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AIR QUALITY DIVISION

Comprehensive Emissions Test Report

East Wakefield Compressor Station
Nitrogen Oxides
Compliance Testing

Testing Date(s): February 26, 2019
Report Date: April 3, 2019
Revision Date: No revision to date



Subject Facility:
Northern Natural Gas
East Wakefield Compressor Station
280 M28E
Wakefield, MI 49968

Regulatory Permit No.:
Permit to Install 3-18
State Registration No. P0890

Subject Emission Sources:

NE2 Turbine	EUTURBINE2
NE1 Turbine	EUTURBINE1

Test Locations:

Stack	SVTURBINE2
Stack	SVTURBINE1

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Pace Project No. 19-01592

Table of Contents

Report Cover	1
Table of Contents	2
Regulatory Summary	3
Introduction	4
Results Summary	5
Summary Tables	6
Table 1 Gas Monitoring Results, NE2 Turbine Stack	7
Table 2 Gas Monitoring Results, NE1 Turbine Stack	8
Process Description	9
Test Procedures	10
Report Signatures	15
Appendix A Field Data Sheets and Documentation	A-1
Appendix B Quantitation and Laboratory Reports	B-1
Appendix C Calculation Equations and Report Nomenclature	C-1
Appendix D Quality Assurance Information	D-1
Appendix E Source/Process/Plant Information	E-1
Appendix F Test Protocol and Pretest Correspondence	F-1

Regulatory Summary

Subject Facility: Northern Natural Gas
 East Wakefield Compressor Station
 Plant Address: 280 M28E
 Wakefield, MI 49968

Permit to Install: 3-18
 State Registration: P0890

Emission Unit IDs	Emission Unit Name	Regulated Constituent	Regulatory Citations	Regulatory Limit	Average Test Result
EUTURBINE2	NE2 Turbine	Nitrogen Oxides	40 CFR 60.4320(a) 40 CFR 52.21(c) & (d)	≤100 PPM @ 15% O ₂	73.5 PPM, Dry @ 15% O ₂
			R 336.1205(1)(a), 40 CFR 52.21(c) & (d)	≤7.24 LB/HR	4.47 LB/HR
EUTURBINE1	NE1 Turbine	Nitrogen Oxides	40 CFR 60.4320(a) 40 CFR 52.21(c) & (d)	≤100 PPM @ 15% O ₂	76.7 PPM, Dry @ 15% O ₂
			R 336.1205(1)(a), 40 CFR 52.21(c) & (d)	≤7.24 LB/HR	4.67 LB/HR
	Natural Gas Sample	Total Sulfur Content	40 CFR Section 60.4330(a)(2)	0.06 LB/MMBTU	<0.000044 LB/MMBTU

Introduction

Pace Analytical Services, LLC personnel conducted nitrogen oxides (NO_x) emission compliance testing on two natural gas-fired combustion turbine stacks (NE2 Turbine & NE1 Turbine) at the Northern Natural Gas - East Wakefield Compressor Station located in Wakefield, Michigan. Matt McDermott performed on-site testing activities on February 26, 2019. Terry Borgerding provided administrative project management. Kelly Henry with Northern Natural Gas coordinated plant activities during testing. Pace Analytical Services, LLC prepared a comprehensive test protocol that was submitted to the Michigan Department of Environmental Quality (MDEQ) prior to testing. On-site activities consisted of the following measurements on each stack:

- Oxygen (O₂), three independent one-hour monitoring periods.
- Nitrogen oxides (NO_x), three independent one-hour monitoring periods.
- Fuel sample for sulfur content.

The project objectives were to quantify NO_x emission constituents and compare them to applicable air emissions regulations stipulated by MDEQ and the facility permit. These measurements were performed while the turbine was operating at or above 75% peak load and the ambient temperature was above 0°F. Quality protocols comply with regulatory compliance testing requirements.

Subsequent sections summarize the test results and provide descriptions of the process and test methods. Supporting information and raw data are in the appendices.

Results Summary

Results of NO_x determinations for the NE2 Turbine Stack are summarized in Table 1. The NO_x concentration averaged 73.5 PPM, Dry @ 15% O₂ and the emission rate averaged 4.47 LB/HR. The NO_x emission limits for this source are 100 PPM @ 15% O₂ and 7.24 LB/HR.

Results of NO_x determinations for the NE1 Turbine Stack are summarized in Table 2. The NO_x concentration averaged 76.7 PPM, Dry @ 15% O₂ and the emission rate averaged 4.67 LB/HR. The NO_x emission limits for this source are 100 PPM @ 15% O₂ and 7.24 LB/HR.

The NO_x emission rate (LB/HR) was calculated using EPA Method 19 procedures and the engine fuel flow (MMBTU/HR).

The laboratory report of the sulfur analyses performed on a fuel gas sample collected during testing is included in Appendix B. The sulfur content was <0.032 GR/100 SCF.

The data in this report are indicative of emission characteristics of the measured sources for process conditions at the time of the test. Representations to other sources and test conditions are beyond the scope of this report.

Summary Tables

Northern Natural Gas
 East Wakefield Compressor Station
 Wakefield, MI
 Pace Project No. 19-01592

Table 1
Gas Monitoring Results
NE2 Turbine Stack
Test 1

Parameter	Run 1	Run 2	Run 3	Average
Date of Run	2/26/19	2/26/19	2/26/19	
Time of Run	0950-1050	1103-1203	1230-1330	
Sample Duration (Minutes)	60	60	60	
Compressor Flow, MMscfd	92.37	92.47	92.93	92.59
Oxygen, %v/v - Dry	16.06	15.95	15.95	15.99
Constituent Concentration, PPMv - Dry				
Nitrogen Oxides as NO2	58.9	62.6	62.1	61.2
Corrected Constituent Concentrations, PPM, dry @ 15% Oxygen				
Nitrogen Oxides as NO2	71.8	74.6	74.1	73.5
Constituent Emission Factors, LB/MMBTU (F-factor = 8710)				
Nitrogen Oxides as NO2	0.264	0.275	0.273	0.271
Heat Input, MMBTU/HR	16.53	16.60	16.43	16.52
Fuel Input, MMCF (natural gas=1030 BTU/CF)	0.0160	0.0161	0.0160	0.0160
NOx, LB/HR (LB/MMBTU x MMBTU/HR)	4.37	4.57	4.49	4.47
NOx LB/MMCF Fuel Burned	272	283	281	279

Northern Natural Gas

East Wakefield Compressor Station
 Wakefield, MI
 Pace Project No. 19-01592

Table 2
Gas Monitoring Results
NE1 Turbine Stack
Test 1

Parameter	Run 4	Run 5	Run 6	Average
Date of Run	2/26/19	2/26/19	2/26/19	
Time of Run	1355-1455	1510-1610	1713-1813	
Sample Duration (Minutes)	60	60	60	
Compressor Flow, MMscfd	86.97	87.23	87.30	87.17
Oxygen, %v/v - Dry	15.88	15.87	15.92	15.89
Constituent Concentration, PPMv - Dry Nitrogen Oxides as NO2	63.8	67.5	64.0	65.1
Corrected Constituent Concentrations, PPM, dry @ 15% Oxygen Nitrogen Oxides as NO2	75.0	79.2	75.8	76.7
Constituent Emission Factors, LB/MMBTU (F-factor = 8710) Nitrogen Oxides as NO2	0.276	0.292	0.279	0.283
Heat Input, MMBTU/HR	16.50	16.53	16.55	16.53
Fuel Input, MMCF (natural gas=1030 BTU/CF)	0.0160	0.0160	0.0161	0.0160
NOx, LB/HR (LB/MMBTU x MMBTU/HR)	4.56	4.82	4.62	4.67
NOx LB/MMCF Fuel Burned	285	301	288	291

Process Description

Northern Natural Gas - East Wakefield Compressor Station is a natural gas compressor station located in Wakefield, Michigan. Compressor stations compress natural gas to specified pressure along natural gas pipelines allowing the gas to continue moving through the pipeline to the intended recipient. The facility consists of two 1,679 HP simple-cycle natural gas-fired combustion turbines for compressing natural gas.

Test related process and operational details were collected by Northern Natural Gas personnel and included in Appendix E.

Test Procedures

EPA Method 1 specifies test location acceptability criteria and defines the minimum number of traverse points for representative sampling. Linear measurements from upstream and downstream flow disturbances and the duct equivalent diameter are compared and the distances related to number of diameters. A flow disturbance can be defined as anything that changes or upsets the direction of flow within the duct including bends, dampers, fans, shape or size transitions, and open flames. Method 1 stipulates that test ports should be located at least eight diameters downstream and two diameters upstream of any flow disturbance. The minimum acceptable criteria are two diameters downstream and 0.5 diameters upstream of flow disturbances. The test location must also be free of cyclonic or multidirectional flow. Once the distances have been determined, the values are used to select the minimum number of traverse points for representative sampling. Shorter distances require a greater number of traverse points. The test site configuration and measurement details are documented on EPA Method 1 Field Data Sheet.

Pace FSD conducts the method as written with no routine deviations.

EPA Method 3A defines procedures to measure carbon dioxide (CO₂) and oxygen (O₂) concentrations from stationary sources. A stainless steel sampling probe and a sampling line draw a sample of the gas stream from the duct to a thermo-electric gas conditioner to remove moisture. The conditioned gas stream is delivered to an infrared gas analyzer to quantify CO₂ concentrations and paramagnetic gas analyzer to quantify O₂ concentrations. Zero grade cylinder air or a zero gas generator provides zero gas. Span gases include varying concentrations of EPA Protocol 1 CO₂/O₂ mixed standards specific to the target calibration range. A computerized data acquisition system logs CO₂/O₂ concentrations for one-minute averages. The logged results are integrated to test periods and tabulated with standardized and validated spreadsheets in Microsoft Excel. The operator also maintains comprehensive test records in the electronic Project Results Instrumental Workbook. Equipment used for CO₂/O₂ testing includes:

Probe Material:	Stainless Steel
Moisture Removal:	Thermo-electric
Transfer Line:	Teflon™
Analytical Technique:	Non-dispersive Infrared Detector (CO ₂) Paramagnetic Detector (O ₂)
Calibration Gas:	EPA Protocol 1

Method Defined Quality Control:

- Sampling system leak-checks are performed before each test and following any component change. Absence of leaks is confirmed through the bias check after each run.

- Calibration gas standards of the highest quality, Protocol 1 or traceable to NIST, are used in calibrations.
- Analyzer calibration error is determined before initial run and after any failed bias or drift test.
- Analyzer bias is verified once per test.
- System bias check is performed before and after each test.
- Calibration drift test is performed after each test run.
- System response time is determined during initial sampling system bias test.
- Stratification test is performed prior to first run.
- Purge time of $\geq 2x$ the response time observed before starting data collection and recording stratification traverse point values.

Pace FSD conducts the method as written with no routine deviations.

EPA Method 7E defines procedures to measure nitrogen oxide (NO_x) emissions from stationary sources. A stainless steel sampling probe and a heat-traced Teflon™ sampling line draw a sample of the gas stream from the duct to a thermo-electric gas conditioner to remove moisture. The sample gas stream is delivered to a chemiluminescence NO-NO₂-NO_x analyzer to quantify NO_x emissions. Zero grade cylinder air or a zero gas generator provides zero gas. Span gases include varying concentrations of EPA NO_x standards specific to the target calibration range. A computerized data acquisition system logs NO_x concentrations for one-minute averages. The logged results are integrated to test periods and tabulated with standardized and validated spreadsheets in Microsoft Excel. The operator also maintains comprehensive test records in the electronic Project Results Instrumental Workbook. Equipment used for NO_x testing includes:

Probe Material:	Stainless Steel
Moisture Removal:	Thermo-electric
Transfer Line:	Teflon™
Analytical Technique:	Chemiluminescence
Calibration Gas:	EPA Protocol 1

Method Defined Quality Control:

- Sampling system leak-checks are performed before each test and following any component change. Absence of leaks is confirmed through the bias check after each run.
- Calibration gas standards of the highest quality, Protocol 1 or traceable to NIST, are used in calibrations.
- Analyzer calibration error is determined before initial run and after any failed bias or drift test.
- Analyzer bias is verified once per test.
- System bias check is performed before and after each test.
- Calibration drift test is performed after each test run.

- System response time is determined during initial sampling system bias test.
- Stratification test is performed prior to first run.
- Purge time of $\geq 2x$ the response time observed before starting data collection and recording stratification traverse point values.
- NO₂ to NO converter efficiency verified $\geq 90\%$ before or after each test.

Pace FSD conducts the method as written with no routine deviations.

EPA Method 19 describes data reduction procedures relating to particulate matter (PM), sulfur dioxide (SO₂), and nitrogen oxide (NO_x). This method is used to determine emission rates, overall reduction of potential SO₂ emissions, and SO₂ removal efficiency. Oxygen (O₂) or carbon dioxide (CO₂) concentrations and appropriate F-factors (ratios of combustion gas volumes to heat inputs) are used to calculate pollutant emission rates from pollutant concentrations. An overall SO₂ emission reduction efficiency is computed from the efficiency of fuel pretreatment systems, where applicable, and the efficiency of SO₂ control devices. The sulfur removal efficiency of a fuel pretreatment system is determined by fuel sampling and analysis of the sulfur and heat contents of the fuel before and after the pretreatment system. The SO₂ removal efficiency of a control device is determined by measuring the SO₂ rates before and after the control device. The inlet rates to SO₂ control systems are determined by fuel sampling and analysis; when SO₂ control systems are not used, SO₂ emission rates to the atmosphere are determined.

Pace FSD conducts the method as written with no routine deviations.

Reference Standards. Pace implements a comprehensive program to verify and validate reference standards to further enhance and support method standards. Primary reference standards are directly comparable to a reference base. The National Institute of Standards and Technology (NIST) maintains primary reference materials or very closely traceable secondary standards. These materials are then used to certify secondary or transfer standards for use in quality management programs. Secondary reference standards are calibrated with primary standards using a high precision comparator. Materials that have a documented path to the primary standard are often referred to as traceable to NIST or NIST traceable. Where commercially and feasibly available, Pace uses primary reference standards to perform calibrations and verifications. In other cases, Pace maintains traceable secondary reference standards. Primary and secondary reference standards are used to calibrate and verify equipment and materials. Pace reference standards are calibrated by external vendors that have a formal, registered quality system. Calibrations are performed with equipment and materials that are traceable to NIST.

Quality Controls (not defined in test methods):

- Sampling/Recovery Reagents are Reagent Grade or better.
- Reference Temperature Simulator is calibrated annually.

- Reference Pressure Transducer is calibrated annually.
- Reference DryCal airflow meter is calibrated annually.
- Mercury Barometer is a primary reference standard.
- Liquid Manometers are primary reference standards.
- Angle Blocks, Gauge Blocks, and Measuring Rods are verified every five years.
- Angle Gauges are verified each day of use.
- Calipers are verified annually.
- Stainless steel reference weights are verified every five years.
- Analytical balances are calibrated annually and verified at each use.
- Field balances are calibrated annually and verified at each use.

Quality Management System. To produce data that is complete, representative, and of known precision and accuracy, Pace Analytical Field Services Division has designed and implemented a rigorous and innovative quality management system. The system was initially based on the USEPA Quality Assurance Handbook for Air Pollution Measurement Systems and continually developed as procedural complexities and standards progressed. The Field Services Division Quality Management System (Pace FSD QMS) is now accredited by the American Association of Laboratory Accreditation (A2LA) to comply with three national accreditation standards:

- ASTM D7036 - Standard Practice for Competence of Air Emission Testing Bodies (AETB).
- ISO 17025 - General Requirements for the Competence of Testing and Calibration Laboratories
- The NELAC Institute - General Requirements for Field Sampling and Measurement Organizations (FSMO)

The Pace FSD QMS includes:

- Quality Programs
 - Ethics policy and training.
 - Corrective Action and Preventative Action (CAPA).
 - Continuous Process Improvement.
 - Documented Demonstrations of Capability.
 - Internal and third party proficiency testing.
 - Qualified Individual program (QI)
 - Internal and external audits.
 - Annual management reviews.
- Documentation and Traceability
 - High quality traceable standards and reagents.
 - Reagent tracking and management system.
 - Use of matrix spikes, duplicate analysis, internal standards, and blanks.
 - Validated workbooks for data collection and results reporting.
 - Electronic quality, training, and safety documents available in-field.
 - Sample security and preservation procedures.

- Chain of custody maintained from sample collection through laboratory analysis.
- Equipment Calibration
 - Full time staff dedicated to equipment maintenance and calibration.

All equipment and instruments are calibrated by trained personnel on a frequency that meets or exceeds method requirements.

Report Signatures

Field Testing and Reporting Performed by: Pace Analytical Services, LLC
Field Services Division
1700 Elm Street, Suite 200
Minneapolis, MN 55414

Field Testing Affirmation

All field testing was performed in accordance with stated test methods subject to modifications and deviations listed herein. Raw field data presented in this report accurately reflects results and information as recorded at the time of tests or otherwise noted.



Mathew A. McDermott, QSTI
Team Lead

Date 3/29/19

Report Affirmation

To the best of my knowledge, this report accurately represents the compiled field and laboratory information with no material omissions, alterations or misrepresentations.

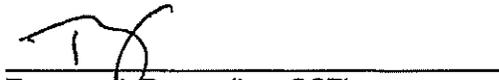


Beth Kelm
Client Coordinator

Date 4/1/19

Responsible Charge Affirmation

I have reviewed the information herein and it is approved for distribution.



Terence J. Borgerding, QSTI
Operations Manager, Air

Date 4/1/19

Appendix A

Field Data Sheets and Documentation

No handwritten or analogue data were collected during this monitoring event. Digital and electronic data collections are included in Appendix B.