Alaska Department of Environmental Conservation

Air Quality Division

Review of

ConocoPhillips Alaska Inc.

Continuous Emissions Monitoring Data

from a

2014 Drill Rig Study at

Kuparuk Drill Site 2N

October 28, 2015

Executive Summary and Conclusions

The Alaska Department of Environmental Conservation (ADEC) conducted a quality assurance review of a Continuous Emissions Systems (CEMS) dataset collected by ConocoPhillips Alaska Inc. (CPAI) as part of a drill rig study. CPAI collected the data between September 7, 2014 and December 31, 2014 while conducting oil and gas drilling operations with the Nabors 9ES rig at Drill Site 2N (DS2N) of the Kuparuk River Unit (KRU). ADEC reviewed the data from a research perspective, rather than a permit or New Source Performance Standard (NSPS) compliance evaluation perspective. ADEC found that the sampling equipment and instrumentation generally met the performance specifications in 40 CFR 60, Appendix F – Quality Assurance Requirements, and that the CEMS measurements met the quality control requirements approximately 65 percent of the time.

ADEC attempted to compare the CEMS measurements to vendor or source test data in order to add further confidence that the CEMS setup was accurately measuring the drill rig emissions. However, ADEC was unable to make this comparison since the CEMS data appears to reflect low load conditions and the available vendor/source test data reflect high load conditions.

ADEC is aware that various parties are interested in this data. ADEC cannot determine on their behalf what data is or is not appropriate for their purposes.

Within Alaska, the data may not be used to estimate potential emissions for purposes of permit applicability, or to demonstrate that the emission rates from the tested equipment comply with State or federal emissions limits. The data may not be used for such purposes since they do not represent full-load conditions (maximum emissions), and since they were not confirmed with Relative Accuracy Test Audits (RATA). The data should only be used to represent the emissions that the Nabors 9ES rig likely emitted during the monitoring period.

ADEC further notes that the total oxides of nitrogen (NOx) and nitric oxide (NO) measurements for the Tioga Heater were very low – with both channels typically measuring 6 to 7 parts per million (ppm). These concentrations reflect a far lower heater load than what ADEC would have expected for this time of year. The resulting nitrogen dioxide (NO_2) concentrations were also typically 0 ppm ($\pm$1 ppm), which is within the electronic noise range of the sensor. These concentrations are too low and unreliable to draw any conclusions regarding the in-stack ratio (ISR) of NO_2 to NOx for the heater. For example, some of the ISRs calculated from the measured NO_2 and NOx values are negative, which is unrealistic.

ADEC's detailed findings regarding the instrumentation and system performance is provided in Attachment A. ADEC's detailed comparison of the DS2N CEMS data to other emissions data is provided in Attachment B. Additional background information regarding the study is provided below.

Background

CPAI is one of several companies participating in a State-Industry Drill Rig Workgroup to determine whether ADEC can stream-line the air quality permitting obligations of portable oil and

gas operations.[1] A major focus of the State-Industry Drill Rig Workgroup regards the difficulty with using current modeling techniques to demonstrate that portable oil and gas operations comply with the 1-hour NO_2 Alaska Ambient Air Quality Standard (AAAQS). Industry has therefore been obtaining and submitting a variety of data sets to support their position that oil and gas drilling operations do not threaten the 1-hour NO_2 AAAQS, or any other AAAQS.

CPAI proposed the collection of ambient NO_2 and emissions data during a North Slope drilling operation to help support the overall effort. They described their proposal in an August 2014 monitoring plan entitled, *Alaska Field Study Design – Drill Rig 1-Hour NO_2 Collaborative Study*. CPAI stated, "The purpose of this study is to collect ambient pollutant measurements adjacent to oil drilling rigs on the North Slope of Alaska to evaluate actual 1-hour NO_2 ambient air quality impacts from drilling operations." CPAI further stated, "In addition to this purpose, drill rig operational, fuel use, and emission date, along with concurrent meteorological data will be collected primarily to understand the sensitivity of measured impacts to drill rig operation." The findings described by ADEC in this October 28, 2015 report only regards the CEMS data.

It is important to note that CPAI developed their monitoring plan as part of a research project. They purposely did not put the level of effort needed to obtain data that could be used to support a permitting action, or to demonstrate compliance with an enforceable permit condition or NSPS requirement. For example, CPAI stated on page 8 of the Monitoring Plan, "CEMS monitoring will conform to 40 CFR Part 60 Appendix B, Performance Specifications 2 and 3 *with the exception that Relative Accuracy Test Audits (RATA) will not be conducted*" (emphasis added).[2] ADEC therefore conducted a general quality assurance review rather than a compliance evaluation. ADEC likewise only conducted a general review of the August 2014 monitoring plan, rather than the detailed review that is typically conducted in support of a regulatory action.

[1] CPAI and ADEC are also participating in a national drill rig workgroup headed by the Bureau of Land Management (BLM). The findings in this report are solely those of ADEC. ADEC is not in a position to speak for the national workgroup or to determine what datasets are viable for their purposes.

[2] Instead of conducting a RATA, CPAI stated they would, "Instead, at least once during the study a gas cylinder audit will be conducted using separate gas cylinders and at different concentration ranges than used for instrument calibration. Calibration and audit gas concentrations will be National Institute of Standards and Technology (NIST) traceable."

Attachment A – ADEC's Review of the CEMS Instrumental Performance on the Nabors 9ES Drill Rig at KRU DS2N

Drill Rig 1-Hour NO_2 Collaborative Study
A Review of the CEMS Instrumental Performance

Background

ADEC air quality staff reviewed the continuous emission monitoring systems (CEMS) data collected during the ConocoPhillips Drill Rig 1-Hour NO_2 Collaborative Study. The monitoring plan and all supporting documentation were included in the review.

Data were collected from five emissions units (EUs) on the Nabors drill rig 9ES located at Drill Site 2N (DS2N) within the Kuparuk River Unit (KRU). Emissions data were collected using two CEMS units. One CEMS collected data from two Caterpillar 3512B engines, each in service to an electrical generator with the two generators configured for load sharing. The other CEMS collected data from the remaining three EUs: two 150 horsepower boilers and a 2.96 MMBtu/hour heater. Both CEMS units utilized integrated sequential sampling systems to collect hourly average data values from each EU. Data were submitted from the period from September 7, 2014 through December 31, 2014.

The information and data reviewed included:

- Monitoring Plan and drawings;
- CEMS 7-Day calibration drift assessments;
- CEMS Calibration and Bias Checks;
- CEMS Cylinder Gas Audit worksheet;
- Post-Study NO_X converter checks;
- Daily zero and span checks, and;
- 1-hour data from both CEMS units.

Review Findings

The instrumentation and equipment described in the monitoring plan for the extractive sampling system including: sample probes, heated sample lines, sample conditioners for moisture removal, sample distribution and calibration systems, $NO_X/NO/NO_2$ and O_2 analyzers, and data acquisition systems, all of which if installed and operated correctly, would meet U.S. Environmental Protection Agency (EPA) requirements as prescribed in 40 CFR 60, Appendix B, Performance Specifications 2 and 3 (PS2 and PS3). Certificates of analysis were provided all calibration gases used during the monitoring program. The gases were prepared by specialty gas vendors in accordance with EPA protocols and certified as traceable to standard reference materials with the National Institute of Standards and Technology (NIST).

Emissions data for each monitoring parameter NO_X, NO_2, NO, and O_2 were provided for each EU associated with the two CEMS. Monitoring data were provided for the period from September 7, 2014 through December 31, 2014.

A 7-day calibration drift (CD) assessment was conducted on both CEMS units September 18 through the 24. Typically this assessment is performed before the monitoring period commences. Results were submitted for the NO_X monitoring parameter for each EU associated with the two CEMS. The EPA PS2 requirement for calibration drift is $\leq$2.5 percent for 7 consecutive days without adjustment to the analyzer. The results indicated that each NO_X monitoring channel for

each EU passed the CD requirement. Data were not submitted for the NO or O_2 monitoring parameters. This was a deficiency in the reported data.

Calibration bias and accuracy checks were performed on October 7th. The results indicated that the NO_X and O_2 monitoring channel data for both CEMS were accurate, showed a good linear response across the entire measurement range of the analyzers and that the sample system did not cause a significant bias to the measurements.

Cylinder gas audits for both CEMS units were conducted on October 7th using an independent set of NO_X calibration gases. The audits consisted of the testing at 3-upscale concentrations with the gases introduced at the probe connection to assess the integrity of the entire sample system. The audit results confirmed that the NOx monitoring channel data for both CEMS were accurate, the analyzer responses were linear, and no significant bias was introduced from the sample system. Data from the other monitoring channels for NO/NO_2 and O_2 were not provided.

Data were submitted for post-study NO_X converter testing on both CEMS unit $NO_X/NO_2/NO$ analyzers. The 30-minute time-lapse data and graphic illustration indicate good converter efficiency for the NO_X to NO catalyst on both analyzers.

Data results were submitted for daily zero/span checks. These automated quality control checks were programmed functions through the CEMS calibration system and the data acquisition system to assess daily calibration drift using a zero gas and an up-scale concentration calibration gas. Analyzer response data were provided for each monitoring channel, NO_X, NO_2, NO, and O_2. The zero/span spreadsheet also provided a percentage difference calculation for NO_X and O_2 monitoring values as compared to the true concentration of the up-scale span concentrations. The quality control limit as prescribed by 40 CFR 60, Appendix F and PS2 for NO_X and O_2 CEMS is twice the daily CD requirement (i.e. 5%) for 5 consecutive days or any one day that exceeds 4 times the daily CD requirement (i.e. 10%). Most days the response for both CEMS units to zero and span gases were within quality control limits. There were periods in mid-September and during the last week of October and first week of November that the analyzer responses were outside quality control limits. Other days the zero/span data were marked as invalid with spreadsheet notes indicating issues with depletion of calibration gases. Roughly 65 percent of the data met quality control requirements.

Some deficiencies in the information were noted.

- No information was made available in regards to the sample location, placement of the sample probe in the flue gas flow, or characteristic flue gas flow at the sample location. Although these factors can influence emission measurements, the flue gas in small stacks with no emission controls would be expected to be well mixed showing no characteristic stratification to bias the emission concentrations.
- No data were submitted for start-up calibrations and linearity checks. However, verification of measurement accuracy was provided by the daily zero/span checks. Linearity and system response were verified on October 7th.
- No monitoring logs or report narratives were submitted with the data, which would have provided more detail and explanation of data variables.

- No relative accuracy test audits were conducted, which would have provided verification of CEMS performance using a completely independent set of instrumentation and sampling system.

Review Conclusions

Although some deficiencies were noted and information found lacking, from an instrumental and systems performance perspective, the sampling equipment and instrumentation generally met EPA performance specifications and approximately 65 percent of the time the CEMS measurements met quality control requirements.

Attachment B – ADEC's Comparison of the Nabors 9ES CEMS Data to Other Data

ADEC air quality staff attempted to conduct a "reality check" of the Nabors 9ES CEMS data by comparing the measured values with vendor data and source test data obtained from public sources. Staff conducted the check since there were no Relative Accuracy Test Audits (RATA) – i.e., source tests – to help confirm the accuracy of the CEMS setup. Staff hoped that the comparison would increase ADEC's confidence that the measured values accurately reflect the actual emission rates of the monitored emissions units (EUs). However, staff was unable to make the desired comparison since the CEMS data were obtained under low load conditions and the vendor/source test data reflect high load conditions. This report describes the attempt to make this comparison.

Data Verification Methodology:

Staff compared the reported CEMS data against the following open-source public data.

1. In the case of Engine_1 and Engine_2, Caterpillar 3512B liquid-fueled diesel generator sets, data is widely available on Caterpillar's (Cat) website and in an accumulation of data reported to ADEC from permitted stationary sources using the same model of generator for electrical generation.

2. For the Superior boilers 4x751, staff requested vendor emissions performance data from Superior Boiler for the Mohawk 4-5-751-S150 family of boilers. However, Superior's local Alaska vendor was unable to supply the data for the boiler, or even boiler family, used on the Nabors 9ES drill rig. Thus staff tried to rely upon an Internet search of available data for like- or similar-units.

3. For the Tioga IDF-11 Heater used in the drill rig pipe barn, staff contacted Tioga Heaters and obtained 3 sets of vendor data representing similar IDF-11 diesel-fuel fired 2.4 MMBtu units that could be used for comparison. Staff also obtained 2 other sets of Tioga IDF-11 heater data from a permit application on file with ADEC.

Data Comparison Results:

1. For the CAT 3512B engines, Cat's website data reported design fuel consumption values of between 50 gallons per hour (gph) at 50% load to 90 gph at 100% load. CEMs data showed operating fuel consumption values between 0.2 and 0.8 gpm (correlated to 12 gph to 48 gph). These values appear low when compared to Cat's 3512B production data. The test data provided with the CEMs data package does not provide a load value during operations for direct comparison. Fuel meter calibration data was not provided as part of the test package however since both Engine_1 and Engine_2 data was directly similar, it was not believed that calibration could explain the difference between field and vendor data. CEMs data represents a unit operating at mid-to-low load values. Since the units were electrical generating sets operated in parallel to load-share, such operation is not out of the ordinary. The majority of the CEMs test data showed performance results measured at the 0.2 to 0.6 gpm range of operations with corresponding values of NOx in the 400 to 800 ppm range. Absent an operational load value, it was not possible to correlate the emissions from the Engine_1 or Engine_2 data to historical test data on file at ADEC. ADEC maintains files of historical stack test data and a direct comparison of test data for similar Cat 3512B

electrical generators shows high load fuel consumption data in the 80 to 120 gph (1.3 to 2.0 gpm) range with corresponding NOx values in the 1200 to 1600 ppm range. Similarly, mid-load stack test data on CAT 3512B historical data shows fuel consumption values of 50 to 80 gph (0.8 to 1.3 gpm) with corresponding NOx values in the 800 to 1400 ppm range.

CAT 3512B Fuel Rate	Source Test A (NOx ppm)	Source Test B (NOx ppm)	Source Test C (NOx ppm)	CEMs (NOx ppm)
CEMS: 0.2 to 0.6 gpm				400 - 800
Source Test: 1.3 – 2.0 gpm	1553 – 1586 (1.5 – 1.85 gpm)	1480 – 1631 (1.4 gpm)	1120 – 1158 (1.46 gpm)	

2. For the Superior boilers, the CEMs data reported nominal average fuel consumption data in the range of 0.4 to 1.1 gpm, with corresponding NOx values clustered between 50 to 80 ppm. The fuel consumption data was consistent as would be expected of a unit(s) that operates at a steady state load value without wide load swing variations. Superior Boilers sales literature reports a nominal fuel consumption value of 45 gph (0.75 gpm) when operating on No. 2 diesel fuel at steam operating pressures. CEMs data appears to be consistent with real-world expected results so far as fuel consumption values. Staff experience with drill rig operations is consistent with the expectation of boiler load to vary as drilling demands change. ADEC was not able to discover any historical test data for Superior Boilers of this model despite having a few similar units in the emissions inventory retained by the State. Using data from a burner unit typical of those supplied by Superior Boiler for this model of boiler, ADEC was able to find the following data for comparison.

Superior 4x751 S150 Boiler Firing Rate	Research Data (NOx ppm)	CEMs (NOx ppm)
Drill Rig (0.2 to 1.1 gpm)		50 - 80
Research (0.75 gpm typical)	110	

3. For the Tioga IDF-11 2.4MMBtu heater, data provided by Tioga (Tioga A – C) shows fuel values at low firing rate (100 psi at the burner nozzle) in the .18 gpm range and high firing rate (280 psi at the nozzle) to be 0.3 gpm. The CEMs data provided showed the majority of the data for the Nabors 9ES rig pipe barn heater to be at operating ranges of 0.15 to 0.19 gpm. The corresponding CEMs NOx data ranged in the 4 to 12 ppm range, whereas Tioga's provided data ranged from 40 ppm (low firing rate) to mid-70's ppm at the high firing rate. All of Tioga's test data was taken at ambient temperatures of 50 to 75 degF. For external combustion sources, ADEC was not able to correlate higher ambient heater inlet temperatures to higher NOx values in post-combustion gases. ADEC also discovered permit application data provided by an industrial activity for North Slope use citing additional Tioga IDF-11 heater emissions data (Tioga D & E). ADEC could not account for the variation of Tioga D without further investigation. Ambient temperature data was not provided in the test data package, however an online research shows historical ambient

temperatures for the North Slope during the October to December timeframe to be in the range of -10 degF to 20 degF.

IDF-11 Tioga Heater Firing Rates	Tioga A (NOx ppm)	Tioga B (NOx ppm)	Tioga C (NOx ppm)	Tioga D (NOx ppm)	Tioga E (NOx ppm)	CEMs (NOx ppm)
100 psi (11 gph; .18 gpm)	43	50	41	5	46	4 - 12
280 psi (18 gph; 0.3 gpm)	72	78	63	7	74	

Qualitative Review Conclusions:

1. For the CAT 3512B diesel engines, a linear forecast of the trendline on the CEMs data plot appears to correlate the historical stack test data to CEMs data only if the NOx function is directly linear to fuel consumption. ADEC was not able to directly correlate the provided CEMs data to be within the expected range of real-world test results without further investigation because we lacked load data for a direct comparison of CEMs emission data to representative source test data. An approximate correlation between engine fuel consumption data and typical load ranges for these units would suggest that the Nabors 9ES electrical generators were operating at a very low operational load and that high operational ranges (and thus higher fuel consumption) data were not represented by the data provided.

2. For the Superior 4x751 S150 boilers, ADEC was not able to correlate the provided CEMs data to be within the expected range of real-world test results without further investigation because we lacked emissions data on the exact burner model supplied by the vendor for this installation and any representative source test data. Further, the emissions data collected by ADEC's Internet search was only available for like- and similar-units.

3. For the Tioga IDF-11 2.4MMBtu heater, ADEC was not able to correlate the provided CEMs data to be within the expected range of real-world test results without further investigation. The Tioga heater appeared to be operating at a much reduced heat load than would be expected when compared to vendor data obtained by ADEC considering the seasonal test data provided. All Tioga test data obtained used similar liquid-fuel burner models (C-120 or G-120) but the exact burner model used in the Nabors 9ES rig Tioga IDF-11 heater was not available for direct comparison.

Summary:

ADEC was unable to confirm that the CEMs data accurately reflects real-world emissions since the various datasets were obtained at different loads.