13E-05	1.48E-06	7.67
Location 1	Compressor	1-Hexene	7.40E-06	2.07E-06	3.58
Location 1	Compressor	1-Butene	6.09E-05	6.90E-05	0.88
Location 1	Compressor	Benzene	2.36E-05	5.82E-05	0.41
Location 1	Compressor	Toluene	5.26E-06	5.82E-05	0.090
Location 1	Reboiler	Nitrogen	3.31E+02	3.49E+00	95
Location 1	Reboiler	Carbon dioxide	4.98E+01	5.82E-01	86
Location 1	Reboiler	Methane	2.71E-04	5.82E-06	46
Location 1	Reboiler	Isopentane	1.00E-06	5.32E-08	19
Location 1	Reboiler	Acetone	3.02E-06	2.86E-07	11
Location 2	Compressor	Methane	3.67E-02	5.82E-06	6,301
Location 2	Compressor	Phthalic anhydride	1.88E-04	1.09E-07	1,723
Location 2	Compressor	Ethylene	3.45E-03	5.82E-06	593
Location 2	Compressor	Ethane	1.33E-03	5.82E-06	229
Location 2	Compressor	Isopentane	5.47E-06	5.32E-08	103

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.					
	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 2	Compressor	Carbon dioxide	4.98E+01	5.82E-01	85
Location 2	Compressor	Nitrogen	2.47E+02	3.49E+00	71
Location 2	Compressor	Ethyne, dichloro-	3.58E-06	6.95E-08	52
Location 2	Compressor	Pyridine, 3,5-dimethyl-	3.50E-06	7.91E-08	44
Location 2	Compressor	Methane, nitro-	8.32E-07	4.51E-08	18
Location 2	Compressor	Benzene	2.92E-04	5.82E-05	5.02
Location 2	Compressor	Isobutane	2.05E-05	5.82E-06	3.52
Location 2	Compressor	Formic acid	3.62E-06	1.13E-06	3.19
Location 2	Compressor	Butane	1.65E-05	5.82E-06	2.83
Location 2	Compressor	Toluene	3.89E-05	5.82E-05	0.67
Location 2	Compressor	1-Butene	3.66E-05	6.90E-05	0.53
Location 2	Compressor	Isopropylbenzene	1.09E-05	5.82E-05	0.19
Location 2	Compressor	Ethyl benzene	1.60E-06	5.82E-05	0.027
Location 2	Compressor	m,p-Xylene	1.34E-06	5.82E-05	0.023
Location 2	Reboiler	Methane	1.20E-02	5.82E-06	2,062
Location 2	Reboiler	Isopentane	1.88E-05	5.32E-08	353
Location 2	Reboiler	Nitrogen	6.04E+02	3.49E+00	173
Location 2	Reboiler	Carbon dioxide	5.35E+01	5.82E-01	92
Location 2	Reboiler	Methylcyclopentane	1.78E-06	6.21E-08	29
Location 2	Reboiler	Butane	3.27E-05	5.82E-06	6
Location 2	Reboiler	Isobutane	2.73E-05	5.82E-06	4.69
Location 2	Reboiler	Cyclopropane, 1-methyl-1-isopropenyl-	8.71E-06	2.36E-06	3.68
Location 2	Reboiler	Toluene	4.77E-05	5.82E-05	0.82
Location 2	Reboiler	Benzene	9.32E-06	5.82E-05	0.16
Location 2	Reboiler	1-Butene	6.48E-06	6.90E-05	0.09
Location 3	Reboiler	Methylcyclohexane	1.09E-05	7.24E-08	150
Location 3	Reboiler	2,2,4-Trimethylpentane	9.50E-06	8.42E-08	113
Location 3	Reboiler	Nitrogen	3.04E+02	3.49E+00	87
Location 3	Reboiler	2,3-Dimethylpentane	6.23E-06	7.39E-08	84

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.					
	Sources	**Component**	**Emission Factor**		**Ratio of Measured/LDL**
			Measured	**LDL**	
			kg /(GJ fuel)		
Location 3	Reboiler	Carbon dioxide	4.77E+01	5.82E-01	82
Location 3	Reboiler	3-Methylhexane	5.52E-06	7.39E-08	75
Location 3	Reboiler	2,3,4-Trimethylpentane	5.96E-06	8.42E-08	71
Location 3	Reboiler	Octane	5.90E-06	8.42E-08	70
Location 3	Reboiler	Decane	7.33E-06	1.05E-07	70
Location 3	Reboiler	2-Methylpentane	4.27E-06	6.35E-08	67
Location 3	Reboiler	Methane	3.88E-04	5.82E-06	67
Location 3	Reboiler	2-Methylhexane	3.82E-06	7.39E-08	52
Location 3	Reboiler	Cyclohexane	3.09E-06	6.21E-08	50
Location 3	Reboiler	Heptane	3.44E-06	7.39E-08	47
Location 3	Reboiler	Undecane	5.30E-06	1.15E-07	46
Location 3	Reboiler	Methylcyclopentane	2.77E-06	6.21E-08	45
Location 3	Reboiler	3-Methylpentane	2.82E-06	6.35E-08	44
Location 3	Reboiler	Nonane	4.02E-06	9.46E-08	43
Location 3	Reboiler	Hexane	2.58E-06	6.35E-08	41
Location 3	Reboiler	3-Methylheptane	3.15E-06	8.42E-08	37
Location 3	Reboiler	Carbonyl sulphide	4.80E-05	1.48E-06	32
Location 3	Reboiler	m-Ethyltoluene	8.06E-05	2.96E-06	27
Location 3	Reboiler	Dodecane	3.21E-06	1.26E-07	26
Location 3	Reboiler	1,2,3-Trimethylbenzene	6.33E-05	2.96E-06	21
Location 3	Reboiler	2-Methylheptane	1.79E-06	8.42E-08	21
Location 3	Reboiler	Benzene, (1-methyl-1-propenyl)-, (Z)- (C	6.59E-05	3.25E-06	20
Location 3	Reboiler	o-Ethyltoluene	4.63E-05	2.96E-06	16
Location 3	Reboiler	Sulfur dioxide	7.06E-07	4.73E-08	15
Location 3	Reboiler	Benzene, 1-ethyl-2,3-dimethyl-	4.78E-05	3.30E-06	14
Location 3	Reboiler	Benzene, 1-methyl-2-(1-methylethyl)- (CA	4.49E-05	3.30E-06	14
Location 3	Reboiler	Endo-tricyclo[5.2.1.0(2.6)]decane	4.45E-05	3.35E-06	13
Location 3	Reboiler	Benzene, 1,2,3,4-tetramethyl-	3.71E-05	3.30E-06	11
Location 3	Reboiler	Naphthalene, 2-methyl-	3.16E-05	3.50E-06	9.03

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 3	Reboiler	Carbon disulfide	1.62E-05	1.87E-06	8.66
Location 3	Reboiler	p-Ethyltoluene	2.01E-05	2.96E-06	6.79
Location 3	Reboiler	Benzene, 1-methyl-2-propyl-	2.00E-05	3.30E-06	6.07
Location 3	Reboiler	Formaldehyde	7.78E-06	1.48E-06	5.26
Location 3	Reboiler	Naphthalene, decahydro-, trans-	1.57E-05	3.40E-06	4.63
Location 3	Reboiler	1,2,4-Trimethylbenzene	1.86E-04	5.82E-05	3.19
Location 3	Reboiler	1,4-Pentadiene, 3,3-dimethyl-	6.32E-06	2.36E-06	2.67
Location 3	Reboiler	m-Diethylbenzene	8.23E-06	3.30E-06	2.49
Location 3	Reboiler	Dimethyl disulphide	4.36E-06	2.32E-06	1.88
Location 3	Reboiler	o-Xylene	8.17E-05	5.82E-05	1.40
Location 3	Reboiler	1,3,5-Trimethylbenzene	6.93E-05	5.82E-05	1.19
Location 3	Reboiler	m,p-Xylene	6.35E-05	5.82E-05	1.09
Location 3	Reboiler	Acetic Acid	1.37E-06	1.48E-06	0.93
Location 3	Reboiler	Methyl ethyl disulfide	2.33E-06	2.66E-06	0.88
Location 3	Reboiler	Cyclohexane, 1,2-dimethyl-, cis-	2.26E-06	2.76E-06	0.82
Location 3	Reboiler	Cyclohexane, ethyl-	1.85E-06	2.76E-06	0.67
Location 3	Reboiler	Toluene	3.15E-05	5.82E-05	0.54
Location 3	Reboiler	Cyclohexane, 1,3-dimethyl-, trans-	1.23E-06	2.76E-06	0.45
Location 3	Reboiler	n-Propylbenzene	2.38E-05	5.82E-05	0.41
Location 3	Reboiler	Ethyl benzene	2.30E-05	5.82E-05	0.40
Location 3	Reboiler	trans-2-Butene	1.19E-05	6.90E-05	0.17
Location 3	Reboiler	Benzene	5.09E-06	5.82E-05	0.087
Location 3	Compressor	Methane	1.69E-01	5.82E-06	29,015
Location 3	Compressor	Ethylene	4.38E-03	5.82E-06	752
Location 3	Compressor	1-Pentene	3.60E-05	5.17E-08	697
Location 3	Compressor	Ethane	2.12E-03	5.82E-06	364
Location 3	Compressor	Isopentane	8.94E-06	5.32E-08	168
Location 3	Compressor	Nitrogen	3.28E+02	3.49E+00	94
Location 3	Compressor	Carbon dioxide	5.35E+01	5.82E-01	92

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 3	Compressor	Formic acid	5.76E-05	1.13E-06	51
Location 3	Compressor	1-Hexene	4.02E-05	2.07E-06	19
Location 3	Compressor	Isobutane	4.21E-05	5.82E-06	7.22
Location 3	Compressor	Cyclopentene-3-carboxylic acid, 1-(trime	3.41E-05	5.27E-06	6.46
Location 3	Compressor	Benzene	3.17E-04	5.82E-05	5.45
Location 3	Compressor	Butane	2.01E-05	5.82E-06	3.45
Location 3	Compressor	Silane, chlorotrimethyl-	7.65E-06	2.66E-06	2.88
Location 3	Compressor	1-Butene	1.60E-04	6.90E-05	2.32
Location 3	Compressor	s-Dichloroethyl ether	6.49E-06	3.50E-06	1.85
Location 3	Compressor	Toluene	8.02E-05	5.82E-05	1.38
Location 3	Compressor	Acetic Acid	1.47E-06	1.48E-06	0.99
Location 3	Compressor	m-Ethyltoluene	2.71E-06	2.96E-06	0.92
Location 3	Compressor	1,3-Pentadiene, (Z)-	1.06E-06	1.67E-06	0.63
Location 3	Compressor	Nonanol	2.17E-06	3.55E-06	0.61
Location 3	Compressor	trans-2-Butene	1.71E-05	6.90E-05	0.25
Location 3	Compressor	cis-2-Butene	7.43E-06	6.90E-05	0.11
Location 3	Compressor	m,p-Xylene	5.56E-06	5.82E-05	0.095
Location 3	Compressor	Ethyl benzene	2.32E-06	5.82E-05	0.040
Location 3	Compressor	o-Xylene	2.32E-06	5.82E-05	0.040
Location 4	Steam Gen	Isopentane	1.99E-05	5.32E-08	375
Location 4	Steam Gen	Methane	1.00E-03	5.82E-06	173
Location 4	Steam Gen	Carbon dioxide	5.15E+01	5.82E-01	88
Location 4	Steam Gen	Nitrogen	2.57E+02	3.49E+00	74
Location 4	Steam Gen	2-Methylpentane	3.30E-06	6.35E-08	52
Location 4	Steam Gen	3-Methylpentane	1.63E-06	6.35E-08	26
Location 4	Steam Gen	Hexane	7.96E-07	6.35E-08	13
Location 4	Steam Gen	Cyclopentane	5.83E-07	5.17E-08	11
Location 4	Steam Gen	Methylcyclopentane	6.20E-07	6.21E-08	9.98
Location 4	Steam Gen	Ethane	3.19E-05	5.82E-06	5.48

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 4	Steam Gen	Methylene chloride	8.94E-10	1.16E-03	7.68E-07
Location 4	Steam Gen	2-Methylpentane	5.99E-03	6.35E-08	94,197
Location 4	Treater	Pentane	3.74E-03	5.32E-08	70,230
Location 4	Treater	3-Methylpentane	2.99E-03	6.35E-08	47,099
Location 4	Treater	Heptane	2.68E-03	7.39E-08	36,230
Location 4	Treater	Hexane	1.84E-03	6.35E-08	28,984
Location 4	Treater	Cyclopentane	1.27E-03	5.17E-08	24,525
Location 4	Treater	Methylcyclopentane	1.04E-03	6.21E-08	16,749
Location 4	Treater	Methylcyclohexane	4.42E-04	7.24E-08	6,103
Location 4	Treater	Isopentane	4.11E-05	5.32E-08	772
Location 4	Treater	Methane	2.44E-03	5.82E-06	419
Location 4	Treater	Nitrogen	4.79E+02	3.49E+00	137
Location 4	Treater	Carbon dioxide	5.28E+01	5.82E-01	91
Location 4	Treater	Benzene	3.68E-03	5.82E-05	63
Location 4	Treater	Ethane	1.24E-04	5.82E-06	21
Location 4	Treater	Toluene	1.19E-03	5.82E-05	20
Location 4	Treater	Chlorobenzene-d5	2.31E-06	2.76E-06	0.84
Location 5	Tank Heater	Nonane	5.46E-03	9.46E-08	57,772
Location 5	Tank Heater	Decane	2.29E-03	1.05E-07	21,795
Location 5	Tank Heater	Undecane	1.26E-03	1.15E-07	10,898
Location 5	Tank Heater	Octane	6.35E-04	8.42E-08	7,539
Location 5	Tank Heater	Dodecane	2.01E-04	1.26E-07	1,597
Location 5	Tank Heater	Camphor	4.43E-03	3.74E-06	1,182
Location 5	Tank Heater	Benzene, 1,3,5-trimethyl-	3.46E-03	2.96E-06	1,171
Location 5	Tank Heater	Dimethyl trisulphide	2.35E-03	3.10E-06	757
Location 5	Tank Heater	Cyclopentane, 1-methyl-2-propyl-	2.31E-03	3.10E-06	743
Location 5	Tank Heater	.delta.-Fenchane	2.45E-03	3.40E-06	721
Location 5	Tank Heater	Naphthalene, decahydro-2-methyl-	2.69E-03	3.74E-06	719
Location 5	Tank Heater	1,2,3-Trimethylbenzene	2.05E-03	2.96E-06	694

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 5	Tank Heater	Methane	3.79E-03	5.82E-06	652
Location 5	Tank Heater	Camphane	1.99E-03	3.40E-06	584
Location 5	Tank Heater	Neopentylidenecyclohexane	1.86E-03	3.74E-06	497
Location 5	Tank Heater	m-Ethyltoluene	1.20E-03	2.96E-06	408
Location 5	Tank Heater	2-Methylheptane	3.13E-05	8.42E-08	372
Location 5	Tank Heater	Nitrogen	1.25E+03	3.49E+00	357
Location 5	Tank Heater	p-Ethyltoluene	8.67E-04	2.96E-06	293
Location 5	Tank Heater	o-Ethyltoluene	7.48E-04	2.96E-06	253
Location 5	Tank Heater	3-Methylheptane	2.07E-05	8.42E-08	246
Location 5	Tank Heater	Hexane, 3-ethyl-	3.93E-04	2.81E-06	140
Location 5	Tank Heater	Carbon dioxide	6.48E+01	5.82E-01	111
Location 5	Tank Heater	2-Pentene, 3-ethyl-4,4-dimethyl-	3.30E-04	3.10E-06	106
Location 5	Tank Heater	Heptane, 2,6-dimethyl-	3.06E-04	3.15E-06	97
Location 5	Tank Heater	Cyclohexane, 1,1,3-trimethyl-	2.92E-04	3.10E-06	94
Location 5	Tank Heater	m-Diethylbenzene	2.45E-04	3.30E-06	74
Location 5	Tank Heater	Cyclohexane, ethyl-	1.62E-04	2.76E-06	59
Location 5	Tank Heater	1,2,4-Trimethylbenzene	2.40E-03	5.82E-05	41
Location 5	Tank Heater	Cyclopentane, propyl-	5.91E-05	2.76E-06	21
Location 5	Tank Heater	m,p-Xylene	1.21E-03	5.82E-05	21
Location 5	Tank Heater	Heptane, 2,4-dimethyl-	5.94E-05	3.15E-06	19
Location 5	Tank Heater	1,3,5-Trimethylbenzene	9.20E-04	5.82E-05	16
Location 5	Tank Heater	o-Xylene	6.61E-04	5.82E-05	11
Location 5	Tank Heater	Allyl sulphide	2.66E-05	2.81E-06	9.47
Location 5	Tank Heater	Methyl Alcohol	7.11E-06	7.88E-07	9.02
Location 5	Tank Heater	n-Propylbenzene	3.40E-04	5.82E-05	5.84
Location 5	Tank Heater	Cyclohexane, 1,4-dimethyl-	1.24E-05	2.76E-06	4.48
Location 5	Tank Heater	Cyclopentane, 1,1,3,4-tetramethyl-, tran	1.36E-05	3.10E-06	4.39
Location 5	Tank Heater	Dimethyl disulphide	9.80E-06	2.32E-06	4.23
Location 5	Tank Heater	Ethyl benzene	1.41E-04	5.82E-05	2.42

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 5	Tank Heater	Benzene	1.46E-05	5.82E-05	0.25
Location 5	Tank Heater	Toluene	9.34E-06	5.82E-05	0.16
Location 5	Tank Heater	Chlorobenzene-d5	6.18E-09	2.76E-06	0.0022
Location 5	Pump Engine	CYCLOBUTANE, ISOPROPYL-	1.06E-02	2.41E-06	4372
Location 5	Pump Engine	Cyclopentane, 1,3-dimethyl-	7.55E-03	2.41E-06	3129
Location 5	Pump Engine	Cyclohexane, 1,3-dimethyl-, cis-	7.29E-03	2.76E-06	2641
Location 5	Pump Engine	Cyclopentane, ethyl-	4.27E-03	2.41E-06	1769
Location 5	Pump Engine	Methane	9.97E-03	5.82E-06	1712
Location 5	Pump Engine	Cyclopentane, 1,2,4-trimethyl-	4.55E-03	2.76E-06	1651
Location 5	Pump Engine	Cyclopentane, 1,1-dimethyl-	3.33E-03	2.41E-06	1380
Location 5	Pump Engine	Cyclohexane, 1,2-dimethyl-, trans-	3.04E-03	2.76E-06	1103
Location 5	Pump Engine	Propane, 2,2-dimethyl-	1.73E-03	1.77E-06	976
Location 5	Pump Engine	Hexane, 2,4-dimethyl-	2.10E-03	2.81E-06	748
Location 5	Pump Engine	Ethanone, 1-cyclohexyl-	2.16E-03	3.10E-06	695
Location 5	Pump Engine	Cyclohexanepropanol-	2.20E-03	3.50E-06	628
Location 5	Pump Engine	Cyclohexane, 1,1-dimethyl-	1.52E-03	2.76E-06	553
Location 5	Pump Engine	Pentane, 2,4-dimethyl-	1.08E-03	2.46E-06	437
Location 5	Pump Engine	Octane	3.53E-05	8.42E-08	419
Location 5	Pump Engine	Cyclohexane, 1,3-dimethyl-, trans-	1.08E-03	2.76E-06	393
Location 5	Pump Engine	Cyclopropane, 1-ethyl-1-methyl-	7.58E-04	2.07E-06	366
Location 5	Pump Engine	Nitrogen	1.19E+03	3.49E+00	341
Location 5	Pump Engine	Hexane, 2,5-dimethyl-	9.22E-04	2.81E-06	328
Location 5	Pump Engine	Nonane	2.48E-05	9.46E-08	262
Location 5	Pump Engine	Undecane	2.28E-05	1.15E-07	198
Location 5	Pump Engine	Decane	1.38E-05	1.05E-07	132
Location 5	Pump Engine	Isopentane	5.98E-06	5.32E-08	112
Location 5	Pump Engine	Methylcyclohexane	7.55E-06	7.24E-08	104
Location 5	Pump Engine	2-Methylheptane	6.61E-06	8.42E-08	78
Location 5	Pump Engine	Pentane	2.69E-06	5.32E-08	51

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.					
	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 5	Pump Engine	Heptane	3.63E-06	7.39E-08	49
Location 5	Pump Engine	Cyclohexane	2.75E-06	6.21E-08	44
Location 5	Pump Engine	Dodecane	5.48E-06	1.26E-07	44
Location 5	Pump Engine	3-Methylheptane	3.57E-06	8.42E-08	42
Location 5	Pump Engine	3-Methylhexane	3.09E-06	7.39E-08	42
Location 5	Pump Engine	2-Methylpentane	2.16E-06	6.35E-08	34
Location 5	Pump Engine	Methylcyclopentane	1.89E-06	6.21E-08	30
Location 5	Pump Engine	Ethane	1.64E-04	5.82E-06	28
Location 5	Pump Engine	Hydrogen sulphide	1.76E-05	8.37E-07	21
Location 5	Pump Engine	3-Methylpentane	1.29E-06	6.35E-08	20
Location 5	Pump Engine	1-Cyclohexyl-2-methyl-prop-2-en-1-one	6.41E-05	3.74E-06	17
Location 5	Pump Engine	Bicyclo[4.1.0]heptane, 3-methyl-	2.87E-05	2.71E-06	11
Location 5	Pump Engine	Cyclohexanone, 2-(2-methylpropylidene)-	3.12E-05	3.74E-06	8.32
Location 5	Pump Engine	Benzene, 1,2,3,5-tetramethyl-	2.55E-05	3.30E-06	7.72
Location 5	Pump Engine	Cyclohexane, 1,2-diethyl-3-methyl-	2.92E-05	3.79E-06	7.70
Location 5	Pump Engine	Carbon dioxide	4.33E+00	5.82E-01	7.43
Location 5	Pump Engine	1,3-Hexadiene, 3-ethyl-2-methyl-, (Z)-	2.15E-05	3.05E-06	7.03
Location 5	Pump Engine	2-Ethyl-3-methylcyclopentene	1.57E-05	2.71E-06	5.79
Location 5	Pump Engine	Cyclopentane, 1-ethyl-3-methyl-	1.40E-05	2.76E-06	5.08
Location 5	Pump Engine	3-CYCLOHEXYL-PROPANOL	1.51E-05	3.50E-06	4.33
Location 5	Pump Engine	Heptane, 2,3-dimethyl-	9.17E-06	3.15E-06	2.91
Location 5	Pump Engine	Heptane, 2,6-dimethyl-	8.96E-06	3.15E-06	2.84
Location 5	Pump Engine	Cyclohexane, 1,1,3-trimethyl-	6.52E-06	3.10E-06	2.10
Location 5	Pump Engine	1,2,3-Trimethylbenzene	5.82E-06	2.96E-06	1.97
Location 5	Pump Engine	Cyclohexane, ethyl-	4.62E-06	2.76E-06	1.67
Location 5	Pump Engine	m-Ethyltoluene	4.14E-06	2.96E-06	1.40
Location 5	Pump Engine	Cyclohexane, 1,4-dimethyl-	3.46E-06	2.76E-06	1.25
Location 5	Pump Engine	p-Ethyltoluene	2.95E-06	2.96E-06	1.00
Location 5	Pump Engine	HEXA-4,5-DIENE CARBOXYLIC ACID	2.75E-06	2.76E-06	1.00

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.					
	Sources	**Component**	**Emission Factor**		**Ratio of Measured/LDL**
			Measured	**LDL**	
			kg /(GJ fuel)		
Location 5	Pump Engine	o-Ethyltoluene	2.34E-06	2.96E-06	0.79
Location 5	Pump Engine	m,p-Xylene	3.09E-05	5.82E-05	0.53
Location 5	Pump Engine	Toluene	1.55E-05	5.82E-05	0.27
Location 5	Pump Engine	o-Xylene	1.01E-05	5.82E-05	0.17
Location 5	Pump Engine	Ethyl benzene	6.55E-06	5.82E-05	0.11
Location 5	Pump Engine	1,2,4-Trimethylbenzene	6.39E-06	5.82E-05	0.11
Location 5	Pump Engine	Benzene	3.31E-06	5.82E-05	0.057
Location 5	Pump Engine	n-Propylbenzene	2.25E-06	5.82E-05	0.039
Location 5	Pump Engine	1,3,5-Trimethylbenzene	1.78E-06	5.82E-05	0.031
Location 5	Pump Engine	Chlorobenzene-d5	6.12E-09	2.76E-06	0.0022
Location 6	Steam Boiler	Methane	2.93E-02	5.82E-06	5,035
Location 6	Steam Boiler	Butane	1.17E-02	5.82E-06	2,013
Location 6	Steam Boiler	Ethane	7.42E-04	5.82E-06	127
Location 6	Steam Boiler	Ethylene	6.92E-04	5.82E-06	119
Location 6	Steam Boiler	Nitrogen	3.02E+02	3.49E+00	86
Location 6	Steam Boiler	Carbon dioxide	4.66E+01	5.82E-01	80
Location 6	Steam Boiler	Propane	3.84E-04	5.82E-06	66
Location 6	Steam Boiler	Propyne	4.65E-04	4.93E-05	9.45
Location 6	Steam Boiler	Dodecane	1.15E-06	1.26E-07	9.17
Location 6	Steam Boiler	Decane	8.32E-07	1.05E-07	7.93
Location 6	Steam Boiler	Undecane	8.60E-07	1.15E-07	7.46
Location 6	Steam Boiler	Pentadecane	3.51E-05	5.22E-06	6.73
Location 6	Steam Boiler	Propane, 2-methyl-	7.62E-06	1.43E-06	5.33
Location 6	Steam Boiler	Methyl Alcohol	2.84E-06	7.88E-07	3.61
Location 6	Steam Boiler	Nitrous acid, methyl ester	4.83E-06	1.50E-06	3.21
Location 6	Steam Boiler	2-Propanone	3.64E-06	1.43E-06	2.55
Location 6	Steam Boiler	Butane, 2-methyl-	3.96E-06	1.77E-06	2.23
Location 6	Steam Boiler	1,2-Propadiene	1.29E-06	9.85E-07	1.31
Location 6	Steam Boiler	Benzene	6.22E-05	5.82E-05	1.07

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 6	Steam Boiler	1,3-Butadiyne	1.11E-06	1.23E-06	0.90
Location 6	Steam Boiler	Hexanal	2.20E-06	2.46E-06	0.89
Location 6	Steam Boiler	m-Ethyltoluene	1.53E-06	2.96E-06	0.52
Location 6	Steam Boiler	1,2,3-Trimethylbenzene	1.26E-06	2.96E-06	0.43
Location 6	Steam Boiler	1-Buten-3-yne	5.44E-07	1.28E-06	0.42
Location 6	Steam Boiler	p-Ethyltoluene	7.24E-07	2.96E-06	0.25
Location 6	Steam Boiler	Cyclopentanol	4.75E-07	2.12E-06	0.22
Location 6	Steam Boiler	o-Ethyltoluene	5.41E-07	2.96E-06	0.18
Location 6	Steam Boiler	Toluene	8.04E-06	5.82E-05	0.14
Location 6	Steam Boiler	1,2,4-Trimethylbenzene	3.53E-06	5.82E-05	0.061
Location 6	Steam Boiler	o-Xylene	3.39E-06	5.82E-05	0.058
Location 6	Steam Boiler	m,p-Xylene	3.36E-06	5.82E-05	0.058
Location 6	Steam Boiler	Ethyl benzene	1.09E-06	5.82E-05	0.019
Location 6	Steam Boiler	Chlorobenzene-d5	1.63E-09	2.76E-06	0.00059
Location 7	Tank Heater	Methane	3.71E-03	5.82E-06	638
Location 7	Tank Heater	Dodecane	1.49E-04	1.26E-07	1,186
Location 7	Tank Heater	Undecane	7.13E-05	1.15E-07	619
Location 7	Tank Heater	Nitrogen	7.62E+02	3.49E+00	218
Location 7	Tank Heater	Isopentane	1.11E-05	5.32E-08	208
Location 7	Tank Heater	Pentane	9.45E-06	5.32E-08	178
Location 7	Tank Heater	Hydrogen sulphide	7.61E-05	8.37E-07	91
Location 7	Tank Heater	Ethane	3.12E-04	5.82E-06	54
Location 7	Tank Heater	Butane	2.01E-04	5.82E-06	34
Location 7	Tank Heater	2-Methylpentane	2.15E-06	6.35E-08	34
Location 7	Tank Heater	Decane	3.46E-06	1.05E-07	33
Location 7	Tank Heater	Hexane	2.02E-06	6.35E-08	32
Location 7	Tank Heater	Propane	1.52E-04	5.82E-06	26
Location 7	Tank Heater	3-Methylpentane	1.04E-06	6.35E-08	16
Location 7	Tank Heater	Carbon dioxide	8.64E+00	5.82E-01	15

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 7	Tank Heater	Propyne	2.77E-04	4.93E-05	5.62
Location 7	Tank Heater	Formaldehyde	5.23E-06	1.48E-06	3.54
Location 7	Tank Heater	Undecane, 4,6-dimethyl-	1.47E-05	4.53E-06	3.25
Location 7	Tank Heater	2-Propanone	4.04E-07	1.43E-06	0.28
Location 7	Tank Heater	Benzene	1.49E-06	5.82E-05	0.026
Location 7	Tank Heater	Chlorobenzene-d5	3.88E-09	2.76E-06	0.0014
Location 7	Reciprocating	Pentane	4.03E-04	5.32E-08	7,581
Location 7	Reciprocating	Isopentane	2.91E-04	5.32E-08	5,464
Location 7	Reciprocating	Hexane	1.93E-04	6.35E-08	3,037
Location 7	Reciprocating	Methane	1.52E-02	5.82E-06	2,605
Location 7	Reciprocating	2-Methylpentane	1.37E-04	6.35E-08	2,152
Location 7	Reciprocating	3-Methylpentane	8.63E-05	6.35E-08	1,357
Location 7	Reciprocating	Heptane	7.19E-05	7.39E-08	973
Location 7	Reciprocating	Dodecane	1.09E-04	1.26E-07	870
Location 7	Reciprocating	Cyclopentane	4.20E-05	5.17E-08	813
Location 7	Reciprocating	Methylcyclopentane	3.96E-05	6.21E-08	637
Location 7	Reciprocating	Cyclohexane	3.83E-05	6.21E-08	617
Location 7	Reciprocating	Methylcyclohexane	4.37E-05	7.24E-08	604
Location 7	Reciprocating	Octane	4.89E-05	8.42E-08	581
Location 7	Reciprocating	Ethane	3.11E-03	5.82E-06	535
Location 7	Reciprocating	3-Methylhexane	3.32E-05	7.39E-08	449
Location 7	Reciprocating	2-Methylhexane	2.89E-05	7.39E-08	391
Location 7	Reciprocating	Nonane	3.38E-05	9.46E-08	357
Location 7	Reciprocating	Undecane	4.02E-05	1.15E-07	349
Location 7	Reciprocating	Decane	3.41E-05	1.05E-07	325
Location 7	Reciprocating	Propane	1.55E-03	5.82E-06	266
Location 7	Reciprocating	2,3-Dimethylbutane	1.62E-05	6.35E-08	255
Location 7	Reciprocating	Nitrogen	7.55E+02	3.49E+00	216
Location 7	Reciprocating	2-Methylheptane	1.38E-05	8.42E-08	163

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.					
	Sources	**Component**	**Emission Factor**		**Ratio of Measured/LDL**
			Measured	**LDL**	
			kg /(GJ fuel)		
Location 7	Reciprocating	2,3-Dimethylpentane	1.16E-05	7.39E-08	156
Location 7	Reciprocating	Butane	8.72E-04	5.82E-06	150
Location 7	Reciprocating	Hydrogen sulphide	1.01E-04	8.37E-07	121
Location 7	Reciprocating	3-Methylheptane	9.92E-06	8.42E-08	118
Location 7	Reciprocating	2,2-Dimethylbutane	6.68E-06	6.35E-08	105
Location 7	Reciprocating	Oxygen	2.43E+02	3.49E+00	69
Location 7	Reciprocating	Nonadecane	1.79E-04	2.61E-06	69
Location 7	Reciprocating	Isobutane	3.05E-04	5.82E-06	52
Location 7	Reciprocating	2-Pentanone, 4-methyl-4-phenyl-	9.02E-05	2.12E-06	43
Location 7	Reciprocating	1-Methyl-2-n-hexylbenzene	7.62E-05	2.12E-06	36
Location 7	Reciprocating	Naphthalene, 2-methyl-	1.09E-04	3.50E-06	31
Location 7	Reciprocating	Benzene, 1-methyl-2-(phenylmethyl)-	5.96E-05	2.07E-06	29
Location 7	Reciprocating	Dodecane, 4,6-dimethyl-	6.17E-05	2.41E-06	26
Location 7	Reciprocating	Naphthalene, 2,6-dimethyl-	6.05E-05	2.76E-06	22
Location 7	Reciprocating	Tetradecane	1.01E-04	4.88E-06	21
Location 7	Reciprocating	Propyne	7.75E-04	4.93E-05	16
Location 7	Reciprocating	m-Ethyltoluene	1.16E-05	2.96E-06	3.92
Location 7	Reciprocating	Carbon dioxide	2.27E+00	5.82E-01	3.90
Location 7	Reciprocating	Octane, 2,6-dimethyl-	9.90E-06	2.56E-06	3.86
Location 7	Reciprocating	Cyclotrisiloxane, hexamethyl-	7.06E-06	2.46E-06	2.87
Location 7	Reciprocating	1,2,3-Trimethylbenzene	6.64E-06	2.96E-06	2.25
Location 7	Reciprocating	CYCLOBUTANE, ISOPROPYL-	4.43E-06	2.41E-06	1.83
Location 7	Reciprocating	o-Ethyltoluene	5.01E-06	2.96E-06	1.69
Location 7	Reciprocating	Cyclohexane, ethyl-	4.43E-06	2.76E-06	1.61
Location 7	Reciprocating	Cyclopentane, 1,3-dimethyl-	3.37E-06	2.41E-06	1.40
Location 7	Reciprocating	p-Ethyltoluene	3.84E-06	2.96E-06	1.30
Location 7	Reciprocating	Octane, 2-methyl-	2.92E-06	2.61E-06	1.12
Location 7	Reciprocating	Cyclohexane, 1,4-dimethyl-	2.81E-06	2.76E-06	1.02
Location 7	Reciprocating	Cyclopentane, ethyl-	2.26E-06	2.41E-06	0.94

Table 46: Comparison of determined and LDL emission factors and ratio of measured to LDL for all organic and fixed gas compounds in the 13 sources sampled.

	Sources	Component	Emission Factor		Ratio of Measured/LDL
			Measured	LDL	
			kg /(GJ fuel)		
Location 7	Reciprocating	Heptane, 3-ethyl-2-methyl-	2.48E-06	2.81E-06	0.88
Location 7	Reciprocating	m-Diethylbenzene	2.68E-06	3.30E-06	0.81
Location 7	Reciprocating	1,2,4-Trimethylcyclopentane	1.42E-06	2.12E-06	0.67
Location 7	Reciprocating	Toluene	3.04E-05	5.82E-05	0.52
Location 7	Reciprocating	1-trans-2-cis-3-trans-trimethylcyclopent	1.06E-06	2.07E-06	0.51
Location 7	Reciprocating	Hexane, 2,4-dimethyl-	1.35E-06	2.81E-06	0.48
Location 7	Reciprocating	Heptane, 2,3-dimethyl-	1.29E-06	3.15E-06	0.41
Location 7	Reciprocating	Cyclopentane, 1,1-dimethyl-	9.24E-07	2.41E-06	0.38
Location 7	Reciprocating	m,p-Xylene	1.85E-05	5.82E-05	0.32
Location 7	Reciprocating	Hexane, 2,5-dimethyl-	8.52E-07	2.81E-06	0.30
Location 7	Reciprocating	Hexane, 2,3-dimethyl-	5.83E-07	2.27E-06	0.26
Location 7	Reciprocating	Benzene	1.45E-05	5.82E-05	0.25
Location 7	Reciprocating	1,2,4-Trimethylbenzene	1.35E-05	5.82E-05	0.23
Location 7	Reciprocating	Cyclohexane, 1,1-dimethyl-	4.77E-07	2.76E-06	0.17
Location 7	Reciprocating	o-Xylene	7.85E-06	5.82E-05	0.13
Location 7	Reciprocating	Ethyl benzene	7.60E-06	5.82E-05	0.13
Location 7	Reciprocating	n-Propylbenzene	3.32E-06	5.82E-05	0.057
Location 7	Reciprocating	1,3,5-Trimethylbenzene	3.25E-06	5.82E-05	0.056
Location 7	Reciprocating	Chlorobenzene-d5	4.36E-09	2.76E-06	0.0016

9 APPENDIX B - FIELD DATA COLLECTION HISTORIES

Table 47: Field sample location details and site specific data collection histories.

Location	Sources	Sampling time	Comments
Location 1 - Sweet Gas Gathering System - (Plains Region)	Reciprocating Engine	Summer, 2012	The temperature was above zero and the sampling went smoothly.
	Process Heater	Summer, 2012	
Location 2 - Sweet Gas Gathering System - (Foothills Region)	Reciprocating Engine	Summer, 2012	
	Process Heater	Summer, 2012	
Location 3 - Sweet Gas Processing Plant	Reciprocating Engine	Summer, 2012	
	Process Heater	Summer, 2012	
Location 4 - Thermal Heavy Oil Production	Treater - sweet gas	Fall, 2012	Although the treater and steam generator were exposed to cold weather, the atmospheric temperature was above zero and did not affect the sampling.
	Steam Generators, mixed fuel gas, slightly sour.	Fall, 2012	
Location 5 - Cold Heavy Oil Production	Tank Heaters	Fall, 2012	The treater and screw pump engine were exposed to cold weather. Hydrate most likely formed in metals sampling train during sampling and affected results. The fuel/flue gases for organic components may not have been affected by the weather since the sampling time was short. The metal impinger sampling train might be affect by the cool weather due to long sampling time.
	Screw Pump Engine	Fall, 2012	
Location 6 - Sour Processing Plant	Tail Gas Incinerator	Fall, 2012	The source was not easily accessible and a high angle rescue team was required by operator (cost not in budget). For these reasons this source was not sampled.
	Turbine Engine	Fall, 2012	Sample was not collected due to weather issue.

Table 47: Field sample location details and site specific data collection histories.			
Location	**Sources**	**Sampling time**	**Comments**
	Process Heater/Steam Boiler	Fall, 2012	The steam boiler is located in a building and the fuel/flue gases were sampled without the effect of cool weather.
Location 7 - Conventional Oil Production	Enclosed Flare	Fall, 2012	The enclosed flare system could not be accessed and it was not sampled.
	Reciprocating Engine	Fall, 2012	The reciprocating engine is located in a building and the fuel/flue gases were sampled without the effect of cold weather.
	Treater	Fall, 2012	The treater was exposed to cold weather. Hydrate might form during sampling. The fuel/flue gases for organic components might not affect by the weather since the sampling time was short. The metal impinge sampling train might affect by the cool weather due to long sampling time.

Table 48: Fuel gas normalization procedure and site specific comments.			
	Sources	**Sampling time**	**Comments**
Location 1 - Sweet Gas Gathering System - (Plains Region)	Reciprocating Engine	Summer, 2012	The fuel gas for the reciprocating engine and heater are the same. The analytical results for both sources agreed well with each other. The calculated total mole fraction equaled more than 100%.The normalized composition was calculated by dividing the individual component concentration by the total composition. After normalizing, the composition agreed well with the typical gas analysis information
	Process Heater	Summer, 2012	

Table 48: Fuel gas normalization procedure and site specific comments.			
	Sources	**Sampling time**	**Comments**
			provided by client.
Location 2 - Sweet Gas Gathering System - (Foothills Region)	Reciprocating Engine	Summer, 2012	The fuel gas for the reciprocating engine and heater are the same. The analytical results for both sources agreed well with each other. The total vol% of composition before normalization was 107.167%. To normalize the fuel gas composition, the extra 7.167% was subtracted from the nitrogen content. After normalizing, the composition agreed well with the typical gas analysis information provided by client.
	Process Heater	Summer, 2012	The fuel gas for the reciprocating engine and heater are the same. The analytical results for both sources agreed well with each other. The total vol% of composition before normalization was 107.178%. To normalize the fuel gas composition, the extra 7.178% was subtracted from the nitrogen content. After normalizing, the composition agreed well with the typical gas analysis information provided by client.
Location 3 - Sweet Gas Processing Plant	Reciprocating Engine	Summer, 2012	The fuel gas for the reciprocating engine and heater are the same. The analytical results for both sources agreed well with each other. The normalized composition was calculated by dividing the individual component with the total composition before normalization. After normalizing, the organic composition agreed well with the typical gas analysis information provided by client.
	Process Heater	Summer, 2012	
Location 4 - Thermal Heavy Oil Production	Treater, sweet gas	Fall, 2012	The normalized composition was calculated by dividing the individual component with the total composition before normalization. The C1 and N2 agreed with the typical analysis provided by client. The C2 and C3 do not agree and the differences were accepted.

Table 48: Fuel gas normalization procedure and site specific comments.			
	Sources	**Sampling time**	**Comments**
	Steam Generators, mixed fuel gas, slightly sour.	Fall, 2012	The normalized composition was calculated by dividing the individual component with the total composition before normalization. The C1 and N2 agreed with the typical analysis provided by client. The C2 and C3 do not agree and the differences were accepted.
Location 5 - Cold Heavy Oil Production	Tank Heaters	Fall, 2012	The normalized composition was calculated by dividing the individual component with the total composition before normalization. The C1, C2 and N2 agree well with the typical analysis provided by operator.
	Screw Pump Engine	Fall, 2012	
Location 6 - Sour Processing Plant	Tail Gas Incinerator	Fall, 2012	Not applicable. No sample was collected for this source.
	Turbine Engine	Fall, 2012	Not applicable. No sample was collected for this source.
	Process Heater/Steam Boiler	Fall, 2012	The normalized composition was calculated by dividing the individual component with the total composition before normalization. After normalizing, the organic composition agreed well with the typical gas analysis information provided by the operator.
Location 7 - Conventional Oil Production	Enclosed Flare	Fall, 2012	Not applicable. No sample was collected for this source.
	Reciprocating Engine	Fall, 2012	The fuel gas for the reciprocating engine and treater are the same. The normalized composition was calculated by dividing the individual component with the total composition before normalization. After normalizing, C1 and C2 agreed with the typical analysis provided by the operator but the C3 was different and accepted.
	Treater	Fall, 2012	

10 APPENDIX C - SAMPLING PROTOCOLS

10.1 PURPOSE

This protocol outlines the test conditions, test procedures, data recording and emission test methods to be followed when testing heaters, boilers and compressors for the purpose of establishing actual acrolein and arsenic (and other pollutant) emission factors.

10.2 TEST CONDITIONS

1. Preferable all units should be operating at 80% – 100% of full load conditions during the test period unless otherwise specified by the manufacturer or operating approval agency. Each unit should be operating at steady conditions for at least one hour prior to the test and for the duration of the test. For fuel modulated equipment this should not be a problem. For heaters, boiler and other combustion units with on/off burner controls, emission testing needs to be coordinated with the firing cycle.

2. For units that normally operate at less than 80%, it is acceptable to test the unit while it is operating within plus or minus 10% of its normal operating range. Again, steady operation before and during the test is required.

3. Air-to-fuel ratios or excess air should be checked prior to the test period and adjustments should be made to the unit if it is found to be operating at outside of normal conditions. Proper conditions may be specified in the operating manual, company procedure or the approving authority's approval. It is expected that the unit will be operated at the specified air-to-fuel ratio and therefore, the test to establish the actual emission factor, should be at the specified condition.

4. Where a process unit combustion chamber or process fluid operating temperature is specified, as is the case for an incinerator or a heat medium heater, the specified temperature must be maintained for one hour prior to and during the test period.

10.3 TEST PROCEDURE

1. The plant operator will schedule the test period and be responsible for maintaining the correct operating conditions prior to and during the test period. The plant operator will provide the approval to start the test and, should conditions change, abort the test.

2. The plant operator will ensure that the required process data is recorded by the plant distributed control system (DCS), plant technicians or the emission testing team.

10.3.1 TEST PROCEDURE FOR ACROLEIN

1. The fuel/flue gases are collected using canister (Figure 1). Initially, the canister has a negative pressure and it will be connected to the sampling port on the source. A pressure regulator may added between the sampling port and canister to regulate inlet pressure in the event of a high pressure source (i.e. The pressure regulator is needed for sampling from high pressure fuel line but is not needed for sampling exhaust stacks).

2. Metal sampling line is used for hot sources. The sampling line is purged of air with a hand pump connected (t-valve) immediately before the sample canister where the exhaust has cooled.

3. After connecting and purging the sampling line, the canister inlet valve is opened slowly. The flue gases will flow through a water knockout vessel and then flow into the canister until the canister pressure is equilibrium with the surrounding.

4. When acrolein testing is complete, a combustion analyzer (TESTO 350) is inserted into the exhaust stack and used to record other flue gas information (i.e. O_2, CO, CO_2, and C_xH_y). Manufacturer testing procedures are followed for these measurements.

10.3.2 TEST PROCEDURE FOR ARSENIC

1. The test for the arsenic and metals will be done using a modified version of NCASI Method IM/CAN/WP-99.02. This is an impinge method for collecting arsenic - metals and is illustrated in Figure 2.

2. The modification of Method IM/CAN/WP-99.02 will involve employing an acid solution (i.e. 1.0% nitric acid in water) instead of a water solution in the impinge train to also scrub any metals from the gas stream. Thus, the liquid from the impinger train will also be subject to a full ICP-MS scan for metals.

3. The sampling rate for this method is measured on dry basis (i.e. the flow meter is installed after the impinger train).

4. The dry flow meter has a temperature sensor used to correct the flow rate to the standard reference condition of 15^{o} C. A differential pressure sensor is used to measure the vacuum at the meter outlet (i.e. put a tee connection at the flow meter outlet with one branch connected to the differential pressure sensor and the other branch connected to the sampling pump). Measure the local barometric pressure,

record the pressure differential and correct the flow rate to the standard reference condition of 101.325 kPa.

5. The acid solution (1% nitric acid in water) is used to clean the impinger train.

6. After cleaning, 20 ml of solution (1% nitric acid in water) is measured and put into the first impinge train.

7. The sampling rate is 500 ml/min. Record the reading on the dry flow meter and collect at least 20 L of sample. When the pump starts, make sure there is gas bubbling through the impinge train.

8. When the dry flow meter gives a reading of 20 L gas flow, stop the pump. The solution in the impinger trains are collected and labeled. These samples will be subjected to full ICP- MS scan for metals.

11 APPENDIX D – GAS SAMPLE ANALYTICAL METHODS

All gas sample chemical analyses were performed by Alberta Innovates Technology Futures (AITF) at their laboratory in Vegreville. A brief summary of the different analytical procedures that were applied is provided in the subsections below.

INERTS

The analysis for inerts determined concentrations of N_2, O_2, CO_2 and CO in the gas samples. The analyses were performed by gas chromatography with thermal conductivity detection (GC/TCD). The minimum detection limit for this method was 50 ppm for CO_2 and 100 ppm for the other inerts.

REDUCED SULPHUR COMPOUNDS (RSCS)

Analyses for sulphur gases were performed by gas chromatography with sulphur chemiluminescence detection (GC/SCD). The minimum detection limit of this method was 1-ppb. The specific sulphur compounds targeted by the analysis are summarized in **Table 49**.

C_1 THROUGH C_4 GASES

The analyses for lighter VOCs were done by gas chromatography with flame ionization detection (GC/FID). The minimum detection limit for individual compounds was 50 ppb. The target compounds are summarized in **Table 50**.

C_5 THROUGH C_{12+} GASES

Analyses for the heavier VOCs in gas samples were done by mass spectroscopy (GC/MS) with cryogenic focusing to provide a minimum detection limit of 10 µg/m^3. For liquid samples, a purge and trap GC/MS analysis was performed for compounds in the C_5 to C_{12} range and a solvent extraction GC/MS analysis was done for compounds heavier than C_{12}. The GC/MS was operated in full scan (or total ion) mode. In this operating mode the substance type denoted by each chromatographic peak is determined based on the best match quality achieved with the available entries in the instrument's mass spectral library. Additionally, the instrument was calibrated using a calibration standard of selected target compounds (see **Table 51**), and therefore provided exact matches where these substances occurred in the collected samples.

Table 49: Listing of the target reduced sulphur compounds (RSCs).	
CAS Number	**Substance Name**
638-02-8	2,5-Dimethyl Thiophene
872-55-9	2-Ethyl Thiophene
554-14-3	2-Methyl Thiophene
616-44-4	3-Methyl Thiophene
592-88-1	Allyl Sulphide
109-79-5	Butyl Mercaptan
544-40-1	Butyl Sulphide
75-15-0	Carbon Disulphide
463-58-1	Carbonyl Sulphide
624-92-0	Dimethyl Disulphide
75-18-3	Dimethyl Sulphide
3658-80-8	Dimethyl Trisulphide
75-08-1	Ethyl Mercaptan
352-93-2	Ethyl Sulphide
111-31-9	Hexyl Mercaptan
7783-06-4	Hydrogen Sulphide
75-33-2	Isopropyl Mercaptan
74-93-1	Methyl Mercaptan
107-03-9	Propyl Mercaptan
7446-09-5	Sulphur Dioxide
110-02-1/513-44-0 and 513-53-1	Thiophene/*iso* and *sec* Butyl Mercaptan
110-66-7	*n* Amyl Mercaptan
1679—09-0	*tert* Amyl Mercaptan
75-66-1	*tert* Butyl Mercaptan

Table 50: Listing of the target substances in the C_1 to C_4 range.	
CAS Number	**Substance Name**
106-99-0	1,3-Butadiene
106-98-9	1-Butene
74-86-2	Acetylene
106-97-8	Butane
74-84-0	Ethane
107-00-6	Ethylacetylene
74-85-1	Ethylene
75-28-5	Isobutane
115-11-7	Isobutylene
74-82-8	Methane
74-98-6	Propane
115-07-1	Propylene
74-99-7	Propyne
590-18-1	Cis-2-Butene
624-64-6	Trans-2-Butene

Table 51: Listing of the target substances in the C_5 to C_{12+} range.	
CAS Number	**Substance Name**
630-20-6	1,1,1,2-Tetrachloroethane
71-55-6	1,1,1-Trichloroethane
79-34-5	1,1,2,2-Tetrachloroethane
79-00-5	1,1,2-Trichloroethane
75-34-3	1,1-Dichloroethane
75-35-4	1,1-Dichloroethylene
563-58-6	1,1-Dichloropropylene
87-61-6	1,2,3-Trichlorobenzene
96-18-4	1,2,3-Trichloropropane
120-82-1	1,2,4-Trichlorobenzene
95-63-6	1,2,4-Trimethylbenzene
96-12-8	1,2-Dibromo-3-chloropropane
106-93-4	1,2-Dibromoethane
95-50-1	1,2-Dichlorobenzene
107-06-2	1,2-Dichloroethane
78-87-5	1,2-Dichloropropane
108-67-8	1,3,5-Trimethylbenzene
541-73-1	1,3-Dichlorobenzene
142-28-9	1,3-Dichloropropane
106-46-7	1,4-Dichlorobenzene
594-20-7	2,2-Dichloropropane
110-75-8	2-Chloroethoxyethylene
95-49-8	2-Chlorotoluene
106-43-4	4-Chlorotoluene
71-43-2	Benzene
108-86-1	Bromobenzene
75-27-4	Bromodichloromethane
75-25-2	Bromoform
74-83-9	Bromomethane
56-23-5	Carbon tetrachloride
108-90-7	Chlorobenzene
75-00-3	Chloroethane
67-66-3	Chloroform
124-48-1	Dibromochloromethane
74-95-3	Dibromomethane
100-41-4	Ethyl benzene
87-68-3	Hexachlorobutadiene

Table 51: Listing of the target substances in the C_5 to C_{12+} range.	
CAS Number	**Substance Name**
98-82-8	Isopropylbenzene (Cumene)
1634-04-4	MTBE
75-09-2	Methylene chloride
91-20-3	Naphthalene
100-42-5	Styrene
127-18-4	Tetrachloroethylene
108-88-3	Toluene
79-01-6	Trichloroethylene
75-69-4	Trichlorofluoromethane
75-01-4	Vinyl chloride
156-59-2	cis-1,2-Dichloroethylene
10061-01-5	cis-1,3-Dichloropropylene
108-38-3 / 106-42-3	m,p-Xylene
104-51-8	n-Butylbenzene
103-65-1	n-Propylbenzene
95-47-6	o-Xylene
99-87-6	p-Isopropyltoluene
135-98-8	sec-Butylbenzene
98-06-6	tert-Butylbenzene
156-60-5	trans-1,2-Dichloroethylene
10061-02-6	trans-1,3-Dichloropropylene